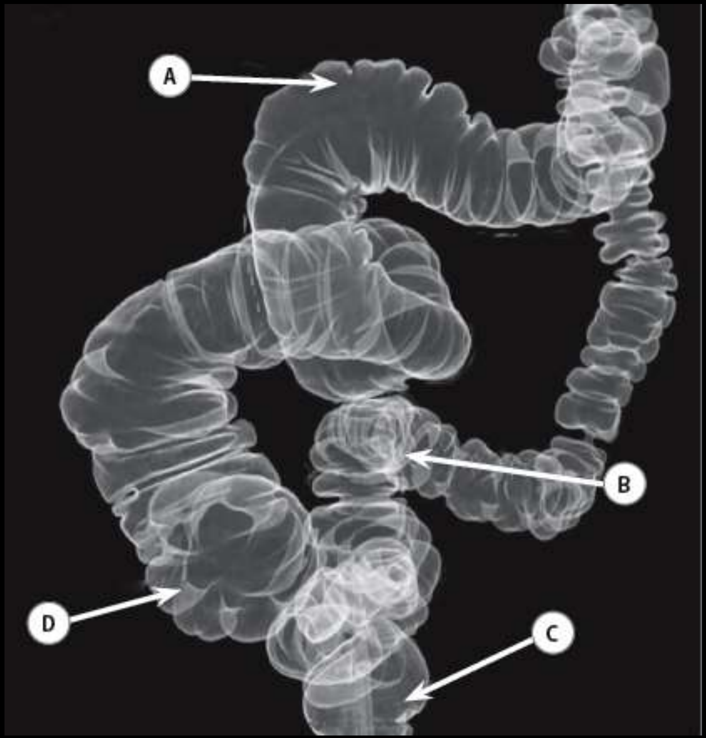
ABDO/PELVIS



CONTENTS

PLAIN FILM

Question 1.11

Name the structures labelled **A** to **E**.

1.11 AP X-ray of the abdomen

A Stomach.
B Left properitoneal fat stripe/line.
C Left pedicle of L1.
D Transverse colon.
E Right psoas shadow/outline.

The properitoneal fat stripe represents the layer of fat that separates the peritoneum from the muscles of the anterior abdominal wall. Loss of the stripe may indicate pathology within the abdomen, such as peritonitis. The large bowel can be differentiated from the small bowel by its peripheral location and mucosal markings with haustra only crossing two-thirds of the bowel wall. The psoas major originates from the transverse processes, vertebral bodies and intervertebral discs of T12–L5 and is defined on the abdominal radiograph by a thin radiolucent fat line. The line may be

Question 1.16

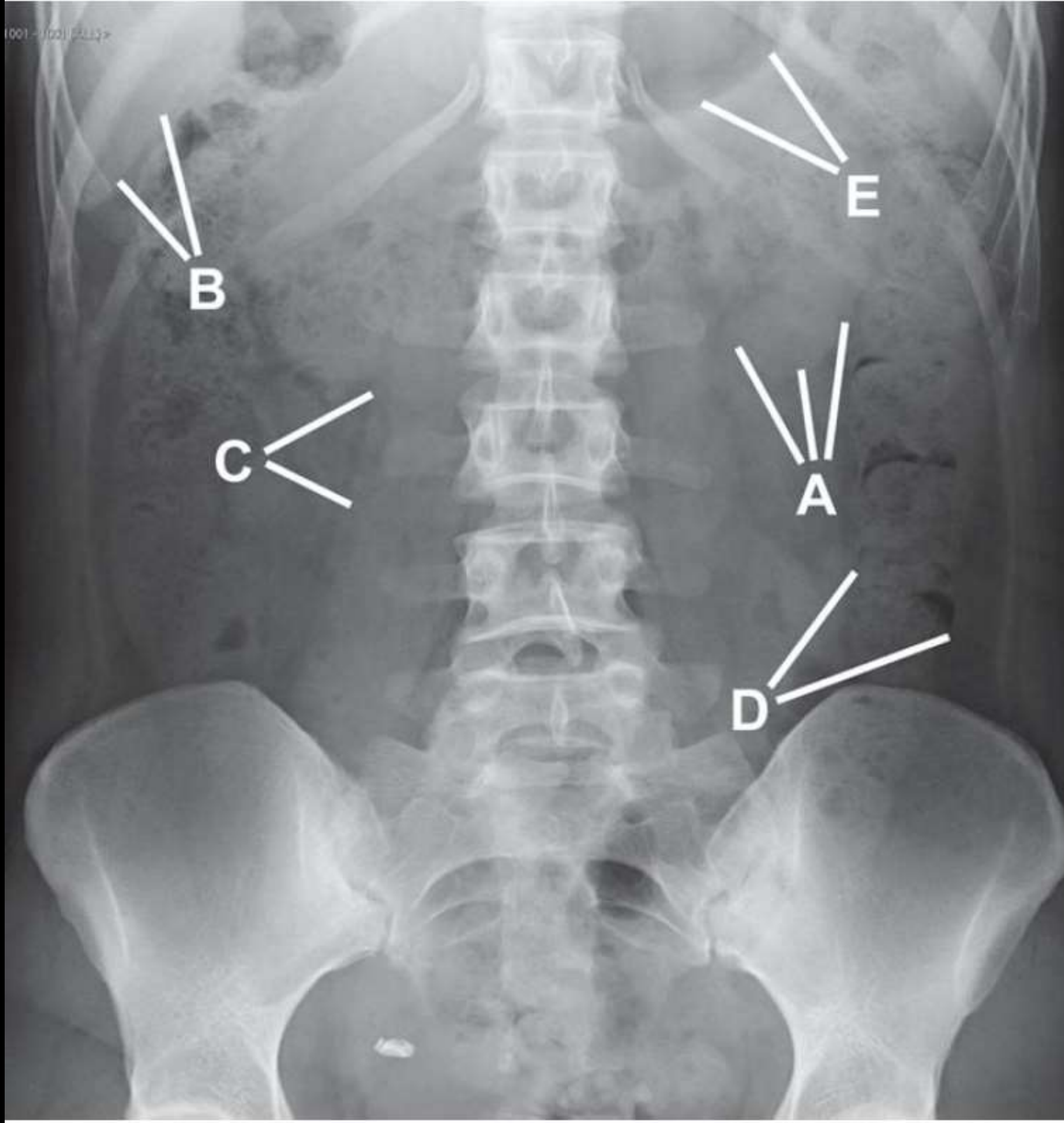
Name the structures labelled **A** to **D**.

E What muscle originates from **A**?

1.16 AP X-ray of the pelvis

A Right anterior inferior iliac spine.
B Right ischial spine.
C Spinous process of L5.
D Right inferior pubic ramus.
E Right rectus femoris muscle.

The pelvis is formed by the sacrum and coccyx posteriorly and the two hip bones laterally and anteriorly. The hip bones are composed of the pubis, ischium and ilium. The anterior inferior iliac spine is the origin for the rectus femoris and is a recognized site for avulsion fractures. The ischium is situated inferiorly to the ilium and posteriorly to the pubis. The ischial tuberosity is the origin for the hamstring muscles and is another recognized site for avulsion fractures. The ischial spine is a triangular bony eminence to which the levator ani and sacrospinous ligament are attached.


E
B
A
C
D

Q1 Answers

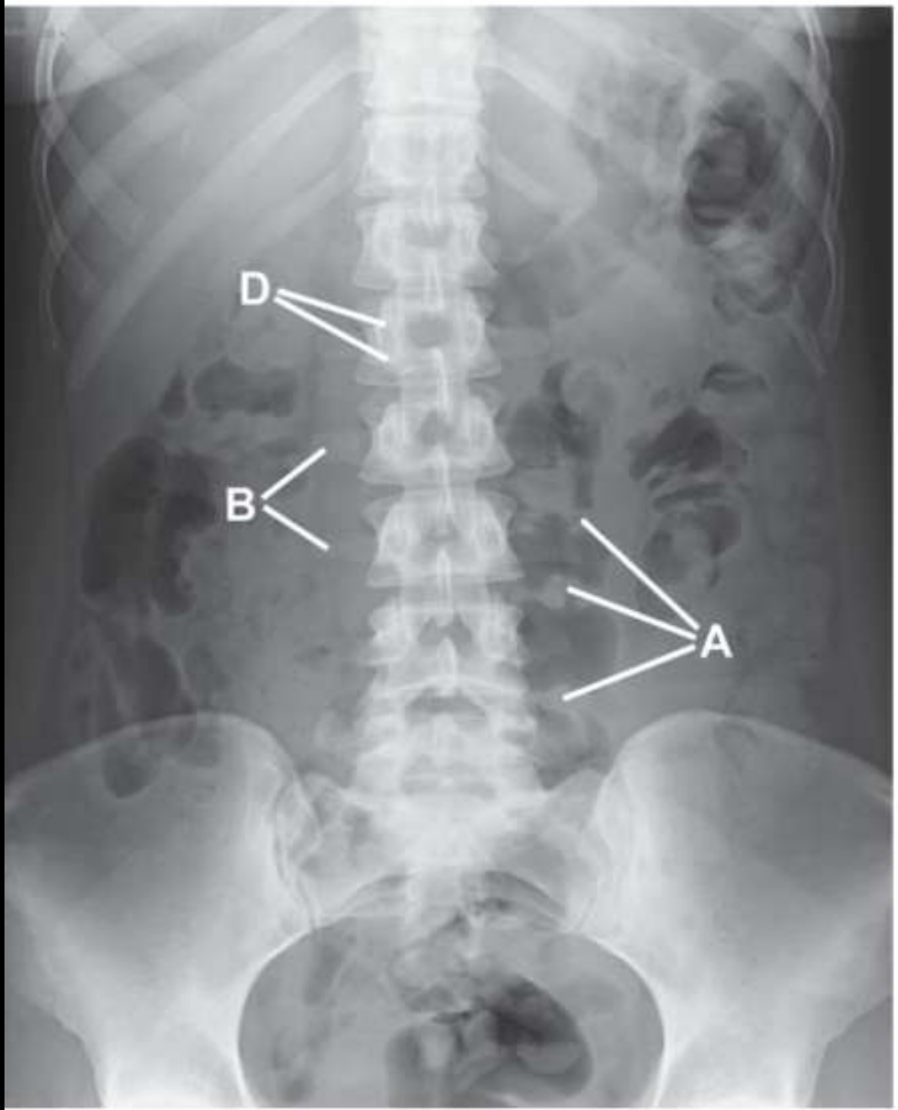
a Left kidney
b Liver
c Right psoas muscle
d Descending colon
e Stomach

Abdominal radiograph

On plain radiography, the presence of an interface between tissues of differing contrast is required to enable visualization of structures. In the case of the liver, kidney and psoas muscles there is para-renal, peri-renal and retroperitoneal fat to provide this contrast. The descending colon is surrounded on three sides by peritoneum but there is adjacent preperitoneal fat which can give contrast, as in this case. There is often gas within the lumen of the bowel to provide negative contrast as is commonly seen in the stomach and colon.

Q2

a Name the structures labelled A
b Name the structures labelled B
c Name the structure that partially arises from the antero-medial aspect of the structures labelled B
d Name the structure labelled D
e Name the skeletal anatomical variant demonstrated in this image



Q2 Answers

a Haustra
b Transverse processes of lumbar spine
c Psoas major muscle
d Right pedicle of L2
e Six lumbar vertebrae (or one pre-sacral vertebra)

Abdominal radiograph

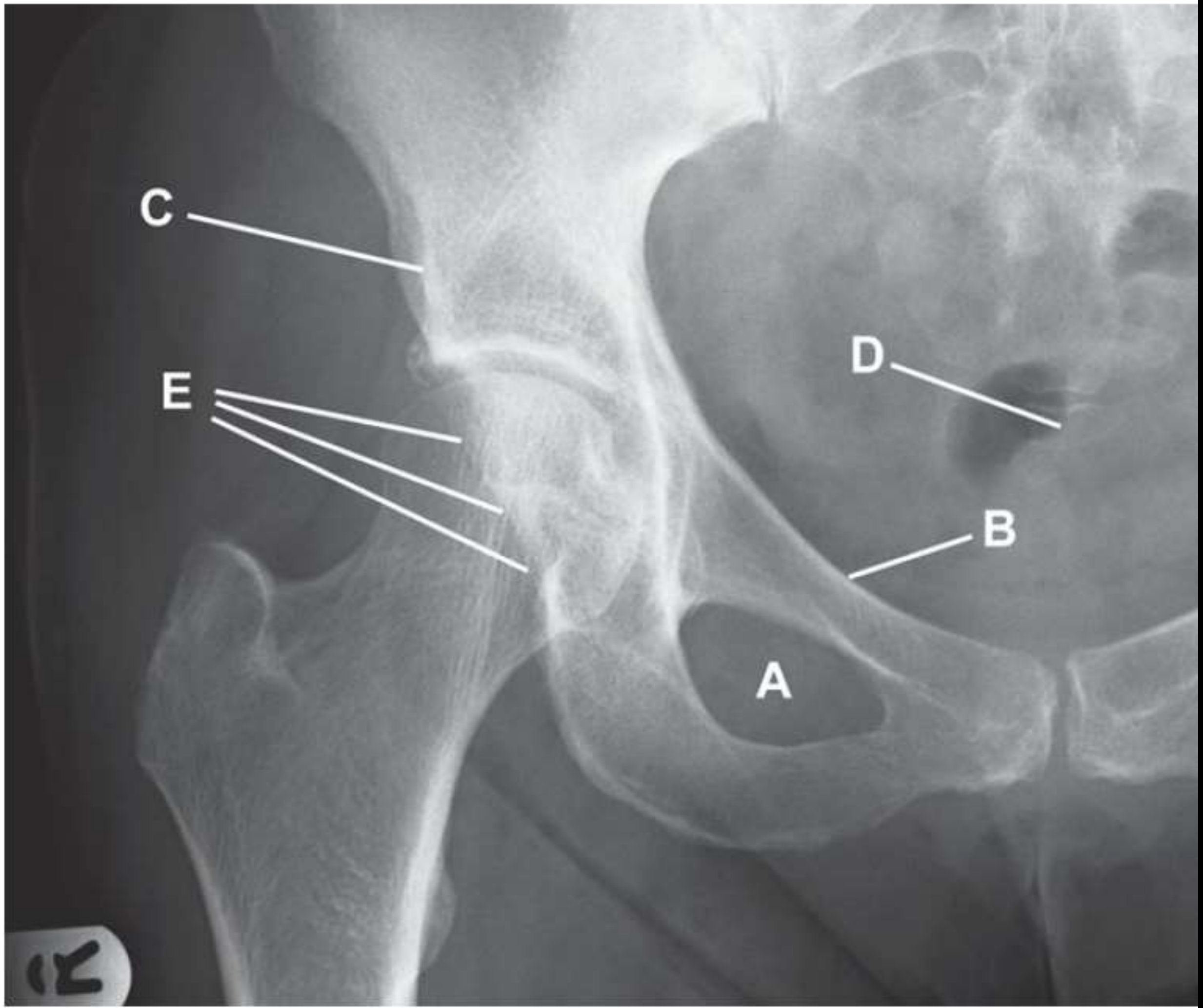
The teniae coli run the length of the colon, from the caecum to the sigmoid. They are focal areas of thickening in the longitudinal muscular layer which run along the anterior, postero-medial and postero-lateral aspects of the colon. As they are shorter than the colon, the bowel is pulled into folds, or haustra, which can be seen on radiographs. The taeniae coli converge at the appendix base proximally and the rectum distally.

The psoas major muscle arises from the antero-medial aspect of the lumbar transverse processes and the lower borders of the T12–L5 vertebral bodies.

Aberrations at the lumbar-sacral junction are occasionally seen. An example is the presence of six lumbar vertebrae, the sixth vertebra being called the first pre-sacral vertebra. 'Sacralization' of L5 occurs when it is fused to S1. 'Lumbarization' of S1, which is less common, occurs when S1 is significantly separated from S2.

Q1

a Name the space labelled A
b Name the bony contour labelled B
c Name the muscle that attaches to C
d Name the bony structure labelled D
e Name the bony structure indicated as E



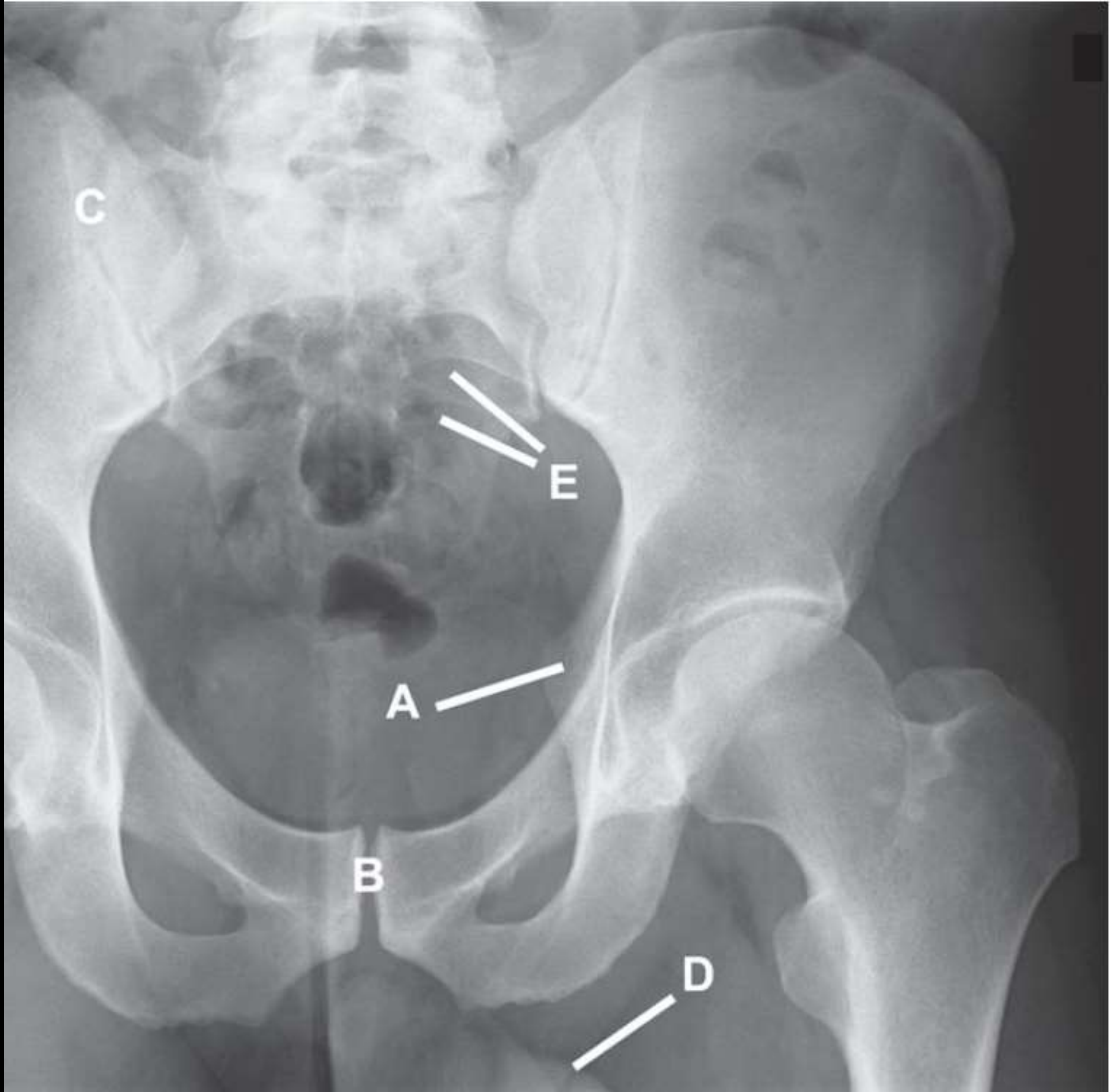
Q1 Answers

a Obturator foramen
b Pectineal line
c The straight head of rectus femoris attaches to the anterior inferior iliac spine
d Coccyx
e Posterior rim of right acetabulum

Radiograph of female pelvis, close up frontal view

The bony pelvis forms a complete ring and is composed of the paired innominate bones (themselves a fusion of three bones; ilium, ischium and pubis), the sacrum and coccyx. The paired sacro-iliac joints and pubic symphysis complete the ring.

The obturator foramina are almost completely closed over by the obturator membrane but do transmit the obturator nerves and vessels which supply the inner thigh.


C
E
A
B
D

Q2 Answers

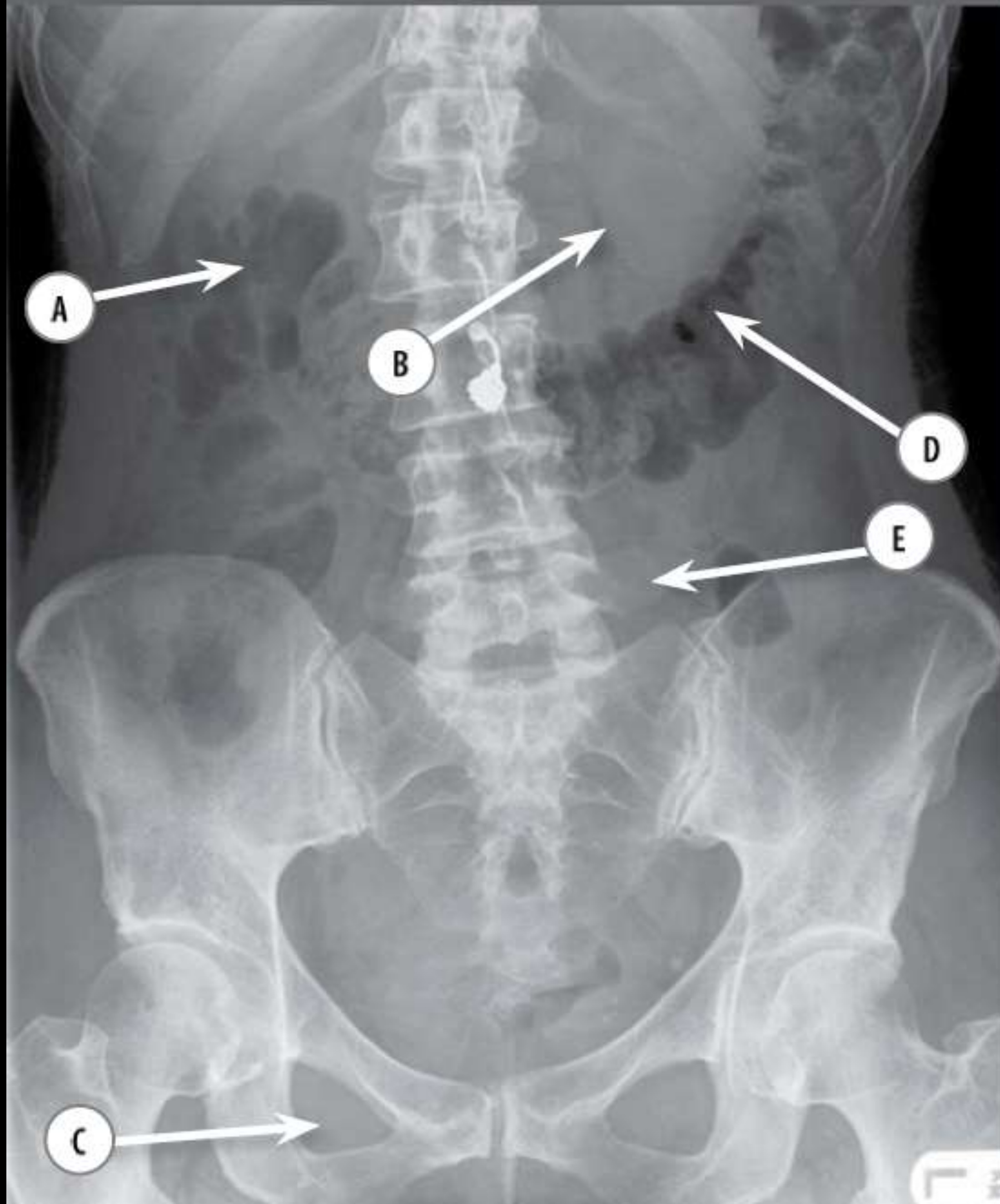
a Ischial spine
b Pubic symphysis
c Sacro-iliac (SI) joint
d Soft tissue penile shadow
e Anterior sacral formina

Radiograph of male pelvis, close up frontal view

The morphology of the male and female pelvis differs in a number of ways. The male pelvis is more narrow and deep and it is said to be heart-shaped compared with the more round or oval, wide and shallow female pelvis. The sub-pubic angle formed by the pubic rami is more acute in the male pelvis and the ischial spines are usually more prominent. Soft tissue shadowing from genitalia or implantable contraceptive devices may give further clues as to the gender of the patient.

The sacral foramina allow passage of the sacral nerves and accompanying vessels.

Case 3.10



Case 3.10

- **A** Gas within the colon; hepatic flexure
- **B** Left renal outline, lower pole
- **C** Right obturator foramen
- **D** Gas within the transverse colon
- **E** Left transverse process of the L5 vertebra

Plain supine abdominal radiograph.

Structures on plain film are differentiated from one another based on their differing densities. Some abdominal organs are clearly outlined by the fat which surrounds them. On this film, the left kidney can be clearly identified, with its upper pole projected over the lower ribs, and its lower pole adjacent to the left psoas.

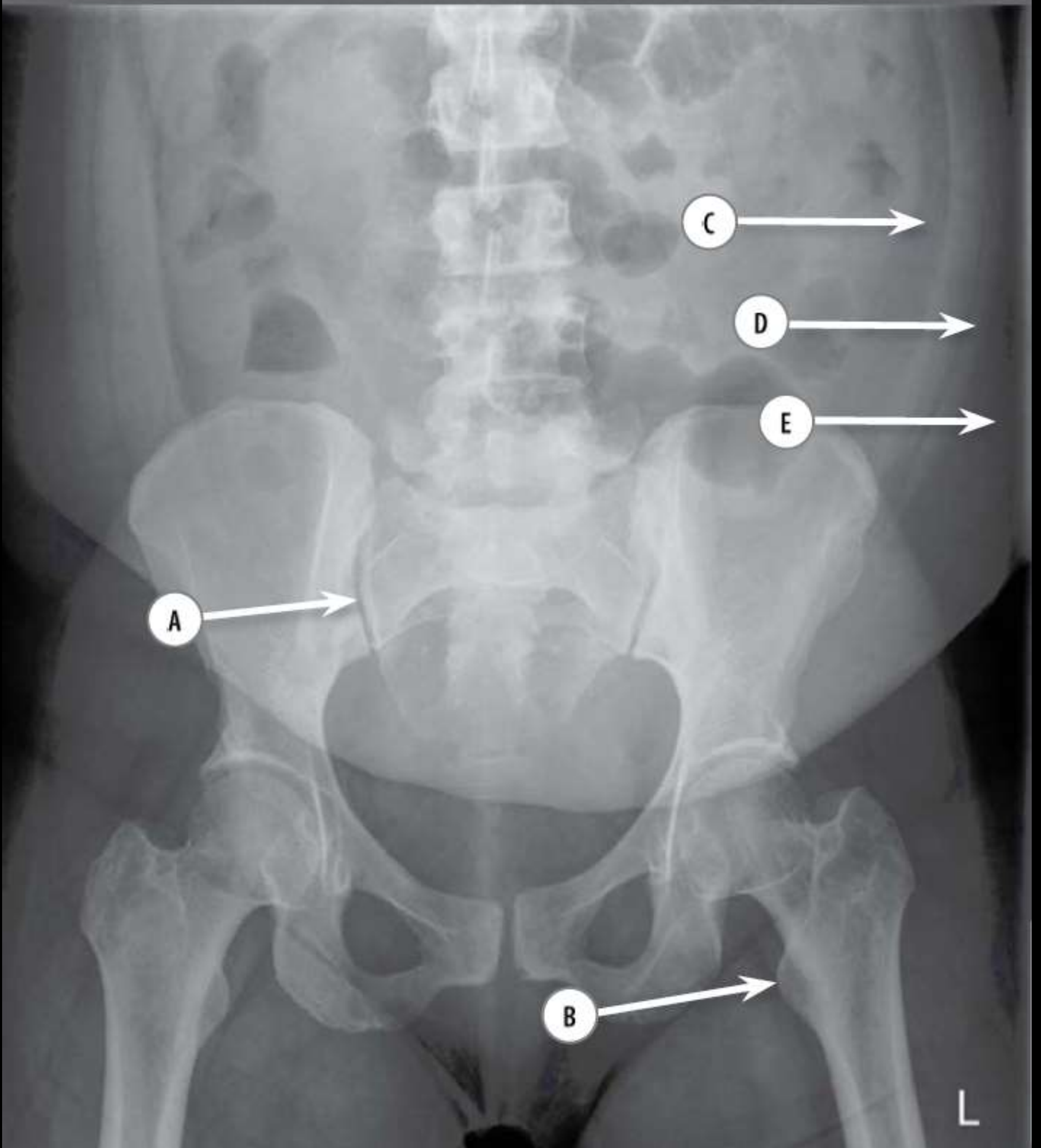
Gas within bowel can outline valvulae conniventes and haustral markings, which helps identify small and large bowel respectively. Haustrae are fixed structures in the proximal colon, but are formed by muscular contraction more distally, and so are variable. Haustral markings may be absent from the mid transverse colon onwards. Small and large bowel can be further differentiated by their position within the abdomen. The large bowel is located around the periphery, and can be said to 'frame the abdomen'. **Table 3.1** outlines the anatomical features which differentiate large from small bowel on plain film.

Table 3.1 Anatomical features of small bowel and large bowel on plain radiograph

	Small bowel	Large bowel
Position	Central	Peripheral
Septations	Complete (valvulae conniventes)	Incomplete (haustrae)
Diameter	<3 cm	<5.5 cm
Contents	Air Fluid	Solid faeces may be present

Ryan S, McNicholas M, Eustace SJ. Anatomy for Diagnostic Imaging, 3rd edn. Edinburgh: Saunders, 2011: 167–174.

Case 3.22



Case 3.22

A Right sacroiliac joint

B Lesser trochanter of left femur

C Pro-peritoneal fat line

D Left external oblique

E Subcutaneous tissue/fat in the left abdominal wall

Plain pelvic radiograph.

In this image, the soft tissues can be easily outlined due to the fat which is surrounding them. There is a layer of fat which separates the muscles of the anterior abdominal wall from the peritoneum, which is known as properitoneal fat. This can be seen as a hypodense line or stripe on abdominal plain radiographs: the properitoneal fat line.

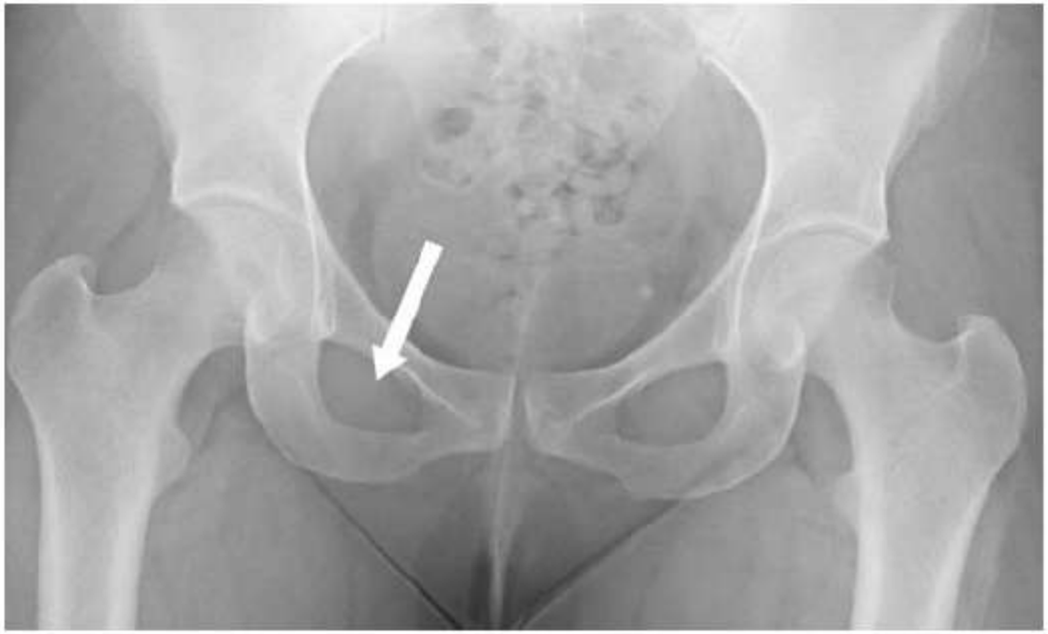
The anterolateral abdominal wall has three muscle layers, which are interposed with fat. The largest and most superficial of these muscles is the external oblique. It arises as slips from the inferolateral borders of the eight inferior ribs, and its posterior fibres extend to insert into the anterior half of the iliac crests. The middle and uppermost fibres are continuous with the aponeurosis of the muscle, anteriorly. This aponeurosis continues medially and becomes part of the rectus sheath and linea alba. Inferiorly, the aponeurosis extends to the pubic symphysis. The free edge of the aponeurosis, between the anterior superior iliac spine and the pubic tubercle, forms the inguinal ligament.

Deep to external oblique, forming the other two muscle layers of the anterolateral abdominal wall are internal oblique and transversus abdominis.

There are four different densities which can be appreciated on plain radiograph: air, fat, fluid/soft tissue, and bone. Edges and borders can only be seen on plain film if there is an interface with a tissue of differing density (silhouette sign).

Ryan S, McNicholas M, Eustace SJ. Anatomy for Diagnostic Imaging, 3rd edn. Edinburgh: Saunders, 2011: 158.
Butler P, Mitchell AM, Ellis H. Applied Radiological Anatomy. Cambridge: Cambridge University Press, 1999: 201.

- **Question 5:**

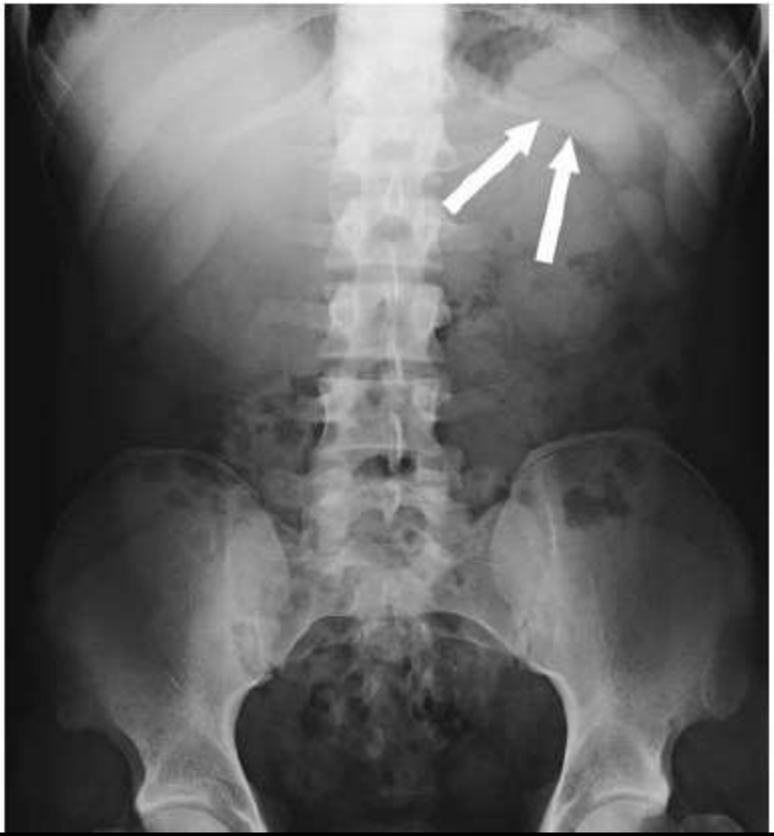


■ Question 5: AP radiograph of the pelvis

Answer: Right obturator foramen

- The obturator foramen is bordered by the pubic rami and the ischial bone.
- The foramina are almost entirely covered by a ligamentous membrane.
- The obturator externus muscle originates from the external surface of the obturator membrane. The obturator internus muscle originates from the deep surface and hooks around the pelvic bones to insert onto the femur.

- **Question 7:**



Question 7: AP radiograph of the abdomen

Answer: Left 12th rib

- The 12th rib is one of the free floating ribs, which means that it is not attached anteriorly to the sternum.
- It can be seen on abdominal radiographs as the most inferior rib, tapering after a few centimetres.
- The 12th ribs can be helpful when counting the vertebral levels of the lumbar spine because their origin defines the T12 vertebral level.
- The 12th ribs can vary in length and may be absent.

Question 14:

Question 14: AP radiograph of the pelvis

Answer: Right psoas major muscle

- The psoas major muscle may be seen on plain radiographs as an elongated, wedge-shaped density running obliquely next to the lumbar spine.
- It is one of the flexors of the hip, originating from the lateral border of the spine (T12 to L5) and inserting into the lesser trochanter of the femur.

Question 15:

Question 15: AP radiograph of the abdomen

Answer: Descending colon

- The descending colon is often seen as a gas-filled structure on plain radiography, running in the super-oinferior direction in the left flank.
- It can be identified as large bowel by its haustral pattern and faeces may be seen within.
- The upper limit of normal for the descending colon is 6 cm in diameter. The caecum may measure up to 9 cm and small bowel up to 3 cm.

Question 47:

Question 47: AP radiograph of the pelvis

Answer: Right superior pubic ramus

- The superior pubic ramus is one third of the pubic bone.
- It forms the superior border of the obturator foramen and the anterior aspect of the pelvic brim.
- Its superior surface is the continuation of the iliopectineal line and forms the insertion point for the pectineus muscle.

Question 2.11

Name the structures labelled **A** to **E**.

2.11 AP X-ray of the abdomen

A Stomach.
B Right kidney.
C Ascending colon.
D Right lobe of liver.
E Left psoas muscle.

The outline of the kidneys can be seen on an abdominal radiograph. The right kidney is usually slightly lower than the left, owing to the overlying liver. The upper poles of the kidneys are located at approximately the level of T12 and the lower poles at approximately L3. The renal hilum is usually located at the level of L1/2.

Question 7.13

Name the structures labelled **A** to **E**.

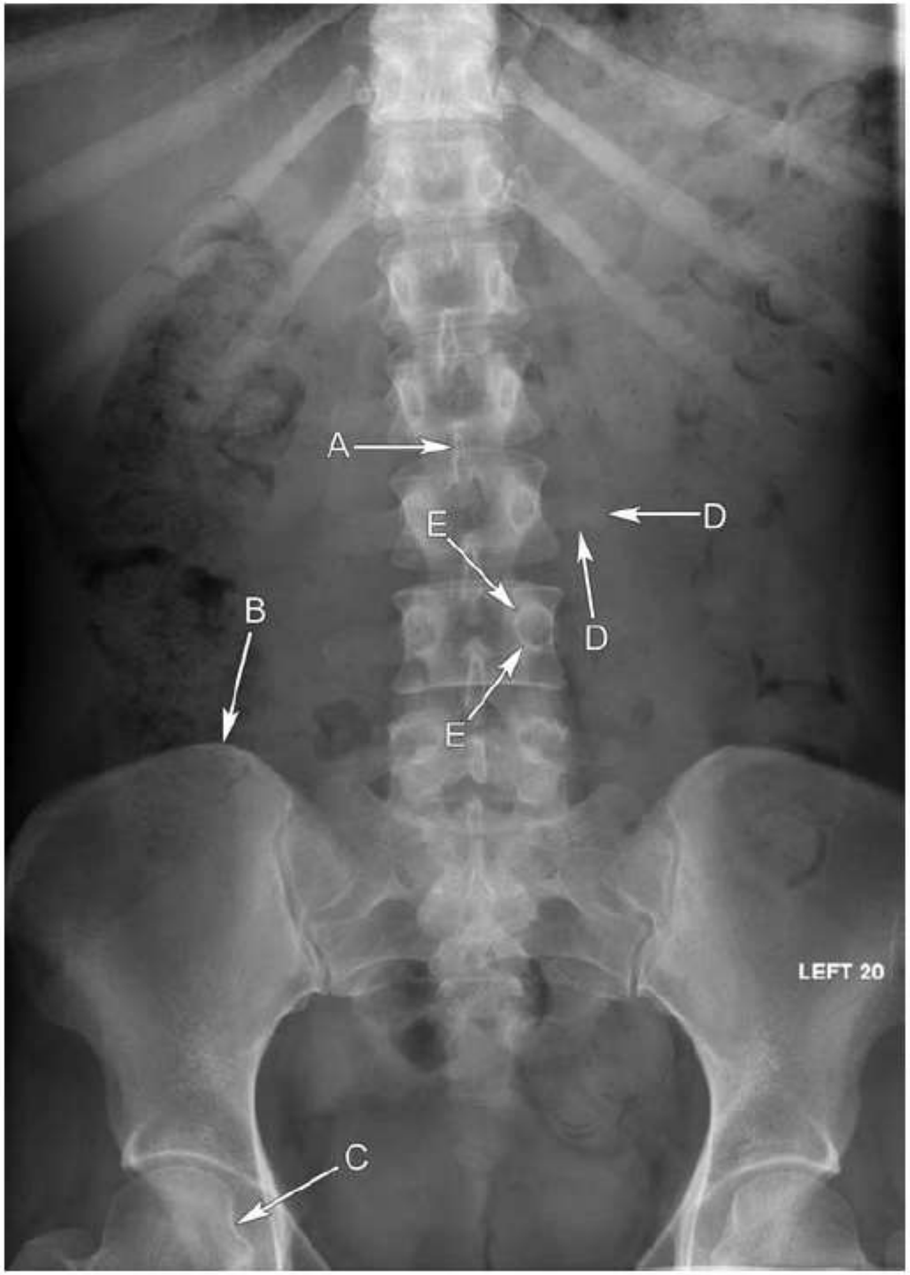
7.13 X-ray of the abdomen

A Hepatic flexure of colon.
B Caecum.
C Left S2 foramina.
D Right sacroiliac joint.
E Right greater trochanter.

The hepatic flexure is the bend of colon between the ascending colon and the transverse colon. It is supplied by the right colic artery (a branch of the superior mesenteric artery).

The sacroiliac (SI) joint is the largest axial joint in the body. Only the anterior third of the sacroiliac joint is a true synovial joint. The rest of the joint is composed of a complex set of fibro-ligamentous connections.

Question 8.17



Name the structures labelled **A** to **E**.

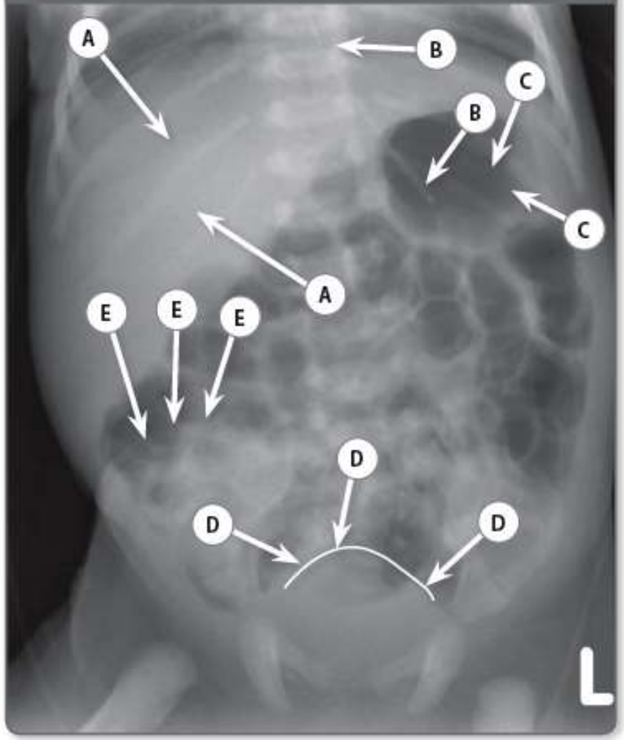
8.17 AP X-ray of the abdomen

A Spinous process of L2.
B Right posterior superior iliac spine/right ilium.
C Right fovea capitis.
D Left transverse process of L3.
E Left pedicle of L4.

The fovea capitis is a depression on the anterosuperior part of head of femur giving rise to the ligamentum teres.

The two pedicles and the spinous process resemble the appearance of an owl. The 'winking owl' sign refers to the erosion of a pedicle by a lytic process, such as metastatic disease.

Case 2.17



Case 2.17

QUESTION		WRITE YOUR ANSWER HERE
A	Name the structure labelled A.	
B	Name the tube labelled B.	
C	Name the gaseous structure labelled C.	
D	Name the structure outlined by D.	
E	Name the osseous structure labelled E.	

Case 2.17

A Liver

B Nasogastric tube

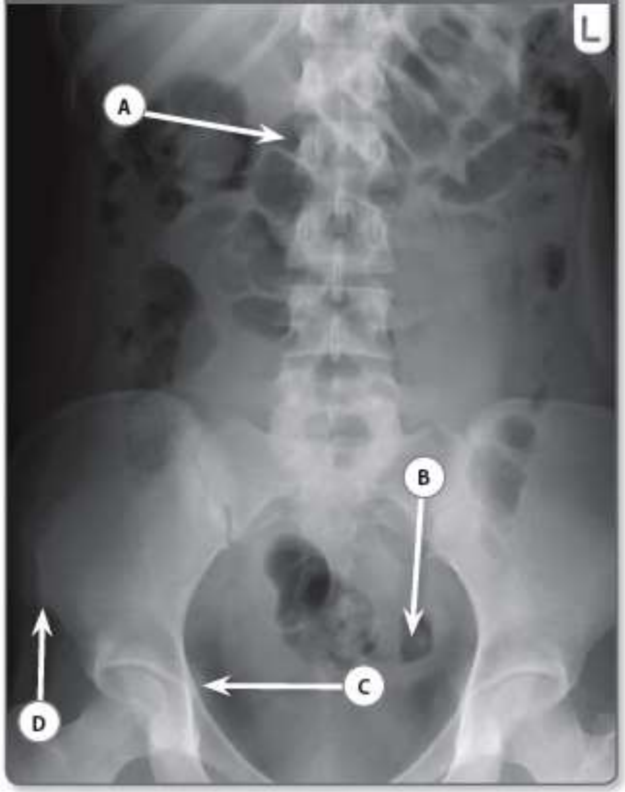
C Fundus of stomach

D Urinary bladder

E Right iliac crest

On this radiograph, of a one day old infant, the urinary bladder and liver are both made conspicuous as a result of the bowel gas pattern, with gaseous bowel running along the inferior edge of the liver and over the dome of the urinary bladder. This feature is useful for assessing for the presence of organomegaly or abdominopelvic masses, which result in abnormal displacement of bowel loops.

Case 8.12



Case 8.12

	QUESTION	WRITE YOUR ANSWER HERE
A	What part of the colon is labelled A?	
B	What part of the colon is labelled B?	
C	Name the bony prominence labelled C.	
D	Name the structure labelled D.	
E	What muscle exits the pelvis through the greater sciatic foramen?	

Case 8.12

A Transverse colon

B Sigmoid colon

C Right ischial spine

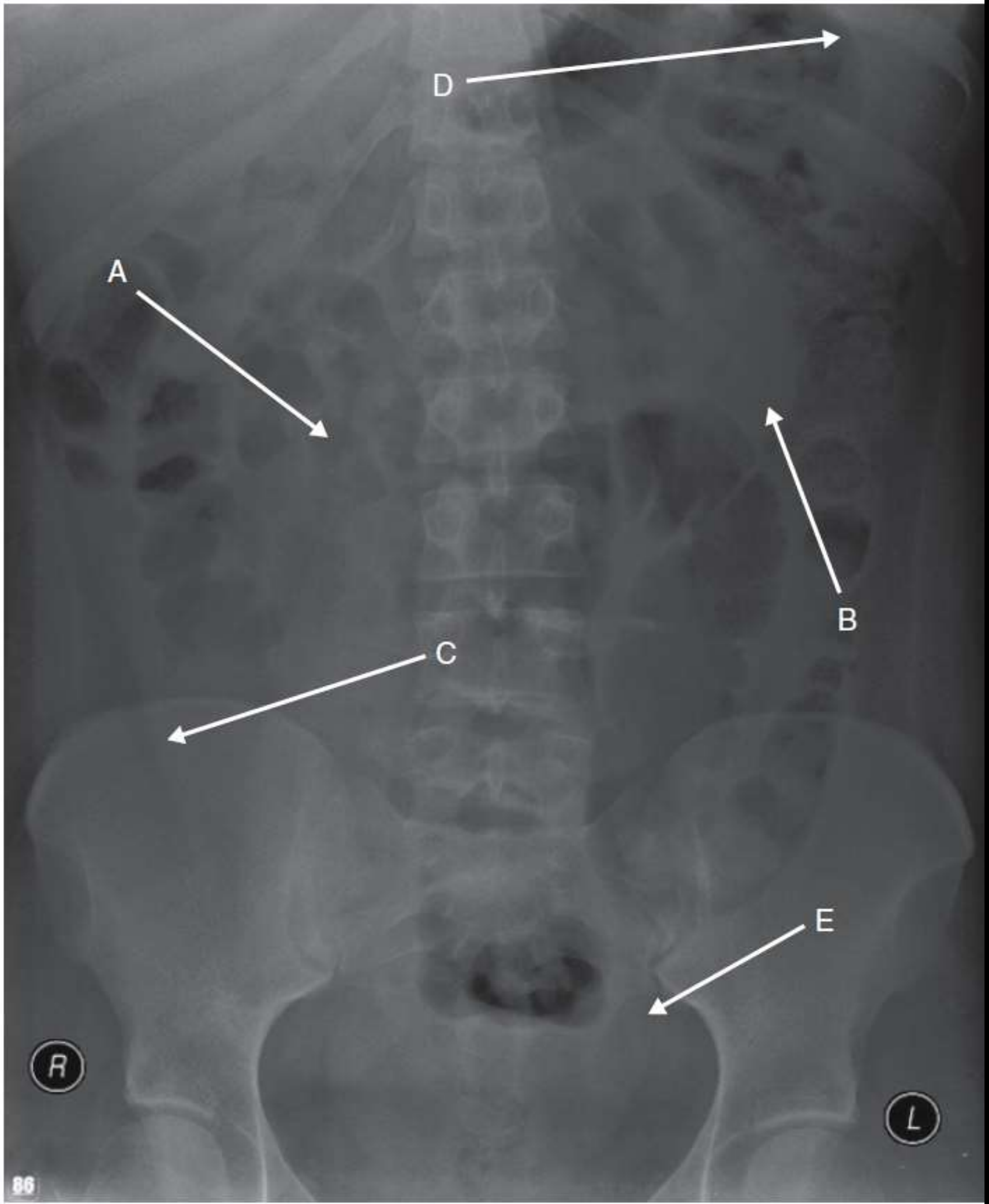
D Right anterior inferior iliac spine

E Piriformis

The sacrospinous ligament is attached laterally to the ischial spine and medially to the lateral aspects of the sacrum and coccyx, lying anterior to (and merging with) the sacrotuberous ligament. These two ligaments help form the boundaries of the greater and lesser sciatic foramina. The ischial spine also has muscular attachments (for coccygeus, levator ani and gemellus superior). It forms an important landmark for pudendal nerve blocks in obstetric anaesthesia.

Rectus femoris is attached to the anterior inferior iliac spine, whereas sartorius is attached to the anterior superior iliac spine – knowledge of these attachments is important in both examinations and in real life scenarios since avulsion injuries are not infrequent. Remember – **S**artoriu**S** – a**S**i**S**; rectus **FE**moris – anterior in**FE**rior iliac spine.

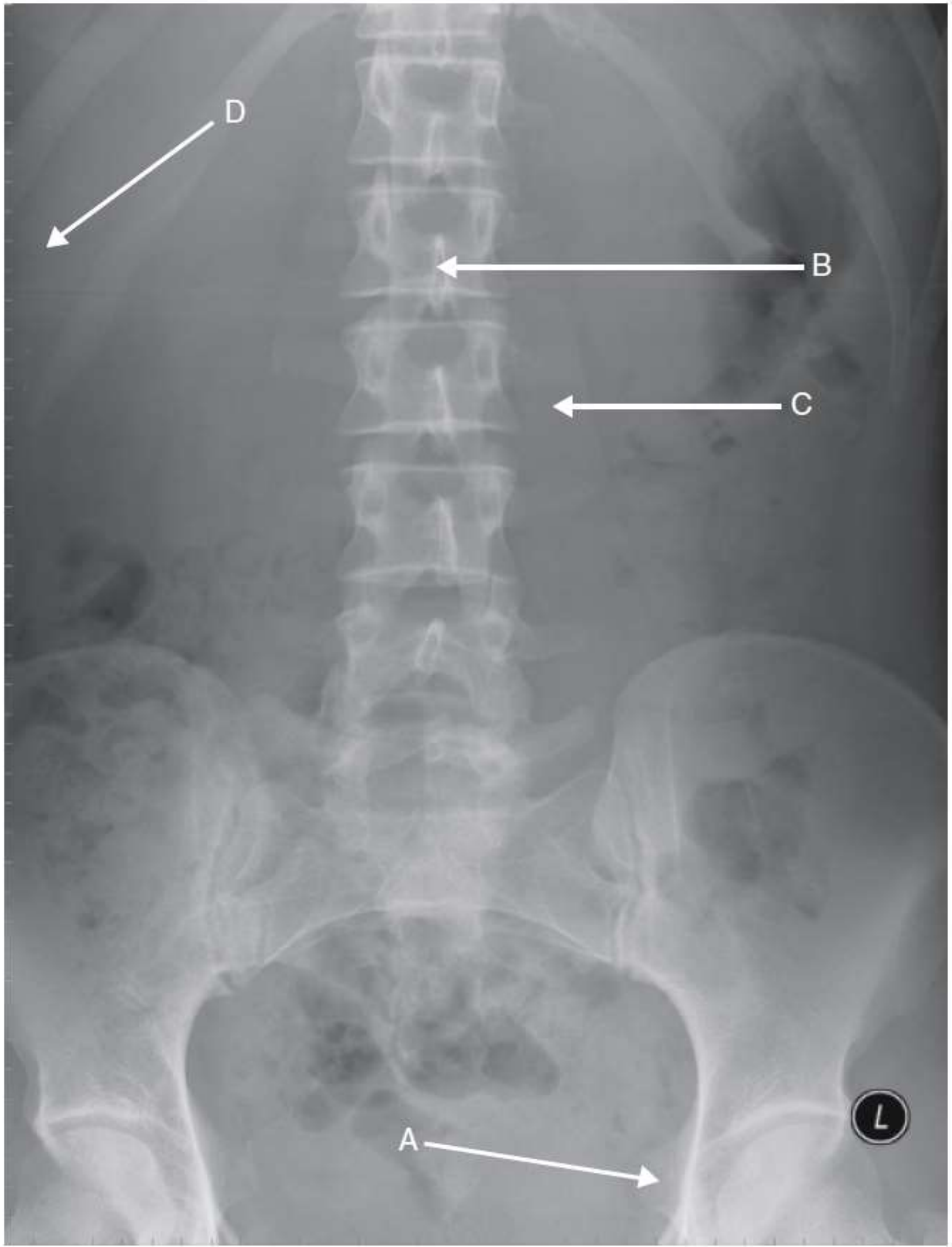
Case 3.5



3.5 AP abdominal radiograph

(a) Right psoas muscle. The psoas shadow is blurred in 19% of the population and is an insensitive sign of retroperitoneal pathology.
(b) Left kidney. The perinephric fat surrounding the kidney makes it visible.
(c) Right properitoneal fat line. This will not be visible in 18% of the population.
(d) Spleen. The outline cannot be identified in 42% of the population.
(e) Bladder outline. Like the kidneys, the distended bladder is visualized due to surrounding perivesical fat.

Case 4.4



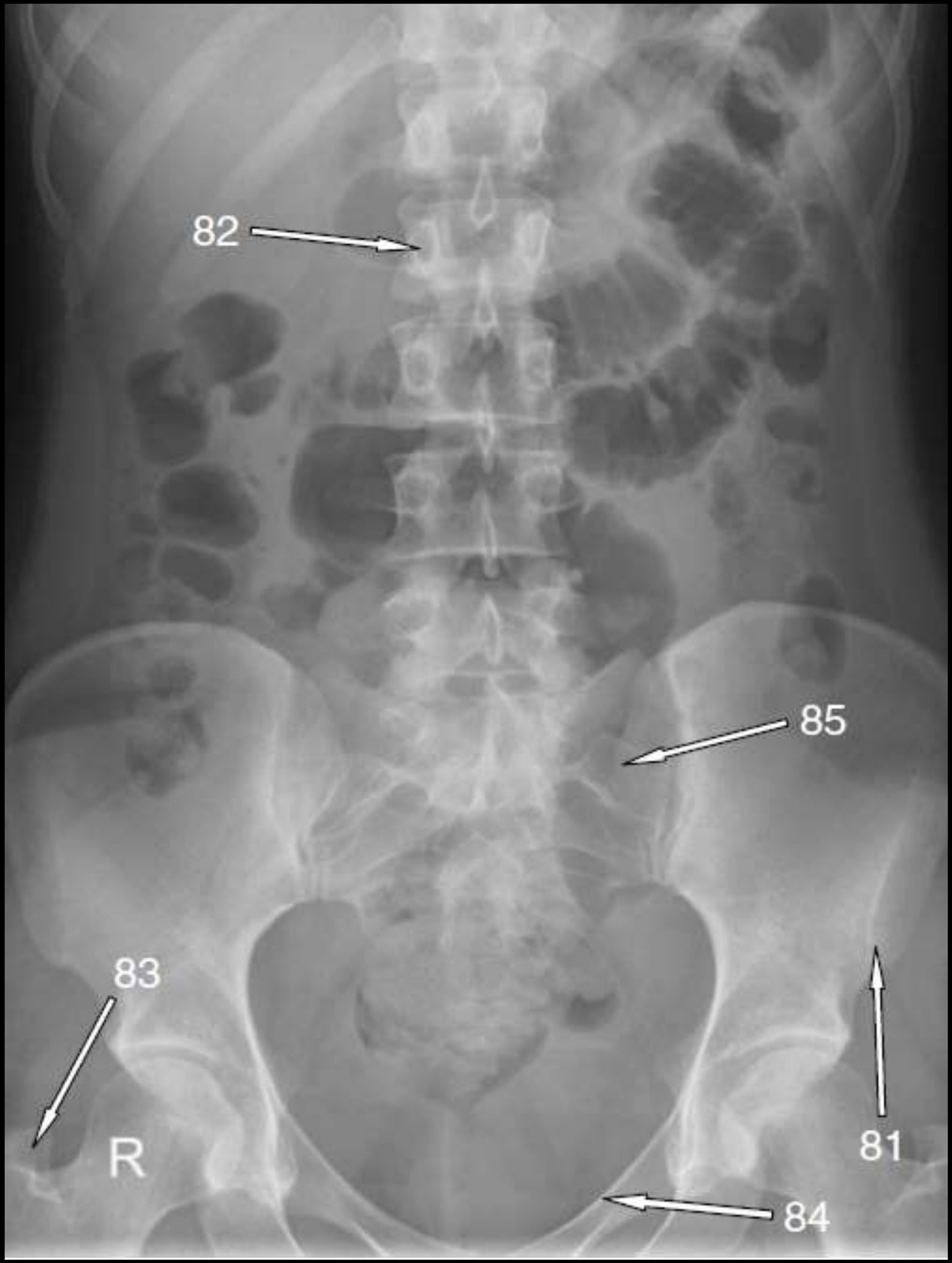
(e)	Which normal variant is present on this image?

4.4 Abdomen radiograph

(a) Left ischial spine.
(b) Spinous process of L2.
(c) Left psoas muscle.
(d) Right lobe of liver (segment 7).
(e) Lumbarization of S1. This is a common congenital abnormality of the lumbosacral spine present in up to 12% of the population. The first sacral vertebra shows transition to a lumbar configuration. A more common abnormality is sacralization, where the fifth lumbar vertebra shows signs of assimilation to the sacrum.

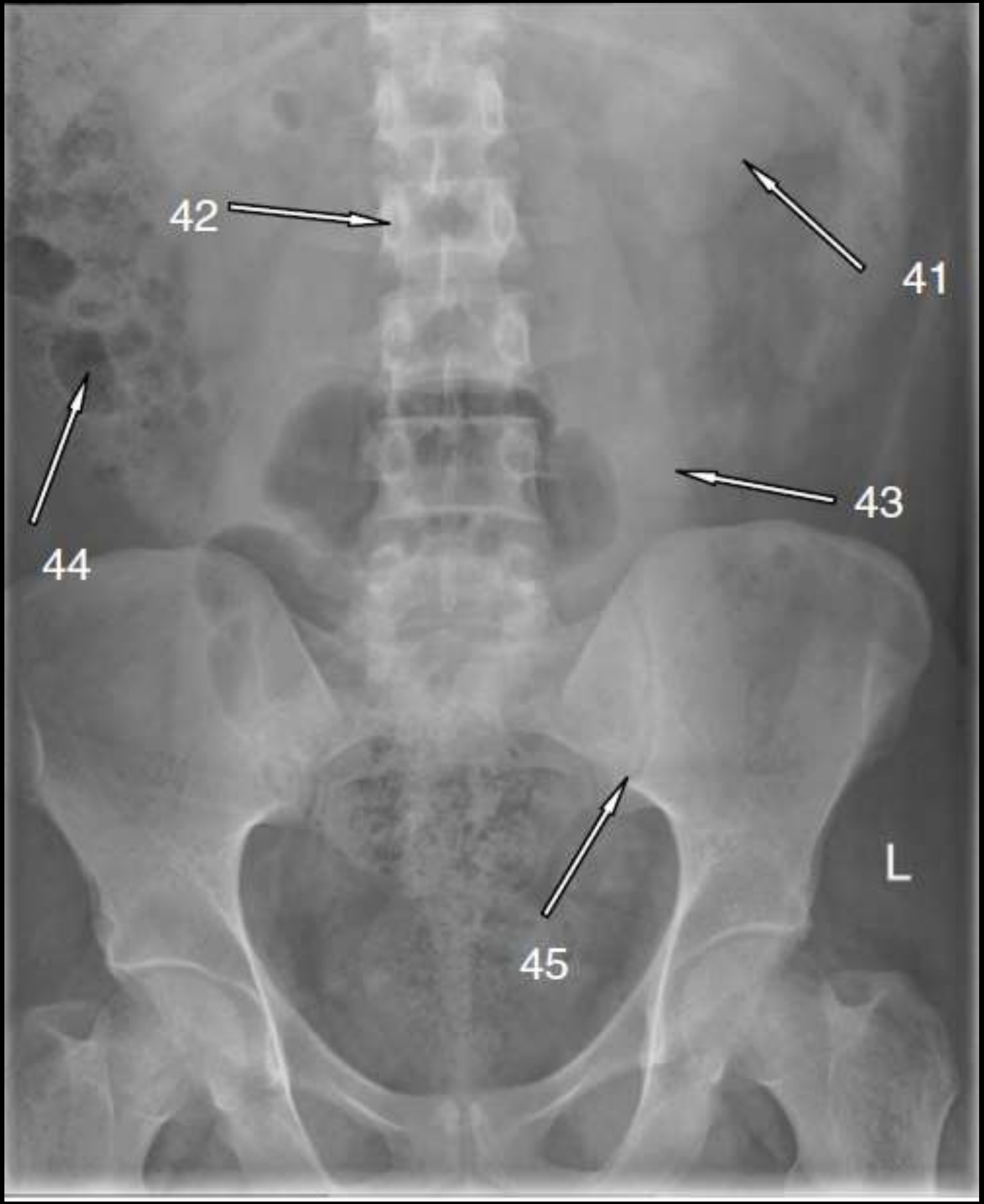
There is no evidence to support that either abnormality predisposes to spinal pathology.

Accurate numbering of the lumbar vertebrae can be an issue in this condition and is best done counting down from the T12 vertebra.


82
85
83
R
81
84

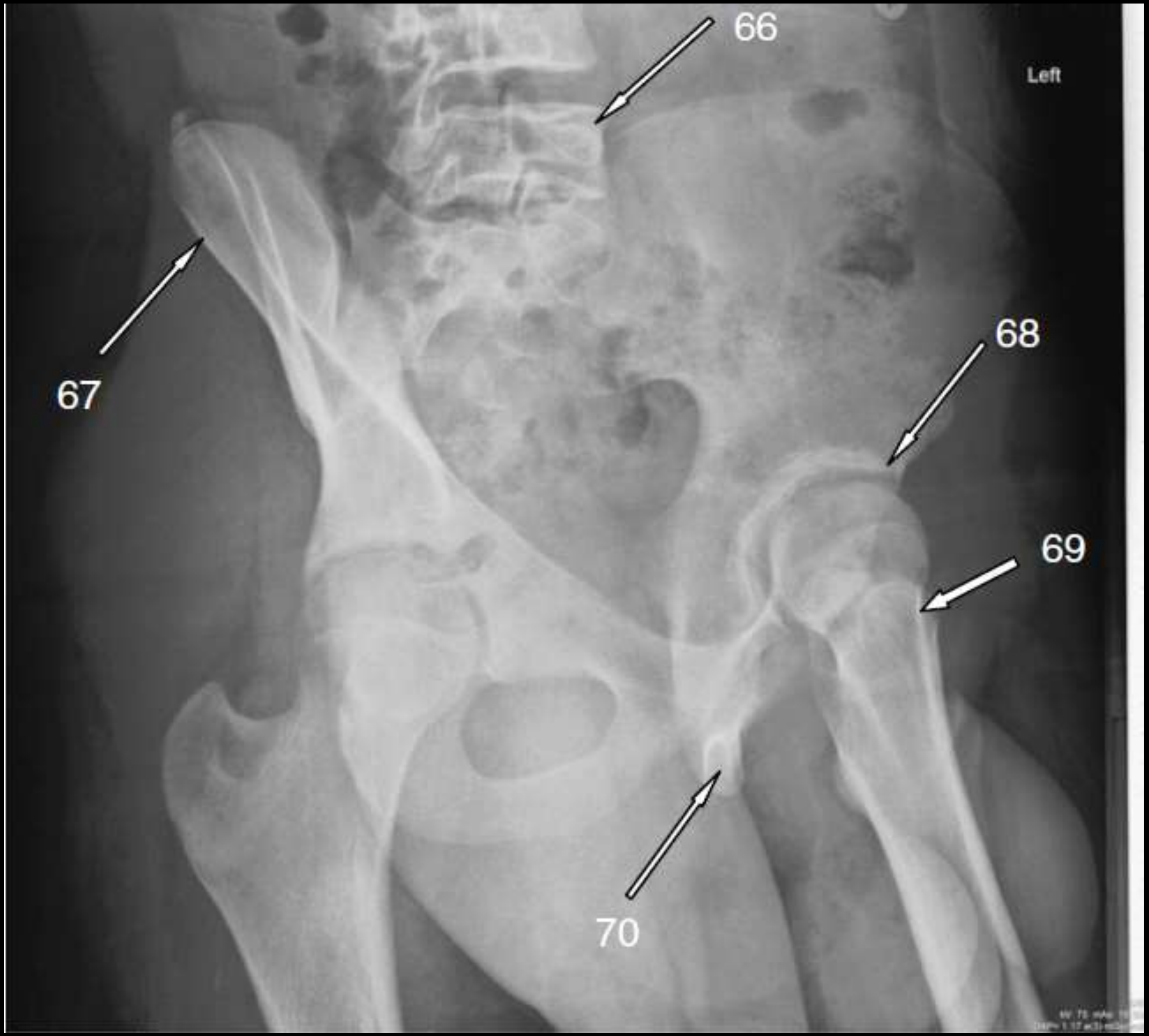
Abdominal Radiograph

81. Left anterior inferior iliac spine
82. Right pedicle of L2 vertebra
83. Greater trochanter of right femur
84. Left superior pubic ramus
85. Left ala of sacrum


42
41
44
43
45
L

Abdominal Radiograph

41. Left kidney
42. Right pedicle of L2 vertebra
43. Left psoas muscle
44. Ascending colon
45. Left sacroiliac joint


66
Left
67
68
69
70

Pelvic Radiograph

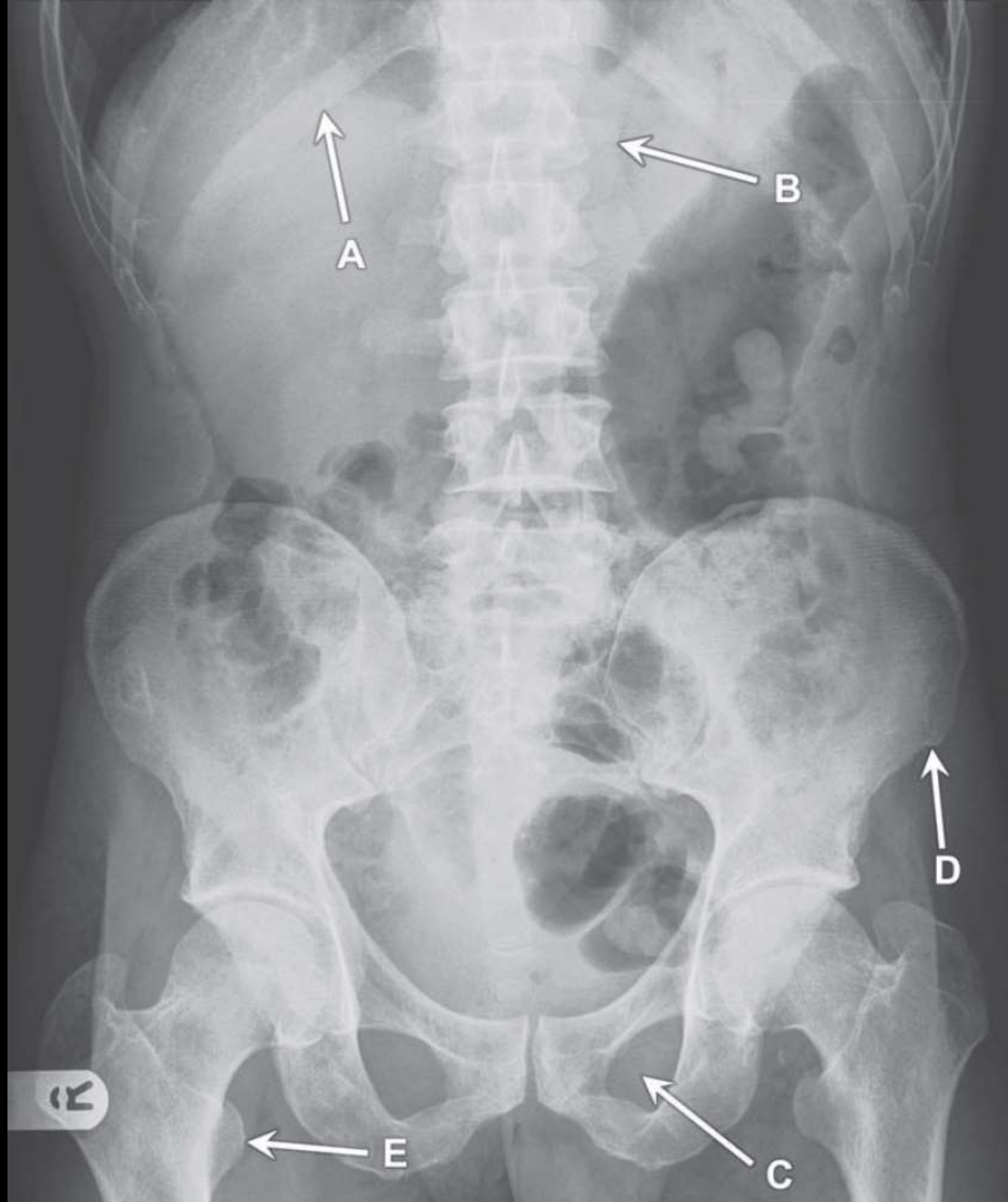
66. L5 vertebral body
67. Right ilium
68. Left acetabulum
69. Left neck of femur
70. Left ischial tuberosity

Name the normal variant

Abdominal Radiograph

Complete situs inversus
Abdominal situs refers to the position of the liver and stomach. On this abdominal X-ray the liver is seen on the left side of the abdomen as is the caecum, and gas within the stomach can be seen on the right. This is seen in complete situs inversus. Remember to look at the side marker to ensure that this diagnosis is correct.

Situs ambiguous is when the liver is symmetrical, and the stomach is seen in the midline.



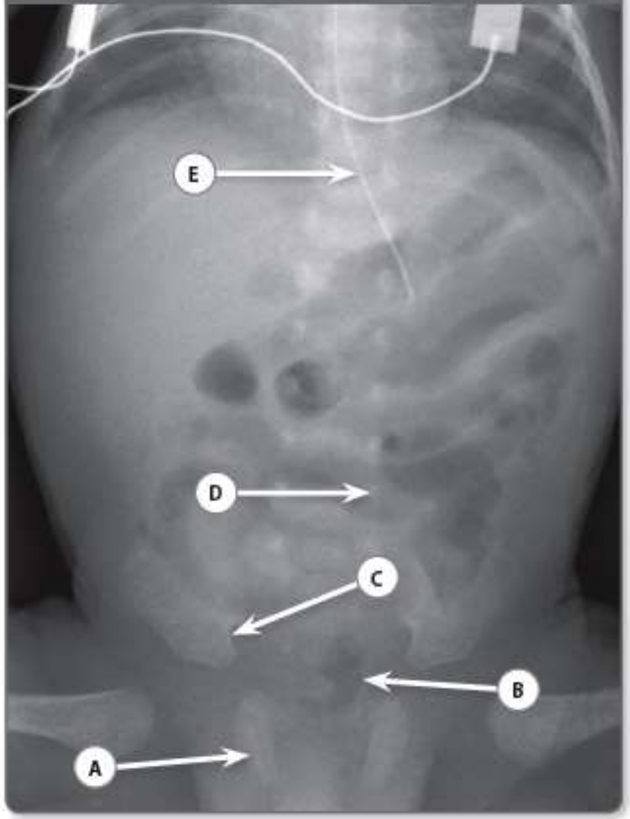
Name the muscle that attaches to the structure labelled D.

Case 8

Plain radiograph. AP abdomen.

1. Right twelfth rib
2. Left transverse process of L1 vertebra
3. Left obturator foramen
4. Left sartorius
5. Right lesser trochanter

Case 9.15



Case 9.15

QUESTION		WRITE YOUR ANSWER HERE
A	Name the structure labelled A.	
B	In which structure does gas labelled B lie?	
C	Name the line labelled C.	
D	Name the structure labelled D.	
E	Name the tube labelled E.	

Case 9.15

A Right ischium

B Rectum

C Right iliopectineal line

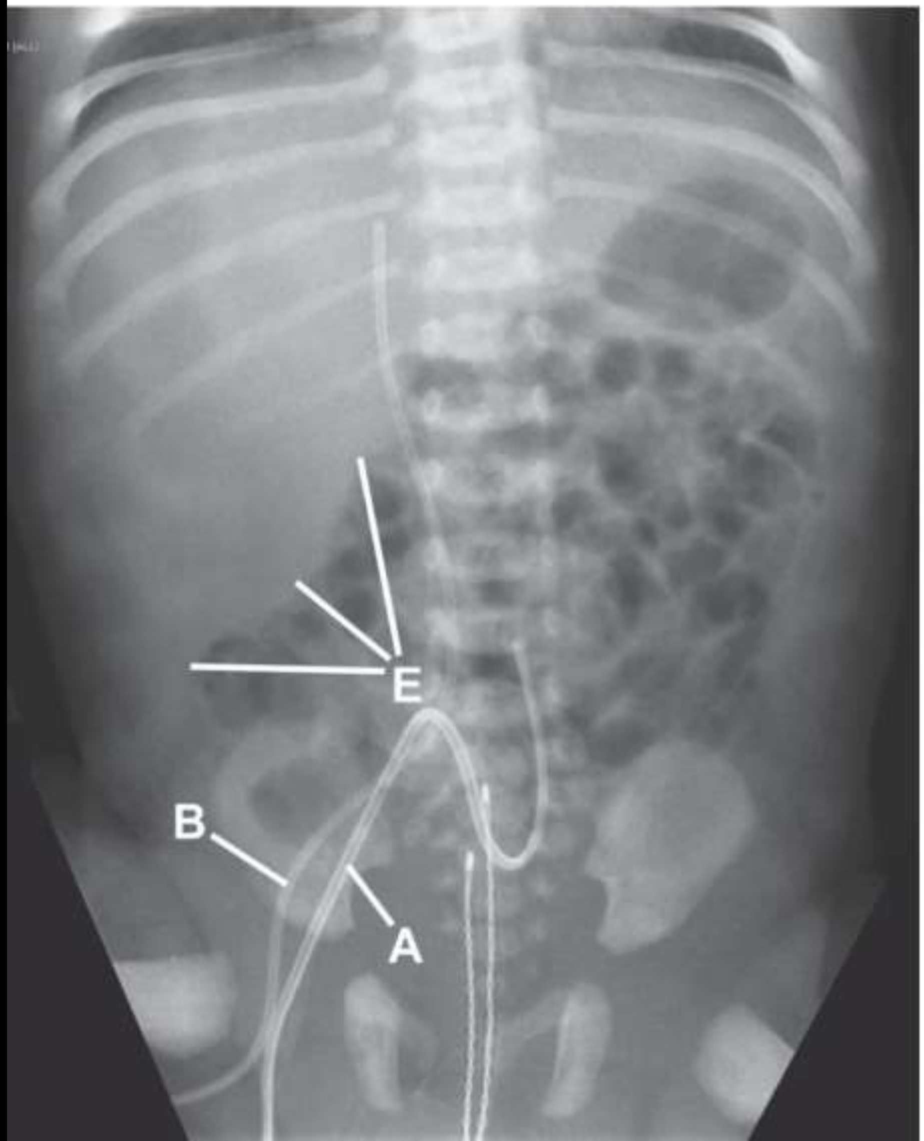
D Left pedicle of L4

E Nasogastric tube

Anatomical detail on abdominal radiographs in neonatal and paediatric patients is often limited in comparison with adult patients. Accordingly, questions relating to this area are more likely to focus on osseous anatomy, or on lines and tubes that may be present on the radiograph. A nasogastric tube is shown here, but umbilical arterial and venous catheters (UAC and UVC) also typically feature on neonatal radiographs. These can be differentiated as follows: the UAC takes a characteristic inferior dip in the pelvis as it enters the iliac arteries, whereas the UVC travels in a cephalad direction throughout.

Q3

a Name the superficial blood vessel into which catheter A has been inserted
b Name the superficial blood vessel into which catheter B has been inserted
c Name the vessels/structures through which the tip of catheter A has travelled
d Name the vessels/structures through which the tip of catheter B has travelled
e Name the structure labelled E



Q3 Answers

a Left umbilical artery
b Umbilical vein
c Umbilical, left internal iliac and left common iliac arteries, aorta
d Umbilical vein, left portal vein, ductus venosus, IVC
e Liver

Abdominal radiograph of a neonate

Umbilical vascular catheters can be used for vascular sampling and monitoring in the neonatal period.

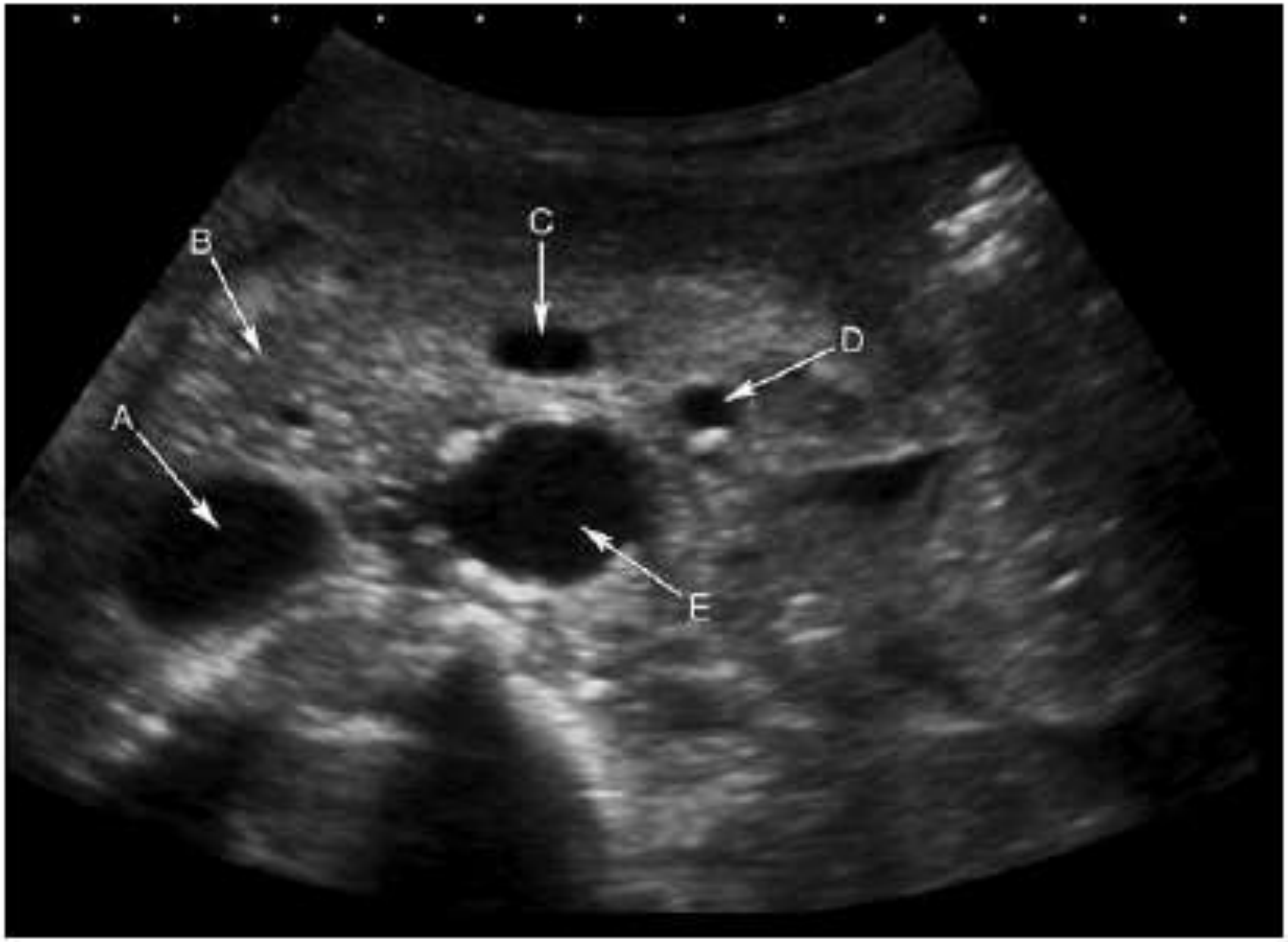
There are paired umbilical arteries which are branches of the internal iliac arteries on both sides. The distal artery will normally occlude shortly after transection of the cord at birth, going on to form the medial umbilical ligament. The proximal artery will remain patent however and provides branches to the bladder and ductus deferens. Early in-utero there is a pair of umbilical veins but only one usually persists to birth. This umbilical vein carries oxygenated blood towards the foetal heart and initially drains into the left portal vein, where it then bypasses the hepatic circulation to enter the inferior vena cava (IVC) through the ductus venosum. Both the ductus venosum and umbilical vein occlude and become fibrotic following birth, becoming the ligamentum venosum and ligamentum teres respectively.

The relative size of the normal liver is large in neonates. Proportional to total body height, the longitudinal length of the right lobe in neonates is almost twice that at aged 16 years.

Konuş OL, Ozdemir A, Akkaya A *et al.* Normal liver, spleen, and kidney dimensions in neonates, infants, and children: evaluation with sonography. *Am J Roentgenol* 1998; 171:1693–1698.

ULTRASOUND

Question 1.12 This is a transverse ultrasound of the abdomen.



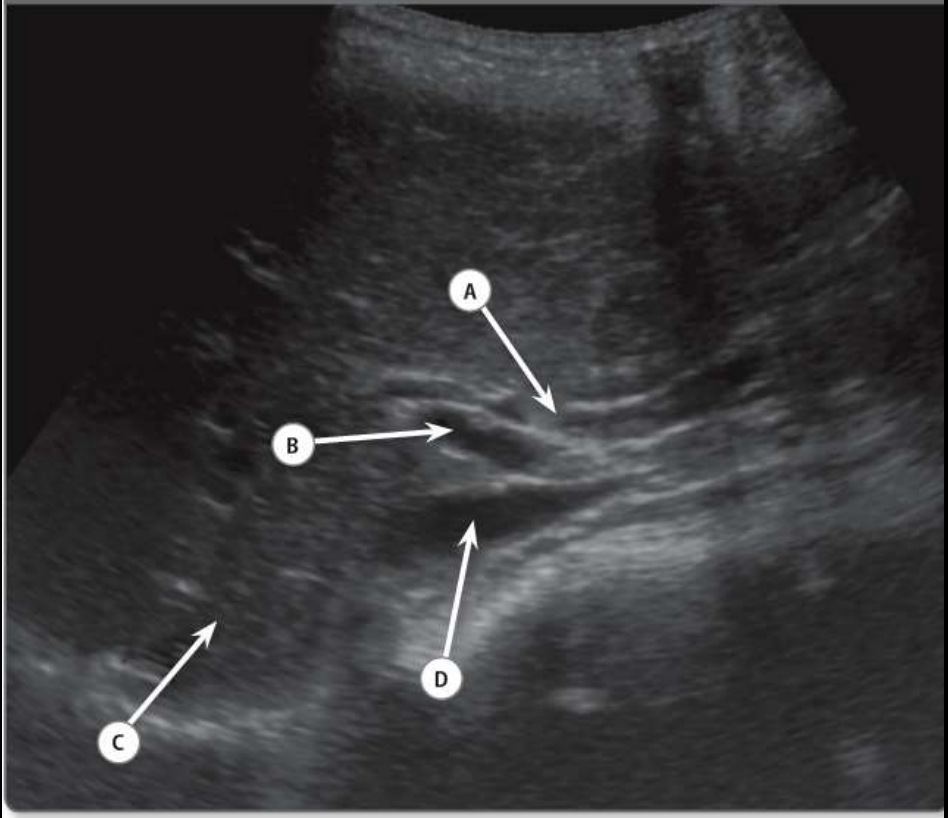
Name the structures labelled **A** to **E**.

1.12 Transverse ultrasound of the abdomen

A Inferior vena cava.
B Head of the pancreas.
C Superior mesenteric vein.
D Superior mesenteric artery.
E Aorta.

The inferior vena cava (IVC) lies to the right of the abdominal aorta. The superior mesenteric vein lies to the right of the superior mesenteric artery. The superior mesenteric artery can also be differentiated from the vein on ultrasound as its wall is more echogenic. The superior mesenteric vein and artery run between the neck and body of the pancreas anteriorly and the uncinate process of the pancreas posteriorly. The left renal vein can sometimes be seen at this level, crossing the aorta anteriorly to drain into the inferior vena cava.

Case 15.1



Case 15.1

QUESTION		WRITE YOUR ANSWER HERE
A	Name the structure labelled A.	
B	Name the structure labelled B.	
C	Name the structure labelled C.	
D	Name the structure labelled D.	
E	What is the upper limit of normal for the common bile duct diameter?	

Case 15.1

A Common bile duct

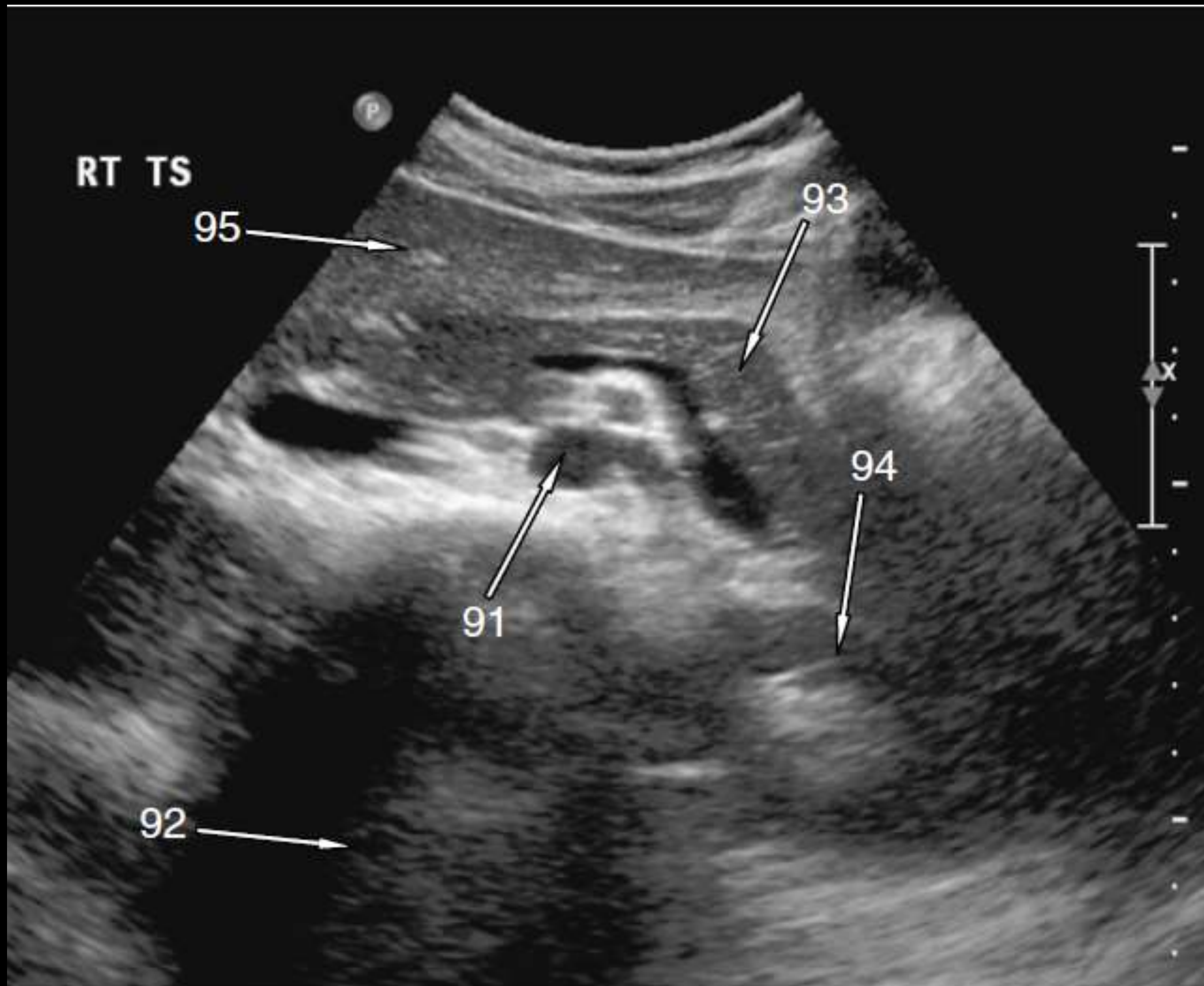
B Portal vein

C Right liver lobe

D Inferior vena cava

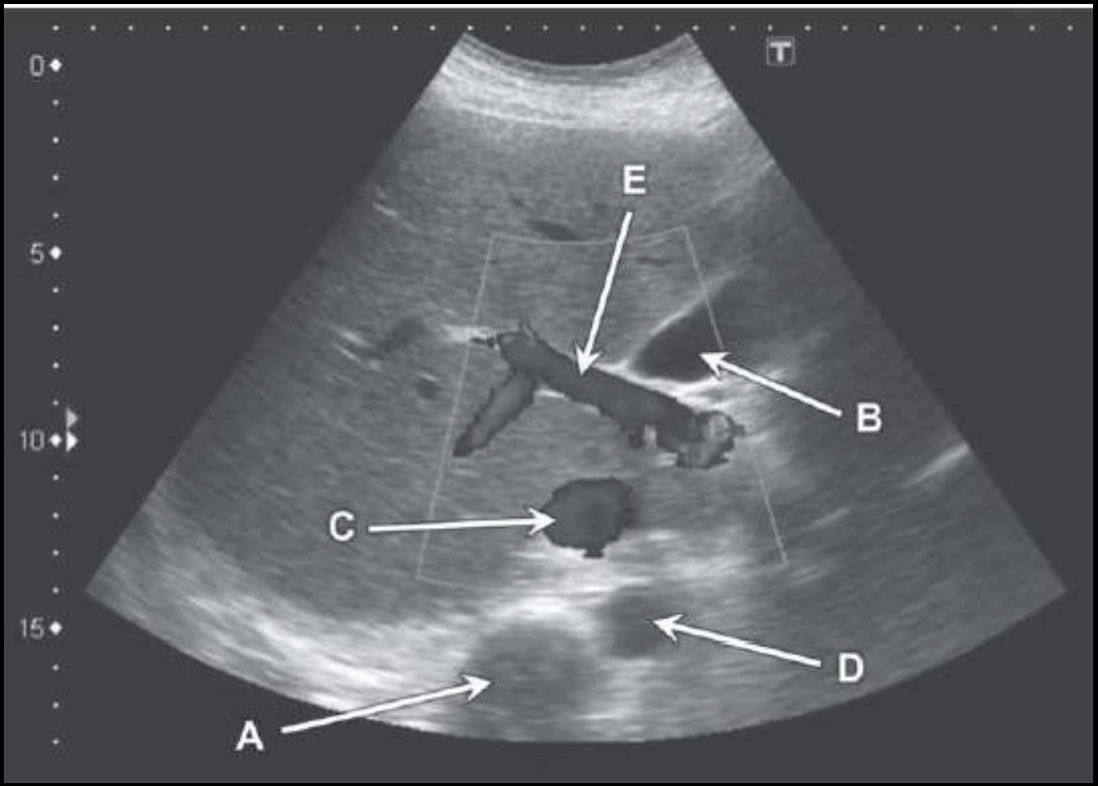
E 6 mm

This example demonstrates the relationship of the portal vein to the inferior vena cava and common hepatic duct, with the portal vein located between those two structures. Note the position of the common bile duct anterior to the portal vein at the porta hepatis. The normal size of the common bile duct in a healthy biliary system is up to 6 mm, but may increase by up to 9 mm in elderly patients and post-cholecystectomy.


RT TS
95
93
94
91
92

Abdominal Ultrasound

91. Abdominal aorta
92. Lumbar vertebra
93. Pancreas
94. Left renal cortex
95. Left lobe of liver

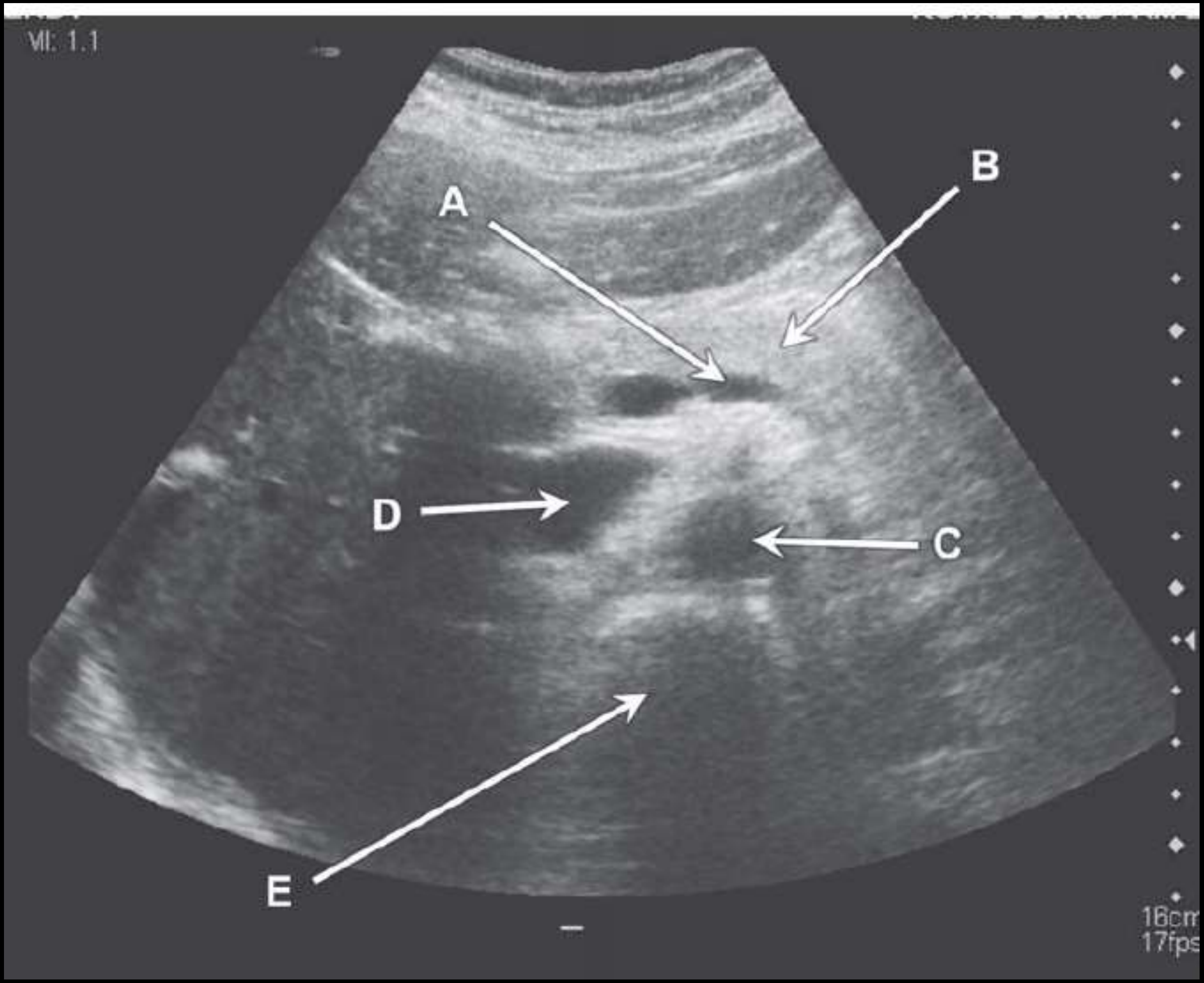


0
5
10
15
T
E
B
C
D
A

Case 16

Abdominal ultrasound. Oblique view at the porta hepatis.

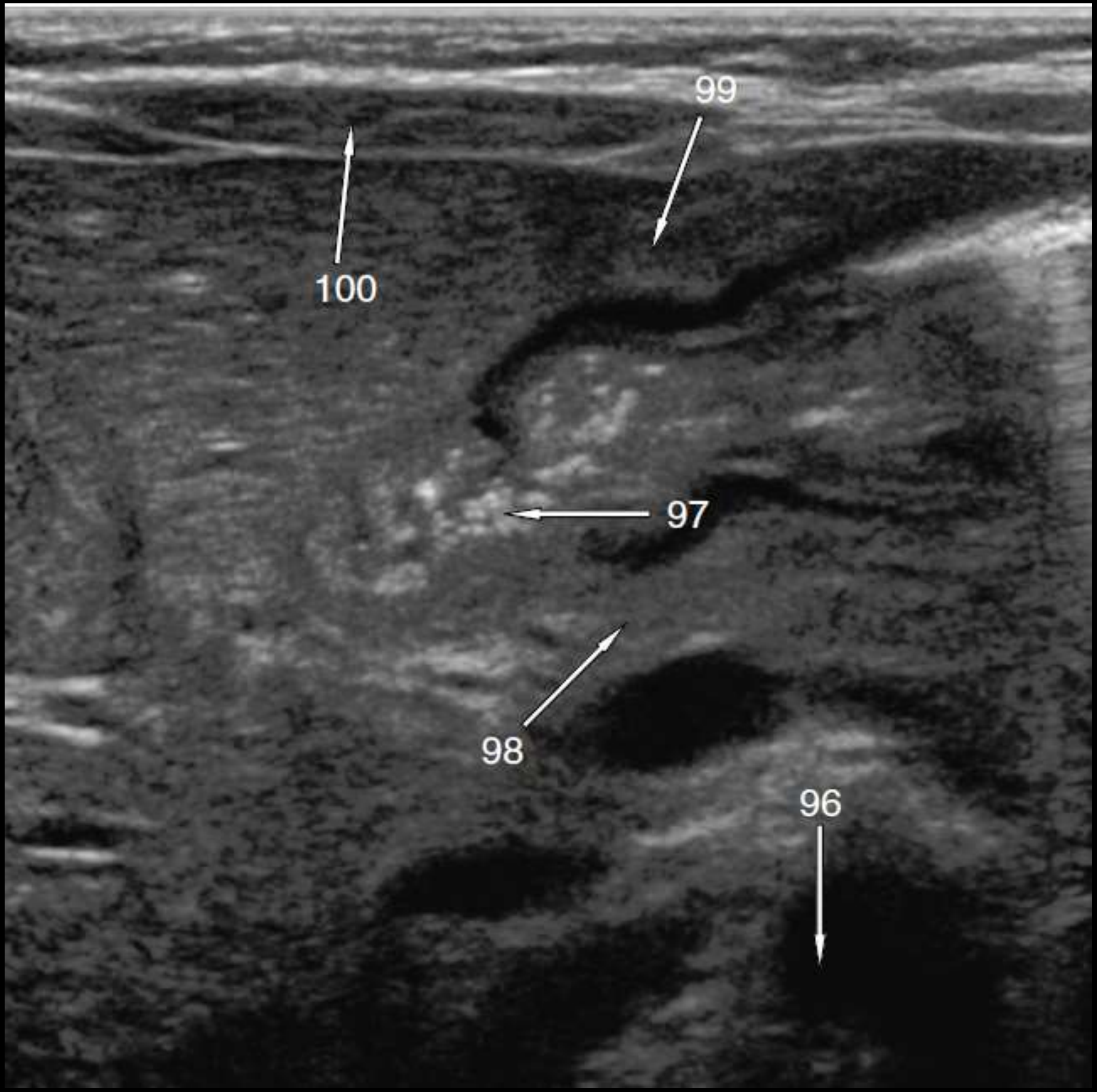
1. Spinal column
2. Gallbladder
3. Inferior vena cava
4. Abdominal aorta
5. Hepatic portal vein


MI: 1.1
A
B
C
D
E
16cm
17fps

Case 11

Ultrasound abdomen. Transverse section at the epigastrium.

1. Splenic vein
2. Body of pancreas
3. Abdominal aorta
4. Inferior vena cava
5. Vertebral body

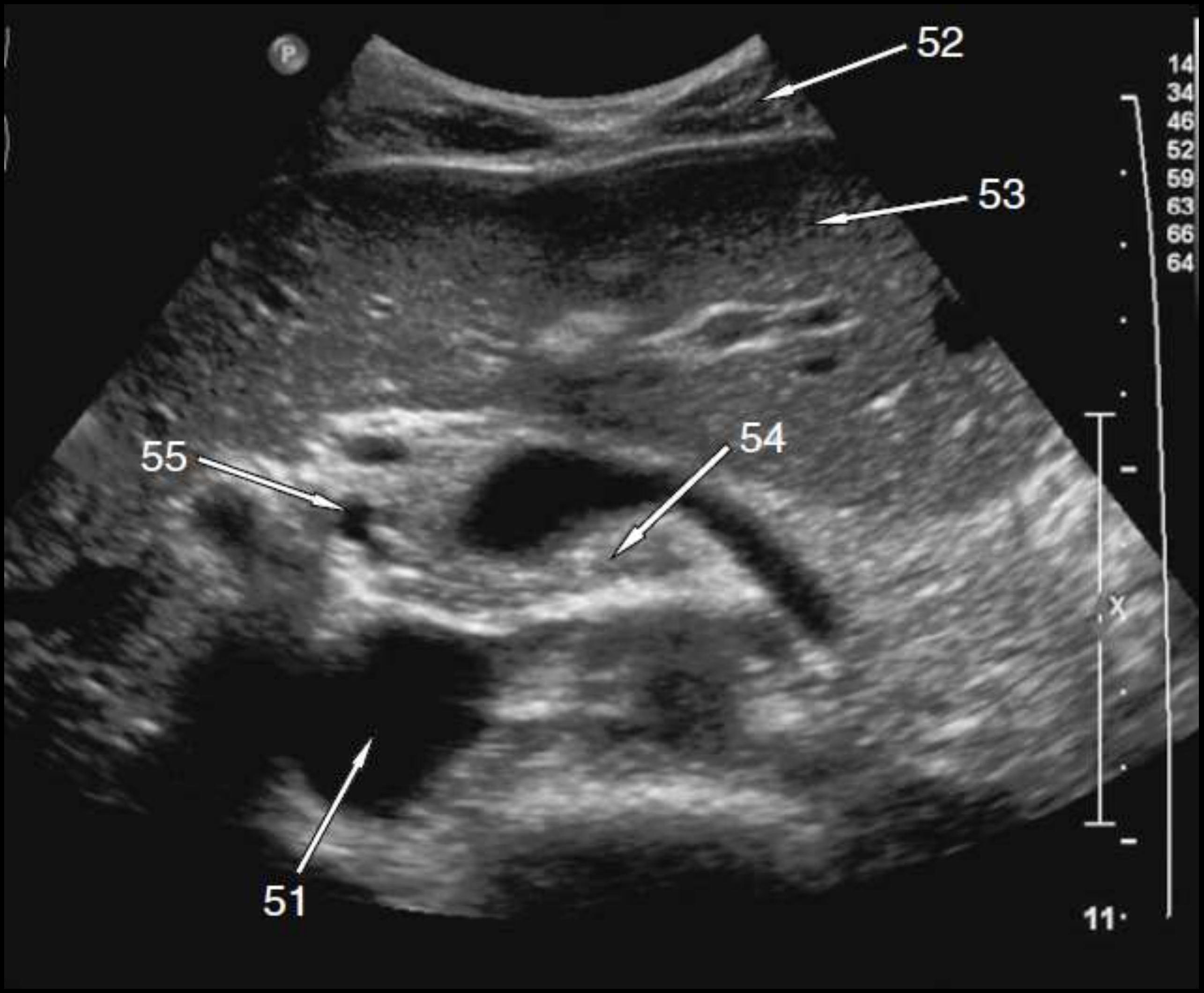


99
100
97
98
96

Ultrasound Abdomen

96. Aorta
97. Pyloric canal
98. Head of pancreas
99. Left lobe of liver
100. Right rectus abdominus

Hypertrophic pyloric stenosis is suggested in the presence of a thickened, elongated pylorus (single muscle thickness >3 mm, canal length >17 mm). This may be associated with prominent gastric peristaltic waves and a failure to see opening of the pyloric canal after a test feed.



52
53
54
55
51
P
14
34
46
52
59
63
66
64
11

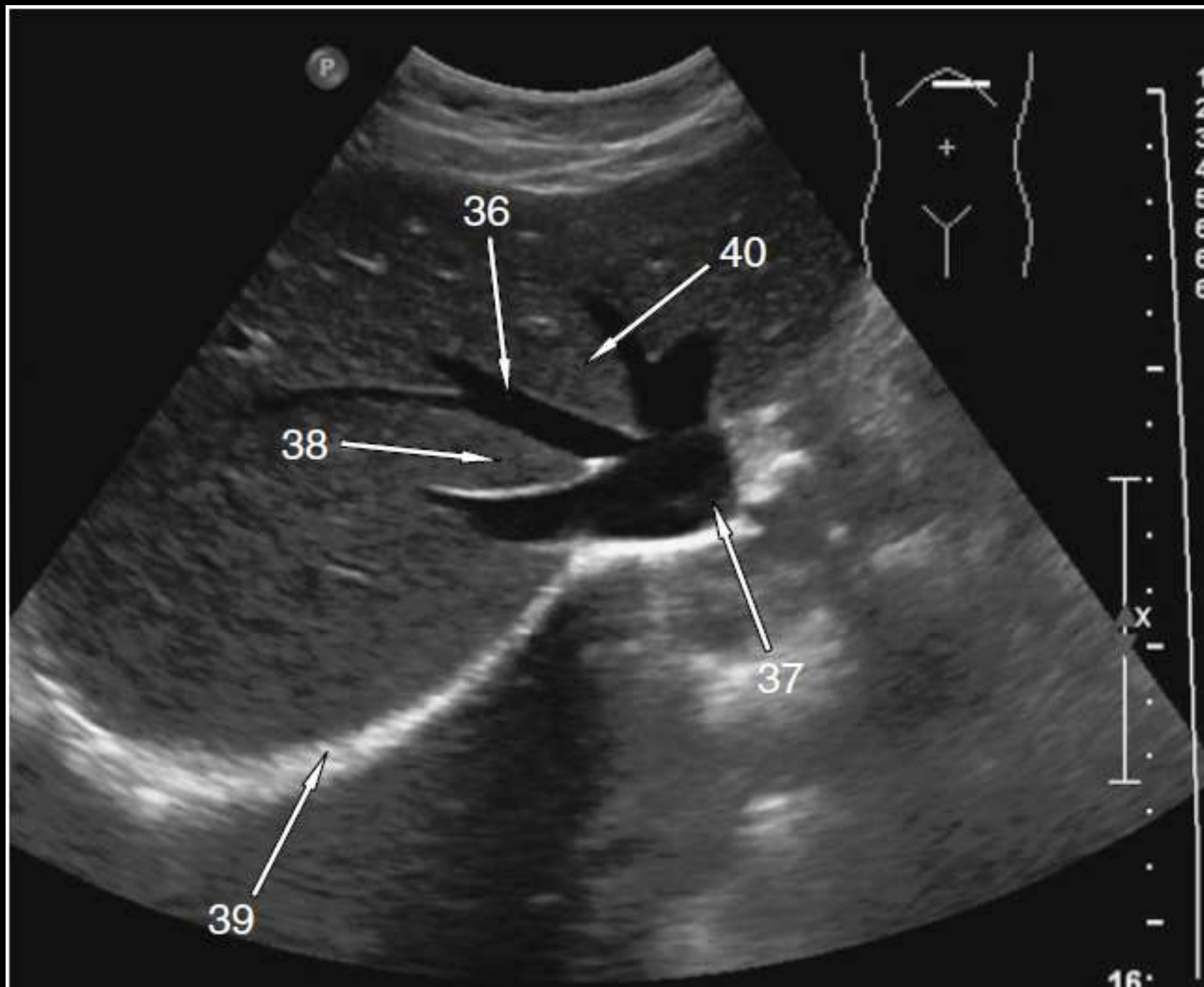
51. Inferior vena cava
52. Left rectus abdominis muscle
53. Left lobe of liver
54. Uncinate process/head of pancreas
55. Common bile duct

The pancreas lies at L1.

The dorsal aspect of the head takes the shape of a hook surrounding the right side of the superior mesenteric vein; the sharp left-pointing tip of the hook behind the vein forms the uncinate process. The splenic vein runs from the left along the dorsal border of the tail and body to the superior mesenteric vein, where these veins join to form the portal vein behind the 'neck' of the pancreas.

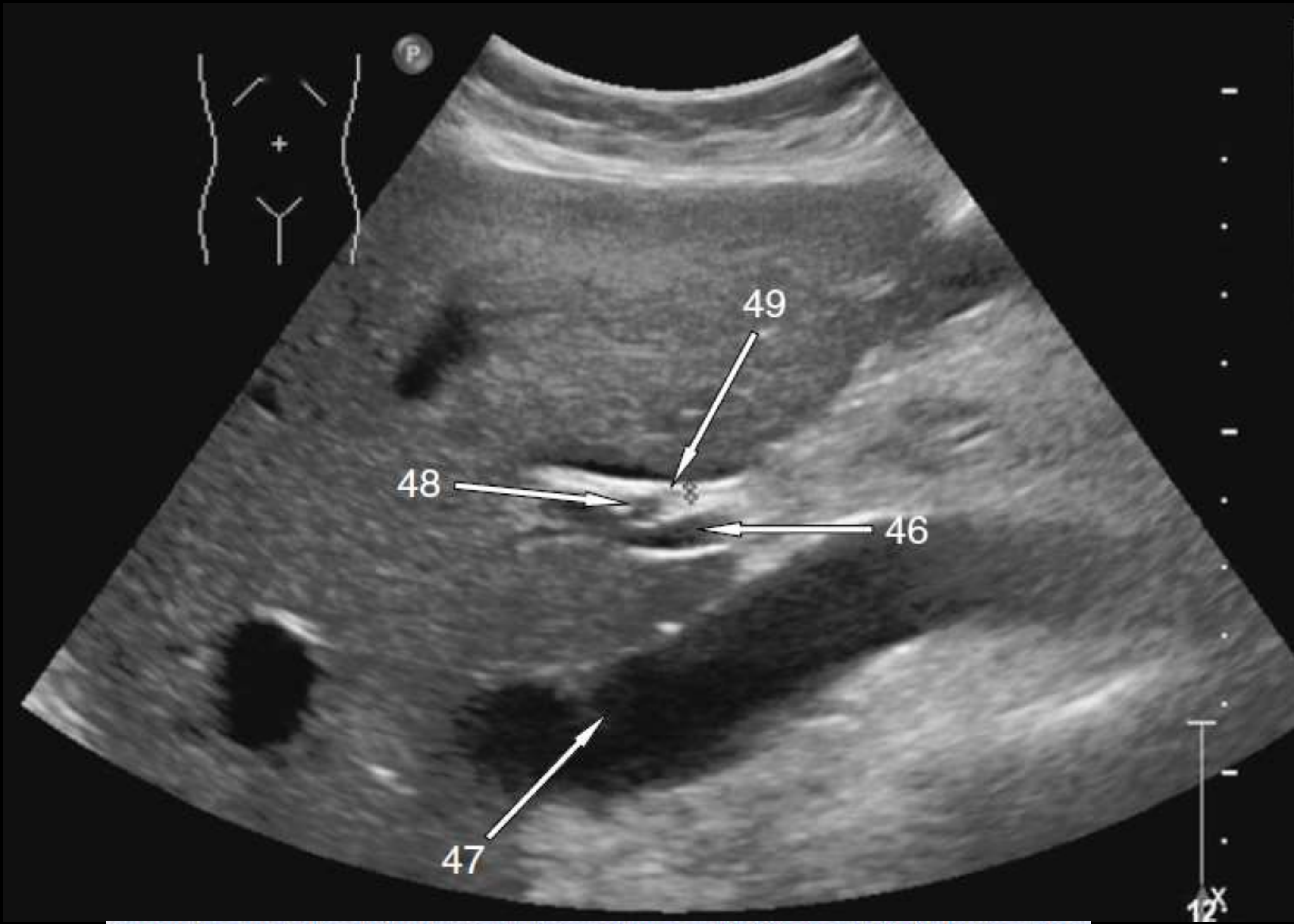
The uncinate process is the only part of the pancreas to lie posterior to the superior mesenteric vessels.

The pancreas tends to be hyperechoic and pancreatic malignancies are hypoechoic.


36
40
38
37
39
P
16

36. Middle hepatic vein
37. Inferior vena cava
38. Segment 8 of the liver
39. Right dome of diaphragm
40. Segment 4 of the liver

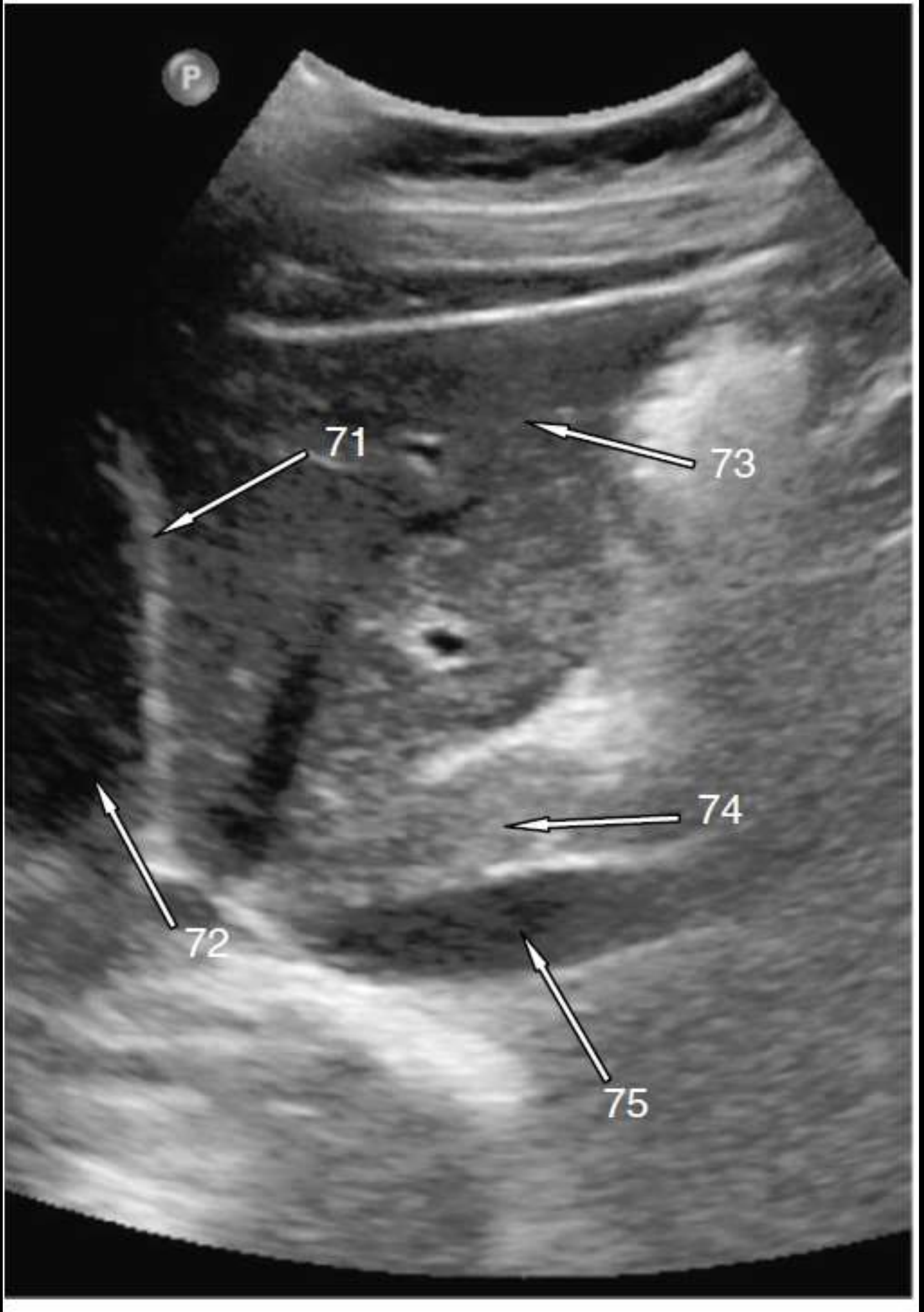
The hepatic veins divide the liver vertically and portal veins divide the liver horizontally into segments. These are named using the Couinaud classification. The hepatic veins can therefore be used to identify liver segments and allow a precise description of the position of focal lesions.



Name the opening into the lesser sac whose anterior margin is formed by structures 46, 48 and 49.

Abdominal Ultrasound

46. Portal vein
47. Inferior vena cava
48. Hepatic artery
49. Common bile duct
50. Epiploic foramen

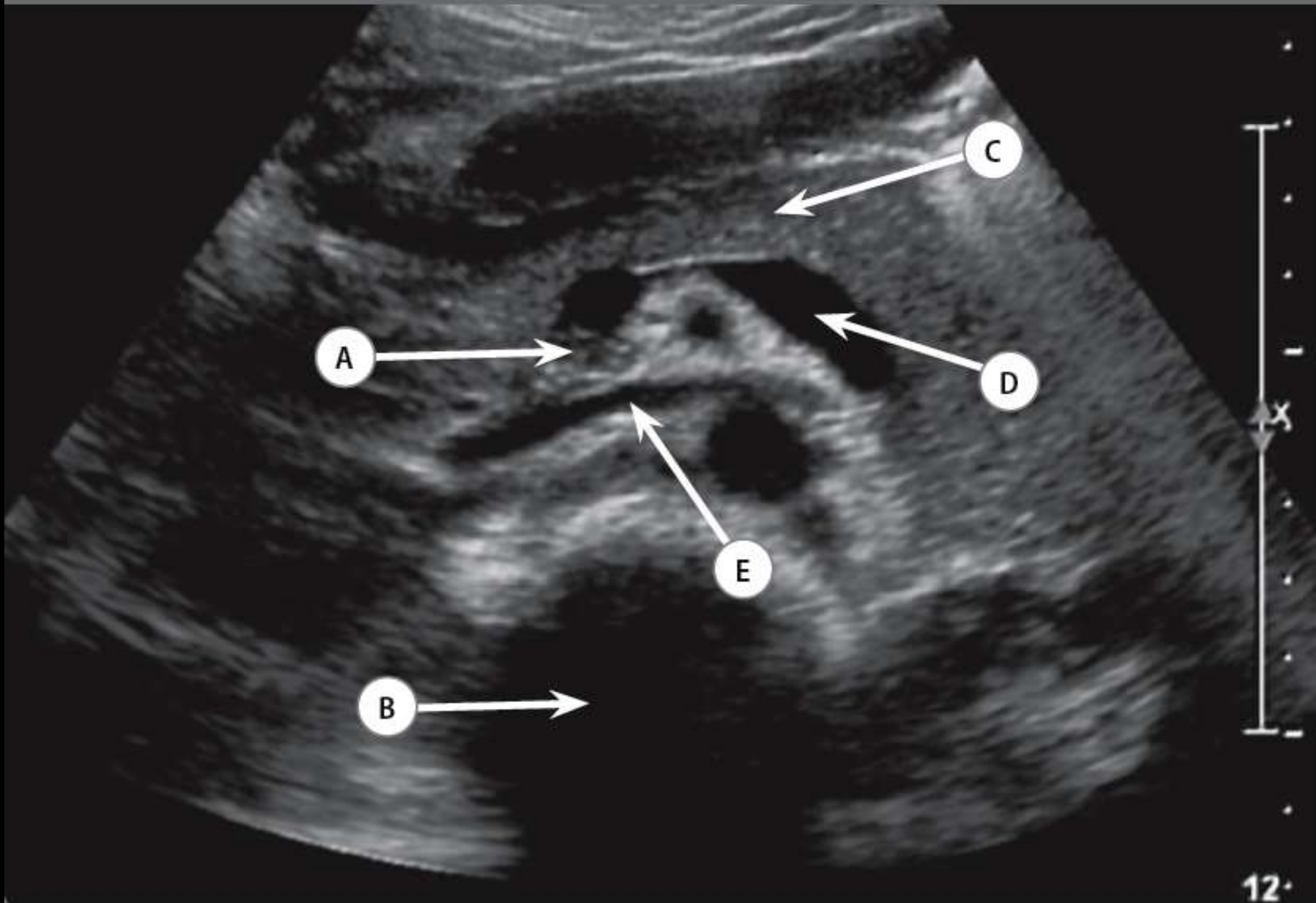

P
71
73
74
72
75

Ultrasound Abdomen

71. Diaphragm
72. Right lung
73. Left lobe of liver
74. Caudate lobe of liver
75. Inferior Vena Cava

This is a standard longitudinal (sagittal) view through the upper abdomen showing the caudate lobe between the left lobe of liver and the IVC. The IVC traverses the central tendon of the diaphragm to the right of midline. The diaphragm is echo bright.

Case 6.15



Case 6.15

A Uncinate process of pancreas

B Vertebral body

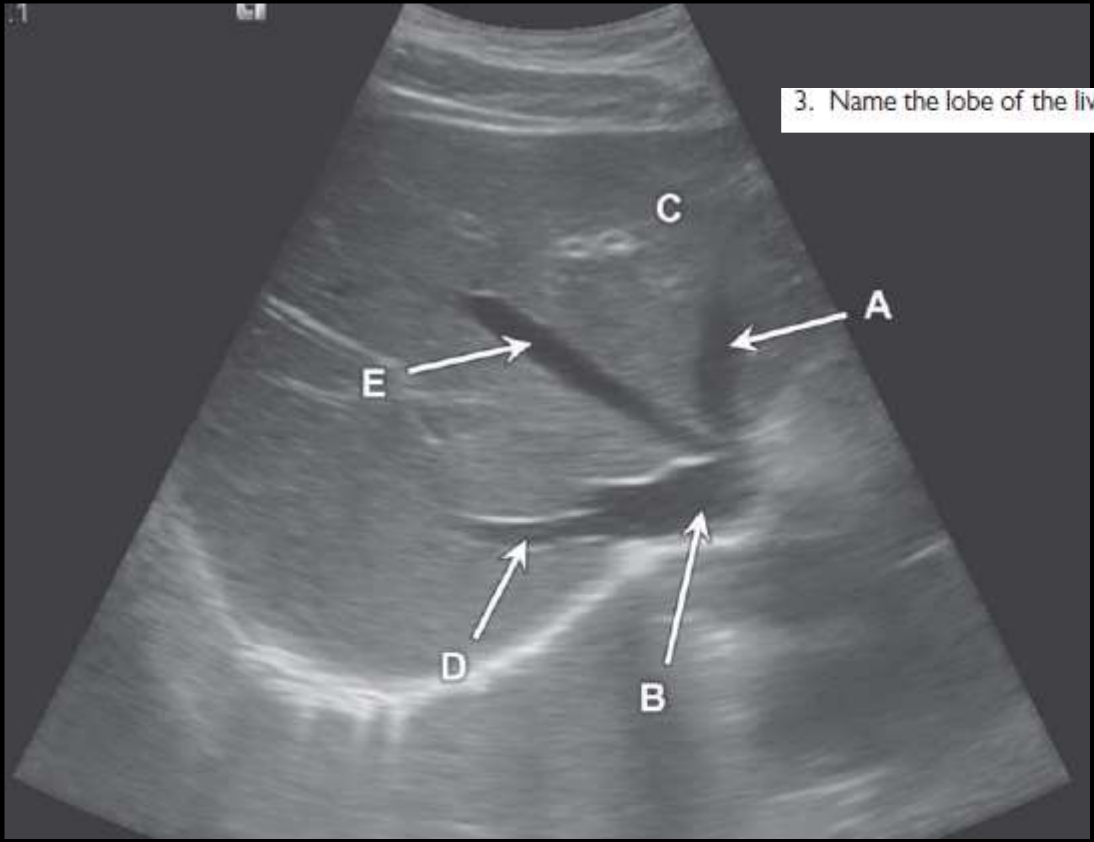
C Body of pancreas

D Splenic vein

E Left renal vein

Transverse image from an abdominal ultrasound.

For further discussion see Chapter 3, Case 3.3.



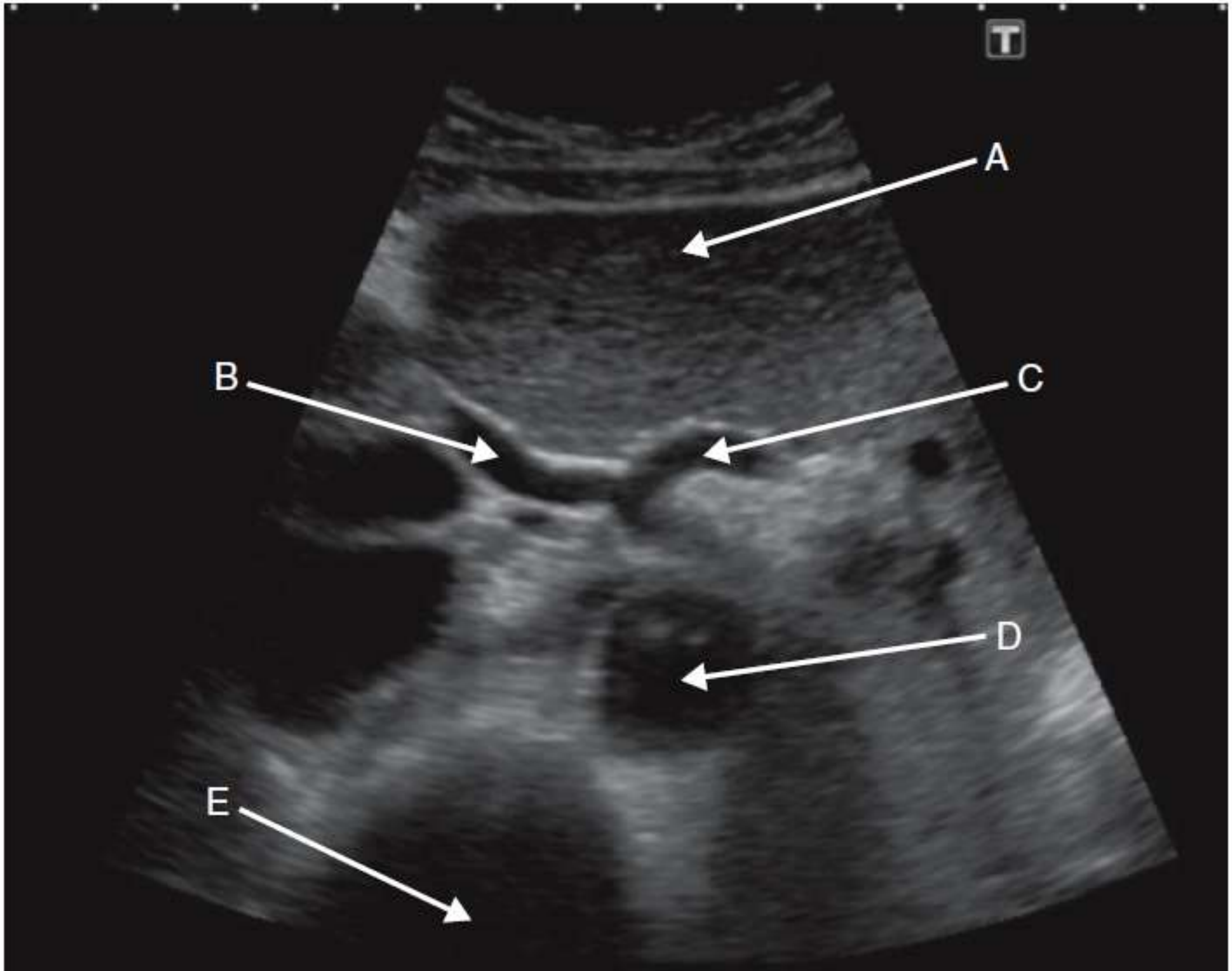
3. Name the lobe of the liver labelled C.

Case 17

Ultrasound liver.

1. Left hepatic vein
2. Inferior vena cava
3. Left lobe of the liver
4. Right hepatic vein
5. Middle hepatic vein

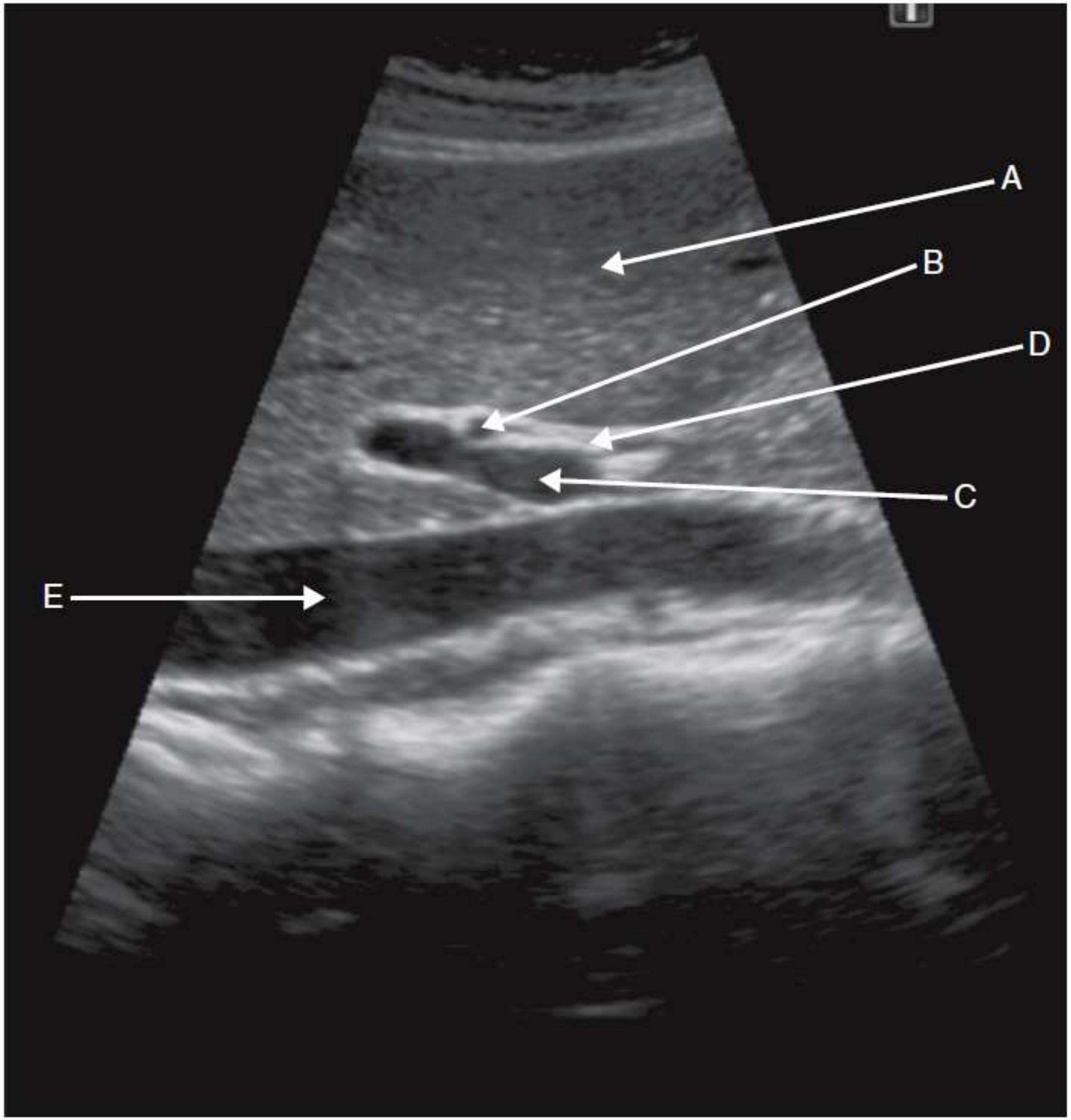
Case 6.14



6.14 Transverse ultrasound through the epigastrium

(a) Left lobe of the liver.
(b) Common hepatic artery. In normal subjects this may be difficult to see on colour Doppler because of its small diameter and tortuous course.
(c) Splenic artery. This is the largest branch of the coeliac trunk that follows a tortuous course posterior to omental bursa along the superior border of the pancreas.
(d) Aorta.
(e) Vertebral body. Typically the coeliac axis arises at the T12/L1 level.

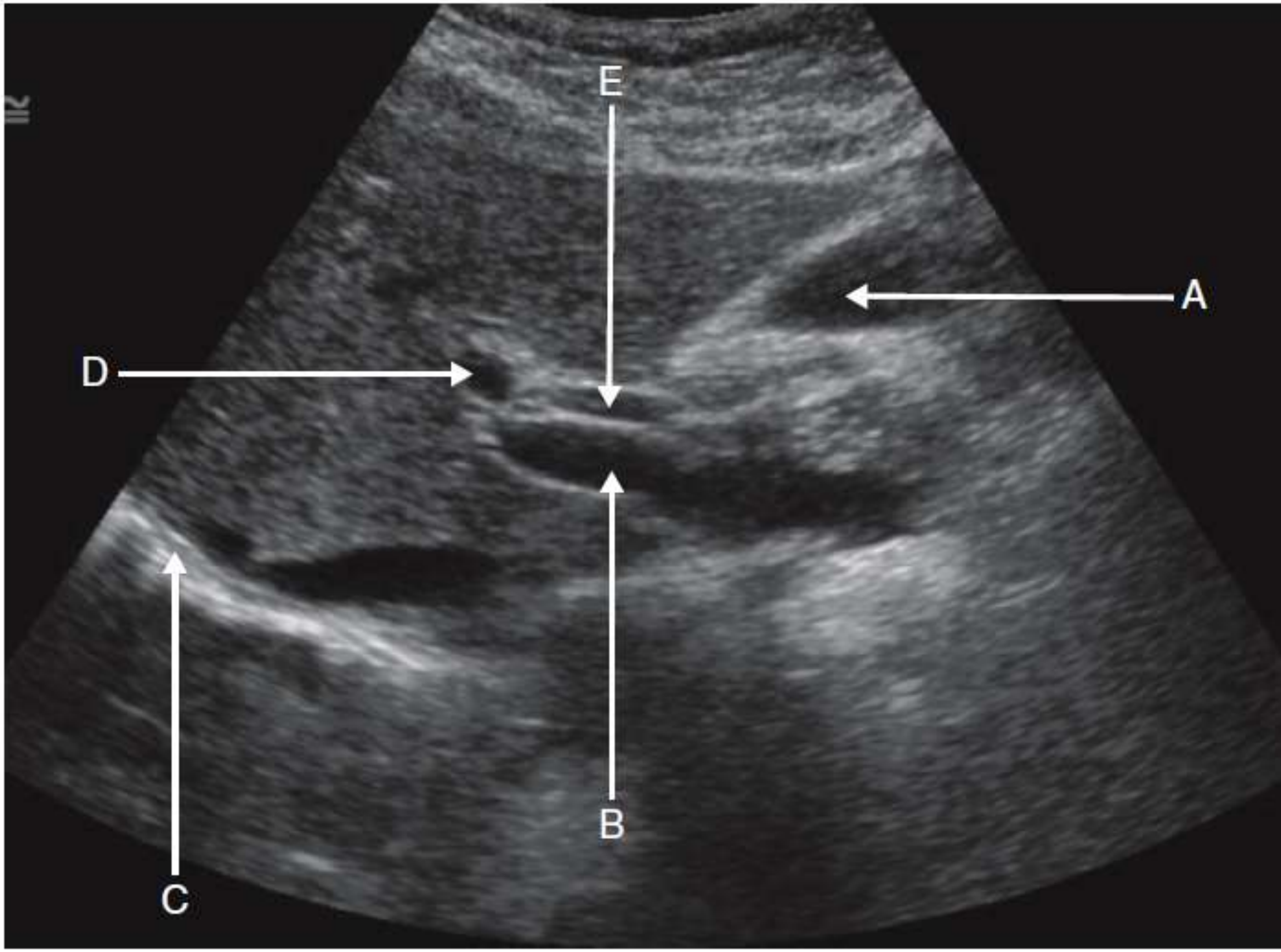
Case 7.5



7.5 Ultrasound liver: oblique image through the porta hepatis

(a) Left lobe of the liver. The liver is typically a homogeneous mid-grey organ with echogenicity slightly increased when compared to cortex of right kidney.
(b) Hepatic artery. Generally crosses the anterior aspect of the portal vein with the common duct anterior to this. A common variant is the artery lying anterior to the common duct.
(c) Portal vein. This enters the liver and is encased by hyperechoic, fibrous walls of the portal tracts.
(d) Common bile duct. This is best seen with the patient supine in a right anterior oblique position. Typically measures approximately 6 mm or less. However, it is age dependent and can be 8–9 mm in the elderly.
(e) Inferior vena cava (IVC). The three hepatic veins drain into the IVC just inferior to the diaphragm. The attachment helps hold the liver in position. The IVC runs posteriorly to the liver before passing through the caval opening in the diaphragm at T8 level.

Case 8.1



8.1 Transverse ultrasound through the porta hepatis

(a) Gallbladder. The gallbladder stores about 50 ml of bile. Its blood supply is from the cystic artery, a branch of the right hepatic artery. It drains into segment 5 of the liver where it also receives a collateral blood supply. There are folds in the mucous membrane of the cystic duct (spiral valve of Heister) which together with underlying smooth muscle serve to regulate the flow of bile.

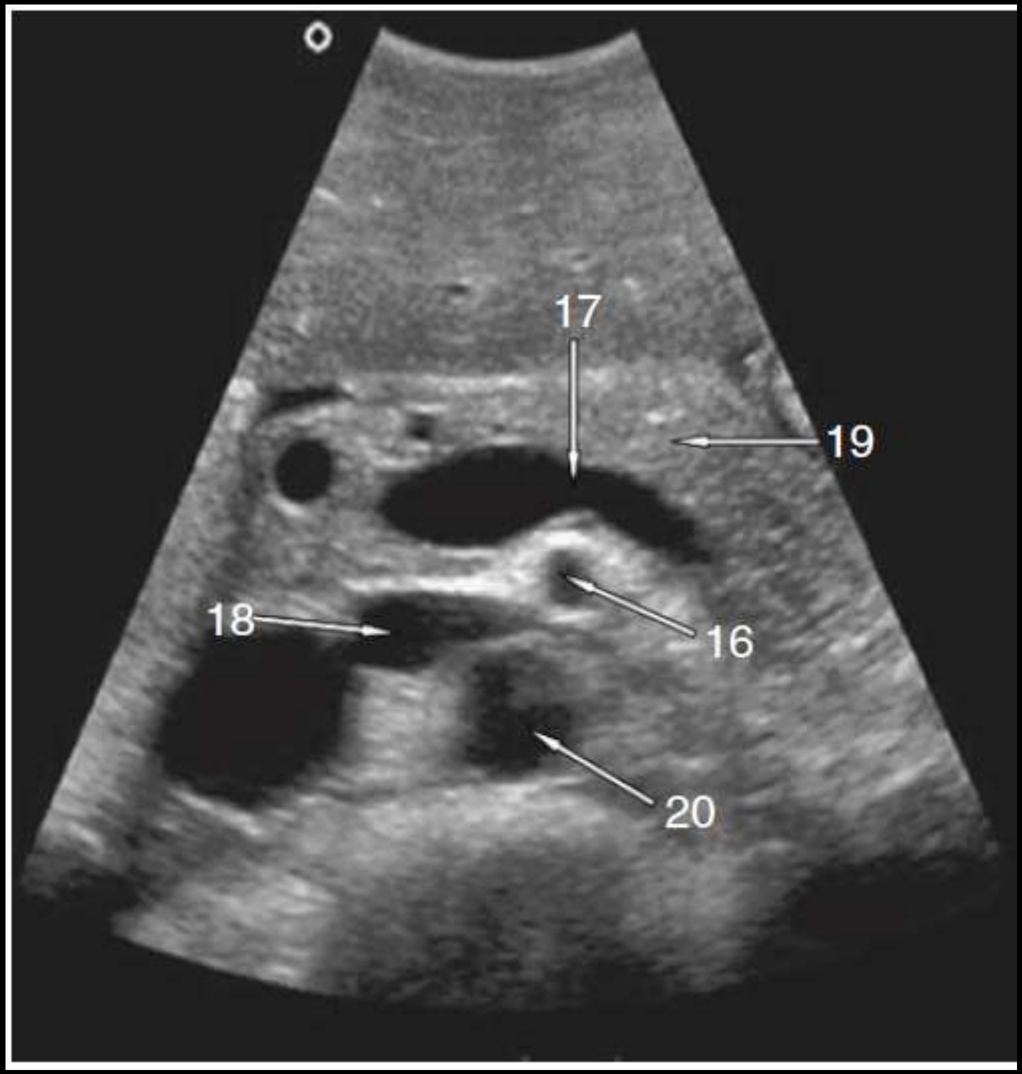
(b) Portal vein. It forms at the confluence of the splenic and superior mesenteric vein at L1/L2 level, posterior to the neck of the pancreas.

The portal vein provides 75% of the liver's inflow with the common hepatic artery supplying the remainder. Of note however, if there is a malignancy within the liver (primary or secondary) its blood supply is invariably arterial in origin.

(c) Right hemidiaphragm. The lung above the diaphragm is not seen as air conducts the ultrasound poorly. If there is a plural effusion however, it will be apparent in this region.

(d) Common hepatic artery. The region of the liver containing the common hepatic artery, common hepatic duct and portal vein is known as the porta hepatis.

(e) Common bile duct. This becomes the common bile duct (CBD) after the confluence with the cystic duct. The normal diameter of the CBD is variable but more than 8 mm can be pathological, though it dilates with increasing age. Generally 1 mm per decade gives a useful approximation.

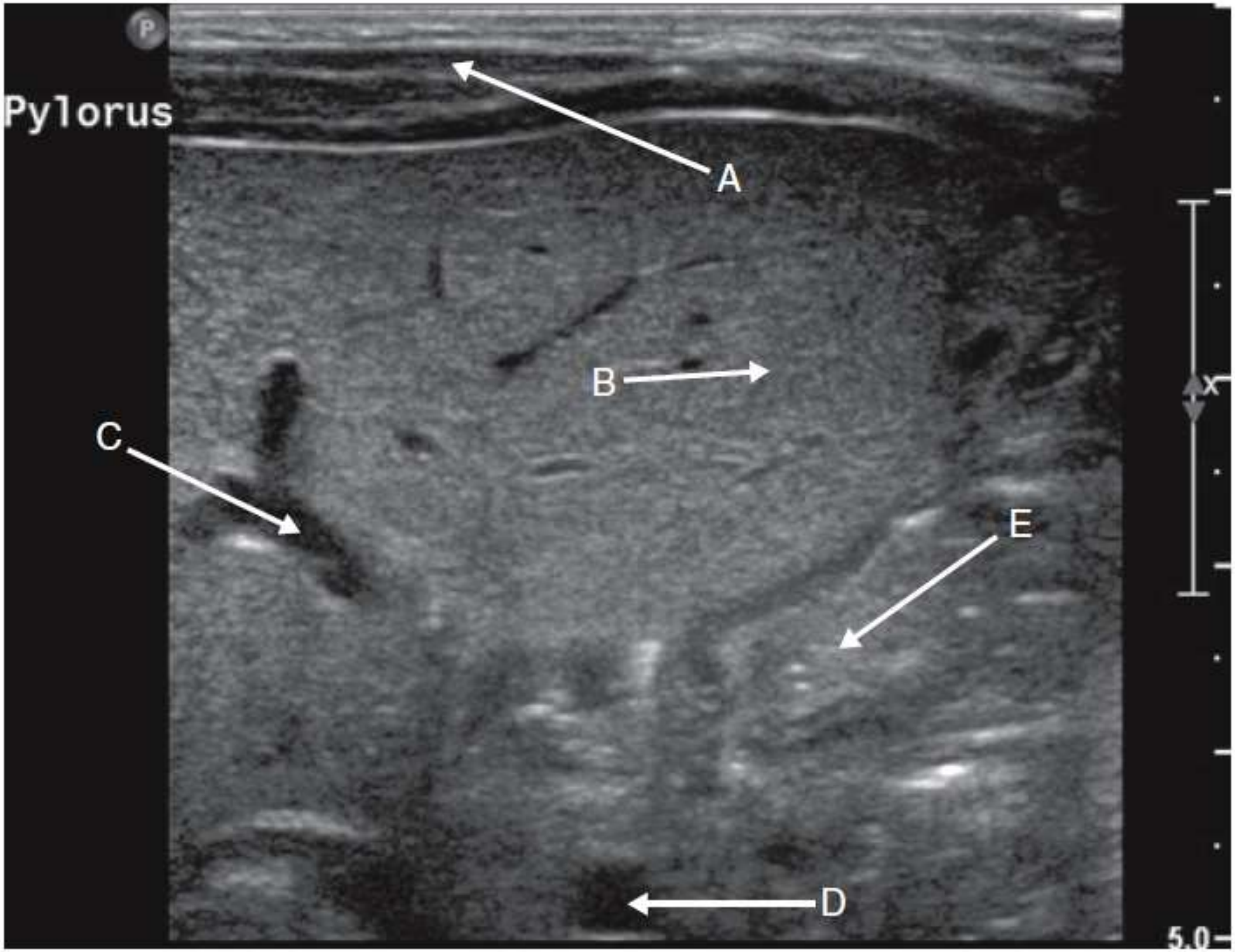

17
19
18
16
20

16. Superior mesenteric artery
17. Confluence of splenic vein and superior mesenteric vein/portal vein
18. Left renal vein
19. Body of pancreas
20. Abdominal aorta

Look for the tadpole shape of the splenic vein (tail) and portal confluence (head). The pancreas is located anteriorly to the 'tadpole'.

To distinguish the aorta from the IVC: the aorta lies to the left of the IVC, is smaller in diameter and is surrounded by a concentric echo-bright area which represents peri-arterial fat.

Case 6.2



6.2 Transverse ultrasound through stomach pylorus and upper abdomen

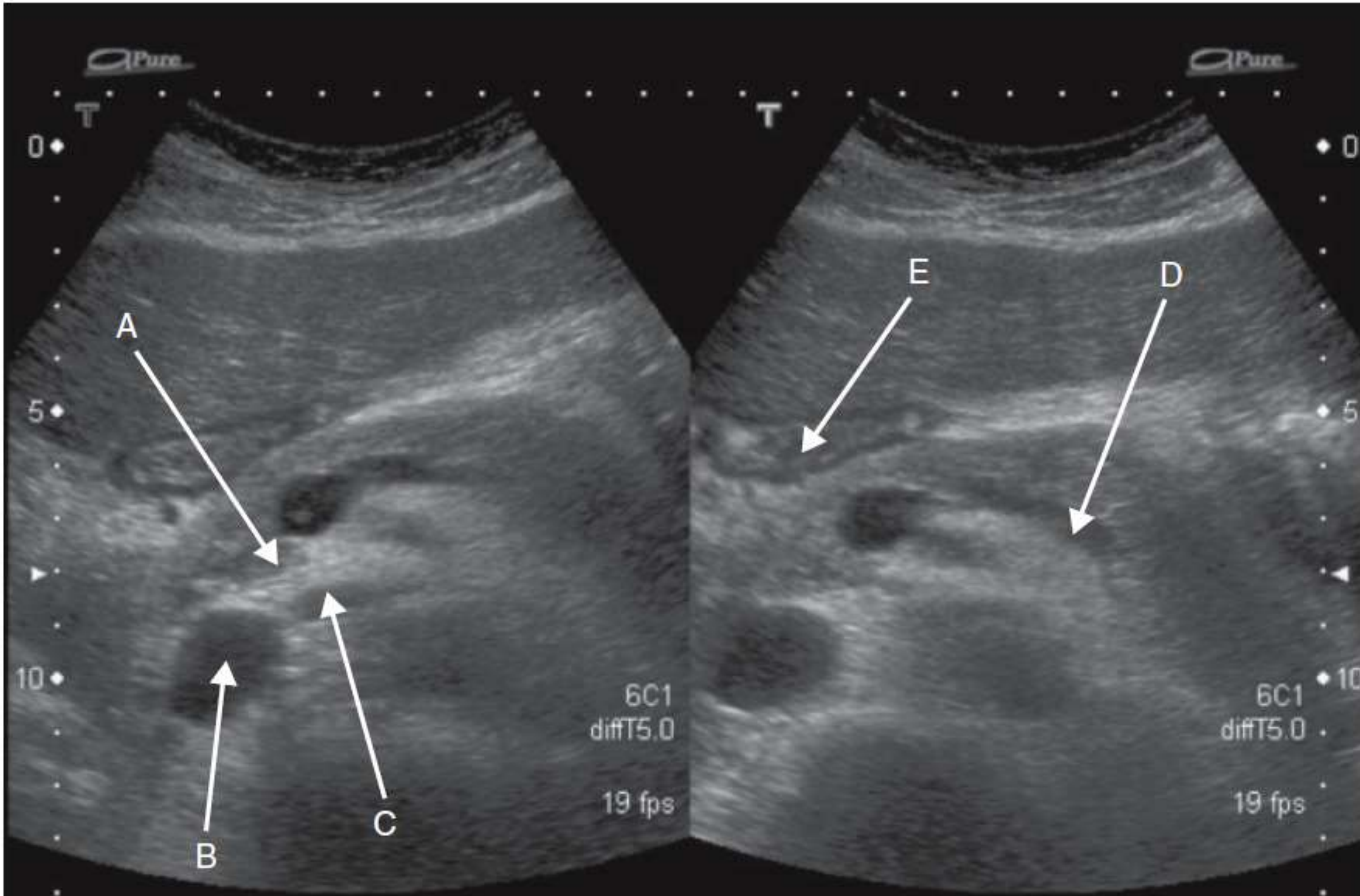
(a) Rectus abdominus muscle.
(b) Left lobe of liver.
(c) Portal vein.
(d) Aorta.
(e) Pylorus.

In infants pyloric stenosis is diagnosed if the single wall thickness of the pylorus is greater than 6 mm and the pyloric length is greater than 17 mm.

The stomach will often be distended with feed despite projectile-type vomiting.

The pylorus is not seen open and there is no passage of stomach contents into the duodenum during scanning. Typically presentation is at about 6 weeks of life.

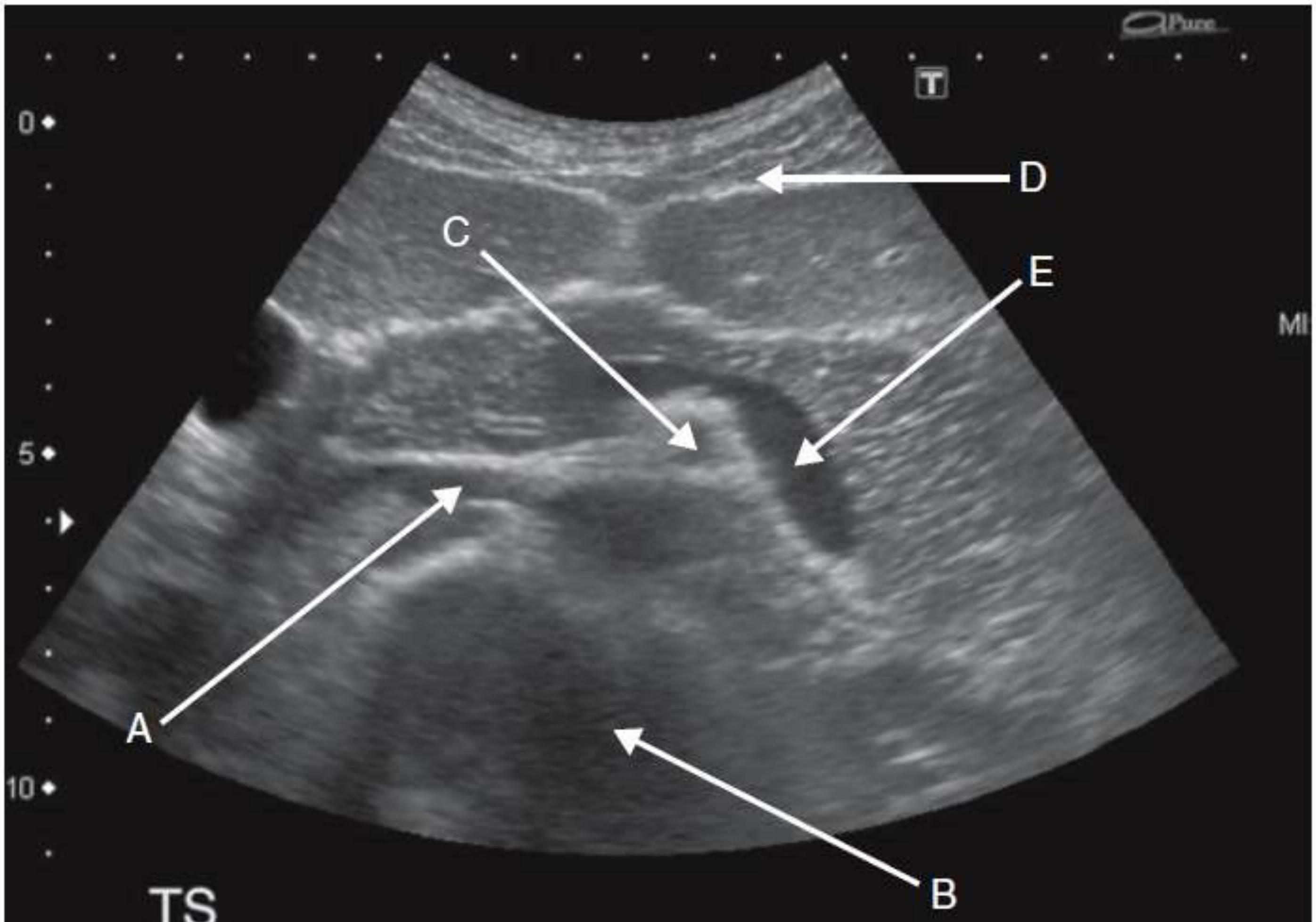
Case 3.17



3.17 Transverse ultrasound upper abdomen

(a) Uncinate process of the pancreas.
(b) Inferior vena cava.
(c) Left renal vein.
(d) Splenic vein.
(e) Duodenum (D1/D2).

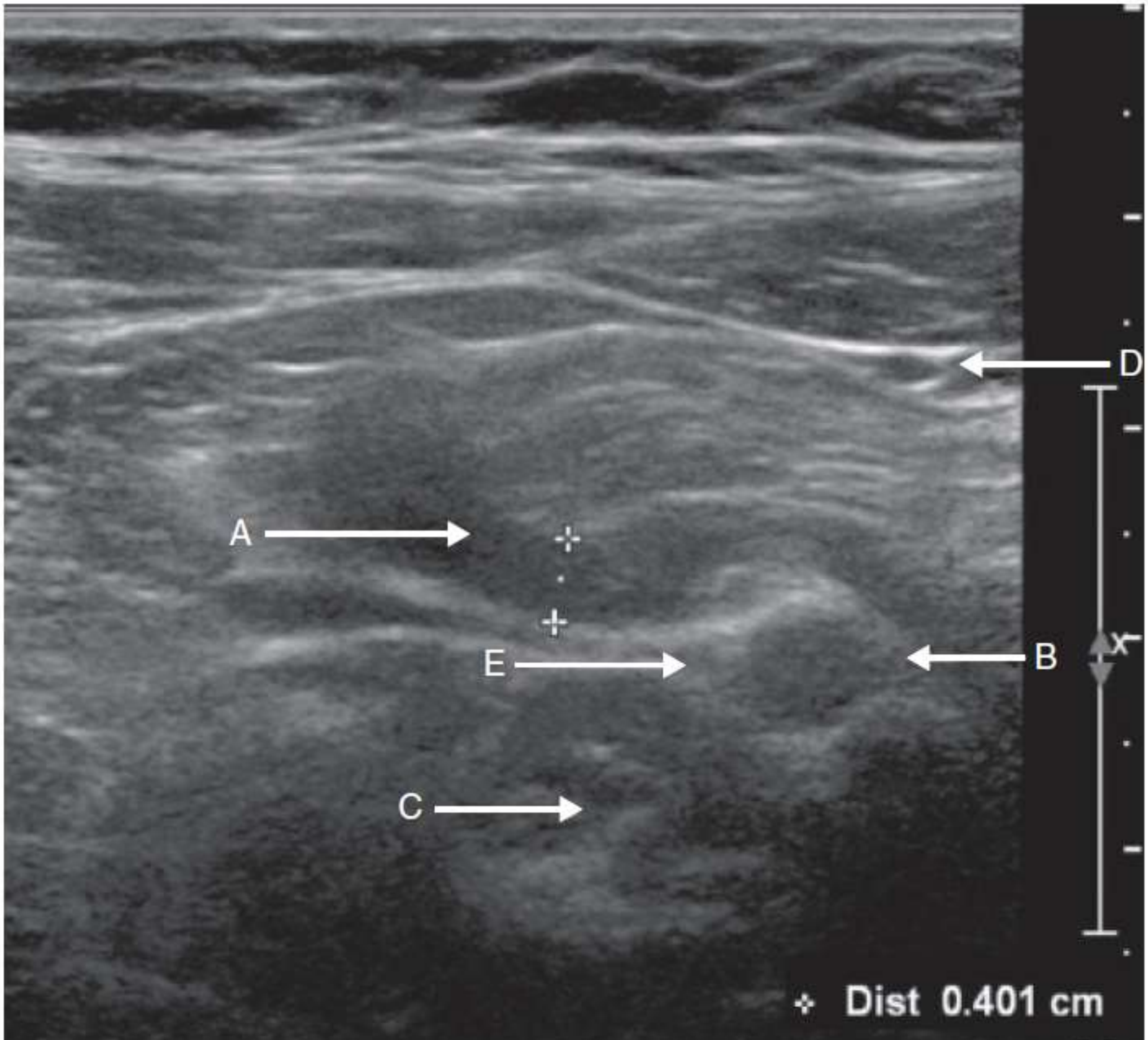
Case 1.19



1.19 Transverse ultrasound through the porta hepatis

(a) Right renal artery.
(b) Lumbar vertebral body.
(c) Superior mesenteric artery.
(d) Left rectus abdominis muscle.
(e) Splenic vein.

Case 1.14



1.14 Abdominal ultrasound over the right iliac fossa

(a) Appendix.
(b) Right femoral artery.
(c) Right psoas muscle.
(d) Right inferior epigastric artery.
(e) Right femoral nerve.

The normal appendix should measure less than 6 mm in its maximum diameter.

There is often a trace of free fluid in the right iliac fossa with appendicitis.

Careful exclusion of a faecolith should be undertaken.

The fat surrounding the appendix should be echogenic and freely compressible.

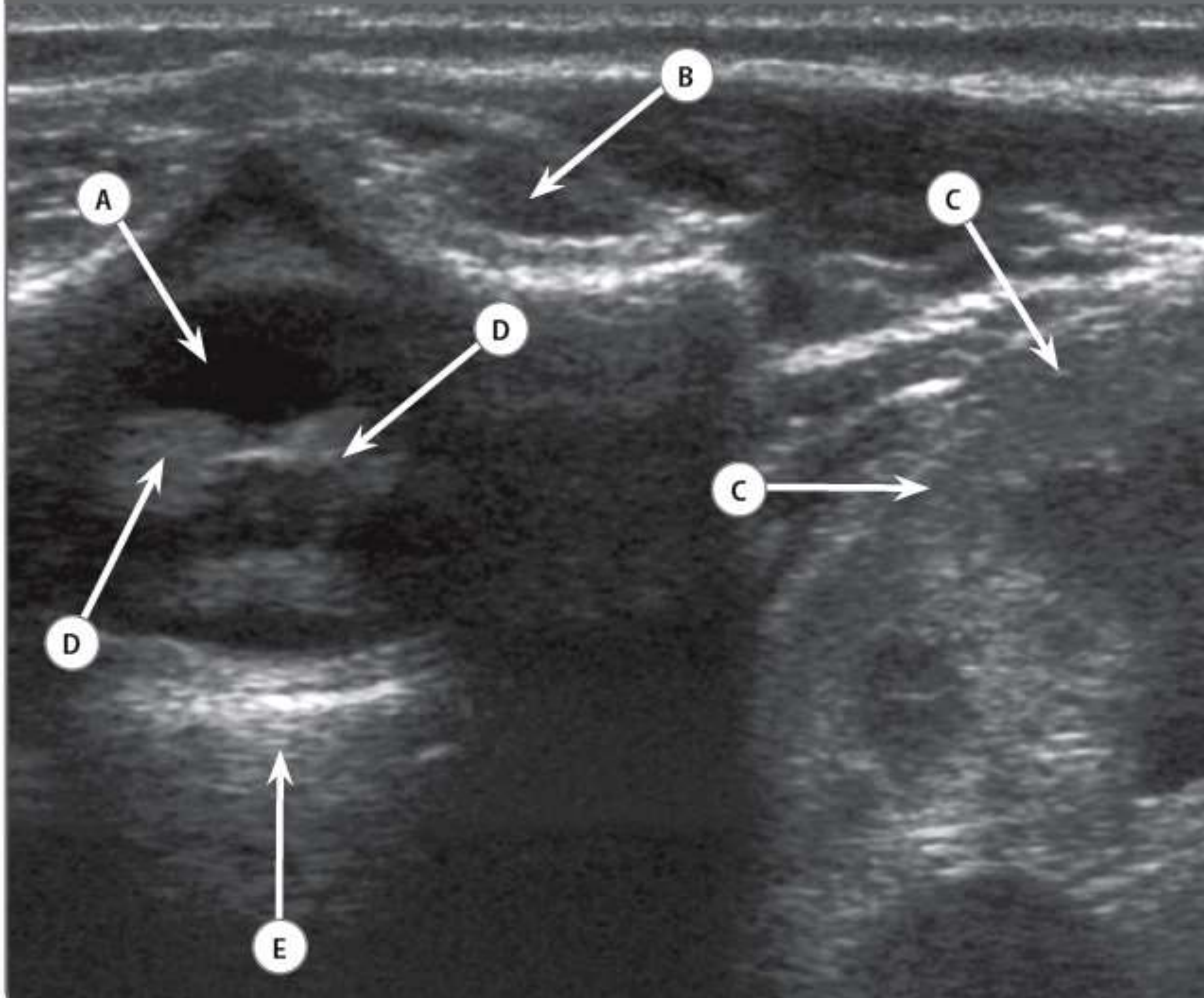
Colour flow Doppler signal should be the same as for the rest of the adjacent bowel.

Enlarged mesenteric lymph nodes may be apparent and may point to the alternative diagnosis of mesenteric adenitis.

A collection in the right iliac fossa or a pelvic collection anterior to the rectum is often appendix related.

Compression over the inflamed appendix will result in pain and rebound tenderness can often be elicited.

Case 15.12



Case 15.12

A Subarachnoid space

B Left erector spinae muscle

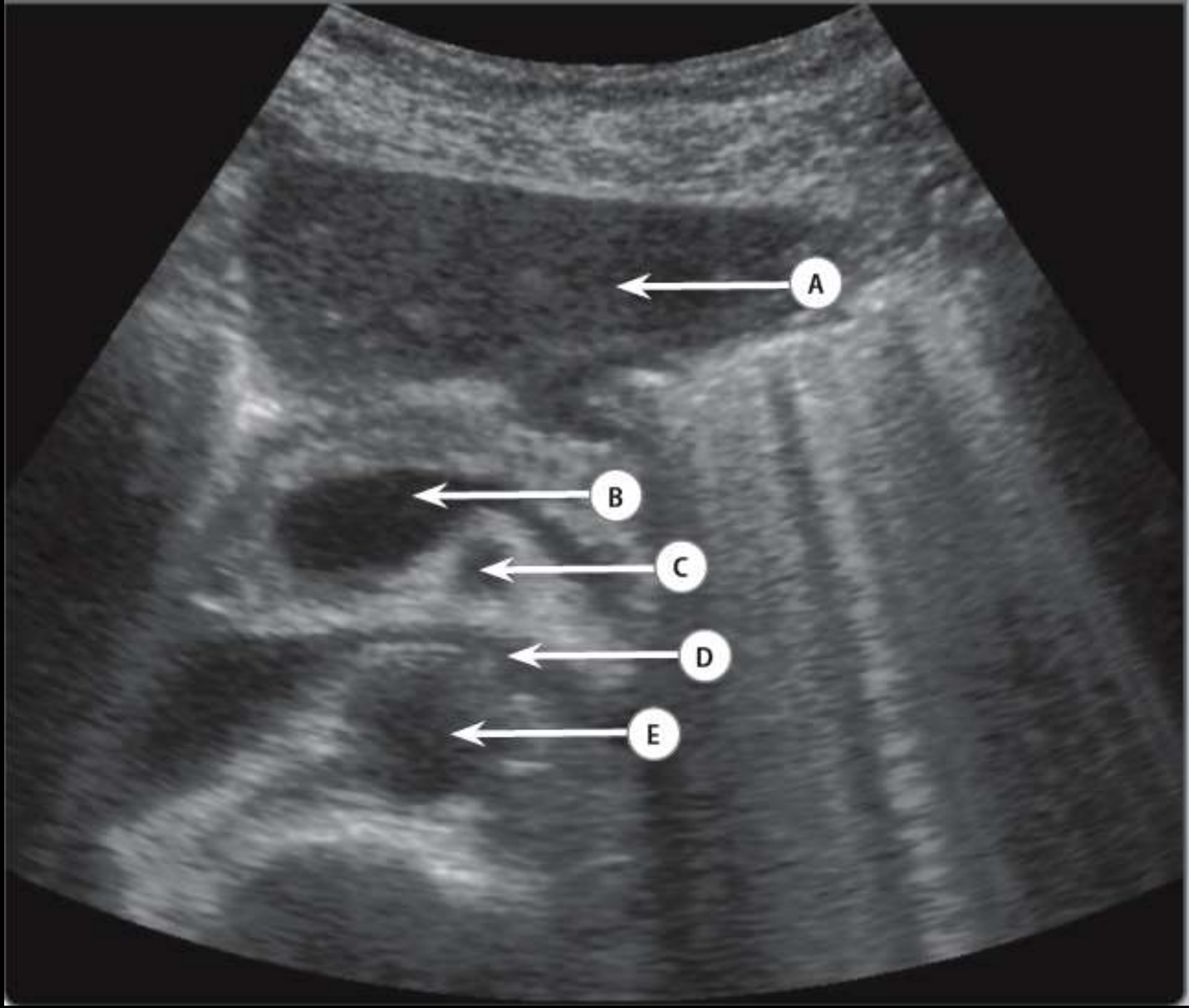
C Left kidney

D Spinal cord

E Vertebral body

The conus medullaris is the expansion at the caudal end of the spinal cord. In neonates, the tip of the conus medullaris typically lies between L1 and L2. A low-lying conus medullaris (i.e. below the level of L2–3) suggests spinal dysraphism, with associated tethering of an abnormally thickened filum terminale. The filum terminale is a condensation of pia mater that continues caudally from the tip of the conus medullaris to attach to the dorsal aspect of the first coccygeal segment. The central canal of the cord continues within the filum terminale for 5–6 cm. The filum terminale should normally measure no more than 2 mm in thickness.

Case 14.1



Case 14.1

A Left lobe of the liver

B Portal venous confluence

C Superior mesenteric artery

D Left renal vein

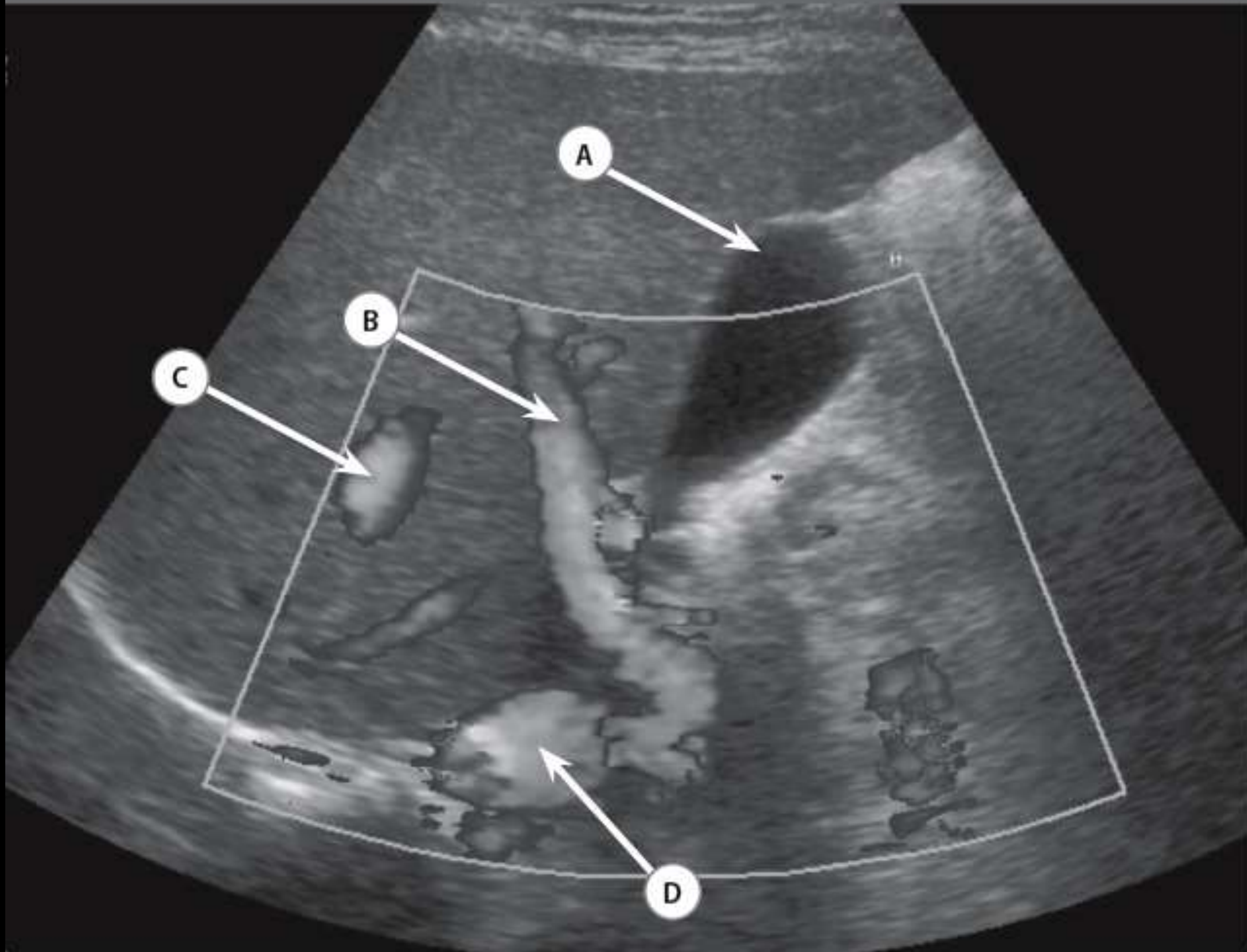
E Aorta

The left lobe of the liver is visualised at the top of the picture (A). The bright streakiness to the right of the image is caused by gas in the gastric lumen.

The portal venous confluence is formed by the splenic and superior mesenteric veins.

The course of the left renal vein is clearly demonstrated, running anterior to the abdominal aorta and posterior to the superior mesenteric artery.

Case 12.8



E	From what two structures is structure B usually formed?	

Case 12.8

A Gallbladder

B Portal vein

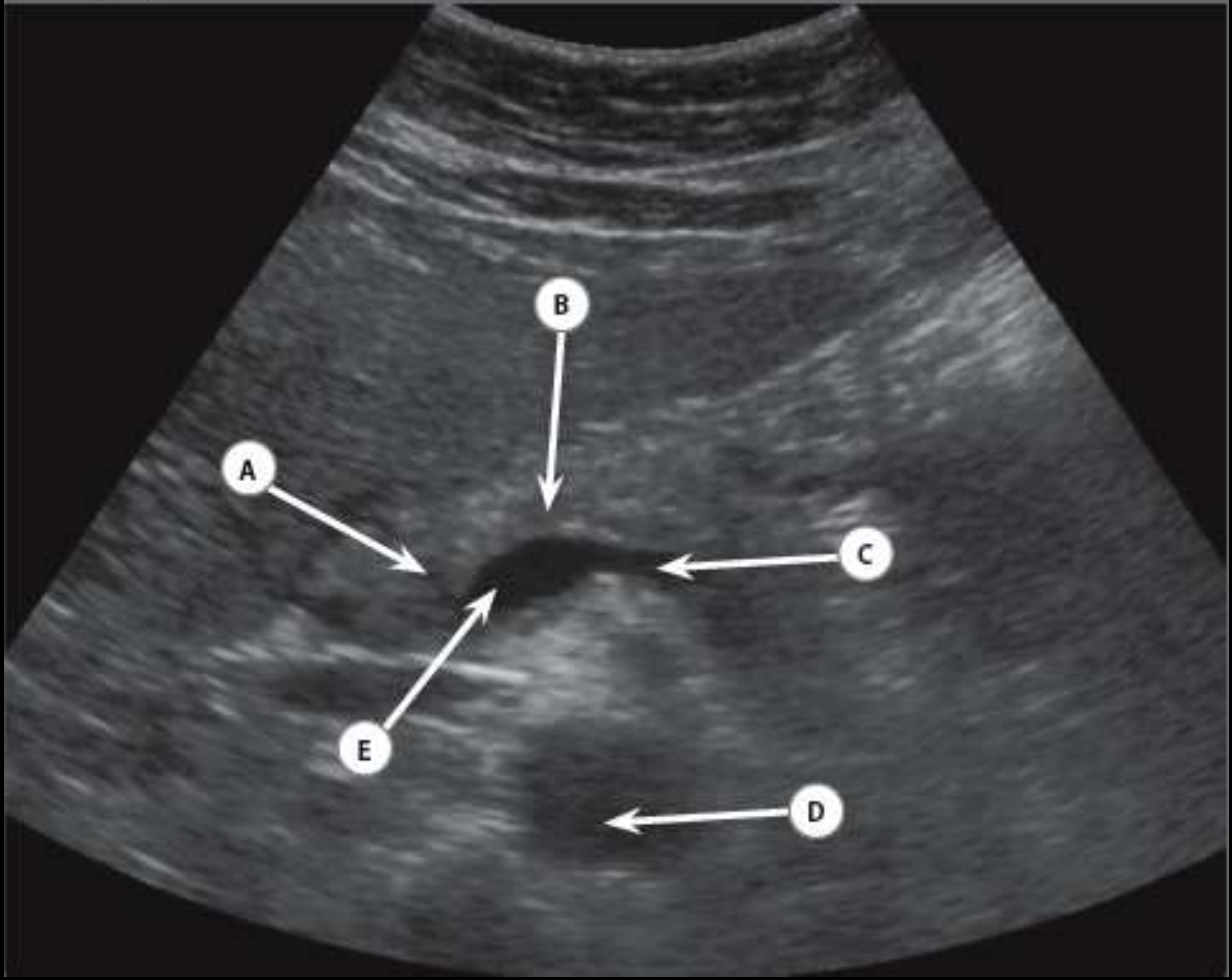
C Middle hepatic vein

D Inferior vena cava (IVC)

E Splenic vein and superior mesenteric vein

The portal vein is usually formed by the superior mesenteric vein and splenic vein (which itself usually receives the inferior mesenteric vein). The portal vein, along with the hepatic artery (shown on this image as the circle lying between the portal vein and the neck of the gallbladder), represents the blood supply to the liver. In the normal physiological state, the portal vein exhibits hepatopetal flow, i.e. flow of blood towards the liver. The hepatic veins, of which there are usually three (right, middle and left) converge on the IVC, joining it just below the inferior cavoatrial junction.

Case 10.7

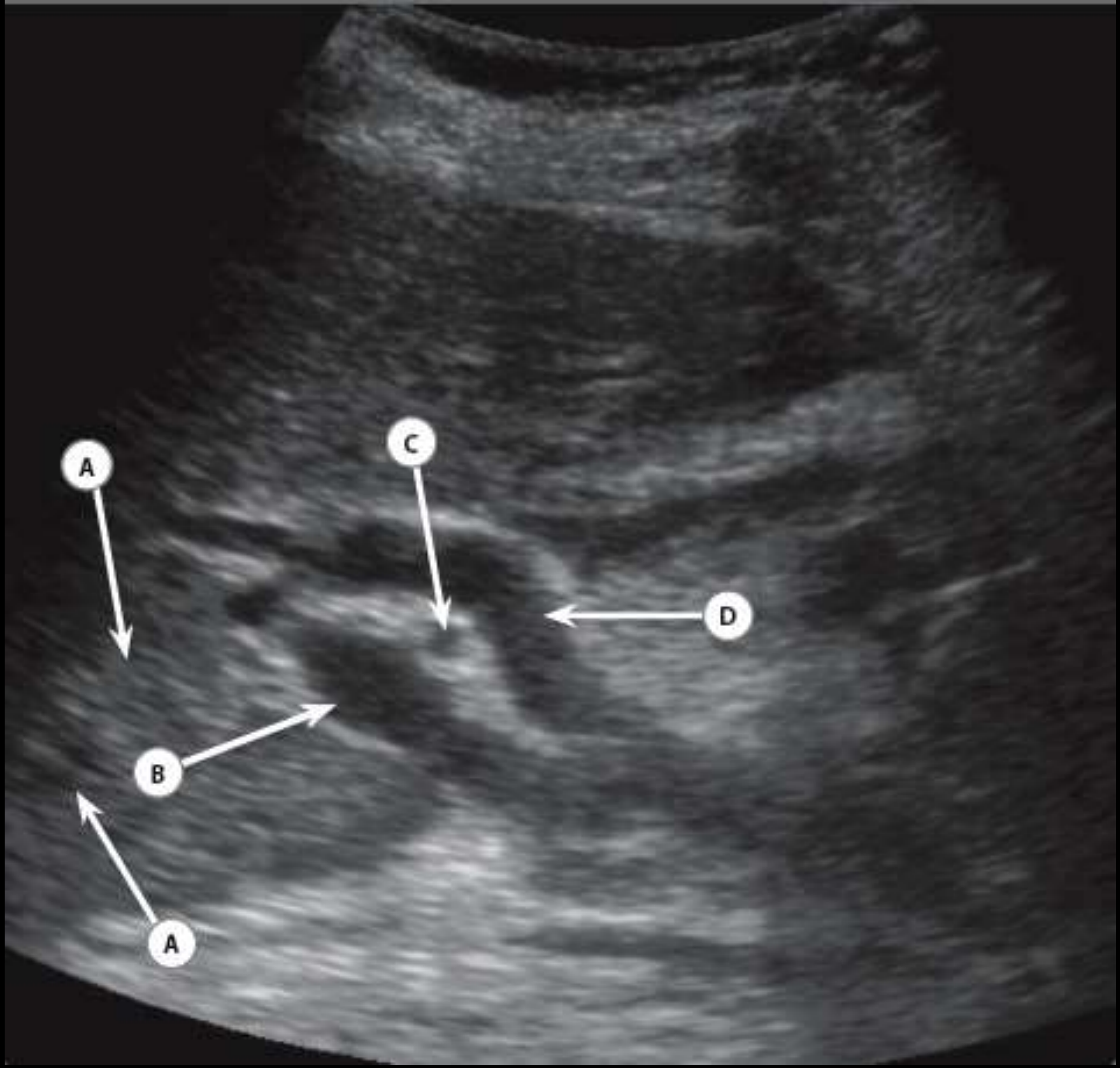


Case 10.7

- **A** Head of pancreas
- **B** Neck of pancreas
- **C** Splenic vein
- **D** Abdominal aorta
- **E** Portal venous confluence

The pancreas is a retroperitoneal structure, and as such is often obscured by bowel gas on ultrasound imaging. The pancreas itself is composed of a head (lying to the right of the midline, with the uncinate process lying inferiorly), neck (which passes the midline anterior to the L1/L2 vertebrae), body and tail (both of which lie to the left of the midline). The confluence of the portal vein is seen to the right of the midline, posteromedial to the head of the pancreas, as it is formed from the splenic vein and the superior mesenteric vein. The abdominal aorta is an indirect posterior relation of the pancreas.

Case 8.20



E In what direction does portal venous flow relative to the liver?

Case 8.20

A Right lobe of liver

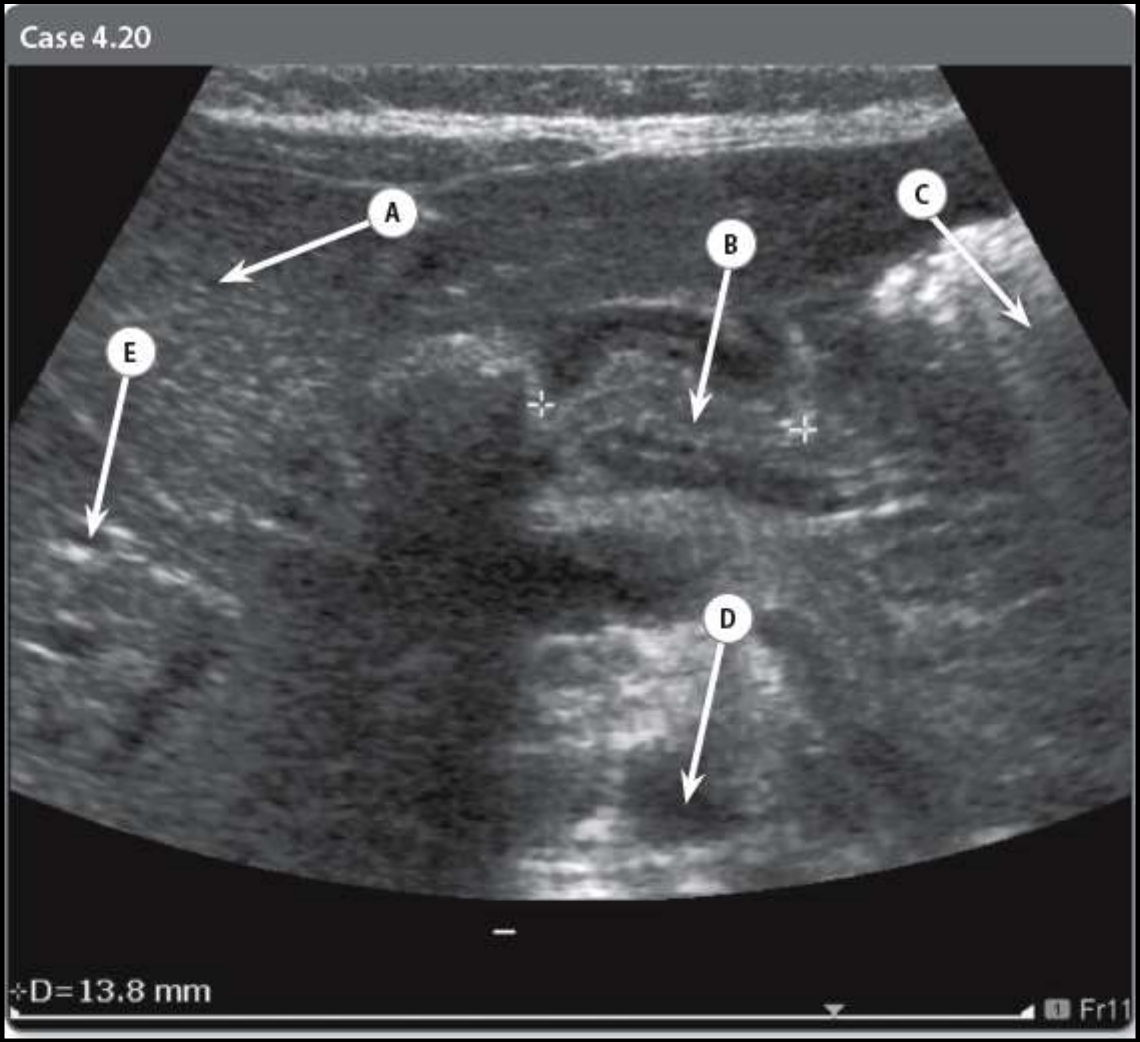
B Portal vein

C Hepatic artery

D Common bile duct

E Hepatopetal (towards the liver)

This is the classic view used to visualise structures at porta hepatis. The round hepatic artery (visualised in transverse section) is seen to be sandwiched between the portal vein and common bile duct (visualised in longitudinal section).


Case 4.20
A
B
C
D
E
D=13.8 mm
Fr11

Case 4.20

A Liver

B Pylorus

C Gastric antrum

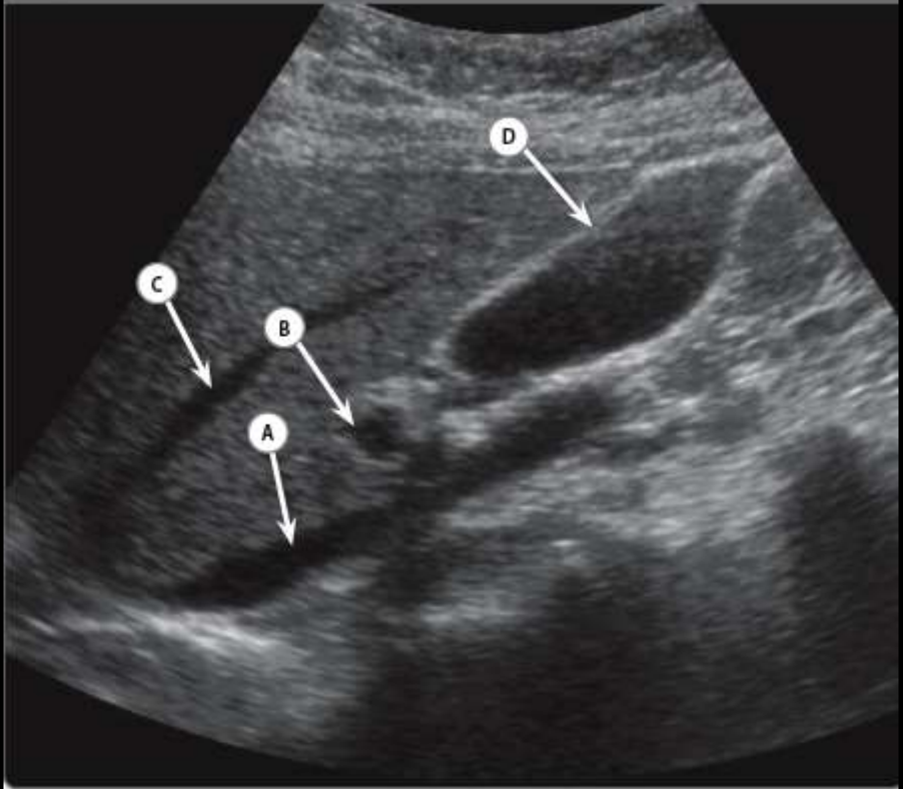
D Abdominal aorta

E Branch of right portal vein

Ultrasound is the imaging modality of choice when evaluating suspected infantile hypertrophic pyloric stenosis. Normally, the pylorus muscle should not exceed 3 mm in thickness and the pylorus should be no more than 17 mm in length, although this is somewhat contingent on the size of the infant. The muscular layers of the pylorus are hypoechoic with hyperechoity of the mucosa. The stomach itself may appear as a solid structure on ultrasound if distended with milk curd.

Portal vein branches can be differentiated from intrahepatic bile ducts by their increased reflectivity, as shown in this case.

Case 5.4



Case 5.4

QUESTION		WRITE YOUR ANSWER HERE
A	Name the structure labelled A.	
B	Name the structure labelled B.	
C	Name the structure labelled C	
D	Name the structure labelled D.	
E	What is the normal upper limit of wall thickness of the gallbladder?	

Case 5.4

A Inferior vena cava

B Portal vein

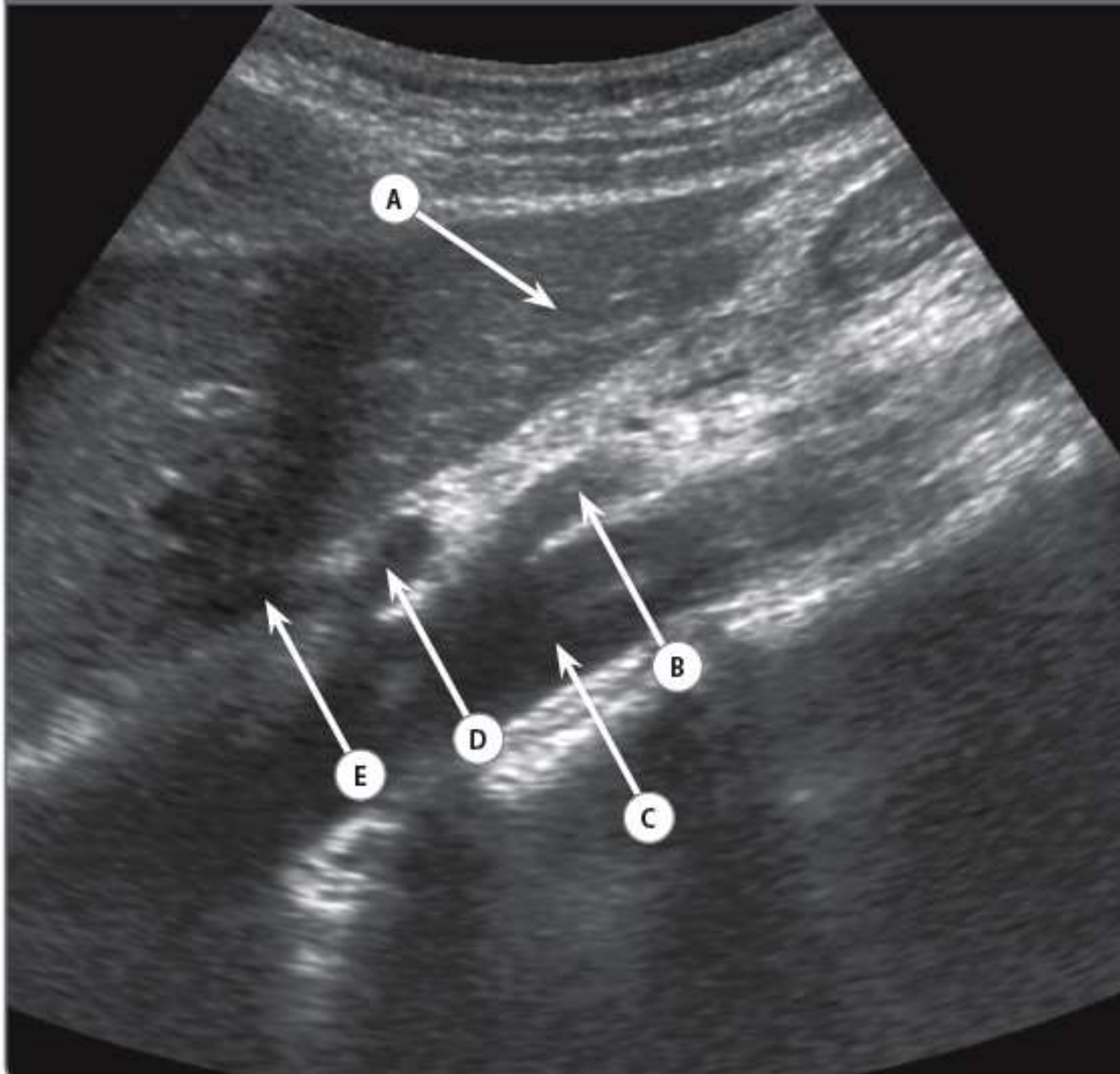
C Hepatic vein

D Gallbladder

E 3 mm

This image shows the gallbladder in longitudinal section, the fundus evident near the top of the image and the neck in the middle of the image. One of the three hepatic veins is seen coursing towards the inferior vena cava, usually joining it just before the inferior vena cava reaches the right atrium.

Case 3.9



Case 3.9

A Left lobe of liver

B Superior mesenteric artery

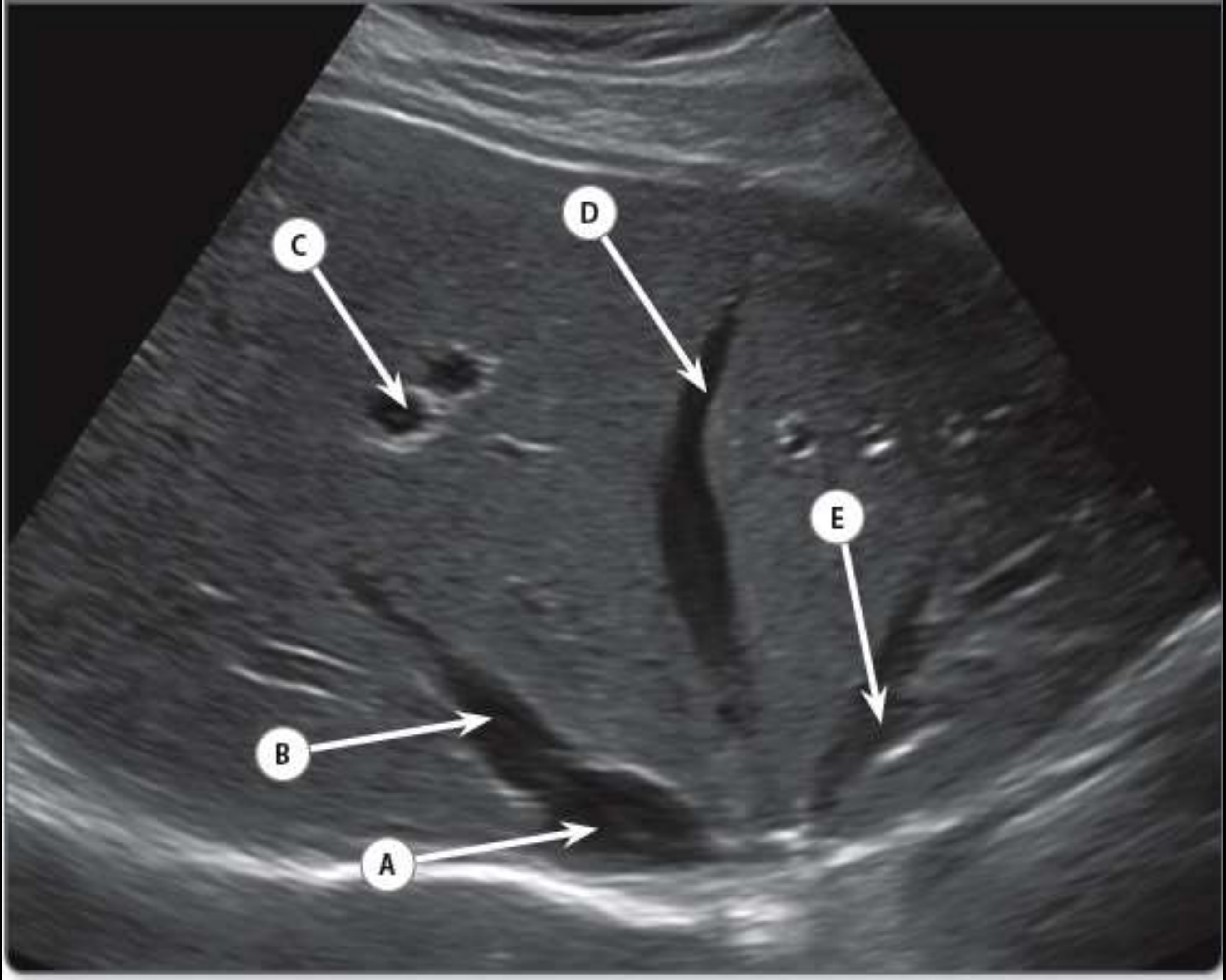
C Aorta

D Coeliac axis

E Portal vein

The relation of the portal vein to the aorta and coeliac axis is well seen on this image. The portal vein is located anteriorly and to the right of the aorta. The portal venous confluence is located just inferior and to the right of the coeliac axis. This should become a very familiar view and you should expect to be able to recognise these major structures on MRI, CT, US and angiography.

Case 1.4



Case 1.4

A Intrahepatic segment of inferior vena cava

B Right hepatic vein

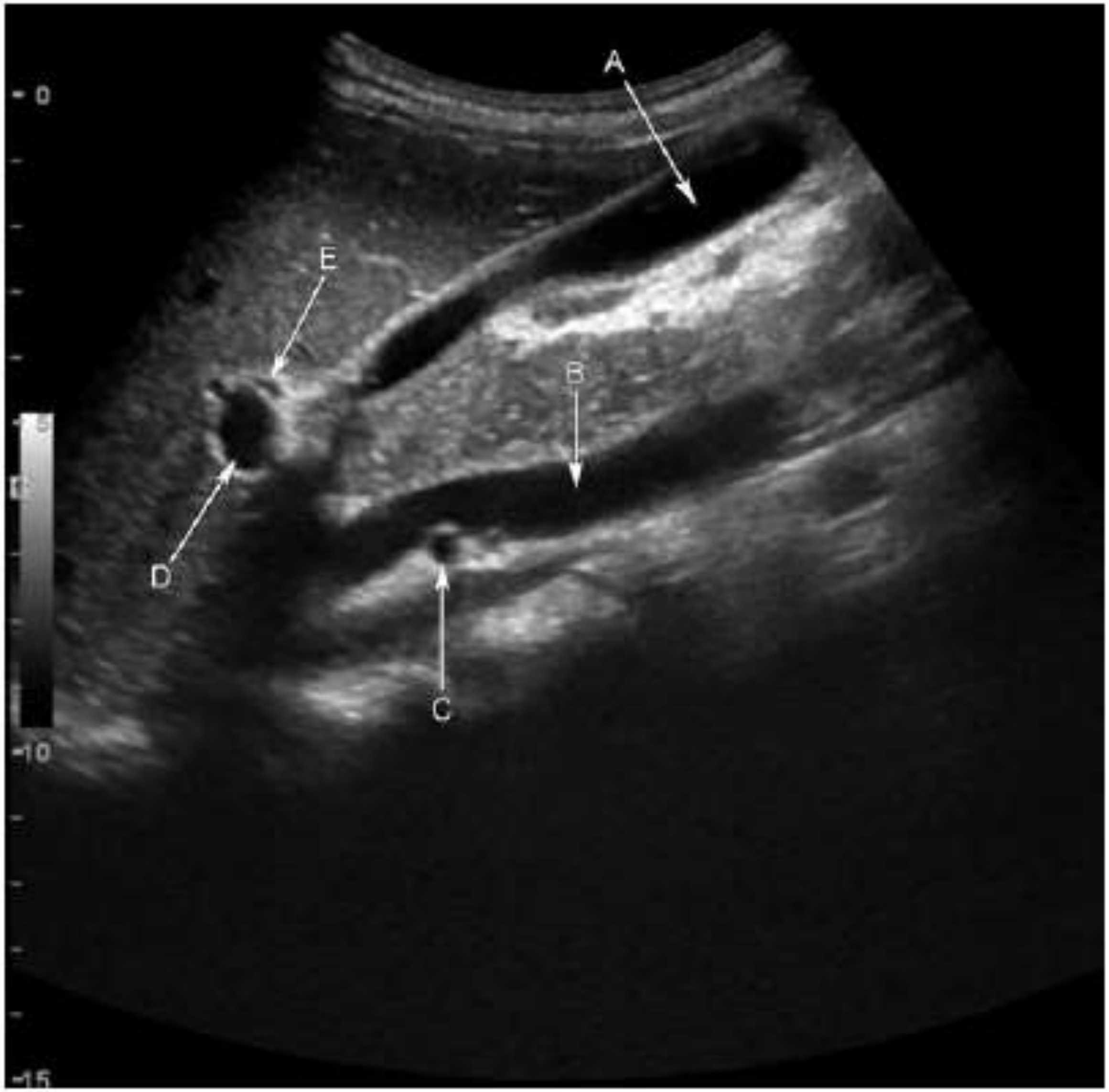
C Branch of right portal vein

D Middle hepatic vein

E Left hepatic vein

This ultrasound image clearly shows the three hepatic veins (right, middle and left) converging to join the intrahepatic segment of the inferior vena cava, just before it drains into the right atrium. Other than different directions of flow, branches of the portal vein demonstrate increased echogenicity of the vessel wall as compared to hepatic veins.

Question 9.15



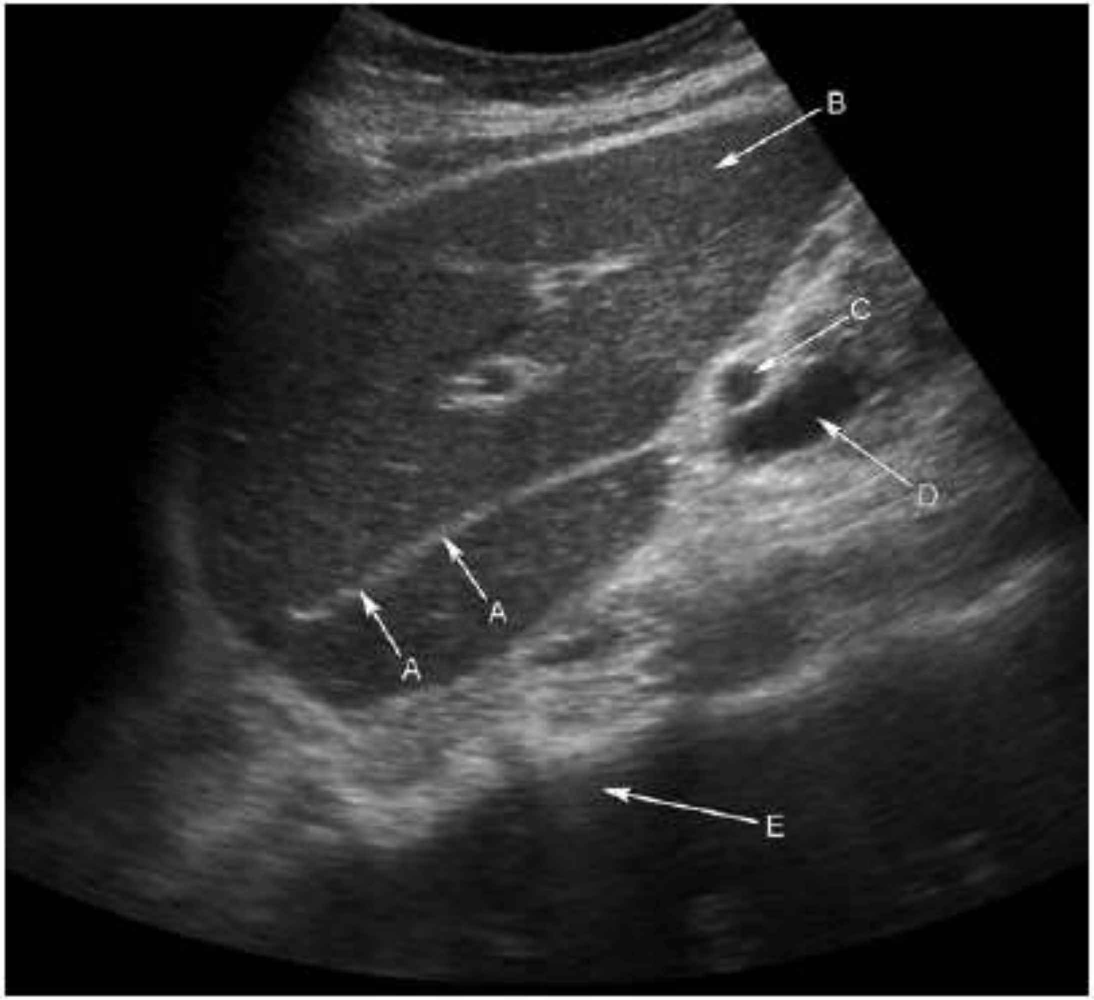
Name the structures labelled **A** to **E**.

9.15 Longitudinal ultrasound of the abdomen

A Gallbladder.
B Inferior vena cava.
C Right renal artery.
D Portal vein.
E Common hepatic duct.

Since the aorta lies to the left of the inferior vena cava, the right renal artery is usually longer than the left. The right renal artery arises from the aorta at vertebral level L1 and passes behind the inferior cava, right renal vein, the head of the pancreas and the descending part of the duodenum before reaching the right kidney. There are several normal variants in renal artery anatomy. The most common of these is multiple renal arteries supplying one kidney, which occurs in 25–40% of the population.

Question 7.15



This is a longitudinal ultrasound through the abdomen.
Name the structures labelled **A** to **E**.

7.15 Longitudinal ultrasound of the liver

A Ligamentum venosum.
B Left lobe of the liver.
C Common bile duct.
D Portal vein.
E Vertebrae.

The ligamentum venosum is the remnant of the ductus venosus of the foetal circulation, and appears as a hyperechoic stripe on ultrasound. It is normally attached to the left branch of the portal vein within the porta hepatis. It lies within a fissure between the caudate lobe and the left lobe of the liver, and serves as a useful landmark for identifying the caudate lobe on ultrasound.

The common hepatic artery is a short branch of the coeliac artery and typical divides into the left and right hepatic, right gastric and gastroduodenal arteries. The inferior vena cava lies to the right of the aorta and is the primary venous return to the heart.

Question 6.12

6.12 Transverse ultrasound of the abdomen

A Head of pancreas
B Left lobe of the liver
C Tail of pancreas
D Body of pancreas
E Superior mesenteric artery

The pancreas lies transversely across the posterior abdominal wall behind the stomach and with the transverse mesocolon at its anterior margin. The head lies in the curve of the second part of the duodenum and gives rise to an uncinate process. The common bile duct passes posteriorly to the head of the pancreas. The neck of the pancreas is adjacent to the pylorus. The portal vein is formed posteriorly to the neck at the confluence of the splenic vein and superior mesenteric vein. The body of the pancreas curves across the midline and is closely related to the splenic vessels. The tail of the pancreas lies in the splenic hilum, within the splenorenal ligament.

Question 6.14

Name the structures labelled **A** to **E**.

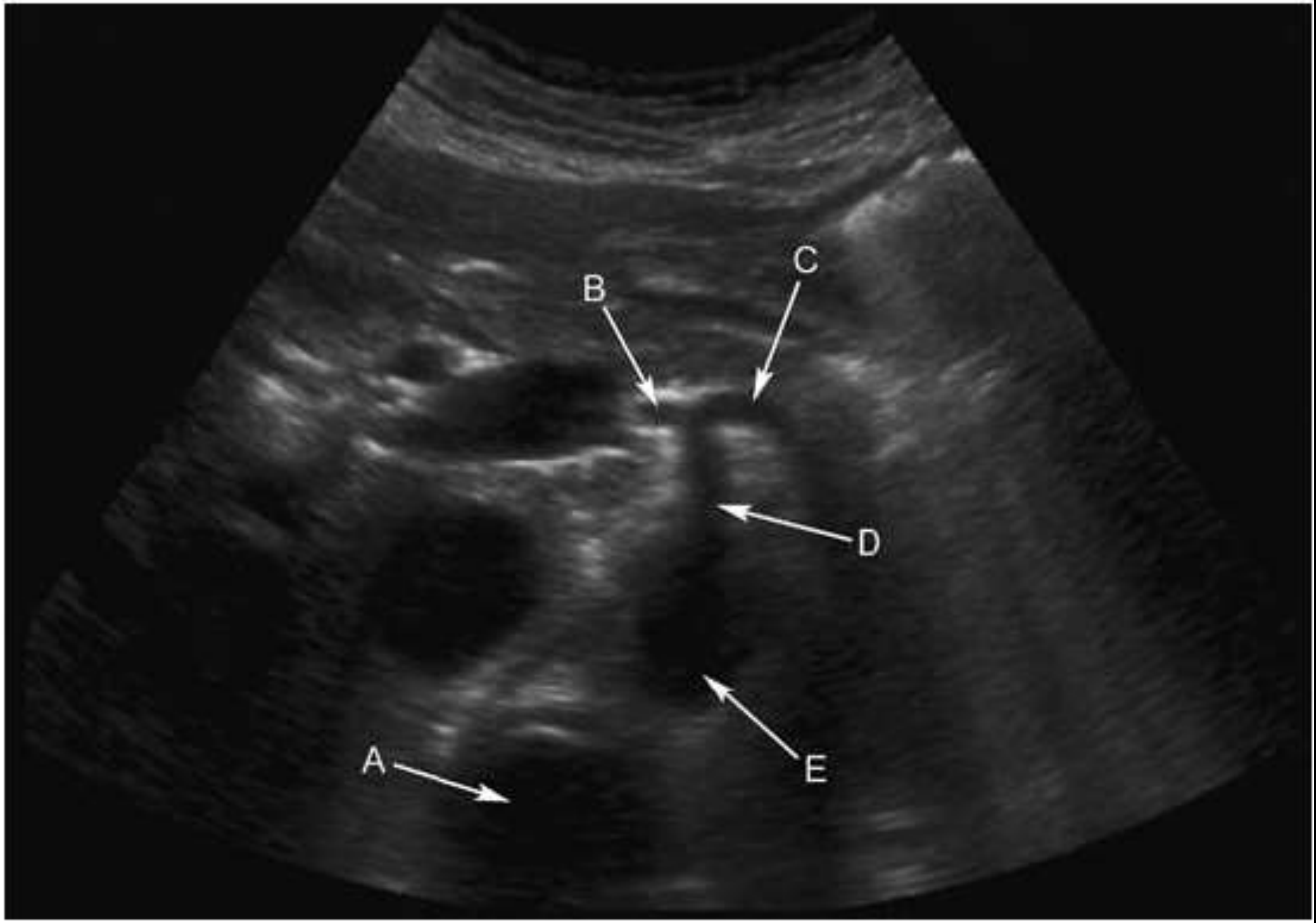
6.14 Transverse ultrasound of the liver

A Liver capsule.
B Middle hepatic vein.
C Right hepatic vein.
D Inferior vena cava.
E Left hepatic vein.

The venous drainage of the liver is principally via the three hepatic veins – right, middle and left. These follow an intrahepatic course and typically join at the inferior vena cava. They are used as some of the landmarks for dividing the liver into segments.

It is important to assess the hepatic veins during routine liver ultrasound as their appearance and flow characteristics can be indicative of many disease processes. Engorgement of the hepatic veins and inferior vena cava can be a sign of right heart failure. Normal hepatic venous flow is pulsatile and triphasic like the jugular venous pulsation – alteration to this pattern can indicate hepatic venous thrombosis, which is suggestive of Budd–Chiari syndrome.

Question 4.12



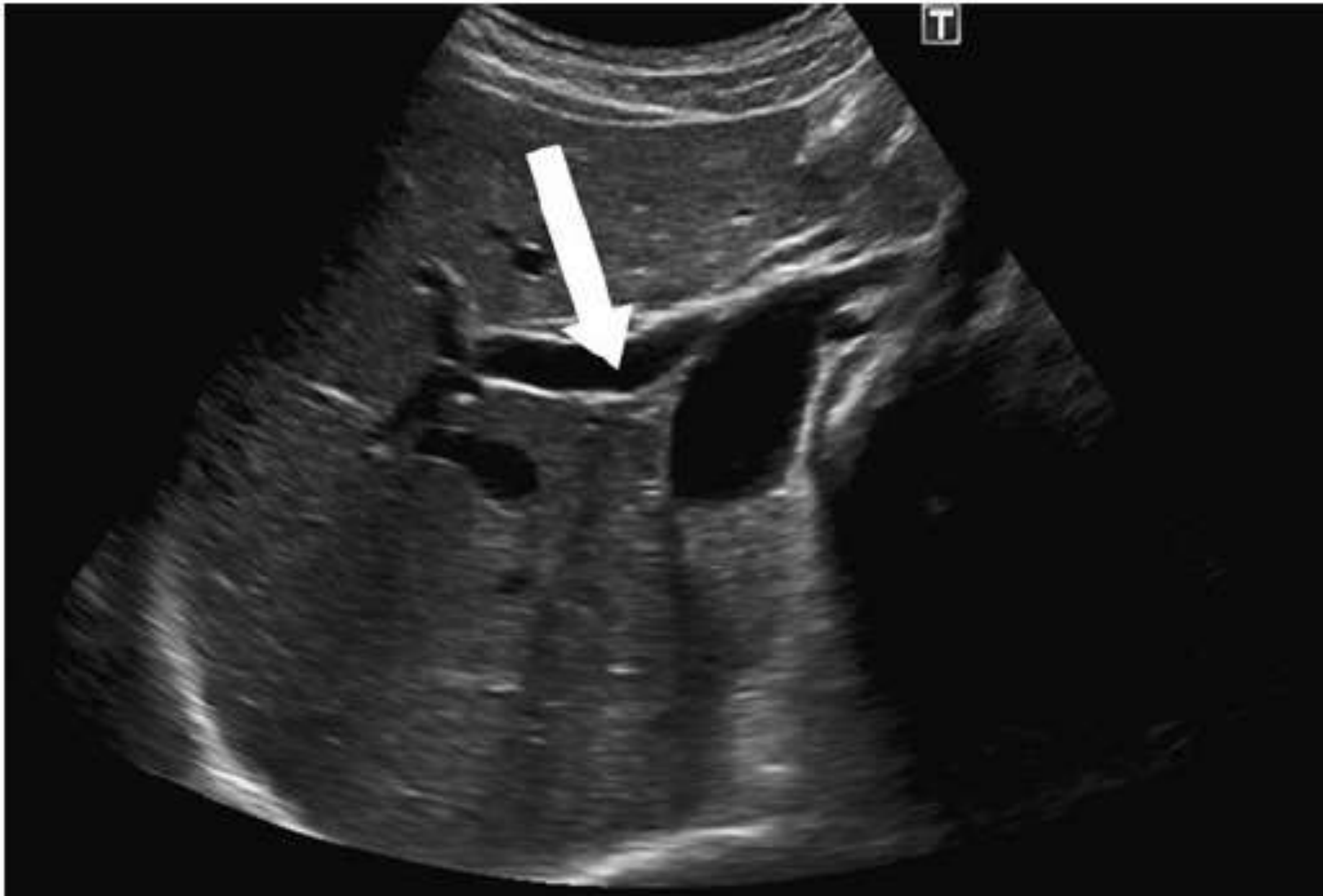
A What vertebral level is this?
Name the structures labelled **B** to **E**.

4.12 Transverse ultrasound of the abdomen

A T12.
B Common hepatic artery.
C Splenic artery.
D Coeliac trunk or axis.
E Aorta.

Radiologists should be comfortable assessing the aorta with ultrasound as it is part of a routine abdominal ultrasound. The aorta and the inferior vena cava can be identified as the two vessels running down the midline anterior to the vertebrae, with the aorta on the patient's left. The coeliac trunk is the first major branch of the abdominal aorta and arises off the aorta at the vertebral level of T12. It can be seen in the transverse plane as a short trunk anteriorly in the midline before dividing into a 'Y'. The fork on the patient's left is the splenic artery and the fork on the right is the common hepatic artery. This classic ultrasound view is called the 'seagull' sign.

Question 38:

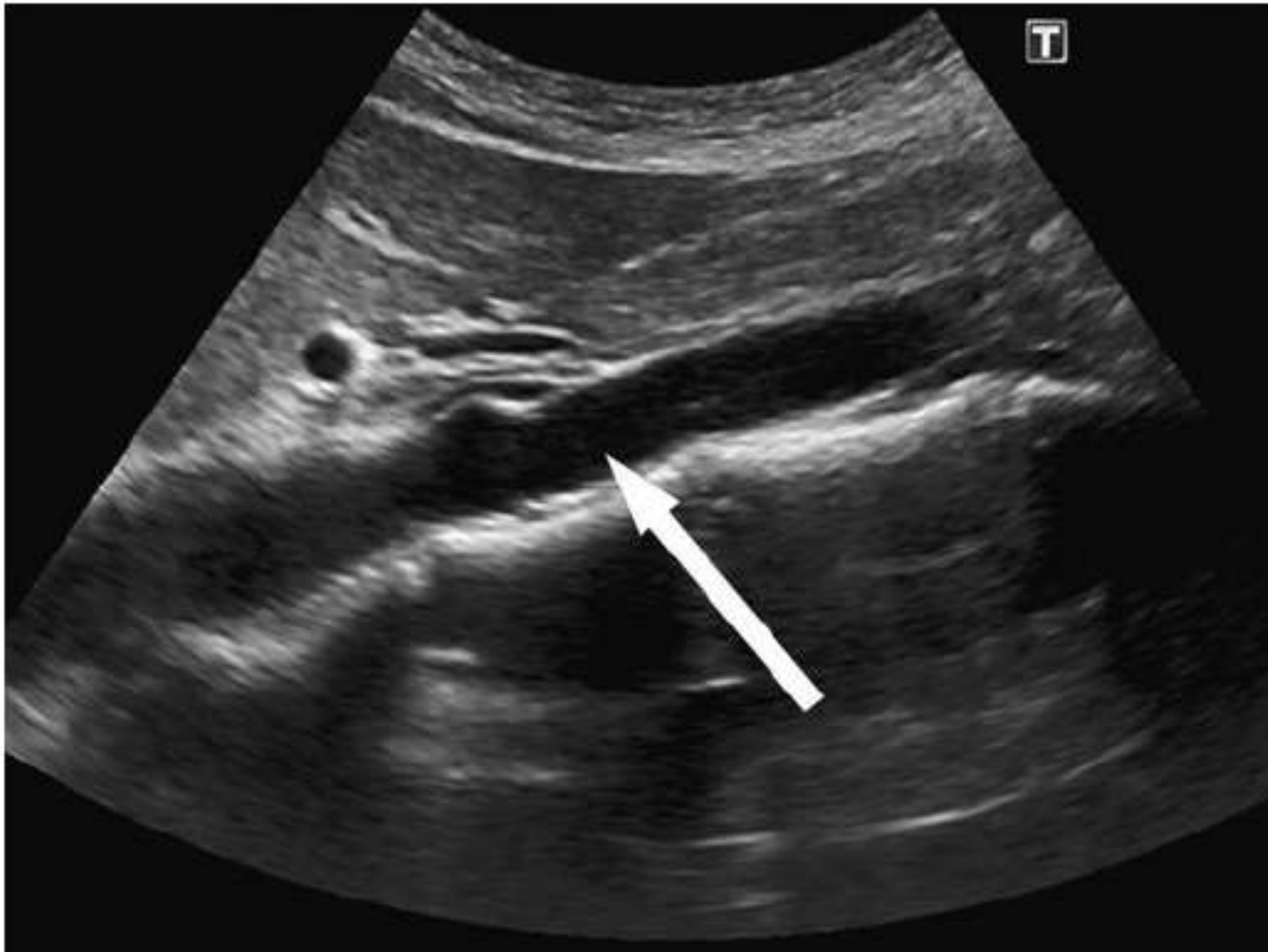


Question 38: Longitudinal US of the liver

Answer: Portal vein

- The portal vein originates at the confluence of the splenic vein and the superior mesenteric vein.
- It provides the liver with the majority of its blood supply, entering the liver at the porta hepatis together with the hepatic artery and the common bile duct. The portal vein bifurcates and supplies the left and right lobes of the liver.
- The flow in the splenic vein is hepatopetal—toward the liver.
- The portal vein and its branches typically have 'bright' (reflective) walls, which distinguishes them from the hepatic veins, which do not have reflective walls.

Question 41:

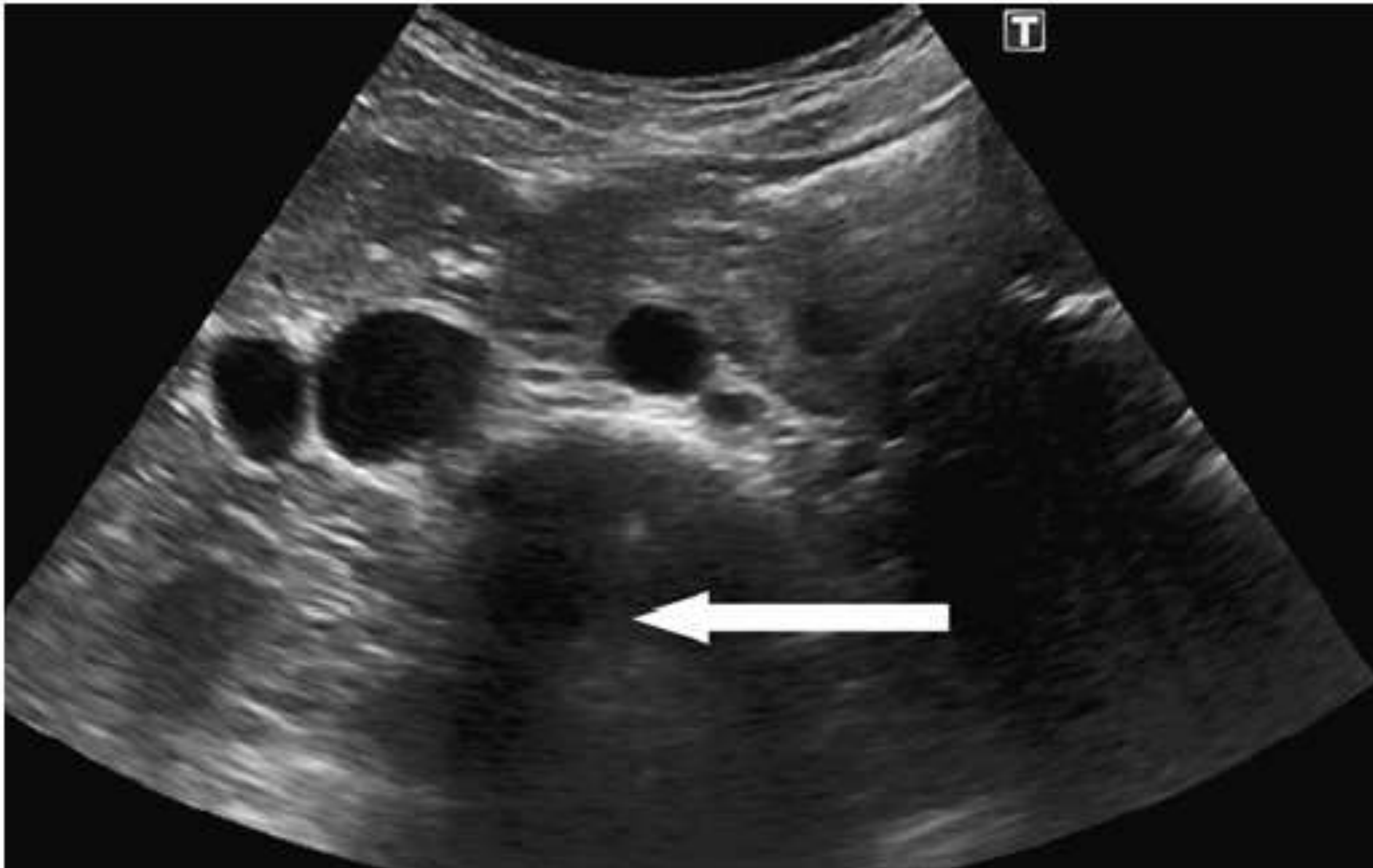


Question 41: US of the abdomen

Answer: Abdominal aorta

- The abdominal aorta can easily be assessed with ultrasound. It may be confused with the inferior vena cava, but only the aorta has anterior branches and lies to the left of the midline.
- The anteroposterior diameter of the normal aorta is < 3 cm.
- Colour Doppler can be used to assess the pulsatile arterial blood flow.

- **Question 42:**

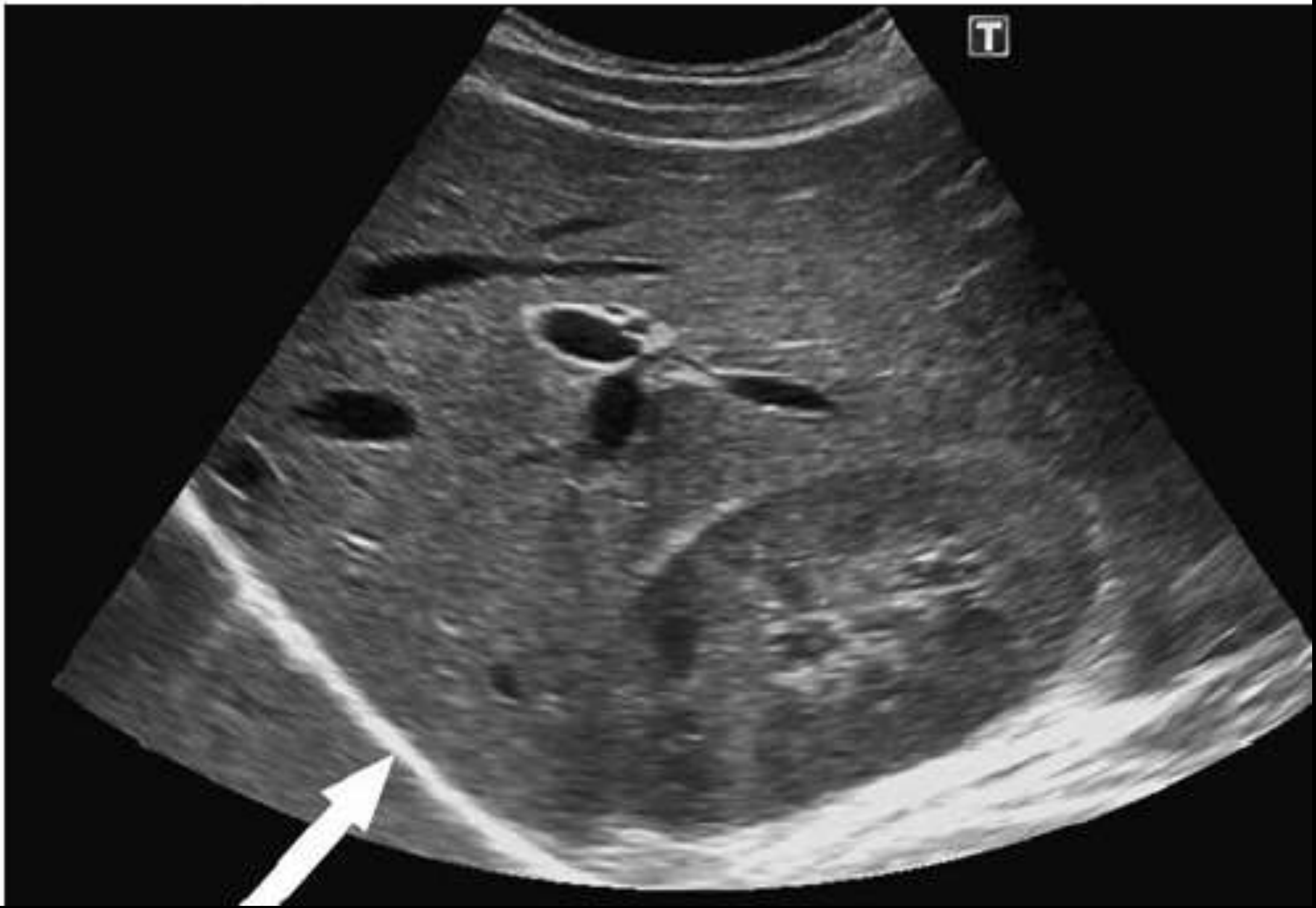


Question 42: Transverse US of the abdomen

Answer: Vertebral body

- The vertebral body may be seen on US as a low reflectivity shadow.
- It lies posterior to the aorta and inferior vena cava.
- The spinal cord and theca can be seen as poorly reflective internal structures.
- Although not usually examined with US, the vertebral body is a common examination question because it is readily visible with US.

Question 46:

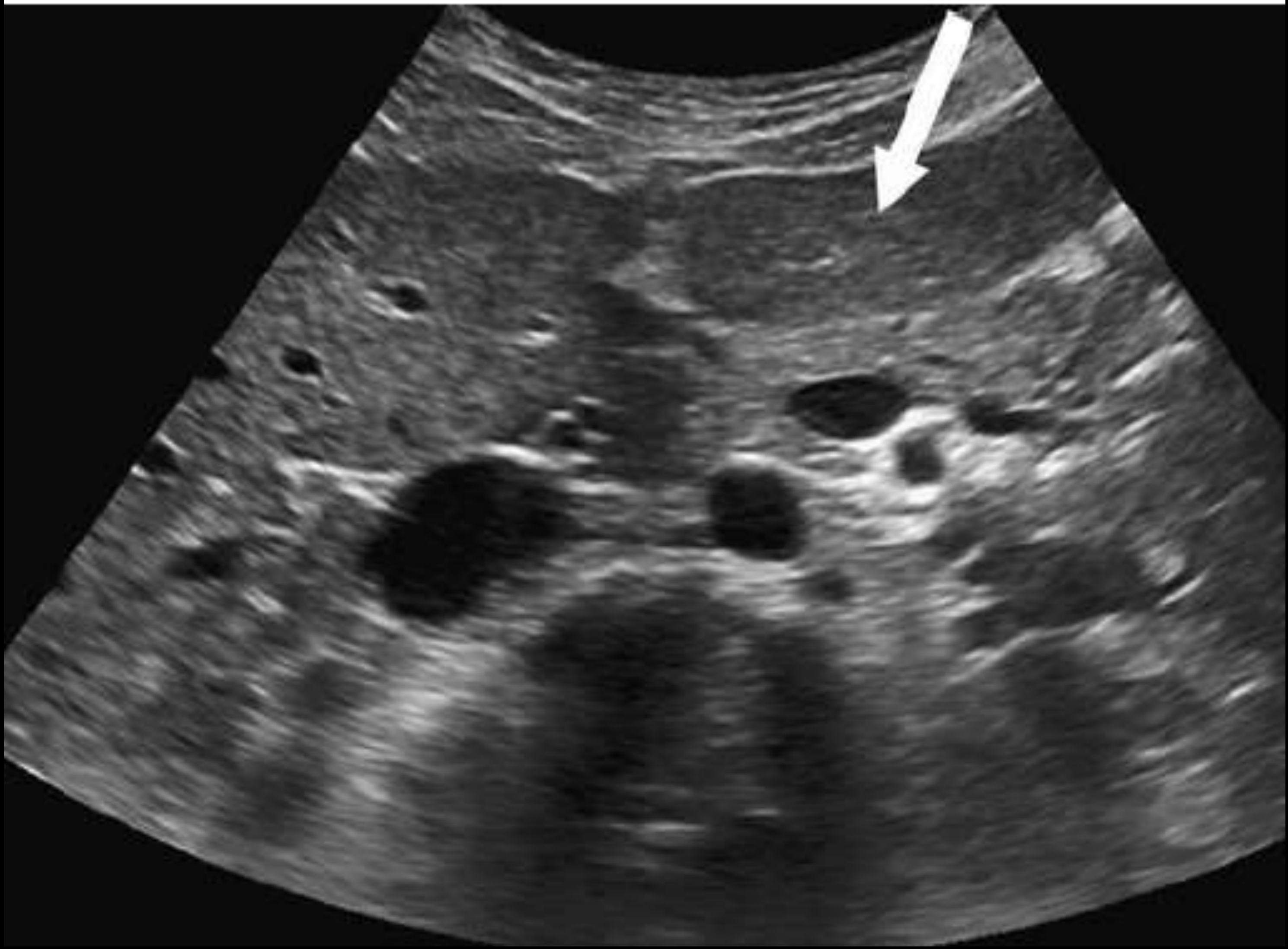


Question 46: US of the liver

Answer: Right hemidiaphragm

- The diaphragm is a reflective, linear structure on US. It may be the source of reverberation artefacts on US.
- It is a dome-shaped sheet of muscle with a central membranous part.
- It is innervated by the C3-5 nerves. It separates the thorax from the abdomen and is pierced by the inferior vena cava (level T8), oesophagus (T10), and aorta (T12).
- Centrally, the crura of the diaphragm extend inferiorly along the lumbar spine.

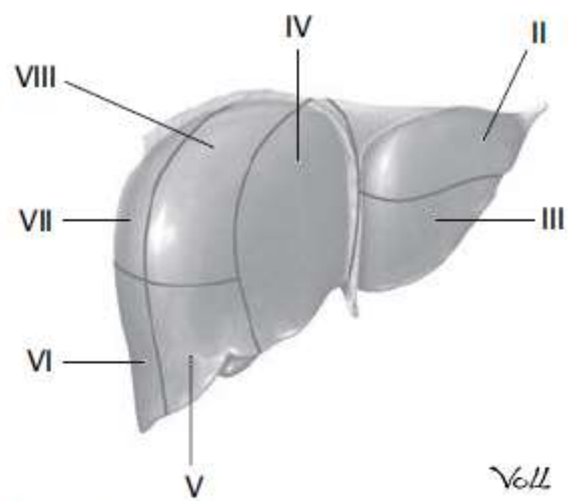
- **Question 16:**



Question 16: Transverse US of the upper abdomen

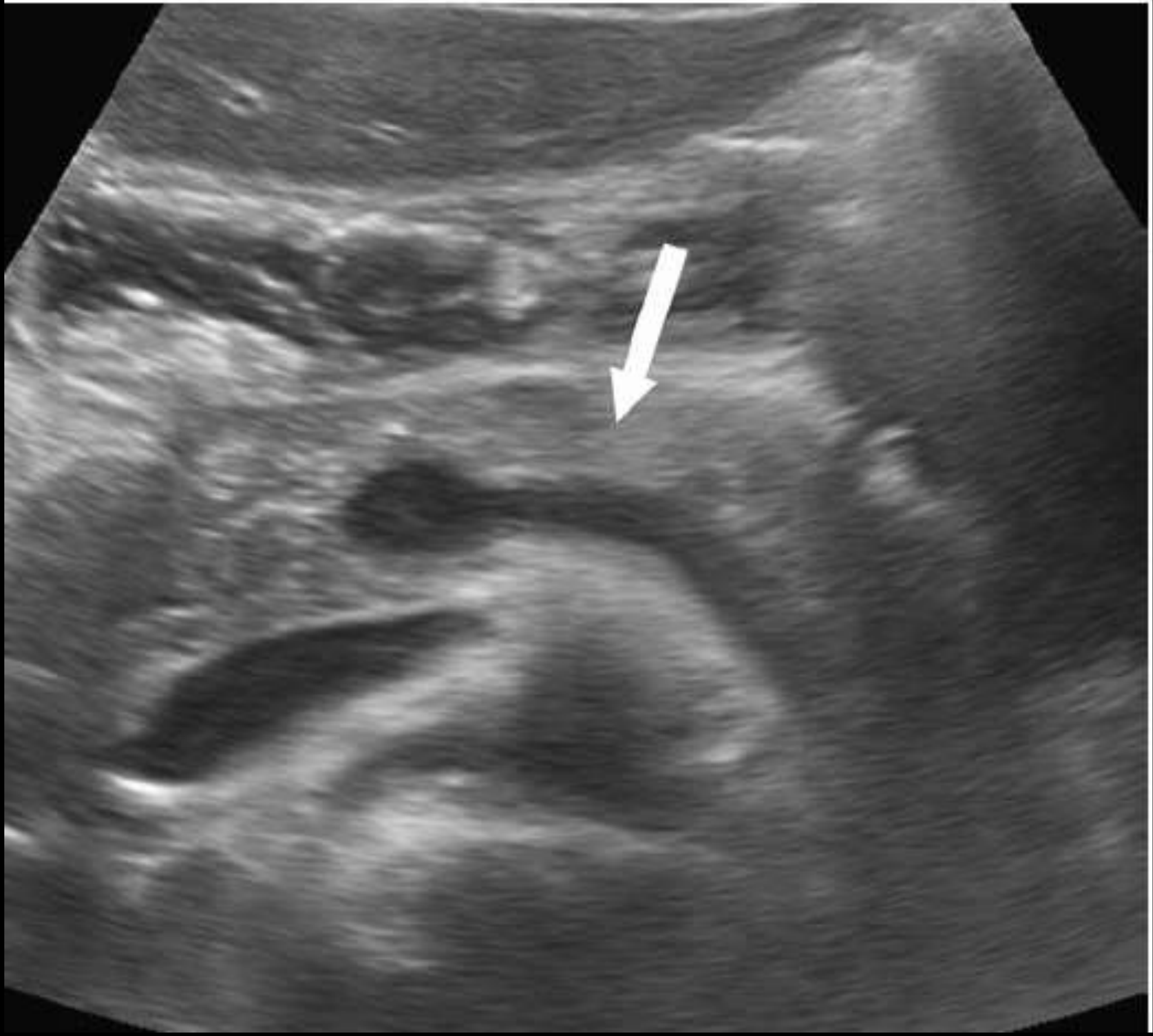
Answer: Lateral segment of the left lobe of liver

- The functional left lobe of the liver lies to the left of the Cantlie line. This is the plane between the inferior vena cava (IVC) and the gallbladder fossa. The left lobe consists of segments I to IV—named by Couinaud.
- It crosses the midline and lies under the diaphragm with the heart superiorly, the stomach and duodenum inferiorly, and aorta and IVC posteriorly.
- The left lobe is supplied by the left portal vein and left hepatic artery. Venous drainage is by the left hepatic vein, and biliary drainage is via the left hepatic duct.
- At first glance, the image is disorientating because only a part of the left and right lobes of the liver can be seen. However, if you look at the rest of the image, you will notice the IVC and aorta are sitting anterior to the vertebral body in the bottom central part of the image. You will also notice the fissure for the falciform ligament, which divides the left lobe into medial and lateral segments. More deeply is the pancreas, which is more reflective than the liver, and the splenic vein posteriorly.
- The figure below shows the segments of the liver as described by Couinaud.



From Atlas of Anatomy, © Thieme 2008, illustration by Markus Voll.

- Question 3:

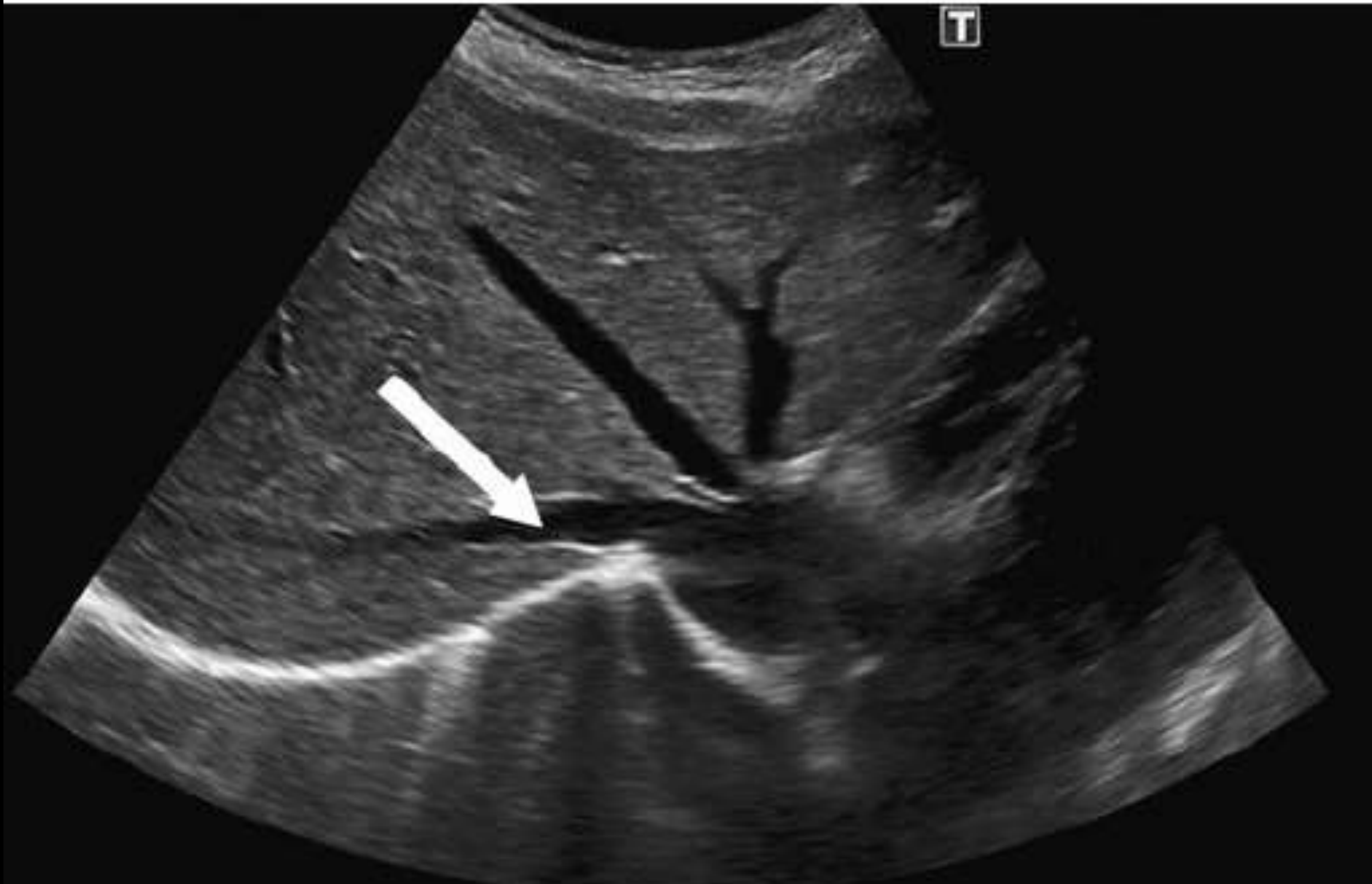


Question 3: US of the abdomen

Answer: Body of the pancreas

- The pancreas is divided into an uncinate process, head, neck, body, and tail.
- Only the neck has an anatomical definition; it is located anterior to the confluence of the superior mesenteric vein and splenic vein.

- **Question 6:**

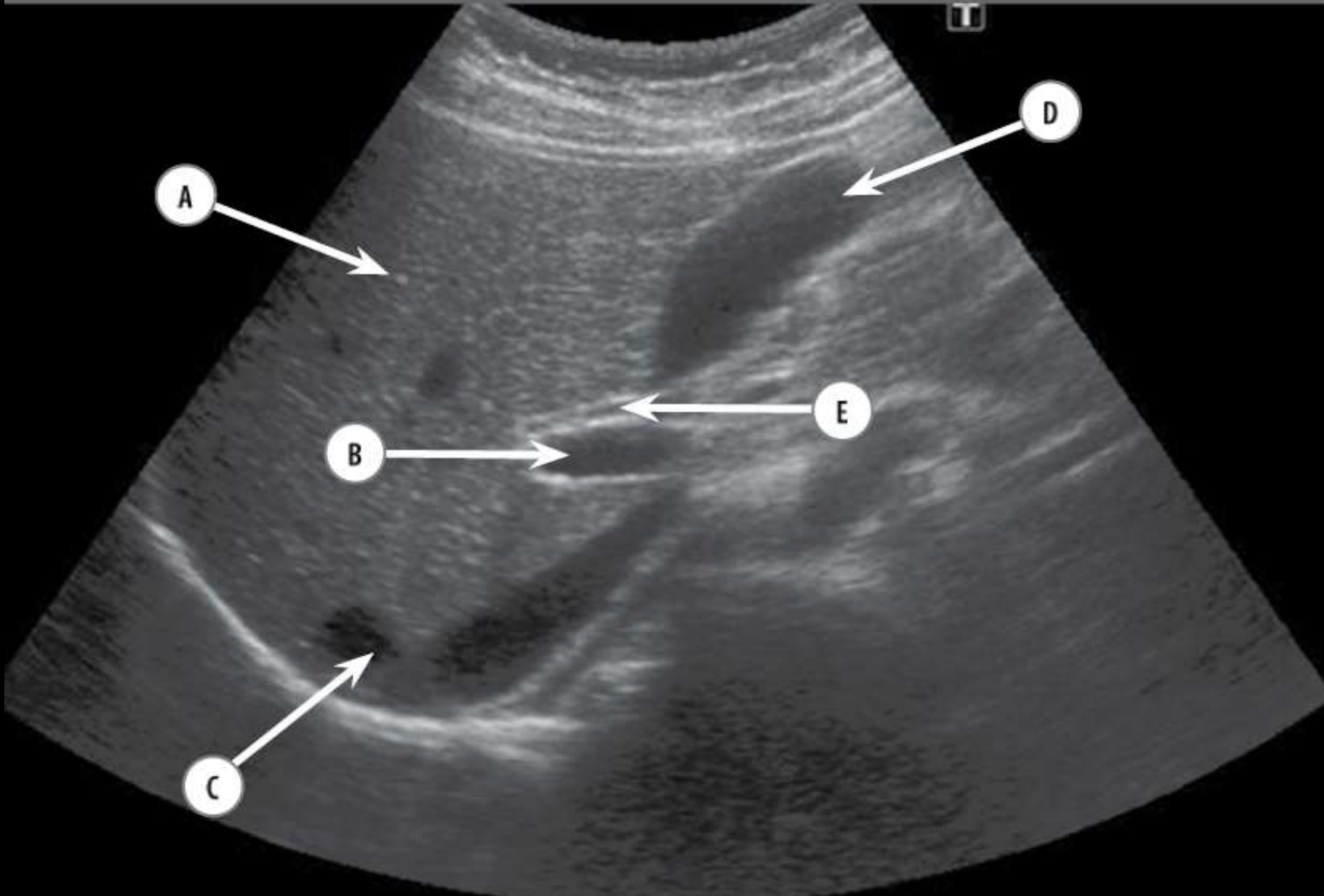


Question 6: Transverse US of the abdomen

Answer: Right hepatic vein

- The venous drainage of the liver is variable, but typically the majority of the liver is drained by three hepatic veins draining into the intrahepatic portion of the inferior vena cava (IVC).
- The caudate lobe drains directly into the IVC, which explains why this part of the liver is often not affected by disease processes in the same way as the remainder of the liver.
- The right hepatic vein is one of the landmarks used to separate segments V and VI as well as VII and VIII of the right lobe of the liver.

Case 3.17



Case 3.17

A Right lobe of liver

B Portal vein

C Intrahepatic IVC

D Gallbladder fundus

E Common bile duct

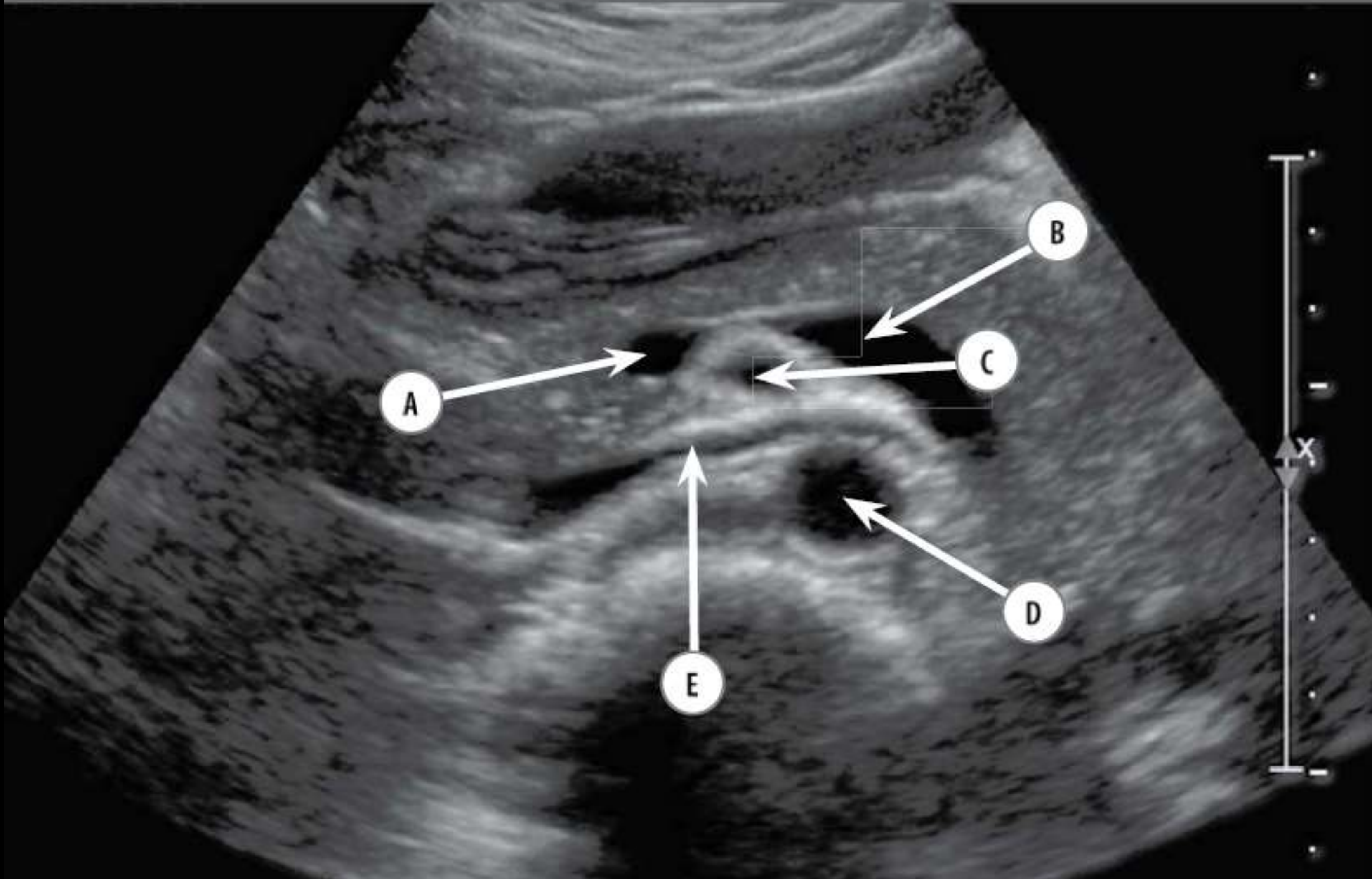
Longitudinal abdominal ultrasound at the porta hepatis.

The common bile duct (CBD), hepatic artery and portal vein are all very closely related to each other at the porta hepatis. Here the CBD is demonstrated running anterior and parallel to the portal vein.

The liver is drained via three main hepatic veins; right, middle and left. These converge superiorly, at the level of T9 to join the inferior vena cava (IVC), near the diaphragmatic hiatus. The caudate lobe drains directly into the IVC via a few smaller veins. It takes its blood supply from both the right and left hepatic arteries, and the right and left portal veins. This vascular arrangement can be of clinical significance in certain clinical states which lead to caudate hypertrophy (such as Budd–Chiari syndrome).

Ryan S, McNicholas M, Eustace SJ. Anatomy for Diagnostic Imaging, 3rd edn. Edinburgh: Saunders, 2011: 175–186.

Case 3.18



Case 3.18

A Portal venous confluence (confluence of superior mesenteric and splenic veins)

B Splenic vein

C Superior mesenteric artery

D Aorta

E Left renal vein

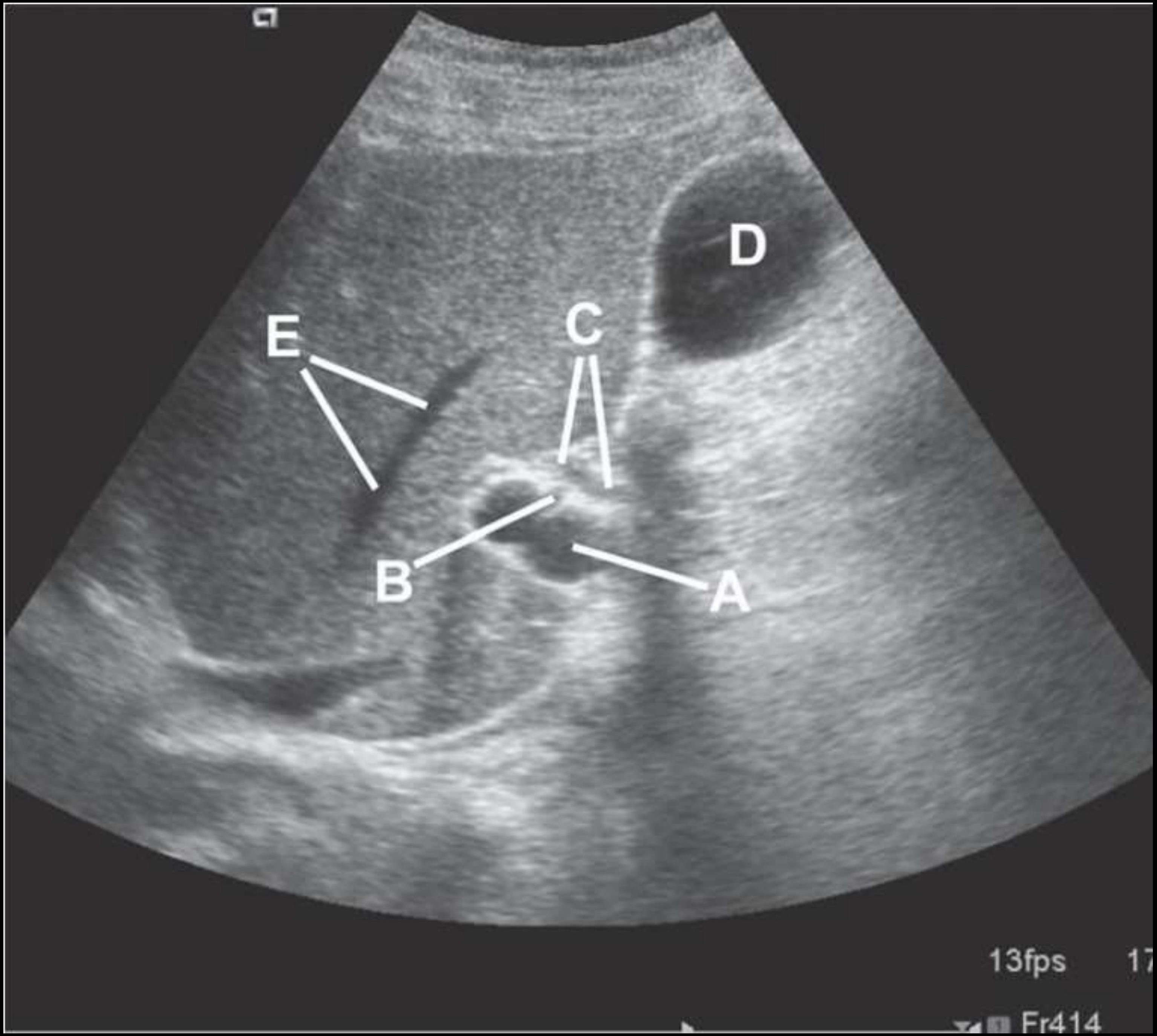
Transverse abdominal ultrasound demonstrating the pancreas and associated major vessels.

The pancreas is a retroperitoneal structure, and has four parts. The head lies to the right of the midline, within the curve of the duodenum. The uncinate process is a hook shaped posterior projection from the head of the pancreas, which lies between the superior mesenteric artery (SMA) and superior mesenteric vein (SMV) anteriorly, and the left renal vein posteriorly. The pancreatic neck lies in the midline, anterior to the portal venous confluence. The body and tail lie to the left of the midline, anterior to the splenic vein.

The SMA is found to the left of the SMV, and can be easily identified on ultrasound as it has a bright fatty halo around it. Between the aorta and SMA lie three structures:

- left renal vein
- third part of duodenum
- uncinate process of the pancreas.

Butler P, Mitchell AM, Ellis H. Applied Radiological Anatomy. Cambridge: Cambridge University Press, 1999: 254.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Q17 Answers

a Portal vein
b Hepatic artery
c Common bile duct
d Gallbladder
e Hepatic vein

Ultrasound of the liver at the porta-hepatis, transverse section

The common bile duct lies anterior to the portal vein at the porta-hepatis. To the left of the common bile duct and running in an oblique course, is the hepatic artery. The diameter of the common bile duct is measured at the level of the hepatic artery and should not exceed 4mm in young adults. The calibre of the common bile duct usually increases with age.

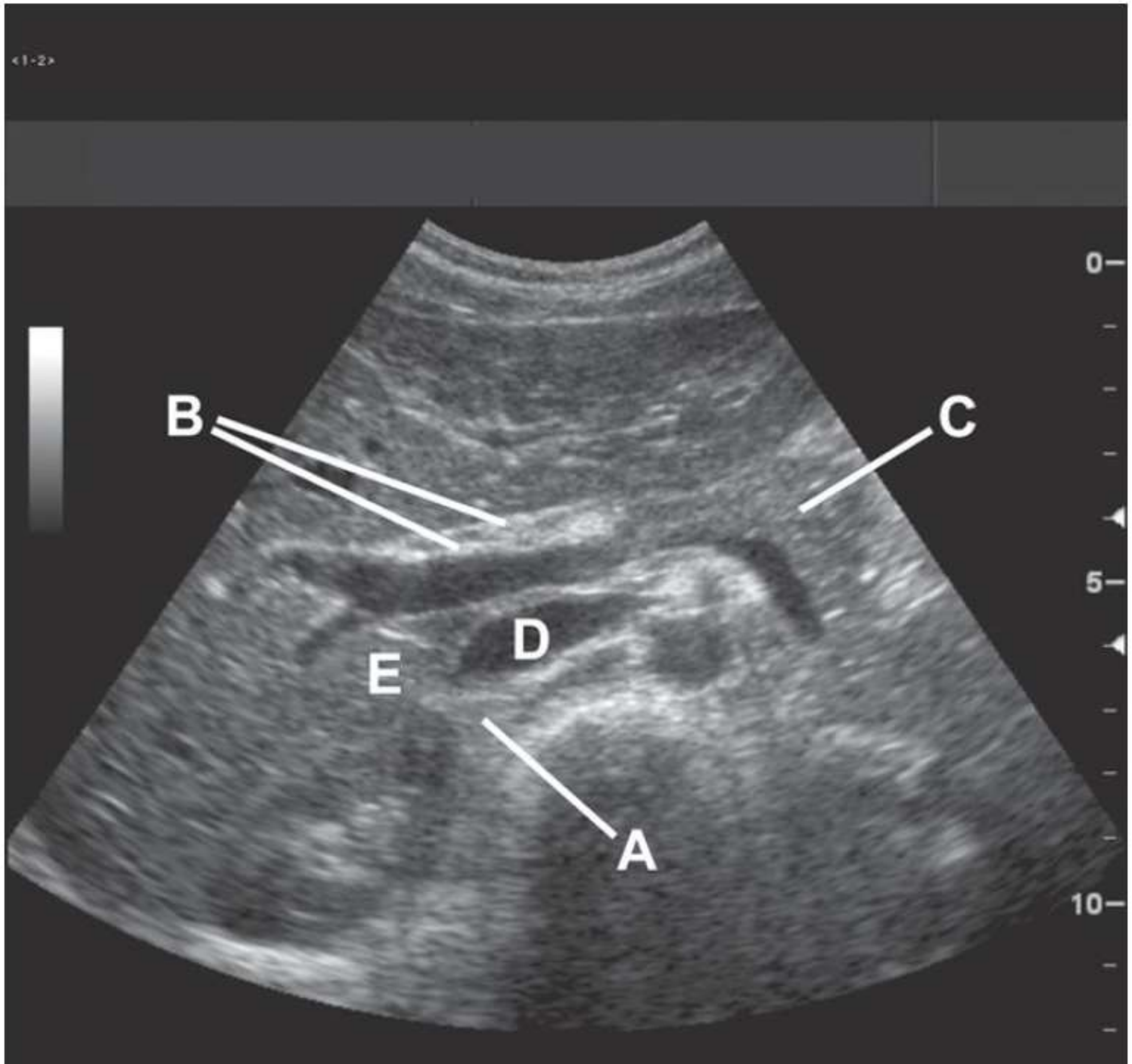
The portal veins characteristically have hyperechoic walls which can enable differentiation on ultrasound from dilated biliary ducts or hepatic veins, which typically do not. The venous drainage of the liver occurs directly into the IVC through the middle, left and right hepatic veins. They form a confluence with the intra-hepatic IVC at the level of T9, just below the caval diaphragmatic hiatus.

Wu CC, Ho YH, Chen CY. Effect of aging on common bile duct diameter: a real time ultrasonographic study. *J Clin Ultrasound* 1984; 12:473–478.

Laing FC. The gallbladder and bile ducts. In *Diagnostic ultrasound* (eds Rumack C, Wilson S, Carboneau JW), Mosby, St Louis, MO, 1998, p. 207.

Q18

a Name the structure labelled A
b Name the structure labelled B
c Name the part of the structure labelled C
d Name the structure labelled D
e Name the part of the structure labelled E



Q18 Answers

a Right adrenal/supra-renal gland
b Common bile duct
c Body of the pancreas
d Inferior vena cava
e Caudate lobe (segment I) of the liver

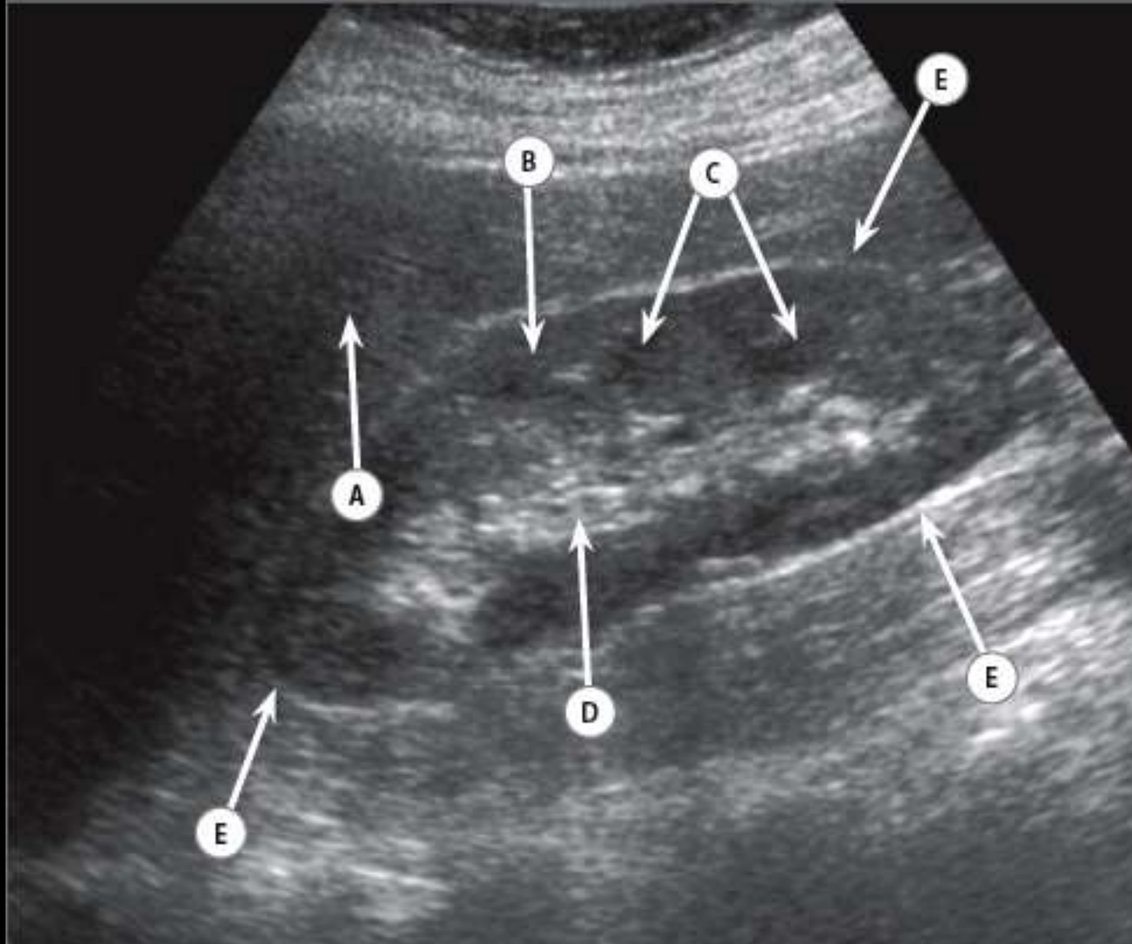
Ultrasound of upper abdomen, transverse section

The right adrenal (supra-renal) gland lies antero-medial to the right upper pole of the kidney and it is adherent to the posterior wall of the inferior cava. The blood supply is principally provided by the suprarenal artery, however collateral supply comes from the renal and inferior phrenic arteries. Venous drainage is through the suprarenal vein, which drains into the IVC on the right and the left renal vein on the left. The adrenals are a similar size on both sides, with the average widths of the anterior, posteromedial and posterolateral limbs being 6.5mm, 3mm and 3mm respectively. The anterior limb of the right adrenal is usually less prominent than the left because of its proximity to the IVC.

The pancreas is divided into four parts – head, neck, body and tail. The head lies to the right of the midline and within the concavity of the duodenal curve and extends inferiorly as the hook-shaped uncinate process. The neck is the part of the pancreas which is immediately anterior to the proximal portal vein. The body begins in line with the left border of the vertebral column and the distal pancreatic tail is the part contained within the lienorenal ligament alongside the splenic vessels.

The caudate lobe (segment I) of the liver is situated posterior and to the right of the hepatic IVC. It is unusual in that it receives a blood supply from both right and left hepatic arteries and portal veins and drains directly into the IVC through small perforating veins.

Case 11.6



C	Name the hypoechoic structures labelled C.
D	Name the echogenic central part of the kidney shown by the letter D?
E	What is the outer covering of the kidney shown by the letter E?

Case 11.6

A Right lobe of liver

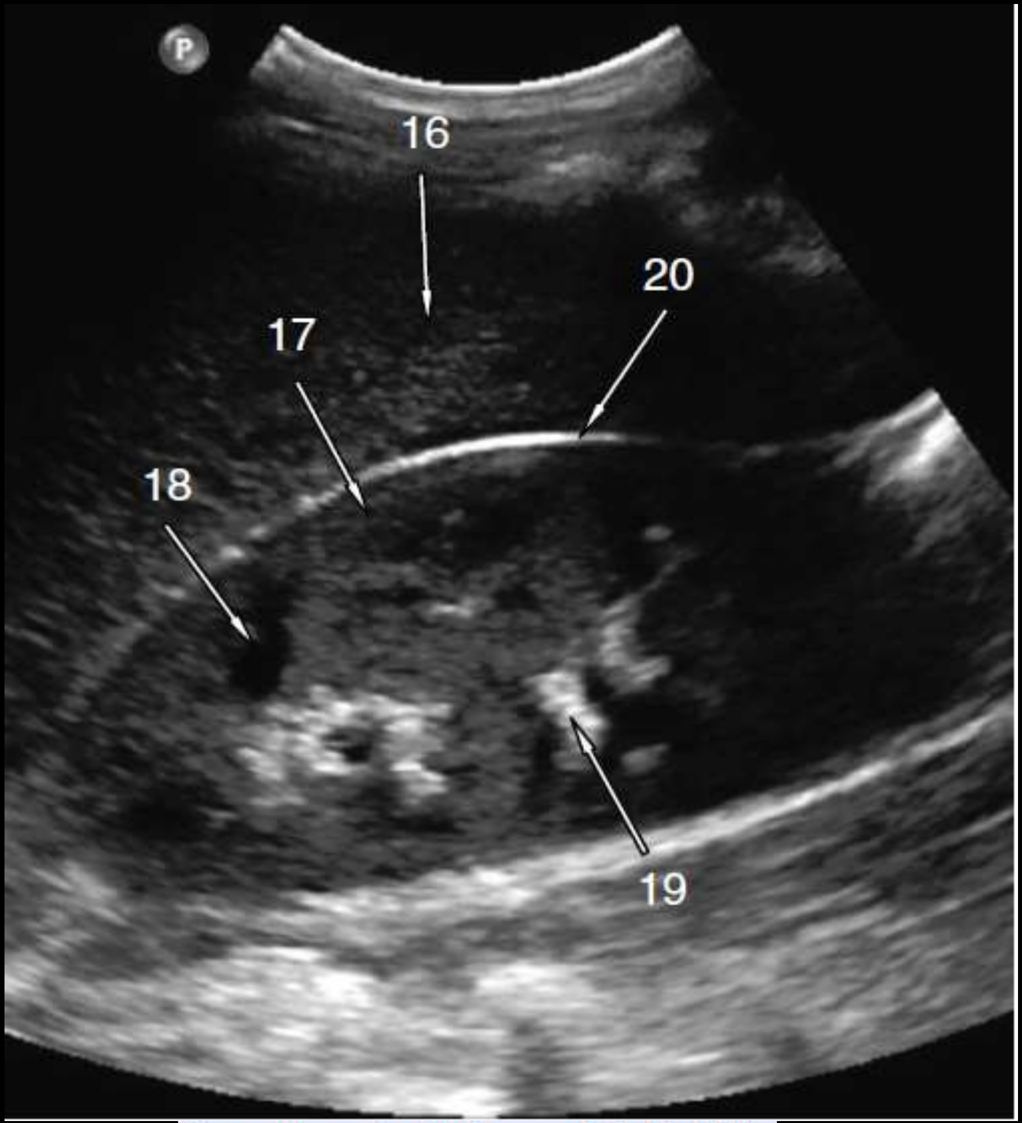
B Renal cortex

C Renal pyramids

D Renal sinus

E Renal capsule

The right kidney is optimally visualised on ultrasound imaging by using the liver as an acoustic window. The contrasting echogenicity at the interface between the renal capsule and the perirenal fat enables the outline of the kidney to be clearly demonstrated. The renal pyramids are so called because of their shape, with bases lying parallel to the renal capsule and apices pointing towards the renal pelvis. Columns of renal cortex known as the columns of Bertin pass between each renal pyramid. A high fatty content renders the renal sinus very echogenic.



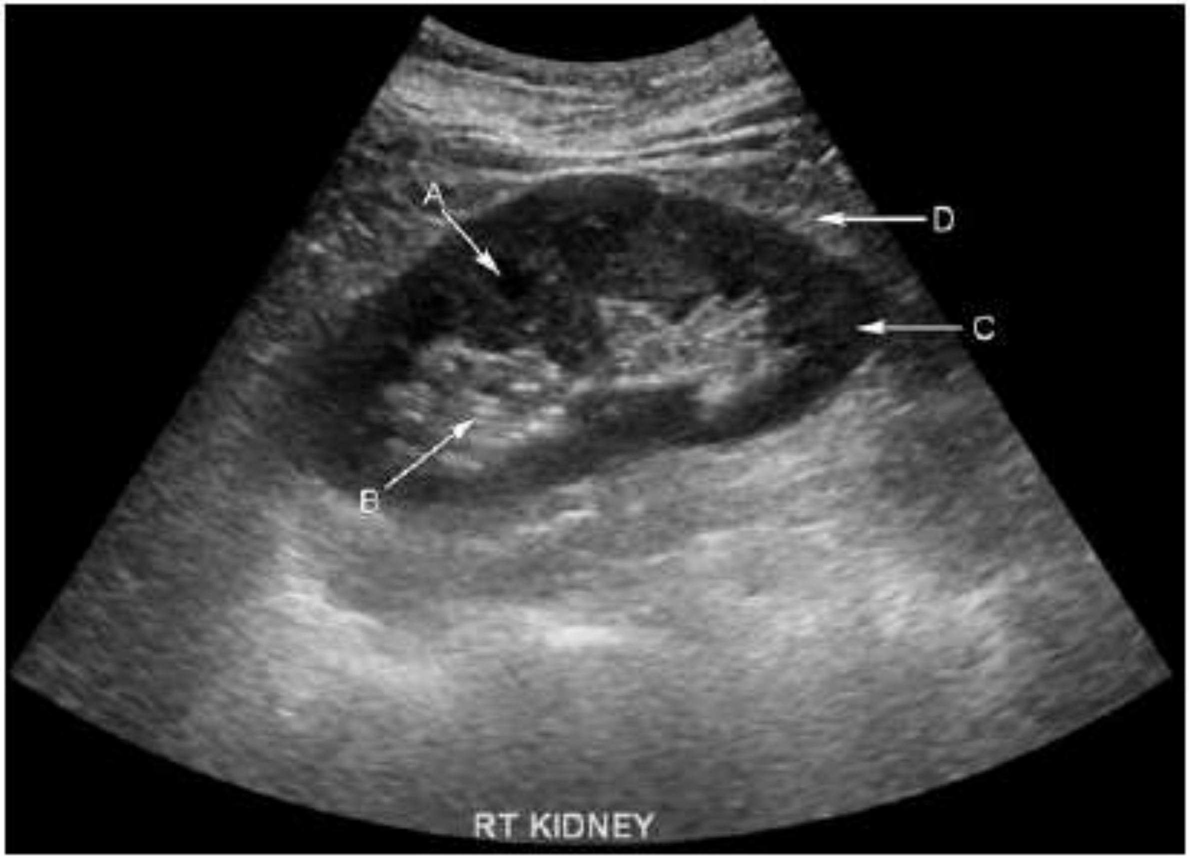
Name the potential space labelled 20.

Ultrasound Abdomen

16. Right lobe of liver
17. Renal cortex of right kidney
18. Medullary pyramid of right kidney
19. Renal sinus fat of right kidney
20. Morrison's pouch

Morrison's pouch lies between the posterior surface of the liver and the right kidney. In the supine position it is the most dependent of the peritoneal spaces, and free fluid will therefore often pool here.

Question 2.12



This is a longitudinal ultrasound of the right kidney.

Name the structures labelled **A** to **D**.

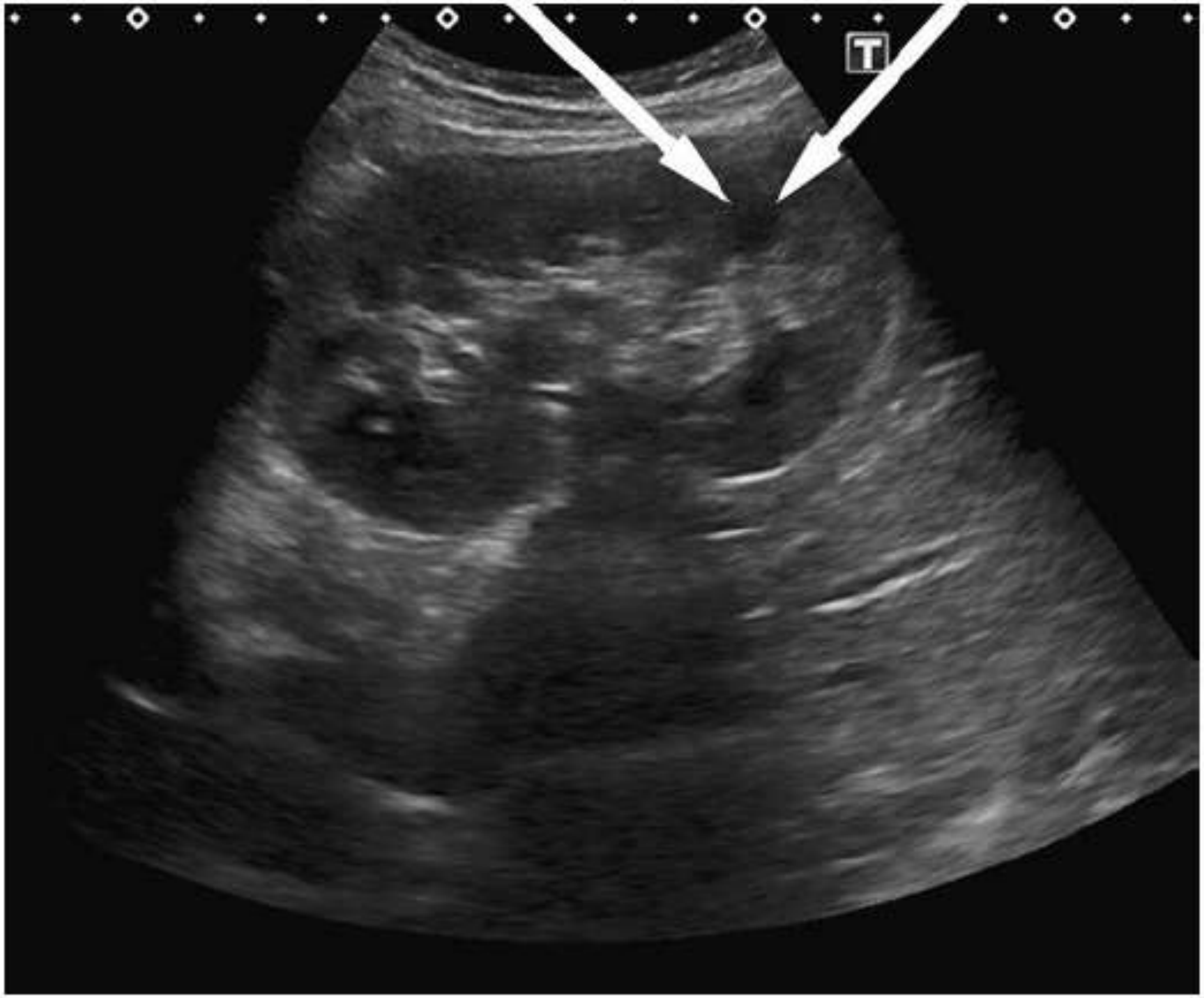
E Name the potential recess that lies between the right lobe of the liver and the kidney.

2.12 Longitudinal ultrasound of the right kidney

A Renal pyramid.
B Renal sinus.
C Renal cortex.
D Perirenal fat.
E Morison's pouch (hepatorenal recess).

The echogenic layer surrounding the kidney is the perirenal fat. The renal capsule is not well visualized on ultrasound. The grey outer layer of the kidney is made up of the renal cortex and the pyramids. Sometimes the pyramids cannot be clearly visualized but they can be identified on this image as hypoechoic spaces within the renal cortex. The renal sinus is located within the centre of the kidney and is echogenic on ultrasound because of its fat content. The renal sinus contains the calyces, renal pelvis and sinus fat. The hepatorenal recess (Morison's pouch) is a potential space that lies between the upper pole of the right kidney and the liver and normally should not contain fluid. In the context of trauma, the recess is readily identified on a FAST (focused assessment with sonography for trauma) scan in the emergency department and if fluid is identified an emergency laparotomy may be indicated. See Question 9.13 for further imaging of Morison's pouch.

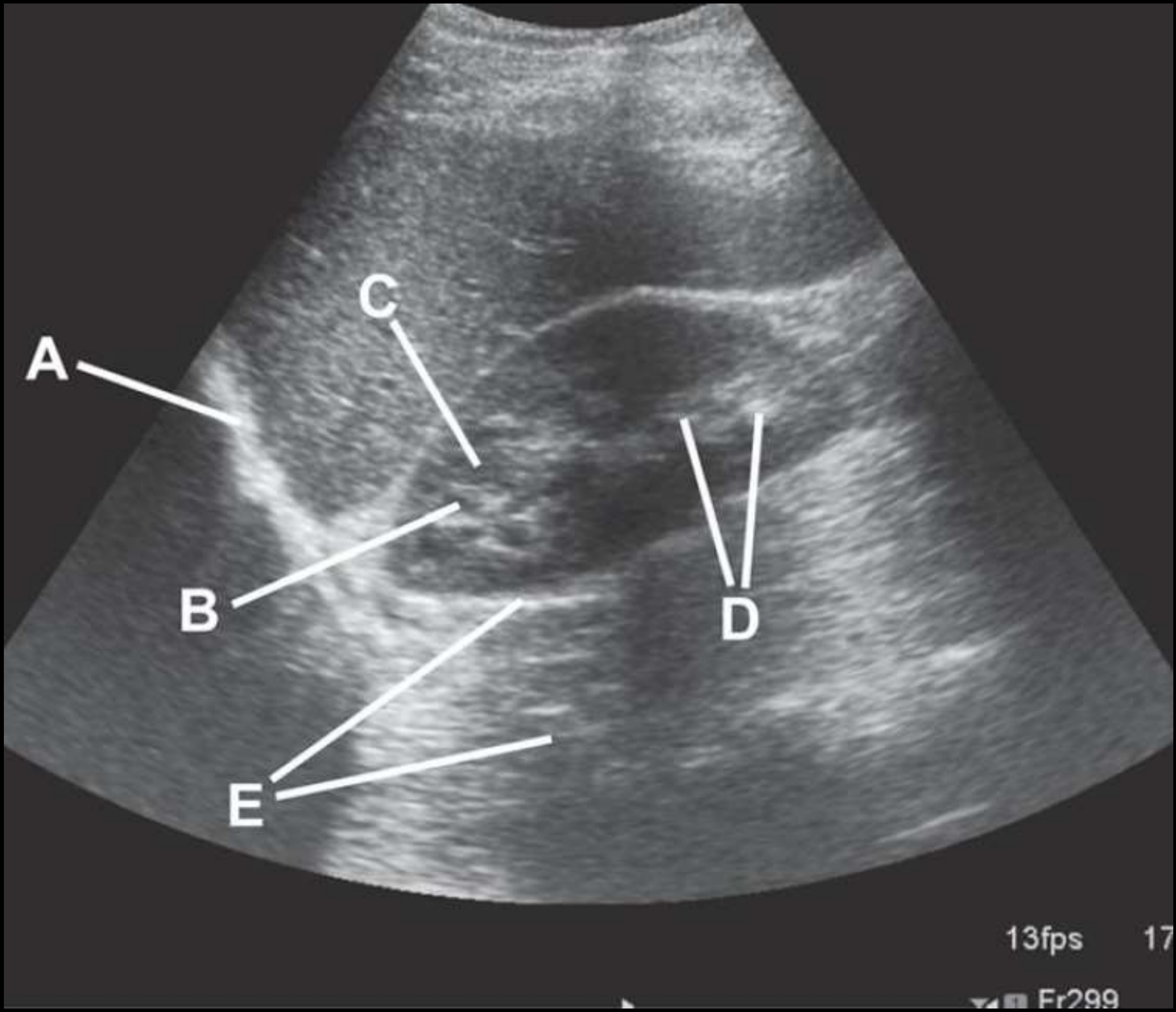
- **Question 39:**



Question 39: Longitudinal US of the kidney

Answer: Renal pyramid

- The kidneys have renal pyramids that are conical structures with renal cortex externally and renal medulla internally.
- The renal papilla is at the apex of the pyramid and is part of the collecting system of the kidney.
- Fetal lobulation may persist in the adult, which makes the pyramidal structure of the kidneys more obvious.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Q19 Answers

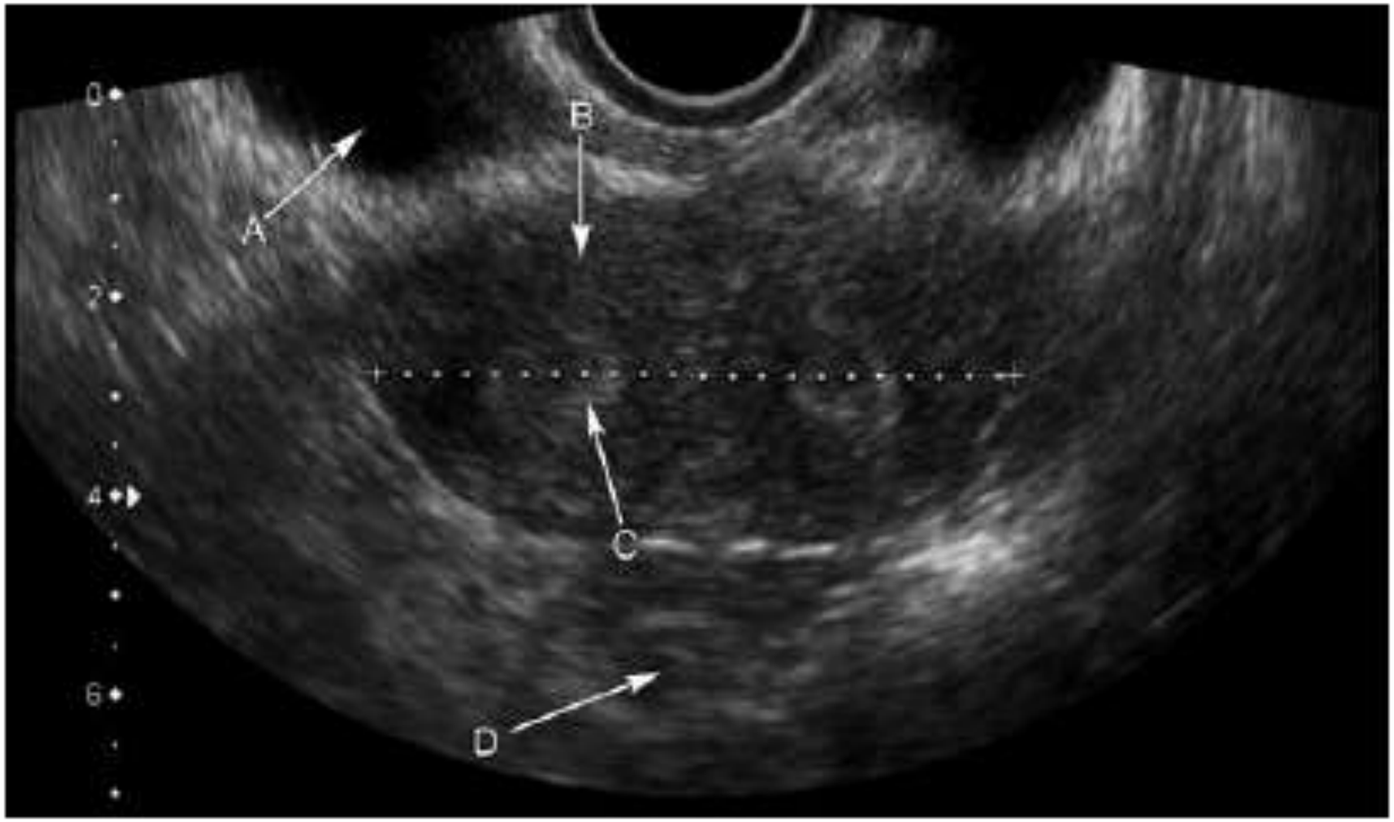
- **a** Right hemi-diaphragm
- **b** Renal pyramid
- **c** Column of Bertin
- **d** Renal sinus fat
- **e** Right psoas major

Ultrasound of right kidney, longitudinal section

The kidney parenchyma comprises of an outer cortex and inner medulla. Columns of Bertin are regions of cortical tissue which pass towards the renal hilum dividing the medulla into several pyramids. At the top of the pyramids, the papillae drain into the calyces which in turn drain into the renal pelvis. The renal sinus partially encloses the renal pelvis and contains fat and lymphatics.

The hemi-diaphragm is located above the kidney and has an echogenic appearance on ultrasound. Psoas major lies postero-medially and can be seen in longitudinal section below the kidney.

Question 1.10 This is a transverse pelvic ultrasound in a 30-year-old woman.



Name the structures labelled **A** to **D**.

E What normal variant is present?

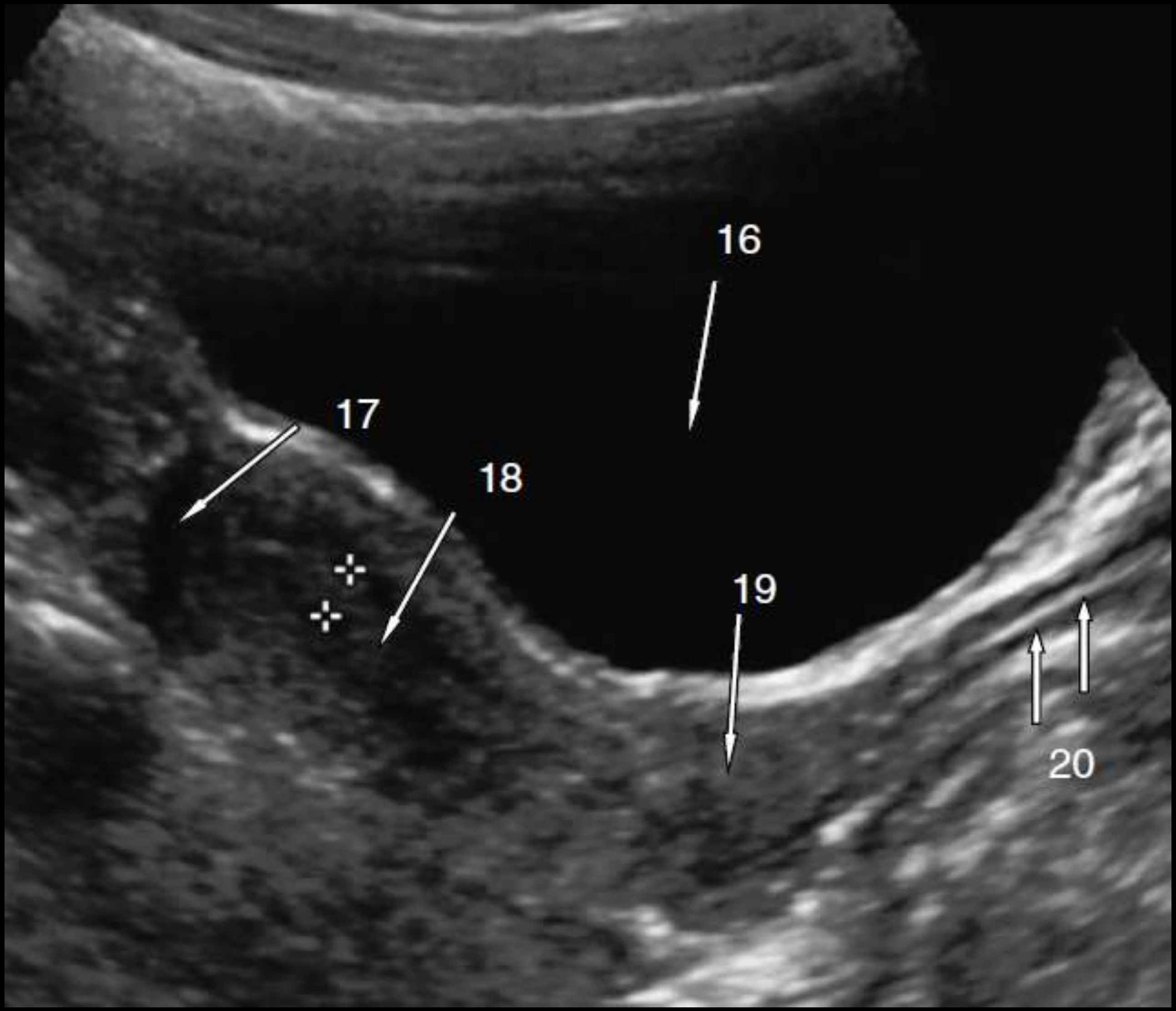
1.10 Transverse transvaginal ultrasound of the female pelvis

A Bladder.
B Myometrium.
C Endometrium.
D Rectum.
E Bicornuate uterus.

The uterus is well demonstrated on transvaginal ultrasound, which is the primary modality for imaging the female reproductive organs. It is located between the bladder and the rectum. The inner thin echogenic layer of the uterus is called the endometrium and the outer less echogenic muscular layer is called the myometrium. This image demonstrates a bicornuate uterus (literally translated as a uterus with two horns) where the inferior aspect of the uterus is normal and the superior aspect is bifurcated giving the uterus a heart shaped appearance.

Other uterine abnormalities include:

Uterine didelphus	The patient has a double uterus
Uterine septum	A septum that splits the uterus into two parts
Unicornuate uterus	Only one side of the uterus forms, giving the uterus a 'penis' shape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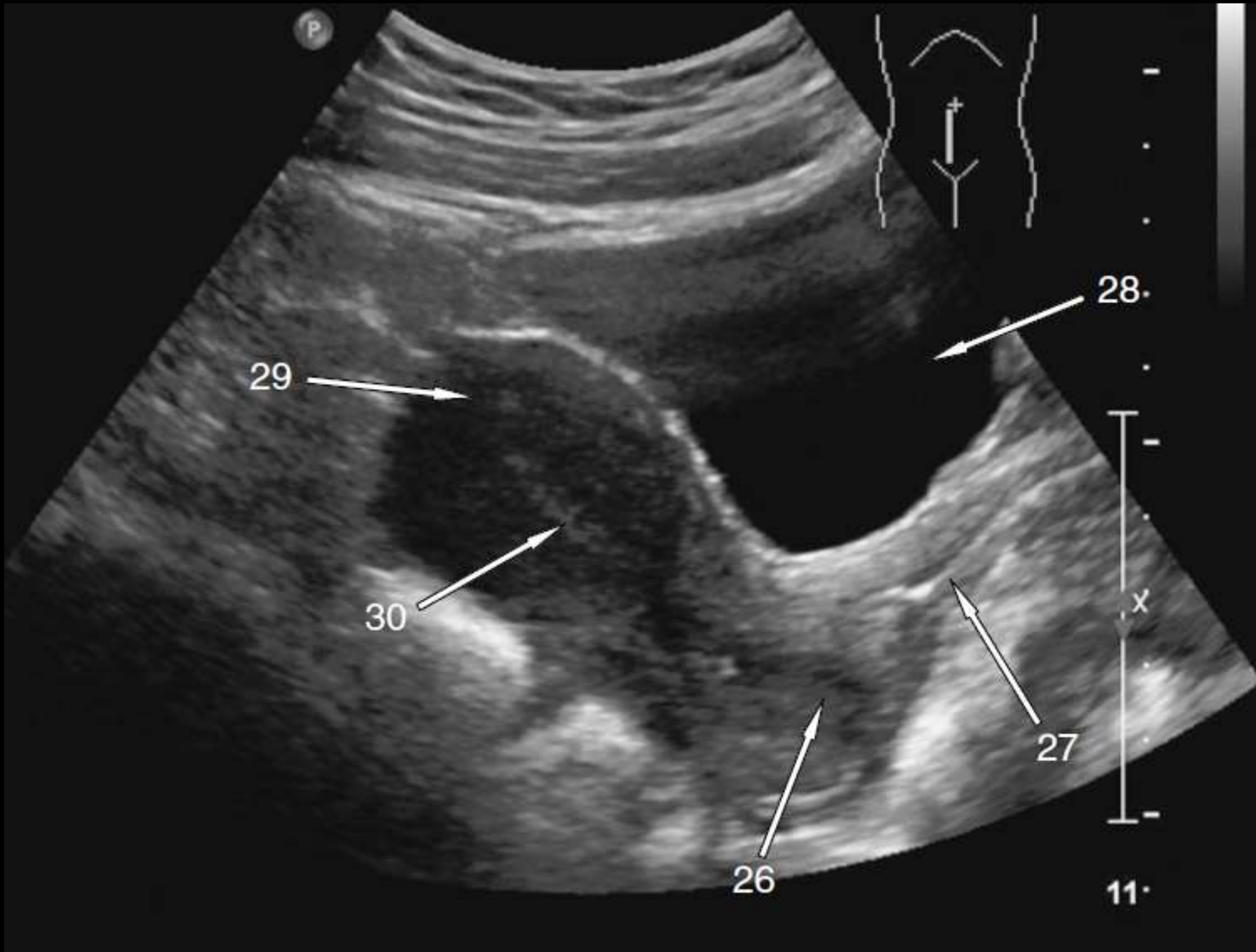
Ultrasound Pelvis

16. Urinary bladder
17. Myometrium
18. Endometrium
19. Cervix
20. Vagina



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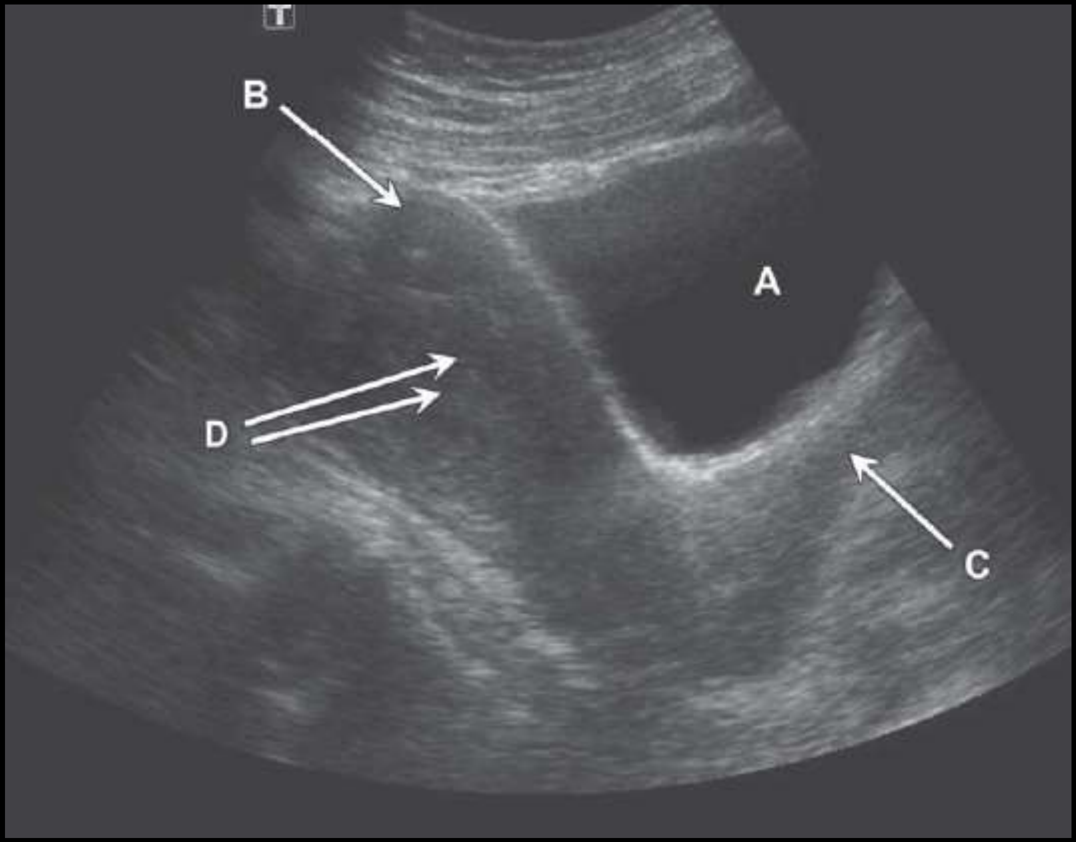
Ultrasound Pelvis

26. Cervix
27. Vagina
28. Bladder
29. Uterine fundus
30. Endometrium

This is a longitudinal scan of the female pelvis. The cervix usually lies in the midline and the uterus may lie obliquely to either side. The endometrium is seen as a thin high-level echo on this image as a long white stripe. The normal endometrial thickness in the postmenopausal woman should be less than 3 mm.



Name the intraperitoneal space between structure C and the rectum.

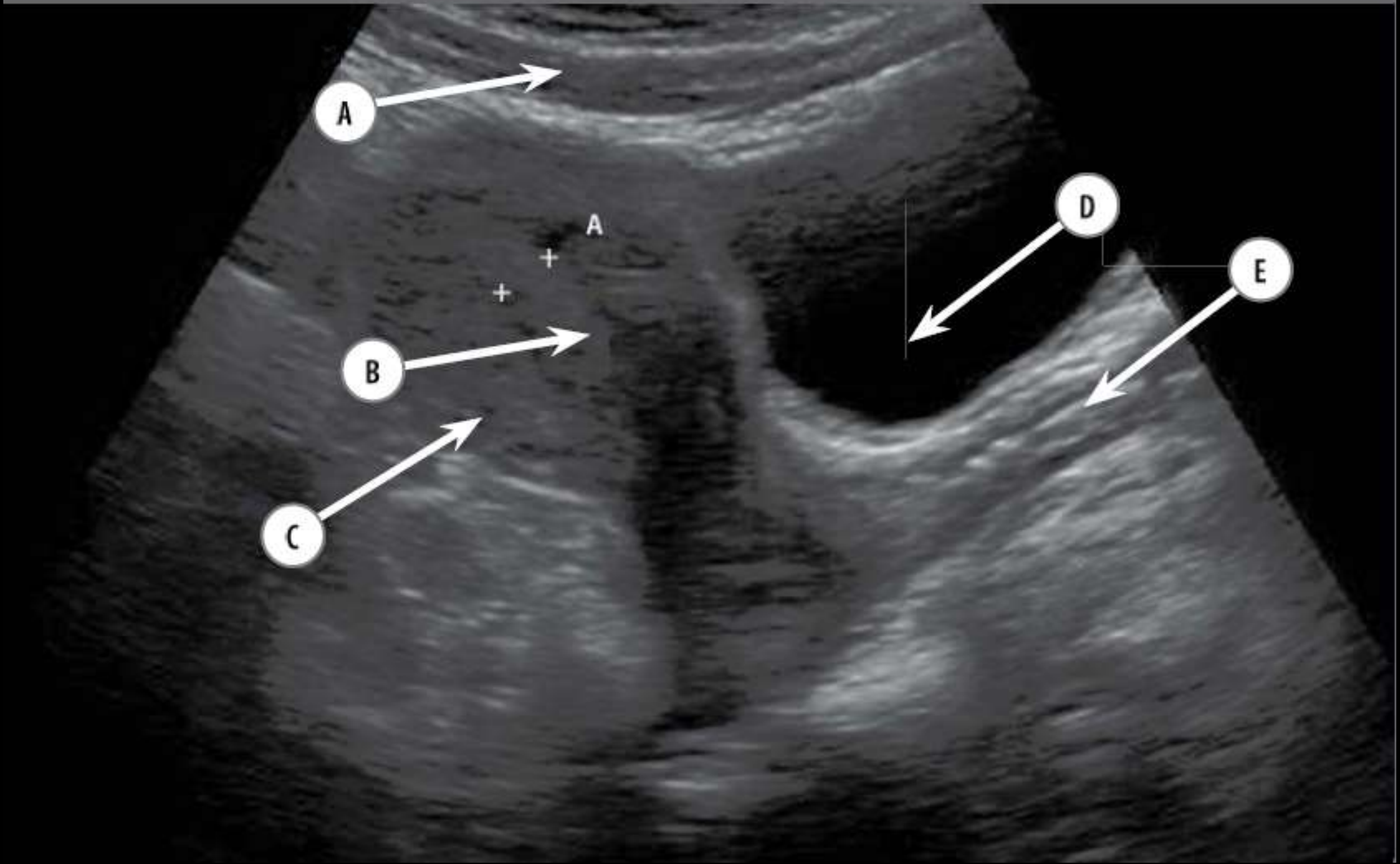
Case 7

Ultrasound pelvis (female patient). Longitudinal section.

1. Urinary bladder
2. Uterine fundus
3. Vagina
4. Endometrium
5. Pouch of Douglas

The radiologist should be familiar with the name and position of the various intraperitoneal spaces.

Case 3.43



Case 3.43

A Muscles of the anterior abdominal wall

B Endometrium

C Myometrium of posterior uterine wall

D Urine within bladder

E Vaginal stripe

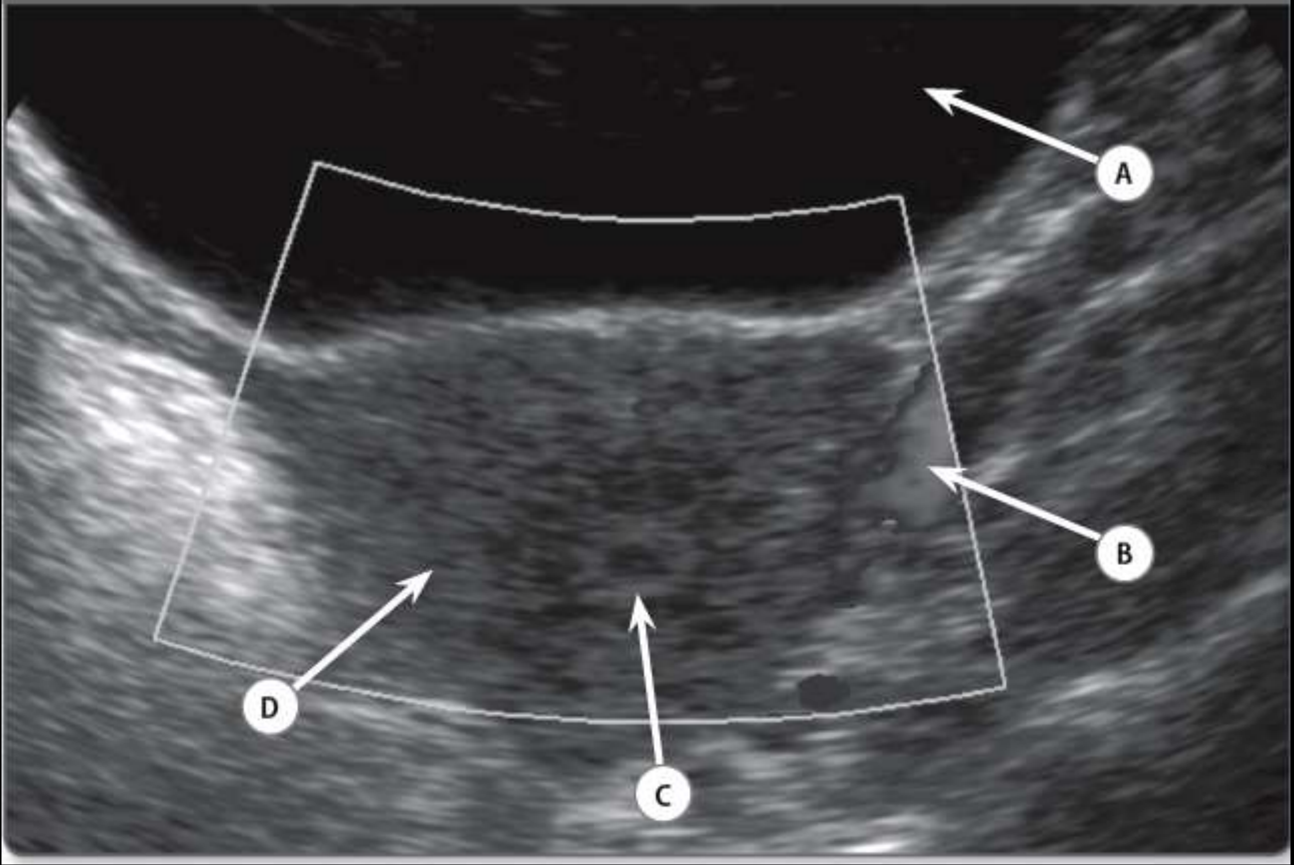
Longitudinal, trans-abdominal ultrasound of the pelvis.

The endometrium appears as a hyperechoic stripe on longitudinal ultrasound images, running from the fundus to the cervix. It has a variable width throughout the menstrual cycle depending on the influence of oestrogen and progesterone. This image was obtained on day 21 of the menstrual cycle, and shows the endometrium to be 6.5 mm in thickness. During the secretory phase, the endometrium thickens and typically measures between 7–16 mm. In the periovulatory period, the endometrium may take on a striated/layered appearance which usually disappears within 48 hours of ovulation. As the endometrium proliferates it becomes thicker and more echogenic, and may demonstrate a degree of posterior acoustic enhancement due to local oedema. A thin, hypoechoic layer can be seen immediately deep to the endometrium, which represents a relatively hypovascular layer of myometrium. This is analogous to the junctional zone seen on MRI.

The vagina is located between the urethra and rectum on transabdominal scans. On a longitudinal scan the vagina is seen as an echogenic 'stripe' which forms an acute angle with the uterine body.

Nalaboff KM. Imaging the endometrium: disease and normal variants. Radiographics 2001; 21: 1409–1424.
Ryan S, McNicholas M, Eustace SJ. Anatomy for Diagnostic Imaging, 3rd edn. Edinburgh: Saunders, 2011: 239–245.

Case 13.9



E	From which artery does the right uterine artery normally arise?	

Case 13.9

A Urinary bladder

B Left external iliac vessels

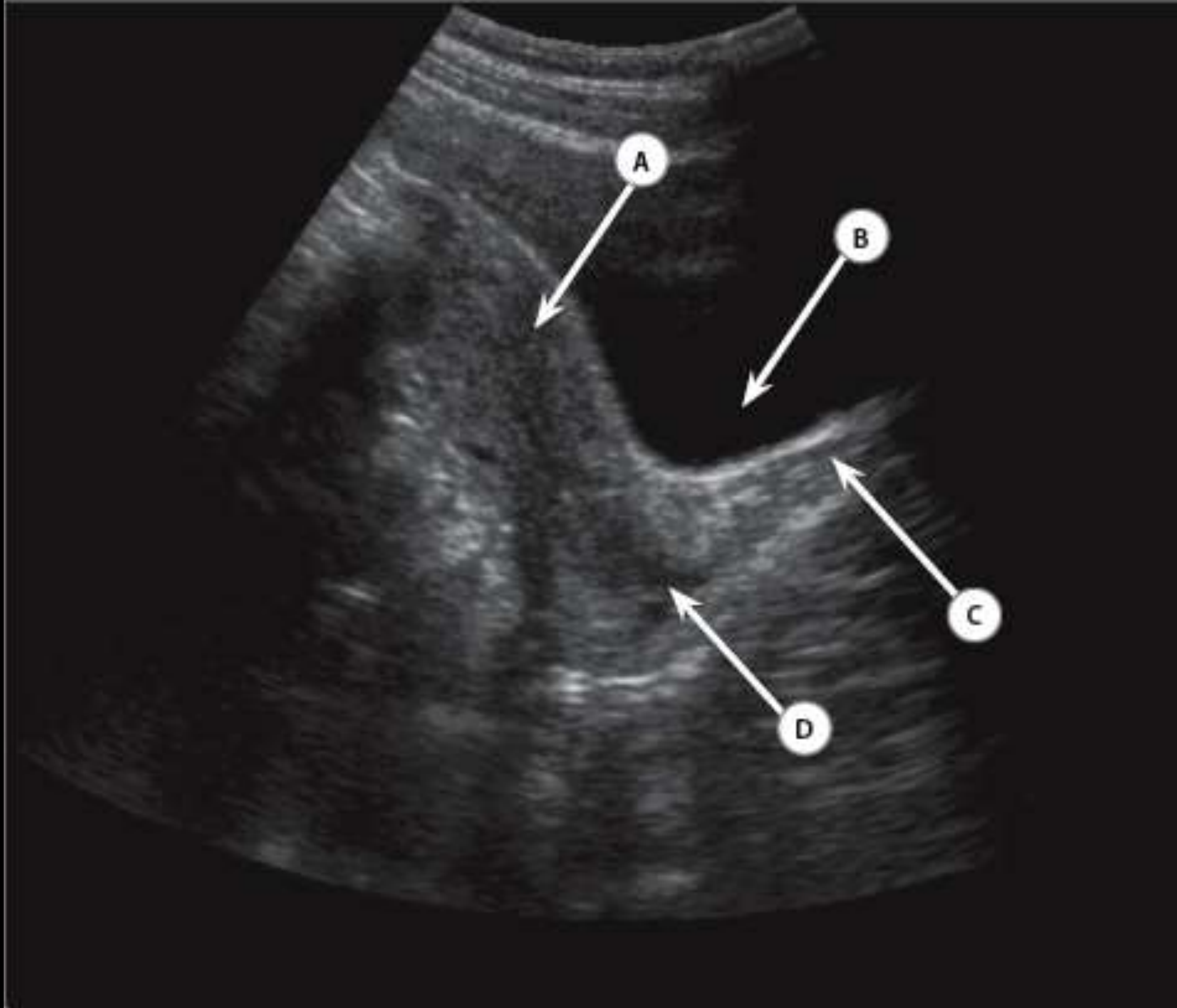
C Endometrium

D Body of uterus/myometrium

E Anterior division of right internal iliac artery

The urinary bladder should be full for transabdominal ultrasound imaging of the female pelvis to enable satisfactory visualisation of the pelvic viscera. The most central hypoechoic area in the uterus represents fluid within the uterine cavity. The hyperechoic ring around this is the endometrium, the thickness of which depends on the stage of the menstrual cycle in premenopausal women. A hypoechoic ring around the endometrium corresponds to the innermost layer of myometrium. The uterine arteries are tortuous vessels which arise from the anterior divisions of the internal iliac arteries – an anatomical fact that is important when considering endovascular intervention of uterine fibroids or in obstetric haemorrhage.

Case 9.3



E	During which phase of the menstrual cycle will the endometrium be thickest?

Case 9.3

A Fundus of the uterus

B Urinary bladder

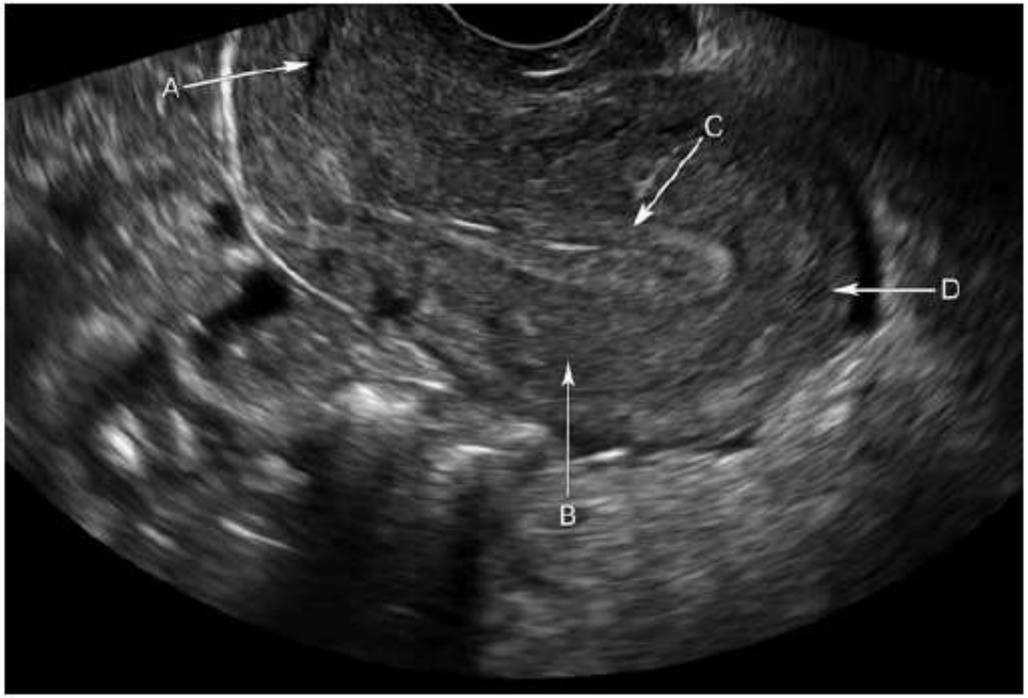
C Vagina

D Uterine cervix

E Secretory phase

Endometrial thickness varies with the menopausal state of the patient and, if pre-menopausal, with the stage of the menstrual cycle. The endometrium is evident as an echogenic stripe on longitudinal ultrasonography, surrounded by hypoechoic myometrium. The vagina is a posterior relation of the bladder and can also be seen as an echogenic stripe which lies at an angle to the body of the uterus.

Question 3.13



Name the structures labelled A to D.

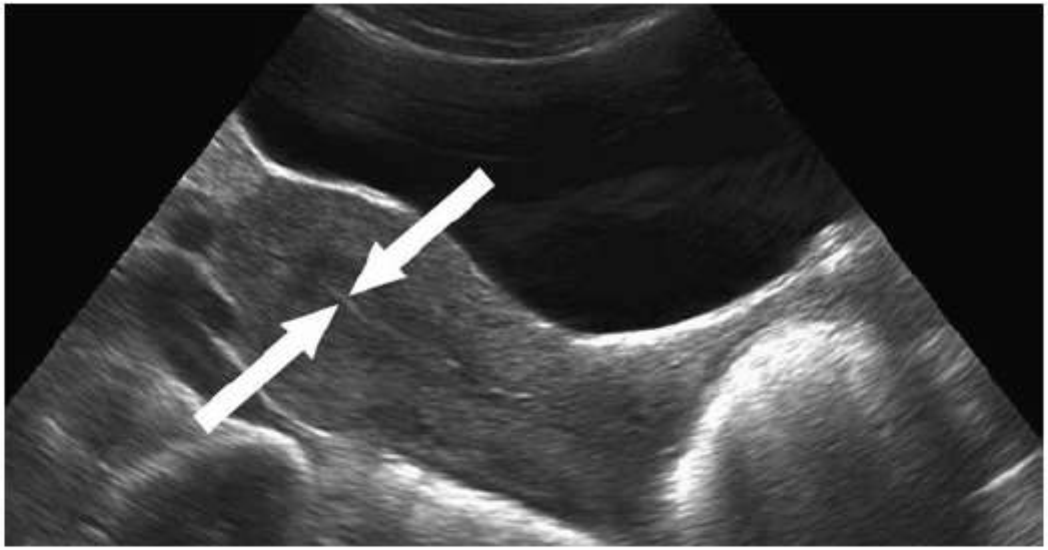
E What is the upper limit of normal thickness (mm) of C in a post-menopausal patient?

3.13 Longitudinal transvaginal ultrasound of the female pelvis

A Cervix.
B Myometrium.
C Endometrium.
D Fundus of the uterus.
E 5 mm.

Transvaginal ultrasound provides good imaging of the uterus and is the primary imaging modality for the female reproductive organs. The uterus is a pear-shaped organ located between the bladder and the rectum. It is composed of four parts – fundus, corpus (or body), cervix and internal os. The area of the body above the insertion of the fallopian tubes is called the fundus. The inner thin echogenic layer of the uterus is called the endometrium and the outer muscular layer is called the myometrium. The normal thickness of the endometrium in the post-menopausal woman is less than 5 mm.

- **Question 27:**

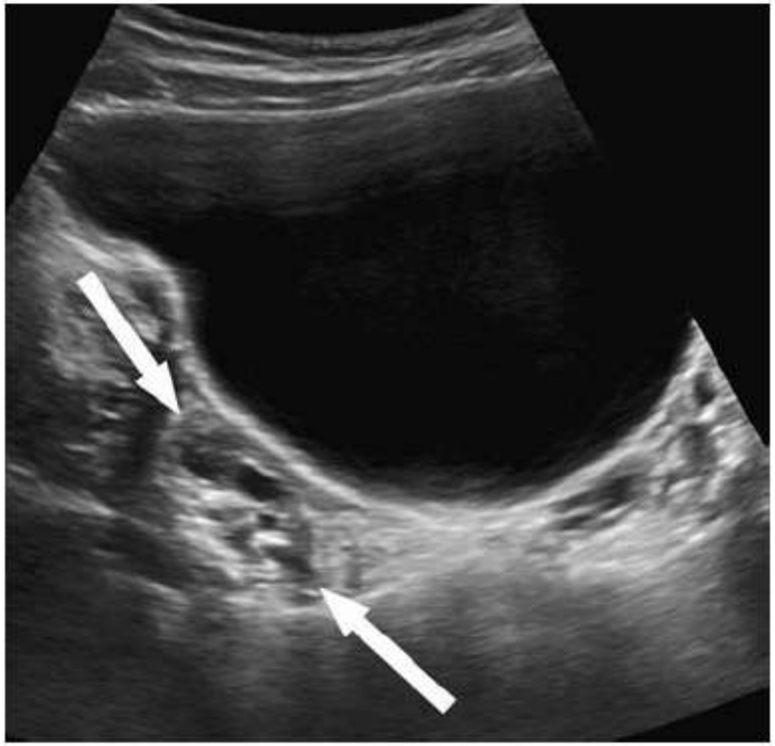


■ Question 27: Longitudinal US of the pelvis

Answer: Endometrium

- The endometrium is the inner lining of the uterus.
- On ultrasound, it can be recognised as a thin, hyperreflective layer.
- In a premenopausal woman, the thickness of the endometrium is dependent on the menstrual cycle but should be < 15 mm.
- The upper limit of normal is 10 mm in an asymptomatic postmenopausal woman. In a postmenopausal woman with bleeding, an endometrial thickness of greater than 4 mm will warrant further investigation.
- The uterus has a thicker outer muscular layer called the myometrium.

■ Question 21:



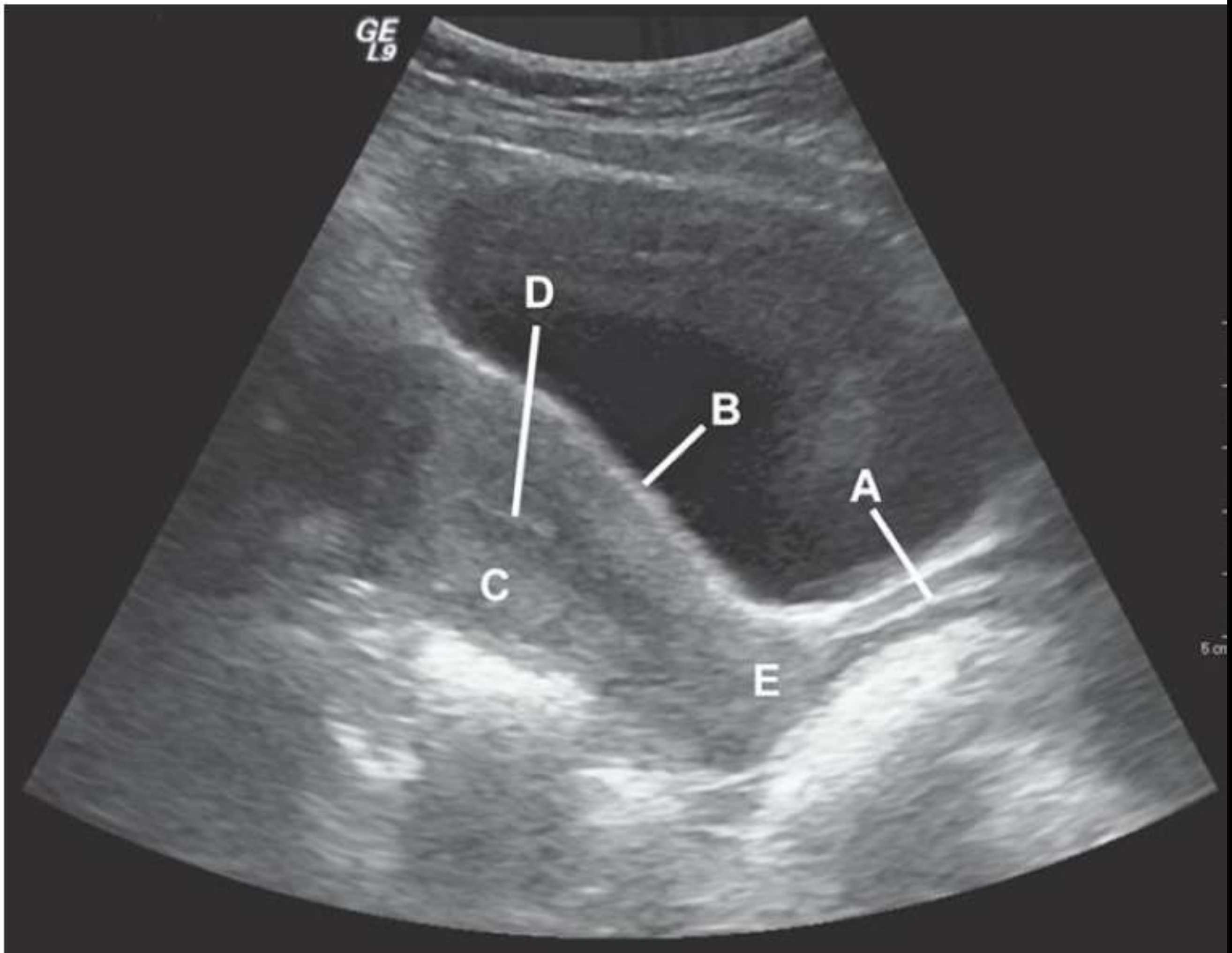
Question 21: Transabdominal US of the pelvis

Answer: Right ovary

- The ovaries are usually found lateral to the uterus and measure approximately $2 \times 2 \times 3$ cm.
- The bladder acts as an acoustic window to allow better visualisation of the pelvic structures, as well as pushing gas-filled bowel out of the way.
- The ovaries are better visualised with a transvaginal US.

Q8

a Name the structure labelled A
b Name the structure labelled B
c Name the layer labelled C
d Name the layer labelled D
e Name the structure labelled E



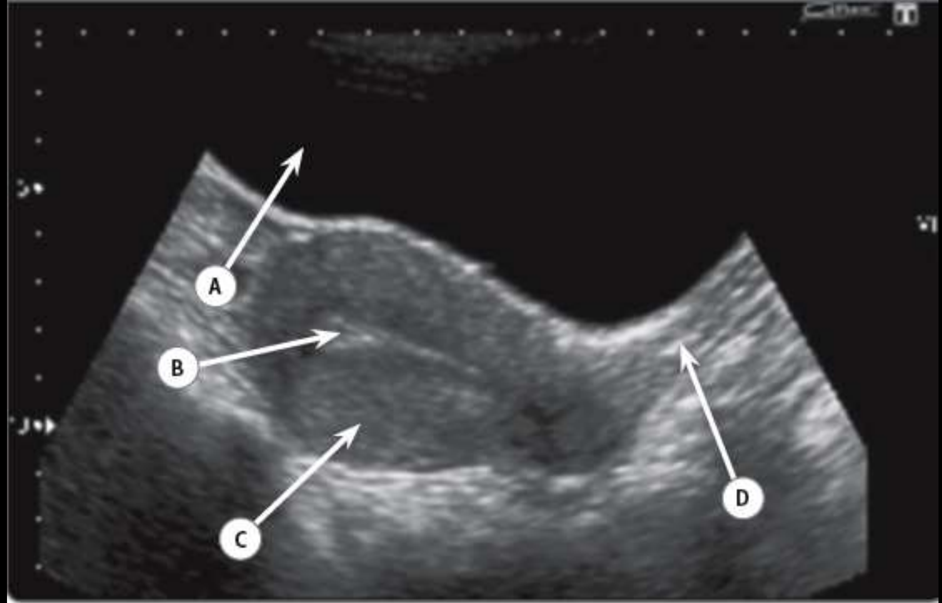
Q8 Answers

- **a** Vaginal stripe (collapsed vaginal cavity)
- **b** Bladder wall
- **c** Myometrium
- **d** Endometrium
- **e** Cervix

Trans-abdominal ultrasound of the female pelvis, midline sagittal view

With trans-abdominal ultrasound of the female reproductive tract, the inferiorly placed vagina lies at an acute angle to the uterus (the latter is anteflexed over the bladder) and its cavity is usually collapsed appearing as an echogenic stripe. The thick muscular (myometrial) layer of the uterus appears less bright and is homogenous. Internal to this, the central endometrial stripe is also echogenic on ultrasound. The thickness of the endometrium changes according to the stage of the menstrual cycle; post menopause, endometrial thickening can indicate disease. The cervix forms the cylindrical inferior part of the uterus and provides communication between the vaginal and uterine cavities.

Case 4.4



Case 4.4

	QUESTION	WRITE YOUR ANSWER HERE
A	Name the structure labelled A.	
B	Name the structure labelled B.	
C	Name the structure labelled C	
D	Name the structure labelled D.	
E	What is the upper limit of normal thickness of the endometrium in a pre-menopausal woman?	

Case 4.4

A Urinary bladder

B Endometrium

C Myometrium

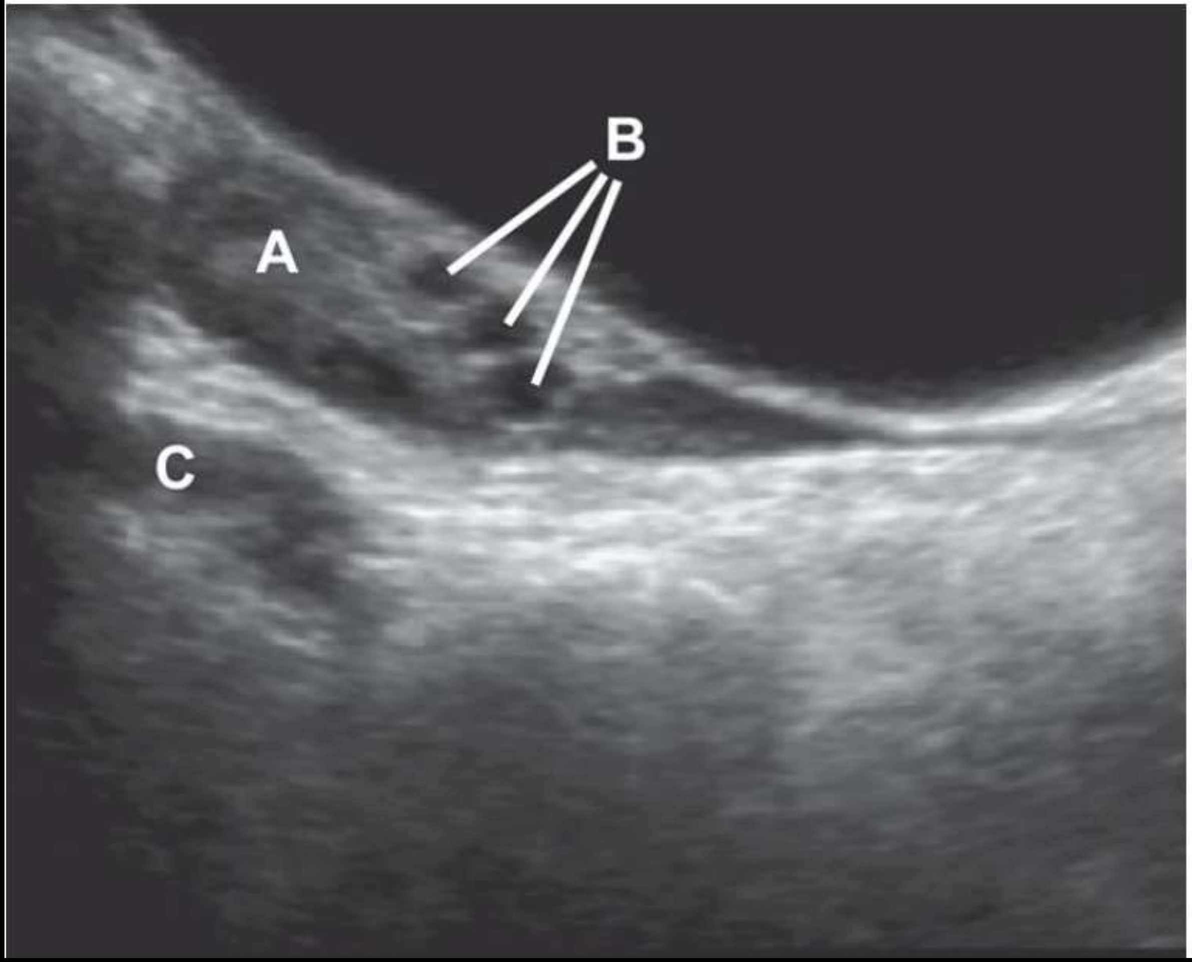
D Vaginal canal

E 15 mm

The uterus lies posterior to the bladder and anterior to the rectum, usually in an anteflexed and anteverted position. The endometrium has a characteristic trilaminar appearance and may be up to 15 mm thick in women of childbearing age. Following menopause, the endometrium atrophies and should measure less than 5 mm.

Q10

a Name the structure labelled A
b Name the structures labelled B
c Name the artery and vein normally found in the position labelled C
d Name the blood vessel from which arterial supply for A arises
e Name the three ligamentous attachments of A



Q10 Answers

a Ovary
b Developing ovarian follicles
c Internal iliac artery and vein
d Aorta
e Ligament of ovary, suspensory ligament of ovary, broad ligament

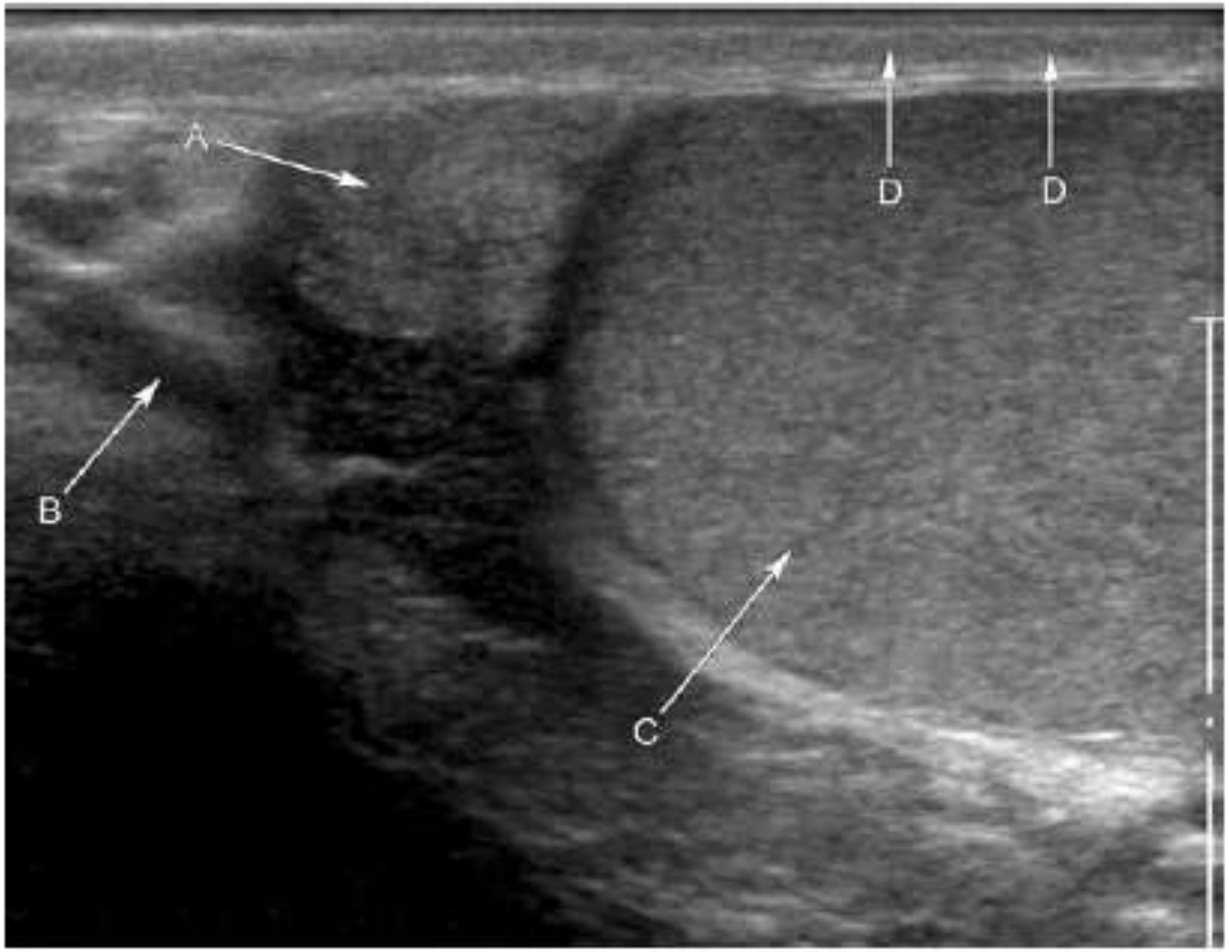
Trans-abdominal ultrasound of ovary, longitudinal view

Developing ovarian follicles may be demonstrated with ultrasound as well defined anechoic areas usually in the periphery of the ovary; the appearances of which vary significantly throughout the menstrual cycle. The ovaries lie posteriorly in the pelvis, on either side of the uterus although their position can vary. Postero-lateral to the ovaries run the internal iliac vessels.

The gonadal arteries arise directly from the aorta in both males and females.

The ovary has three ligamentous attachments; the ovarian ligament connects the ovary to the uterus in the midline, the suspensory ligament of the ovary elevates the ovary towards the lateral pelvic wall and contains the ovarian vessels, lymphatics and nerves, while the broad ligament envelopes the ovaries, uterus and uterine (fallopian) tubes.

Question 2.13



This is a longitudinal ultrasound of the left testis.
Name the structures labelled **A** to **D**.
E What is the normal drainage of the left testicular vein?

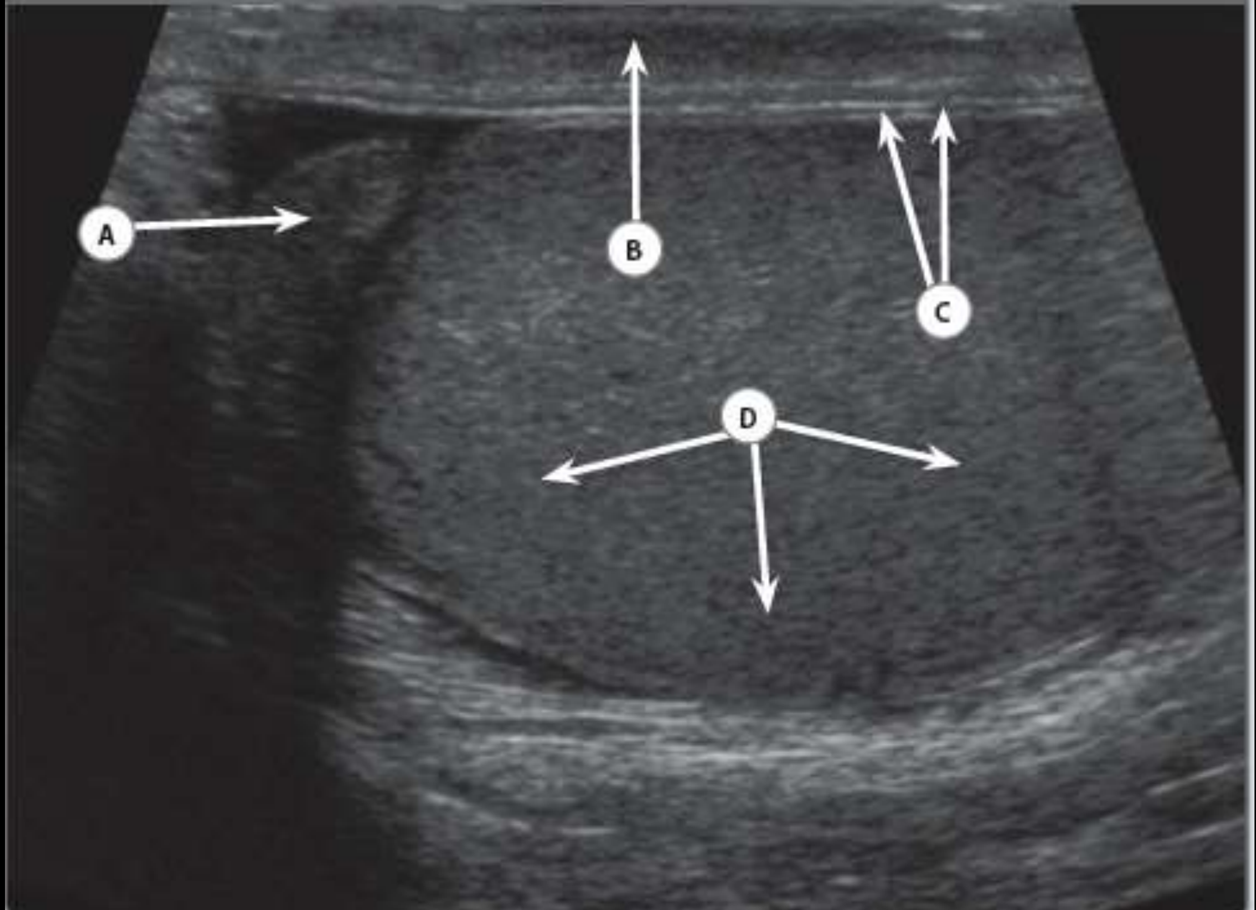
2.13 Longitudinal ultrasound of the left testis

A Head of the epididymis.
B Testicular vein.
C Testicle.
D Scrotal skin.
E Left renal vein.

Each testis is surrounded by a thin layer of peritoneum called the tunica albuginea, which appears as a hyperechoic band on ultrasound. The tunica albuginea is in turn enveloped by the tunica vaginalis, a dense hypoechoic band of fibrous tissue. Peripheral to this layer is the scrotal skin. The mediastinum testis is not demonstrated on this examination but is seen as a thin echogenic band extending through the testis. On ultrasound the epididymis appears isoechoic or slightly more echogenic than the surrounding testis and has a coarser echotexture. The epididymis is composed of a head, body and tail.

The testicular veins are readily identifiable on testicular ultrasound and should not measure more than 3 mm in diameter. The right testicular vein drains directly into the inferior vena cava whereas the left drains into the left renal vein. The longer and more tortuous course of the left renal vein explains why most varicocoeles are left sided. If a left varicocoele is identified during ultrasonography, the left kidney should also be examined to search for a potential renal tumour obstructing venous drainage.

Case 6.13



Case 6.13

	QUESTION	WRITE YOUR ANSWER HERE
A	Name the structure labelled A.	
B	Name the structure labelled B.	
C	What does the hypoechoic line labelled C correspond to?	
D	Name the structure labelled D.	
E	From where does the left testicular artery arise?	

Case 6.13

A Head of epididymis

B Scrotal skin

C Tunica vaginalis

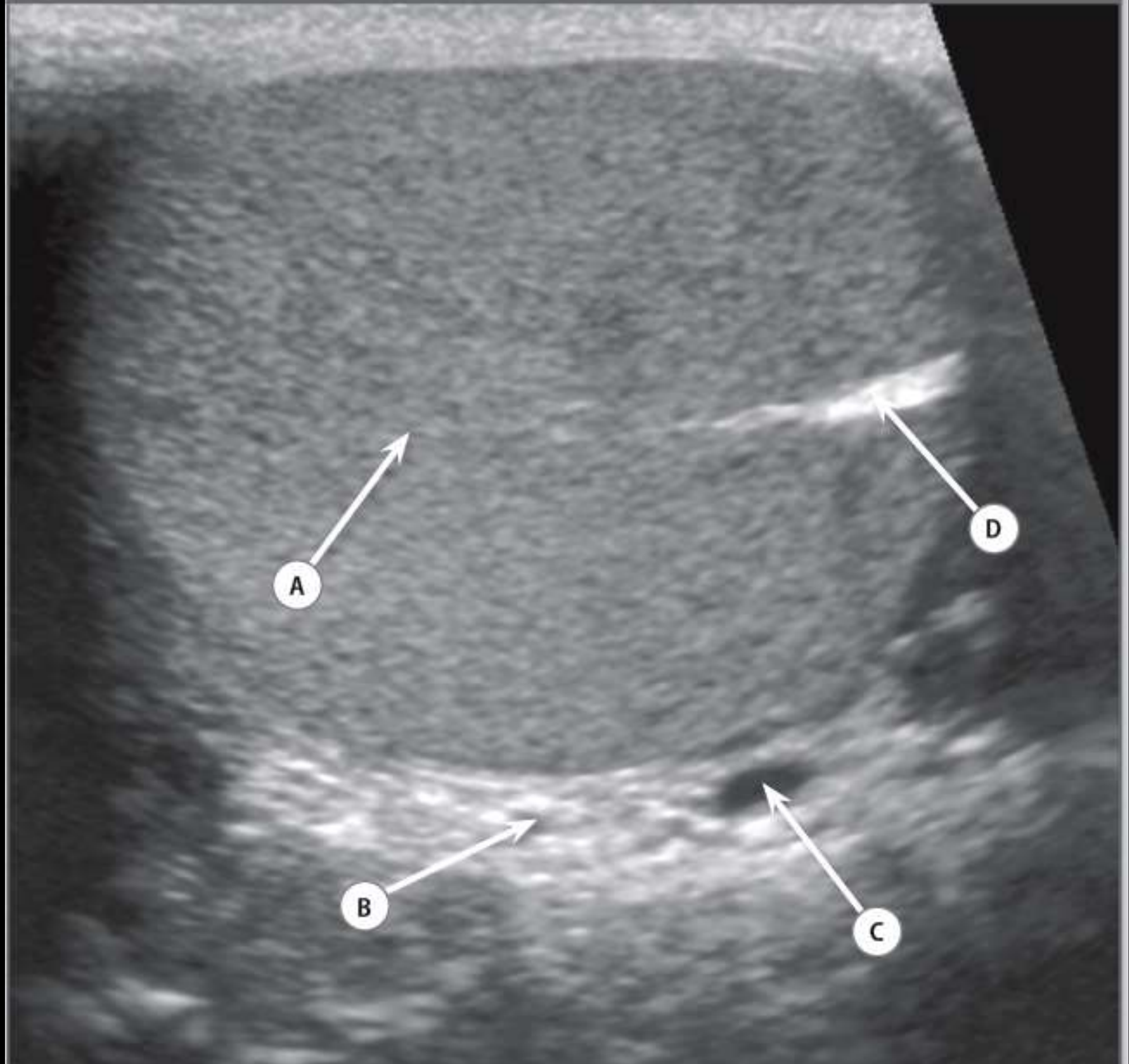
D Testis

E Aorta

Embryologically, the testes originate in the lumbar region before passing through the inguinal canal and eventually descending into the scrotum by the end of puberty. The blood supply relates to the site of origin of the testes, with each testis being supplied by a testicular artery which arises from the aorta just below the renal arteries. Each testicular vein forms from the pampiniform plexus of veins. The right testicular vein then drains to the inferior vena cava, whereas the left testicular vein drains to the left renal vein. For this reason, it is important to image the left kidney whenever a left-sided varicocoele is identified, as renal masses may cause this phenomenon. The lymphatic drainage of the testis is to the para-aortic nodes, which should be examined in the event of a testicular tumour being detected.

The tunica albuginea – the fibrous covering of the testis – is not usually seen on ultrasound unless a hydrocoele is present. The tunica vaginalis is a serous membrane which lies outwith the tunica albuginea and is seen as a hypoechoic ring around the testis on ultrasound.

Case 15.15



E	Where does the left testicular vein drain to?	

Case 15.15

A Body of testis

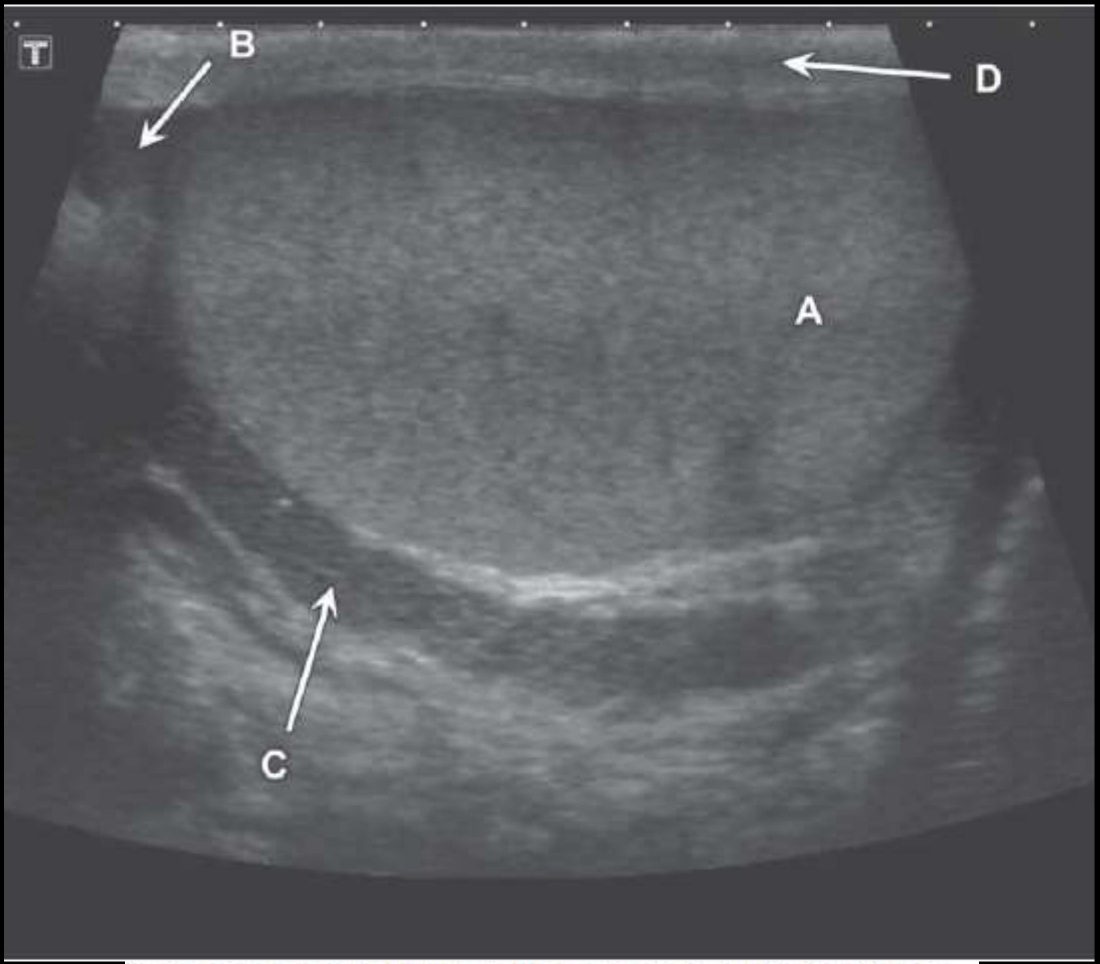
B Epididymis

C Vas deferens

D Mediastinum of testis

E Left renal vein

The mediastinum of the testis is a fibrous band through the mid body of the testis in which the vessels and nerves enter the gland. It is seen as a hyperechoic area (D) on ultrasound. The epididymis is seen posteriorly with the vas deferens coursing through it. The pampiniform plexus is the venous drainage of the testis. Each pampiniform plexus joins to form a testicular vein, of which the left drains into the left renal vein and the right directly into the IVC.

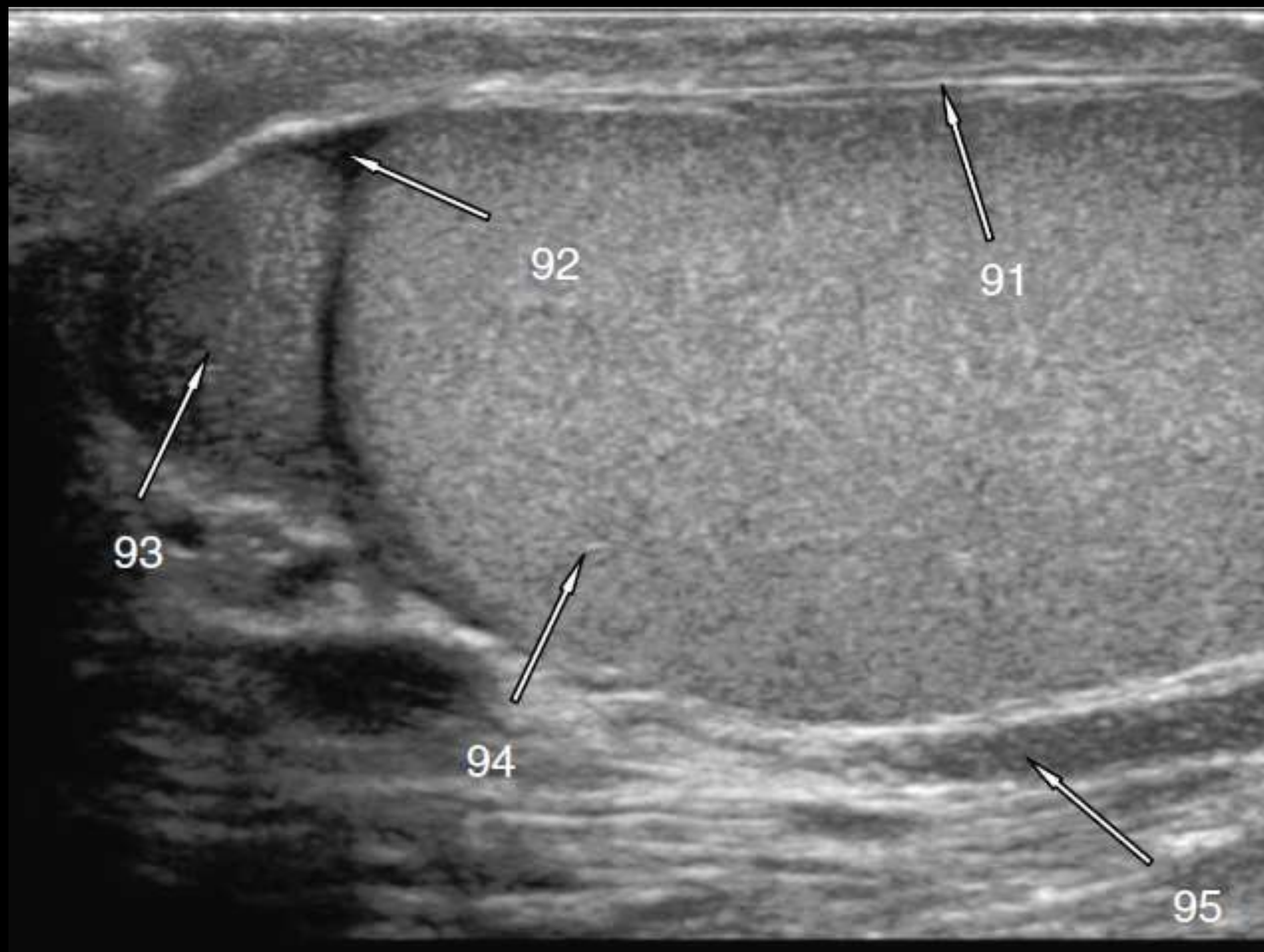


Name the main group of lymph nodes that the structure labelled A drains to.

Case 4

Ultrasound testis. Longitudinal section.

1. Testis
2. Head of epididymis
3. Body of epididymis
4. Scrotal skin
5. Para-aortic lymph nodes

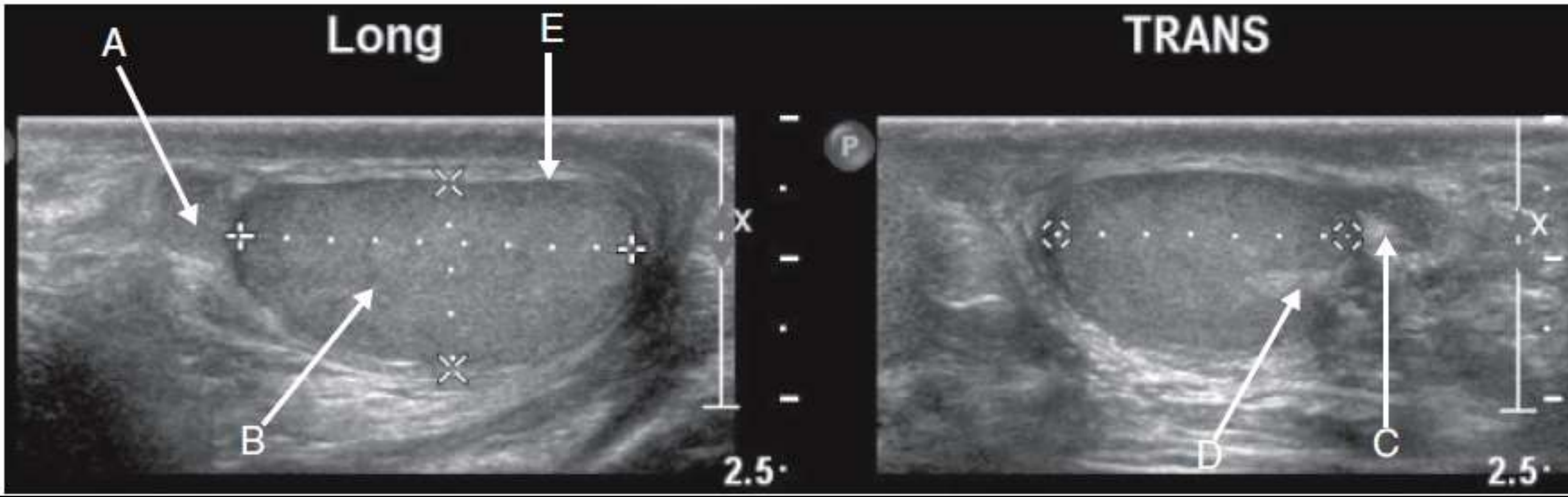


92
91
93
94
95

Ultrasound Testes

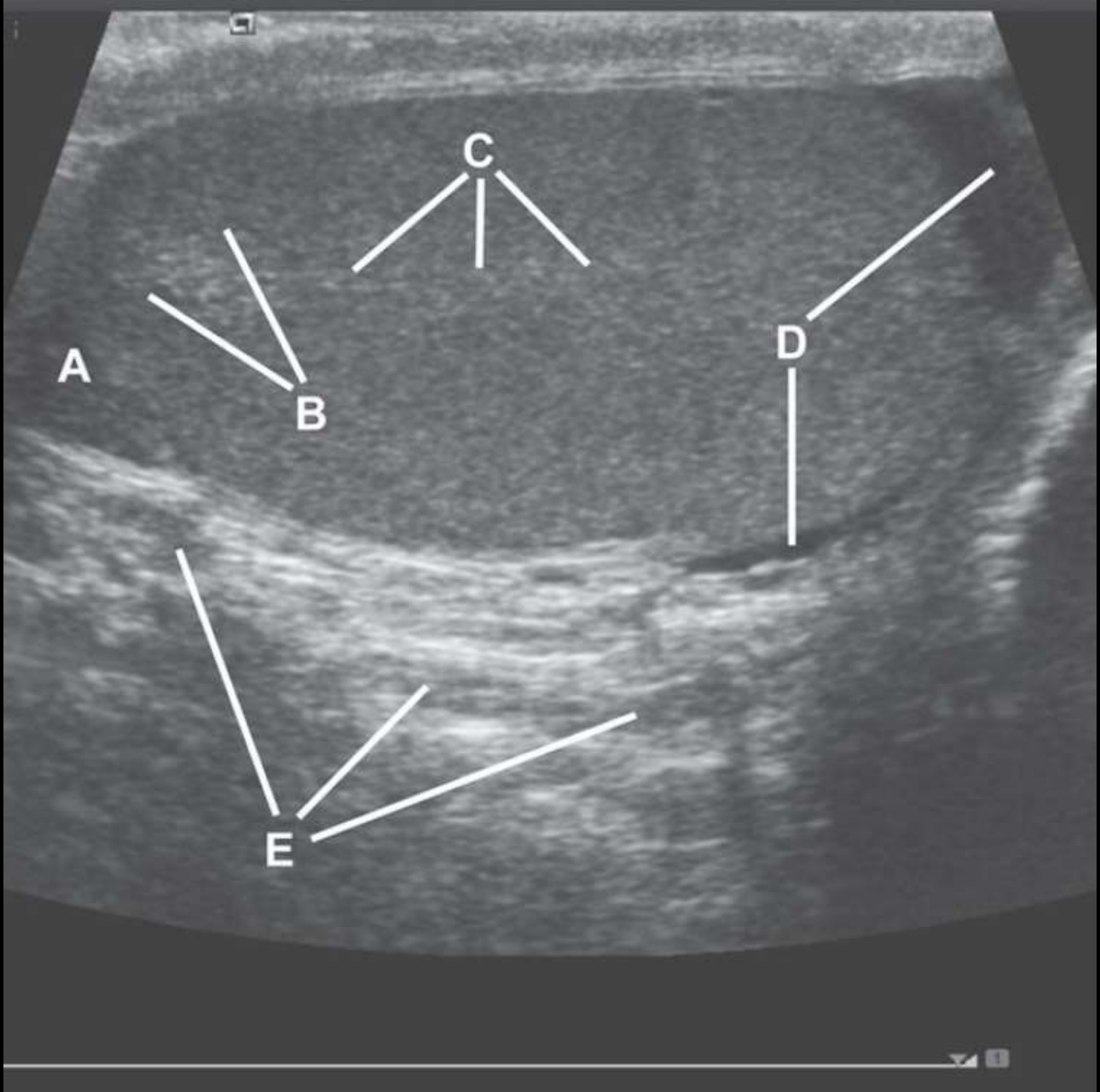
91. Tunica albuginea
92. Fluid within scrotal sac
93. Epididymal head
94. Testis
95. Body of epididymis

Case 6.10



6.10 Transverse and longitudinal ultrasound testis

(a) Epididymal head.
(b) Testis.
(c) Epididymal tail.
(d) Mediastinum testis.
(e) Tunica albuginea.



A
B
C
D
E

Q11 Answers

a Head of epididymis
b Rete testis
c Mediastinum testis

d Trace of fluid within tunica vaginalis/physiological hydrocele
e Vas deferens

Ultrasound of right testis, longitudinal view

The testis has a homogenous appearance on ultrasound. Several distinct structures are however identifiable.

An echogenic line running through the middle of the testis is known as the mediastinum testis and represents fibrous septae which divide the gland into lobules.

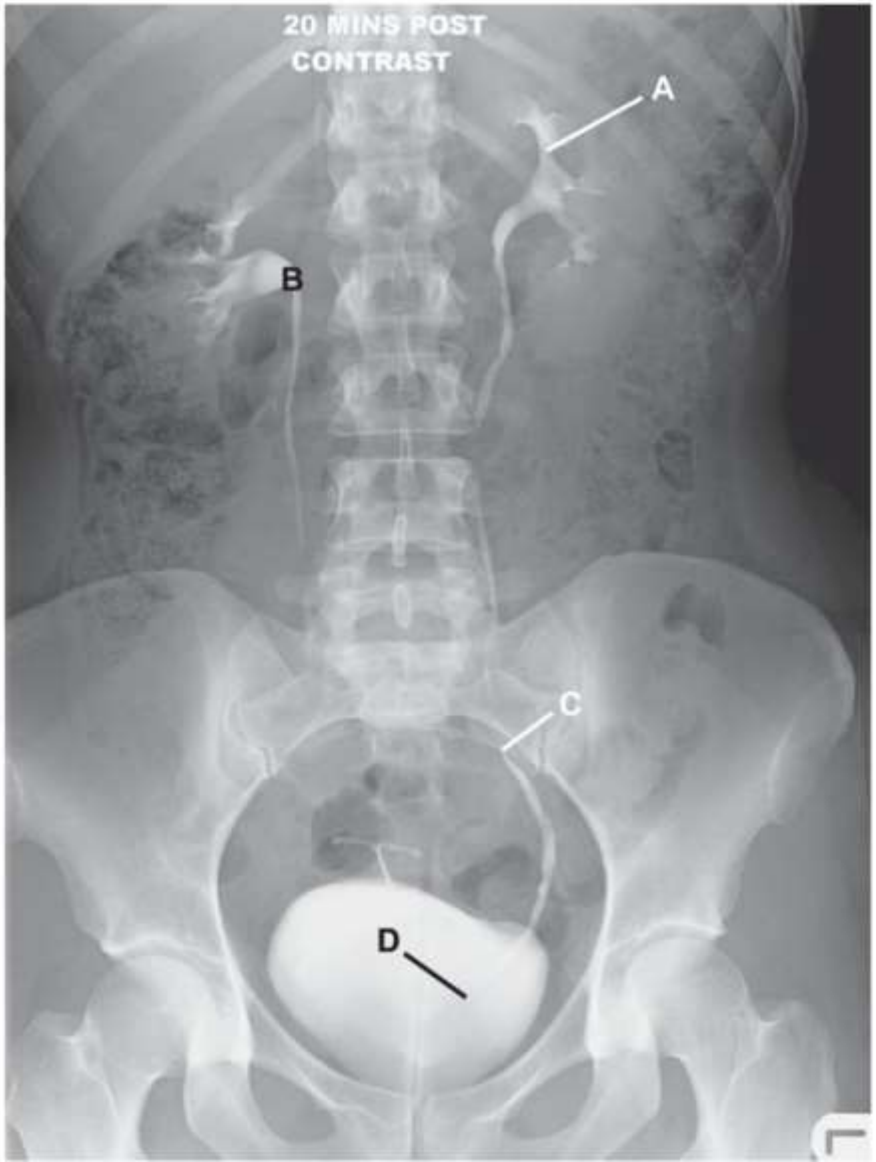
Within the superior end of the testis there is an area of increased echogenicity known as the rete testis. The rete testis is the confluence of the seminiferous tubules which convey sperm from the testis to the epididymis for storage and concentration.

A triangular-shaped area of similar echogenicity to the testis and lying immediately adjacent to its superior pole represents the head of the epididymis. The epididymis runs the length of the testis; at its distal end, the tail of the epididymis is continuous with the origin of the vas deferens. The vas deferens is the tube which delivers sperm from the testis to the ejaculatory duct in the prostatic urethra. From the distal end of the epididymis, the vas deferens turns 180 degrees and travels up the posterior wall of the scrotum. The vas deferens is often visible on ultrasound as a deeply situated tube running parallel to the testis and it becomes more prominent following vasectomy.

FLUORO

Q3

a Name the structure labelled A
b Name the structure labelled B
c Name the vessels over which the ureter crosses at the level labelled C
d Name the structure labelled D which is seen projected through the bladder
e Define the gender of this patient



Q3 Answers

a Upper pole major calyx
b Pelvi-ureteric junction (PUJ)
c Common iliac vessels
d Vesico-ureteric junction (VUJ)
e Female patient. Note an intra uterine contraceptive device is in situ. In addition, the bony pelvis has a classical female configuration

Intravenous Urogram (IVU), full length AP view

At the apex of the renal pyramids (renal papillae) formed urine drains into the cup-shaped minor renal calyces. These coalesce into two or sometimes three major calyces which further join to form the renal pelvis. The ureters are fibromuscular tubes which run from the renal pelvis (pelvi-ureteric junction, PUJ) to the postero-lateral aspect of the bladder (vesico-ureteric junction, VUJ). The ureters run along the posterior abdominal wall over the psoas muscle. At the pelvic brim they run anterior to the common iliac vessels; this causes a narrowing of the ureter seen on IVU which is projected at the level of the sacroiliac joints.

Case 3.33

Case 3.33

A Infundibulum draining left upper pole calyx

B Right lobe of liver

C Right renal pelvis

D Left upper pole calyx

E Left distal ureter

Intravenous urogram.

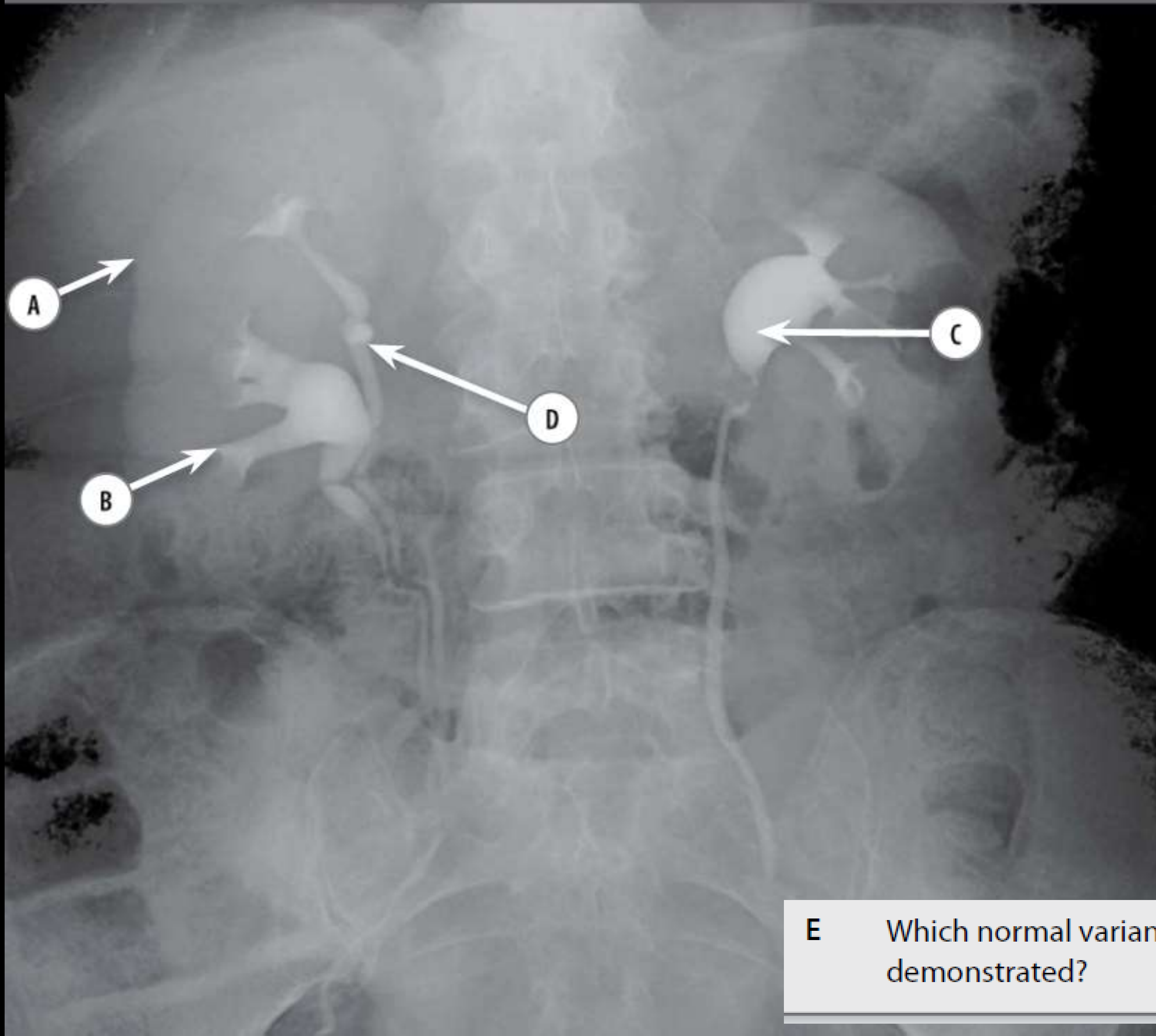
There are approximately 12 collecting ducts which open onto the surface of each renal papilla. Each duct drains into a minor calyx, which drain via infundibula towards the renal pelvis. The angle at which the collecting ducts meet the convex surface of the renal pyramids is designed to prevent reflux of urine into the renal parenchyma. However, compound calyces (with multiple papillae projecting into them) are more prone to reflux, as the crowding of the papillae results in a suboptimal angle for a higher proportion of the ducts. Compound calyces are therefore often thought to be involved in reflux nephropathy.

From the renal pelvis drains the ureter, a fibromuscular tube which extends from the kidney to the posterolateral corner of the bladder. The ureter descends inferiorly and anteriorly within the retroperitoneum, from the kidneys towards the pelvis. Once it crosses the iliac vessels the ureter stays in close proximity to the internal iliac artery, along the pelvic side wall; when the ureter reaches the level of the anterior ischial spines its course changes to run anteromedially towards the bladder.

The narrowest parts of the ureter are found at the pelviureteric junction, the pelvic brim (where the ureter crosses the iliac vessels) and the vesicoureteric junction. These are the most likely sites for a kidney stone to become impacted. A normal calibre ureter on an intravenous urogram will measure up to 7 mm within the pelvis and 5mm above the pelvic brim.

Butler P, Mitchell AM, Ellis H. Applied Radiological Anatomy. Cambridge: Cambridge University Press, 1999: 267.

Case 3.34



E Which normal variant is demonstrated?

Case 3.34

A Nephrogram of right kidney, upper pole

B Fornix of right lower pole calyx

C Left renal pelvis

D Ureter draining the right upper moiety

E Partial duplex collecting system, right kidney

Intravenous urogram.

A partial duplex collecting system is seen on the right of this image. This variant is relatively common, and is seen in approximately 1/70 people. The ureters can fuse before they reach the bladder or they may remain separate throughout their course. In the latter case, the ureter which drains the lower moiety enters the bladder in a normal anatomical position but is prone to vesicoureteric reflux. The upper moiety drains via a ureter which inserts in a more distal position and is prone to obstruction due to the increased incidence of ureterocele formation. **Figure 3.3** demonstrates renal anatomy.

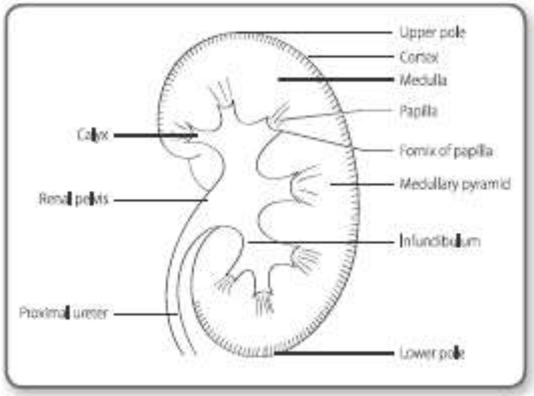
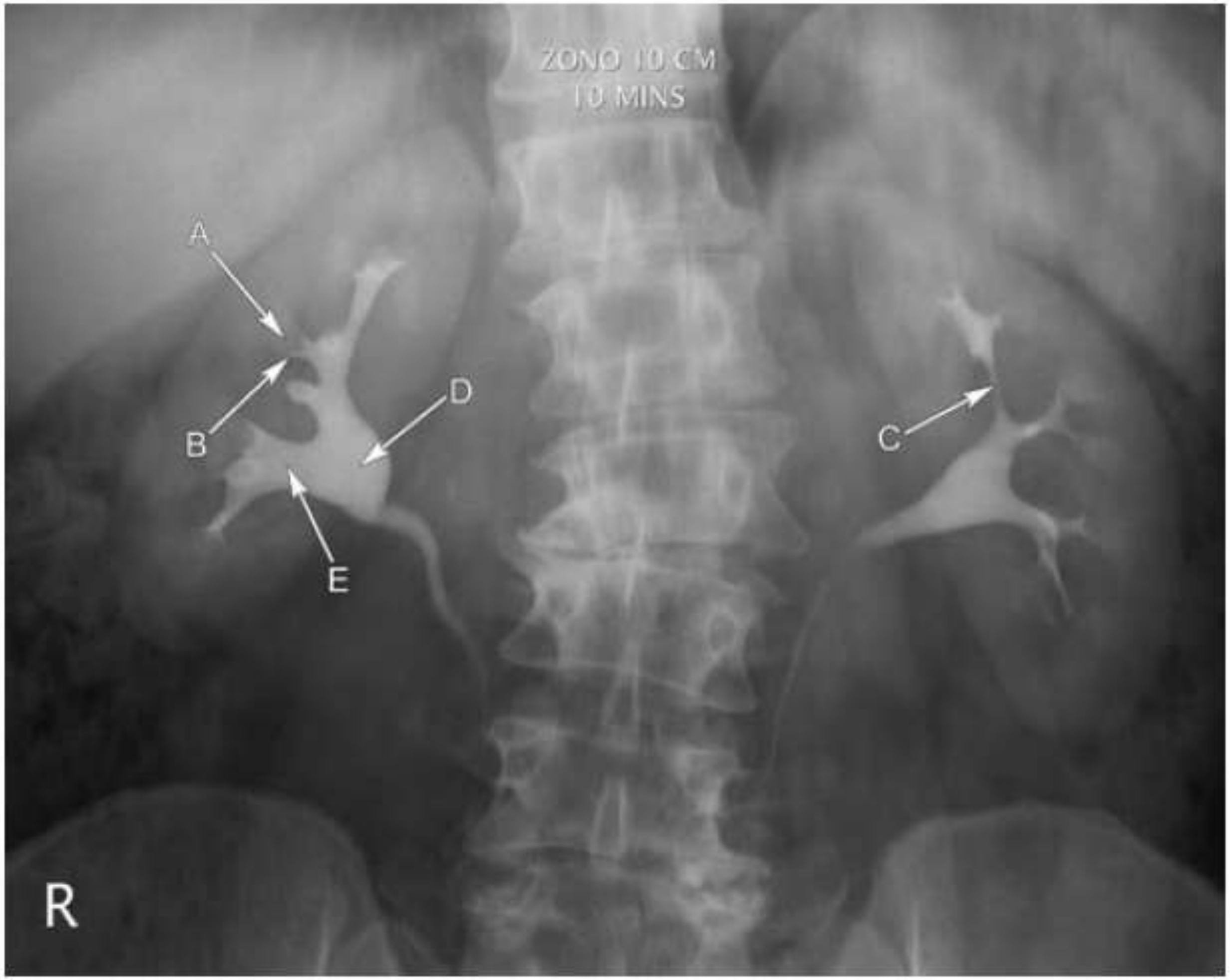


Figure 3.3 Renal anatomy.

Butler P, Mitchell AM, Ellis H. Applied Radiological Anatomy. Cambridge: Cambridge University Press, 1999: 426.
Babyn, PS. Teaching Atlas of Paediatric Imaging. New York: Thieme Medical Publishers, 2006: 363.

Question 5.15



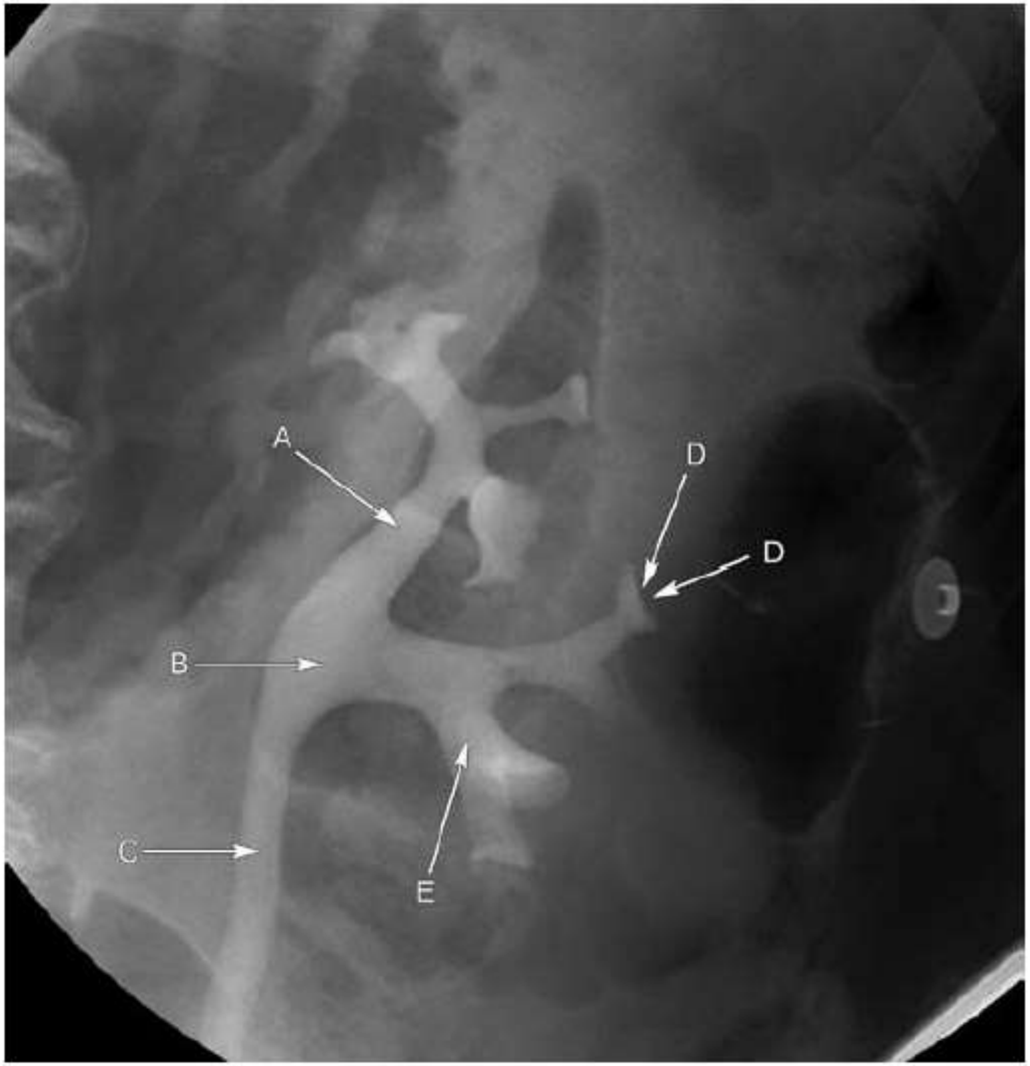
Name the structures labelled **A** to **E**.

5.15 Intravenous urogram

A Right upper pole papilla.
B Right upper pole fornix.
C Left upper pole infundibulum.
D Right renal pelvis.
E Right lower pole major calyx.

The renal collecting system is divided into three major calyces, each of which is subdivided into two or three minor calyces. Each minor calyx meets the apex of a renal pyramid, which is known as the renal papilla. The fornix is the acutely angled portion of the calyx alongside the papilla. The infundibulum is the funnel-shaped channel that connects the calyces to the renal pelvis, which in turn tapers to become the proximal ureter.

Question 8.14



Name the structures labelled **A** to **E**.

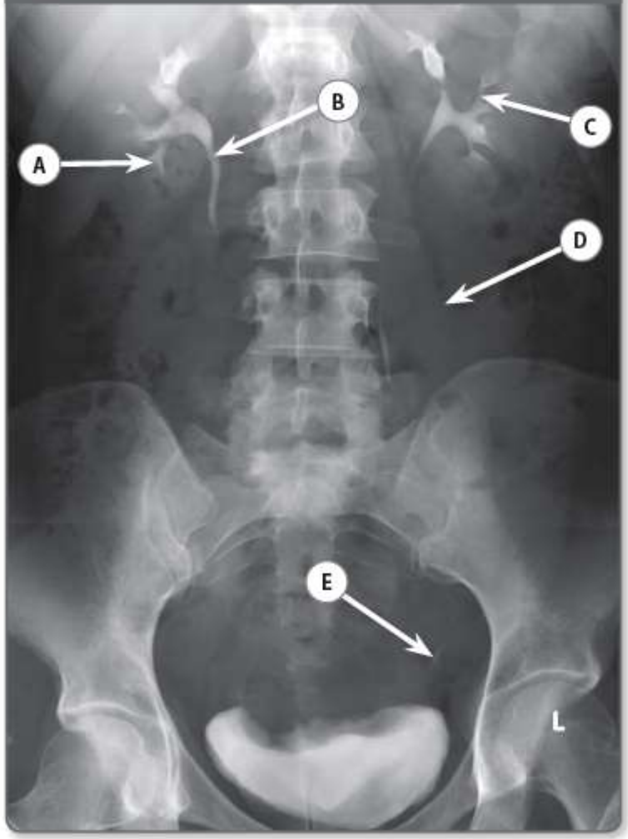
8.14 Retrograde pyelogram of the left kidney

A Left upper pole infundibulum.
B Left renal pelvis.
C Left proximal ureter.
D Left lower pole fornix.
E Left lower pole major calyx.

A kidney generally comprises seven or eight pairs of minor calyces. The minor calyces combine to form two or three major calyces, which in turn drain via their infundibula to the renal pelvis.

For more information about the pelvicalyceal system see Question 5.15.

Case 3.12



Case 3.12

QUESTION		WRITE YOUR ANSWER HERE
A	Name the structure labelled A.	
B	Name the structure labelled B.	
C	Name the structure labelled C.	
D	What does the line labelled D correspond to?	
E	Name the structure labelled E.	

Case 3.12

A Right lower pole calyx

B Right pelviureteric junction

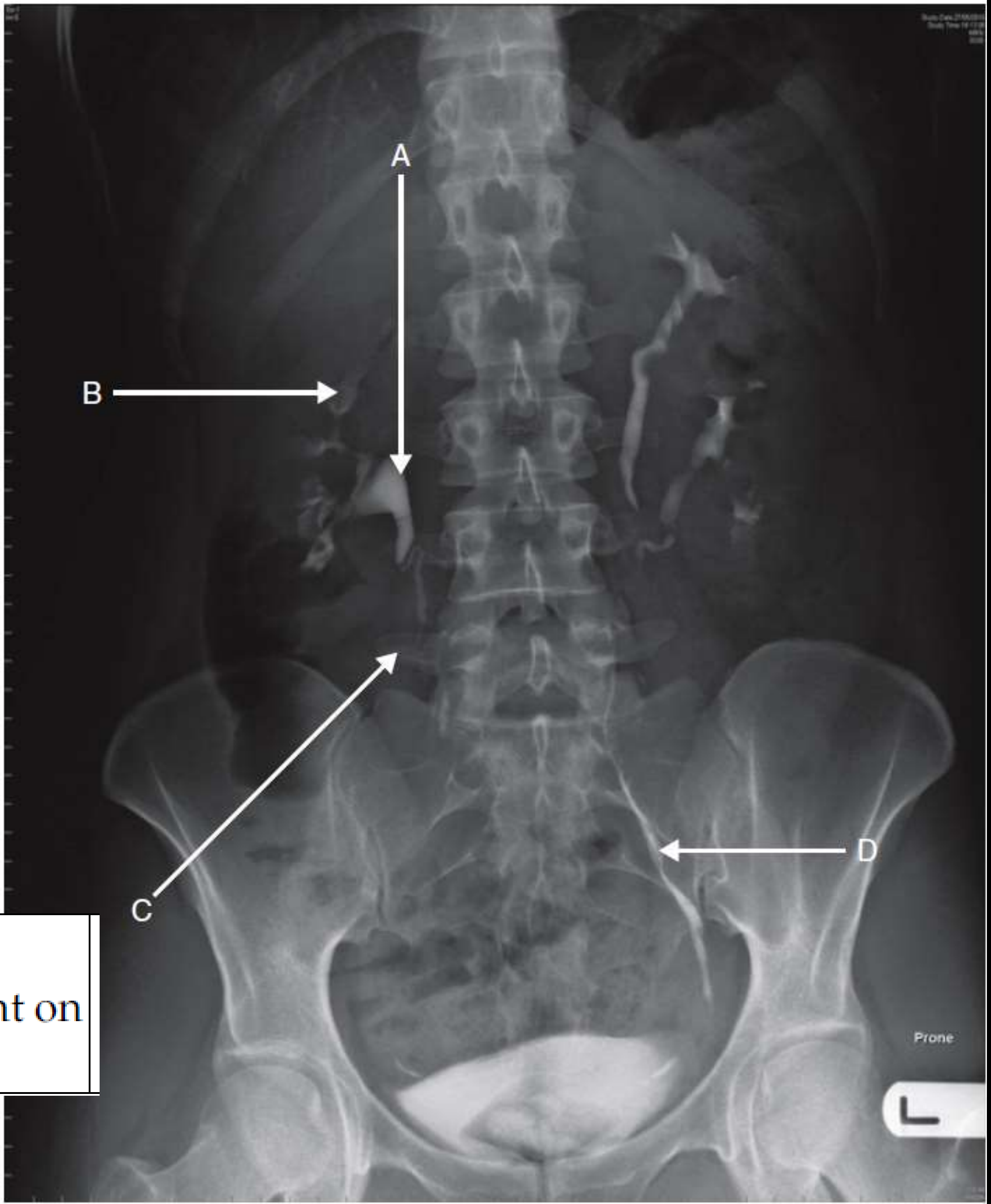
C Left infundibulum

D Left psoas major outline

E Distal left ureter

Although intravenous urography (IVU) is becoming a less popular imaging modality with the advent of CT urography, the IVU remains a classic examination film and is good for demonstrating anatomy of the urinary tract. The psoas major outlines should be scrutinised in any abdominal radiograph, as loss of this fat plane can be a subtle sign of a bleed into the retroperitoneum, for example.

Case 2.11



(e)	Which normal variant is present on this image?

2.11 Intravenous urogram (IVU)

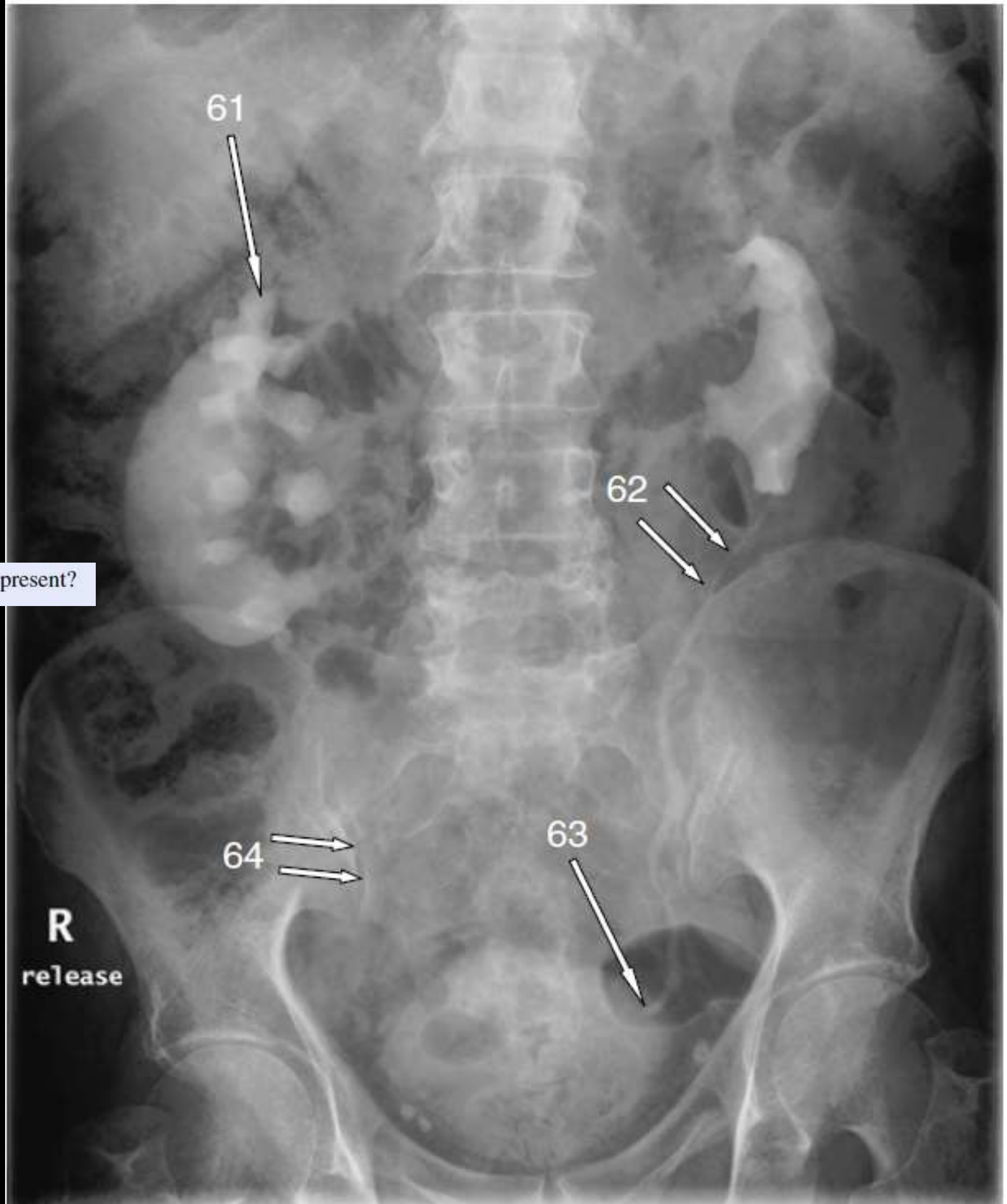
(a) Right renal pelvis.
(b) Right upper pole pyramid.
(c) L5 right transverse process.
(d) Left ureter.
(e) Left duplex kidney. This is also known as ureteric duplication, which occurs when there are two pelvicalyceal collecting systems draining one kidney. It is present in about 1% of the population and is the most common renal anomaly. If the two ureters fuse prior to entering the bladder it is called a partial duplication and is largely an incidental finding.

If the two ureters drain independently into the bladder then this becomes a complete duplication. There is an increased incidence of urinary tract infections and vesicoureteric reflux in the latter cases.

Intravenous urography has been replaced by CT urography (CTU) in many centres, but was previously an important investigation in urinary tract imaging. Contrast was injected intravenously and a series of images taken to look at function and anatomy of the renal tract. The ureters may not be completely seen due to peristalsis, and prone views can aid filling.

Remember to look at the remainder of the image for other abnormalities, including bone lesions, bowel gas pattern and any lesions seen at the lung bases.

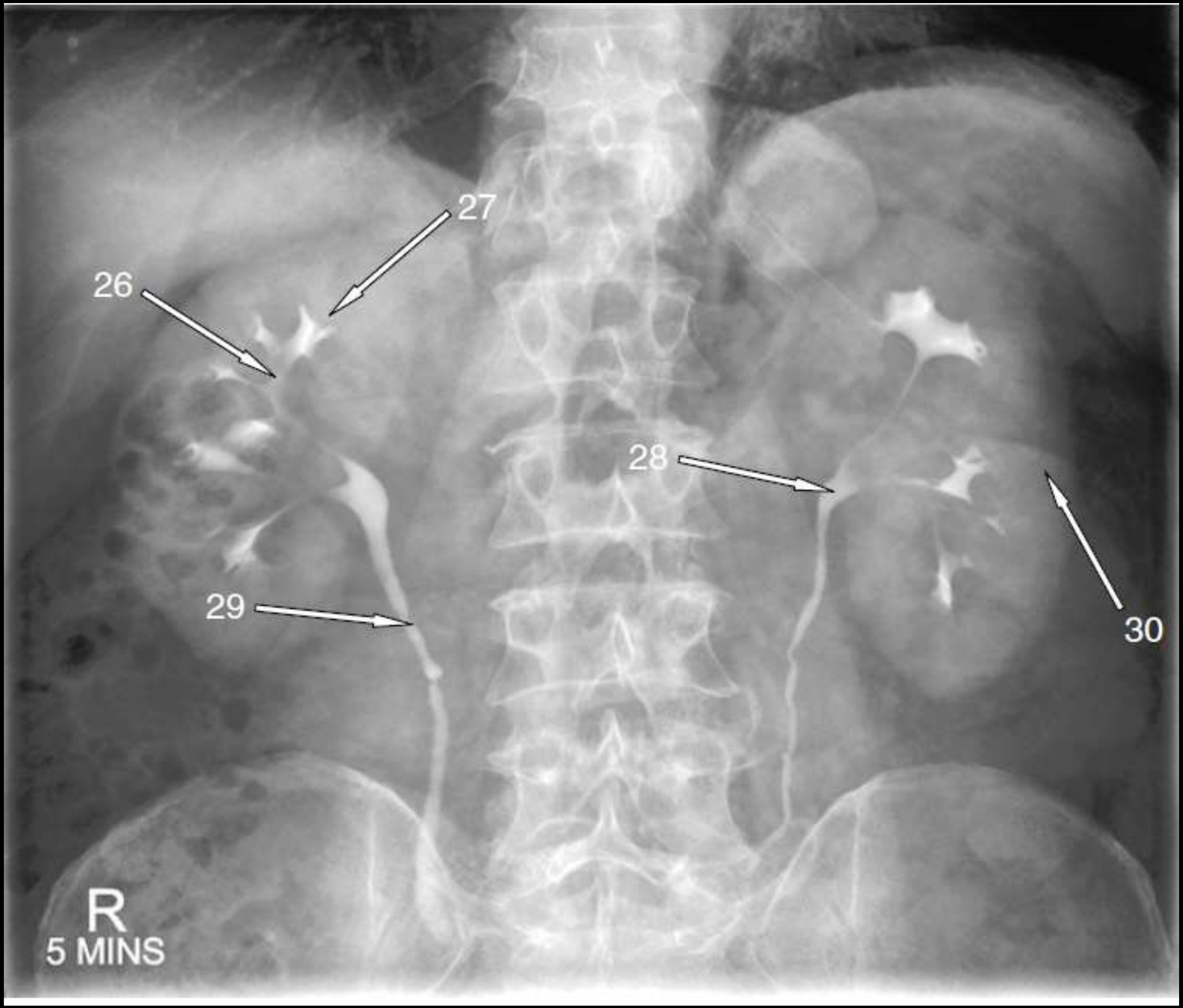
What anatomical variant is present?



IVU

61. Right major calyx (upper pole)
62. Left ureter
63. Left vesicoureteric junction
64. Right sacroiliac joint
65. Horseshoe kidney

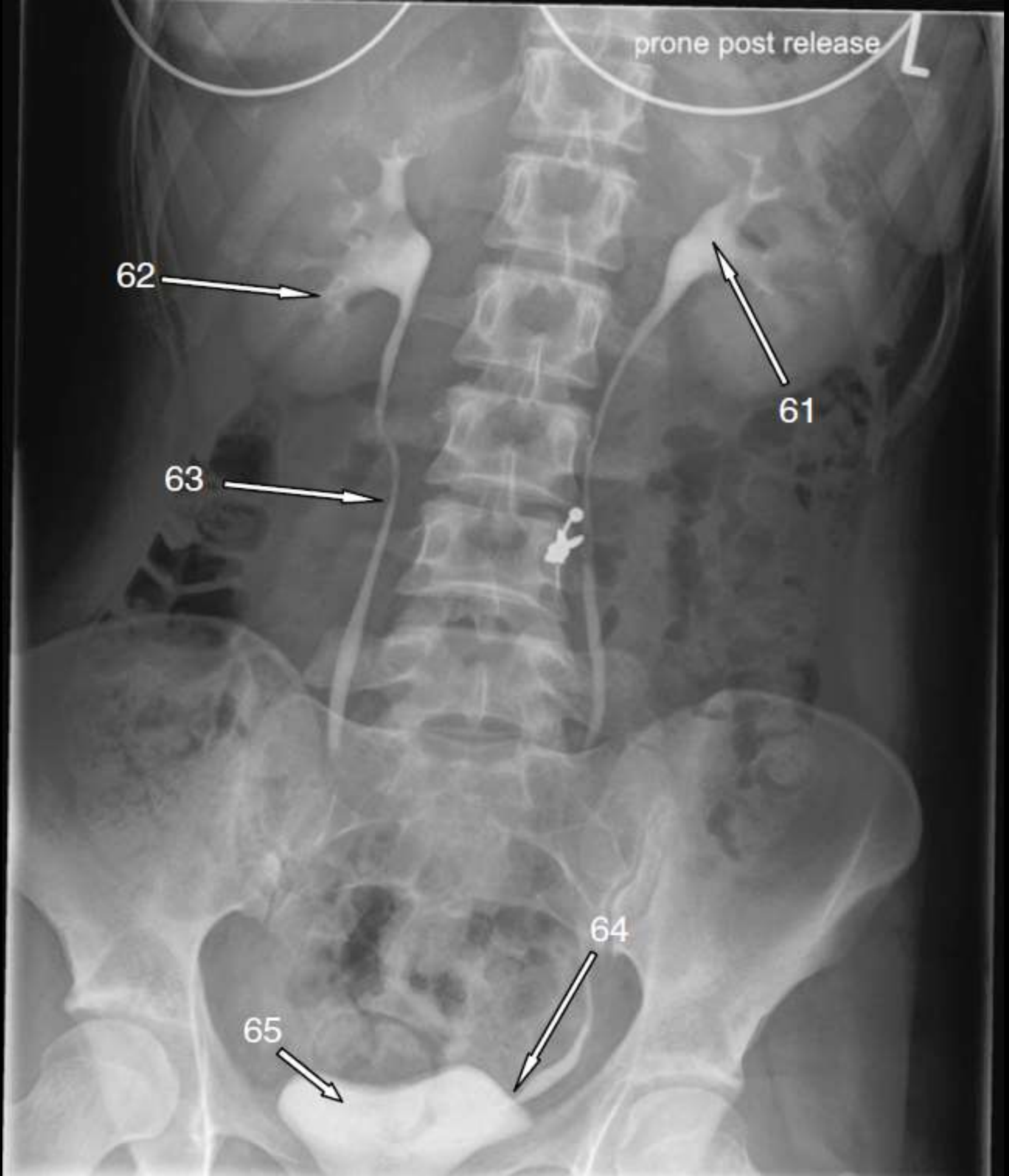
Horseshoe kidney is the most common renal fusion anomaly. In 90 % of cases fusion occurs at the lower pole (as in this example). Note the malrotated collecting systems (renal pelvis laterally, calyces medially).


27
26
28
29
30
R
5 MINS

IVU

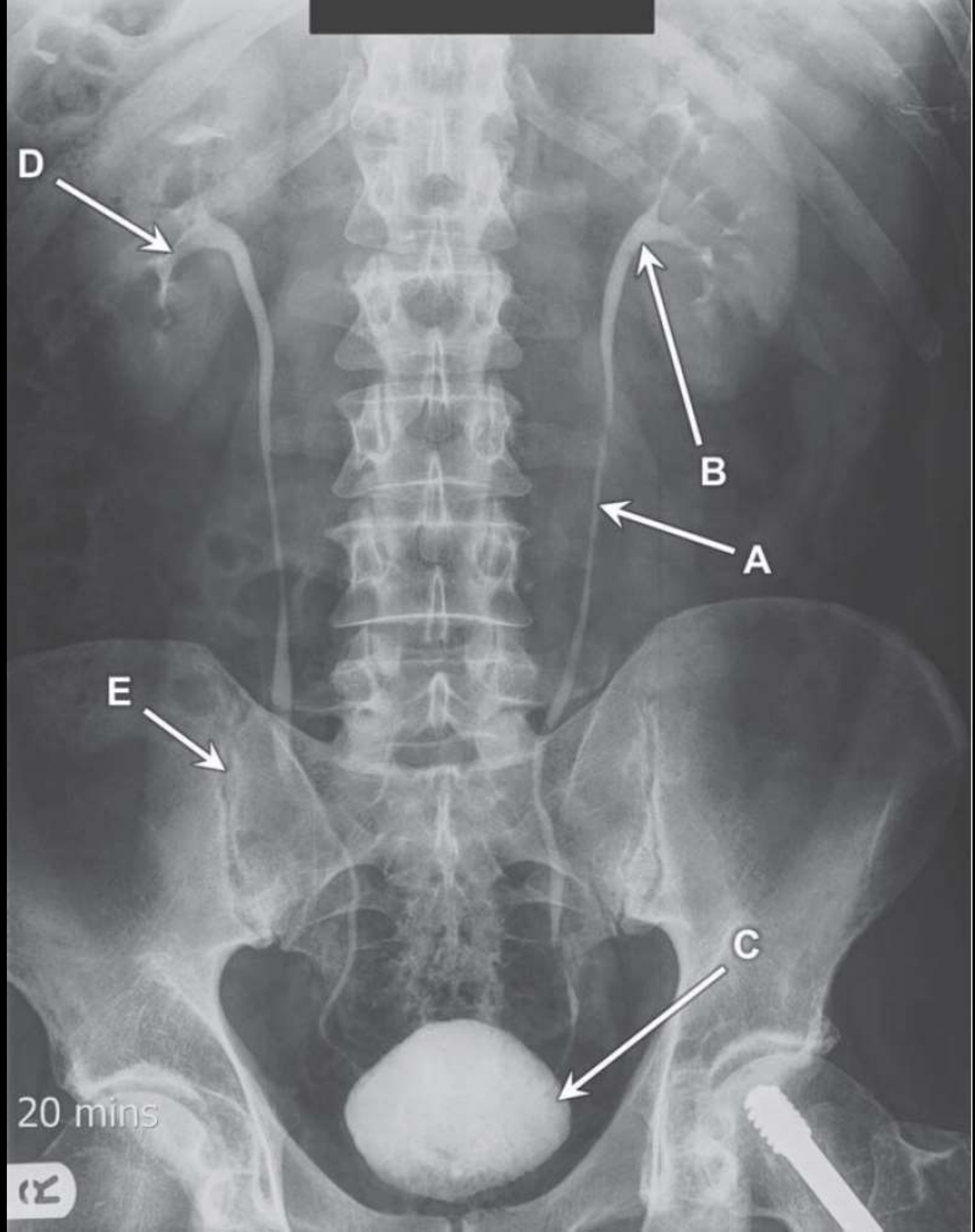
26. Right minor calyx (upper pole)
27. Right renal papilla
28. Left renal pelvis
29. Right ureter
30. Left renal cortex

The renal papilla drains into a minor calyx which then drains into a major calyx, which in turn drains into the renal pelvis.


prone post release
L
62
61
63
64
65

IVU

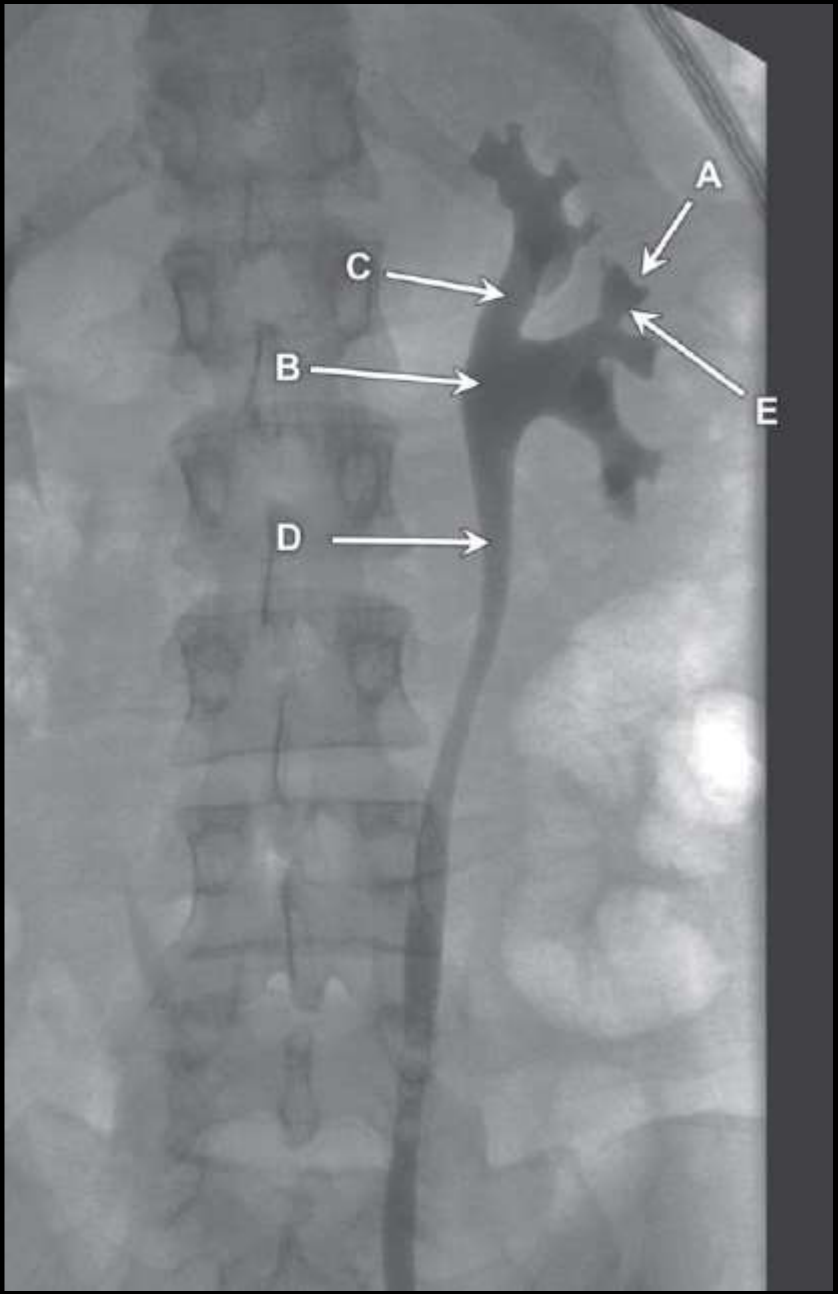
61. Left renal pelvis
62. Right inferior pole – minor calyx
63. Right ureter
64. Left vesicoureteric junction
65. Urinary bladder


D
B
A
E
C
20 mins

Case 12

Intravenous urogram, 20-minute radiograph.

1. Left ureter
2. Left renal pelvis
3. Urinary bladder
4. Right lower pole (major) calyx
5. Right sacroiliac joint

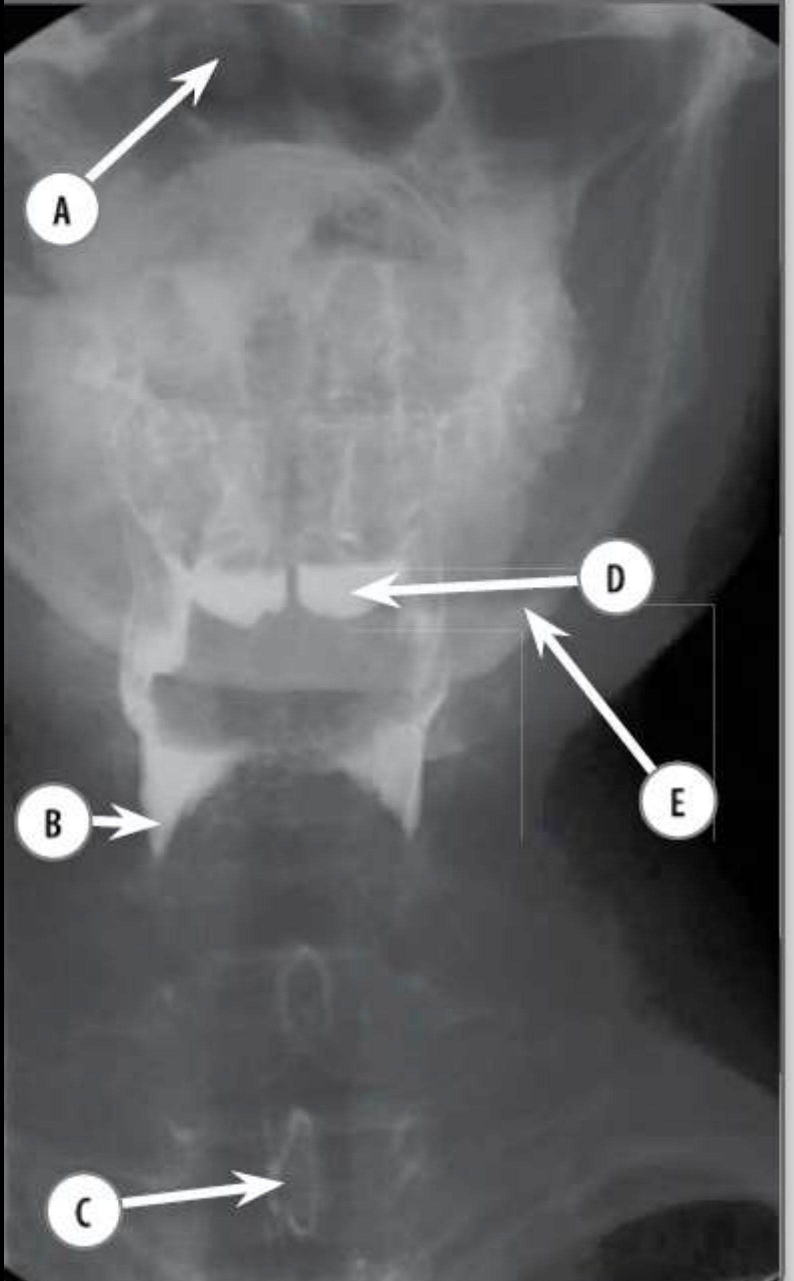

A
C
B
E
D

Case 10

Nephrogram, left kidney.

1. Renal papilla
2. Renal pelvis
3. Major calyx (upper pole)
4. Ureter
5. Minor calyx

Case 3.1



Case 3.1

A Right inferior nasal turbinate

B Right piriform fossa

C Spinous process T1

D Left vallecula

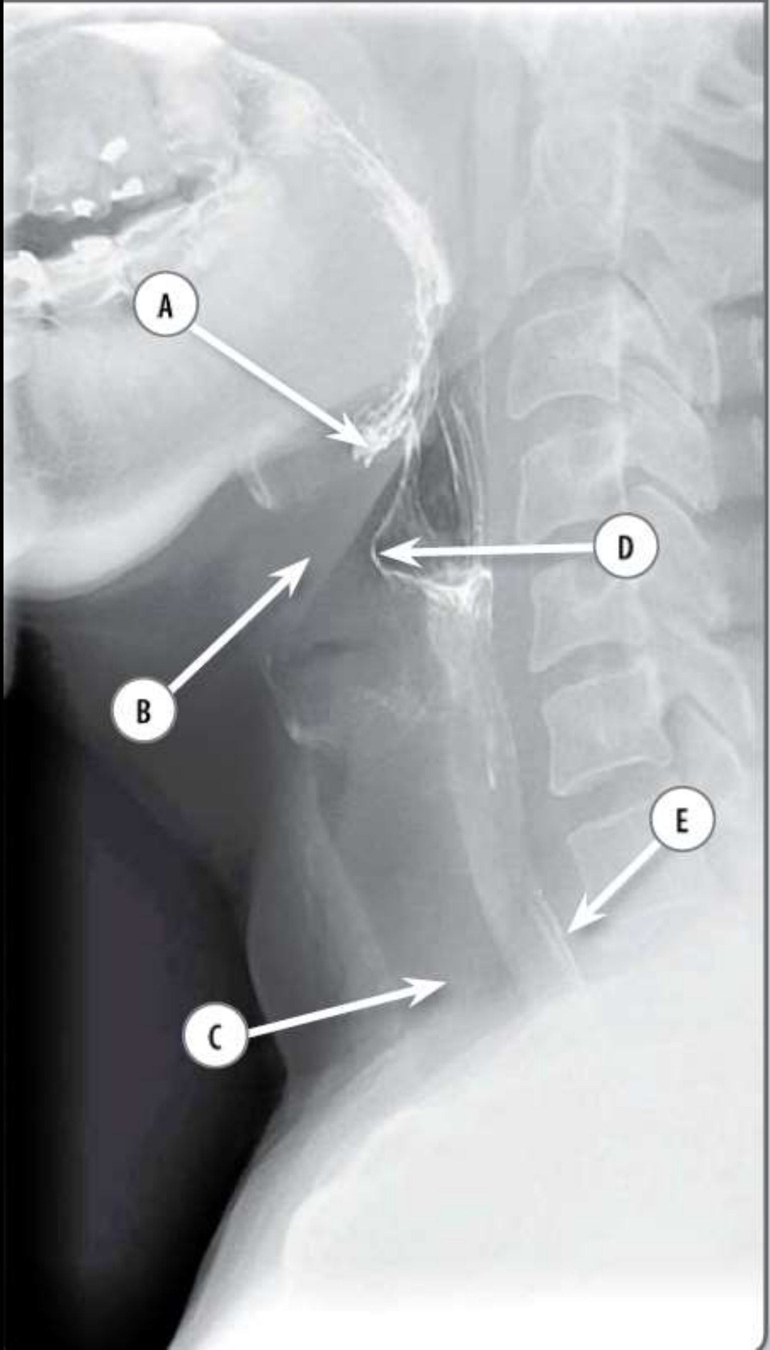
E Left body of mandible

Fluoroscopic image from a barium swallow taken in a frontal projection.

The valleculae are two shallow depressions formed by mucosal folds between the base of the tongue and the epiglottis. They are separated by the median glosso-epiglottic fold, and are bounded laterally by the lateral glosso-epiglottic folds. The piriform, fossae are located between the aryepiglottic folds and the thyroid cartilage on either side. These structures can be examined dynamically during a barium swallow.

Sinnatamby C. Last's Anatomy: Regional and Applied. London: Churchill Livingstone, 2011: 402.
Butler P, Mitchell AM, Ellis H. Applied Radiological Anatomy. Cambridge: Cambridge University Press, 1999: 112.

Case 3.2



Case 3.2

A Vallecula

B Epiglottis

C Trachea

D Piriform fossa

E Cervical oesophagus

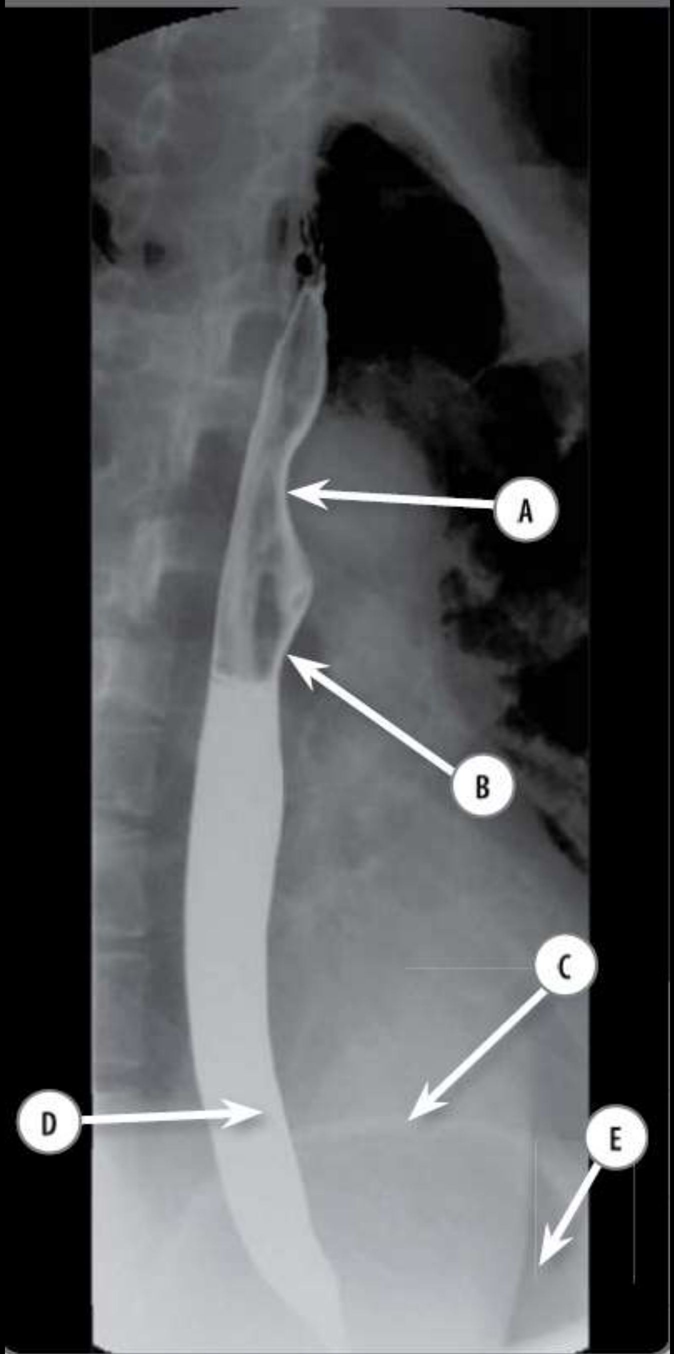
Lateral view of a barium swallow.

The epiglottis is attached at its base to the thyroid cartilage, along with the anterior aspect of the vocal cords. From here, it projects upwards behind the base of the tongue. Its function is to direct boluses of food into the piriform fossae at either side, thus protecting the airway during swallowing. The valleculae are two paired recesses found within the glossoepiglottic folds, which extend from the base of the tongue to the anterior surface of the epiglottis. These structures are made up of three mucosal folds – two lateral glossoepiglottic folds and a central one.

The larynx is separated from the piriform fossae by the aryepiglottic folds, which run from the lateral margin of the epiglottis to the arytenoid cartilages posteriorly.

Ryan S, McNicholas M, Eustace SJ. Anatomy for Diagnostic Imaging, 3rd edn. Edinburgh: Saunders, 2011: 38–39.

Case 3.3



Case 3.3

A Oesophageal impression from aortic knuckle

B Oesophageal impression from left main bronchus

C Left hemi-diaphragm

D Lower third of the oesophagus, distended with barium

E Gas within the gastric fundus

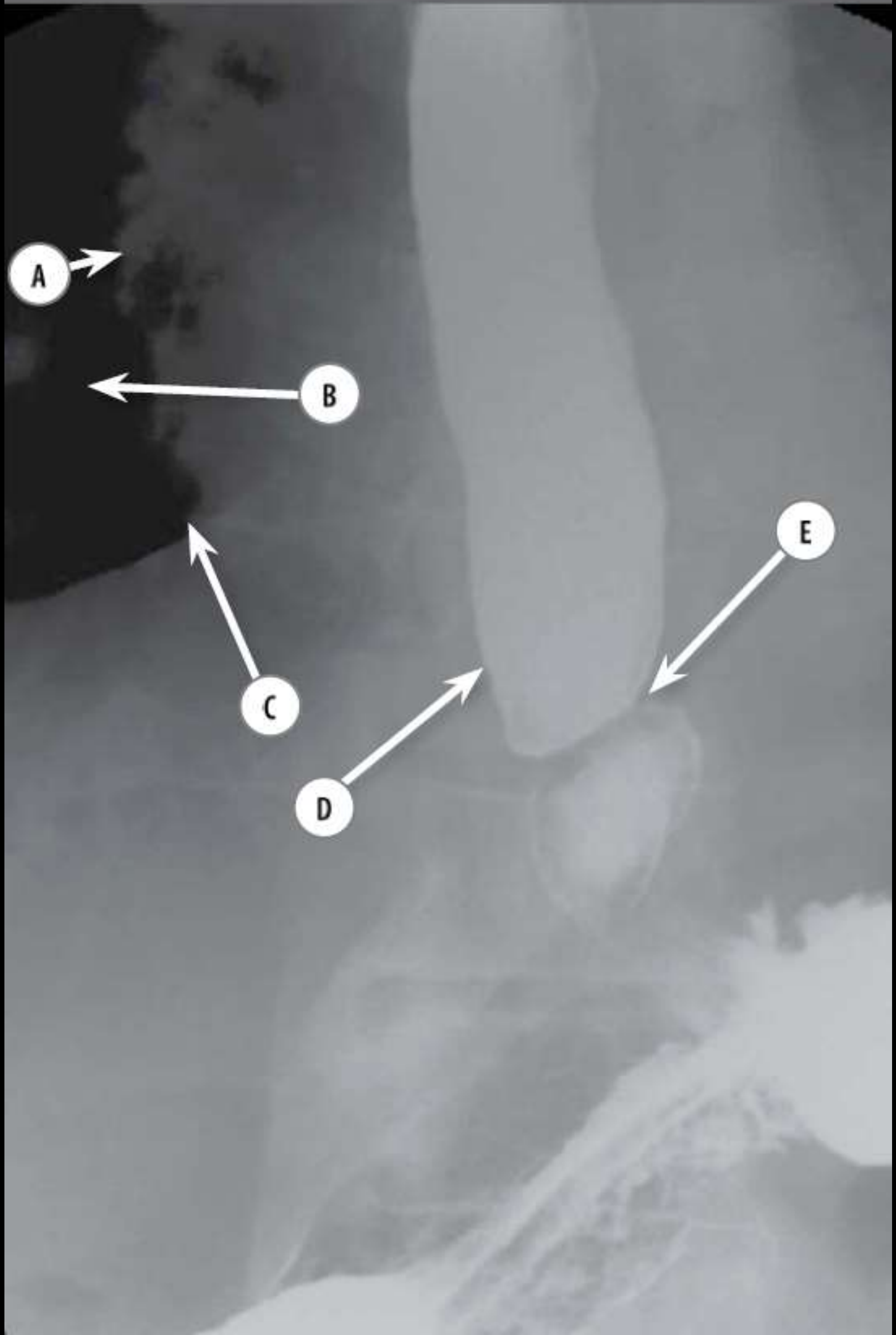
Fluoroscopic image from a barium swallow in a right anterior oblique position.

There are three normal anatomical structures which cause an impression on the anterior aspect of the oesophagus:

- Most cranially, there is an impression from the aortic knuckle – this is seen as a soft tissue density on the image – causing a smooth indentation of the upper oesophagus.
- Below this is a second impression from the left main bronchus. This is identifiable as an ovoid lucency to the left of the oesophagus.
- Lastly, the left sided cardiac chambers can cause an impression on the anterior aspect of the oesophagus in its distal portion. The most posterior cardiac chamber is the left atrium, which lies just anterior to the oesophagus. Enlargement of this chamber can cause dysphagia.

Ryan S, McNicholas M, Eustace SJ. Anatomy for Diagnostic Imaging, 3rd edn. Edinburgh: Saunders, 2011: 144.

Case 3.4



Case 3.4

A Right heart border/right atrium

B Right lung base

C Right cardio-phrenic angle

D Oesophageal vestibule

E B ring/Schatzki ring/transverse mucosal fold

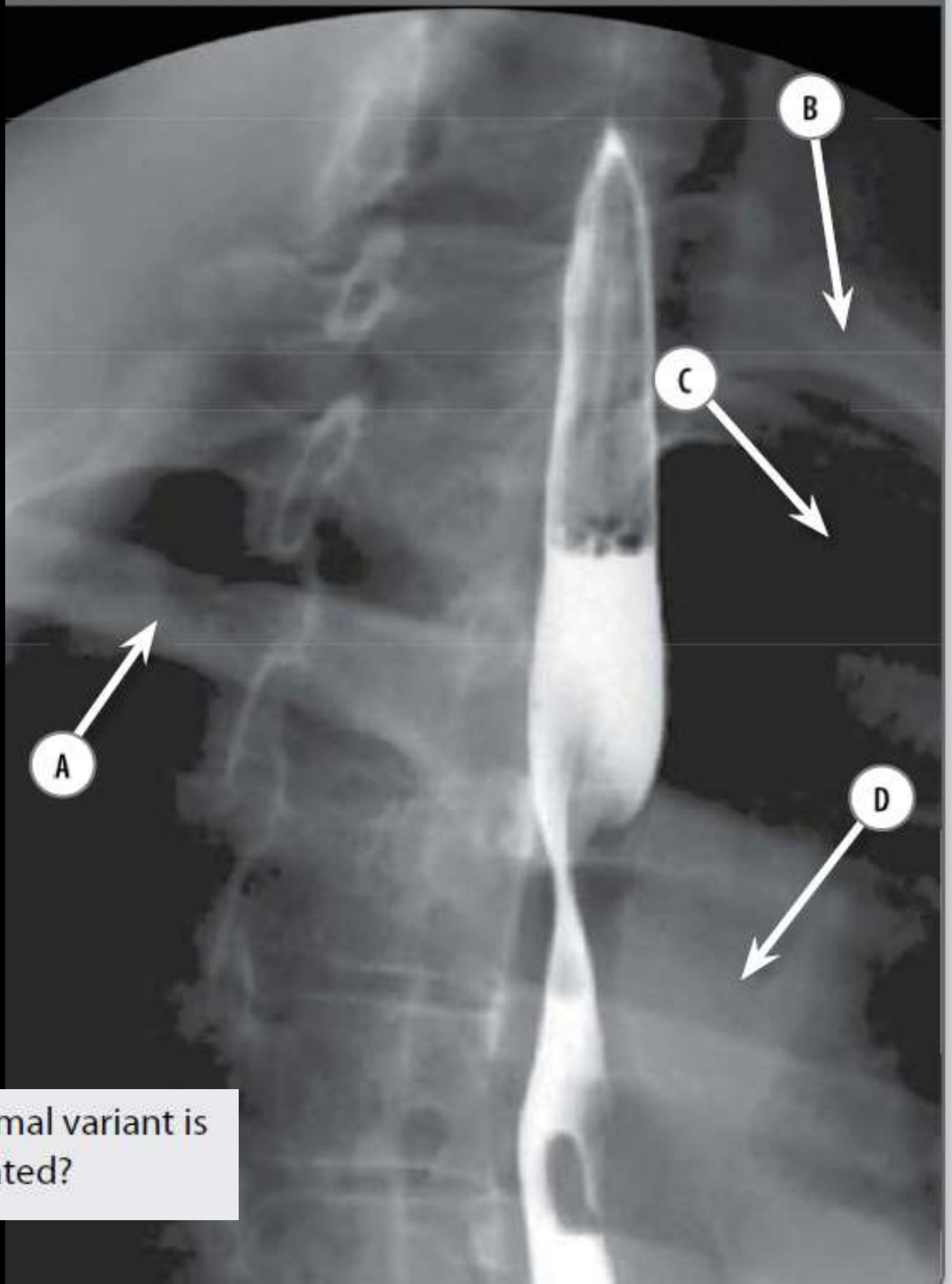
Fluoroscopic image taken from a barium swallow in a right anterior oblique position.

At the distal oesophagus, there is a focal dilatation just proximal to the gastro-oesophageal junction – this is known as the oesophageal vestibule or phrenic ampulla. The upper border of the vestibule is known as the 'A' ring, and the lower border the 'B' ring, Schatzki ring, or transverse mucosal fold. The 'B' ring marks the junction between the squamous epithelium of the oesophagus and columnar epithelium of the stomach. This mucosal change can sometimes be appreciated as a faint line on barium swallow, which is known as the 'Z' line.

B rings are composed of mucosa and submucosa, and are approximately 2–3 mm thick. They are usually located below the diaphragm, and therefore are typically only visualised in the presence of a small hiatal hernia, as demonstrated on this image.

Butler P, Mitchell AM, Ellis H. Applied Radiological Anatomy. Cambridge: Cambridge University Press, 1999: 211.

Case 3.5



E Which normal variant is demonstrated?

Case 3.5

A Right clavicle

B Left 1st rib

C Left lung apex

D Aortic knuckle

E Aberrant right subclavian artery

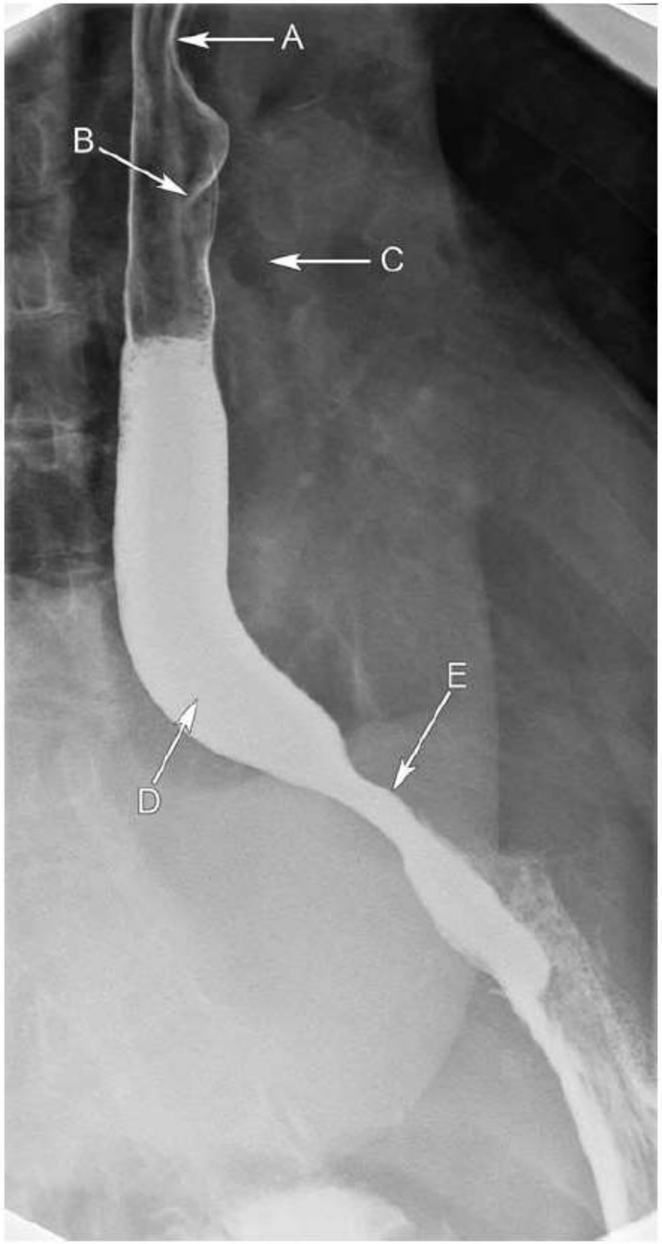
Fluoroscopic image from a barium swallow in a right anterior oblique position.

This study demonstrates the presence of an aberrant right subclavian artery. This is the commonest congenital anomaly of the great vessels. With a left sided aortic arch, the right subclavian artery arises as the last branch from the arch. It then takes an oblique course, rising from left to right, crossing behind the oesophagus as it does so. It therefore causes a posterior impression on the oesophagus at barium swallow. The displacement of the oesophagus by the aberrant vessel is said to produce a 'bayonet deformity'.

There are three normal anatomical impressions on the oesophagus that can be seen at barium swallow. These are seen anteriorly and to the left and are caused by the aortic arch, the left main bronchus, and the heart (left atrium). An aberrant right subclavian artery should therefore be differentiated from these normal impressions. On this image, the subclavian artery is seen to cause an oblique impression just above the aortic knuckle, passing from left to right.

Freed K, Low VH. The aberrant subclavian artery. Am J Roentgenol 1997; 168: 481–484.
Butler P, Mitchell AM, Ellis H. Applied Radiological Anatomy. Cambridge: Cambridge University Press, 1999: 210.

Question 5.13



A What structure makes this impression?
B What structure makes this impression?
Name the structures labelled C to E.

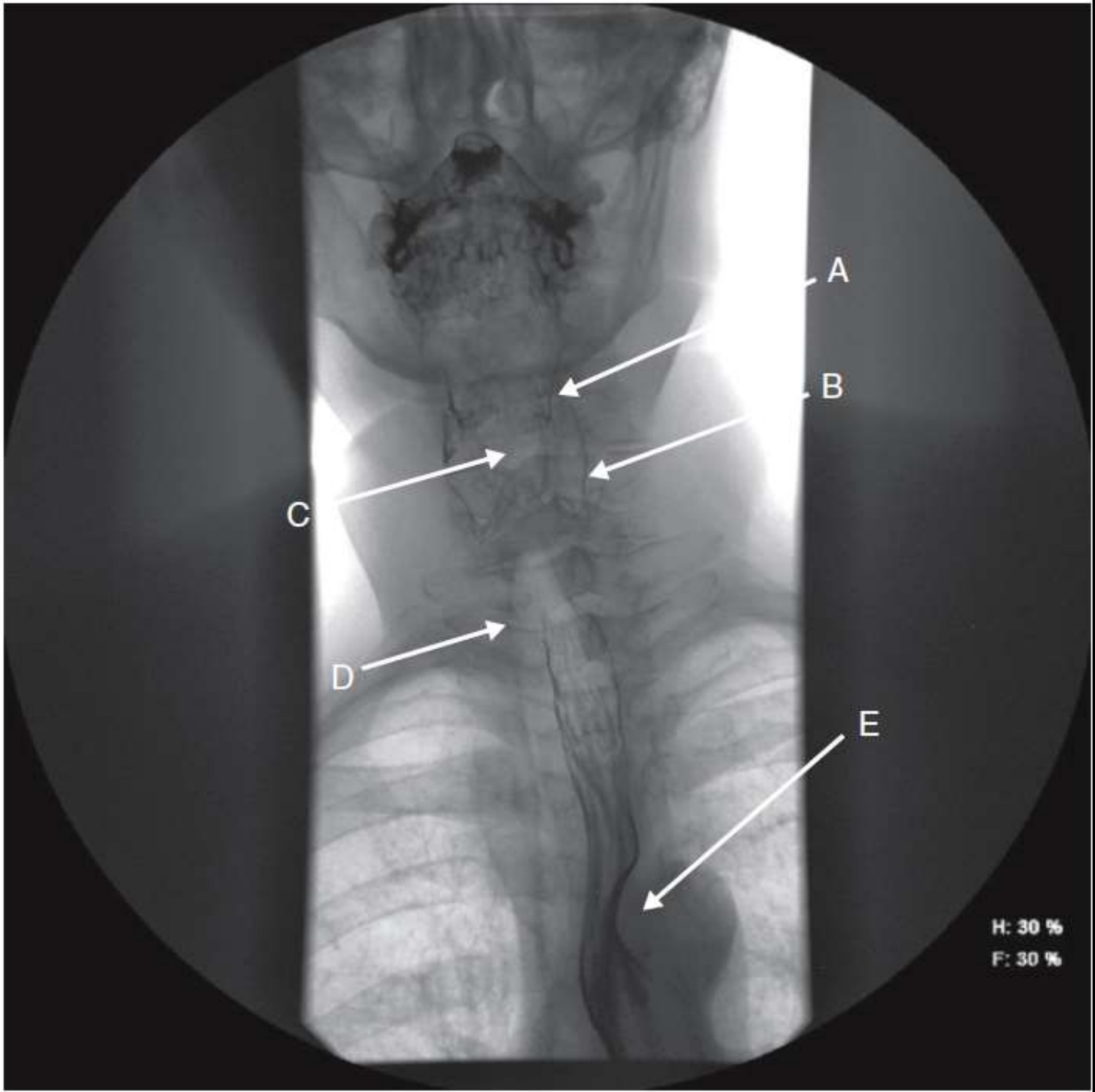
5.13 Barium swallow

A Impression of the arch of the aorta.
B Impression of the left main bronchus.
C Left main bronchus.
D Distal oesophagus.
E Gastro-oesophageal junction.

There are two normal indentations in the anterior and lateral aspect of the thoracic oesophagus. The most superior is the impression of the aortic arch, which often becomes more prominent with age. Just distal to this is the indentation caused by the left main bronchus. In 10% of patients the left inferior pulmonary vein causes an anterior indentation about 5 cm below the carina. Other extrinsic compressions on the thoracic aorta can indicate the presence of anatomical variants and abnormalities. Examples of these include a right-sided or double aortic arch, an aberrant subclavian artery and vascular rings.

- **Right-sided aortic arch**: right oesophageal impression, absent normal left arch impression.
- **Double aortic arch**: impression on the right and left side of the oesophagus, slightly higher and larger on the right. Described as characteristic 'reverse S-shaped indentation'.
- **Aberrant right subclavian artery**: posterior oesophageal indentation, obliquely upward to the right on AP views (see Question 4.3).
- **Aberrant left pulmonary artery**: anterior oesophageal impression.

Case 3.7

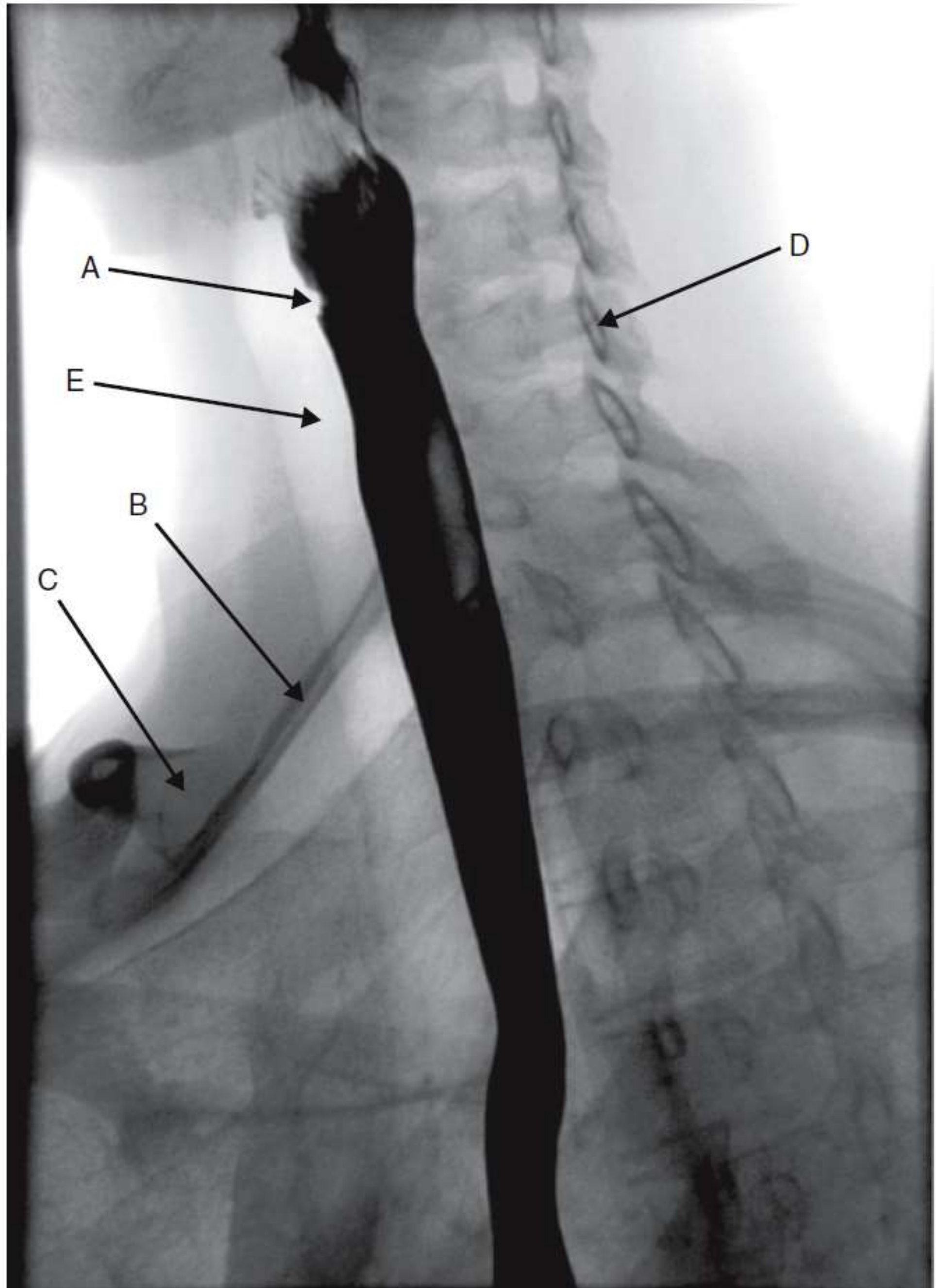


3.7 Barium swallow

(a) Vallecula. The valleculae are paired depressions situated either side of the median glossoepiglottic fold. They separate the epiglottis from the base of the tongue and serve to hold saliva before the swallowing reflex commences.
(b) Piriform fossa. This is a recess bounded medially by the aryepiglottic fold and laterally by the thyroid cartilage. The internal branch of the superior laryngeal nerve is located immediately deep to the mucosa in this region. Fish bones can become lodged in this area.
(c) Laryngeal vestibule. This forms the opening into the larynx and is located above the vestibular folds (false cords).
(d) Air in the trachea. The trachea extends from the lower part of the larynx, level with the sixth cervical vertebra, to the upper border of the fifth thoracic vertebra. It is a midline structure but passes inferiorly to lie just to the right of midline at the level of the aortic arch (T4).
(e) Aortic arch impression.

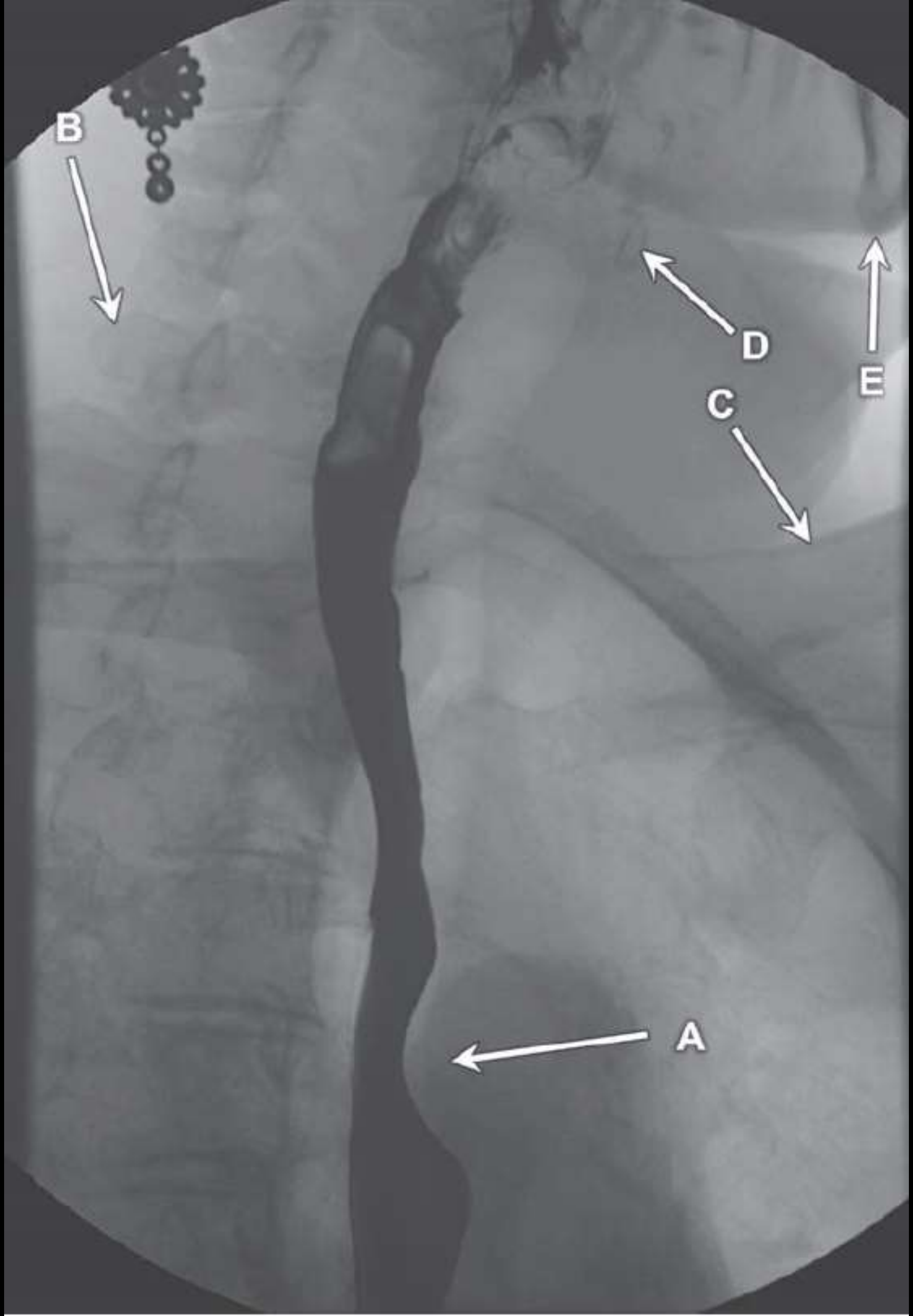
There are three sites of natural oesophageal indentation which include the aortic arch (T4 level), the left main bronchus (T5 level) where the indentation is left-sided and the left atrium. Caustic strictures tend to occur at sites of oesophageal indentation since transit of solids and liquids is slowed at these sites.

Case 2.6



2.6 Barium swallow – oblique view

(a) Post cricoid venous plexus.
(b) First rib.
(c) Clavicle.
(d) Left lamina of C5.
(e) Trachea.

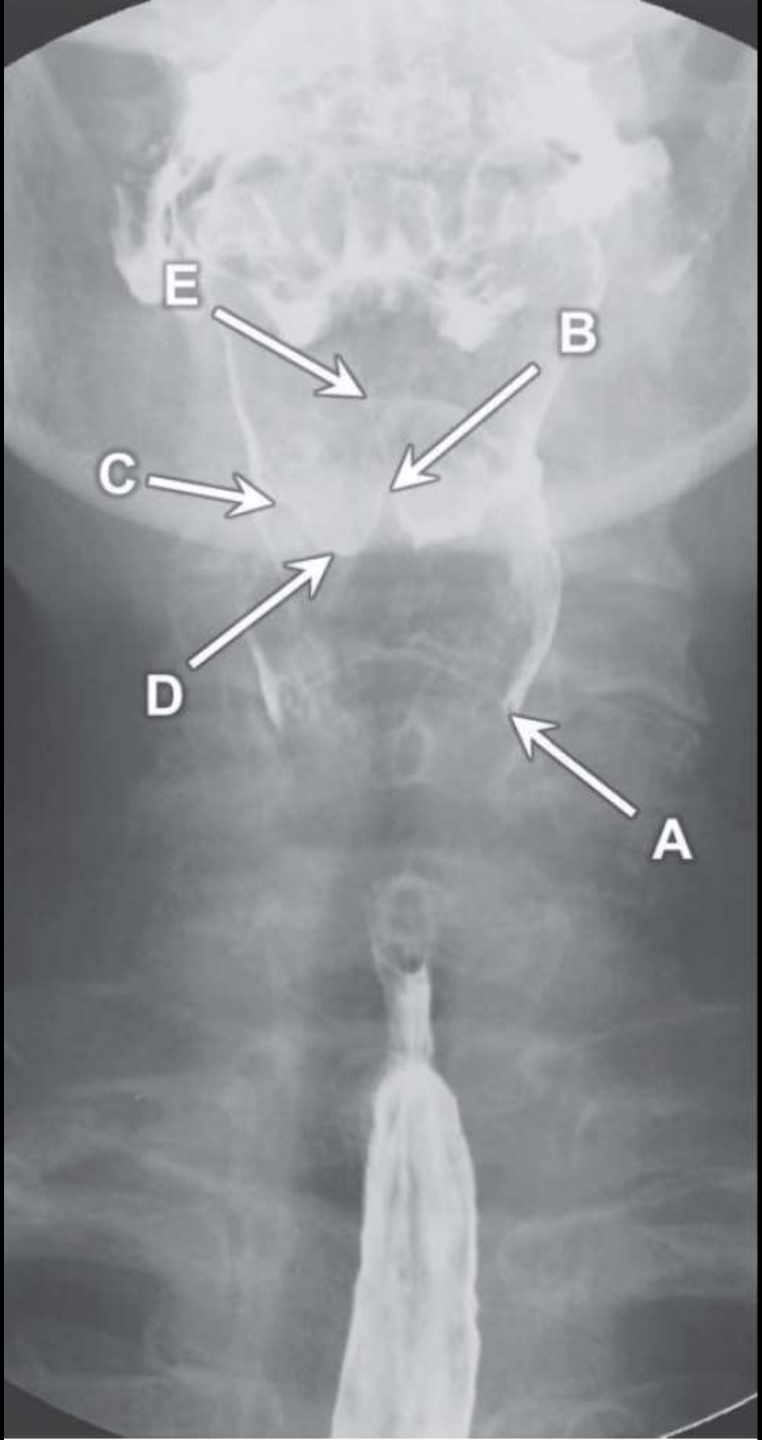

B
D
E
C
A

Case 10

Barium swallow. Oblique 'spot' view of the upper oesophagus.

1. Aortic arch
2. Spinous process of C7 vertebra
3. Left clavicle
4. Thyroid cartilage
5. Mental process of the mandible

Why the left clavicle? The patient is rotated to their left and an oblique view has been taken through their upper chest. The mediastinal structures are projected left of centre. If this were a PA view in the right lateral oblique position, the aortic arch would be on the other side of the image.

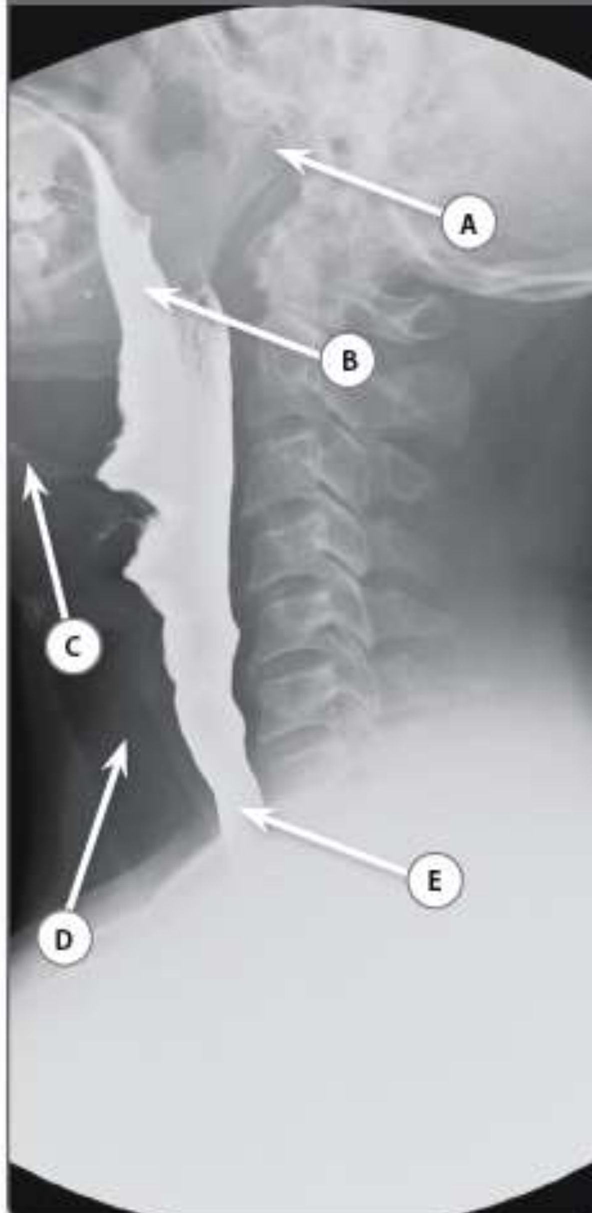

E
B
C
D
A

Case 15

Barium swallow. AP pharyngeal view.

1. Left pyriform sinus
2. Median epiglottic fold
3. Right lateral epiglottic fold
4. Right vallecula
5. Epiglottis

Case 8.5



D	Name the lucent structure labelled D.	

Case 8.5

A Mandibular condyle

B Oropharynx

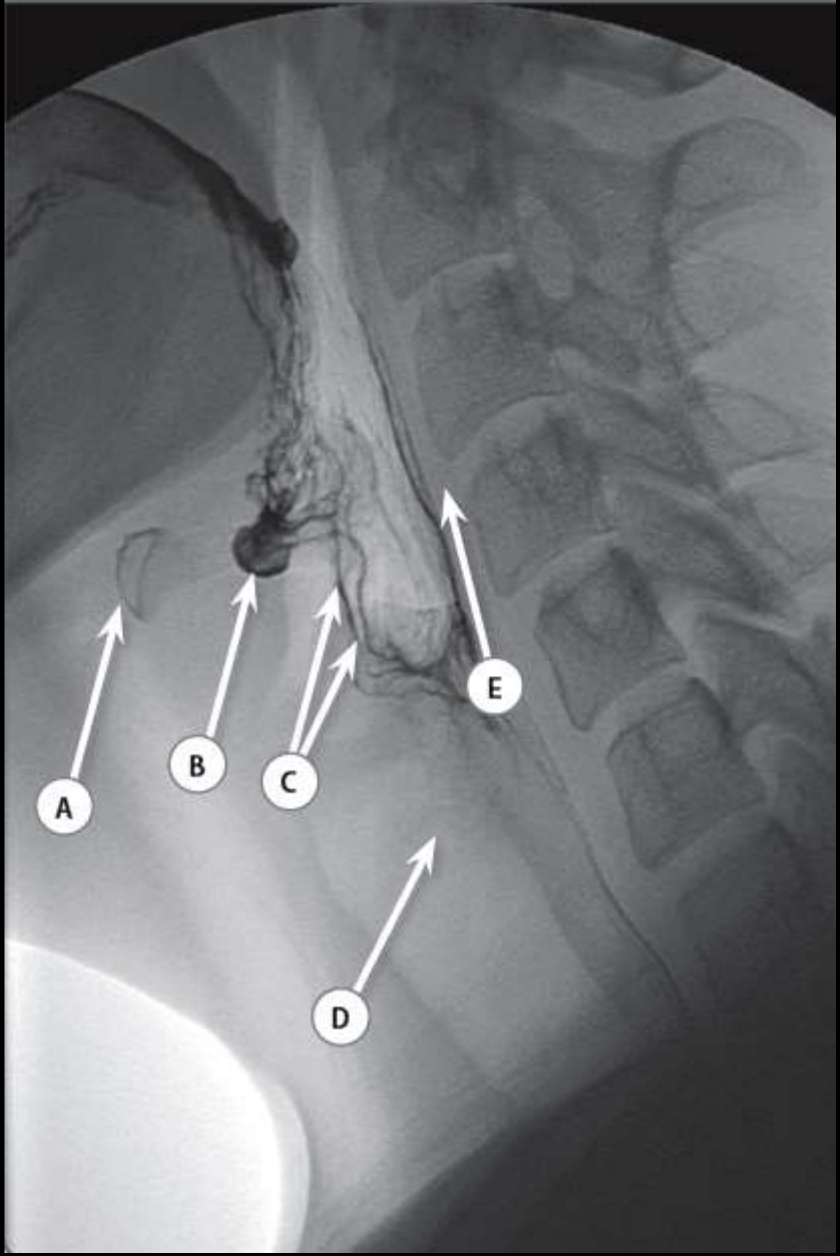
C Hyoid bone

D Trachea

E Oesophagus

The oesophagus is a continuation of the oropharynx. Beginning at the level of C6, it descends posteriorly to the trachea, just anterior to the lower cervical vertebrae (hence osteophytic compression is a not uncommon cause of dysphagia).

Case 12.12



Case 12.12

A Body of the hyoid bone

B Vallecula

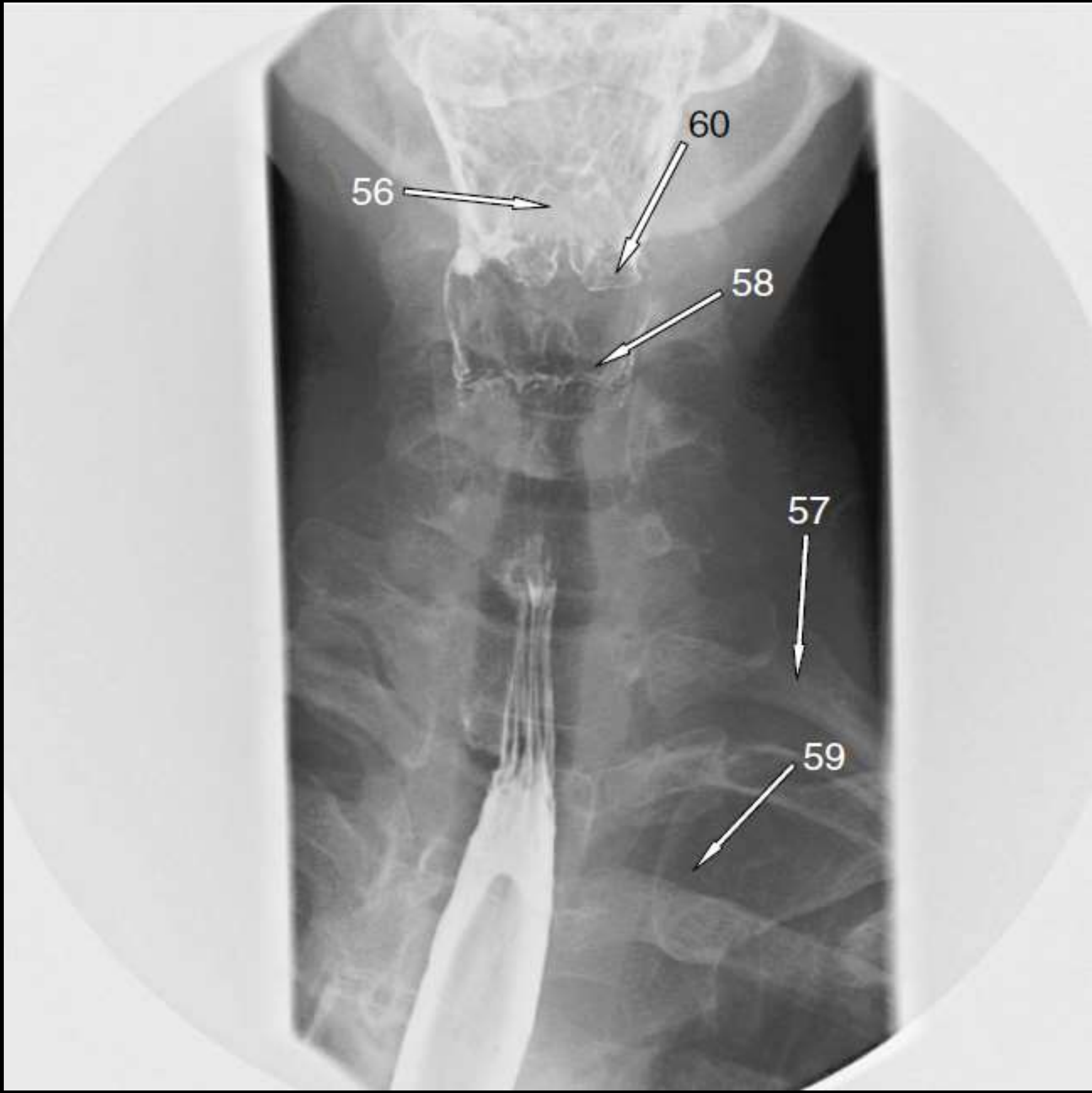
C Piriform fossae

D Trachea

E Retropharyngeal soft tissues

The **hypopharynx** is the most inferior part of the pharynx, extending from the inferior margin of the valleculae to the oesophagus (level of C6 vertebrae).

The **piriform fossa** (from the Latin for 'pear-shaped') is the lateral recess of the hypopharynx at the laryngeal orifice.

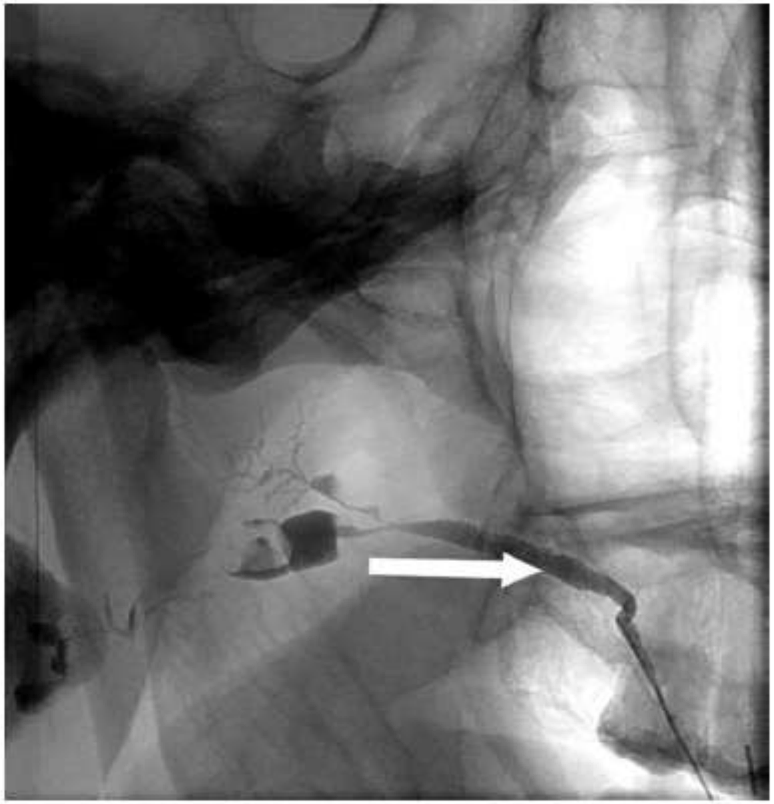

60
56
58
57
59

Barium Swallow (Anterior View Neck)

56. Epiglottis
57. Left first rib
58. Piriform fossa
59. Medial end of left clavicle
60. Valleculae

In the upper part of this image, the en face view of the base of the tongue is seen. The median glossoepiglottic fold crosses from tongue base to epiglottis, dividing the retroglottic space into two cup-shaped valleculae (60).

- **Question 16:**



Question 16: Sialogram

Answer: Parotid (Stensen's) duct

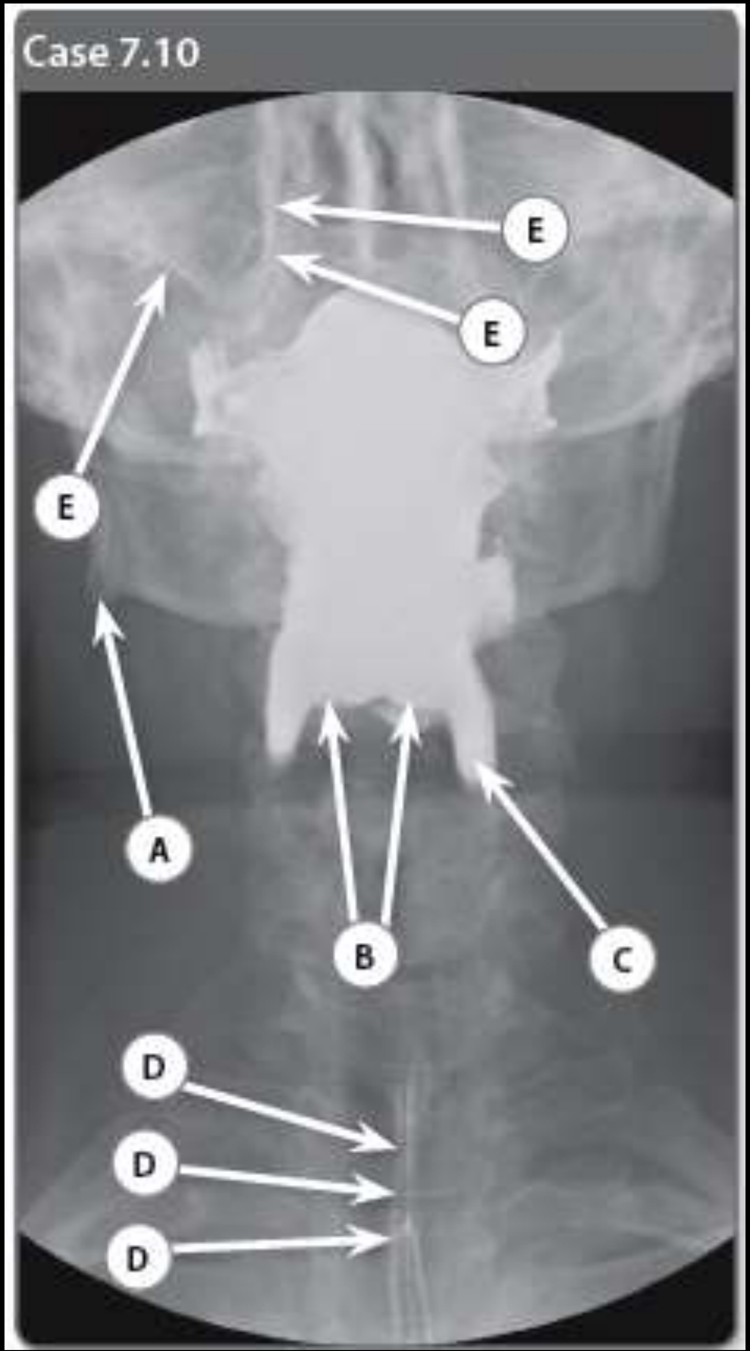
- The parotid duct conveys saliva from the parotid gland into the oral cavity.
- The gland opens out into the mucosal surface of the inner cheek opposite the upper second molar tooth.
- Initially, it is difficult to ascertain what the image shows. Images like this can appear in the examination and the best way to tackle a confusing one is to find recognisable landmarks. If you look carefully, you will see that the mandibular condyle can be discerned on the left side of the image, and teeth can be seen at the bottom right-hand corner.
- By finding these landmarks, you will be guided as to which body part is being shown.

■ Question 48:

Question 48: Barium swallow

Answer: Left pyriform sinus

- The pyriform sinuses are a pair of deep recesses that lie on either side of the laryngeal orifice.
- They are bounded laterally by the thyroid cartilage.
- The valleculae can be seen superior to the pyriform sinuses.



A	Name the structure labelled A.
B	What structure is causing the impression labelled B?
C	Name the structure labelled C.
D	Name the structure labelled D.
E	Name the structure labelled E.

Case 7.10

A Angle of right mandible

B Epiglottis

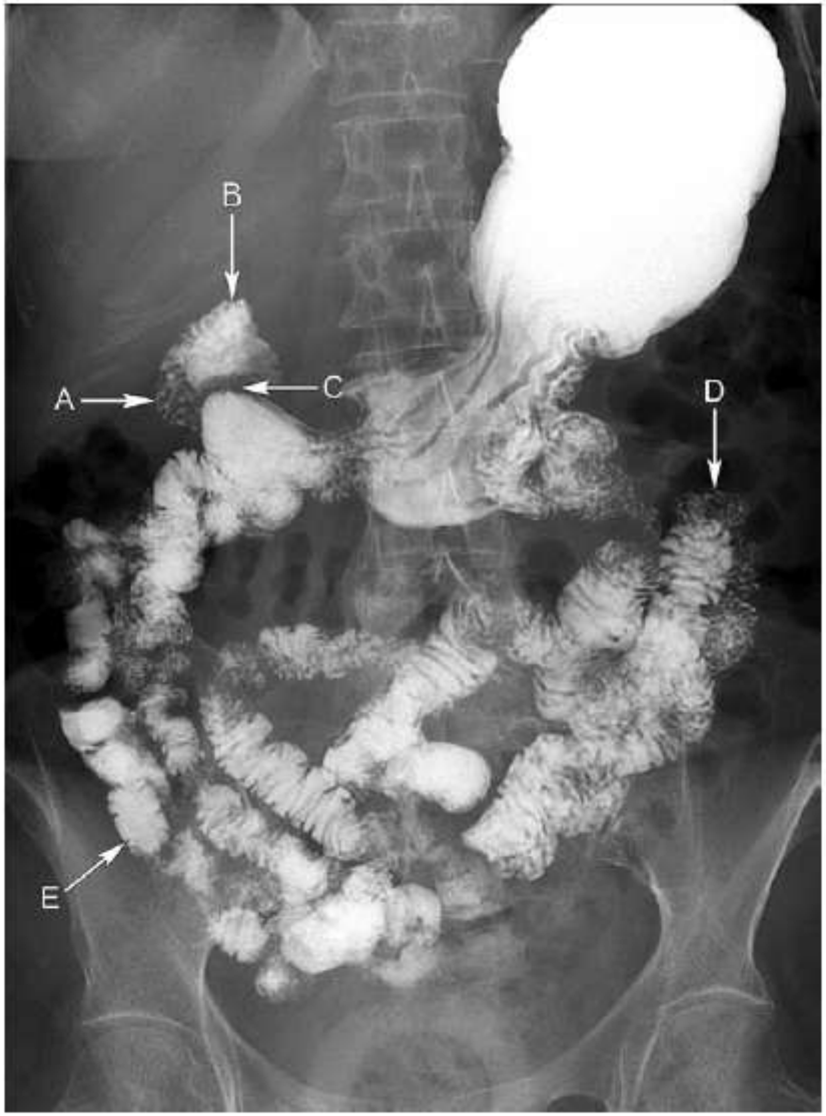
C Left piriform recess

D Oesophagus

E Right maxillary sinus

The pharynx consists of three parts (from superior to inferior): nasopharynx; oropharynx; and laryngopharynx (hypopharynx). The latter two parts are shown filled with barium in this image. The laryngopharynx extends from the tip of the epiglottis to the point at which the pharynx becomes the oesophagus (at the level of the C6 vertebra). The piriform recesses are parts of the laryngopharynx and pass laterally to the larynx.

Question 1.14



Name the structures labelled **A** to **E**.

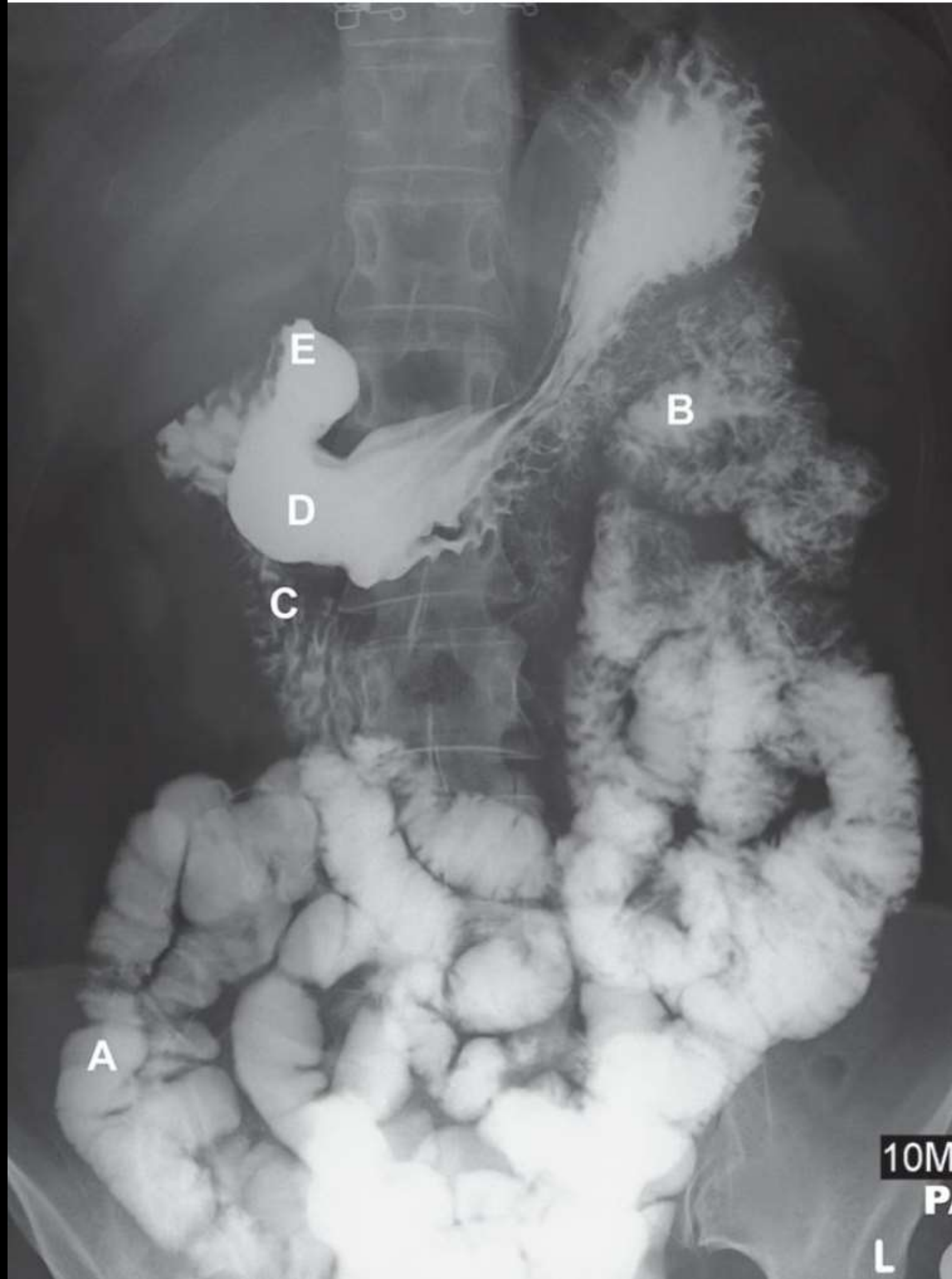
1.14 Barium follow-through

A Second part of the duodenum.
B Duodenal cap.
C Pylorus of the stomach.
D Jejunum.
E Distal ileum.

The duodenum is composed of four parts: it connects the stomach to the jejunum, beginning at the duodenal cap and ending at the duodenal jejunal (DJ) flexure, where it is supported by the ligament of Treitz. The DJ flexure normally lies to the left of the midline in the transpyloric plane, and its location is important in the diagnosis of malrotation of the small bowel. The first three parts of the duodenum form a 'C' shape, within which the head of the pancreas lies within the concavity of the 'C'. The pancreatic and common bile ducts enter into the ampulla of Vater in the second part of the duodenum. Only the proximal aspect of the first part of the duodenum is intraperitoneal with the remainder of the duodenum in the retroperitoneal space.

The proximal two-fifths of the small intestine are called the jejunum and the distal three-fifths, the ileum. They can be distinguished on a barium follow-through by:

- Location (the jejunum is found in the left upper abdomen).
- Mucosal folds (thicker and more prominent valvulae conniventes in the jejunum).
- Lymphoid follicles or Peyer's patches (more numerous in the ileum).


E
B
D
C
A
10M
PA
L

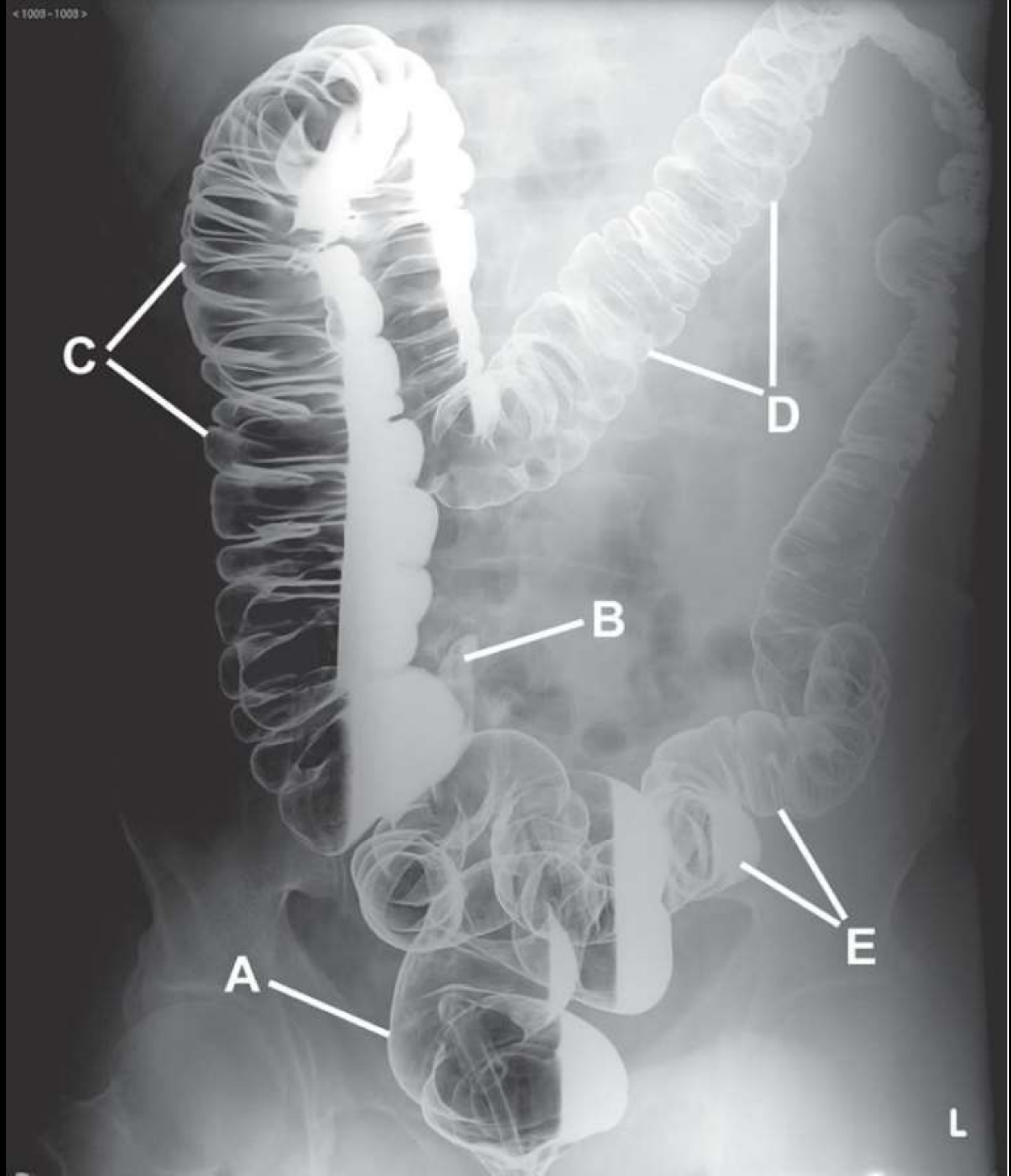
Q5 Answers

a Ileum
b Jejunum
c Descending/second part of duodenum
d Gastric (pyloric) antrum
e Duodenal cap

Barium small bowel follow-through examination

The antrum of the stomach is the area distal to the incisura on the lesser curve and narrows to form the pyloric canal. The duodenum, which is mainly retroperitoneal, is roughly 'C'-shaped with the concavity to the left and is described in four parts. The first part of the duodenum travels posteriorly and superiorly to vertebral level L1, making it appear shortened in a frontal projection. Mucosal folds are thin and lie in a parallel or spiral configuration. The duodenal cap is the proximal 2.5cm of duodenum, which lies between the peritoneal folds of the greater and lesser omenta and forms the inferior boundary of the opening into the lesser sac (epiploic foramen). The second part of the duodenum runs inferiorly to vertebral level L3, and is where circular valvulae conniventes of small bowel begin properly. A longitudinal duodenal fold may be seen which marks the position of the ampulla (of Vater). The third part travels horizontally and the fourth part ascends to vertebral level L2 where it passes out from behind the peritoneum to become the jejunum at the duodenal-jejunal flexure. The ligament of Treitz is a thin musculofibrous suspensory band that connects the fourth part of the duodenum with the right diaphragmatic crus.

The proximal two-fifths of the small bowel is called the jejunum, the distal three-fifths the ileum. When compared to the ileum, the jejunum is usually of wider caliber, with a thicker wall and thicker, more numerous valvulae conniventes. The jejunum is usually positioned in the upper left abdomen, while the ileum lies in the lower right abdomen. In barium studies, the jejunum often shows a 'feathery' mucosal pattern, compared to a more solid and featureless appearance of the ileum.


C
D
B
E
A
L

Q7 Answers

a Rectum
b Appendix
c Ascending colon
d Transverse colon
e Sigmoid colon

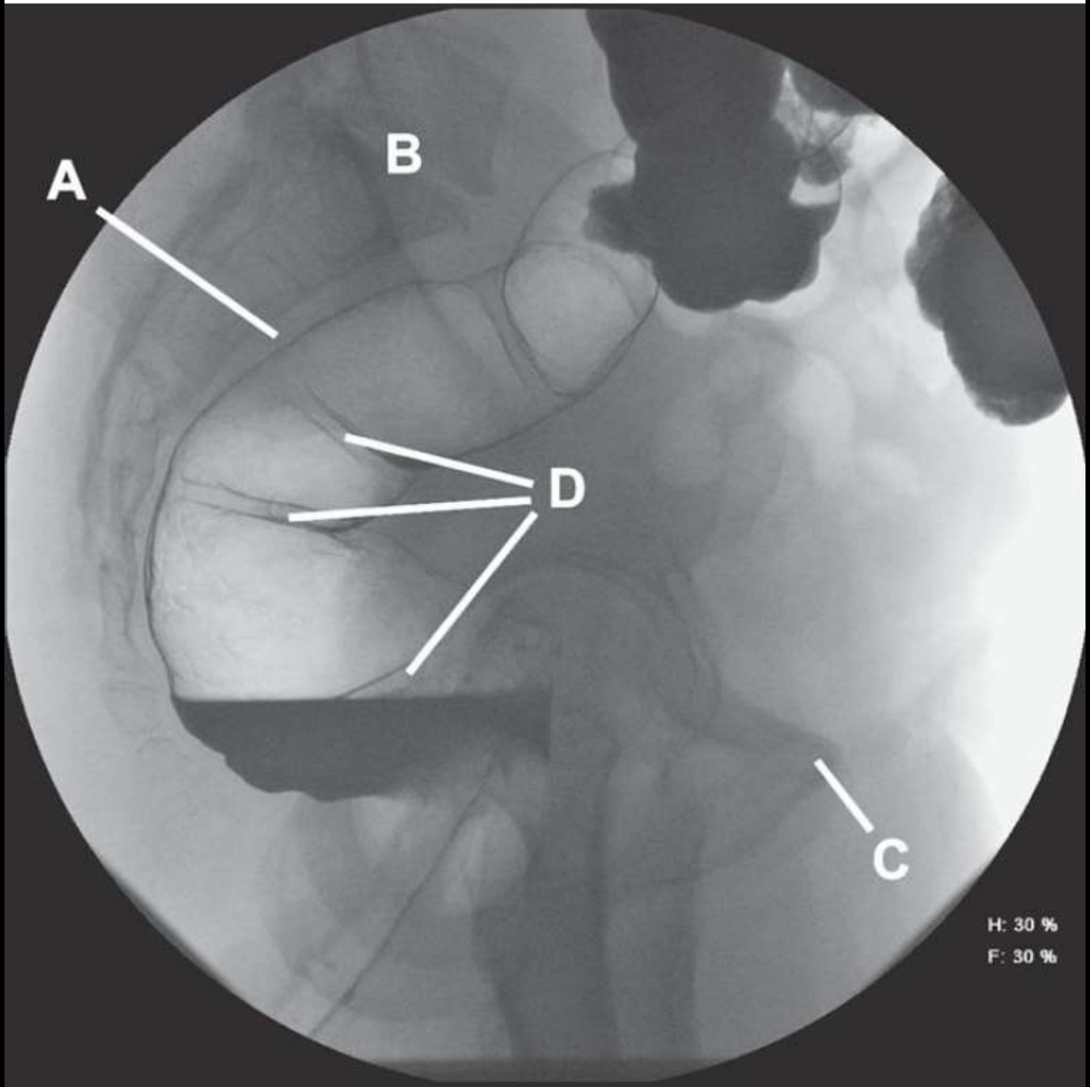
Full length radiograph from a barium enema examination, frontal view

The large intestine consists of eight parts which, from proximal to distal, are: caecum, vermiform appendix, ascending colon, transverse colon, descending colon, sigmoid colon, rectum and anal canal.

The caecum is the blind-ended pouch of the colon just distal to the ileocaecal valve. It is covered with peritoneum which is reflected downwards to the floor of the right iliac fossa and determines both the mobility of the caecum and size of the retrocaecal space. The ascending and descending colon are invested in peritoneum and are relatively immobile. The transverse and sigmoid colon are invested in their own mesentery (or mesocolon), as is the appendix which arises from the posterior aspect of the caecum. These three are therefore the most mobile parts of the large intestine. The rectum is covered on its upper third by peritoneum. Deep to the peritoneal reflection, the rectum is surrounded by pelvic visceral fat and fascia (mesorectum).

Q4

a Name the space indicated by A
b Name the structure labelled B
c Name the structure labelled C
d Name the structures labelled D
e Name the arteries supplying the rectum



Q4 Answers

a Presacral space
b L5/S1 or lumbosacral joint
c Pubic tubercle
d Rectal folds or rectal valves
e Superior, middle and inferior rectal arteries

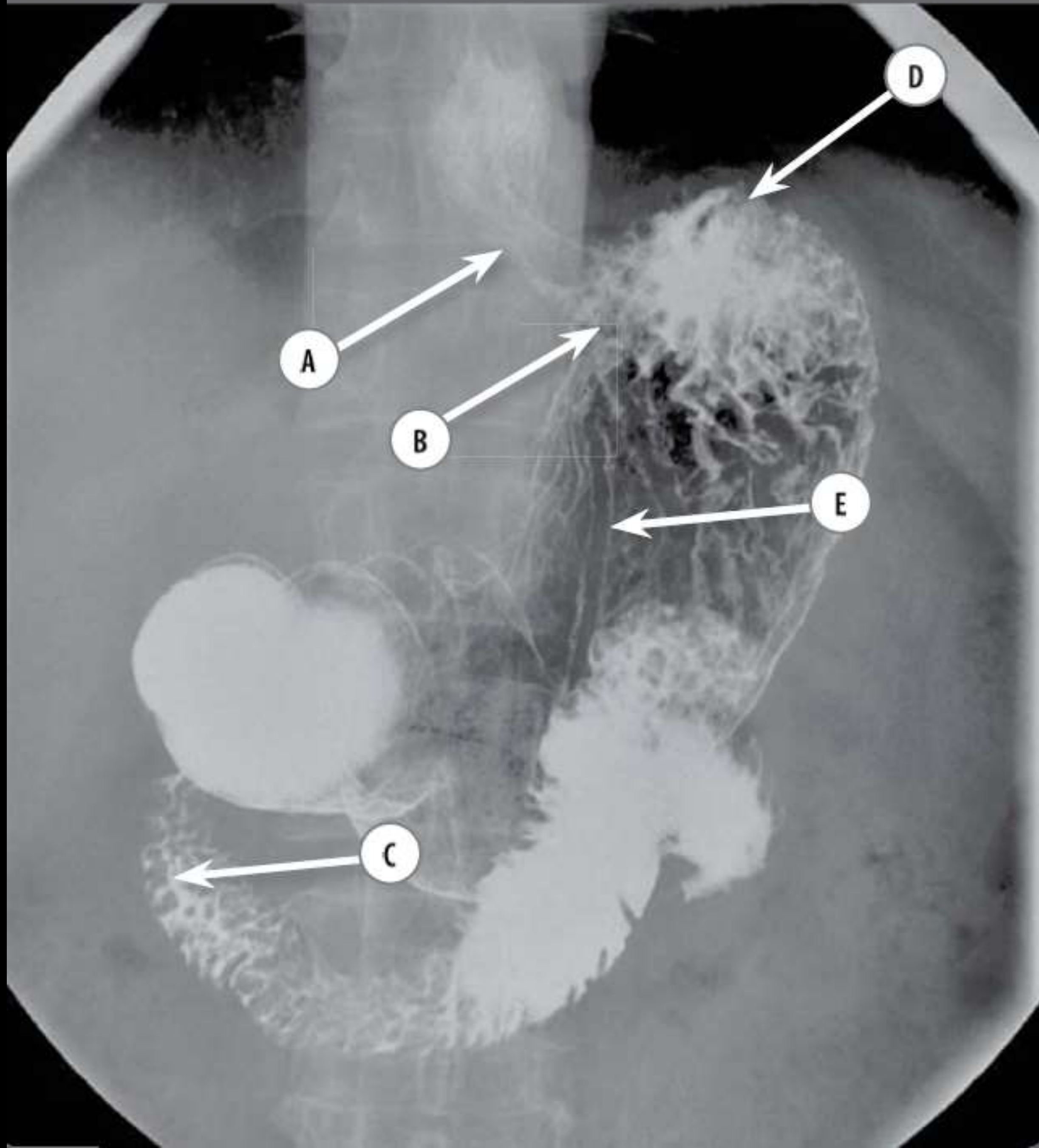
Lateral rectal view from barium enema series

The rectum is the terminal part of the colon. Anatomically the rectum follows the curves of the lower sacrum and coccyx when viewed laterally (as shown) and is S-shaped (when viewed in an AP projection). The three curves of this 'S' are represented internally as transverse folds known as the rectal valves (of Houston).

The presacral space contains fat, blood vessels, lymph nodes and lymphatics and also nerves.

The superior rectal artery represents the continuation of the inferior mesenteric artery and supplies the proximal rectum. The paired middle rectal arteries are branches of the anterior division of the internal iliac artery. The paired inferior rectal arteries are branches of the internal pudendal artery, which is also a branch of the anterior division of the internal iliac.

Case 3.6



Case 3.6

A Mucosal folds in distal oesophagus

B Gastric cardia

C Second part of duodenum

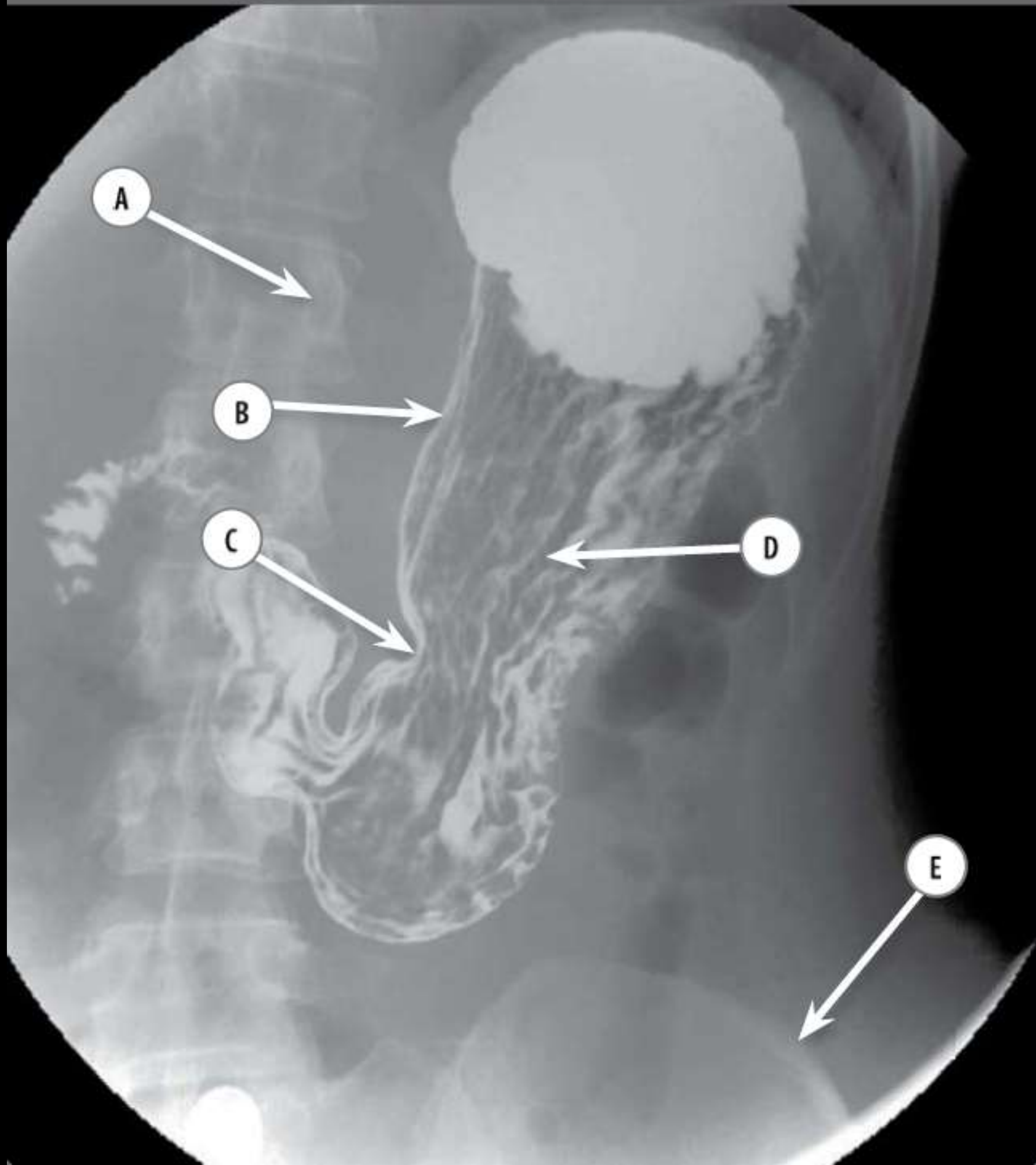
D Gastric fundus

E Rugal fold

Fluoroscopic image from a barium meal taken in a frontal projection.

The oesophagus crosses the diaphragm at the level of T10, where it is surrounded by fibres from the right diaphragmatic crus. The oesophageal mucosa forms longitudinal folds, which measure approximately 3 mm in thickness. They are outlined by barium in a non-distended oesophagus. The rugal folds in the stomach are much thicker, and can help to define the location of the gastro-oesophageal junction. The cardia describes the area of the stomach into which the oesophagus opens – the cardiac orifice. Above the cardia is the fundus, and below the cardia up to the level of the incisura is the gastric body. Beyond the incisura is the antrum.

Case 3.7



Case 3.7

A Left pedicle of L1

B Lesser curve of the stomach

C Incisura angularis

D Rugal fold

E Left iliac crest

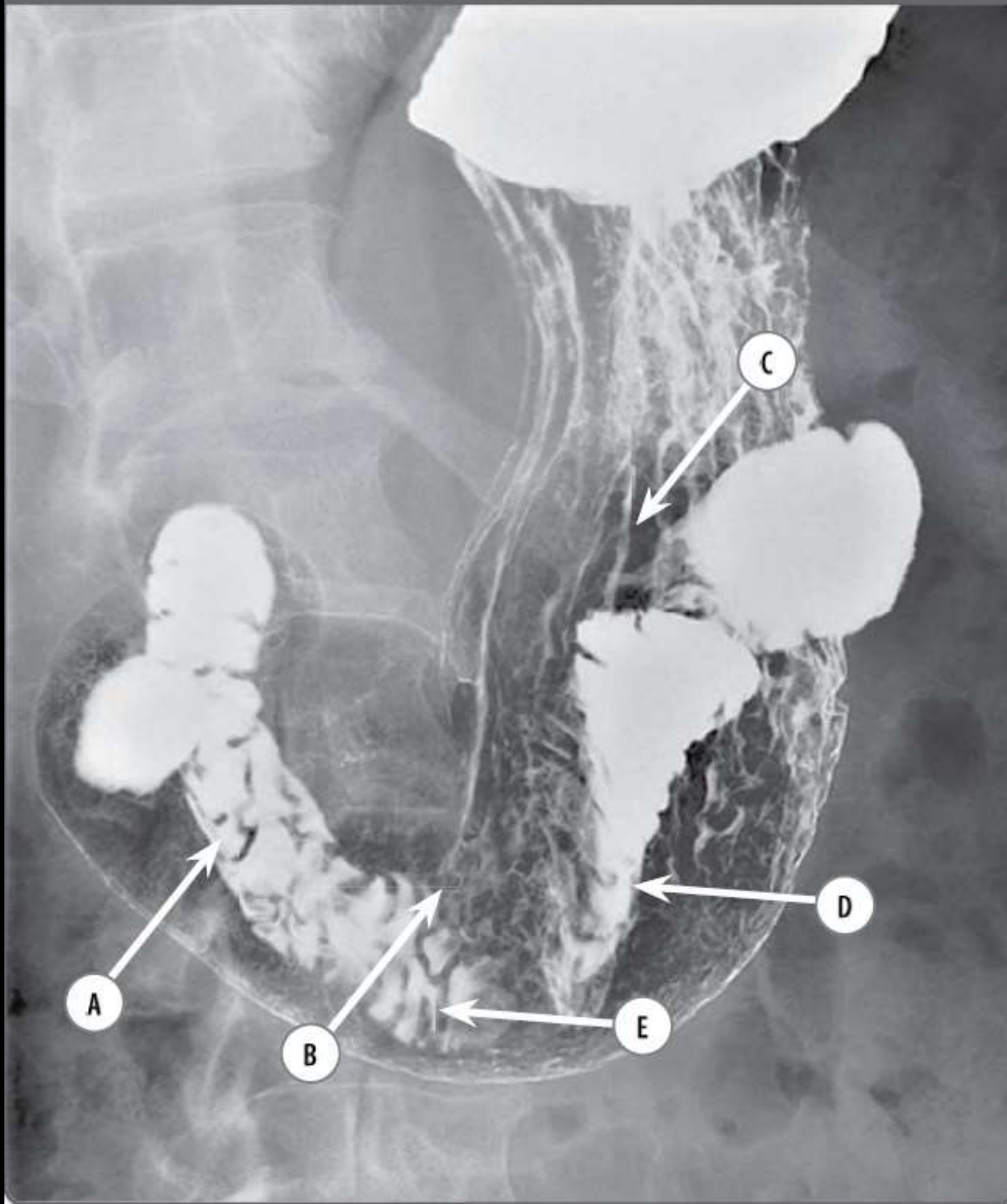
Fluoroscopic image from a double contrast barium meal in a frontal projection in the supine position.

The stomach is made up of the fundus, body, antrum and pylorus (from proximal to distal). The incisura angularis describes a notch at the distal end of the lesser curve of the stomach, which is located between the gastric body and antrum.

The way the barium collects can help work out the patient's position – on an erect film the fundus would be gas-filled. The mucosal folds of the stomach are called rugae, and can easily be appreciated on barium studies. In the region of the lesser curve, they are arranged longitudinally. On this barium meal, they can be seen as parallel lucent lines, as the barium collects in between them. The mucosal surface is covered in a nodular texture caused by 'areae gastricae'; these are best appreciated in the antrum.

Butler P, Mitchell AM, Ellis H. Applied Radiological Anatomy. Cambridge: Cambridge University Press, 1999: 211

Case 3.8



Case 3.8

A Barium within the third part of duodenum

B Areae gastricae within antrum

C Rugal fold

D Barium within the fourth part of duodenum

E Valvulae conniventes

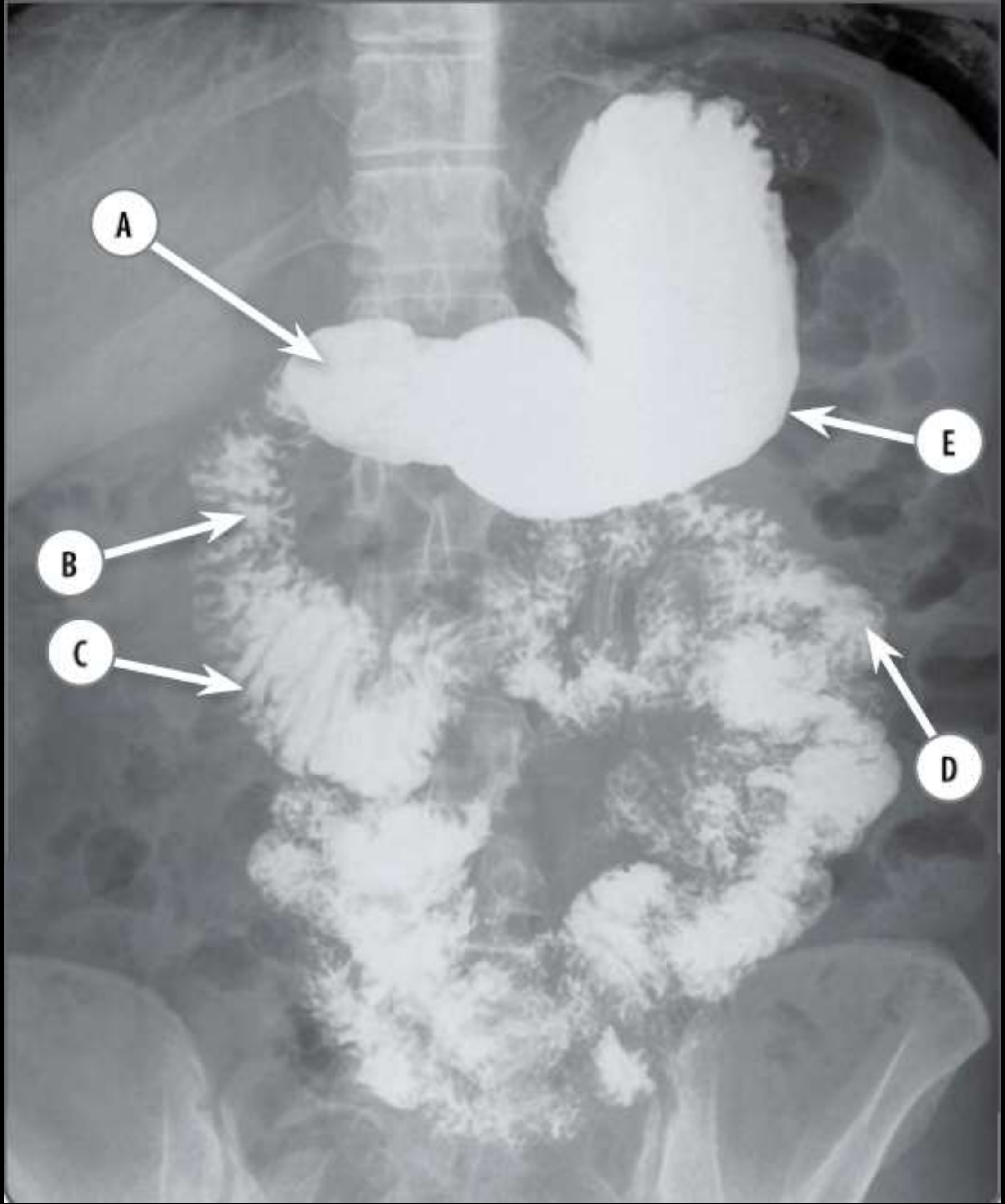
Fluoroscopic image taken from a barium meal in an oblique position.

This image demonstrates the mucosal relief in the body and antrum of stomach, with both the rugal folds and area gastricae being shown. The area gastricae are small nodules, or undulations in the gastric mucosa, which give a 'cobblestone' effect. They are approximately 2–3 mm in diameter, and have grooves in between them that collect barium. This results in a 'mosaic' type pattern on barium meal. This pattern is stable, and remains unaltered by the degree of stretch or the contraction of muscularis mucosae. The rugal fold pattern, however, does change with the peristaltic activity of the stomach. Along the lesser curve, the rugae are arranged longitudinally, in parallel rows known as *Magenstrasse* (main street). In other areas of the stomach, the rugae have a more random pattern.

The duodenum forms a 'C' shape around the head of pancreas, and then continues across the aorta and inferior vena cava before turning superiorly towards its junction with the jejunum. The path taken by the duodenum is demonstrated in this image, with its distinctive mucosal fold pattern projected over the stomach.

Mackintosh CE. Anatomy and radiology of the area gastricae. Gut 1977; 18: 855–864.
Ryan S, McNicholas M, Eustace SJ. Anatomy for Diagnostic Imaging, 3rd edn. Edinburgh: Saunders, 2011: 161–163.

Case 3.9



Case 3.9

A Pylorus

B Second part of duodenum

C Valvulae conniventes

D Barium within proximal jejunum

E Greater curve of stomach

Fluoroscopic image from a barium meal in a frontal projection.

The duodenum has four parts; it begins with the duodenal bulb, and forms a 'C' shape as it runs around the head of the pancreas, and crosses the midline, over the aorta and inferior vena cava to its junction with the jejunum at the ligament of Treitz. The first part of the duodenum (D1) is intraperitoneal, and makes up the duodenal bulb or cap. The remainder of the duodenum is retroperitoneal. The pancreatic and biliary ducts drain into the second (descending) part of the duodenum, and the duodenal papilla may be seen as a filling defect on barium studies. The third part of the duodenum has a horizontal course, which follows the lower margin of the pancreatic head. Finally, the fourth part has a course which runs superolaterally, over the left psoas, and it finishes by turning forwards, to join the jejunum at the level of L2.

The small bowel mucosa has numerous folds called valvulae conniventes or plicae circulares, which encircle two thirds of the inner surface. These are absent from D1, but become more numerous towards the distal duodenum. The jejunum can be differentiated from the ilium on barium studies not only by its position, but also by its mucosal fold pattern. The jejunum is located more towards the left upper quadrant, and has more prominent valvulae conniventes than the ilium, which is located more towards the right lower quadrant.

Butler P, Mitchell AM, Ellis H. Applied Radiological Anatomy. Cambridge: Cambridge University Press, 1999: 213.

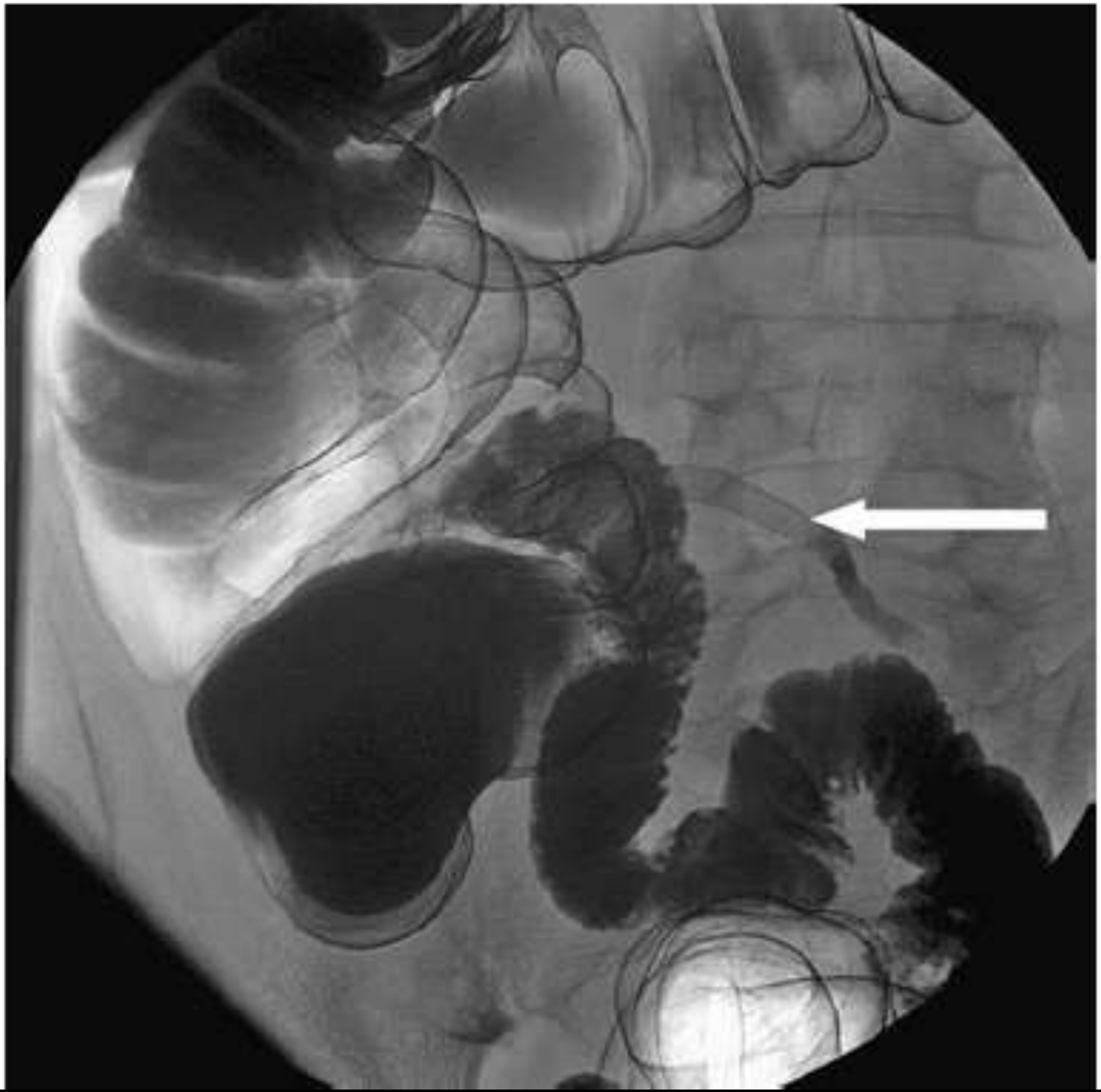
Question 20:

Question 20: Barium meal

Answer: Duodenal cap

- The duodenal cap is the first part of the duodenum and the only intraperitoneal section of the duodenum.
- It is approximately 2.5 cm in length.
- The duodenum extends from the pylorus to the jejunum. Four segments make up its length (D1, 2, 3, and 4).

Question 22:



Question 22: Barium enema

Answer: Appendix

- The appendix is a blind ending loop of bowel that arises from the caecum. It is usually seen in the right lower quadrant.
- On a fluoroscopic study such as this barium enema, the appendix may appear as a contrast medium–filled structure or, as in this case, there is double contrast, with gas in the lumen and contrast medium lining the appendix wall.
- The appendix and a Meckel diverticulum are the only blind ending structures that can be seen on a normal barium examination.

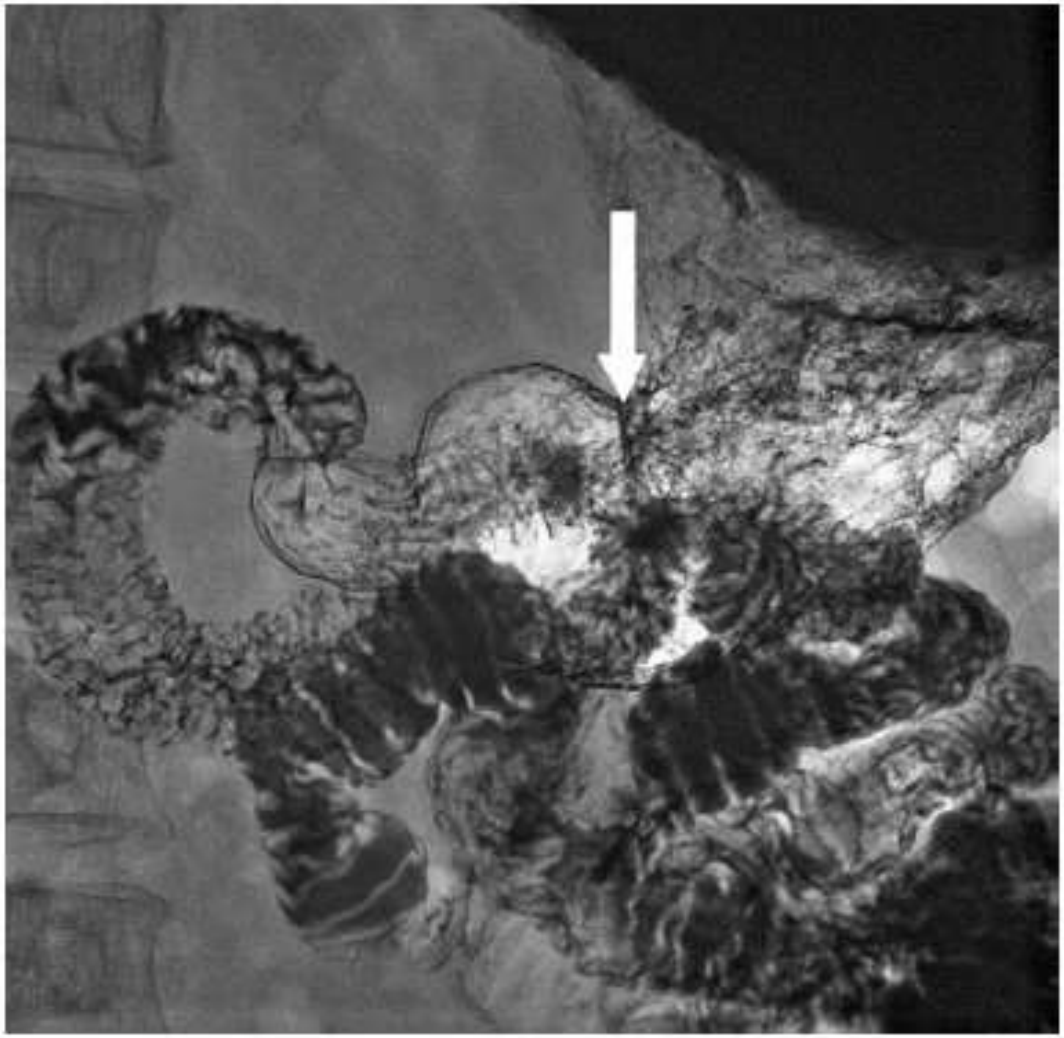
Question 24:

Question 24: Barium meal

Answer: Jejunum

- The jejunum makes up the proximal two fifths of the small bowel. It has a characteristic feathery appearance in contrast to the relatively featureless ileum.
- It begins at the duodenojejunal flexure at the level of L2 and extends to the ileum.
- It has a wider lumen, thicker wall, and more prominent valvulae conniventes than the ileum.

- **Question 50:**



Question 50: Barium meal

Answer: Incisura of lesser curvature

- The incisura is an angulation of the lesser curve of the stomach.
- It indicates the junction of the body and the antrum.

Question 4.5

Name the structures labelled **A** to **E**.

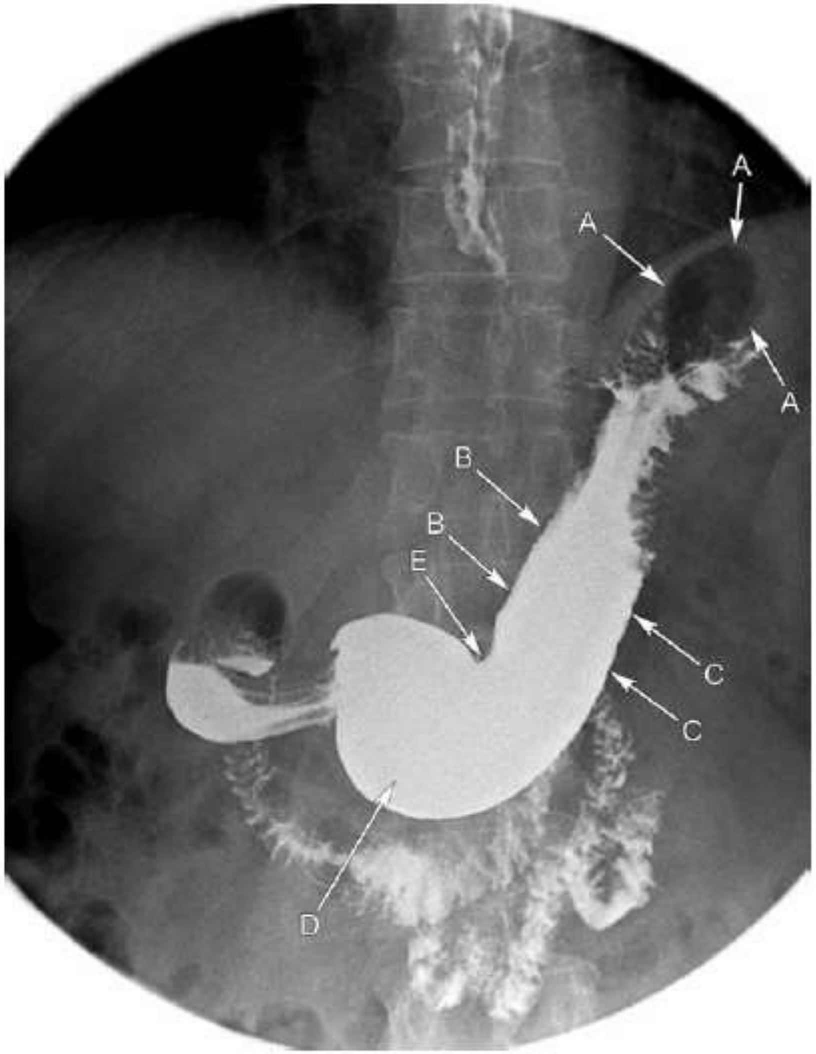
4.5 Double contrast barium meal

A Duodenal cap.
B Lesser curve.
C Gastric folds (rugae).
D Second part of the duodenum.
E Pylorus.

The mucosal lining of the stomach has tiny nodular elevations called areae gastricae (they can be seen in the antrum of the stomach on this image), which are within expandable folds called the gastric rugae. The gastric rugae increase the surface area of the stomach; this increases absorption as well as providing the ability for the stomach to expand and contract with meals. The gastric rugae are usually 3–5 mm thick.

The duodenum is composed of four parts, generally referred to as D1, D2, D3 and D4. The first part (D1) includes the duodenal cap, which is well demonstrated in this image. It is a smooth-walled structure located immediately after the pylorus, and is the only part of the duodenum that is intraperitoneal. The remainder of the first part of the duodenum is retroperitoneal and ends at the superior duodenal flexure. The second part of the duodenum (D2) commences at the superior duodenal flexure and takes a vertical course to the inferior duodenal flexure where the third part of the duodenum (D3) starts. The pancreatic and common bile ducts enter the second part of the duodenum via the ampulla of Vater.

Question 7.14



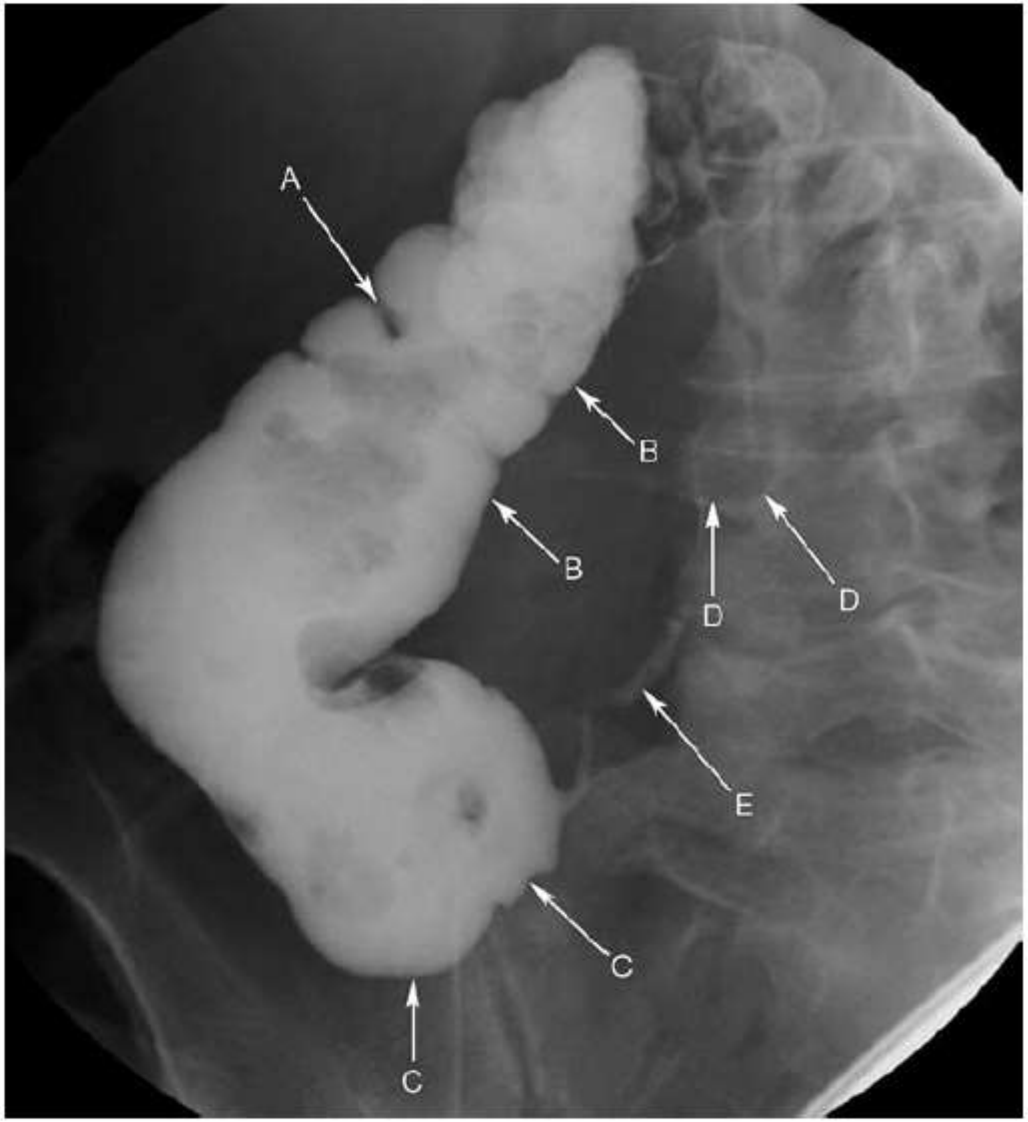
Name the structures labelled **A** to **E**.

7.14 Barium follow-through

A Fundus.
B Lesser curve.
C Greater curve.
D Antrum.
E Incisura angularis.

Anatomically, the stomach can be divided into four regions. The cardia is the region where the oesophagus inserts into the stomach and food content is received. The fundus is the uppermost part and forms the upper curvature. The body is the main central region. The pylorus is the gastric outlet into the duodenum. The gastric antrum is the portion of the pylorus before the outlet. It does not produce acid. The incisura angularis is a well-defined notch in the lesser curvature of the stomach and serves as a landmark for identifying the lower extent of the body of the stomach.

Question 8.13



Name the structures labelled A to E.

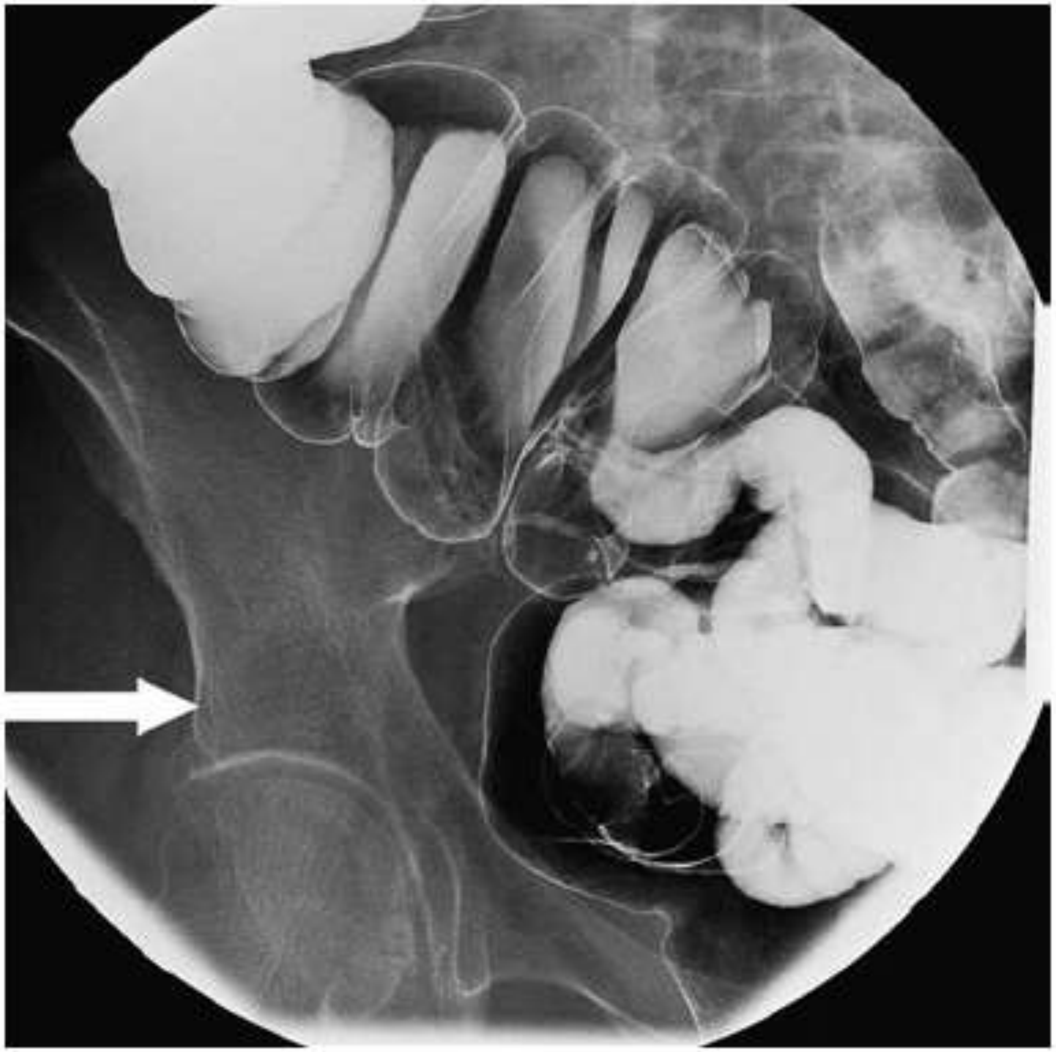
8.13 Barium enema

A Haustrum.
B Ascending colon.
C Caecal pole.
D Right pedicle of L4.
E Appendix.

The tenia coli are longitudinal ribbons of smooth muscle on the exterior of the colon. They are shorter than the bowel and contract longitudinally, causing the colon to become sacculated, forming the pouches known as haustra.

The position of the appendix is variable. Approximately 60% are retrocaecal and 35% are inferomedial.

Question 39:



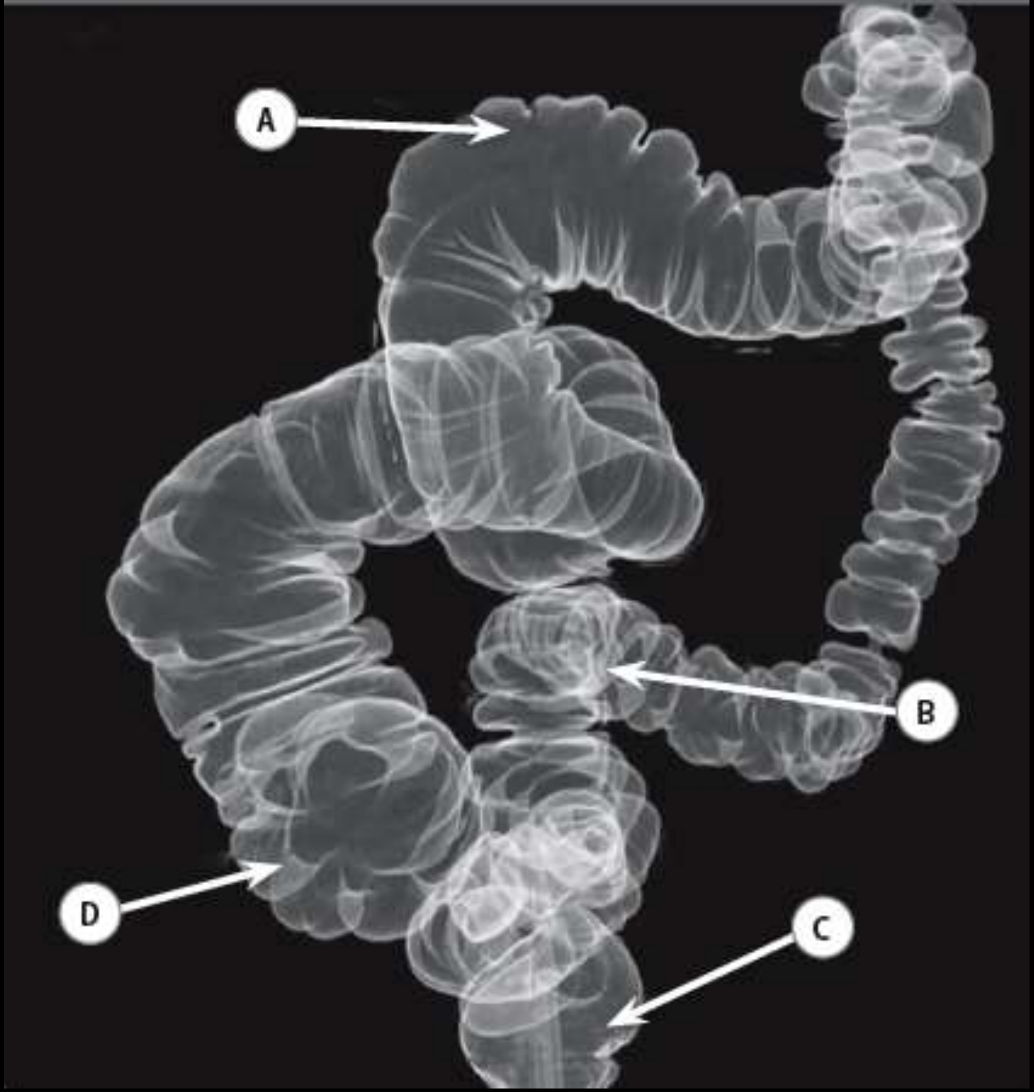
Question 39: Barium enema

Answer: Right anterior inferior iliac spine

- The anterior inferior iliac spine is the attachment for the rectus femoris muscle.
- The barium within the colon is there to act as a distraction from what is actually a simple question to answer.
- The table below summarises the main sites of muscle attachment in the pelvis and the corresponding muscles that insert there.

Pelvic attachment	Muscle(s)
Iliac crest	Abdominal wall muscles (external oblique, internal oblique, and transversus abdominis)
Anterior superior iliac spine	Sartorius
Anterior inferior iliac spine	Rectus femoris
Inferior pubic ramus	Adductors (adductor longus, brevis, and magnus; and gracilis)
Ischial tuberosity	Hamstrings (semimembranosus, semitendinosus, and biceps femoris)
Greater trochanter	Gluteus medius
Lesser trochanter	Iliopsoas

Case 3.3



E What is the blood supply of the proximal transverse colon?

Case 3.3

A Transverse colon

B Sigmoid colon

C Rectum

D Caecum

E Middle colic artery

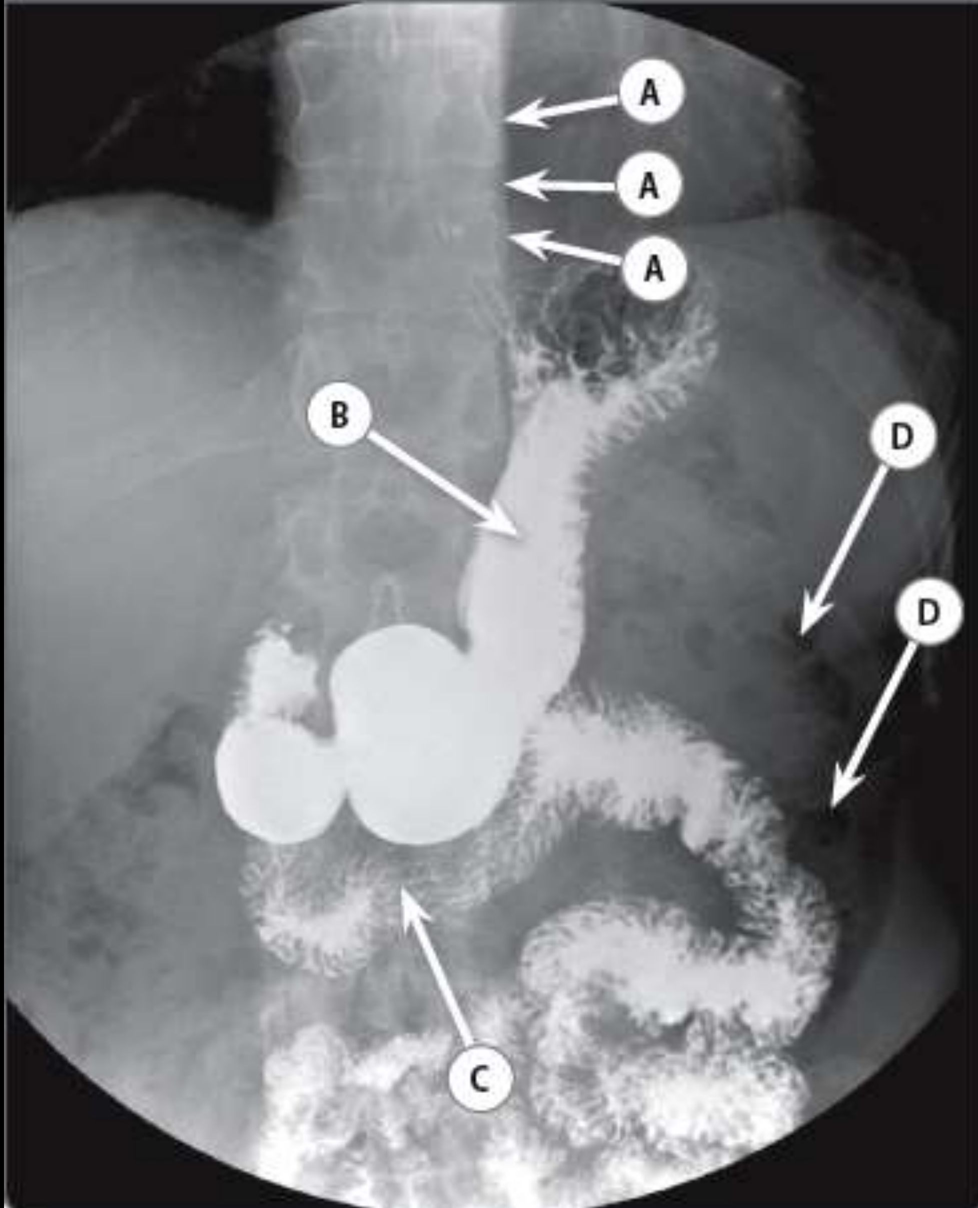
The colon is divided into the caecum, ascending colon, transverse colon, descendin colon, sigmoid colon and rectum. The caecum is the blind-ended area of the colon inferior to the ileocaecal valve. The superior mesenteric artery (SMA) and its branches (ileocolic, right and middle colic arteries) supply up to the distal third of the transverse colon.

Branches of the inferior mesenteric artery (IMA) supply the rest of transverse and descending/sigmoid colon.

The major branches of the IMA can be recalled remembering inferior means LESS:

- Left colic
- Sigmoid branches
- Superior rectal

Case 3.7



A	What name is given to line A?
B	Which unpaired artery arising from the aorta supplies structure B?
C	Which unpaired artery arising from the aorta supplies structure C?
D	In what part of the bowel does the gas labelled D lie?
E	Which part of the duodenum is intraperitoneal?

Case 3.7

A Left paraspinal line

B Coeliac axis (with its gastric branches)

C Superior mesenteric artery

D Descending colon

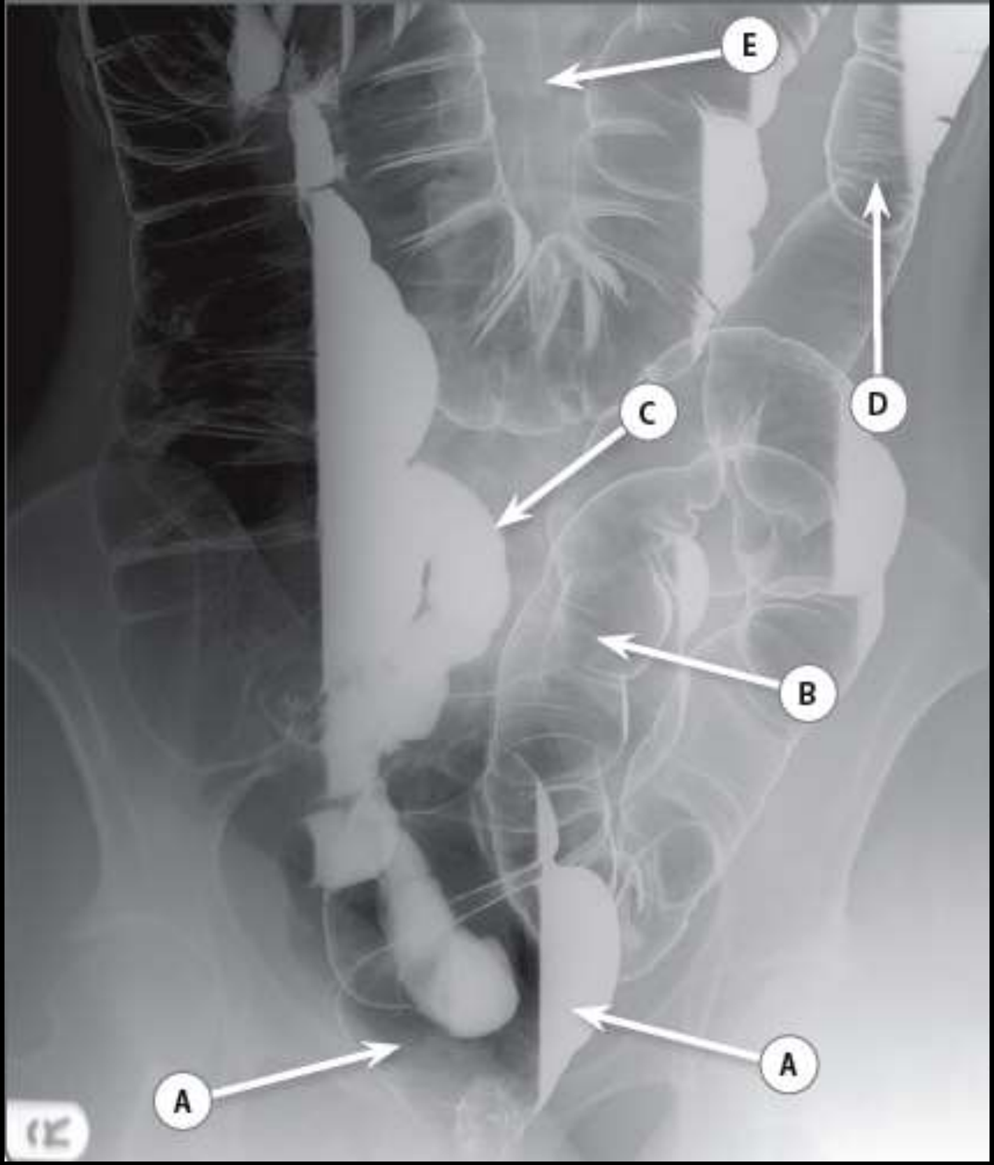
E First part

The left paraspinal line is an important review area on chest radiographs in particular, reflecting the interface between the left lung and pleura with the fat in the posterior mediastinum, left paraspinal muscles and the adjacent soft tissues. Lateral displacement of this line suggests posterior mediastinal pathologies.

The gastrointestinal tract is divided embryologically into foregut (from mouth to the midpoint of the second part of the duodenum), midgut (from termination of foregut up to two-thirds of the way along the transverse colon) and hindgut (from termination of midgut up to and including the upper anal canal). The blood supply reflects the embryology, with foregut being supplied by coeliac axis, midgut by superior mesenteric artery and hindgut by inferior mesenteric artery.

The duodenum is almost entirely retroperitoneal, with only the first part being intraperitoneal. As such, perforation of structure (C) (part 3 of the duodenum) leads to a retroperitoneal air leak which appears radiographically distinct to pneumoperitoneum.

Case 4.18



Case 4.18

A Rectum

B Sigmoid colon

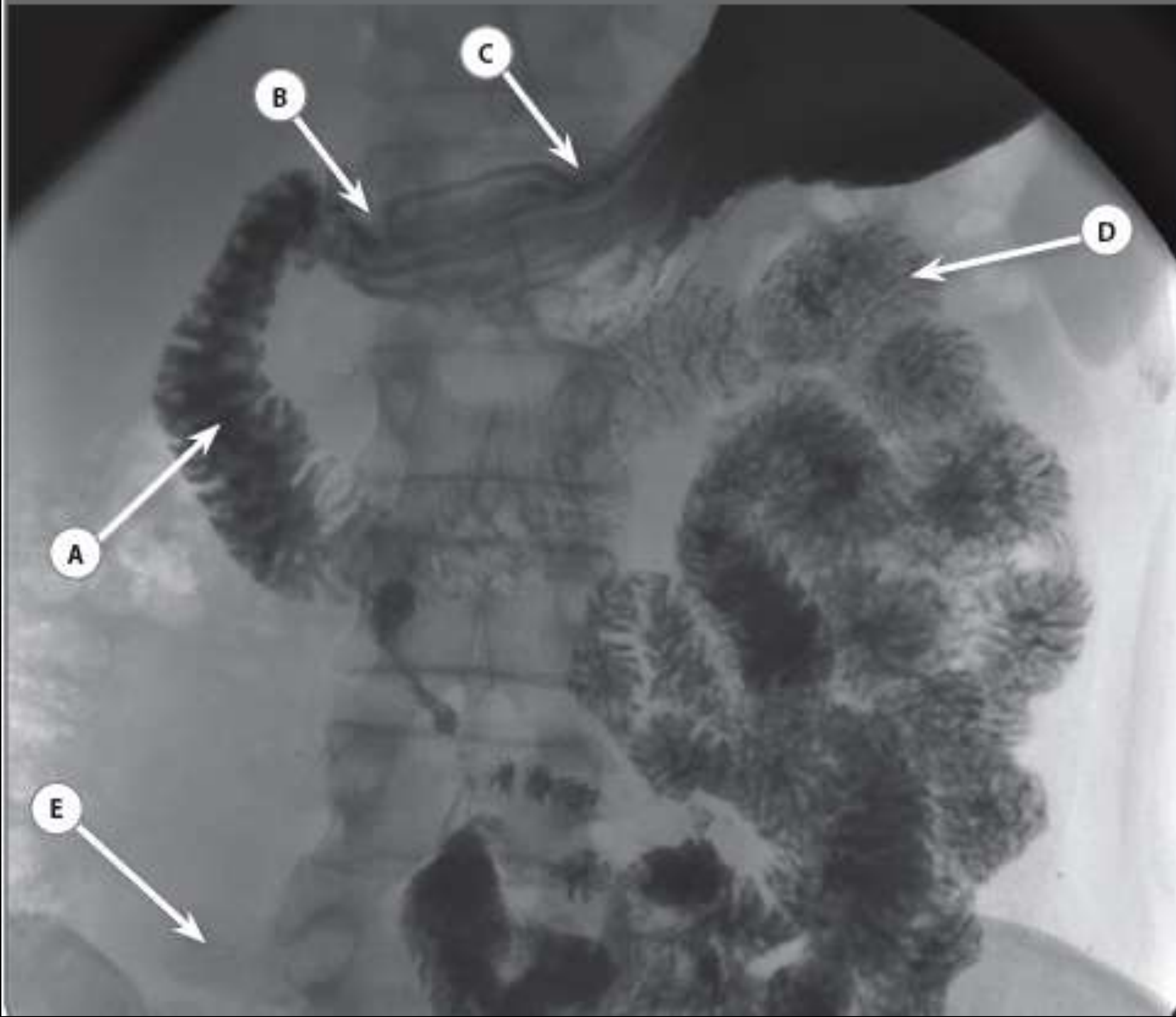
C Terminal ileum

D Descending colon

E Spinous process

On barium enema examinations, retrograde filling of the terminal ileum (as shown here) and/or the vermiform appendix should be specifically examined for as this confirms that contrast has reached the caecum. Visualised bones should always be scrutinised, as normal osseous structures (e.g. pedicles and spinous processes) may mimic bowel pathologies if projected over the colon.

Case 6.2



Case 6.2

A Second part of duodenum

B Pylorus

C Angularis incisura

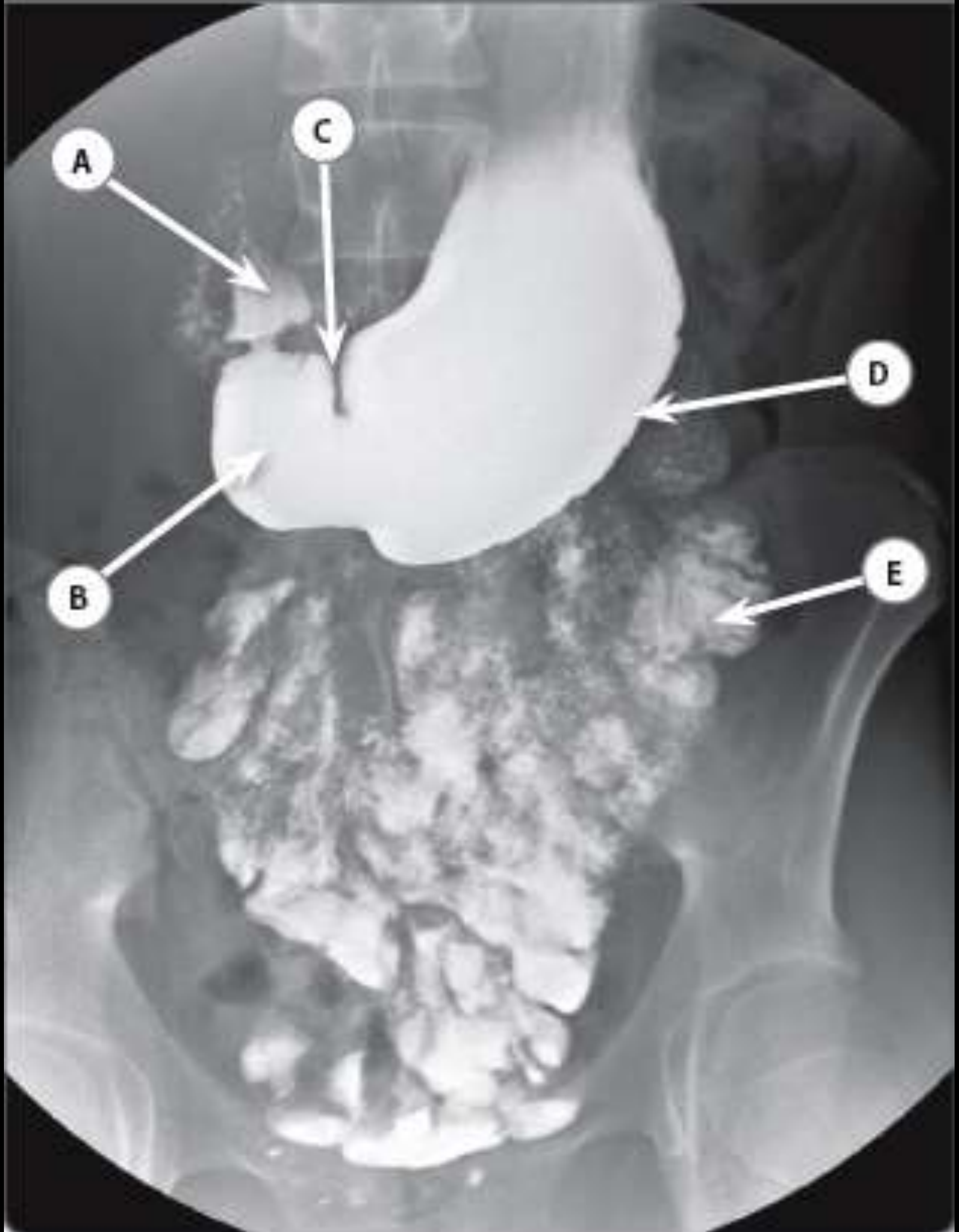
D Duodenojejunal junction/proximal jejunum (alternative acceptable answer)

E Right L5 transverse process

Blood supply to the proximal duodenum is derived from branches of the coeliac axis (gastroduodenal and superior pancreaticoduodenal arteries). The distal duodenum is supplied by branches of the superior mesenteric artery via the inferior pancreaticoduodenal artery.

The ligament of Treitz marks the duodenojejunal junction and the beginning of the jejunum.

Case 10.15



Case 10.15

A Duodenal cap

B Antrum of stomach

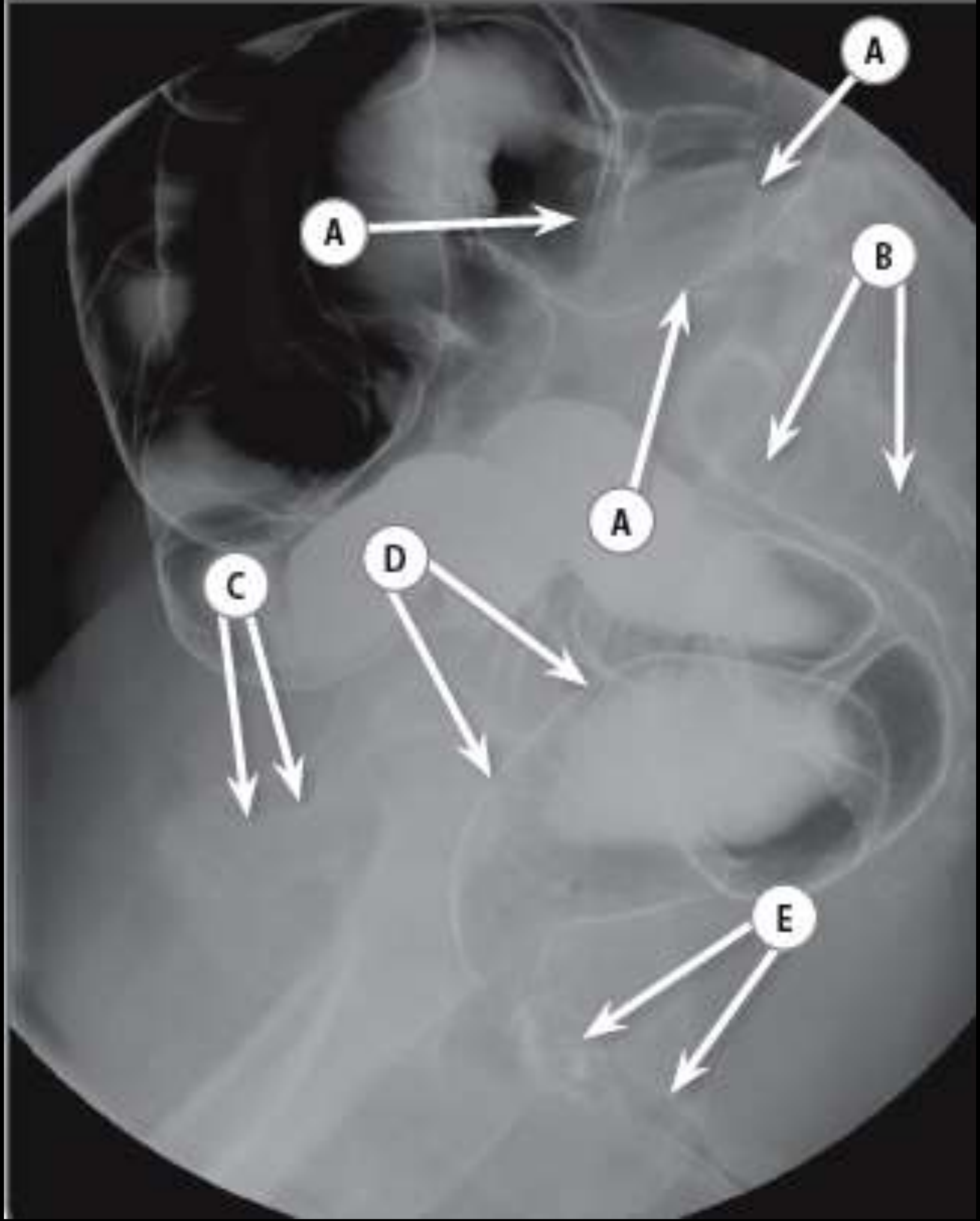
C Incisura angularis

D Greater curvature of stomach

E Jejunum

The incisura angularis – or angular notch – lies between the body of the stomach and the antrum. The duodenal cap represents the first part of the duodenum and is intraperitoneal. The duodenum distal to this is retroperitoneal – an important consideration given the difference in radiographic appearances between intraperitoneal and retroperitoneal visceral perforations. The fourth part of the duodenum is continuous with the jejunum at the duodenojejunal flexure.

Case 11.16



QUESTION	
A	Name the osseous structure labelled A.
B	Name the structure labelled B.
C	Name the structure labelled C.
D	Name the structure labelled D.
E	Name the non-anatomical structure labelled E.

Case 11.16

A Vertebral body of L5

B Sacrum

C Superior pubic ramus

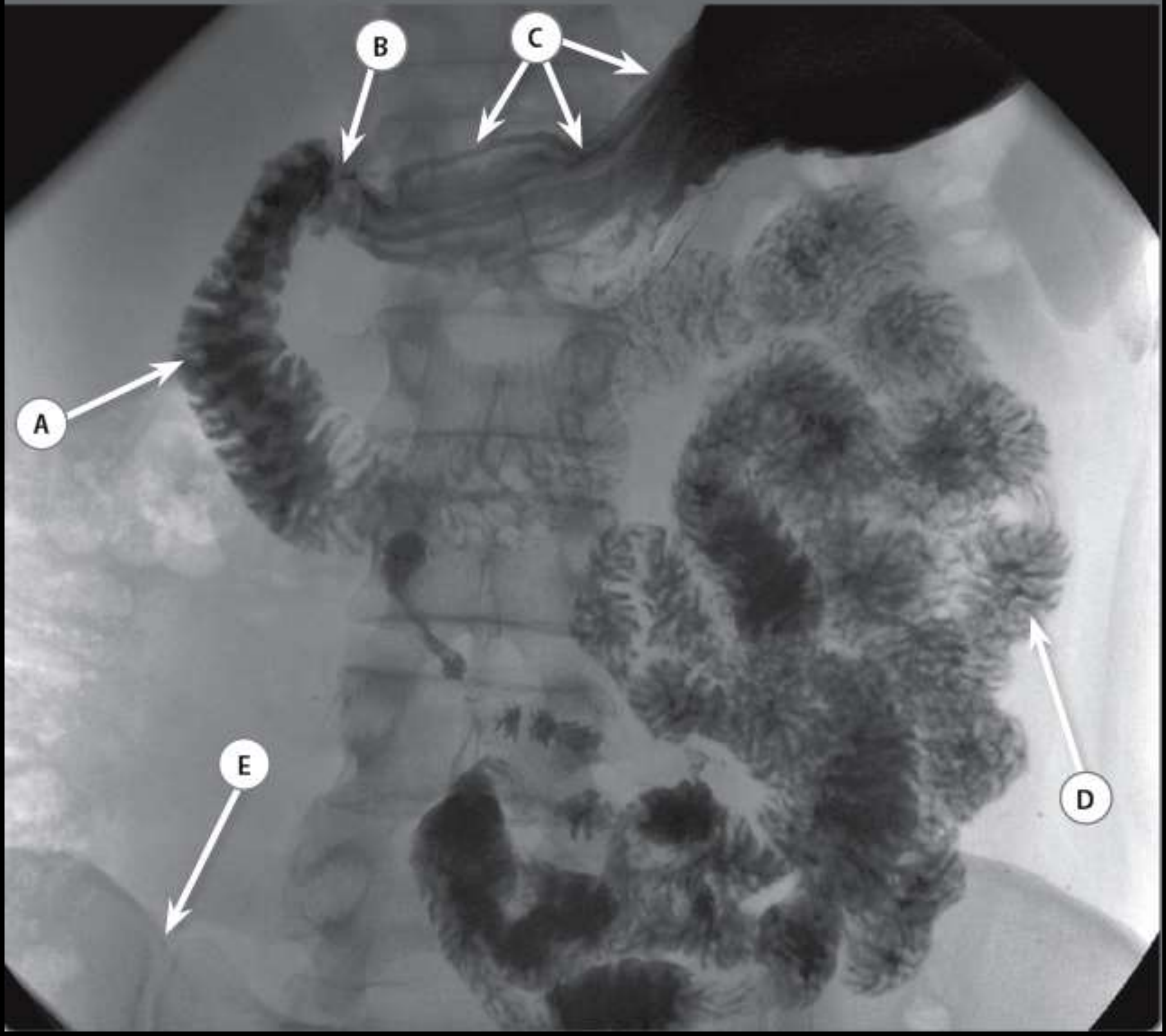
D Rectum

E Rectal contrast tube in anal canal

This image shows the rectum and sigmoid colon in double contrast. Haustra are an important means of differentiating large bowel from small bowel radiographically, but are characteristically absent in the rectum. Taeniae coli are three longitudinal muscle bands which are shorter than the overall length of the unstretched colon and as such result in colonic sacculations (and therefore haustra) between the caecum and sigmoid colon. However, these bands merge to form a complete muscle layer around the rectum meaning that haustra are absent.

The presacral space (posterior to the rectum and anterior to the sacrum and coccyx) is an important review area on lateral views on barium enema examinations, with widening of the space raising suspicions for the presence of such pathologies as tumour, meningocoele and abscess.

Case 13.1



Case 13.1

A Duodenum (second part)

B Pylorus

C Lesser curve of the stomach

D Jejunum

E Right sacroiliac joint

The distal stomach, duodenum and proximal small bowel are visualised on this contrast examination.

The stomach consists of body, fundus, cardia and pylorus. It has a more superior lesser curvature and an inferior greater curvature. Try to be specific with recognised gastric nomenclature when answering questions relating to the stomach.

Case 1.20

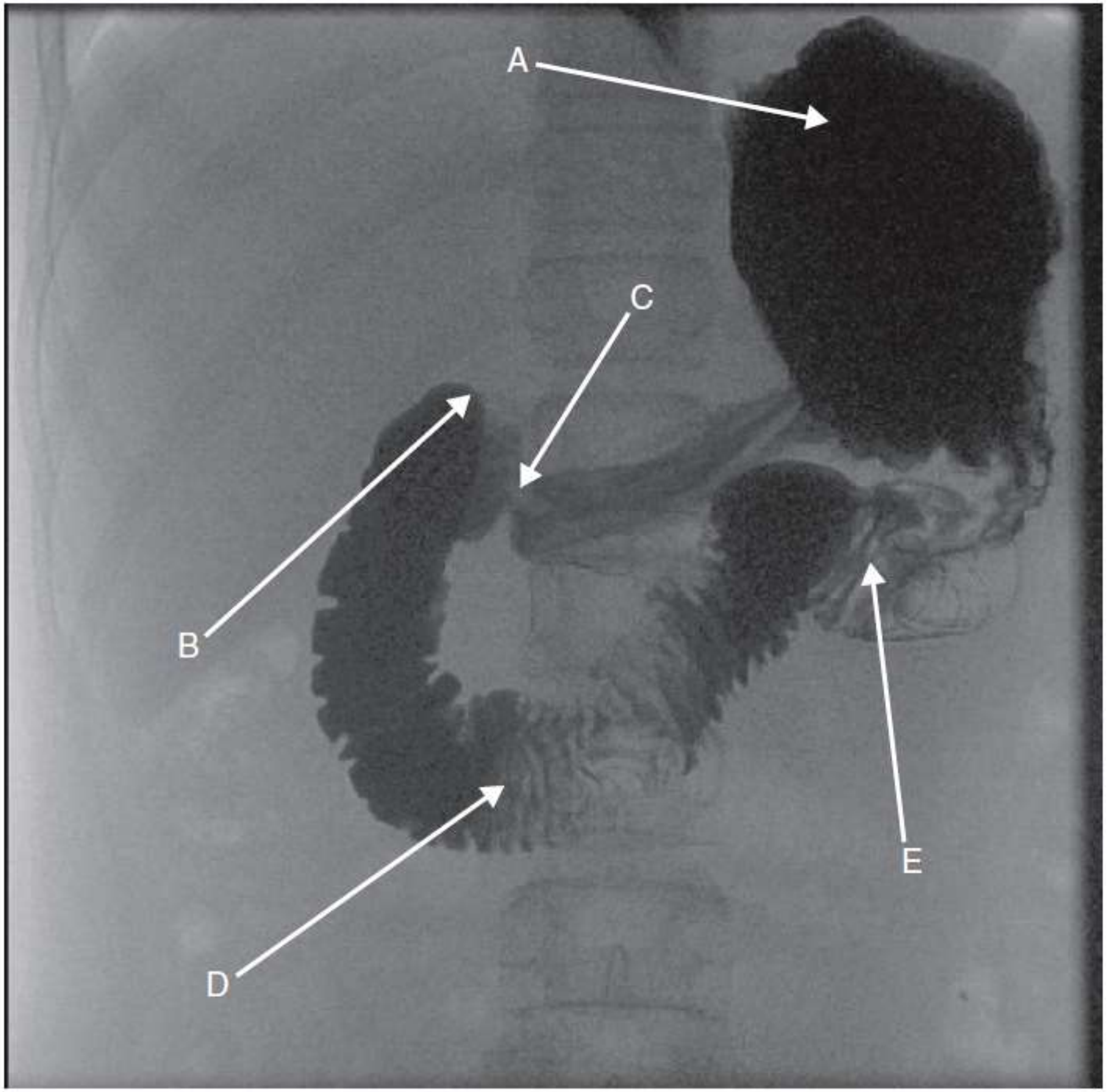


Image courtesy of Dr Alex Williams, Paediatric Radiology Fellow, Alder Hey Children's Hospital, Liverpool, UK.

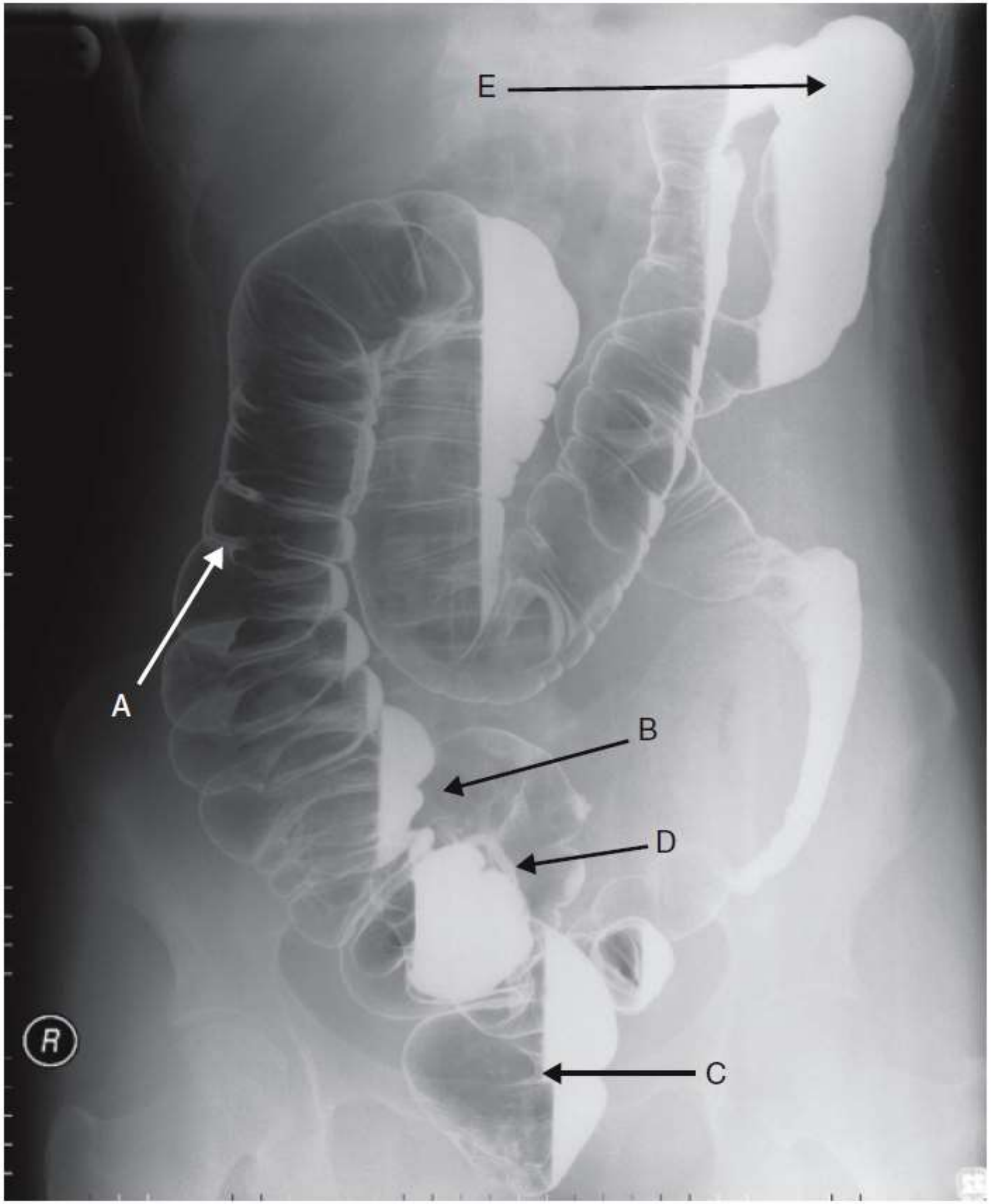
1.20 Paediatric small bowel study

(a) Gastric fundus.
(b) Duodenal cap.
(c) Pylorus.
(d) Third part of duodenum.
(e) Duodeno-jejunal flexure.

This is part of an upper gastrointestinal contrast examination in an infant. The position of the duodeno-jejunal flexure (and therefore the ligament of Treitz) is crucial. It is considered normal when it meets the following two criteria: (1) it is to the left of the spine and (2) it is superior to or at the same level as the duodenal bulb.

The emphasis of this image finding is in making the diagnosis of malrotation. This occurs if *in utero* the bowel fails to rotate counterclockwise through 270 degrees, resulting in a short base of the small bowel mesentery. This can present with midgut volvulus, which requires urgent detection and intervention.

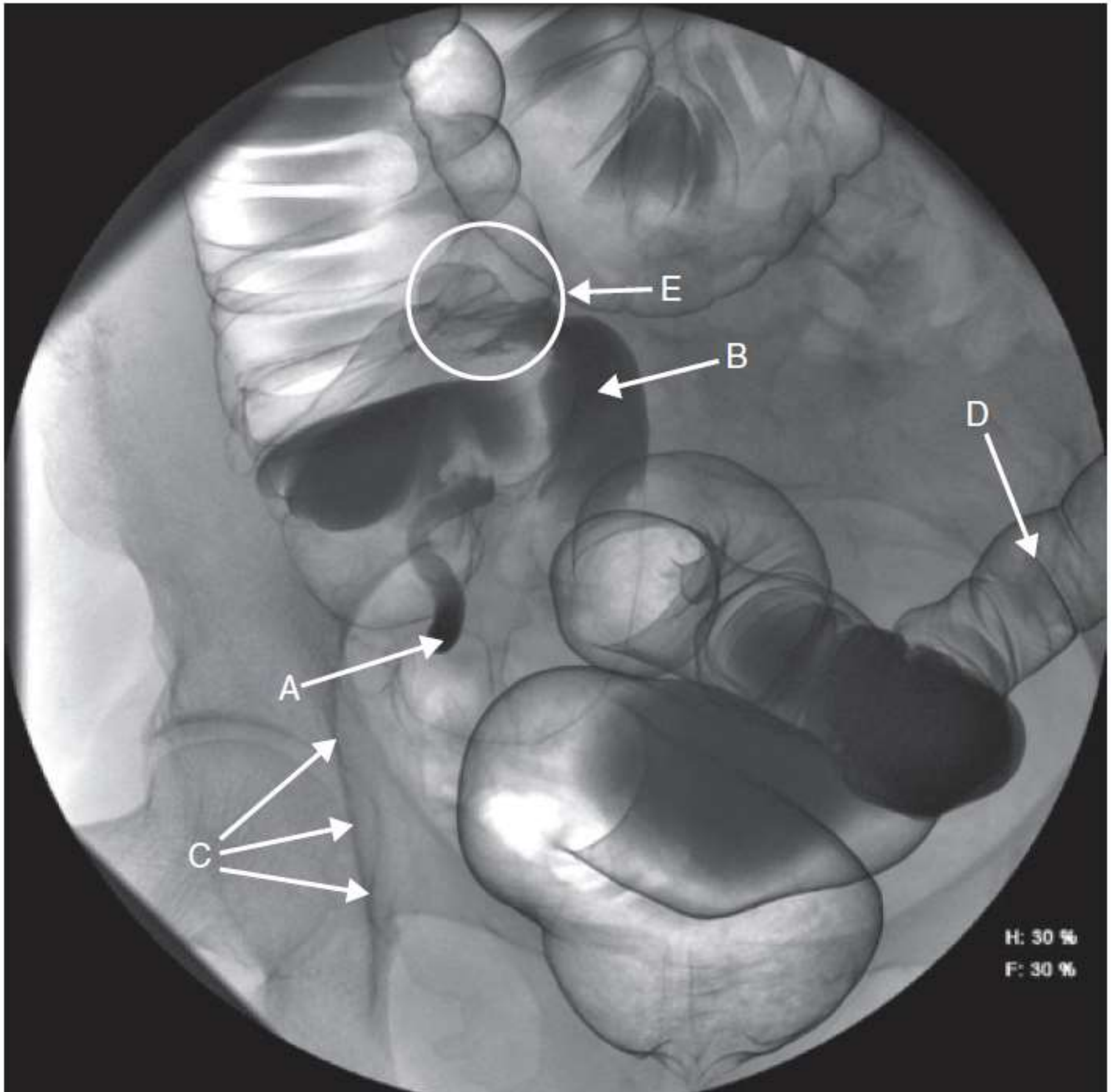
Case 2.7



2.7 Left lateral decubitus film from barium enema

(a) Haustra. The muscularis propria is condensed into three narrow longitudinal bands, the taeniae coli. The taeniae shorten the colon and act as anchorage for the circular muscle. This effect causes the haustral pattern seen on barium enema.
(b) Sigmoid colon. This is entirely surrounded by peritoneum and thus has a posterior mesentery named the sigmoid mesocolon. This allows it considerable freedom of movement within the lower abdomen.
(c) Valves of Houston, or transverse folds of rectum, are formed by fusion of taeniae and support the weight of faecal matter, preventing a constant defaecation urge. They are typically less than 5 mm thick.
(d) Appendix. Its relationship to the caecum is variable. It is retrocaecal in 15% and longer than 9 cm in 25% of individuals.
(e) Splenic flexure. This is the junction between superior and inferior mesenteric arteries at the splenic flexure seen in 80% of individuals. This is the most commonly affected segment in ischaemic colitis since this region is a watershed region between the vascular territories of the inferior and superior mesenteric arteries.

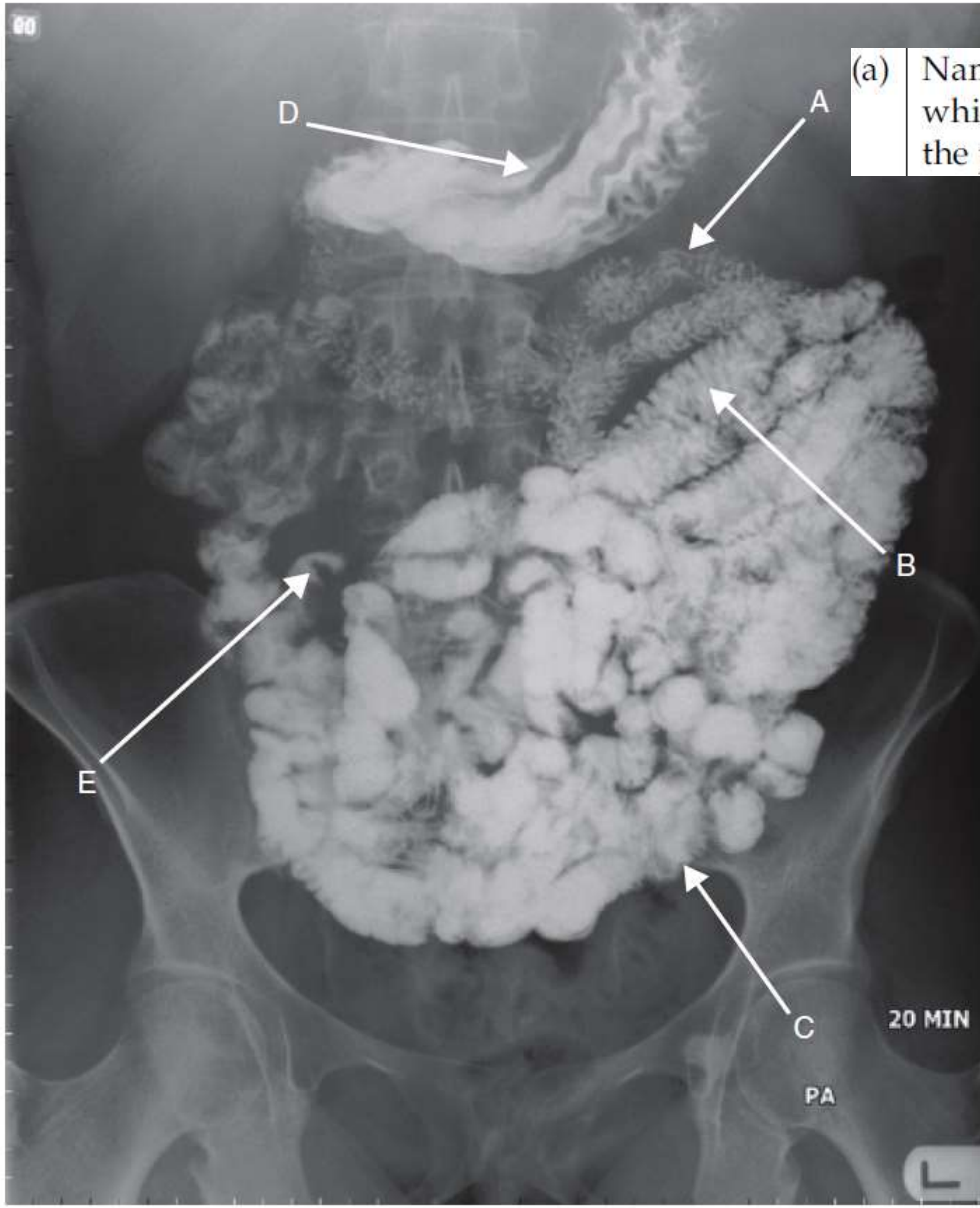
Case 3.20



3.20 Barium enema

(a) Appendix.
(b) Terminal ileum.
(c) Ilio-pectineal line.
(d) Sigmoid colon.
(e) Ileo-caecal valve.

Case 4.7



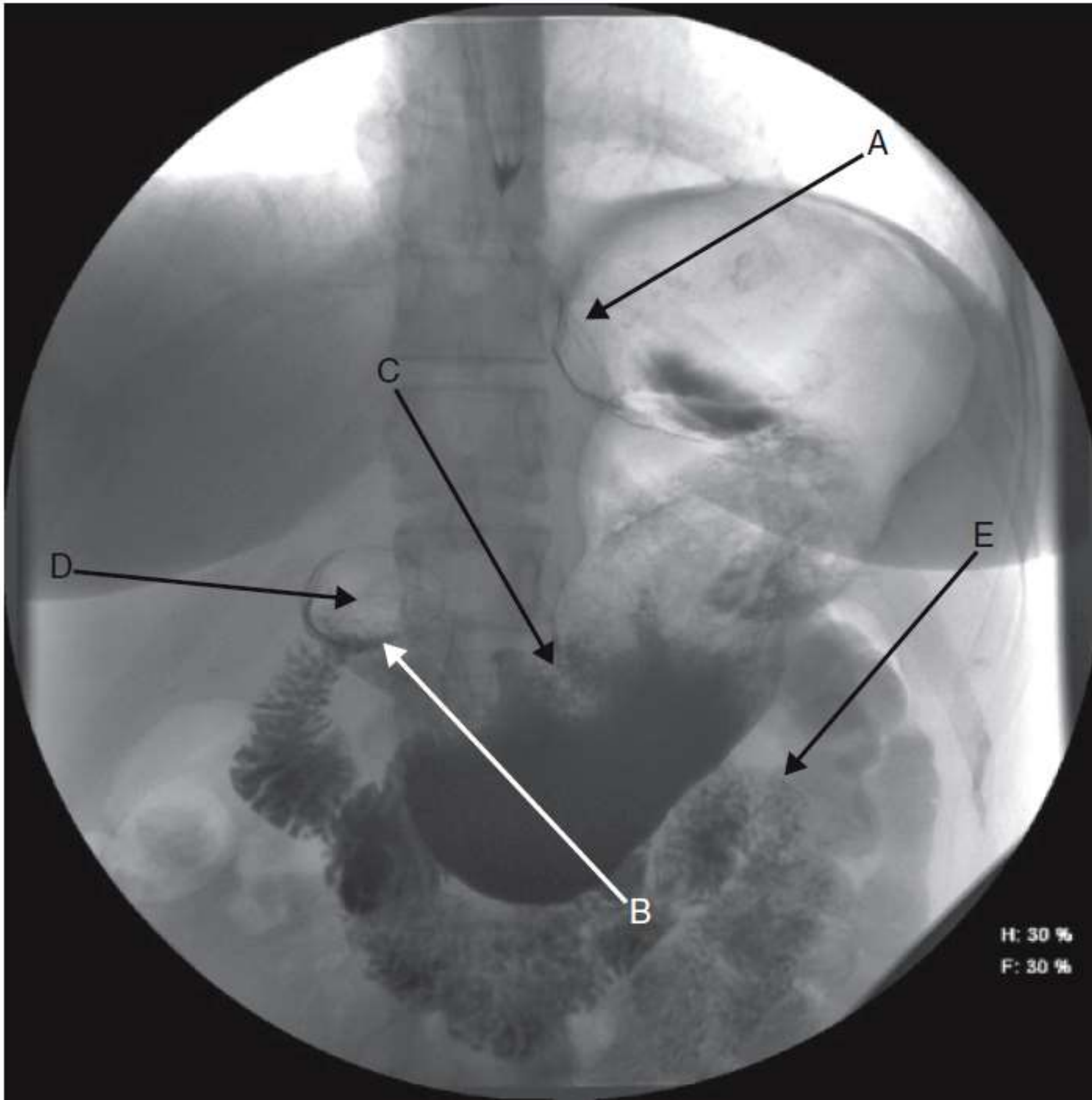
(a)	Name the structure which attaches to the point labelled A.

4.7 Barium small bowel study

(a) The suspensory ligament of the duodenum (ligament of Treitz). This is a muscle composed of a slip of skeletal muscle that arises from the proximal part of the right crus of the diaphragm as it encircles the oesophagus and inserts as a fibromuscular band of smooth muscle into the third and fourth parts of the duodenum. Contraction widens the angle of the duodeno-jejunal flexure helping the movement of bowel contents.
(b) Valvulae conniventes or circular folds (valves of Kerckring). These are reduplicated bands of mucosa that extend into the lumen of the bowel, contain a fibrovascular core of submucosa and extend completely around the whole circumference of the intestine. The folds are more crowded in the jejunum and are deeper and thicker than the ileum.
(c) Ileum. This typically makes up 60% of the small bowel and starts at 6 m.
(d) Gastric rugae. This is gastric mucosa thrown into longitudinal ridges. These are most marked towards the pyloric region and along the greater curve of the stomach.
(e) Terminal ileum. This is the most distal part of the small intestine. The terminal ileum enters the caecum obliquely at the ileo-caecal valve and partly invaginates into it. It is of paramount importance to visualize this region in small bowel studies due to the number of pathologies that occur here.

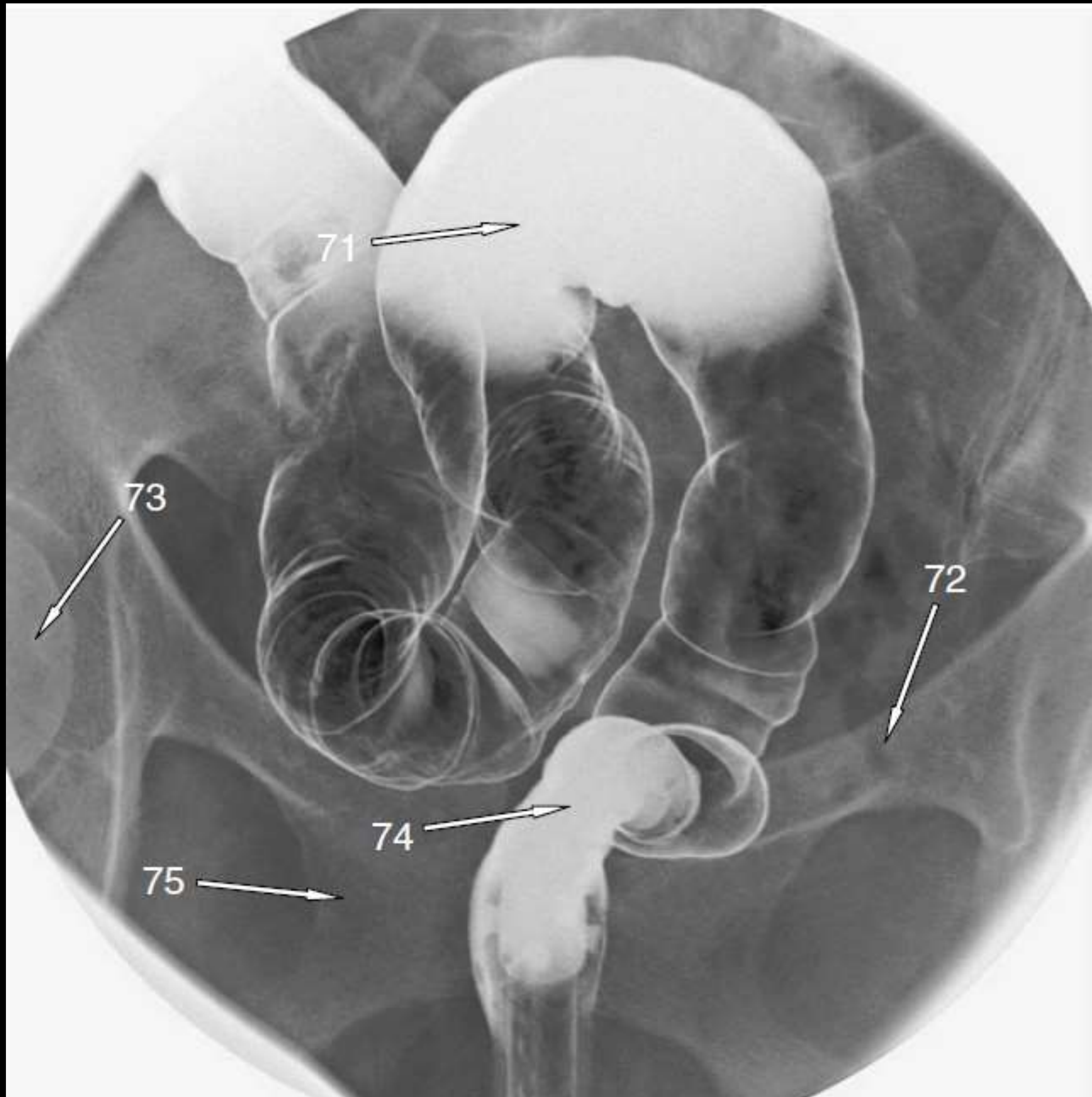
In a small bowel meal barium has been ingested by the patient and radiographs have been taken at intervals. With a small bowel enema a nasogastric tube is passed and barium introduced via this directly into the duodenum. Small bowel investigations are being replaced by MR enteroclysis, which gives similar results without the need for ionizing radiation. This is of relevance as many of these studies are carried out in young patients with inflammatory bowel disease.

Case 5.6



5.6 Barium meal

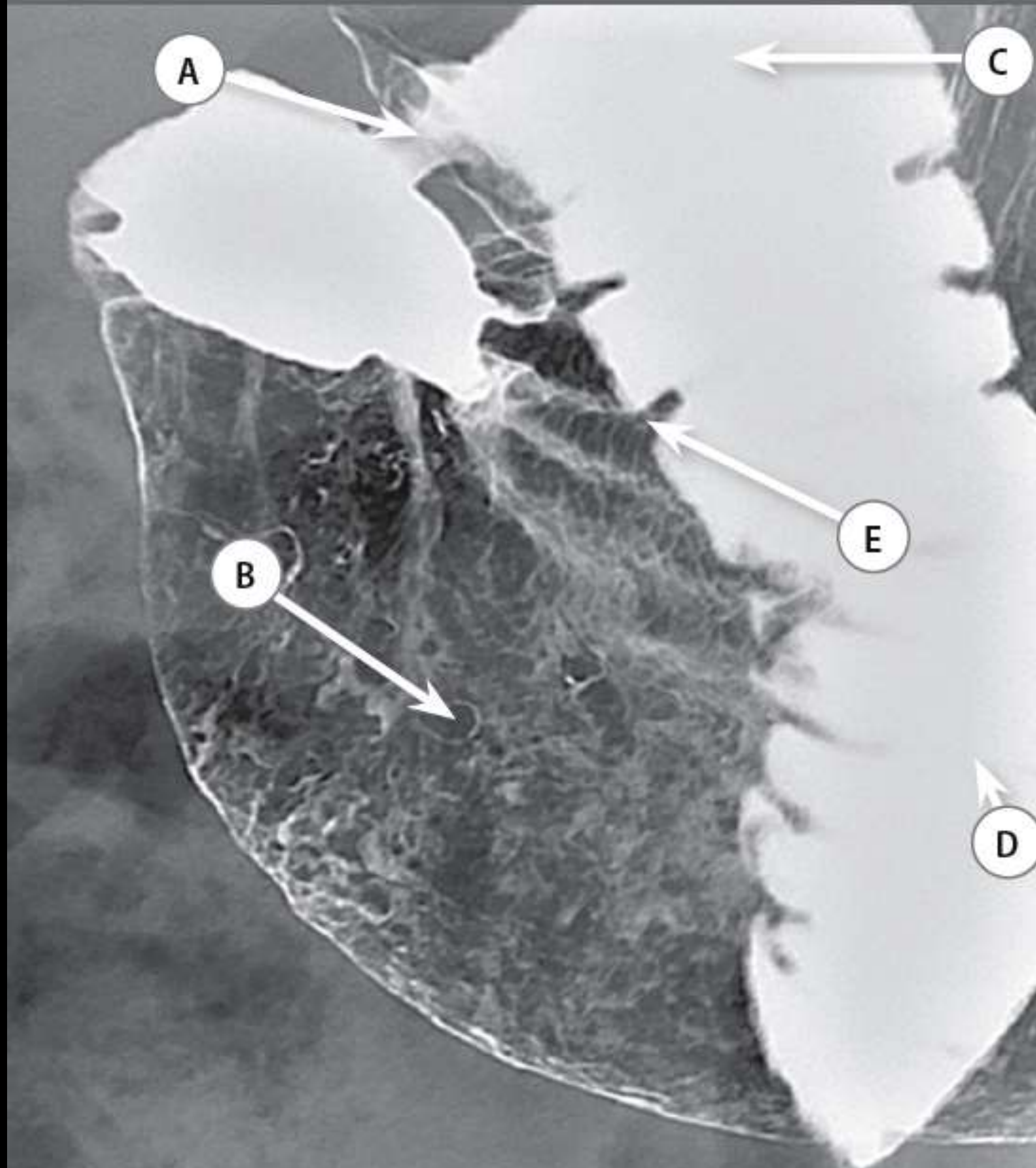
(a) Gastric cardia. The gastric cardia is well seen on double contrast barium studies. A variety of appearances may be seen, such as a filling defect, radiating folds of the cardiac rosette and hooded fold.
(b) Pylorus. This is usually located at the L1 level to the right of the midline.
(c) Angular incisura. This demarcation along the lesser curve of the stomach separates the body from the pylorus.
(d) Superior or first part of the duodenum. Lies antero-lateral to the L1 vertebra. The first part (2 cm in length) has a mesentery and is mobile. This is known as the duodenal cap.
(e) Duodeno-jejunal (DJ) flexure junction. This is situated on the left side approximately at the level of L2 vertebra, 2–3 cm left of the midline.


71
72
73
74
75

Barium Enema

71. Sigmoid colon
72. Left superior ramus of pubis
73. Right head of femur
74. Rectum
75. Right body of pubic bone

Case 5.3



Case 5.3

A Pyloric canal

B Areae gastricae

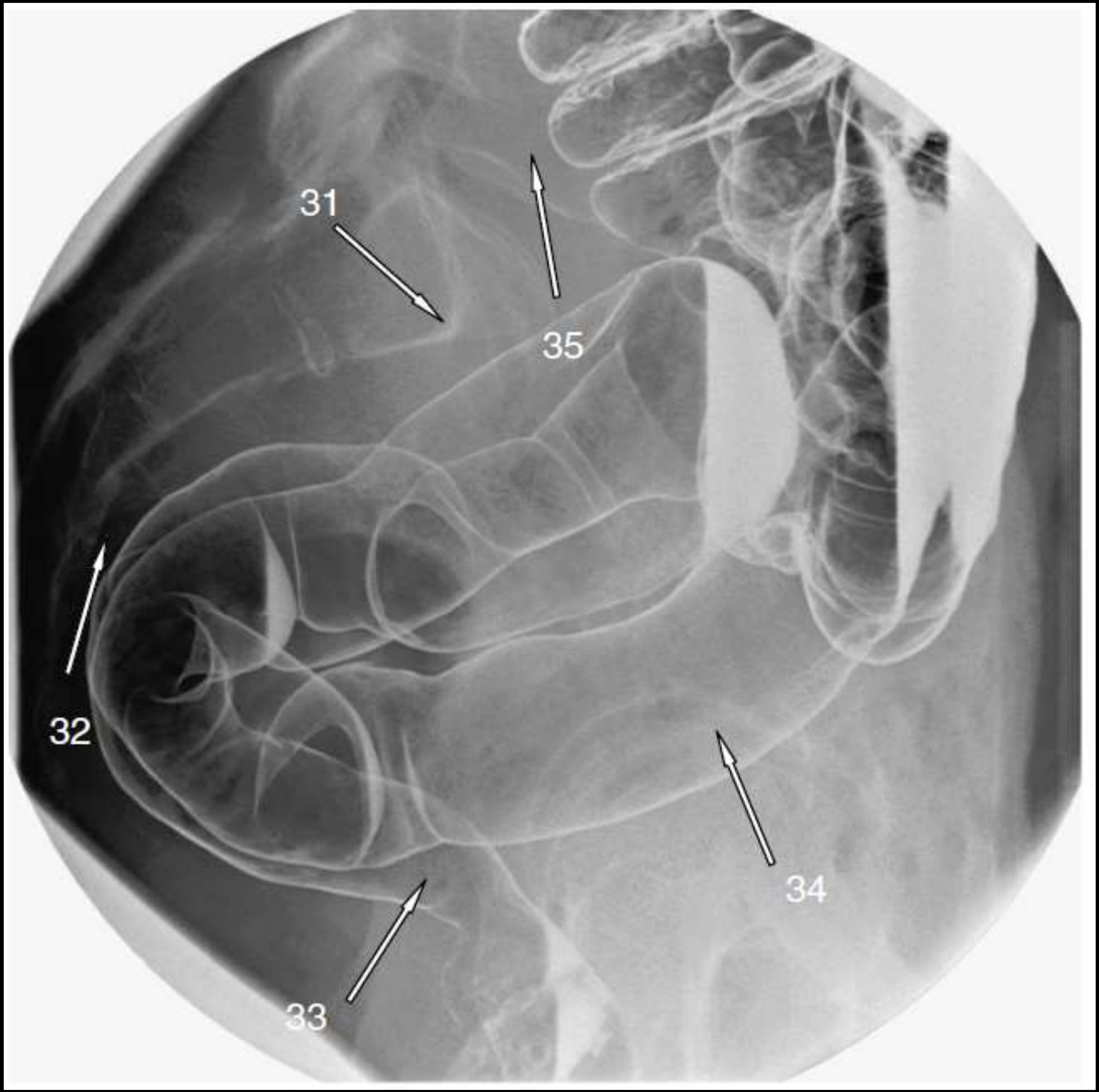
C First part of duodenum/duodenal cap

D Second part of duodenum

E Valvulae conniventes

Spot film from a barium meal, taken at an oblique angle.

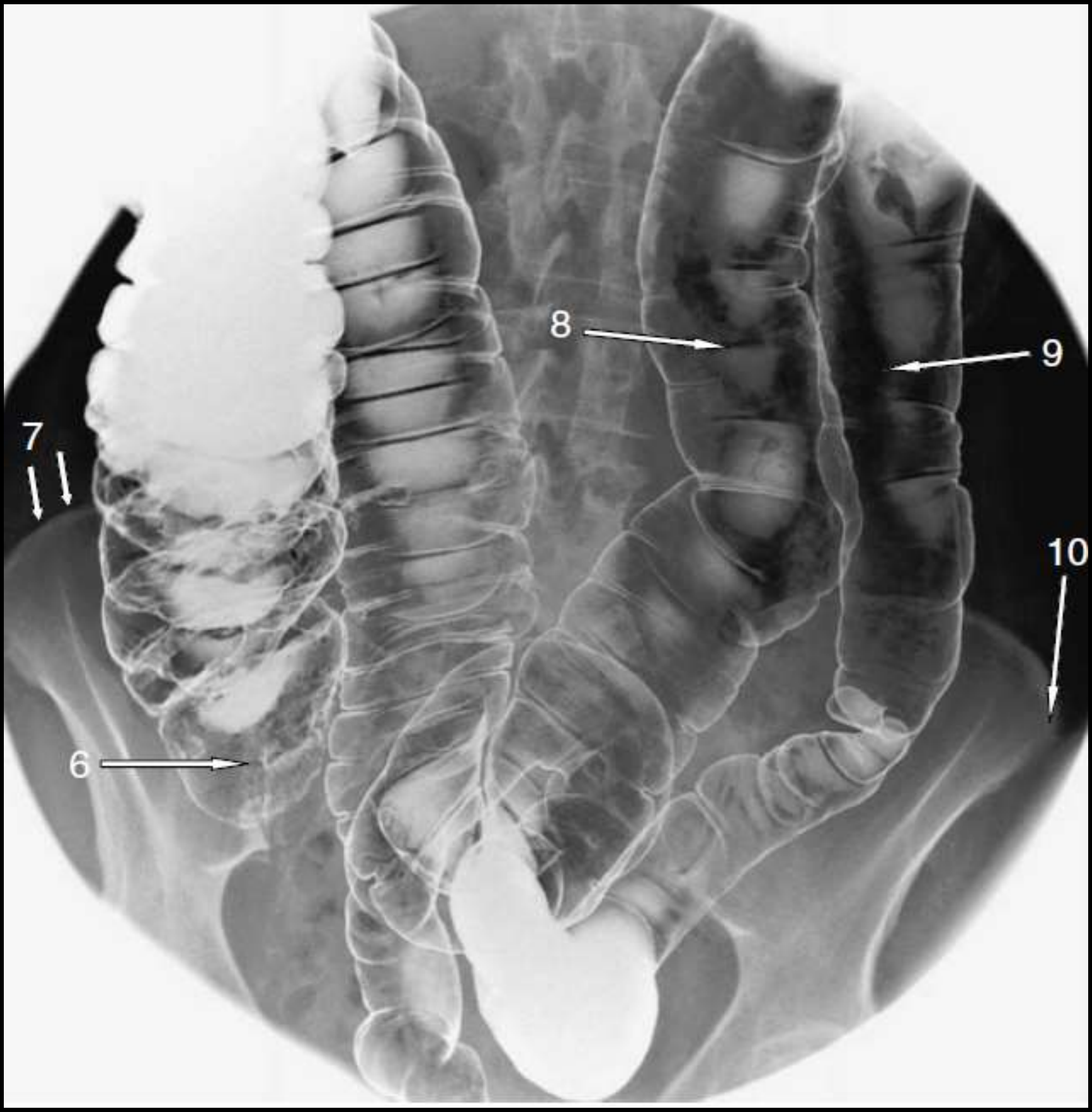
For further discussion see Chapter 3, Case 3.6.


31
35
32
34
33

Barium Enema

31. Sacral promontory
32. Presacral/postrectal space
33. Rectum
34. Sigmoid colon
35. L5 vertebral body

The presacral (or postrectal) space is clinically very important to determine tumour invasion and leaks following bowel anastomosis breakdown. The measurement between the anterior sacrum at the S4 level and the posterior wall of the rectum should not measure more than 4 mm.



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10
6

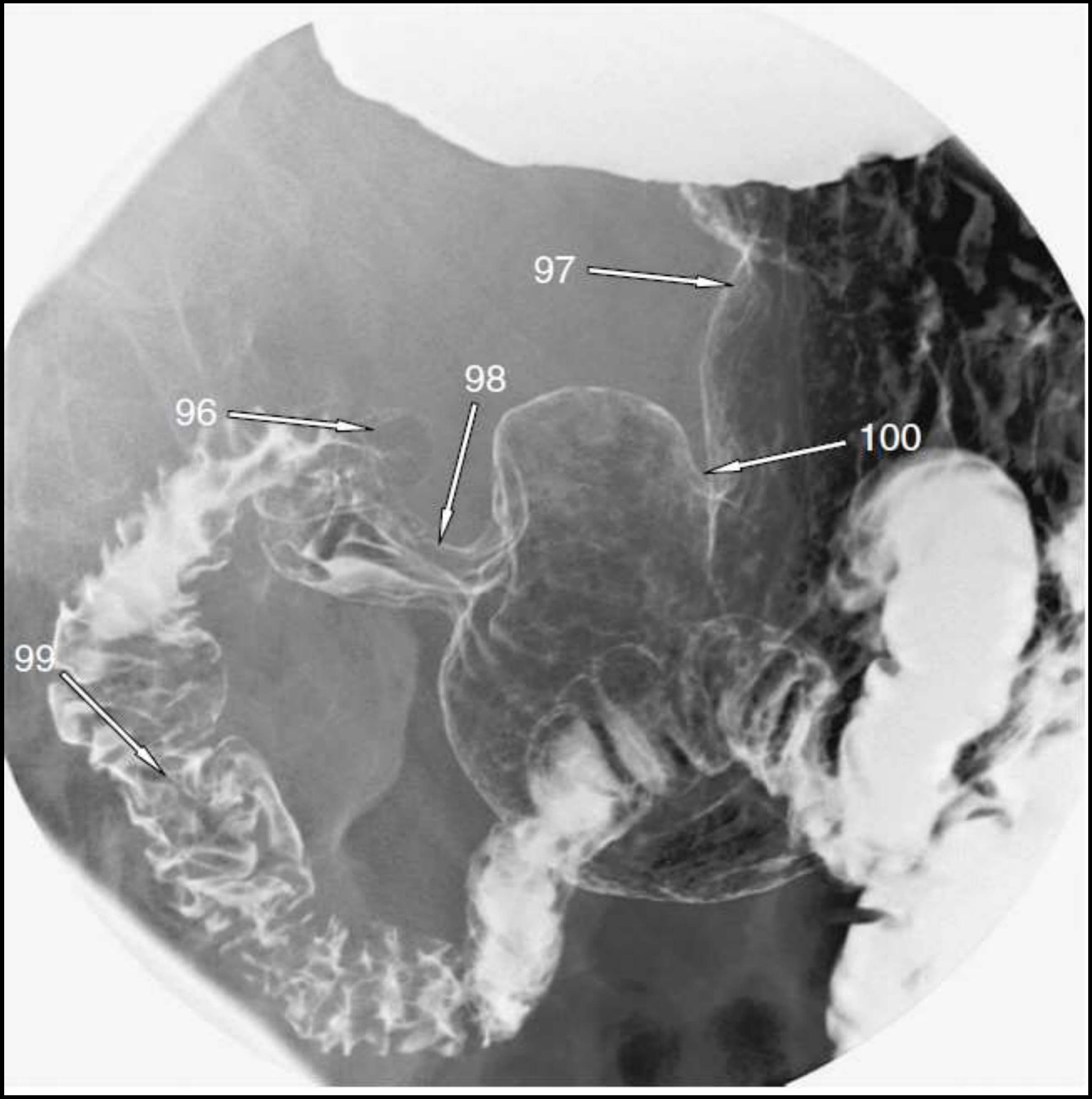
Barium Enema

6. Caecum/caecal pole
7. Right iliac crest
8. Transverse colon
9. Descending colon
10. Left anterior superior iliac spine


21
22
23
24
25

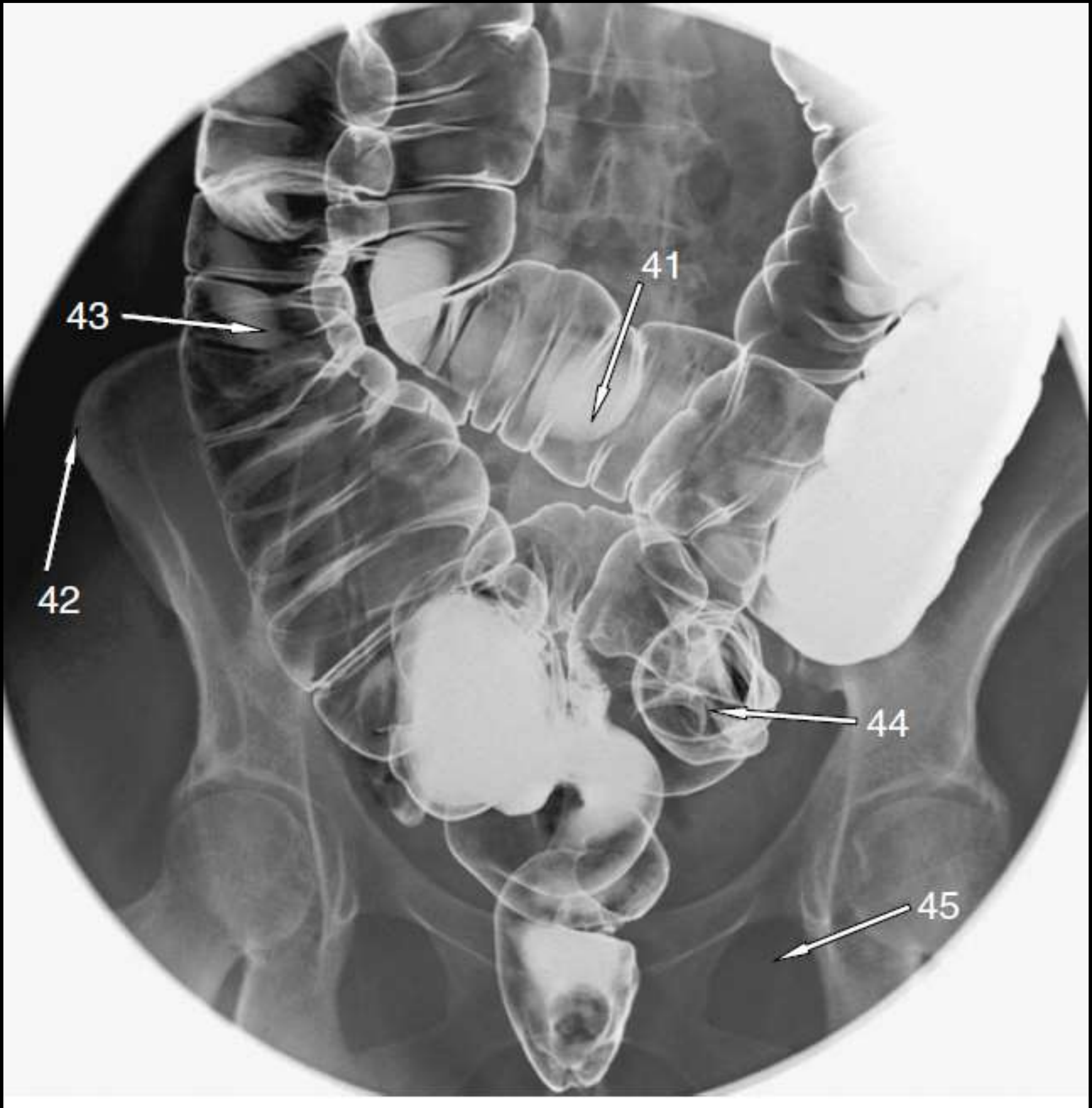
Barium Meal

21. Gastric Fundus (barium within)
22. Lesser curvature of stomach
23. Duodenal cap (D1 segment)
24. 2nd part of duodenum (D2 segment)
25. Antrum of stomach


97
98
96
100
99

Barium Meal

96. Duodenal cap (1st part of duodenum)
97. Lesser curve of stomach
98. Pylorus
99. Second part of duodenum
100. Incisura angularis of lesser curve of stomach


41
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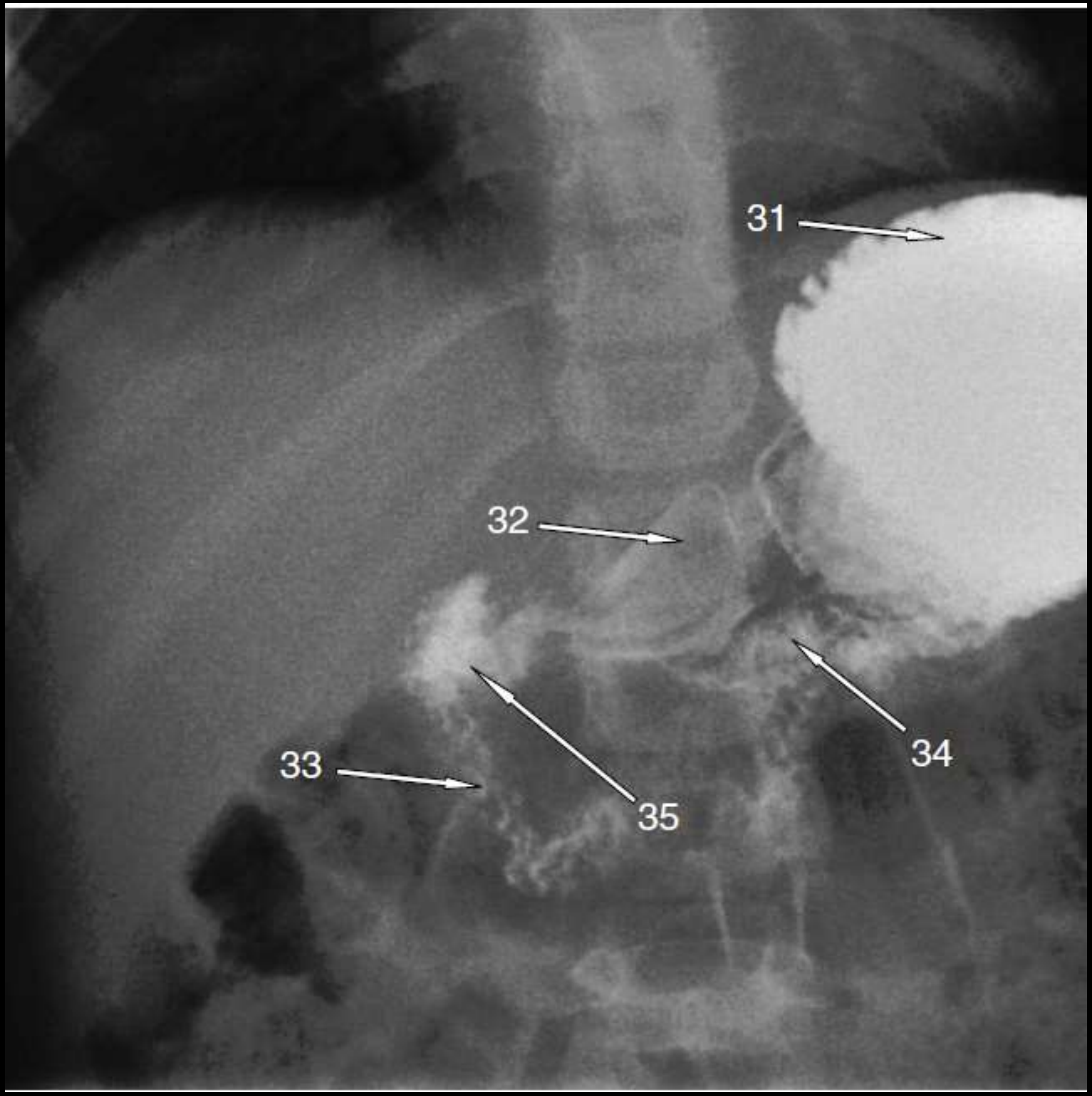
Barium Enema

41. Transverse colon
42. Right anterior superior iliac spine
43. Ascending colon
44. Sigmoid colon
45. Left obturator foramen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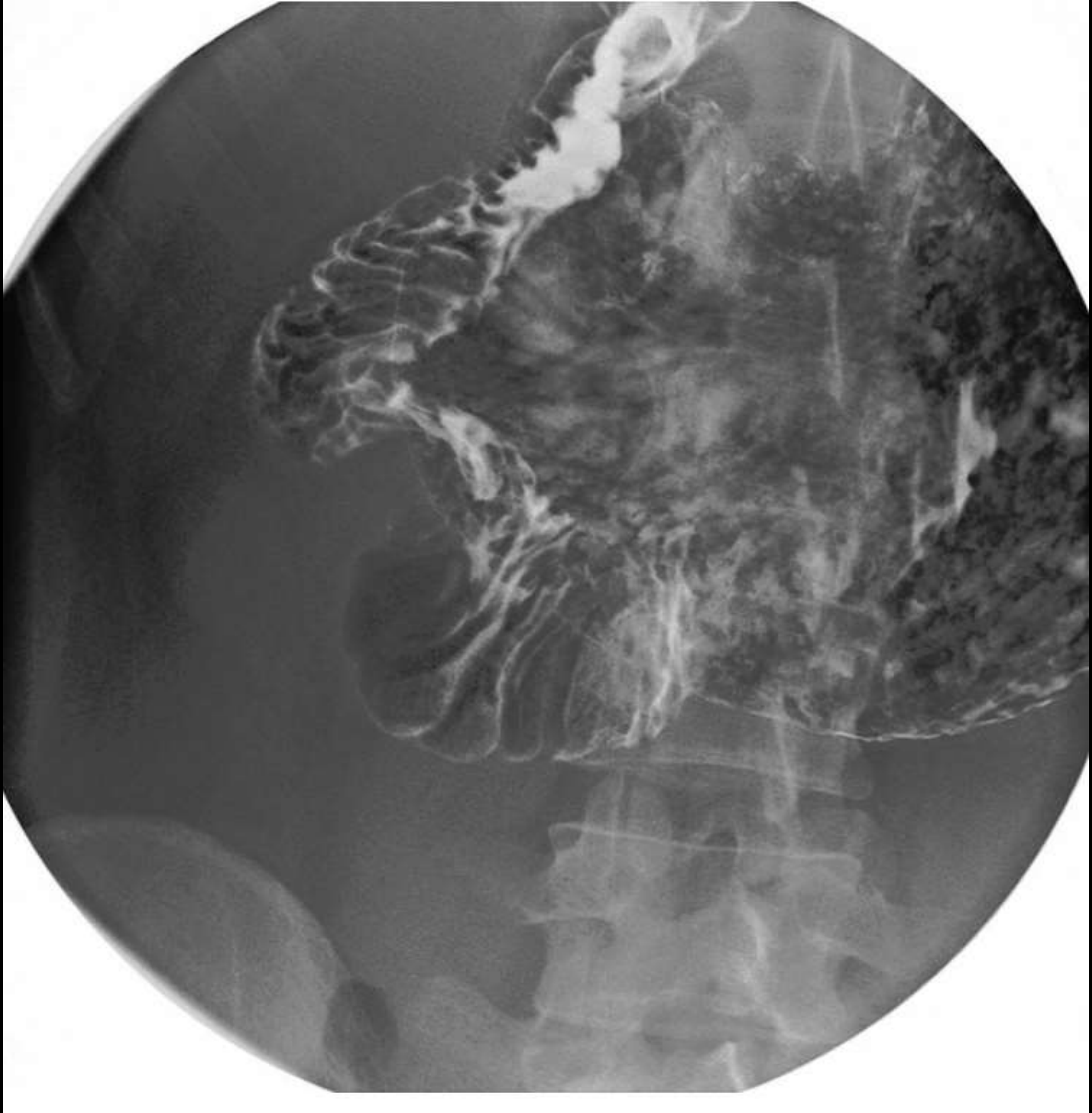
Barium Meal

31. Fundus of the stomach (barium in)
32. Antrum of the stomach
33. Second part of the duodenum
34. Duodenojejunal flexure
35. First part of the duodenum

Often, the primary purpose of the paediatric barium meal is to ascertain the position of the D-J flexure, in order to exclude malrotation. The D-J flexure should normally lie at the same level as the pylorus and lateral to the left pedicles.



Barium Meal

Annular pancreas

This results from abnormal migration of the ventral pancreatic bud. The pancreas surrounds and can cause obstruction of the duodenum. It appears as an annular constriction of the second part of the duodenum on barium studies. There is an increased incidence of pancreatitis and peptic ulcer disease.


A
B
C
D
E

Case 13

Barium follow-through. 'Overcouch' AP radiograph.

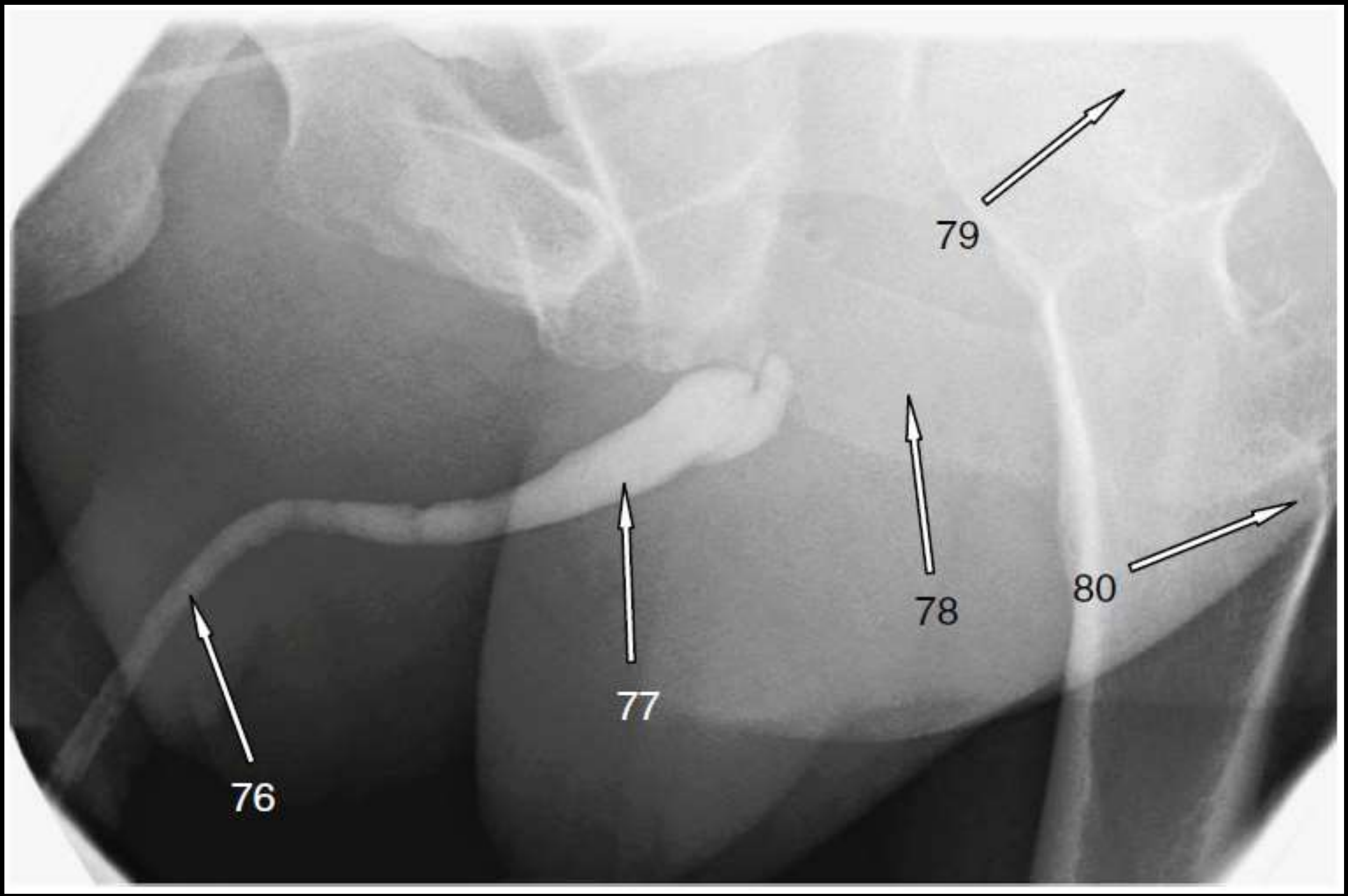
1. Duodenum (second part)
2. Pylorus
3. Jejunum
4. Appendix
5. Ascending colon


A
B
C
D
E

Case 3

Oblique pelvic 'spot' image from a double-contrast barium enema.

1. Caecum
2. Sigmoid colon
3. Appendix
4. Ileum
5. Transverse colon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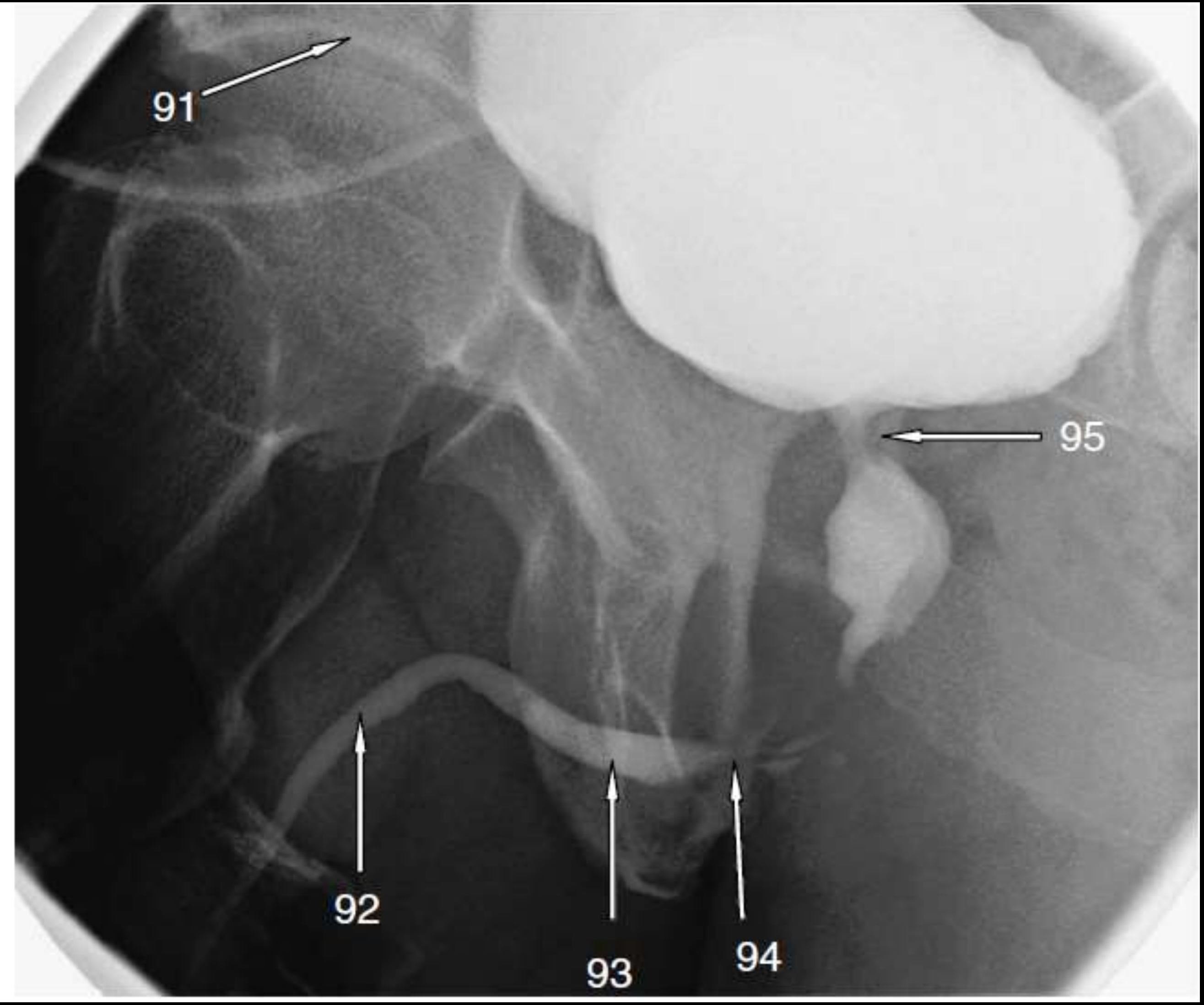
76

Urethrogram

76. Penile urethra
77. Bulbous urethra
78. Inferior pubic ramus
79. Head of femur
80. Greater trochanter of femur



91
92
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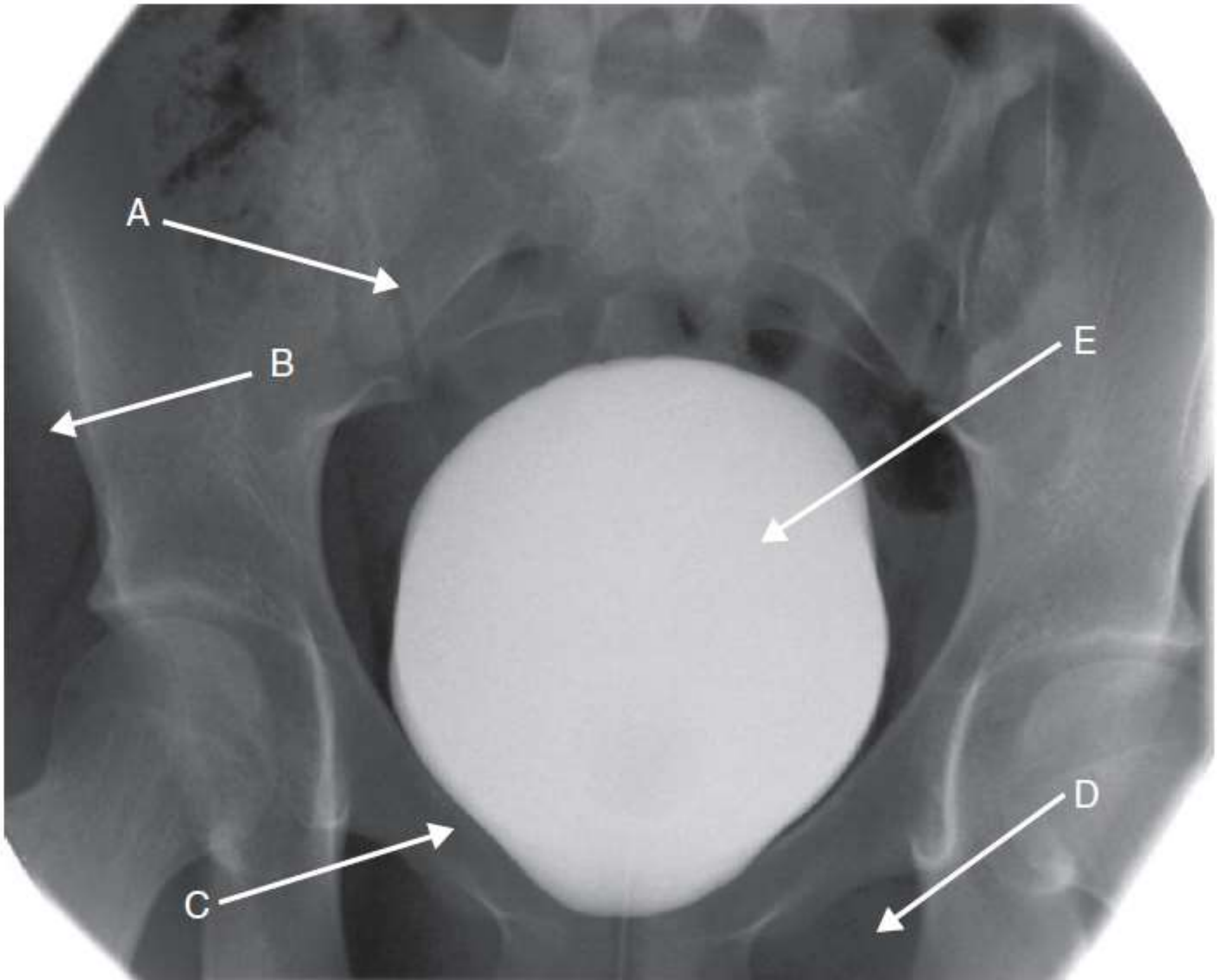
95

Urethrogram

91. Right acetabulum
92. Penile urethra
93. Bulbous urethra
94. External sphincter (sphincter urethrae)
95. Neck of bladder

This is a urethrogram, very simple to identify the anatomy if you are familiar with the procedure. Try to observe a urethrogram at least once before the exam.

Case 2.2



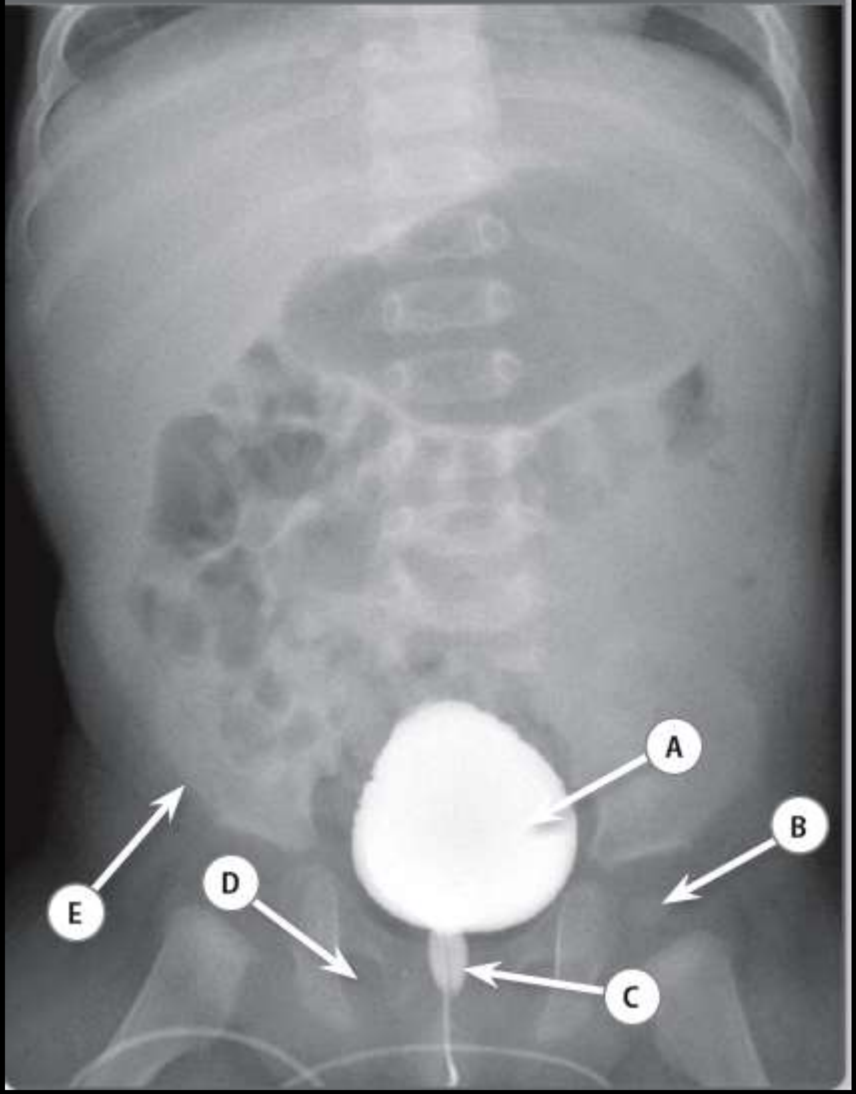
2.2 Cystogram

(a) Right sacroiliac joint.
(b) Right anterior inferior iliac spine.
(c) Right superior pubic ramus.
(d) Left obturator foramen.
(e) Contrast in bladder.

Cystograms are performed by either hand injecting, or running in a contrast infusion through either a urethral or suprapubic catheter. Both antero-posterior (AP) and lateral views should be taken, and the bladder should be filled as much as a patient can tolerate.

Bladder rupture can be either intraperitoneal or extraperitoneal. Extraperitoneal ruptures occur with fractures of the pelvis, due to the rigid fixture of the bladder neck. Intraperitoneal ruptures tend to occur in blunt trauma when the bladder is full. The tear is usually at the junction of the loose and fixed peritoneum at the posterior part of the bladder. Intraperitoneal ruptures are treated surgically, extraperitoneal ruptures are usually managed conservatively. If there is trauma, both retrograde and antegrade imaging should be performed to ensure that no ureteric trauma has occurred.

Case 13.17



Case 13.17

A Urinary bladder

B Ossification centre of left femoral capital epiphysis

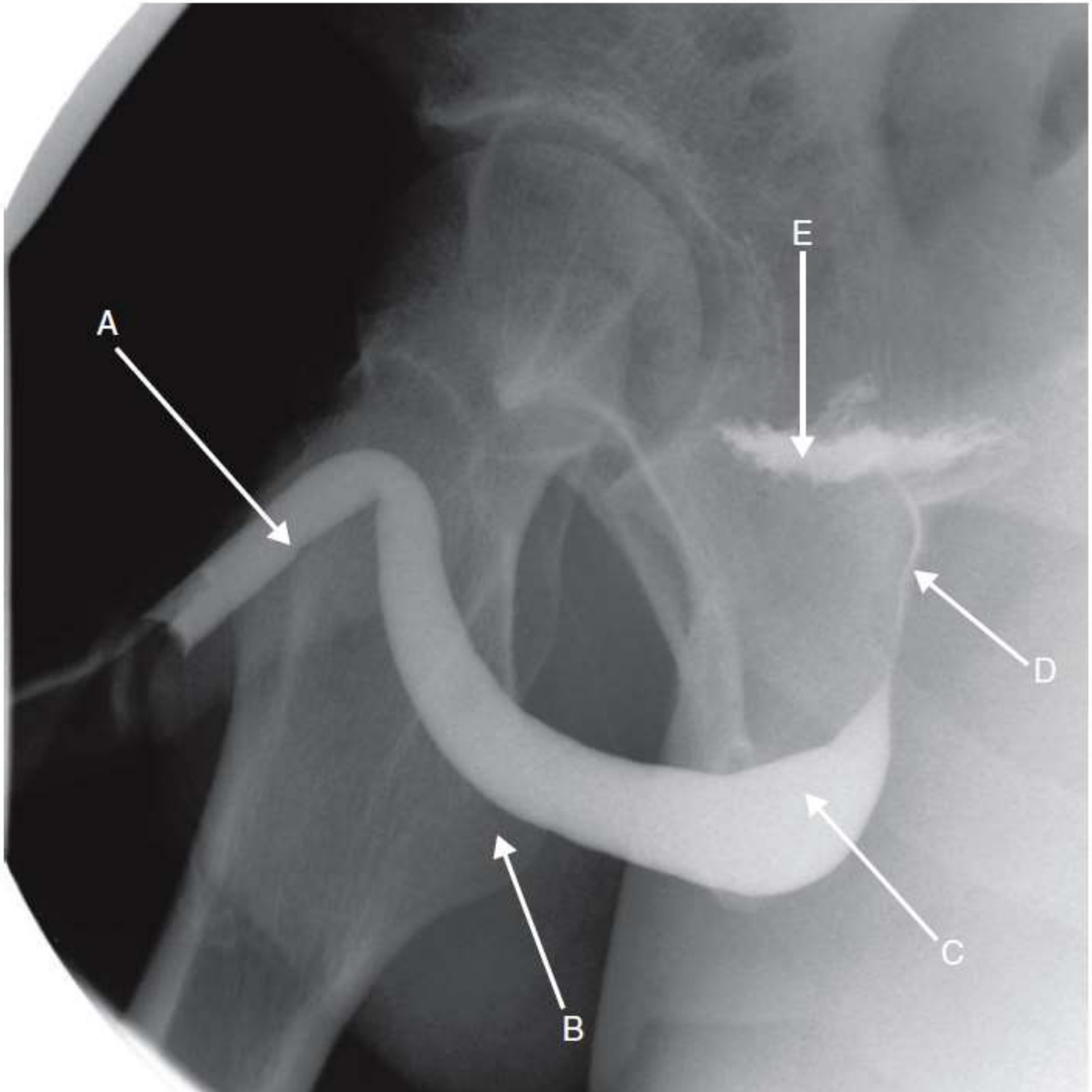
C Urethra

D Right obturator foramen

E Right ilium

In a paediatric context, micturating cystourethrography is typically performed when investigating recurrent urinary tract infections. The urinary bladder is catheterised and contrast instilled in a retrograde fashion, with spot films taken (such as the image shown here) to assess for structural abnormalities (including ureterocoele). Once the bladder is full, the catheter is removed and imaging is performed during micturition to assess for vesicoureteric reflux, which is a potential cause of recurrent urinary tract infections. Vesicoureteric reflux will be seen as contrast which passes superiorly into the ureters and which may reach the pelvicalyceal systems, depending on severity.

Case 1.9



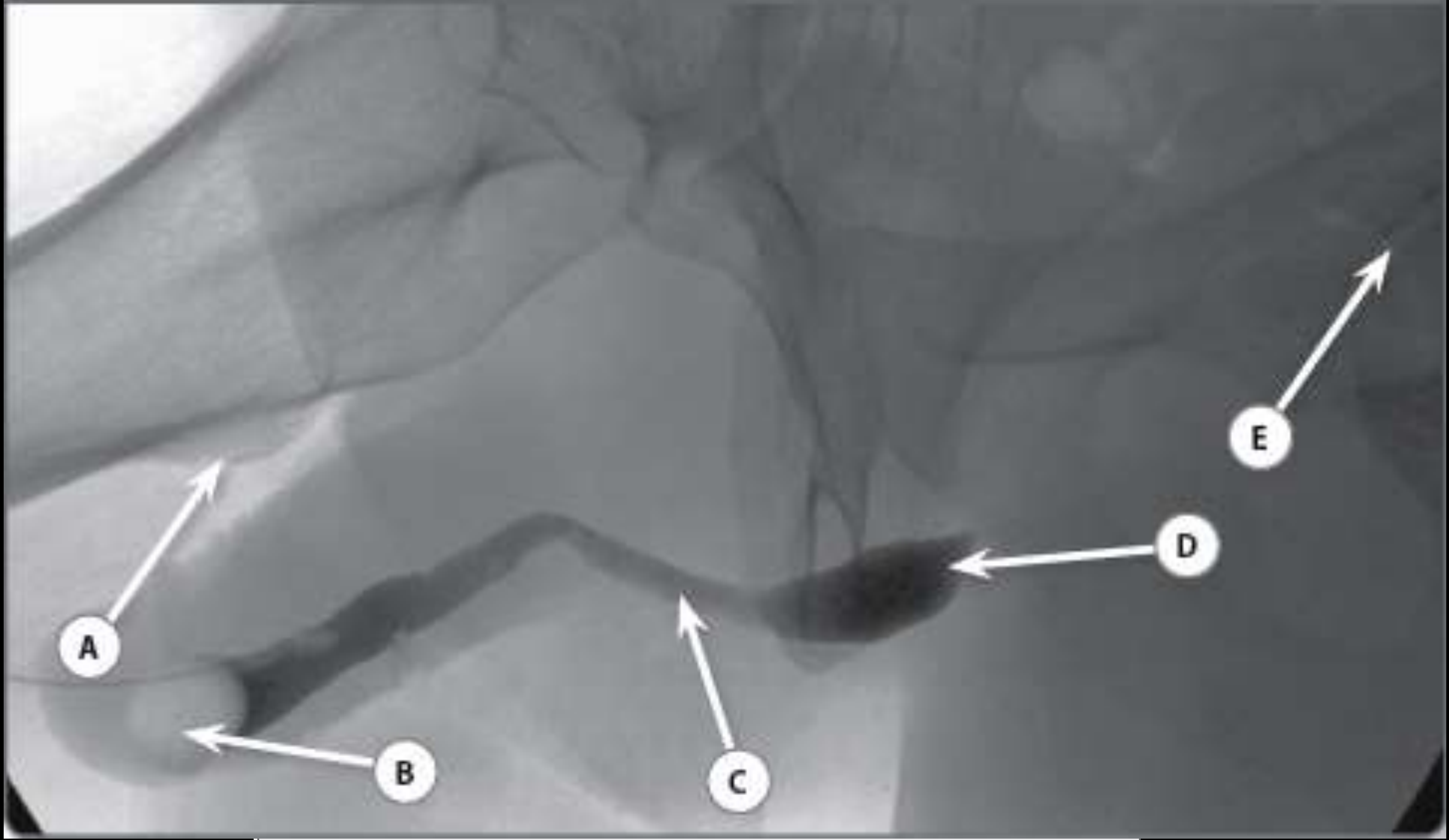
1.9 Urethrogram

(a) Penile urethra. The male urethra runs from the neck of the bladder to the urethral orifice at the tip of the penis. The penile and bulbous urethra constitute the anterior urethra.
(b) Lesser trochanter of the right femur.
(c) Membranous urethra.
(d) Prostatic urethra. The membranous and prostatic urethra constitute the posterior urethra.
(e) Urinary bladder (collapsed).

Urethrograms are performed by placing a small catheter in the fossa navicularis, gently inflating the balloon and slowly injecting contrast to outline the urethra. By placing the patient obliquely on the x-ray screening table this allows the penile urethra to be elongated and ensures adequate views of the entire urethra.

Proximal urethral injuries are seen with pelvic fractures as the distal prostatic and membranous urethra has a fixed attachment to the pelvic bones. It is important to perform retrograde (cystogram through suprapubic catheter) and antegrade (ascending urethrogram) studies in a patient at risk of urethral trauma to ensure there is direct continuity between the bladder and the entire urethra.

Case 6.8



QUESTION		WRITE YOUR ANSWER HERE
A	Name the structure labelled A.	
B	Name the artificial structure labelled B.	
C	Name the structure labelled C.	
D	Name the joint labelled D.	
E	Name the joint labelled E.	

Case 6.8

A Right lesser trochanter

B Catheter balloon in navicular fossa

C Penile urethra

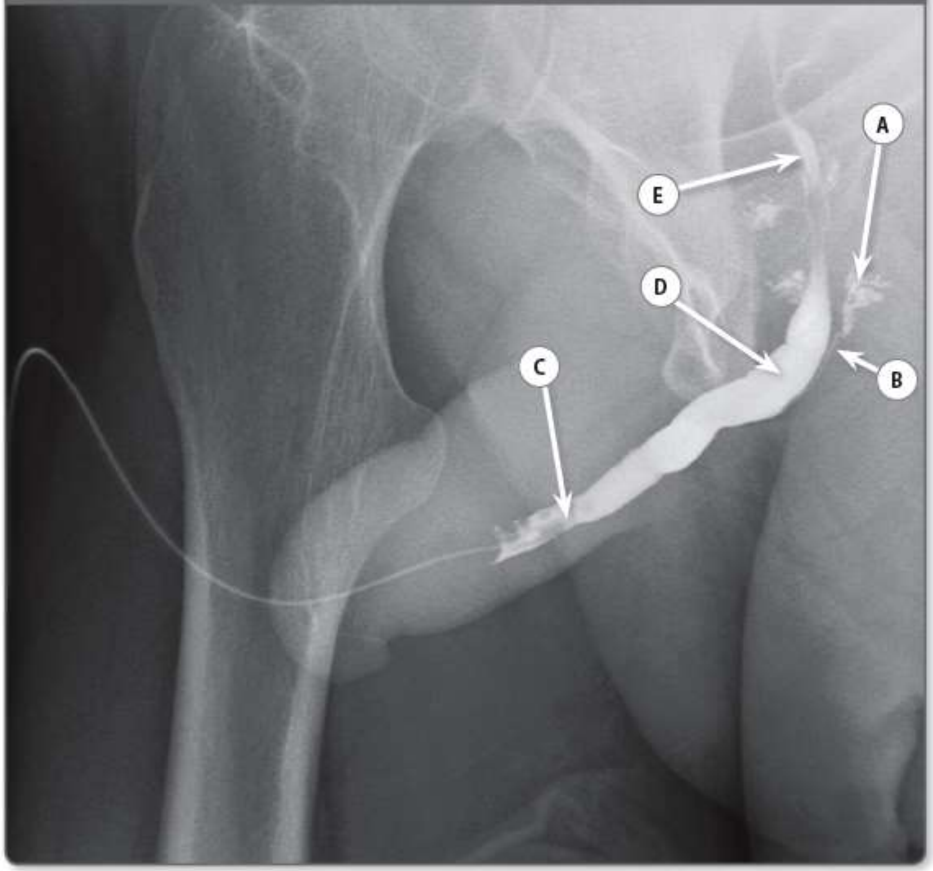
D Bulbous urethra

E Left hip joint

The male urethra has four anatomical parts, from proximal to distal: prostatic, membranous, bulbous and penile. To visualise the prostatic and membranous parts, the bladder is filled retrogradely with contrast before the patient is asked to void.

The navicular fossa is the most distal part of the penile urethra, in which the inflated catheter balloon can be seen in this example.

Case 1.8



Case 1.8

	QUESTION	WRITE YOUR ANSWER HERE
A	Name the structure labelled A.	
B	Name the structure labelled B.	
C	What part of the urethra does C correspond to?	
D	What part of the urethra does D correspond to?	
E	What part of the urethra does E correspond to?	

Case 1.8

A Cowper's (bulbourethral) gland

B Duct of bulbourethral gland

C Penile urethra

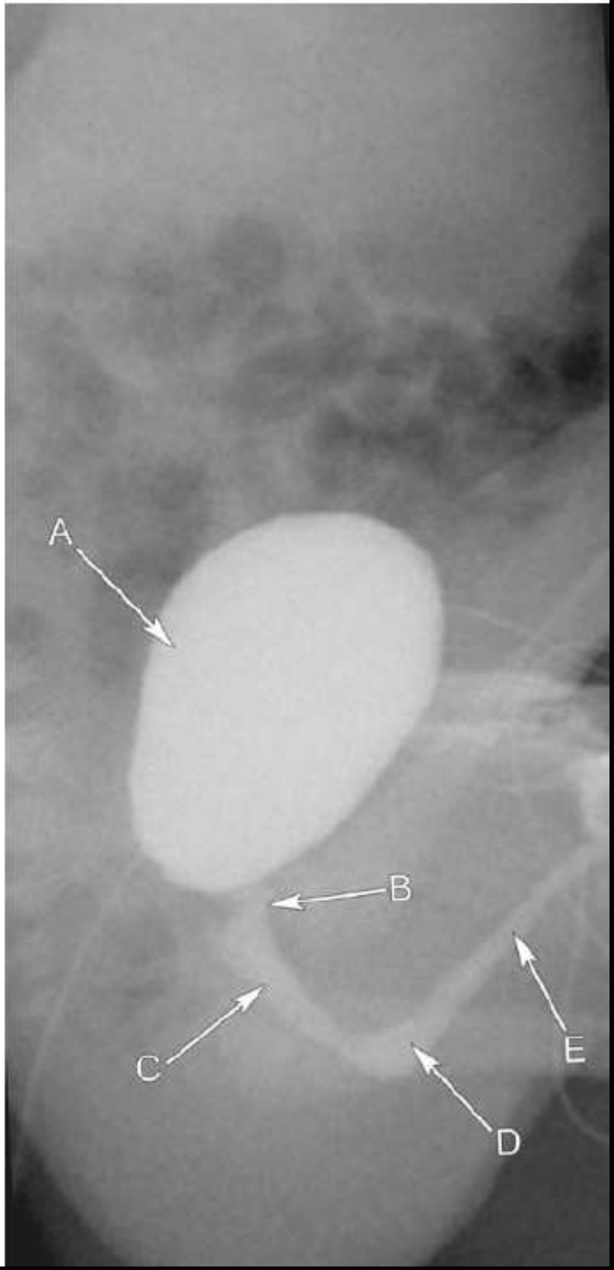
D Bulbous urethra

E Prostatic urethra

Retrograde urethrography is used to demonstrate structural abnormalities of the urethra, including strictures and (in the event of trauma) urethral disruption. It is performed by placing the tip of a catheter inside the navicular fossa – a focal dilatation just proximal to the urethral meatus – and instilling contrast in a retrograde manner. Anatomically, the male urethra is divided into posterior and anterior portions. The posterior urethra comprises the prostatic urethra (the portion passing from the bladder neck through the prostate) and the membranous urethra (which extends through the urogenital diaphragm). The anterior urethra is composed of the bulbar urethra (between the urogenital diaphragm and root of the penis) and the penile urethra. The navicular fossa and meatus may also be included with the anterior urethra.

The paired Cowper's (or bulbourethral) glands are exocrine glands which are equivalent to Bartholin's glands in females.

Question 3.12



3.12 Micturating cystourethrogram (MCUG)

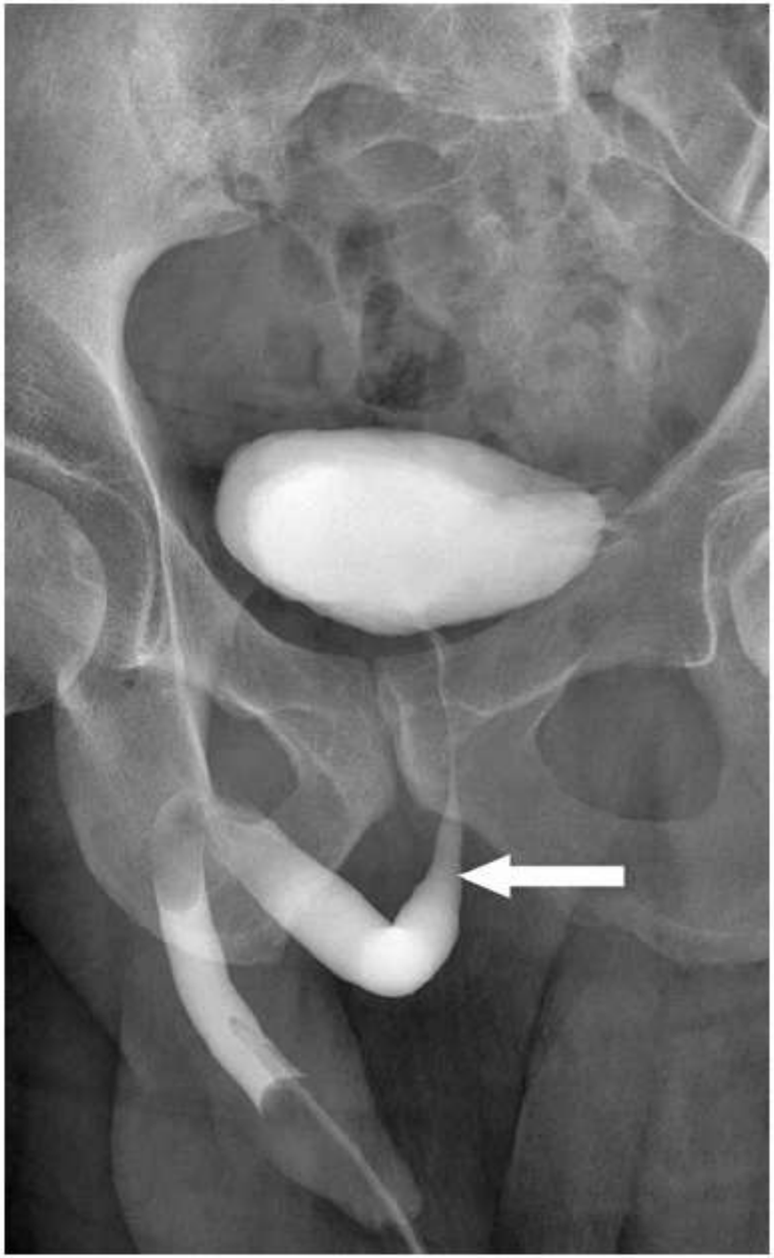
A Bladder.
B Prostatic urethra.
C Membranous urethra.
D Bulbar urethra.
E Penile urethra.

The MCUG is a dynamic examination for assessing the ureters, bladder and urethra whilst the patient voids. It is commonly indicated for the exclusion of vesicoureteric reflux and posterior urethral valves.

The male urethra is divided into anterior and posterior segments:

Anterior segment	Penile urethra: meatus to the root of the penis Bulbar urethra: root of the penis to the urogenital diaphragm
Posterior segment	Membranous urethra: urogenital diaphragm to the verumontanum of the prostate Prostatic urethra: verumontanum of the prostate to the neck of the bladder

Question 28:

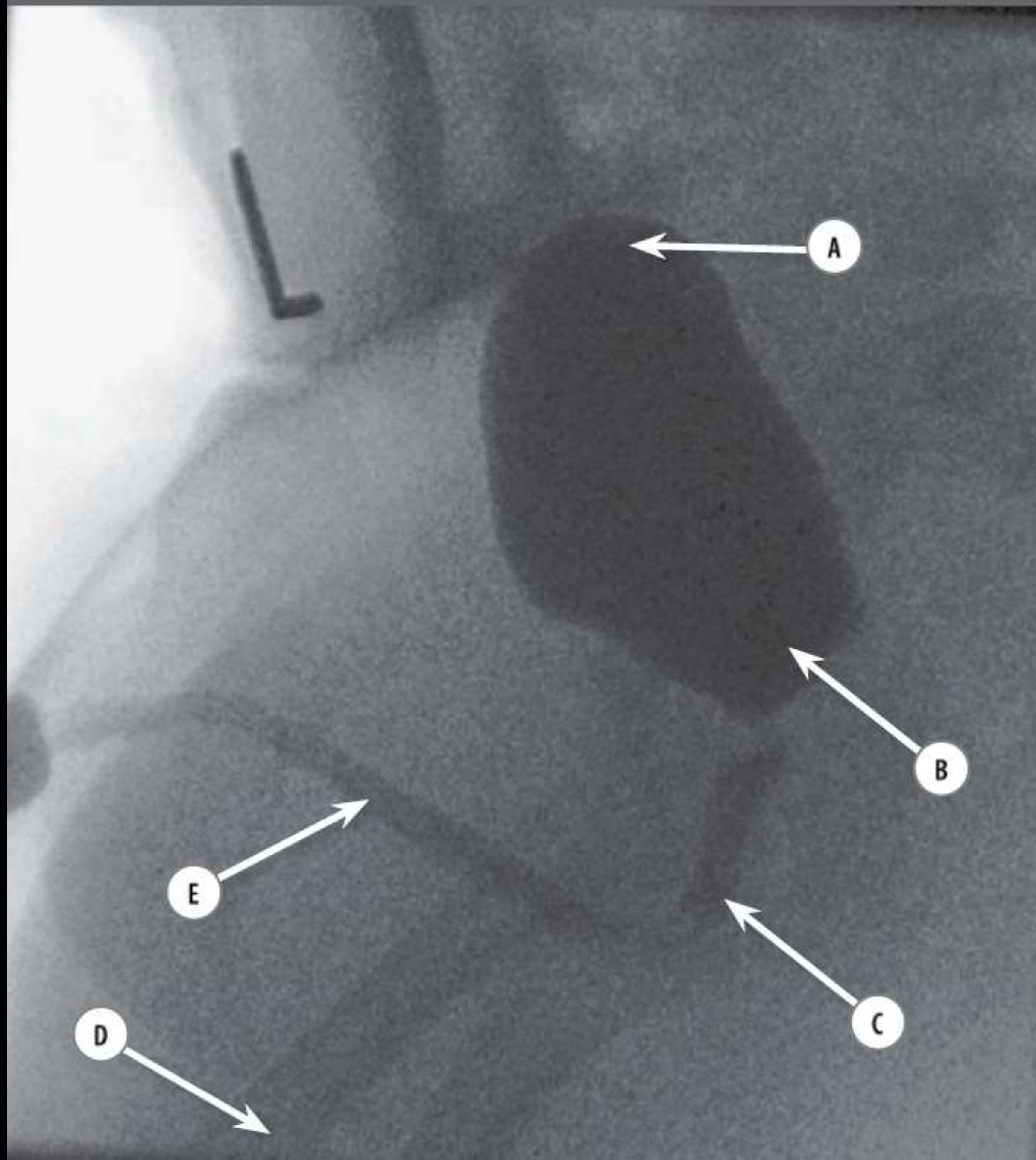


Question 28: Male urethrogram

Answer: Bulbar urethra

- There are not many structures that could have this appearance, so even if you have never seen a urethrogram before, you should be able to guess.
- There are four parts to the male urethra: penile, bulbar, membranous, and prostatic. The membranous urethra is the narrowest.

Case 3.37



Case 3.37

A Bladder dome

B Bladder neck

C Bulbar urethra

D Femoral diaphysis

E Penile urethra

Micturating cystogram, taken in an oblique position.

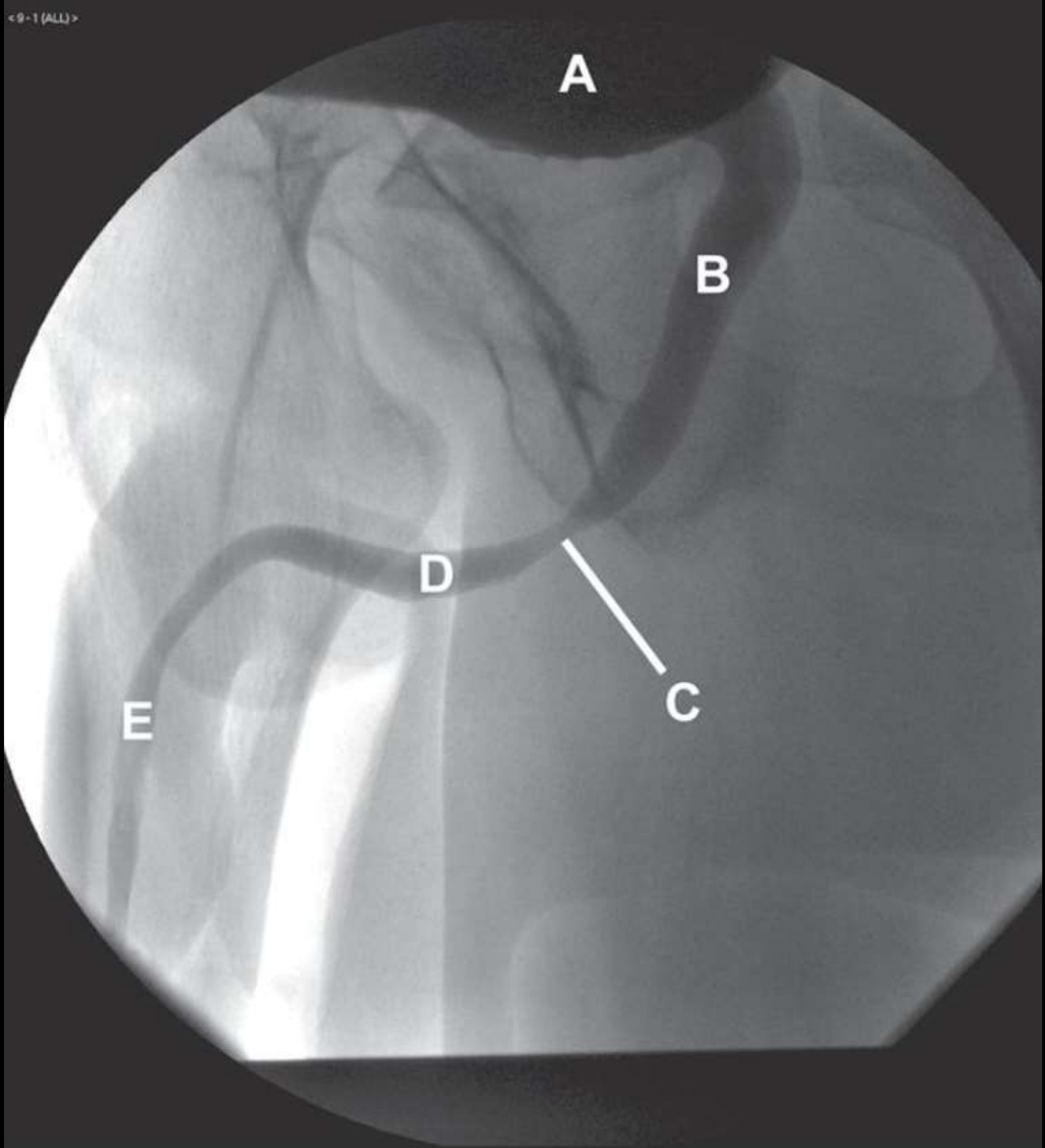
The male urethra runs from the internal urethral sphincter at the bladder neck, to the urethral meatus at the tip of the penis. It is divided into four parts:

- **the posterior urethra** is comprised of the prostatic and membranous sections
- **the anterior urethra** is made up of the bulbar and penile sections

The urethra is widest as it crosses through the ventral part of the prostate. This prostatic portion runs for approximately 3 cm before becoming the membranous urethra. The membranous urethra is approximately 2 cm in length and forms the narrowest segment, as it passes through the membranous urogenital diaphragm (the external sphincter).

The bulbar urethra is so called because it traverses the bulb of the penis, through the corpus spongiosum. There is a focal dilatation in the bulbar segment, which is known as the intrabulbar fossa. Lastly the penile urethra continues towards the meatus through the corpus spongiosum. This segment is relatively long and narrow, but has a small dilatation at the end, the navicular fossa.

Ryan S, McNicholas M, Eustace SJ. Anatomy for Diagnostic Imaging, 3rd edn. Edinburgh: Saunders, 2011: 231–233.


<9-1 (ALL)>
A
B
C
D
E

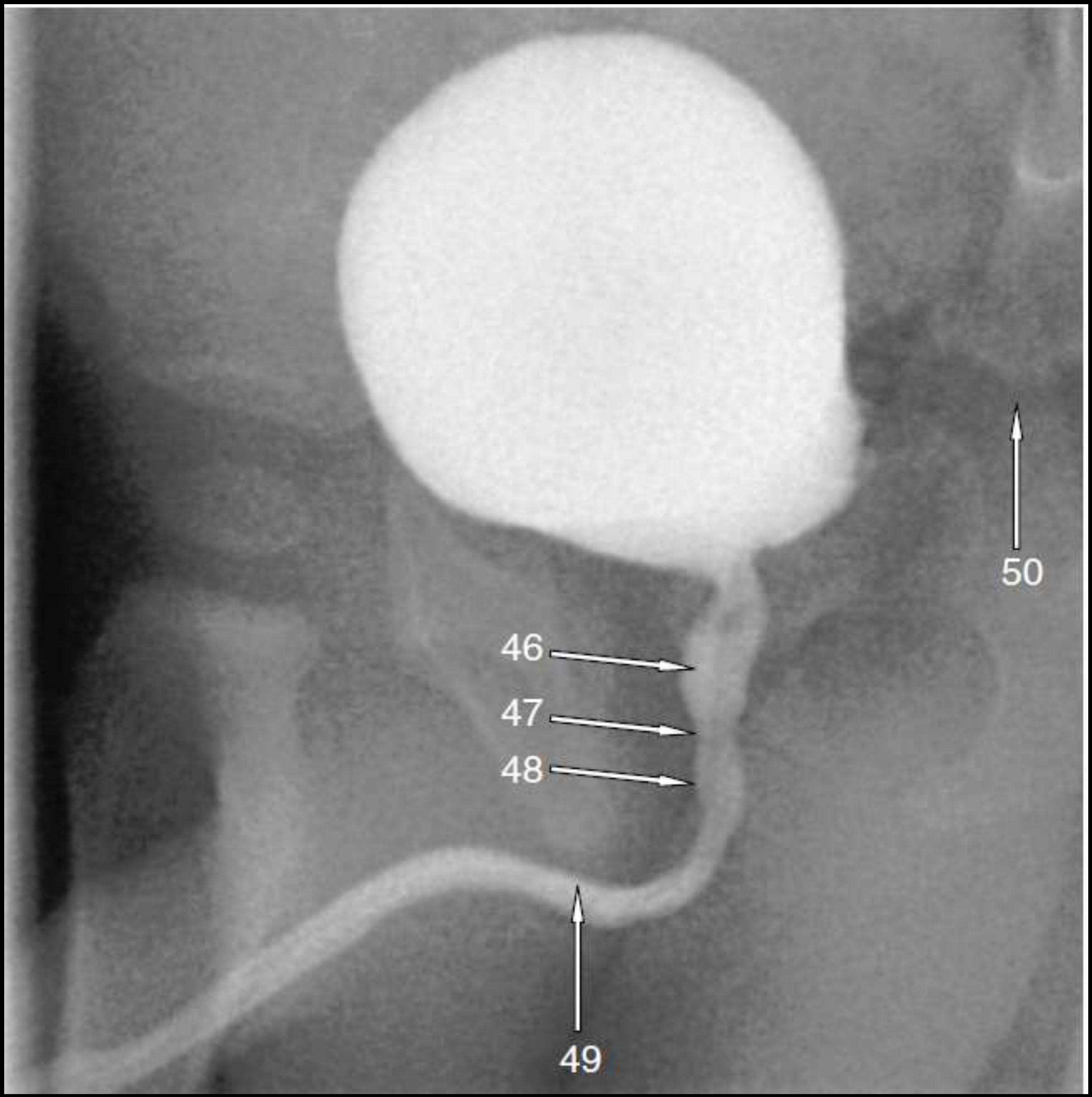
Q6 Answers

a Urinary bladder filled with radio opaque contrast
b Prostatic urethra
c Membranous urethra
d Bulbous urethra
e Penile urethra

Micturating cystourethrogram in an adult male, oblique view

The male urethra is much longer than the female urethra. In general terms, the male urethra is divided into anterior and posterior segments. The posterior urethra runs from the internal (involuntary) sphincter at the bladder neck to the urogenital diaphragm (true pelvic floor) and includes prostatic and membranous parts. The membranous urethra is the narrowest part and represents the external (voluntary) sphincter where the urethra crosses the urogenital diaphragm. Distal to this, the anterior urethra (also known as the spongy urethra due to its course through corpus spongiosum) is composed of bulbous (within bulb of penis) and penile segments.

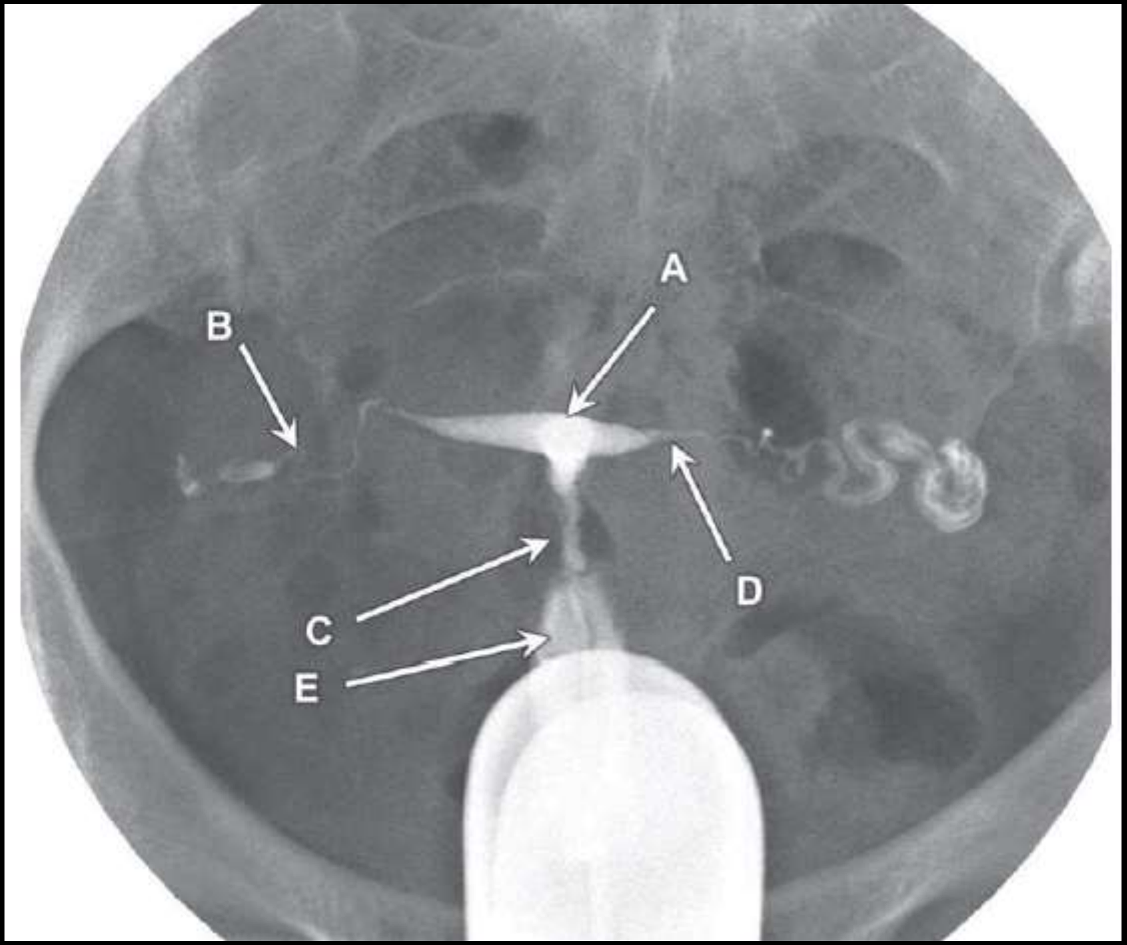
The ejaculatory ducts empty into the prostatic urethra.



46
47
48
49
50

Micturating Cystogram

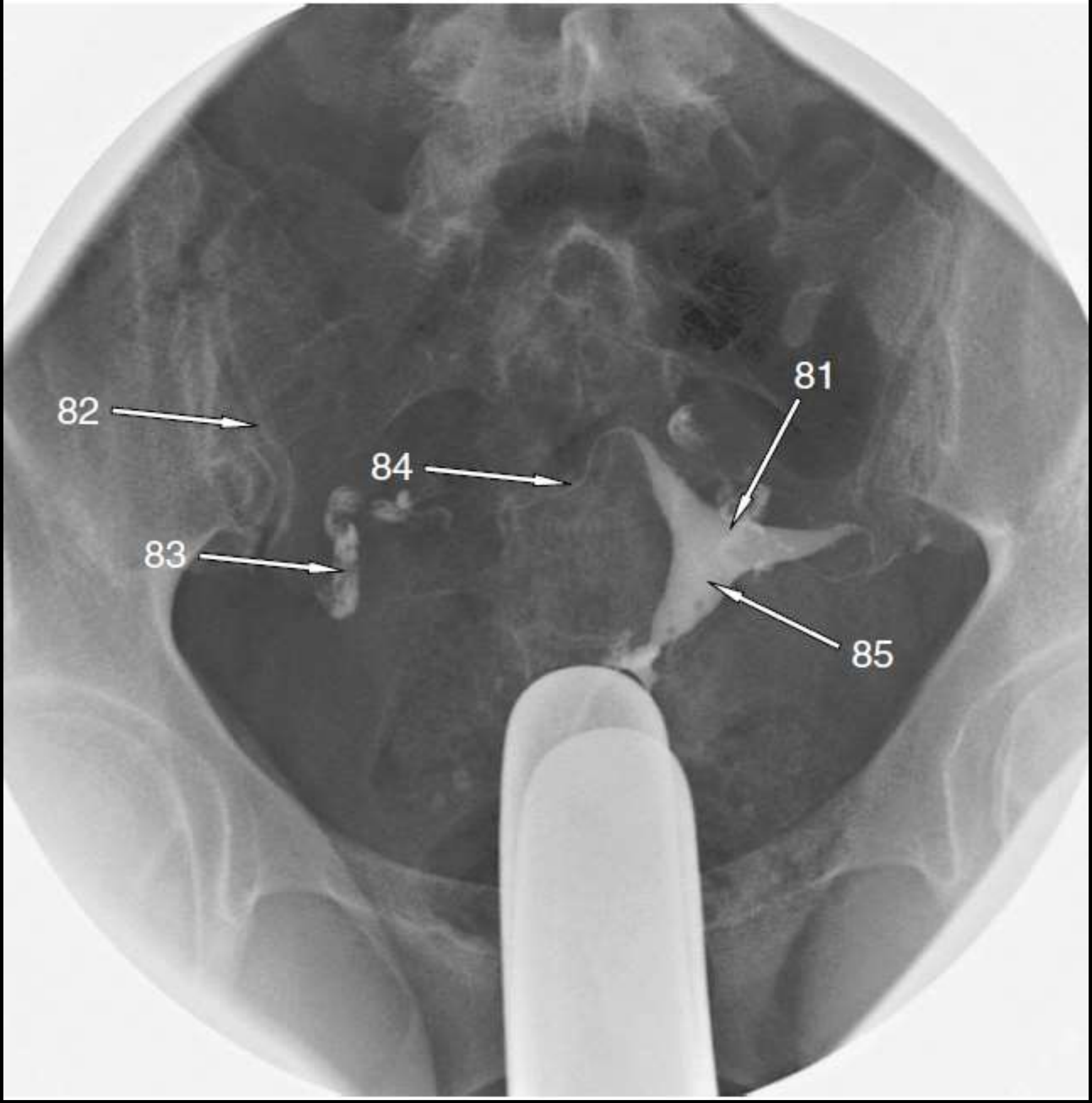
46. Prostatic urethra
47. Membranous urethra
48. Bulbous urethra
49. Penile urethra
50. Unossified left triradiate cartilage


A
B
C
D
E

Case 13

Hysterosalpingogram.

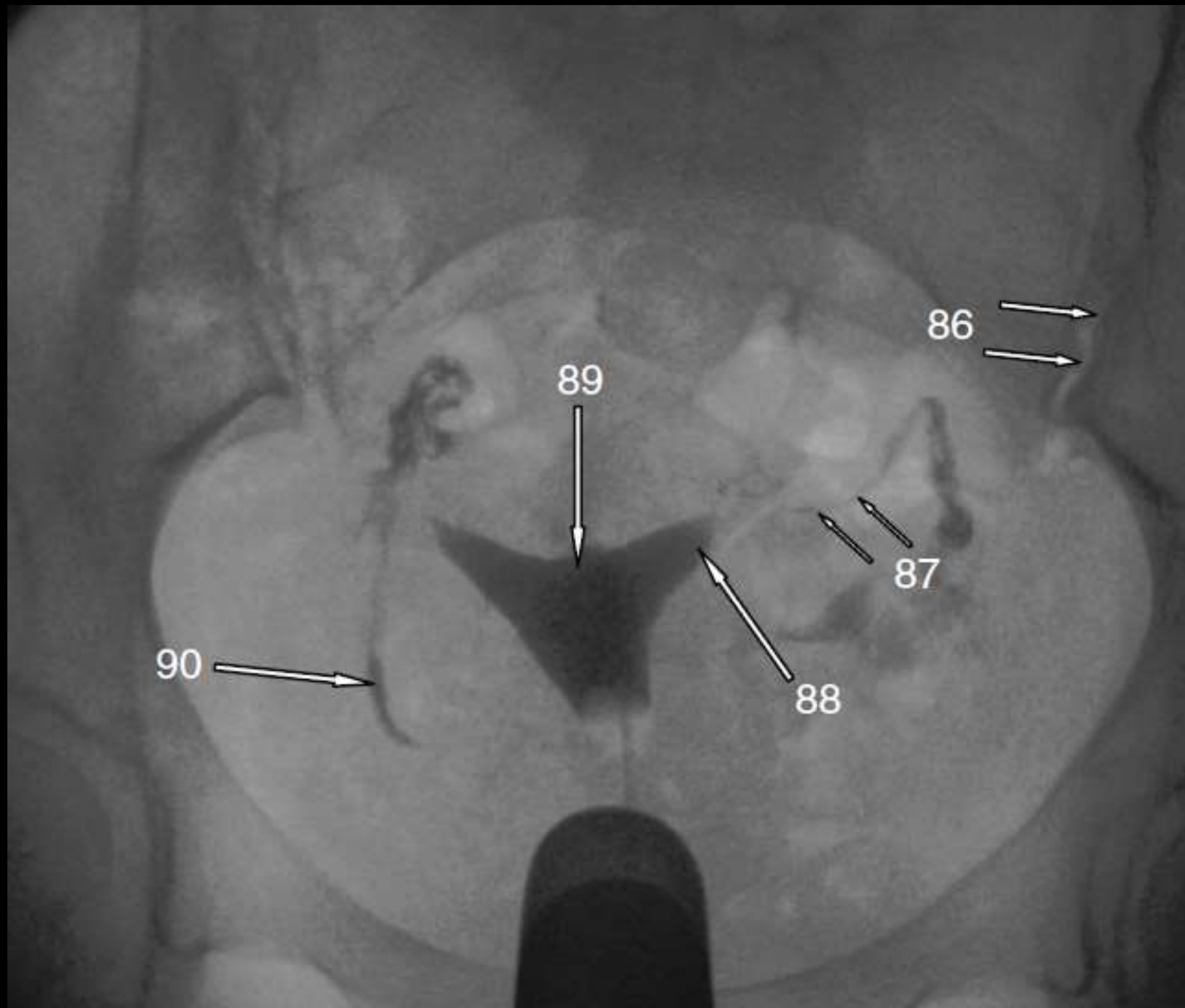
1. Fundus of the uterus
2. Right uterine (Fallopian) tube
3. Cervix
4. Isthmus of the left uterine (Fallopian) tube
5. Vagina



81
82
84
83
85

Hysterosalpingogram (HSG)

81. Uterine fundus
82. Right sacroiliac joint
83. Ampulla of right uterine tube
84. Isthmus of right uterine tube
85. Body of uterus



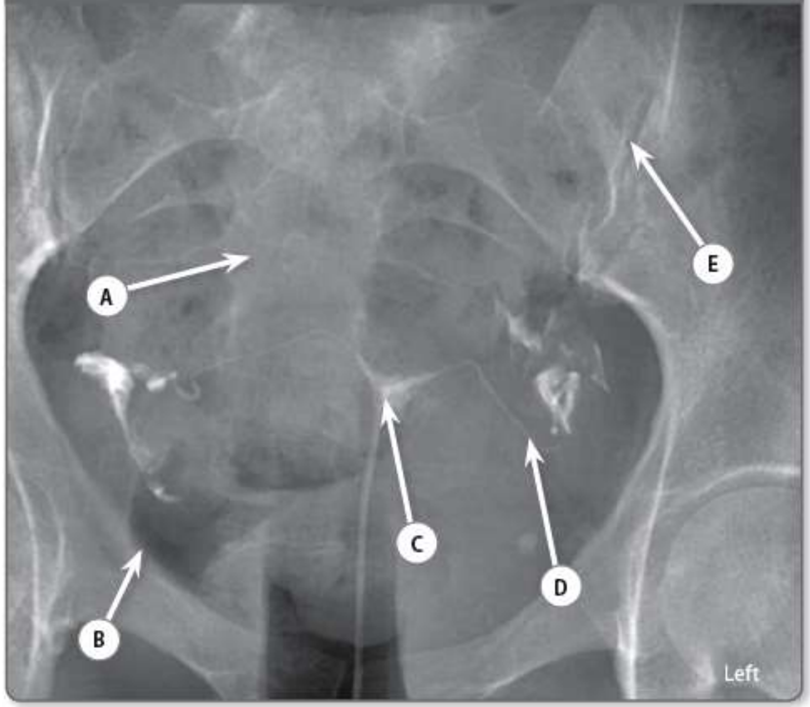
86
89
87
90
88

Hysterosalpingogram

86. Left sacroiliac joint
87. Left Isthmus of uterine tube
88. Left cornu of uterus
89. Fundus of uterus
90. Free peritoneal spillage

This is a hysterosalpingogram (HSG). The metal density object at the bottom of the image is a vaginal speculum. One can also see an inflated balloon just above the cervix.

Case 4.8



Case 4.8

QUESTION		WRITE YOUR ANSWER HERE
A	Name the structure labelled A.	
B	Name the osseous line labelled B.	
C	Name the structure labelled C.	
D	Name the structure labelled D.	
E	Name the structure labelled E.	

Case 4.8

A Sacrum

B Iliopectineal line

C Uterine cavity

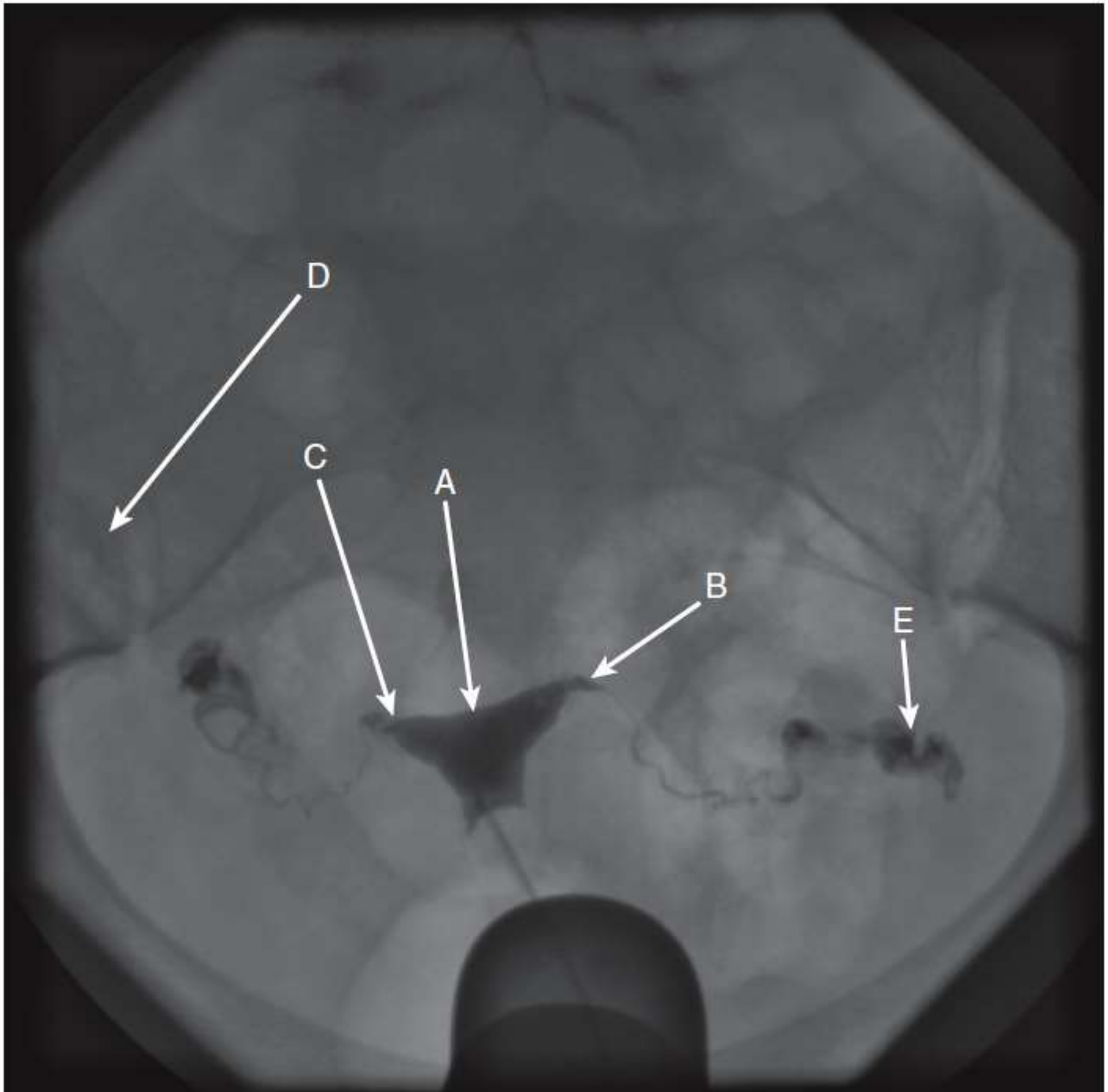
D Lumen of left fallopian tube

E Left sacroiliac joint

Hystosalpingography requires the uterine cavity to be filled with contrast by retrograde catheter injection. It is commonly performed to assess the patency of the fallopian tubes. Similar appearances can be obtained with water and utilising a heavy T2-weighted MRI sequence. Free spillage of contrast into the peritoneal cavity confirms tubal patency.

The uterus is located extraperitoneally between the rectum and the bladder. In 90% of the population, the uterus lies in an anteverted and anteflexed position. Retroversion and retroflexion are normal variations in the remaining 10%. The broad ligament, a peritoneal fold, envelops the anterior uterus and attaches the lateral walls of the organ to the pelvis.

Case 1.17

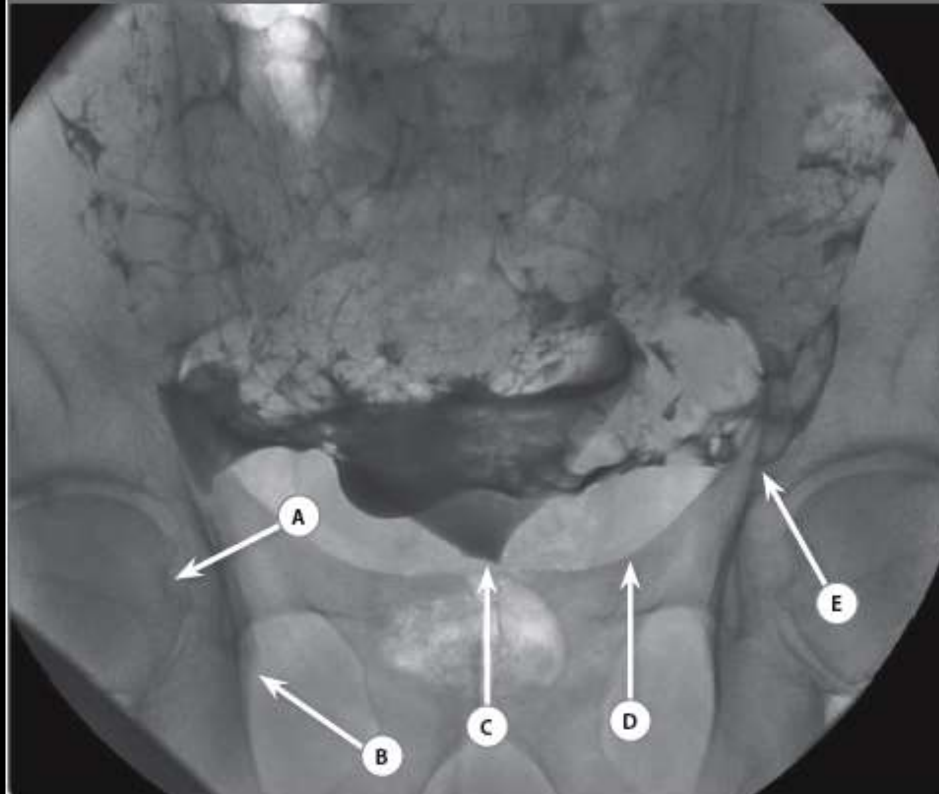


1.17 Hysterosalpingogram

(a) Fundus of the uterus. This is the part of the uterus that lies above the entrance to the fallopian tubes. The body of the uterus lies below the fundus and merges with the cervix.
(b) Isthmus of the left fallopian tube. This is the narrowest part of the tube lying just lateral to the uterus.
(c) Right cornu of the uterus (uterine horn).
(d) Right sacroiliac joint. This is a synovial joint formed between the auricular surfaces of the sacrum and the iliac bones. A small but limited amount of movement occurs at this joint. An important anterior relationship is the ureter which passes over it.
(e) Ampulla of the left fallopian tube (the widest part). The uterus is almost entirely covered with peritoneum (the broad ligament) except at the anterior part of the cervix. The peritoneum reflects over the posterior wall of the bladder at the level of the internal cervical os, leaving the anterior cervix without a peritoneal covering.

The uterus is held in position within the pelvis by condensations of endopelvic fascia or ligaments that include the pubocervical, transverse cervical ligaments and the uterosacral ligaments.

Case 9.20



Case 9.20

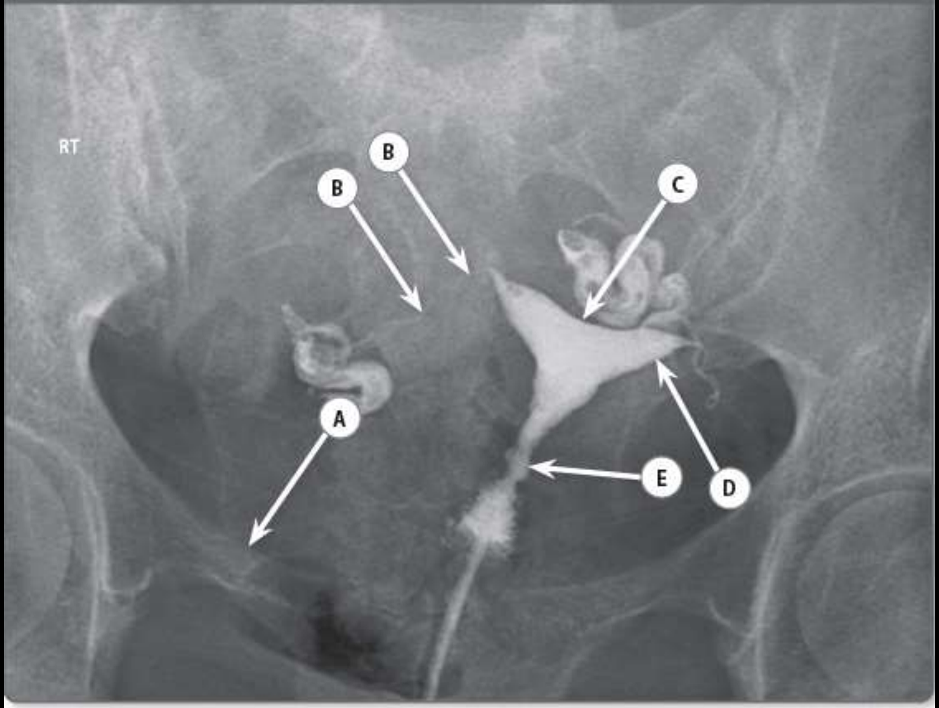
	QUESTION	WRITE YOUR ANSWER HERE
A	Name the structure labelled A.	
B	Name the structure labelled B.	
C	Name the structure that is causing the impression labelled C.	
D	Name the osseous line labelled D.	
E	Which artery courses within this peritoneal reflection?	

Case 9.20

- **A** Fovea of the right femoral head
- **B** Right ischial spine
- **C** Median umbilical fold
- **D** Left iliopectineal line
- **E** Left inferior epigastric artery

This is an example of a herniogram, with contrast injected into the peritoneal cavity. The outlines of the peritoneal reflections in the anterior pelvis are illustrated in **Figure 9.3**. Inguinal herniae medial to the epigastric artery are of the direct type and laterally-sited herniae are of the indirect type. **Figure 9.3** shows the peritoneal reflections at the level of the umbilical ligament. The lateral umbilical fold is formed by the inferior epigastric artery, which is closely related to the deep inguinal ring and its contents.

Case 2.15



Case 2.15

QUESTION		WRITE YOUR ANSWER HERE
A	Name the structure labelled A.	
B	Name the structure labelled B.	
C	Name the structure labelled C.	
D	Name the structure labelled D.	
E	Name the structure labelled E.	

Case 2.15

A Right superior pubic ramus

B Isthmus of right fallopian tube

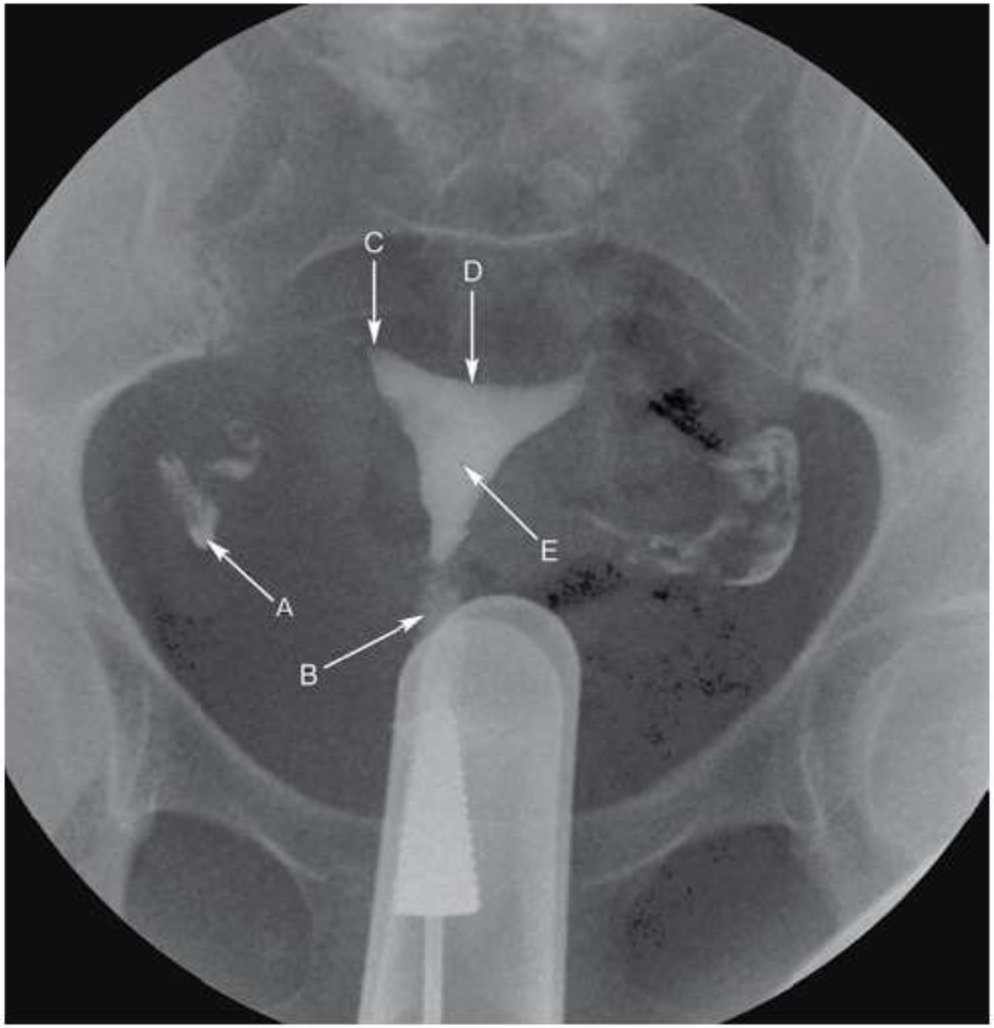
C Uterine fundus

D Left uterine cornu

E Cervical canal

Hysterosalpingography is performed to assess structural causes of infertility and demonstrates the anatomy of the uterine cavity and fallopian tubes. The fallopian tube isthmus is narrow, with contrast passing through here to the wider ampulla, before spilling into the peritoneal cavity.

Question 4.15



Name the structures labelled **A** to **E**.

4.15 Hysterosalpingogram (HSG)

A Ampulla of right fallopian tube (ampulla of right uterine tube).
B Cervix.
C Right uterine cornu.
D Fundus of uterus.
E Body of uterus.

The hysterosalpingogram is principally indicated for the investigation of infertility. It is typically performed in the fluoroscopy room, where contrast dye is injected into the uterus and a series of X-rays obtained. The aim is to identify any anatomical anomalies or obstruction to the fallopian tubes.

There are three radio-opaque structures at the base of this image. The two almost overlapping long structures are the vaginal speculum and the central structure is the metal cannula for introducing the dye.

The uterus consists of a cervix that extends into a body. The fundus lies opposite the cervix and in between the fallopian tubes. The uterine cornu are the two horns found one in each corner of the uterus in the superolateral extremity of the uterine body and mark the entrance for the fallopian tubes.

The fallopian tubes are about 10 cm long and lie within the broad ligament. They allow the passage of eggs from the ovary to the uterus. The fallopian tubes can be divided into four segments:

Infundibulum	The terminal part of the tube that terminates in the ostium and is surrounded by the fimbriae
Ampulla	Forms the major middle segment of the fallopian tube
Isthmus	The narrow segment that lies just lateral to the uterus
Intramural (interstitial)	The part of the tube that pierces the uterine wall to open into the uterine cavity

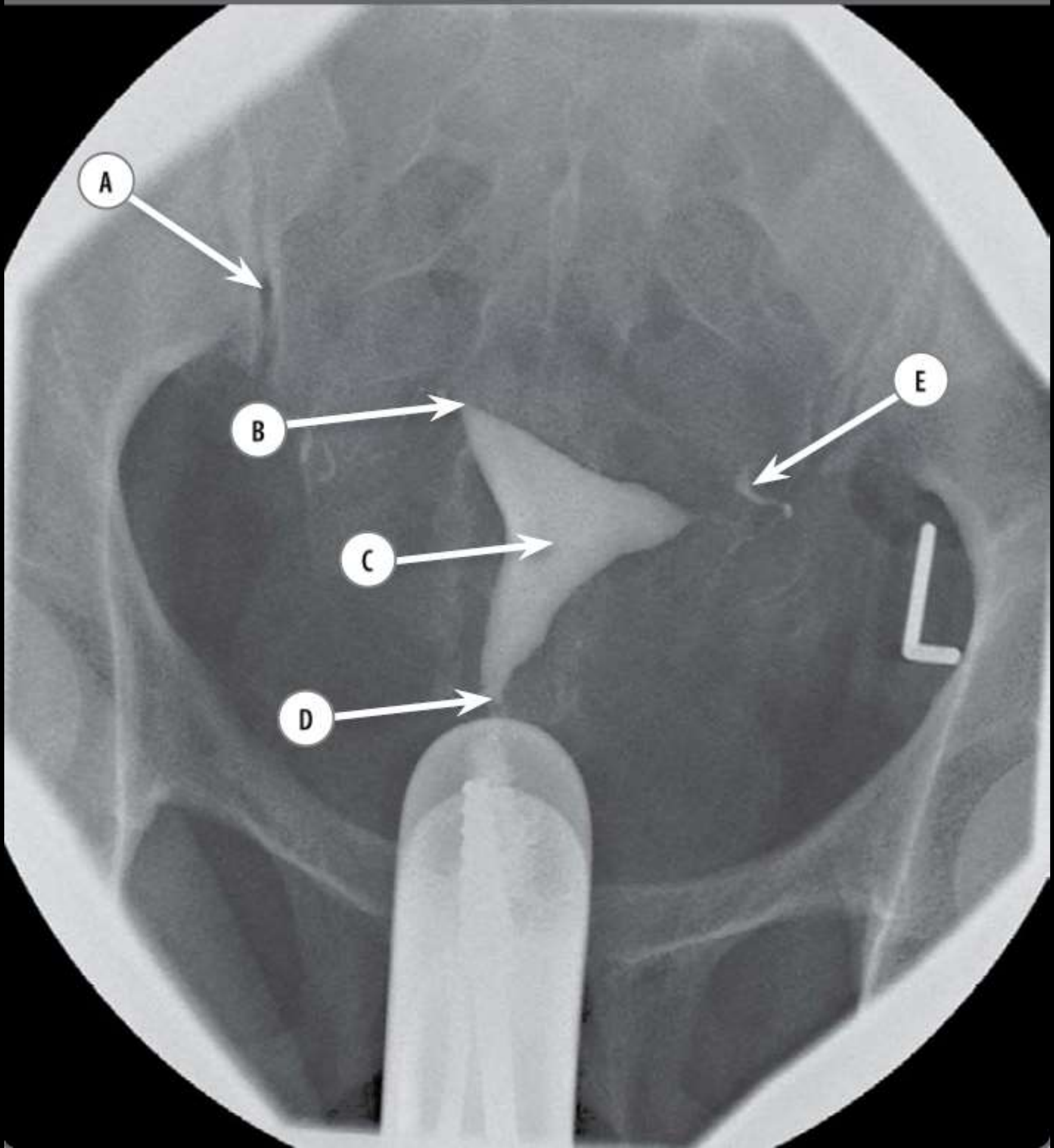
- **Question 23:**

Question 23: Hysterosalpingogram

Answer: Left fallopian tube

- If you have not seen a hysterosalpingogram before, you may have difficulty identifying the fallopian tubes. On the left of the image, you can see the inferior sacroiliac joint and the pelvic brim; therefore, you know it is a pelvic structure.
- On this AP view, the uterus is seen as a triangular, contrast-filled structure with the fallopian tubes arising from each cornua.
- Contrast medium is seen through the length of the fallopian tubes and within the peritoneum where it flows out through the ampulla (the widened structures at the end of the fallopian tubes).

Case 3.41



Case 3.41

A Right sacroiliac joint

B Right uterine cornu

C Endometrial cavity filled with contrast

D Internal cervical os

E Contrast within the distal left fallopian tube

A frontal projection hysterosalpingogram.

From superior to inferior the uterus is made up of a fundus, body and cervix. It is a pear shaped organ which is usually anteverted and anteflexed, and is located extraperitoneally between the bladder and rectum. The fallopian tubes (uterine tubes) join the uterus superolaterally at the uterine cornua, the junction of the fundus and body. The Fallopian tubes have an isthmus, ampulla and infundibulum (from medial to lateral). At the lateral end are the fimbriae which begin the transportation of ova towards the endometrial cavity once they are released from the ovaries.

The endometrial cavity is well demonstrated on a hysterosalpingogram, and is seen as a triangular shape on a frontal view. The anterior and posterior walls of the uterus are apposed, and therefore the endometrial cavity appears slit-like in the sagittal plane. **Figure 3.4** demonstrates the anatomy and relationships of the uterus, fallopian tubes and ovaries.

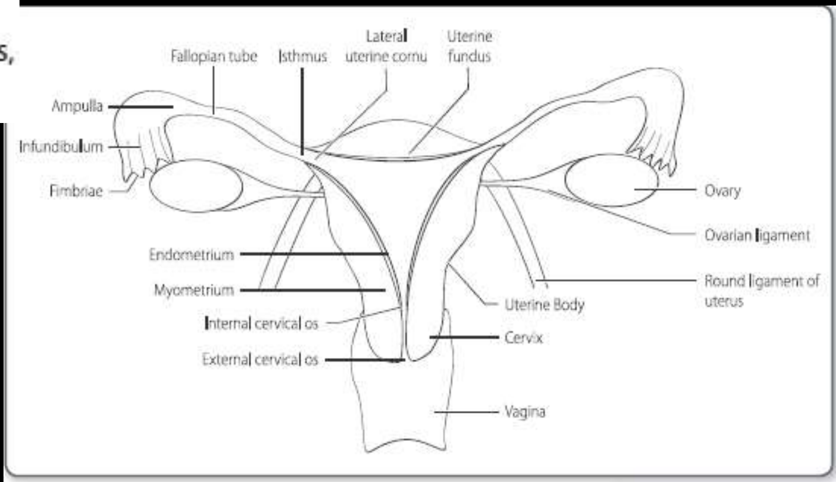


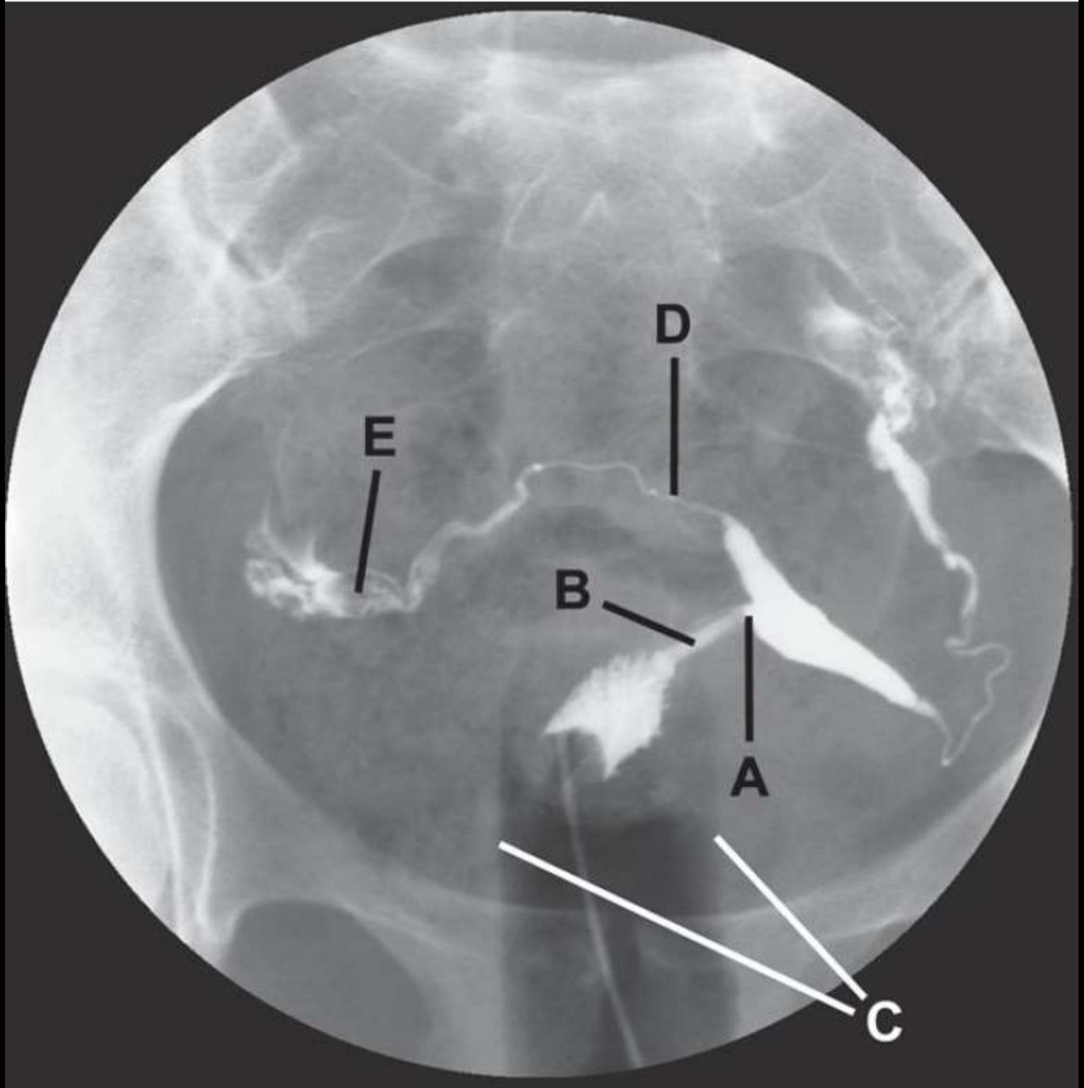
Figure 3.4 Anatomy of the uterus, fallopian tubes and ovaries.

Ryan S, McNicholas M, Eustace SJ. Anatomy for Diagnostic Imaging, 3rd edn. Edinburgh: Saunders, 2011: 240–243.

Butler P, Mitchell AM, Ellis H. Applied Radiological Anatomy. Cambridge: Cambridge University Press, 1999: 295.

Q5

a Name the structure labelled A
b Name the structure labelled B
c Name the structure filled with gas and outlined by C
d Name the structure labelled D
e Name the structure labelled E



Q5 Answers

- **a** Internal cervical ostium (internal os)
- **b** Cervical canal
- **c** Gas-filled vagina
- **d** Isthmus of the fallopian tube
- **e** Infundibulum of the fallopian tube

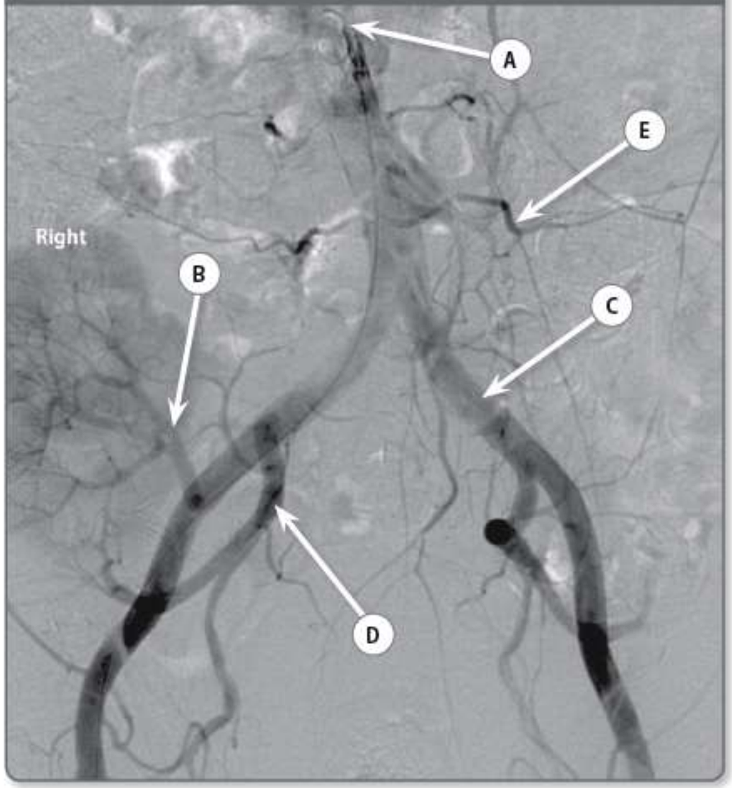
Normal hysterosalpingogram

When investigating female subfertility, uterine tubal patency can be assessed with a fluoroscopic hysterosalpingogram where contrast is passed into the uterine cavity. A normal result demonstrates unobstructed tubal flow and free spillage of contrast into the peritoneal cavity bilaterally. Identifiable features include the cervical canal between the external and internal ostia, a normally triangular-shaped uterine cavity, and the isthmus (narrowest part), ampulla (longest and widest mid portion) and infundibulum (funnel-shaped distal end sited in relation to the ovary) of the uterine (fallopian) tubes.

Sieglar AM. Hysterosalpingography. *Fertil Steril* 1983; 40:139–158.

ANGIO

Case 4.10



Case 4.10

QUESTION		WRITE YOUR ANSWER HERE
A	Name the device labelled A.	
B	What organ is the artery labelled B supplying?	
C	Name the structure labelled C.	
D	Name the structure labelled D.	
E	Name the structure labelled E.	

Case 4.10

A Loop of a pigtail catheter in the distal aorta

B Kidney (transplanted)

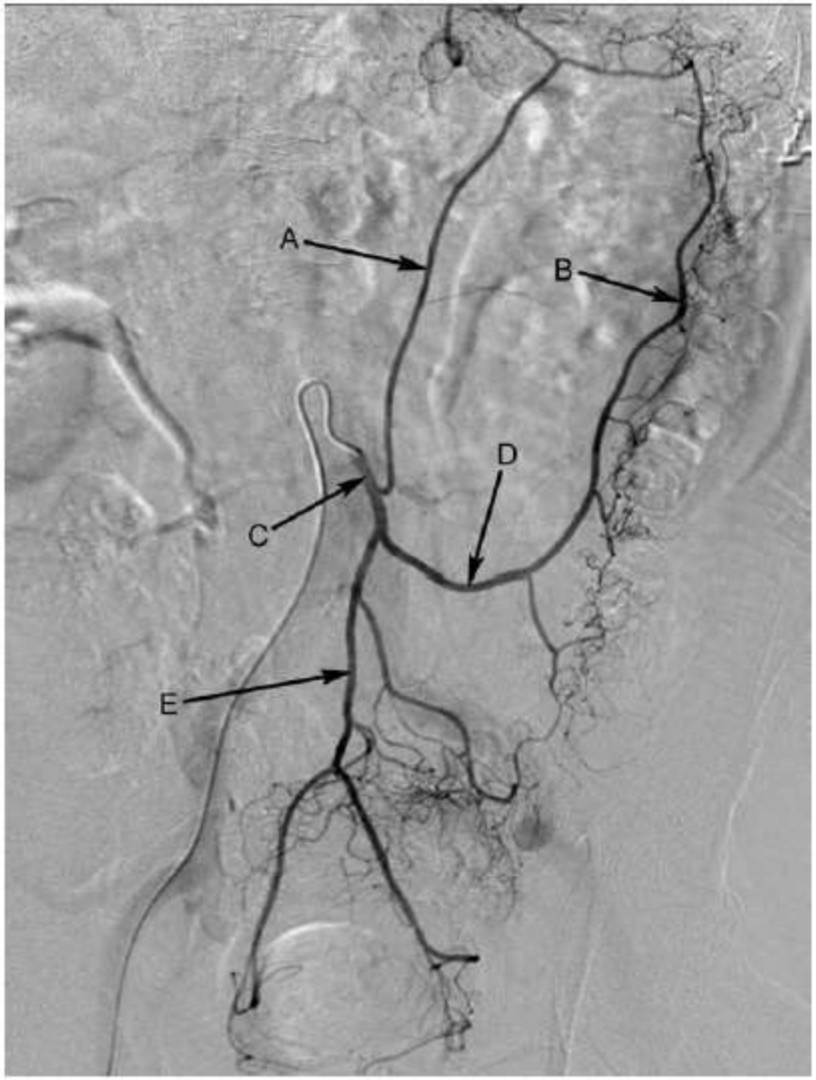
C Left common iliac artery

D Right internal iliac artery

E Left lumbar artery

Kidneys tend to be transplanted within the pelvis to enable excision of short donor pedicles of artery, vein and ureter. The high vascularity within the renal capillary bed causes a characteristic blush when contrast is injected.

Question 10.18



Name the structures labelled **A** to **E**.

10.18 Selective angiogram of the inferior mesenteric artery

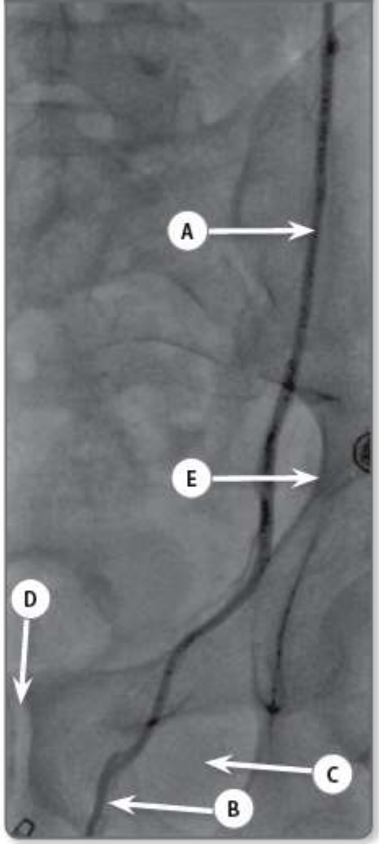
A Left colic artery.
B Marginal artery of Drummond.
C Inferior mesenteric artery.
D Sigmoid artery.
E Superior rectal artery.

The inferior mesenteric artery (IMA) is an anterior branch of the abdominal aorta, arising at the level of L3. It supplies the colon from the distal two-thirds of the transverse colon to the upper rectum. There are three major branches of the inferior mesenteric artery:

Left colic artery	Supplies the distal transverse colon and the descending colon
Sigmoid artery	Supplies the lower part of the descending colon and the sigmoid colon
Superior rectal artery	Supplies the upper rectum

The marginal artery of Drummond is a continuous arterial circle formed by anastomoses of the branches of the colic arteries of both the inferior and superior mesenteric arteries. It runs along the inner border of the colon.

Case 1.3



Case 1.3

	QUESTION	WRITE YOUR ANSWER HERE
A	Name the vein labelled A.	
B	Which plexus of veins is depicted by B?	
C	Name the foramen labelled C.	
D	Name the joint labelled D.	
E	Name the osseous line labelled E.	

Case 1.3

A Left testicular vein

B Left pampiniform plexus

C Left obturator foramen

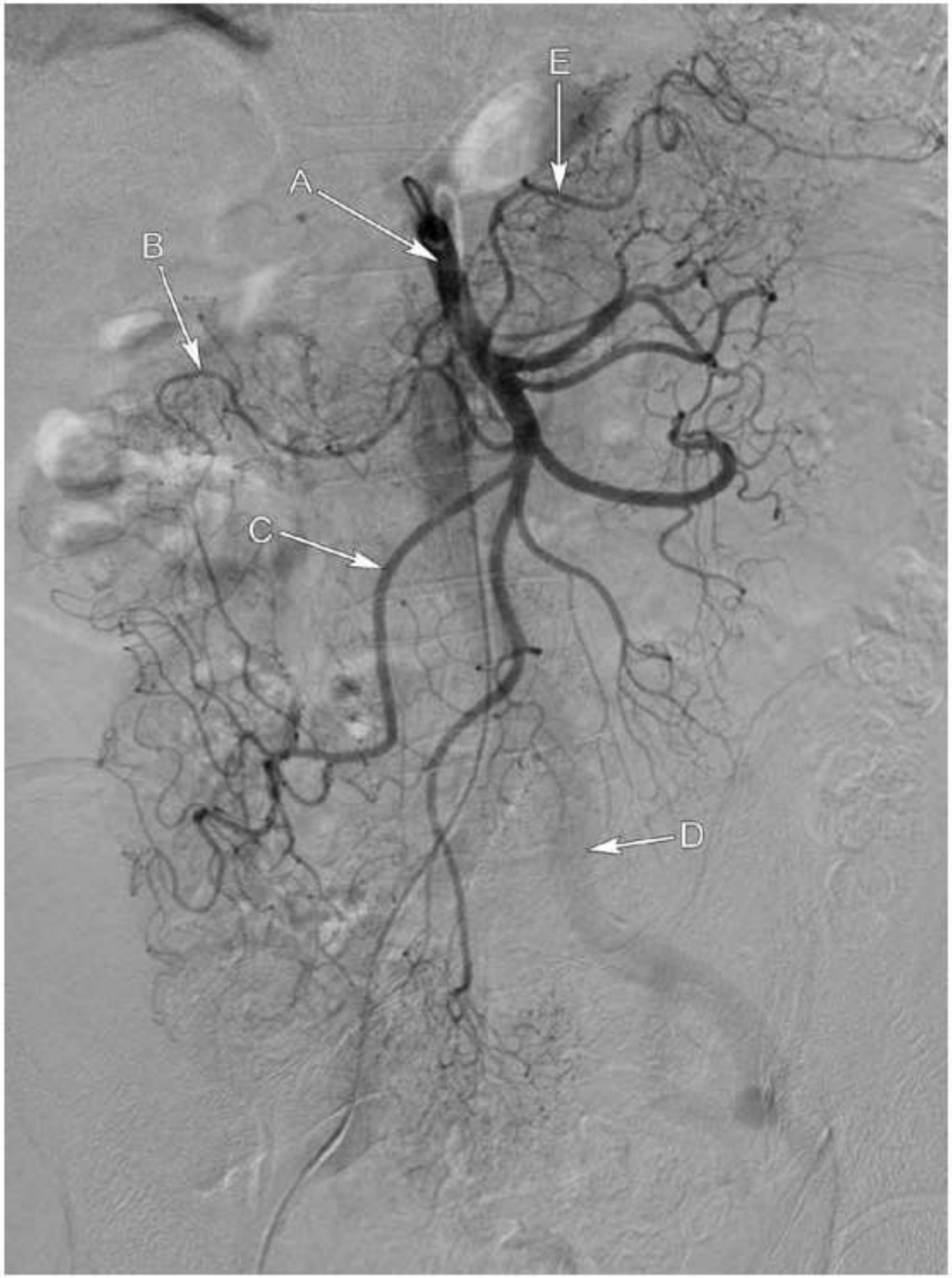
D Symphysis pubis

E Left Iliopectineal line

The testicular vein drains venous blood from the pampiniform plexus of the testes. They usually drain into the left renal vein on the left and inferior vena cava on the right, but considerable variation may be seen. Understanding of venous anatomy is necessary prior to attempting embolisation for varicocoeles.

Testicular arteries are branches of the abdominal aorta arising at the level of the renal arteries.

Question 4.13



Name the structures labelled **A** to **E**.

4.13 Superior mesenteric angiogram

A Superior mesenteric artery.
B Right colic artery.
C Ileocolic artery.
D Left common iliac artery.
E Middle colic artery.

The superior mesenteric artery (SMA) is an anterior midline branch of the abdominal aorta arising at the level of L1, approximately 1 cm inferior to the coeliac trunk. It passes posteriorly to the neck of the pancreas and anteriorly to the uncinate process, travelling to the left of the superior mesenteric vein. The superior mesenteric artery supplies part of the pancreas and the small bowel from the distal duodenum to the distal two-thirds of the transverse colon. The ascending colon can be faintly recognized on the right of the image, thus allowing identification of the colonic branches of the superior mesenteric artery.

The branches of the superior mesenteric artery are listed in the following table:

Small bowel branches	Inferior pancreaticoduodenal artery	Distal duodenum Head of the pancreas
	Intestinal branches	Jejunum Ileum
Colonic branches	Ileocolic artery	Ileum Caecum and appendix Ascending colon
	Right colic artery	Ascending colon
	Middle colic artery	Transverse colon to the distal two thirds

Question 3.14

Name the structures labelled A to E.

3.14 MRA of the abdominal aorta

A Superior mesenteric artery.
B Gastroduodenal artery.
C Common hepatic artery.
D Splenic artery.
E Left internal iliac artery.

The branches of the aorta can be recognized by the position from which they arise off the aorta:

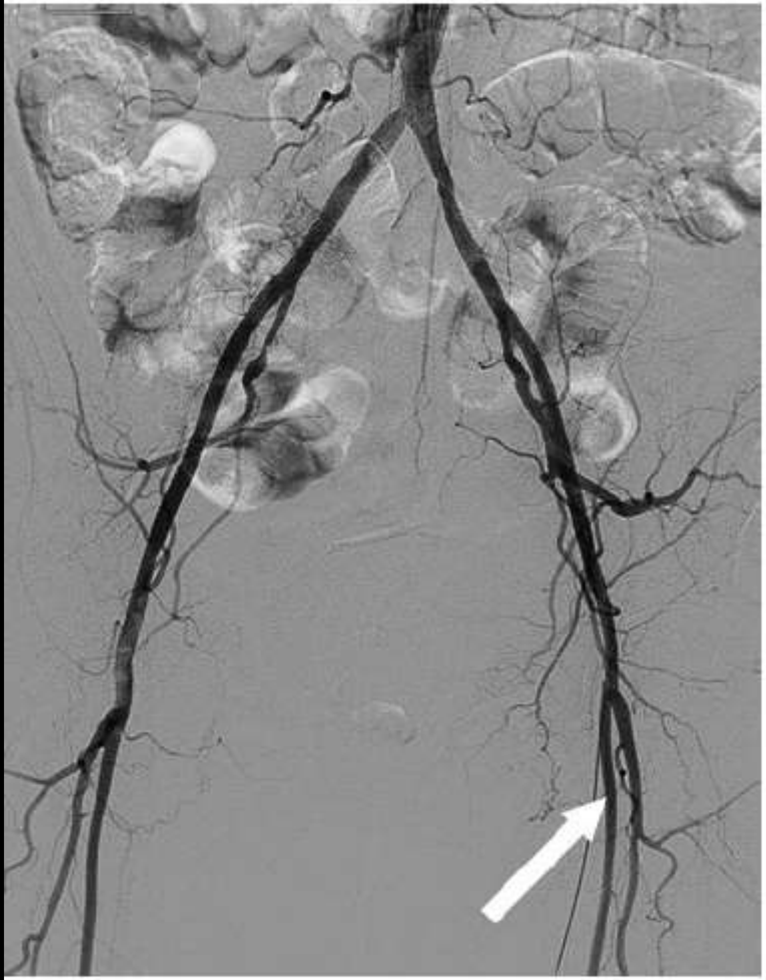
Branch	Artery
Anterior	Coeliac trunk Superior mesenteric artery Inferior mesenteric artery
Lateral	Inferior phrenic Middle suprarenal Renal Gonadal
Posterior	Lumbar Median sacral

The coeliac trunk is the first major branch of the aorta and gives rise to three arteries:

Splenic artery	Takes a horizontal tortuous course to the left
Left gastric artery	Takes a vertical course and is not seen on this image as it overlies the aorta
Common hepatic artery	Courses to the right

The gastroduodenal artery takes a vertical inferior course and arises from the proximal common hepatic artery.

- **Question 50:**



Question 50: Iliac angiogram

Answer: Left superficial femoral artery

- Although detailed knowledge of vascular anatomy is not required for the examination, do not neglect it as part of your revision because it is a common topic.
- The external iliac artery continues below the level of the inguinal ligament as the common femoral artery, which bifurcates into the superficial femoral artery and deep femoral artery.
- The superficial femoral artery passes inferomedially and emerges as the popliteal artery after exiting the Hunter's canal (adductor canal).

Question 2.15

Name the structures labelled **A** to **E**.

2.15 Angiogram of the distal aorta

A Abdominal aorta.
B Left lumbar artery.
C Right common iliac artery.
D Right internal iliac artery.
E Right external iliac artery.

The abdominal aorta begins at T12. The branches and levels of the abdominal aorta are:

Name of branch	Vertebral level	Number of branches	Supply
Inferior phrenic	T12	1	Diaphragm
Coeliac	T12	1	Liver, abdominal oesophagus, stomach, duodenum, pancreas
Superior mesenteric	L1	1	Duodenum to transverse colon Pancreas
Middle suprarenal	L1	2	Adrenal glands
Renal	L1	2	Kidneys
Gonadal (testicular artery in males, ovarian arteries in females)	L2	2	Testicles in males Ovaries in females
Lumbar	L1–4	4 branches on each side	Abdominal wall muscles, lumbar vertebra, spinal cord
Inferior mesenteric	L3	1	Splenic flexure to rectum
Median sacral	L4	1	Sacrum and coccyx
Common iliac	L4	2	Pelvis and lower limbs

Question 36:

Question 36: Iliac angiogram

Answer: Right internal iliac artery

- The common iliac artery bifurcates into the internal and external iliac arteries.
- The internal iliac artery has a posterior course compared to the anterior course of the external iliac artery.
- The internal iliac artery supplies blood to the pelvic viscera and muscles.
- There are two divisions of the internal iliac artery: anterior and posterior.
- Branches of the anterior division are the umbilical artery, obturator artery, inferior vesical artery, middle rectal artery, vaginal artery, uterine artery, internal pudendal artery, and the inferior gluteal artery.
- Branches of the posterior division are the superior gluteal artery, iliolumbar artery, and the lateral sacral artery.

- **Question 37:**

Question 37: Superior mesenteric angiogram

Answer: Ileocolic artery

- The superior mesenteric artery supplies blood to the entire small intestines (foregut) and colon from the caecum through to the mid-transverse colon (midgut).
- The ileocolic artery supplies the caecum, appendix, and proximal ascending colon.
- The branches of the superior mesenteric artery, in a clockwise manner, are as follows:

Artery	**Distribution**
Inferior pancreatico-duodenal artery	Head of pancreas and distal duodenum
Jejunal branches	Jejunum
Ileal branches	Ileum
Ileocolic	Caecum, appendix, and proximal ascending colon
Right colic	Ascending colon (except proximal section)
Middle colic	Transverse colon (up to midpoint)

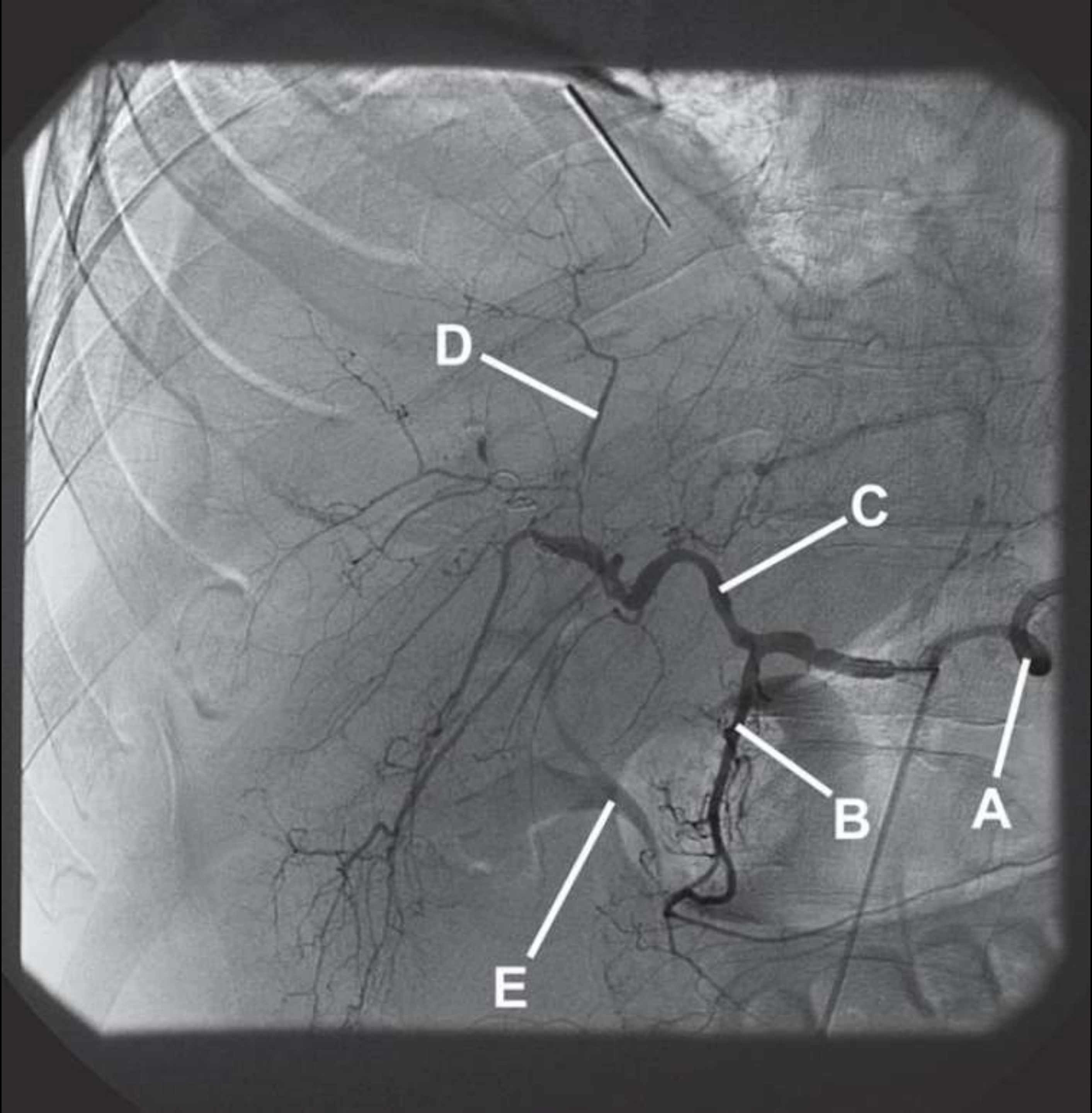
- The terminal superior mesenteric artery is seen in the midline of this angiogram and anastomoses with the ileal branches.

- **Question 49:**

Question 49: Coeliac angiogram

Answer: Right hepatic artery

- You can identify this as an angiogram of the coeliac axis by the long and tortuous splenic artery going to the spleen. The ribs in the left upper corner of the image tell you that it is the upper abdomen.
- The common hepatic artery divides into the right and left hepatic arteries, which supply the right and left lobes of the liver.
- Thirty percent of the blood supply to the liver is from the hepatic arteries. The other 70% is from the portal vein.
- There are a number of normal variants of the hepatic arteries of which to be aware. The common hepatic artery or the right hepatic artery can arise from the superior mesenteric artery instead of the coeliac trunk. The left hepatic artery can arise from the left gastric artery. It is also possible to have accessory hepatic arteries.


D
C
B
A
E

Q6 Answers

a Splenic artery
b Gastroduodenal artery
c Common hepatic artery
d Left hepatic artery
e Right renal pelvis

Digital subtraction angiogram of the coeliac axis, AP view

The coeliac artery is the uppermost of three un-paired aortic branches which provide blood supply to the abdominal viscera. It arises from the anterior aspect of the abdominal aorta at the level of T12–L1 as a single trunk which typically branches into three divisions: the common hepatic, left gastric and splenic arteries which course right, superiorly and left respectively (the left gastric artery is not well opacified on this image). This usual configuration of vessels is present in around 55% of the population.

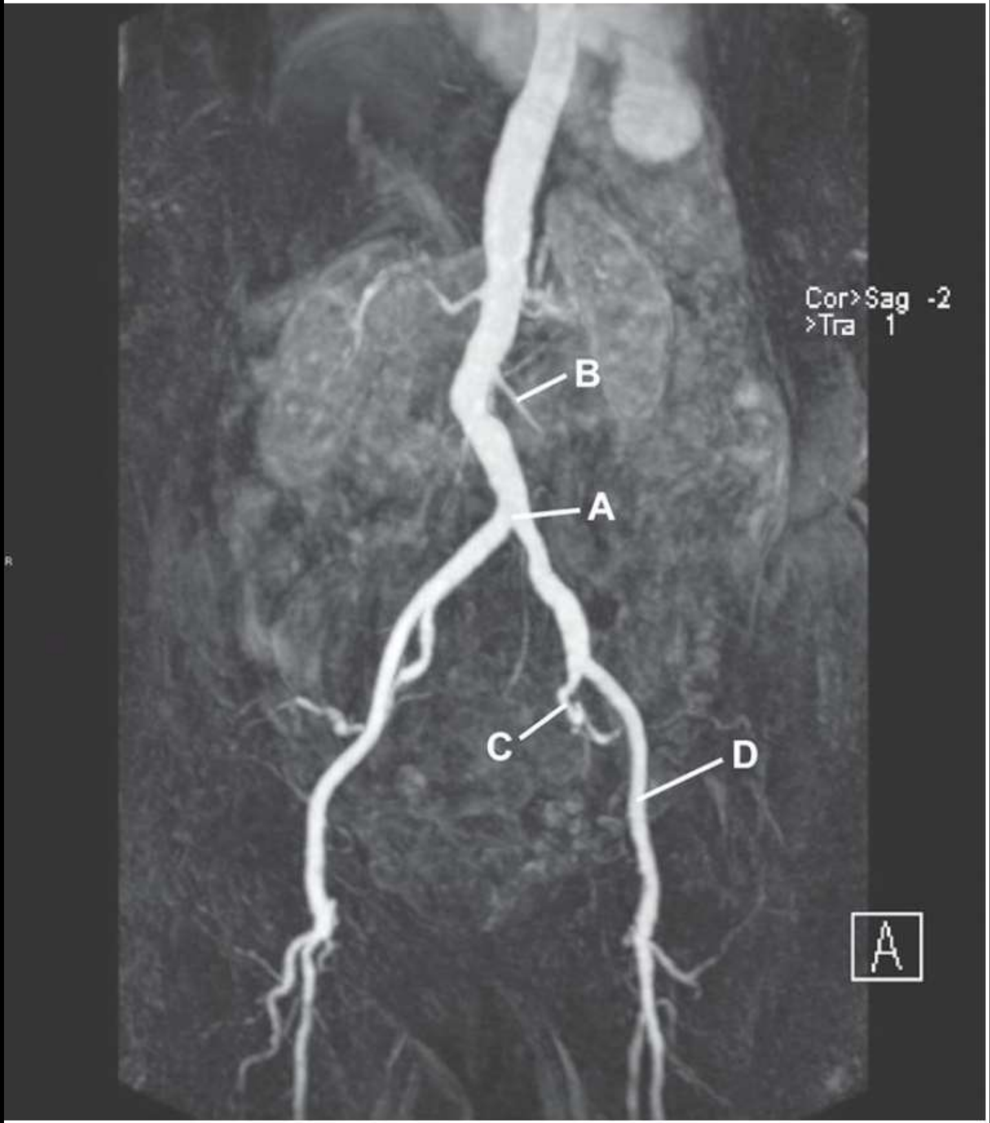
The coeliac trunk is primarily responsible for supplying the foregut structures, the superior mesenteric artery supplying the mid-gut and the inferior mesenteric artery the hindgut. In reality there are often rich vascular connections between these circulations and overlap of the territories they supply. There is a lot of variety in coeliac arterial anatomy amongst individuals. Michel's classification of hepatic arterial supply alone lists ten different normal variations.

Intra-arterial contrast is readily filtered from the blood by the kidneys once it enters the systemic circulation. Opacification of the renal collecting systems is commonly seen during angiographic studies.

Michel NA. *Blood supply and anatomy of the upper abdominal organs with a descriptive atlas*, Lippincott, Philadelphia, 1955, pp. 64–69.

Q19

a Name the vertebral level at which the aorta bifurcates, as labelled A
b Name the artery labelled B
c Name the major divisions of the internal iliac artery
d Name one of the branches of the external iliac artery
e Name the vessel from which the gonadal arteries arise



Q19 Answers

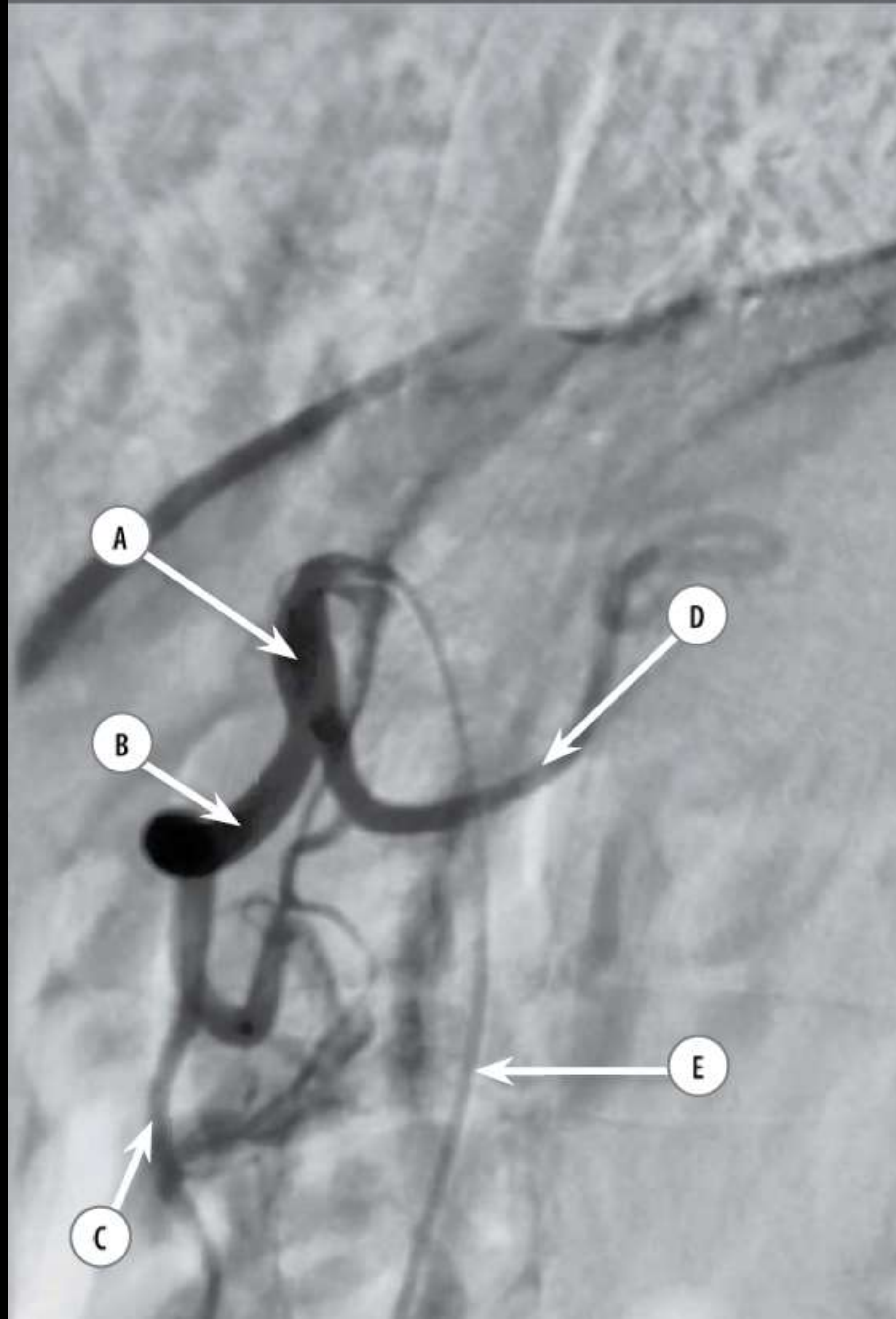
a The aorta bifurcates into the right and left common iliac arteries at the level of L4
b Inferior mesenteric artery
c The internal iliac artery has anterior and posterior divisions
d Inferior epigastric artery or deep circumflex iliac artery
e The gonadal arteries (testicular or ovarian) arise directly from the abdominal aorta at the level of L2

Abdomino-pelvic MRA

The abdominal aorta is a direct continuation of the thoracic aorta and runs from the aortic opening in the diaphragm at T12 to its bifurcation into the two common iliac vessels at the level of L4. In the infra renal portion, the major branches are the right and left gonadal arteries, the inferior mesenteric artery and usually four paired lumbar arteries. The gonadal vascular and lymphatic vessels are in similar locations meaning lymph of testicular or ovarian origin will drain to para-aortic nodes.

The internal iliac artery supplies the pelvis; the posterior division has branches to the posterior pelvic wall and musculature while the anterior division supplies the pelvic viscera and perineum. The external iliac artery predominantly supplies the lower limb becoming the common femoral artery as it passes under the inguinal ligament. Just before leaving the pelvis however, the external iliac artery has two branches which supply the anterior abdominal wall, namely the inferior epigastric and the deep circumflex iliac arteries.

Case 3.48



Case 3.48

A Coeliac axis

B Common hepatic artery

C Gastroduodenal artery

D Splenic artery

E Arterial catheter

Angiogram of the coeliac axis.

The coeliac axis is located between T12 and L1. Its usual course begins in a caudal direction, but it may pass horizontally or superiorly. It arises from the anterior surface of the aorta, and after approximately 1–2 cm divides into the common hepatic, left gastric and splenic arteries.

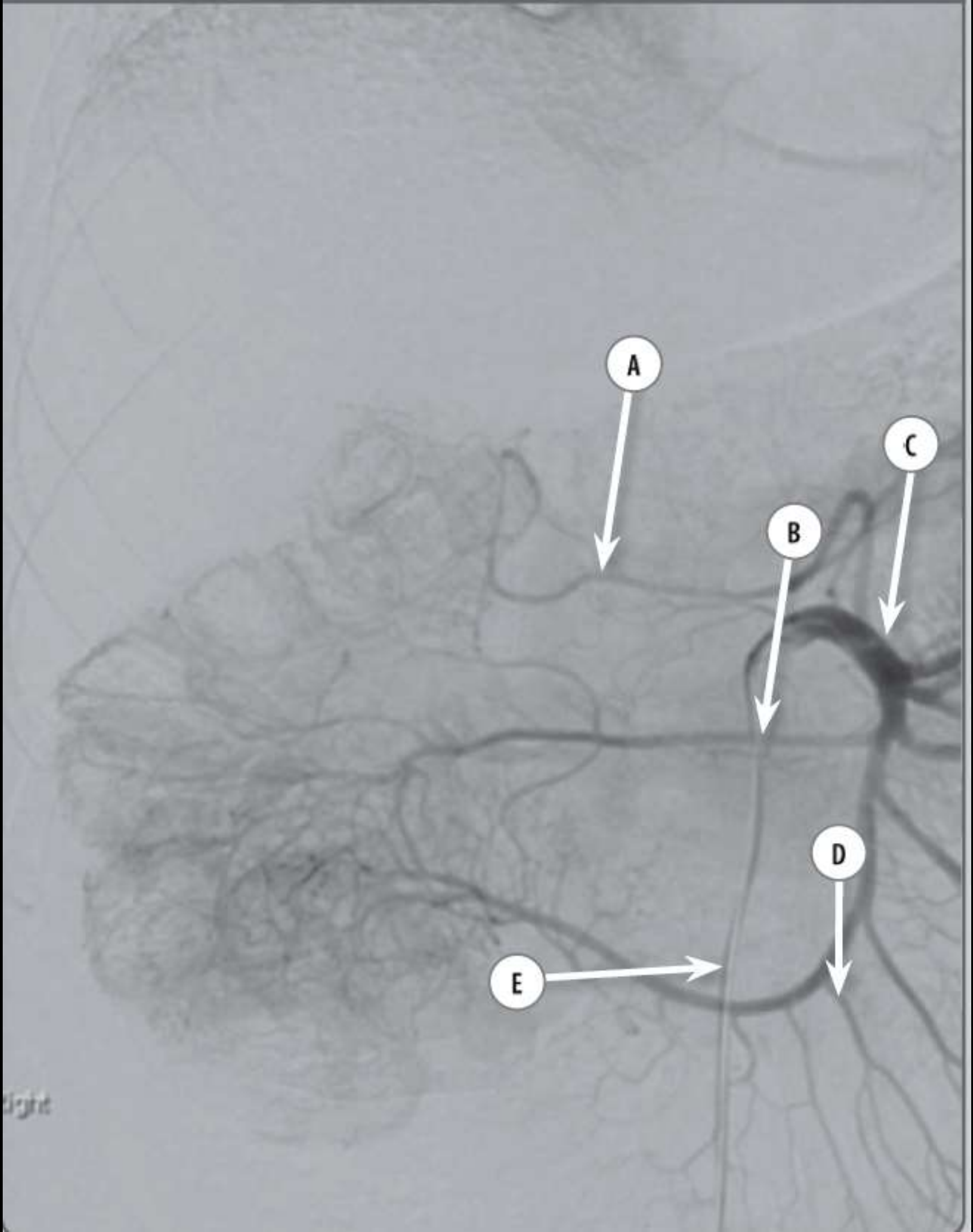
The common hepatic artery runs to the right, along the superior surface of the pancreatic head, to reach the hepatoduodenal ligament. Within this ligament it travels towards the porta hepatis, with the portal vein behind it, and the common bile duct and common hepatic duct just to the right. It gives off the gastroduodenal artery and then continues as the hepatic artery proper, before dividing into the right, middle and left hepatic arteries.

The left gastric artery arises superiorly, and is usually the 1st branch from the coeliac axis; it is also usually the smallest. From its origin it passes superolaterally towards the gastric cardia, where it divides into multiple branches to supply the anterior and posterior surfaces of the stomach.

The splenic artery often has a very tortuous course. It is the largest branch from the coeliac axis and travels along the superior surface of the pancreas towards the splenic hilum. Once it reaches the hilum, the splenic artery divides into superior and inferior branches. Occasionally a third (middle) branch may also be present. These then further divide to become the intrasplenic arteries; approximately 4–6 branches arise from each of the superior middle and inferior splenic arteries. **Figure 3.5** demonstrates the anatomy of the coeliac axis and its branches.

Butler P, Mitchell AM, Ellis H. Applied Radiological Anatomy. Cambridge: Cambridge University Press, 1999: 225–8.

Case 3.49



Case 3.49

A Right colic artery

B Ileocolic artery

C Superior mesenteric artery

D Ileal branch of superior mesenteric artery

E Arterial catheter within aorta

Angiogram of the superior mesenteric artery.

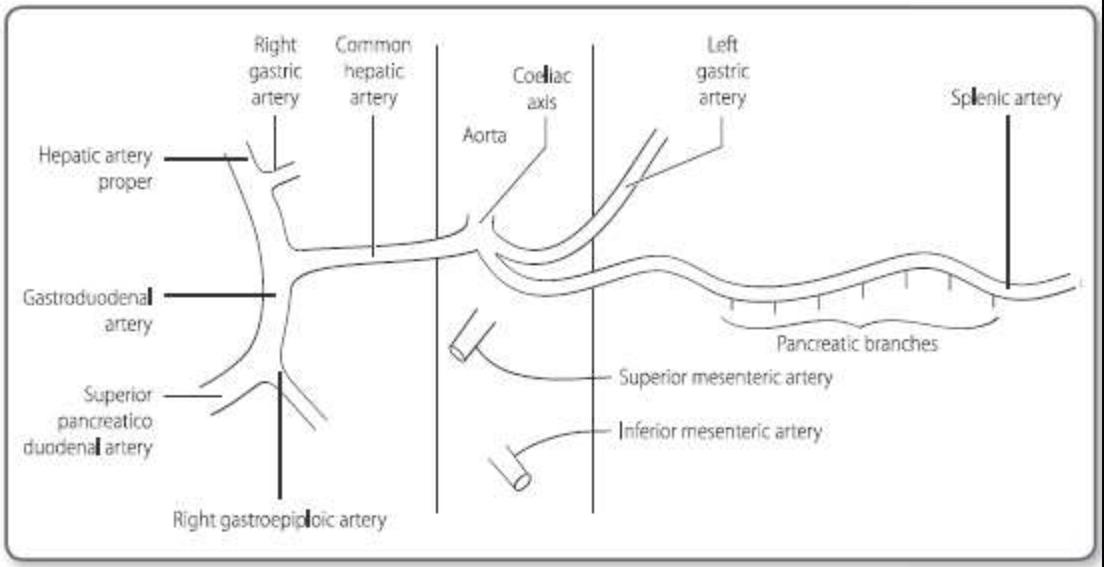


Figure 3.5 Anatomy of the coeliac axis.

Case 3.49

The superior mesenteric artery (SMA) arises at the level of L1 from the anterior surface of the abdominal aorta, approximately 1 cm below the origin of the coeliac axis. It passes anteriorly, before descending behind the pancreatic neck. Between the SMA and the aorta are the uncinate process of the pancreas, the left renal vein and the third part of duodenum. The superior mesenteric vein lies to the right of the SMA – this arrangement is important in the assessment of malrotation.

The branches of the SMA are as follows:

- **Inferior pancreaticoduodenal**: supplies the pancreatic head and distal duodenum (D3 and D4); anastomoses with the superior pancreaticoduodenal artery allowing a collateral circulation between the coeliac axis and the SMA.
- **Jejunal branches**: four—six branches arising from the left side of the SMA. Each branch divides into two, communicating with the vessels either side to form a series of arcades. Three to six further arcades are formed, with vasa rectae arising from the last of them. The vasa rectae have a final division to supply the anterior and posterior surfaces of the small bowel.
- **Ileal branches**: nine–13 branches, which arise beyond the origin of the ileocolic artery. These have a similar pattern of division to the jejunal arteries, with the formation of arcades.
- **Ileocolic**: passes inferiorly to the right, and supplies the terminal ileum, caecum and appendix, as well as part of the ascending colon. This vessel anastomoses with the last ileal artery of the SMA.
- **Right colic**: courses behind the parietal peritoneum to supply the ascending colon. It has an ascending branch which anastomoses with the middle colic artery, and a descending branch which anastomoses with the marginal artery of the ileocolic artery.
- **Middle colic**: arises inferior to the uncinate process of the pancreas, entering the transverse mesocolon. It supplies the transverse colon and usually arises as a common trunk with the right colic artery. However, these vessels may also have separate origins.

The marginal artery of Drummond runs in the large bowel mesentery, alongside the colon, and is part of the system of arcades that forms an anastomosis between the SMA and inferior mesenteric artery, which allows collateral flow. There is a similar marginal artery of Dwight which runs along the small bowel – it is the vessel from which the vasa recta originate. **Figure 3.6** demonstrates the anatomy of the SMA and its branches.

Butler P, Mitchell AM, Ellis H. Applied Radiological Anatomy. Cambridge: Cambridge University Press, 1999: 230–3.

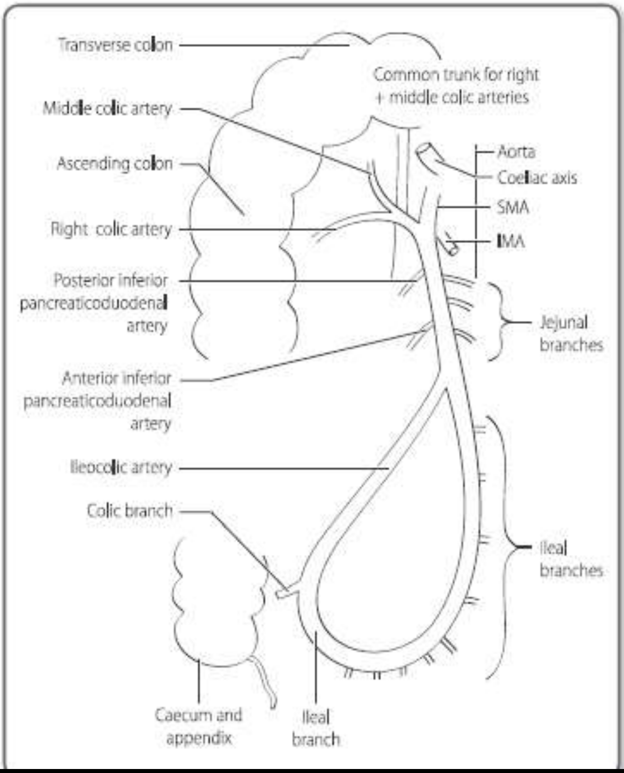
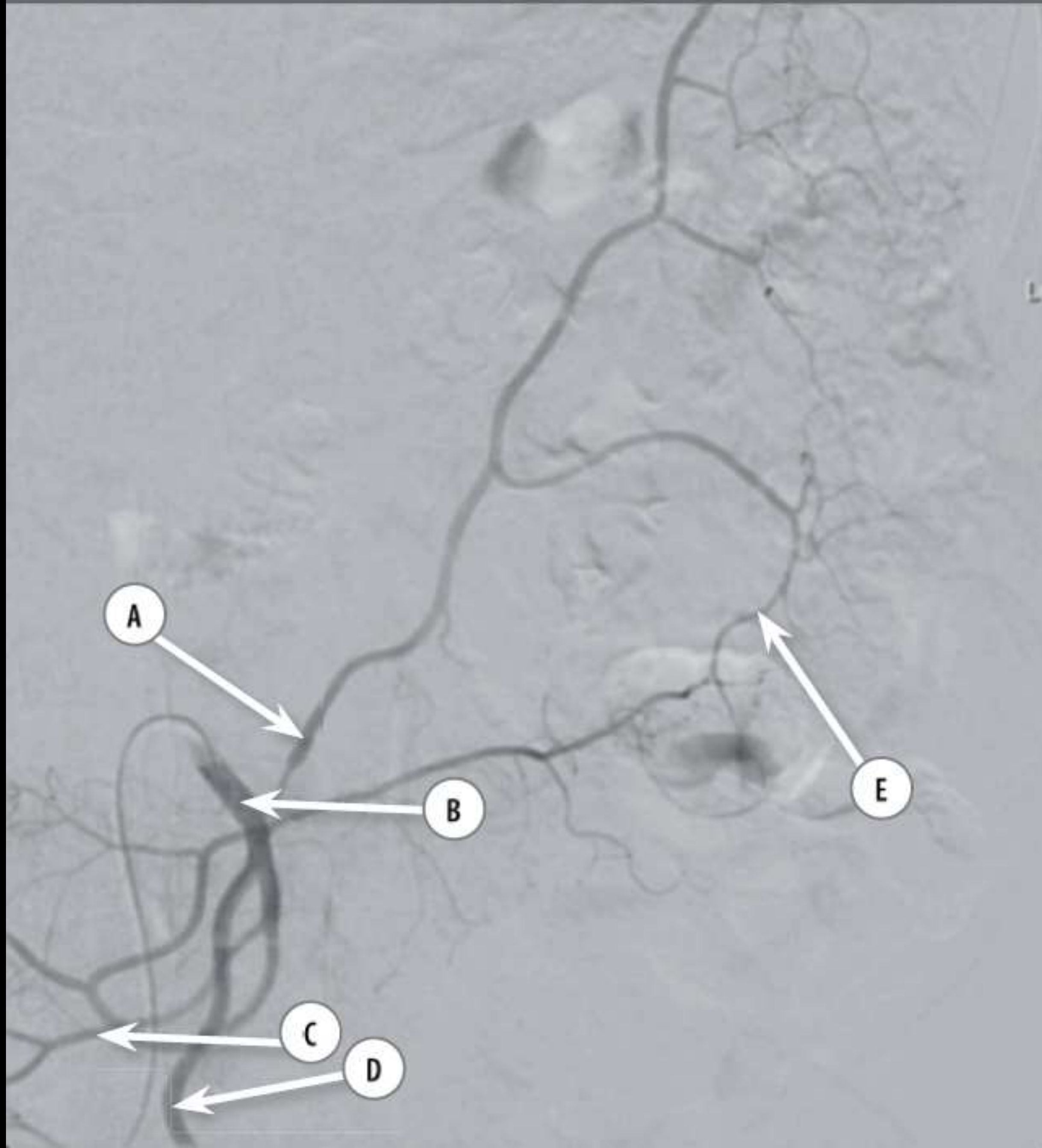


Figure 3.6 Anatomy of the superior mesenteric artery and its branches.

Case 3.50



Case 3.50

A Left colic artery

B Inferior mesenteric artery

C Sigmoid artery

D Superior rectal /haemorrhoidal artery

E Marginal artery of Drummond

Angiogram of the inferior mesenteric artery.

The inferior mesenteric artery (IMA) arises at the level of L3. Its first branch is the left colic artery, which divides into ascending and descending branches after a short distance. The ascending branch forms an anastomosis with the middle colic artery and there is a further anastomosis between the descending branch and the 1st sigmoid artery. There are then two to three sigmoid branches. The superior rectal artery (haemorrhoidal artery) is the terminal artery of the IMA. It branches into a left and right branch, to supply the proximal rectum. These branches communicate with each other, the sigmoid arteries above and the middle and inferior rectal arteries below (which arise from the internal iliac vessels).

The marginal artery of Drummond runs parallel to the colon and connects the main arterial trunks and their arcades to one another, thereby forming a collateral blood supply. It may be absent at the splenic flexure. In the case of arterial compromise to one of the main vessels, it may be seen to hypertrophy. **Figure 3.7** demonstrates the anatomy of the IMA and its branches.

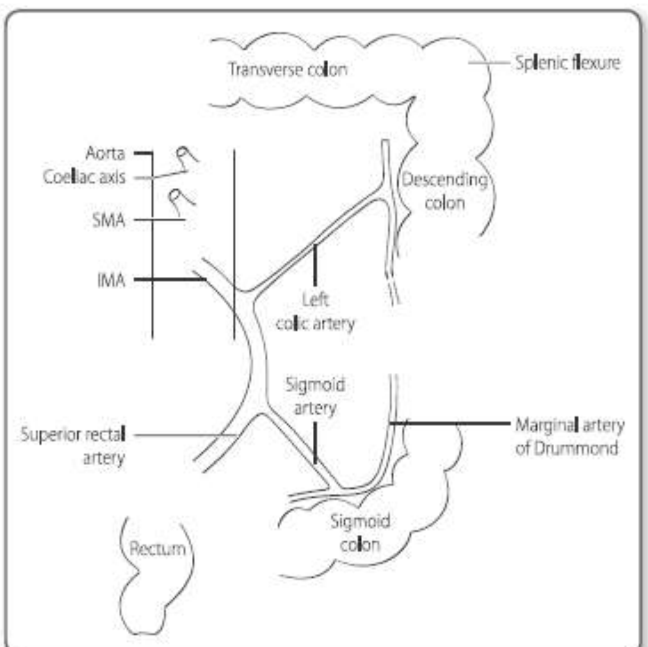
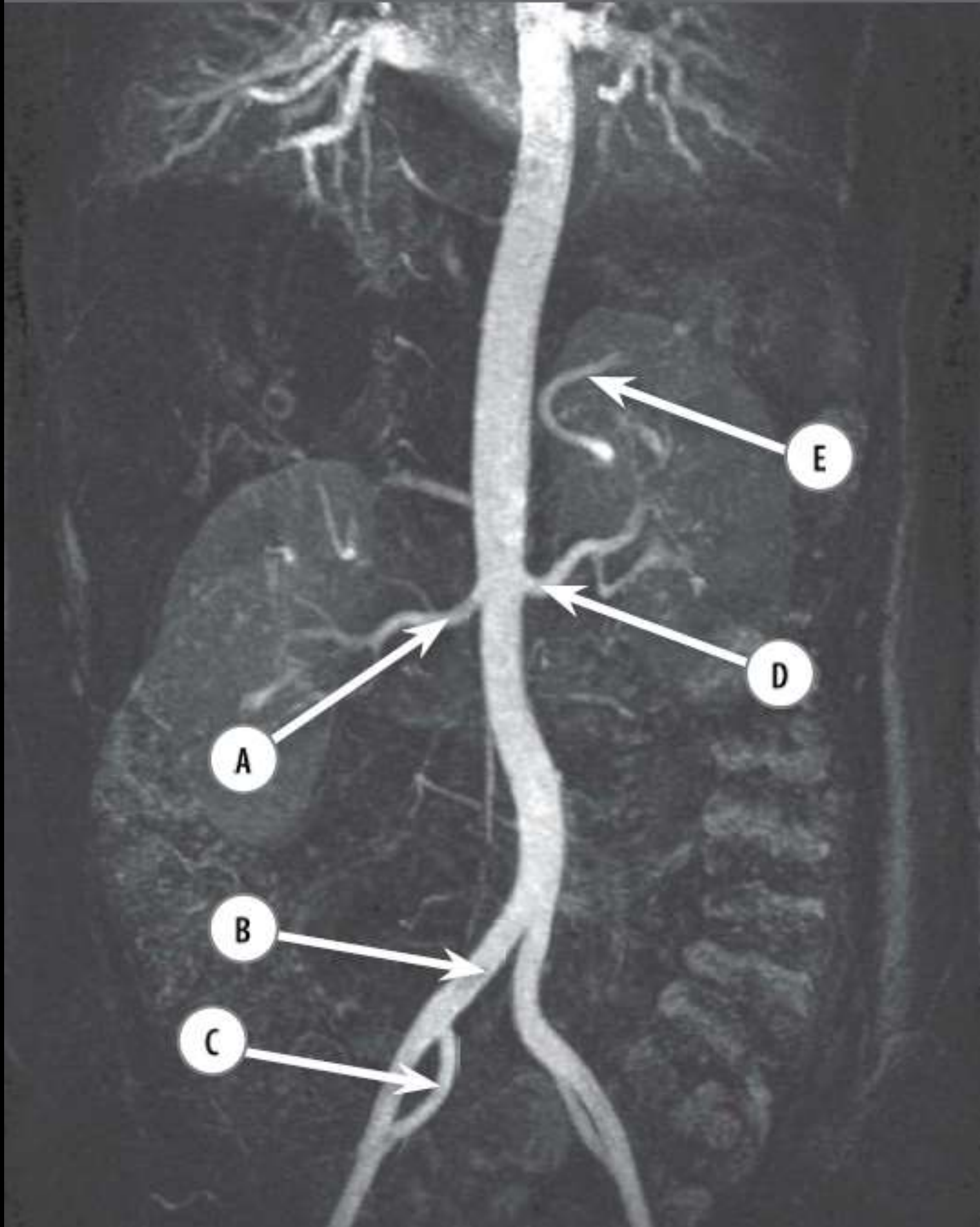


Figure 3.7 Anatomy of the inferior mesenteric artery and its branches.

Butler P, Mitchell AM, Ellis H. Applied Radiological Anatomy. Cambridge: Cambridge University Press, 1999: 230–3.

Case 3.51



Case 3.51

A Right renal artery

B Right common iliac artery

C Right internal iliac artery

D Left renal artery

E Left accessory renal artery

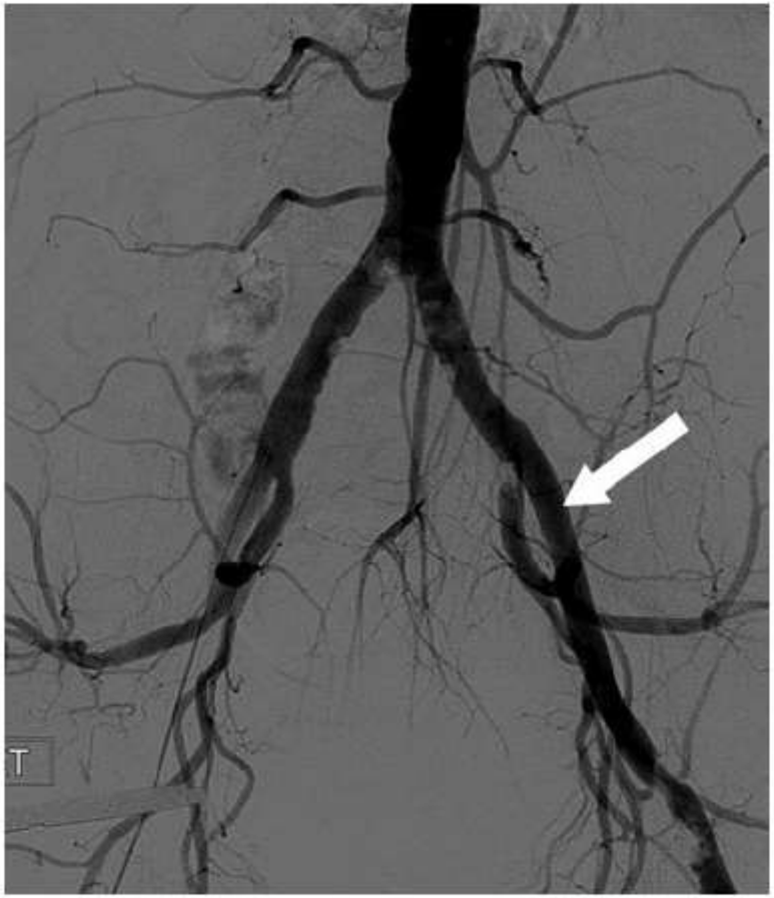
Renal MR angiogram.

The abdominal aorta has three unpaired branches and three paired branches. The renal arteries arise just distal to the origin of the superior mesenteric artery, at the level of the upper border of L2. There can be variation: multiple renal arteries are relatively common. The right renal artery tends to be straighter than the left, with a longer course, as it crosses the midline and passes posteriorly to the inferior vena cava. The renal arteries usually divide into an anterior and posterior division, which pass either side of the renal pelvis. These vessels then further divide into segmental branches (usually five), which enter the kidney via the hilum and continue between the medullary pyramids where they are referred to as interlobar arteries. As they reach the cortex they become the arcuate arteries. The arcuate arteries give rise to the interlobular arteries, and it is from here that the afferent arterioles provide the blood supply to the glomeruli.

The distal abdominal aorta divides into the common iliac arteries at the level of L4, after which it divides into the internal and external iliacs at the level of the pelvic brim, anterior to the lower sacroiliac joints. The external iliac artery is of a larger calibre than the internal iliac, and it goes on to become the common femoral artery as it passes under the inguinal ligament.

Butler P, Mitchell AM, Ellis H. Applied Radiological Anatomy. Cambridge: Cambridge University Press, 1999: 265, 272.

- **Question 8:**

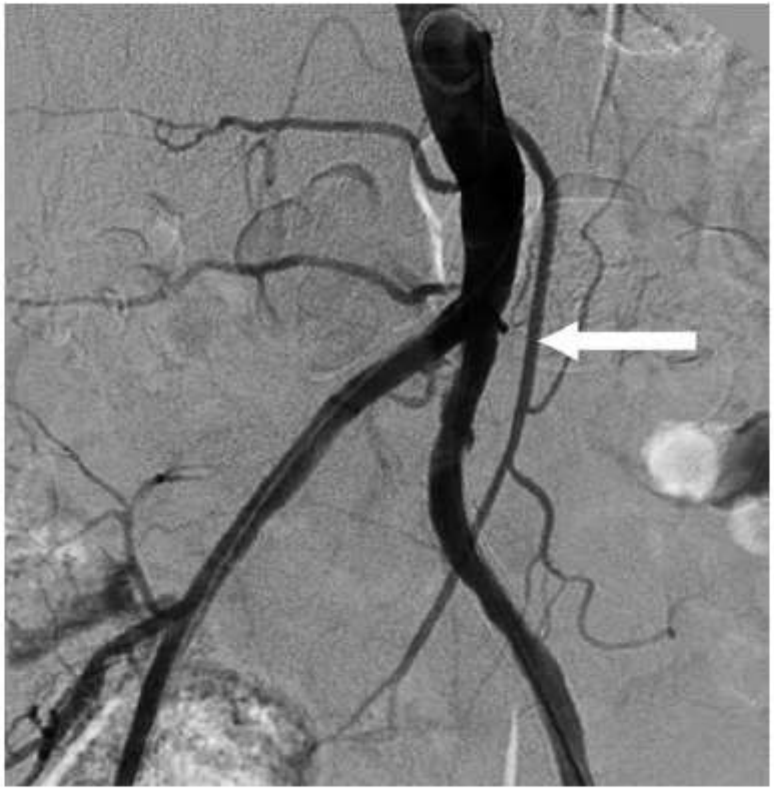


Question 8: Angiogram of the iliac arteries

Answer: Left external iliac artery

- The common iliac arteries divide into the internal and external iliac arteries.
- The external iliac arteries run parallel and usually lateral to the external iliac veins.
- The external iliac artery becomes the femoral artery as it passes the inguinal ligament. This is a common pitfall in the examination.

Question 19:

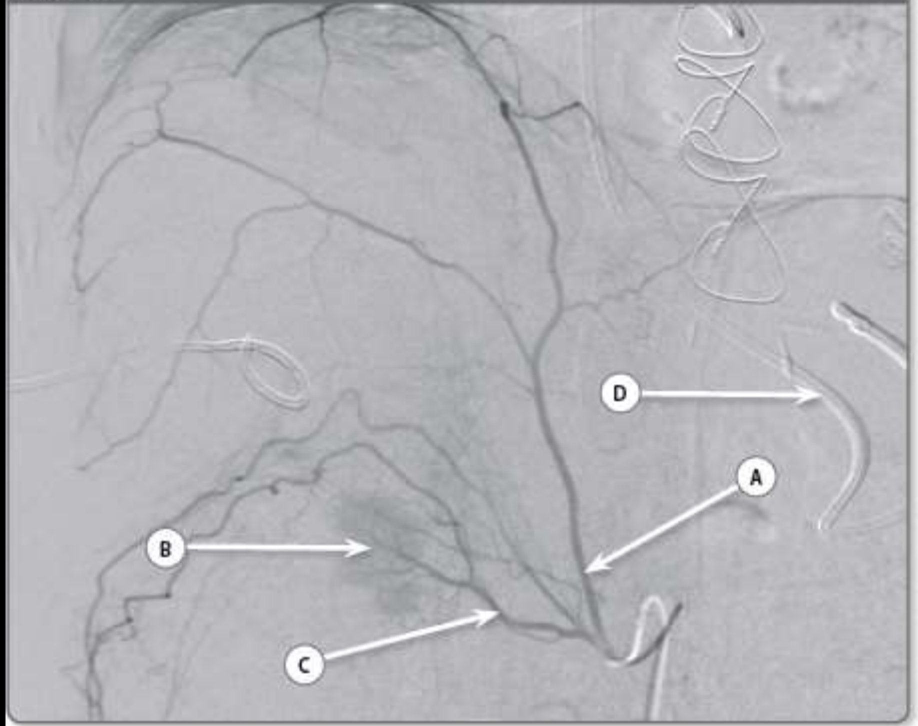


Question 19: Aortic angiogram

Answer: Inferior mesenteric artery

- The inferior mesenteric artery is the third unpaired branch of the aorta.
- It is a much smaller calibre vessel compared with the coeliac trunk or superior mesenteric artery.
- It supplies blood to the mid transverse colon through to the proximal rectum.
- Branches of the internal iliac artery supply the middle and distal rectum and anal canal.
- The watershed area is the region of colon between the supply of the superior mesenteric artery and inferior mesenteric artery, and is more vulnerable to ischaemia.

Case 5.12



Case 5.12

	QUESTION	WRITE YOUR ANSWER HERE
A	Name the structure labelled A.	
B	Name the structure labelled B.	
C	Name the structure labelled C.	
D	Name the tube labelled D.	
E	How many arteries usually supply the adrenal gland?	

Case 5.12

A Right inferior phrenic artery

B Right adrenal gland

C Right superior suprarenal artery

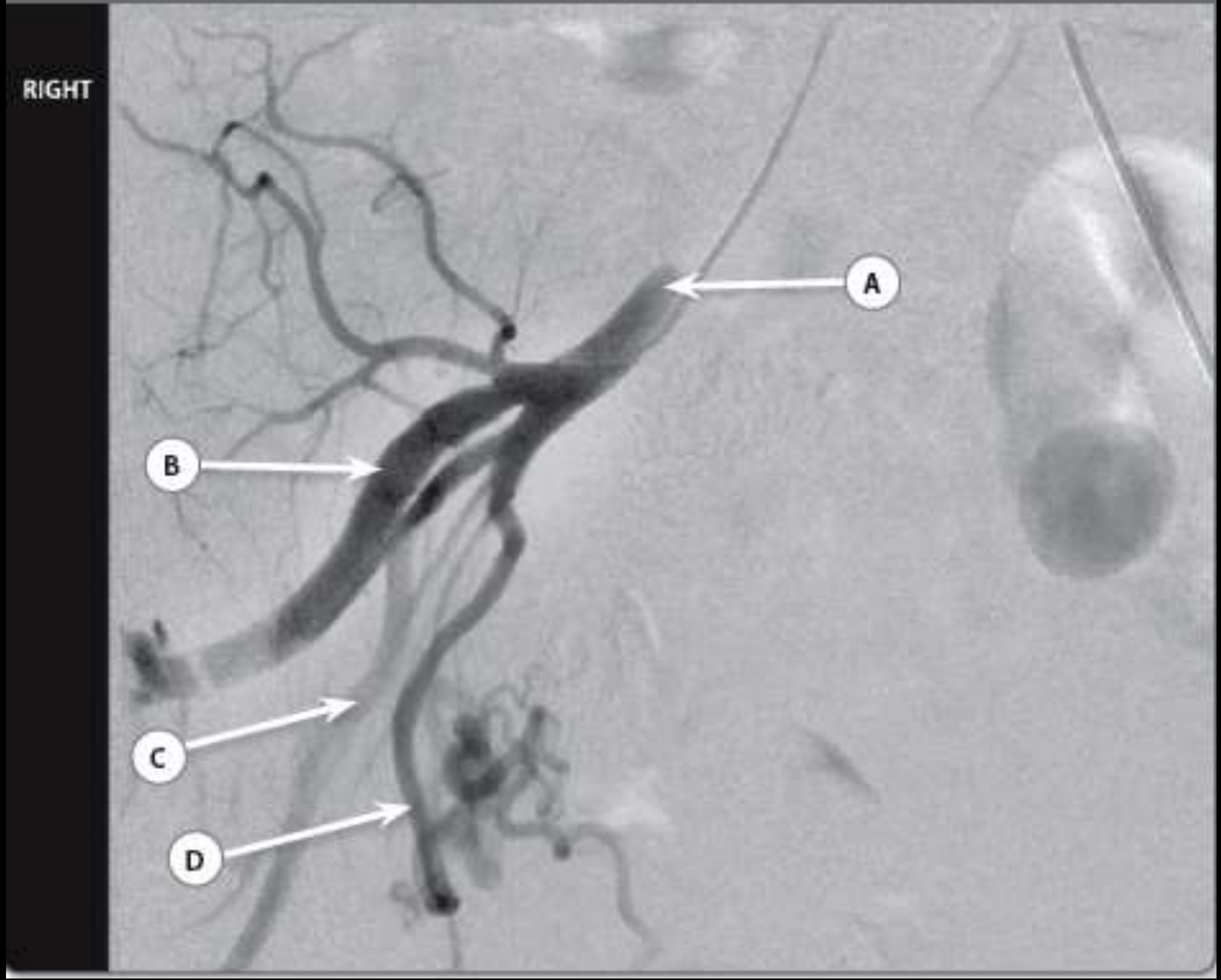
D Nasogastric tube

E Three

The inferior phrenic arteries arise from abdominal aorta close to the origin of the coeliac axis. The superior suprarenal artery can arise from this and supplies the adrenal gland.

The adrenal gland also derives blood supply from the middle suprarenal artery (branch of abdominal aorta) and the inferior suprarenal artery, which is a branch of the renal artery.

Case 7.13



E	Name one branch of the posterior trunk of the internal iliac artery.	

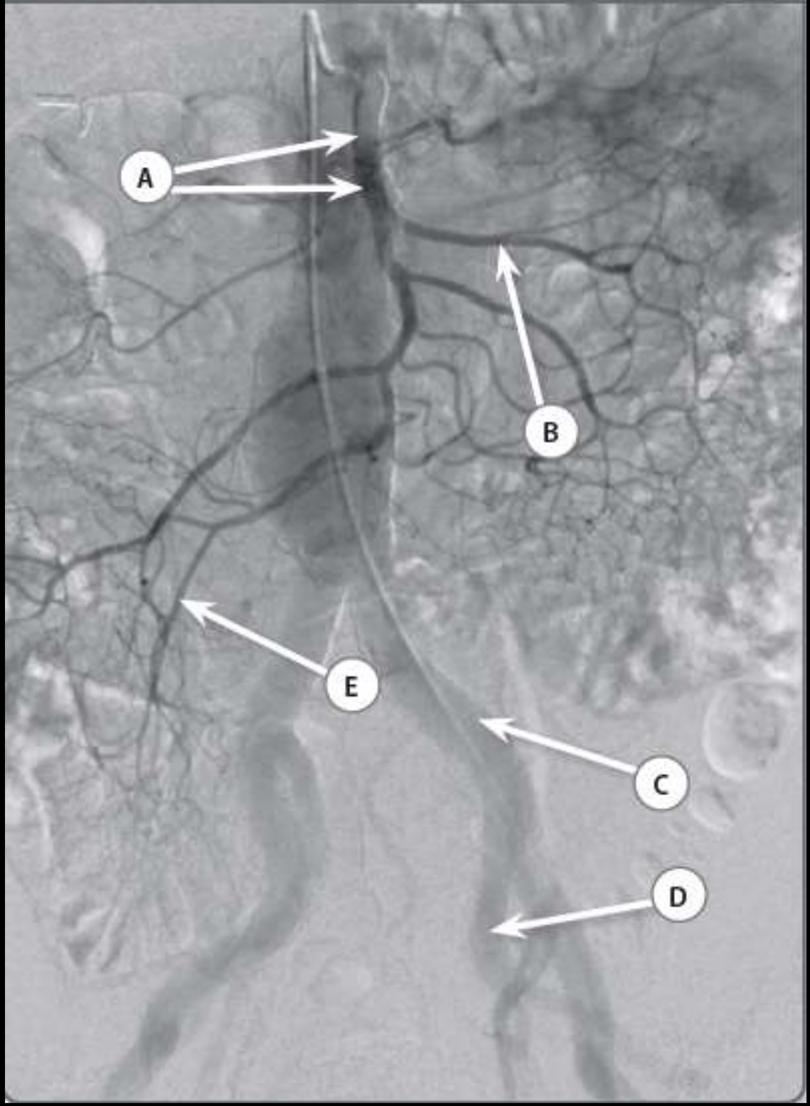
Case 7.13

- A Right common iliac artery
- B Right external iliac artery
- C Posterior trunk of internal iliac artery
- D Right uterine artery
- E Iliolumbar/lateral sacral/superior gluteal artery

The internal iliac artery has anterior and posterior trunks. The uterine artery most commonly arises from the anterior trunk and takes a horizontal route to supply the uterus. The posterior division gives off the iliolumbar, lateral sacral and superior gluteal branches.

The posterior branches can be easily remembered with the mnemonic
PILS: Posterior: Iliolumbar, Lateral sacral, Superior gluteal.

Case 12.1



Case 12.1

A Superior mesenteric artery (SMA)

B Branches to jejunum

C Left common iliac artery

D Left internal iliac artery

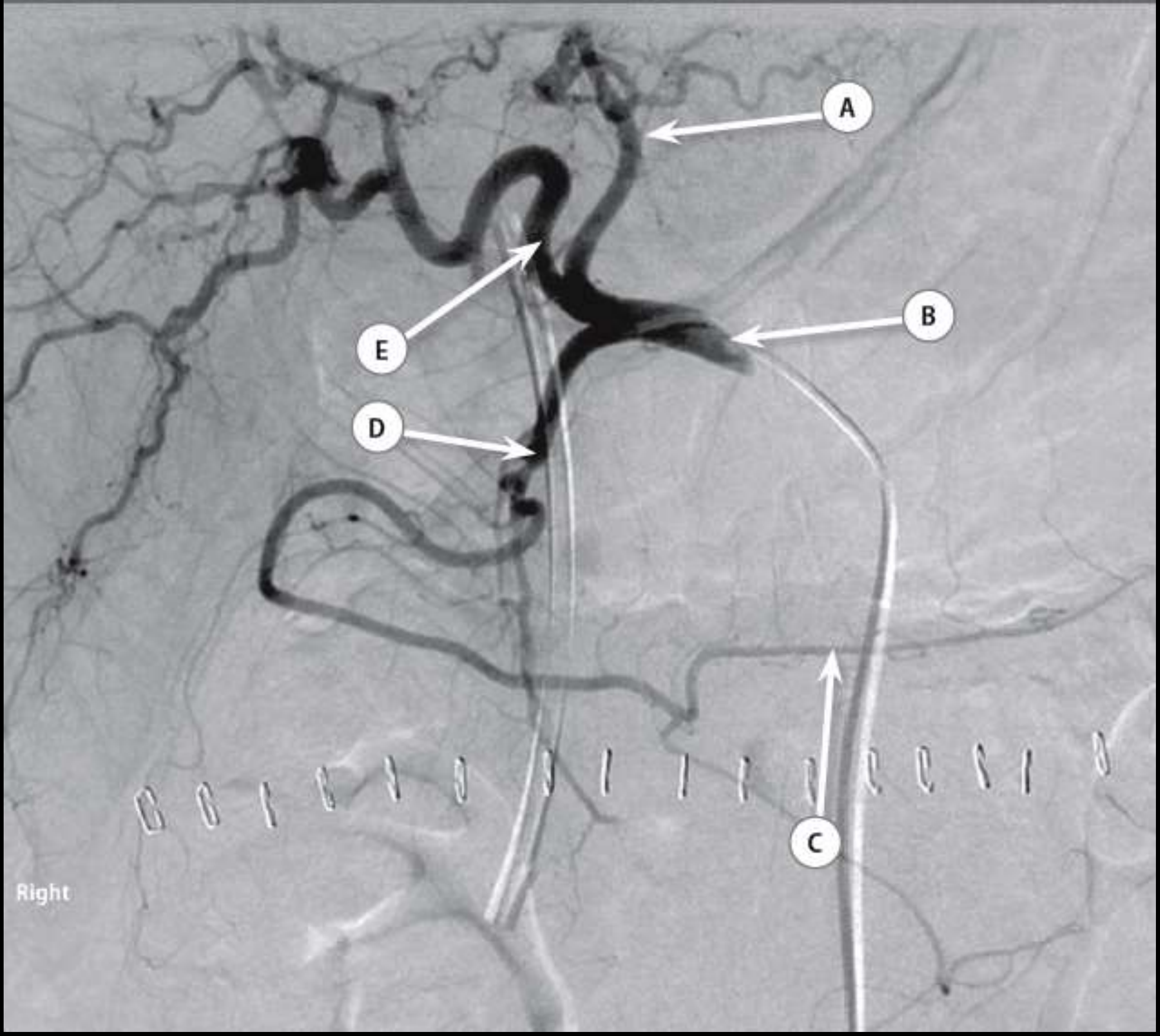
E Ileocolic branch of SMA

The SMA supplies the small bowel and the proximal large bowel up to the mid transverse colon.

If you are a James Bond fan, you may find the following phrase useful for memorising the SMA branches: Sean Connery In froM Russia wIth Love:

- Inferior pancreaticoduodenal
- Middle colic
- Right colic
- Intestinal
- iLeocolic

Case 13.12



Case 13.12

A Left hepatic artery

B Common hepatic artery

C Gastroepiploic artery

D Gastroduodenal artery

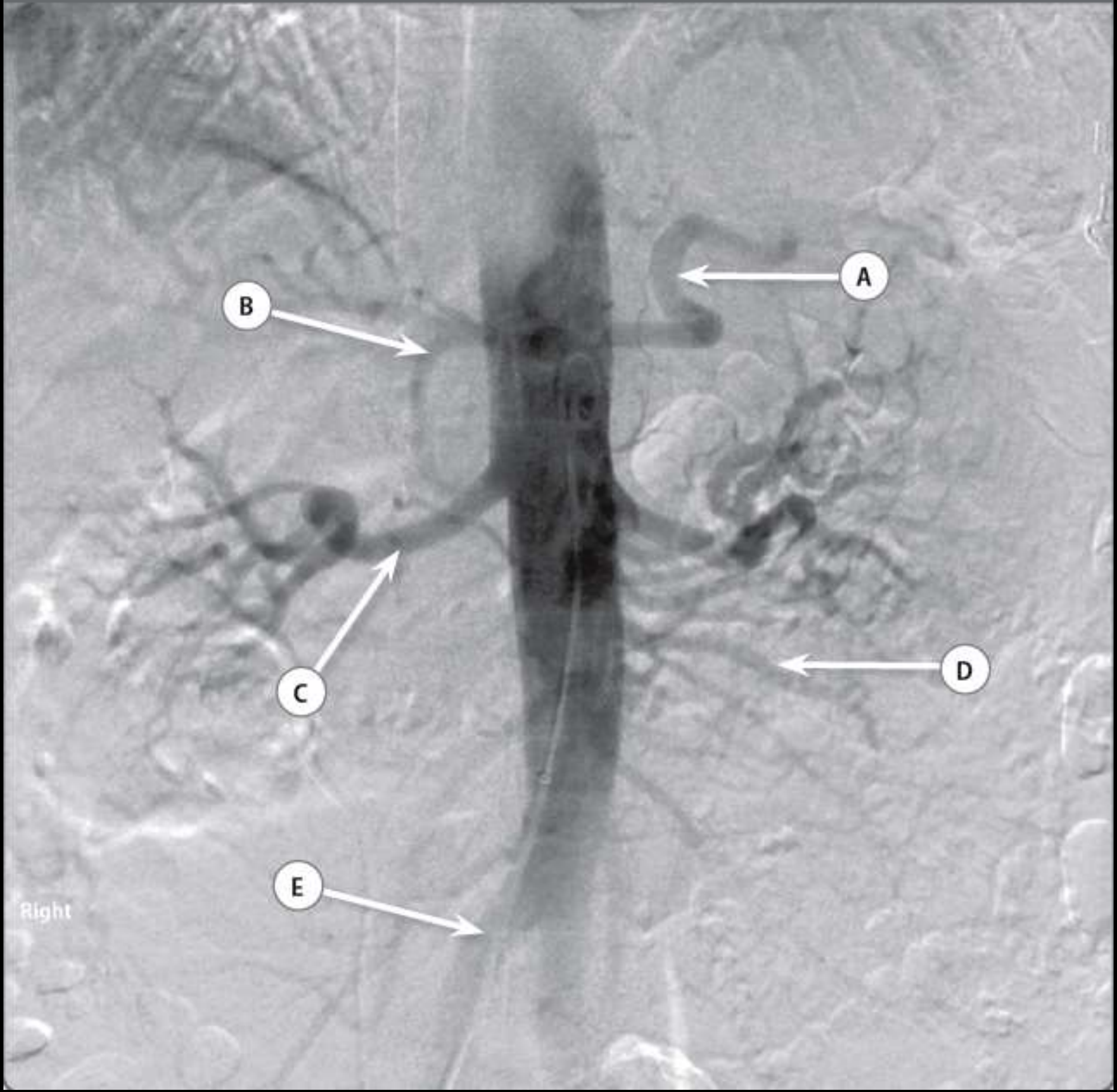
E Right hepatic artery

The gastroduodenal artery supplies the duodenum and then continues as the gastroepiploic artery which supplies the greater curve of the stomach.

Remember **LHS** for the major coeliac axis branches:

Left gastric, **H**epatic and **S**plenic.

Case 14.6



Case 14.6

A Splenic artery

B Gastroduodenal artery

C Right renal artery

D Jejunal branch of superior mesenteric artery

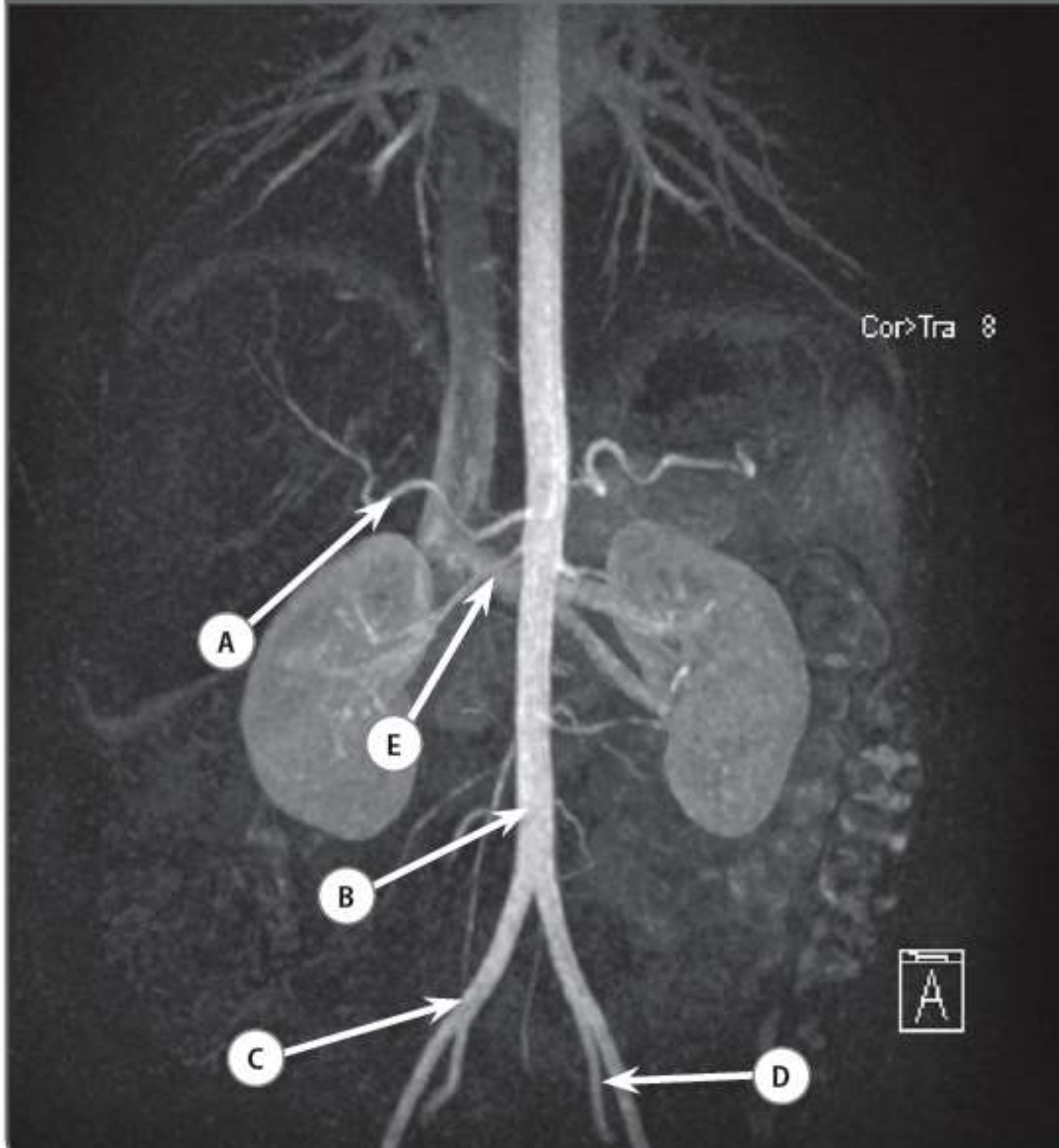
E Right common iliac artery

The coeliac axis arises from the abdominal aorta at the level of T12 and almost immediately trifurcates into the splenic, left gastric and common hepatic arteries.

The right gastric and gastroduodenal arteries are branches of the common hepatic artery. The common hepatic artery then becomes the hepatic artery proper and further divides to give branches to the gallbladder (cystic artery) and lobar branches to the liver.

Variant anatomy is very common here and the hepatic artery and its branches may arise from the aorta or superior mesenteric artery.

Case 15.19



E	What anatomical variant is labelled E?	

Case 15.19

A Common hepatic artery

B Infrarenal aorta

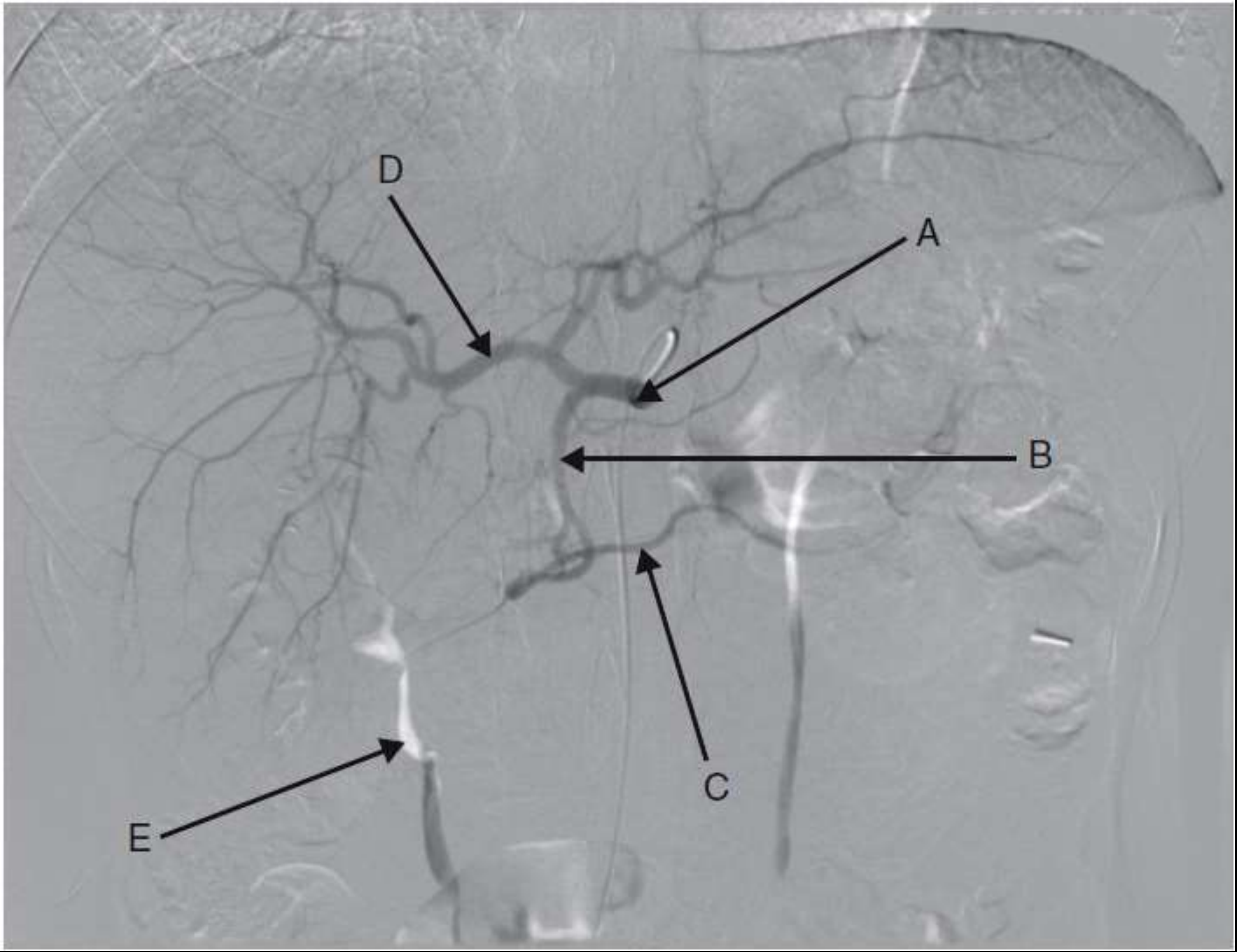
C Right common iliac artery

D Left internal iliac artery

E Retroaortic left renal vein

The major aortic branches are depicted including coeliac axis, hepatic artery, splenic artery and iliac bifurcation. Note the dual left renal arteries and veins and also the retroaortic path of the left renal veins. Retroaortic left renal vein has a reported incidence of 1.8–2.4%.

Case 2.12



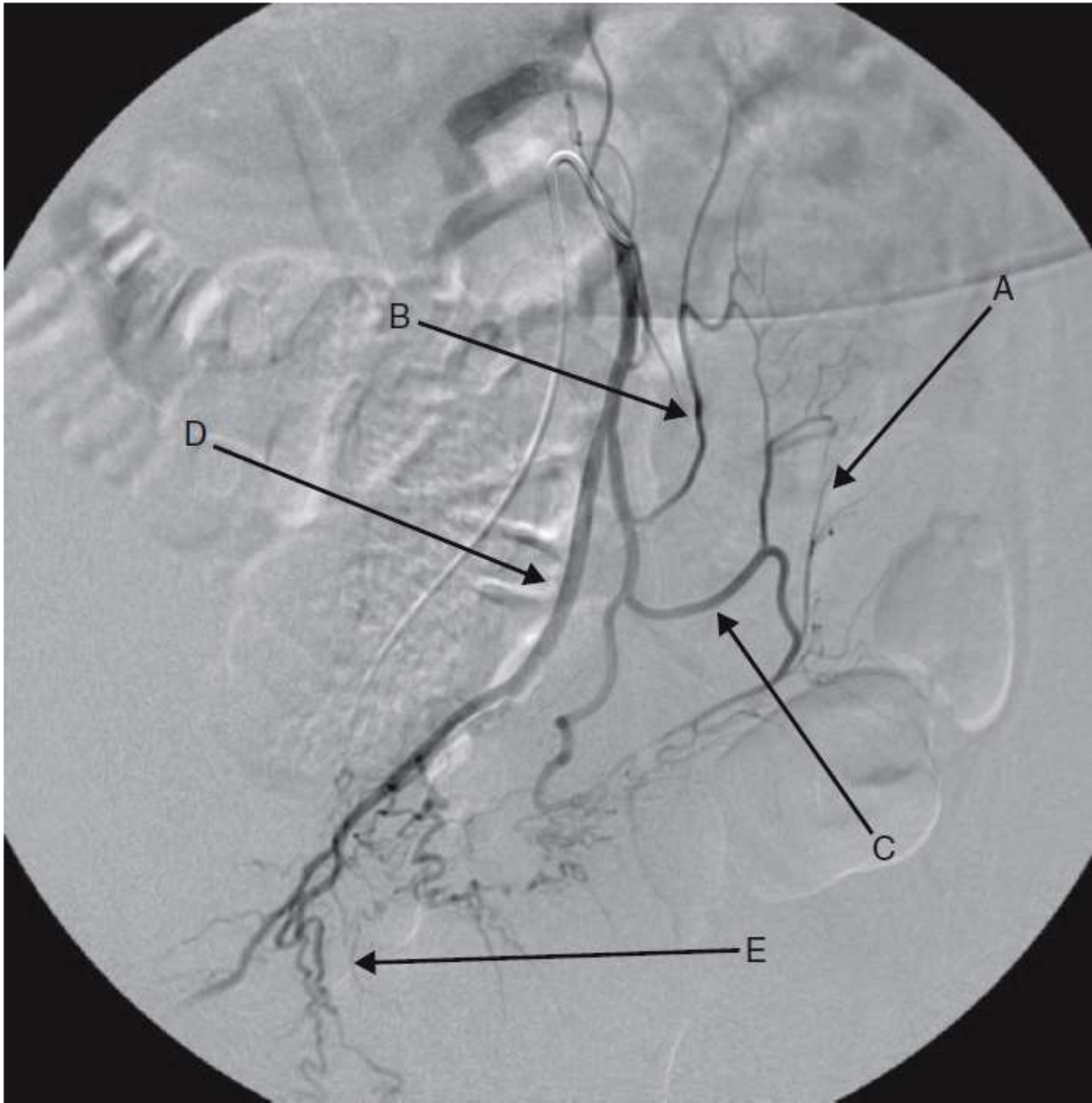
2.12 Coeliac axis angiography

(a) Coeliac axis. This artery arises from the anterior of the aorta at a level between the T12 and L1 vertebral bodies. In 65–75% of individuals it divides into the left gastric artery, splenic and common hepatic arteries, 1–2 cm from its origin.
(b) Gastroduodenal artery. This artery lies immediately behind the first part of the duodenum and therefore ulcers in the posterior wall of the duodenal bulb can result in life-threatening haemorrhage. The first line treatment for this remains endoscopy although embolization with interventional radiology using coils or gelfoam provides a valuable alternative strategy.
(c) Superior pancreatico-duodenal artery.
(d) Right hepatic artery. The common hepatic artery arises from the coeliac axis in 75% of the population. Other common variants to be aware of include an aberrant origin of the right hepatic artery from the superior mesenteric artery (SMA) (replaced right hepatic artery in 10–12% of the population) and a replaced left hepatic artery (off the left gastric artery) in 11–12% of the population.

The blood supply to the liver is divided, with 75% supplied by the portal vein and 25% by the hepatic artery. Interestingly, however, any primary or secondary tumours in the liver invariably have an arterial supply.
(e) Right ureter.

During angiography of the gastrointestinal tract the bladder often fills with contrast and it is therefore customary and advisable to cannulate the inferior mesenteric artery first, so that views of the sigmoid colon are not obscured by an opacified bladder.

Case 4.6



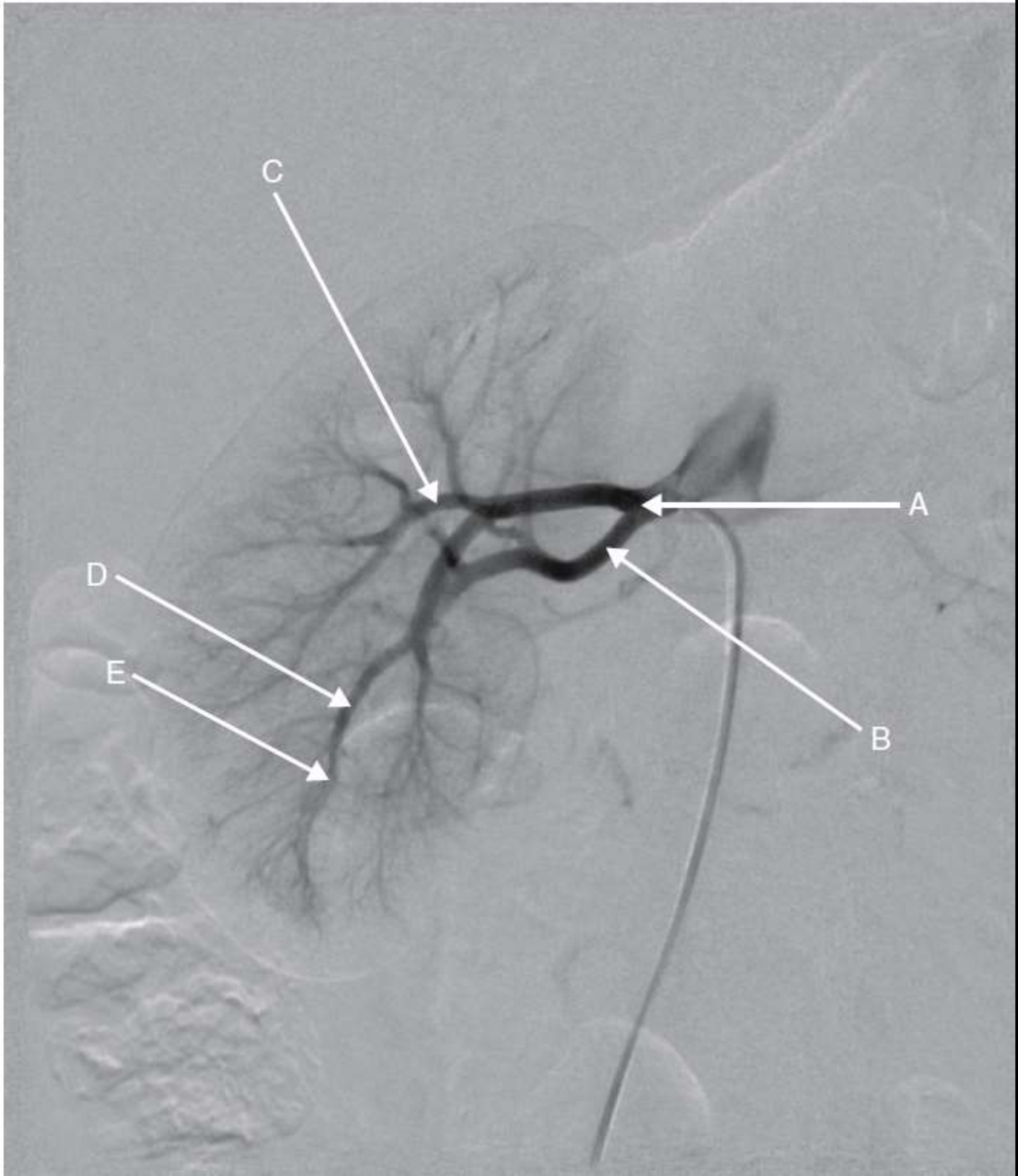
4.6 Inferior mesenteric artery angiogram

(a) This is the arterial branch which anastomoses with the superior mesenteric artery (SMA) and is called the marginal artery (of Drummond).

(b) Ascending branch of left colic artery (or upper left colic artery).
(c) Left colic artery, middle branch.
(d) Superior rectal artery.
(e) Haemorrhoidal arteries. The inferior mesenteric artery (IMA) supplies the large intestine from the splenic flexure to the upper rectum. The proximal territory forms a watershed area with the middle colic artery and represents an area of vascular vulnerability when blood flow is reduced by any cause. This is at the splenic flexure and therefore the differential for a stricture in this lesion should include chronic ischaemia.

In the elderly there are anastomoses, arcades seen at angiography, between the SMA and IMA due to mesenteric arterial occlusion.

Case 5.10



5.10 Right renal angiogram

(a) Right renal artery. The renal arteries arise from the aorta approximately at the upper margin of L2. Sixty-five per cent of kidneys are supplied by a solitary vessel; 35% have an aberrant vascular supply. The right renal artery is usually longer and passes behind the inferior vena cava.

The most sensitive and specific non-invasive screening test for renal vessel disease is MRA (98% and 100% respectively) followed by CT (92% and 83%) and duplex ultrasound (89% and 97%).

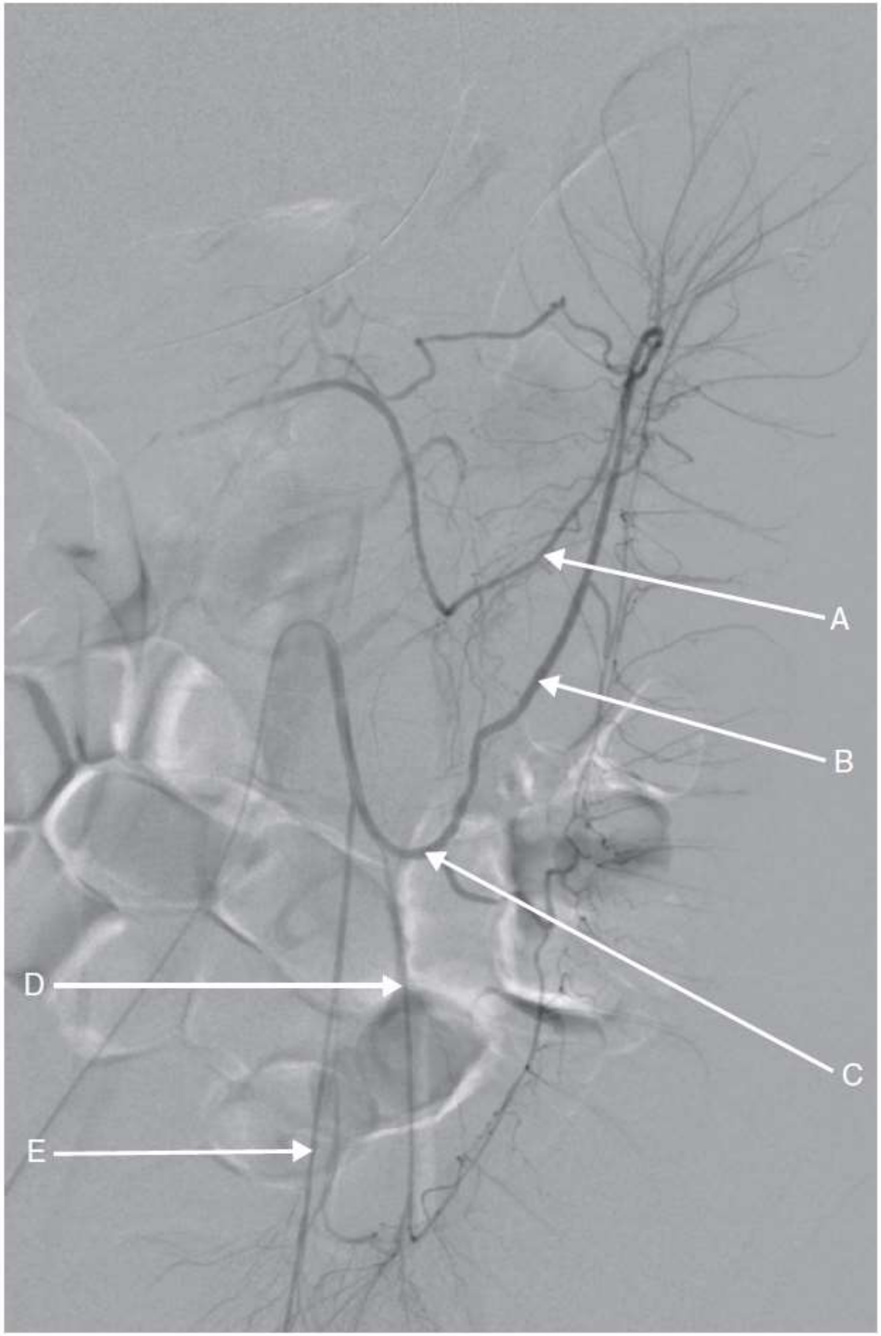
(b) Posterior division of the renal artery.
(c) Segmental artery.
(d) Interlobar artery. These arteries lie between the lobes (or pyramids) of the kidney.
(e) Arcuate artery. These arteries do not anastamose to form arcades, but run along the base of the pyramids.

The branching pattern from the aorta is therefore:

Main renal artery – anterior and posterior division – segmental arteries – interlobar arteries – arcuate arteries.

Between the anterior and posterior divisions of the renal artery is the plane of Brodel, which is at the postero-lateral approach to the kidney. It is relatively avascular and is the plane targeted for when performing percutaneous nephrostomy.

Case 5.17



5.17 Inferior mesenteric angiogram

(a) Arc of Riolan. This vessel lies in the mesentery and provides a connection between the superior mesenteric artery (SMA) and inferior mesenteric artery (IMA) via the middle and left colic arteries at the splenic flexure. There is a more peripheral connection of the intestinal arcades which parallel the bowel wall; in the small bowel this is called the marginal artery of Dwight and in the colon it is called the marginal artery of Drummond.

(b) Ascending branch of the left colic artery.

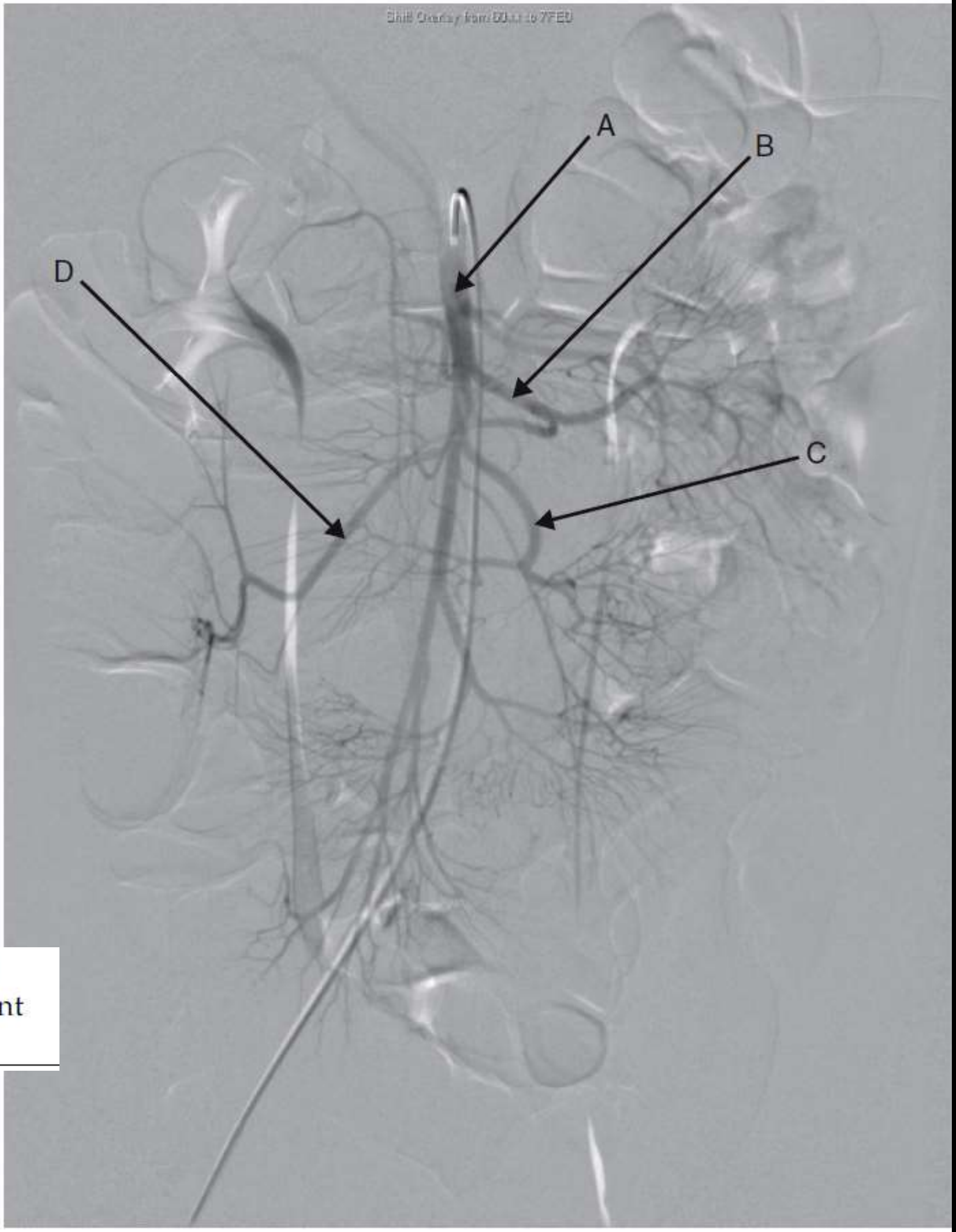
(c) Left colic artery.

(d) Sigmoid arteries.

(e) Superior haemorrhoidal (rectal) artery. The superior haemorrhoidal artery is a continuation of the inferior mesenteric artery and branches from it communicate with the middle haemorrhoidal (rectal) artery, which arises from the internal iliac artery and is one of three potential collateral pathways that allow lower limb perfusion in aortic occlusion:

1. Aorta – SMA – IMA – superior haemorrhoidals – internal pudendal artery – internal iliac artery – external iliac artery.
2. Aorta – lumbar artery – ilio-lumbar – internal iliac – external iliac.
3. Aorta – posterior intercostal and lumbar arteries – deep circumflex iliac artery – external iliac artery.

Case 6.12



(e)	Which normal variant is present on this image?

6.12 Superior mesenteric artery arteriogram

(a) Superior mesenteric artery (SMA). This artery arises from the aorta at the level of the L1 vertebra. The inferior mesenteric artery arises from the anterior or left antero-lateral aspect of the aorta at L3 vertebral level.
(b) Jejunal branch of the SMA. There are usually between four and six jejunal branches.
(c) Ileal branch of the SMA. There are usually between 9 and 13 ileal branches which arise after the ileocolic artery.
(d) Right colic artery.

(e) Replaced right hepatic artery. The right hepatic has an aberrant origin from the SMA rather than from the common hepatic artery. (It is faintly visible rising diagonally to the right from close to the catheter tip.)

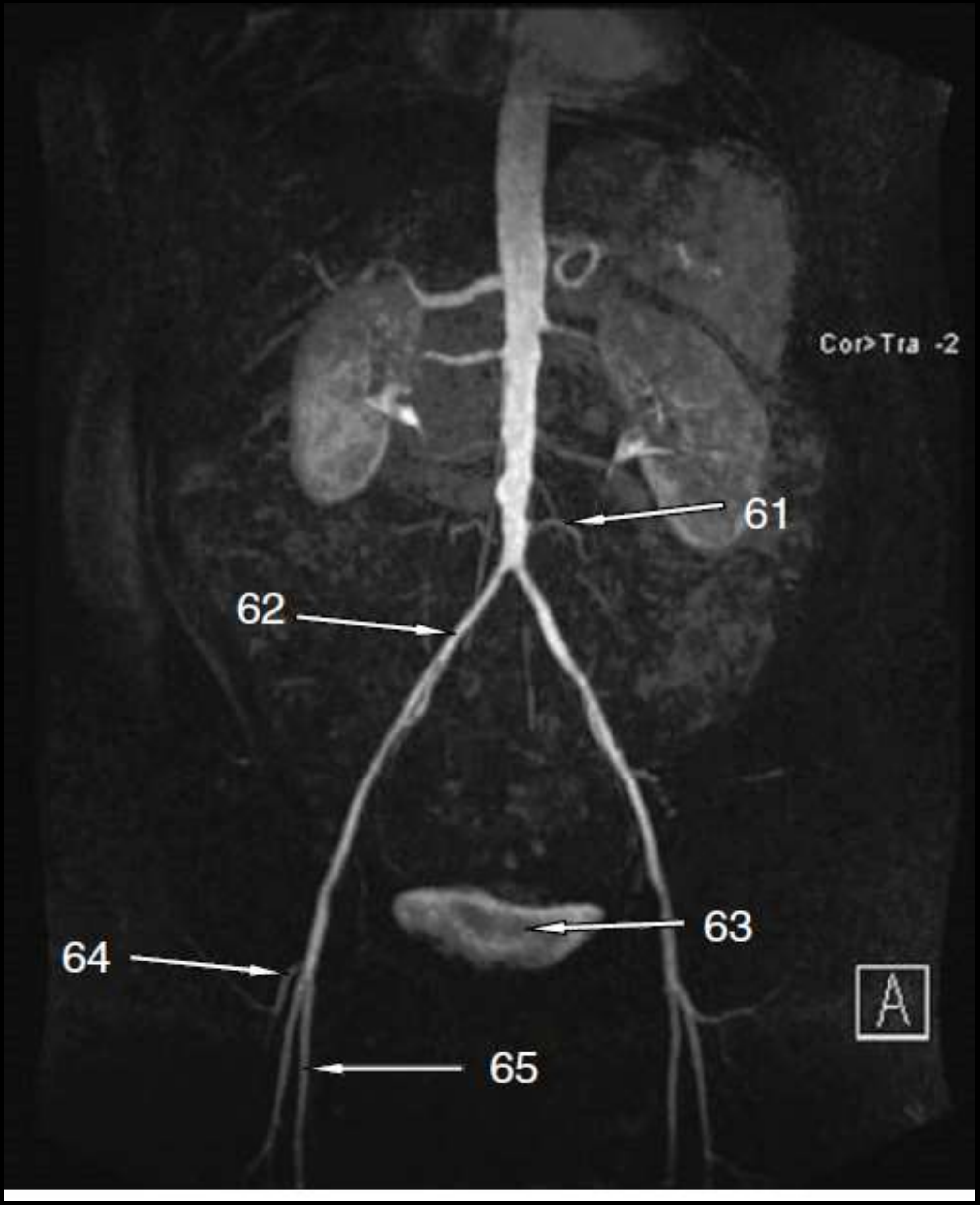

A
B
C
D
E

Case 15

Inferior mesenteric arteriogram with digital subtraction.

1. Inferior mesenteric artery
2. Superior rectal artery
3. Left colic artery
4. Marginal artery of Drummond
6. Descending colon

Digital subtraction will remove all structures that are unchanged between the pre- and postcontrast images, effectively deleting the background. Anything that moves will remain and the patient is asked to hold their breath to limit movement of the internal organs and bony skeleton. Bowel is often seen, however, as it peristalses (this can be limited by the administration of buscopan).



Cor>Tra -2
61
62
63
64
65
A

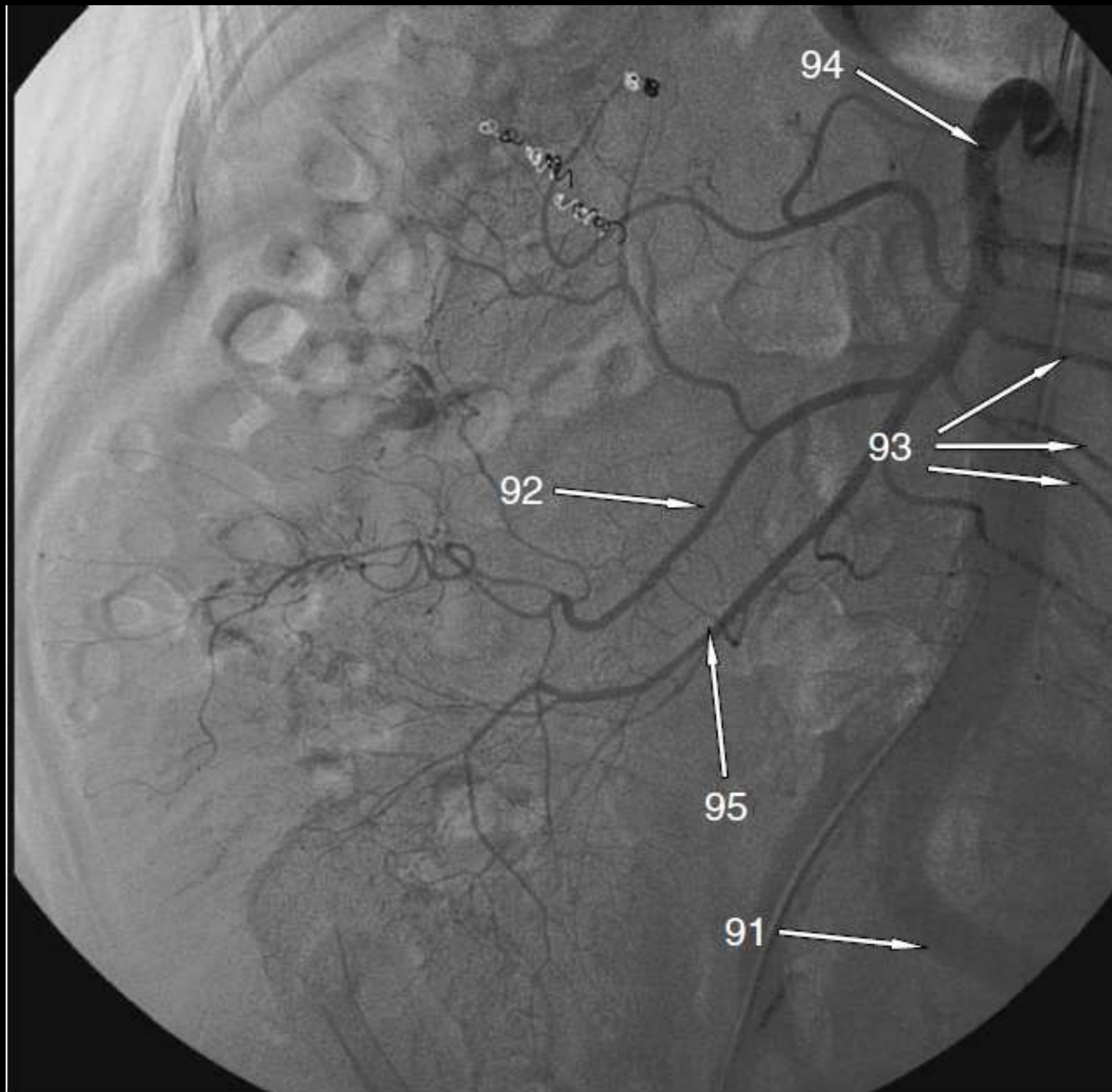
MR Angiogram

61. Left lumbar artery
62. Right common iliac artery
63. Urinary bladder
64. Right lateral circumflex femoral artery
65. Right superficial femoral artery

The bladder fills up with contrast in many investigations including this MRA. Always label as the ‘urinary bladder’.

The lateral circumflex femoral artery delineates the border between external iliac and femoral artery.

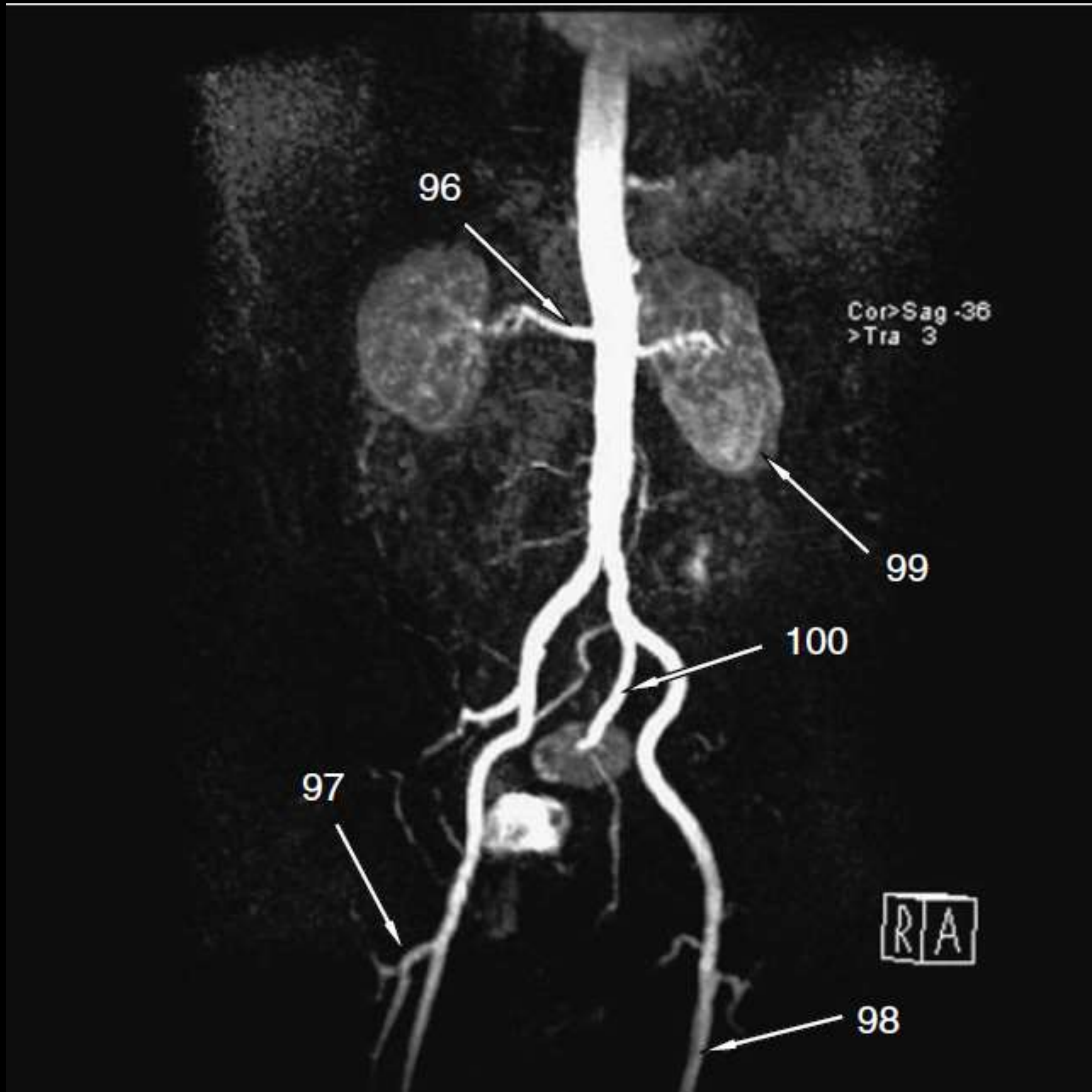
Remember that the superficial femoral lies medial to the profunda femoris artery.


94
93
92
95
91

DSA

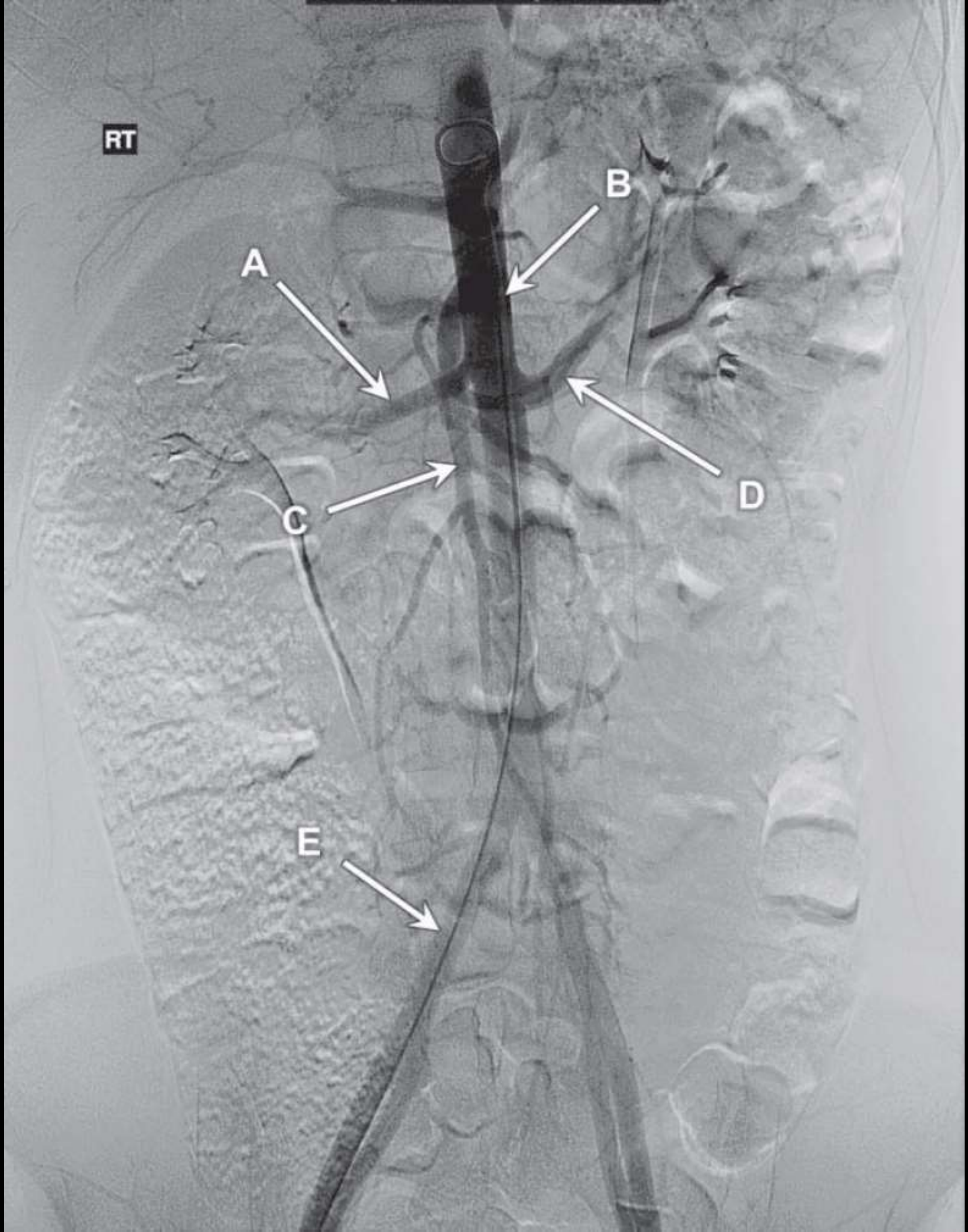
91. Left common iliac artery
92. Right colic artery
93. Jejunal branches of SMA
94. Superior mesenteric artery
95. Ileocolic artery

The superior mesenteric artery originates at the level of L1. (Coeliac artery = T12, IMA = L2)


96
Cor>Sag -36
>Tra 3
99
100
97
R A
98

MRA

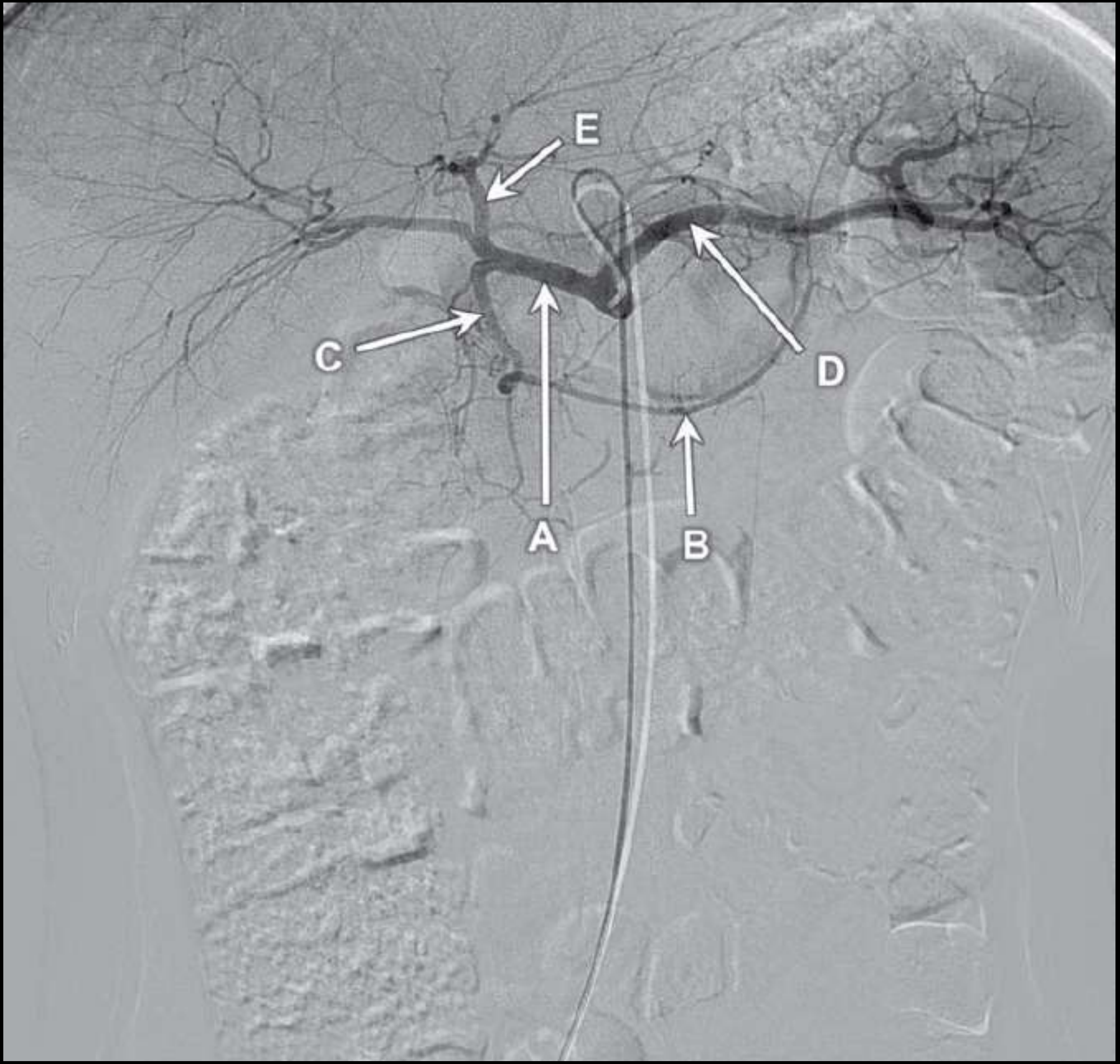
96. Right renal artery
97. Right profunda femoris artery
98. Left superficial femoral artery
99. Left kidney
100. Left internal iliac artery


RT
A
B
C
D
E

Case 7

Abdominal aortogram (fluoroscopic).

1. Right renal artery
2. Abdominal aorta
3. Superior mesenteric artery
4. Left renal artery
5. Right common iliac artery

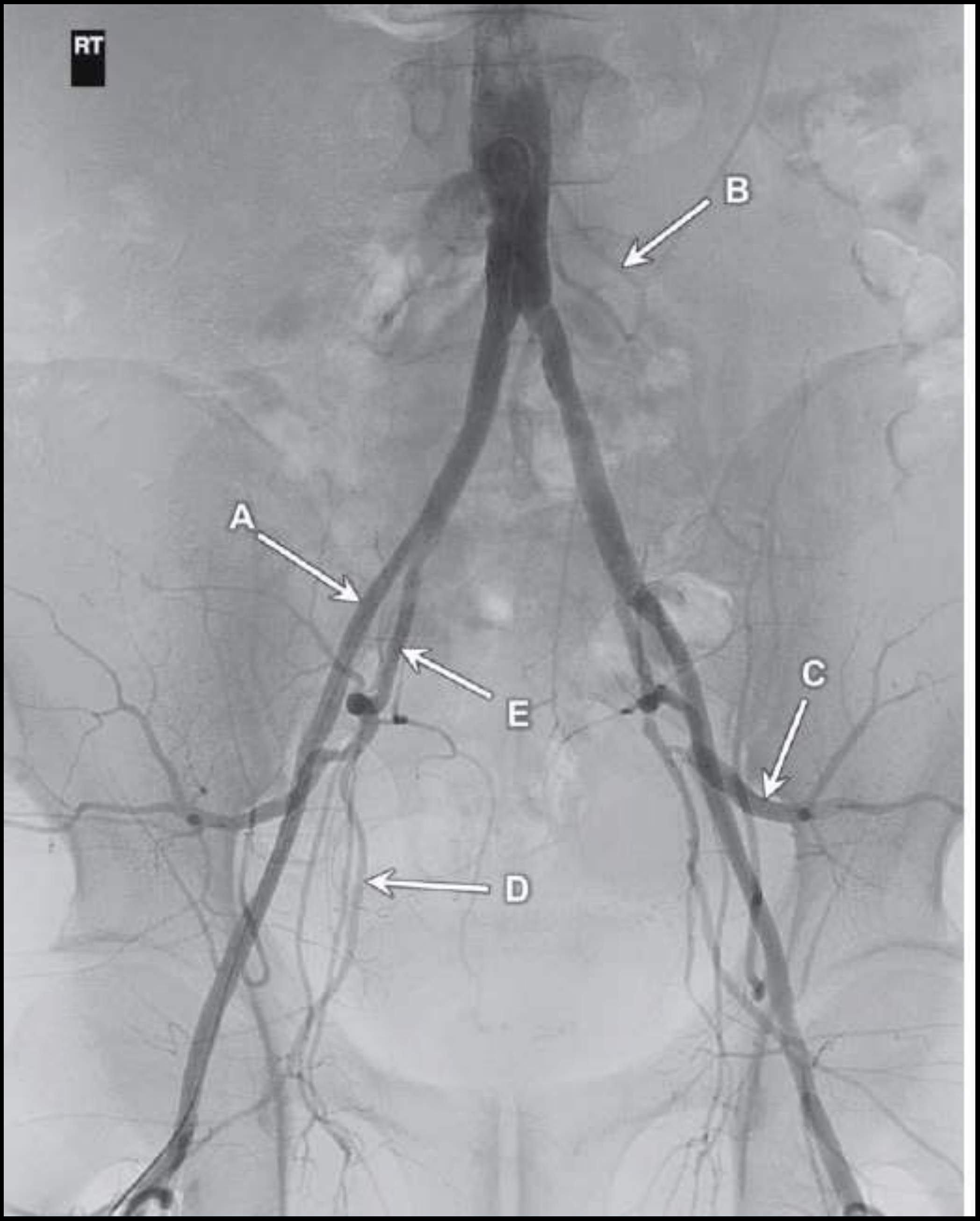

E
C
A
B
D

Case 16

Coeliac axis angiogram.

1. Common hepatic artery
2. Right gastroepiploic artery
3. Gastroduodenal artery
4. Splenic artery
5. Left hepatic artery

Several normal variants may exist in the arterial anatomy here, particularly in relation to the origin of the hepatic arteries. Candidates should be aware of these. Choose your favourite anatomy book and have a look.


RT
A
B
C
D
E

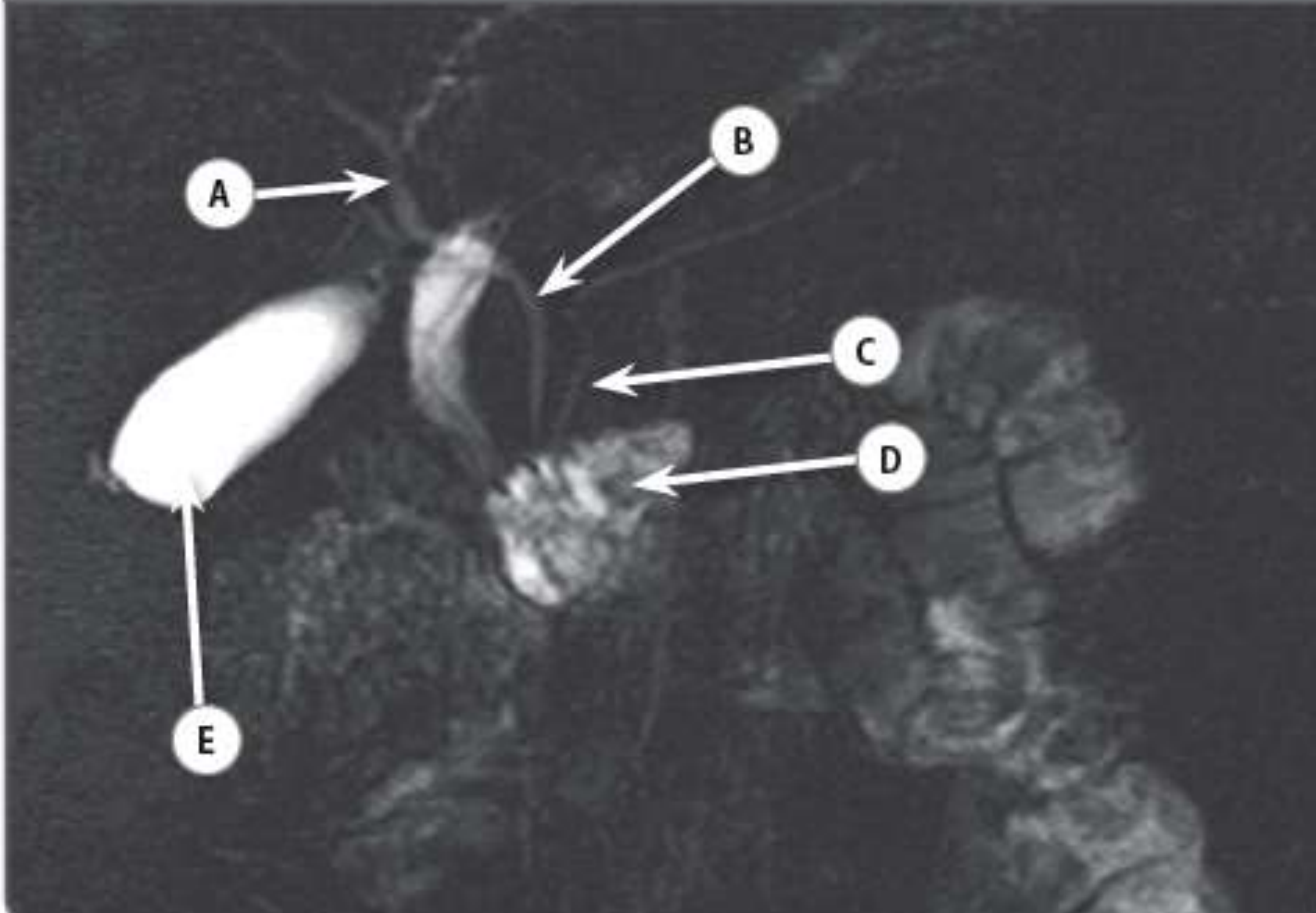
Case 4

Aortogram.

1. Right external iliac artery
2. Left colic artery
3. Left superior gluteal artery
4. Right inferior gluteal artery
5. Right internal iliac artery

BILIARY

Case 4.11



Case 4.11

A Common hepatic duct

B Common bile duct

C Pancreatic duct

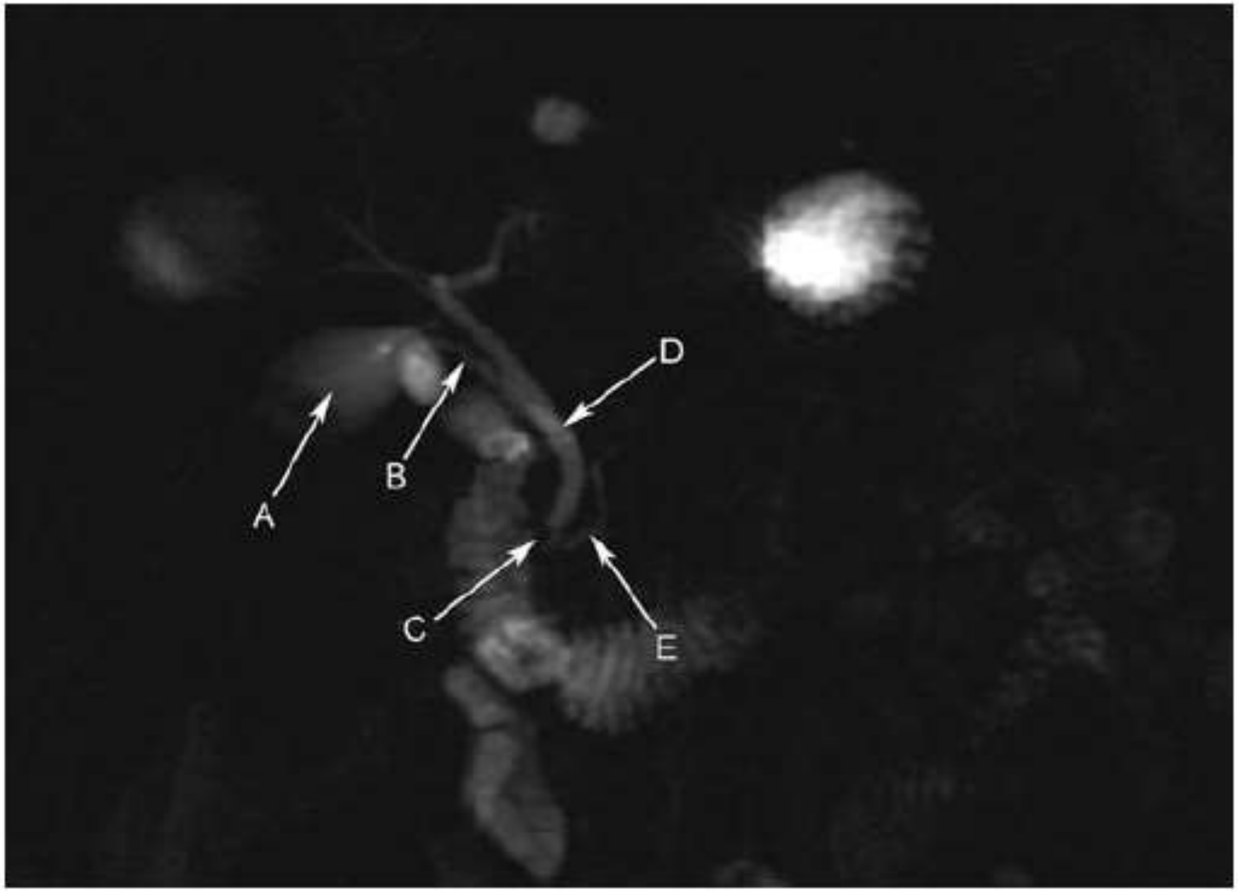
D Duodenum (third part)

E Gallbladder

The commonest anatomical form of the biliary system is depicted in this example. (A) shows the common hepatic duct formed by the right and left hepatic ducts. The cystic duct joins the common hepatic duct to form the common bile duct which drains into the second part of the duodenum. The pancreatic duct is also demonstrated and is seen draining into the ampulla.

Variant anatomy is commonly encountered, with several possible variants in the intrahepatic and extrahepatic biliary tree.

Question 8.11



Name the structures labelled A to E.

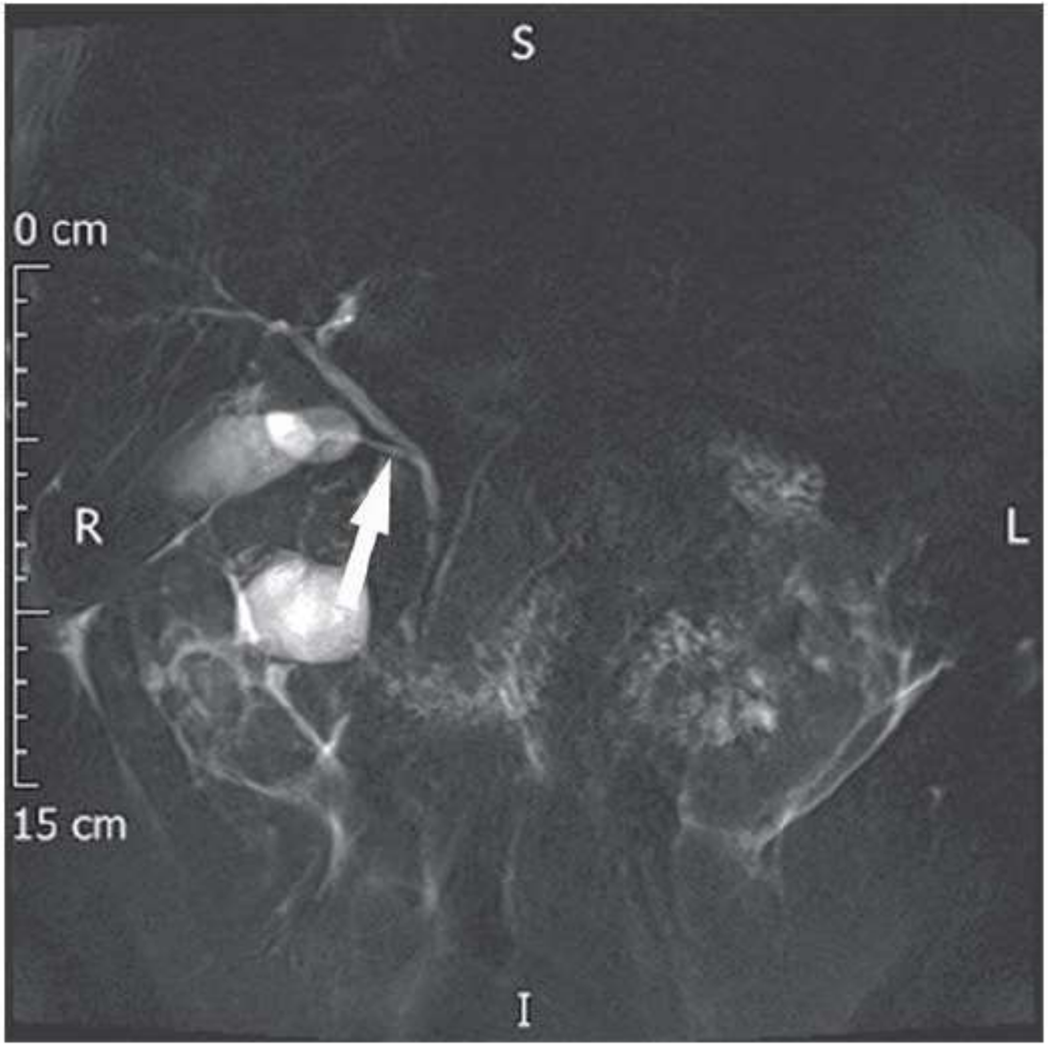
8.11 MR cholangiopancreatography

A Gallbladder.
B Cystic duct.
C Ampulla of Vater (hepatopancreatic ampulla).
D Common bile duct.
E Pancreatic duct.

The common bile duct and pancreatic duct typically unite at the ampulla of Vater. This is located at the major duodenal papilla, halfway along the second part of the duodenum. This is an important point as is marks the transition from foregut to midgut, and is the point where arterial supply changes from the coeliac trunk to the superior mesenteric artery.

In a minority of people there is an additional dorsal pancreatic duct (the duct of Santorini) which usually drains separately into a second smaller (minor) papilla, approximately 2 cm proximal to the main papilla. The ventral pancreatic duct (the duct of Wirsung) continues to drain via the major papilla. This variant is termed pancreas divisum and is a risk factor for pancreatitis.

Question 48:



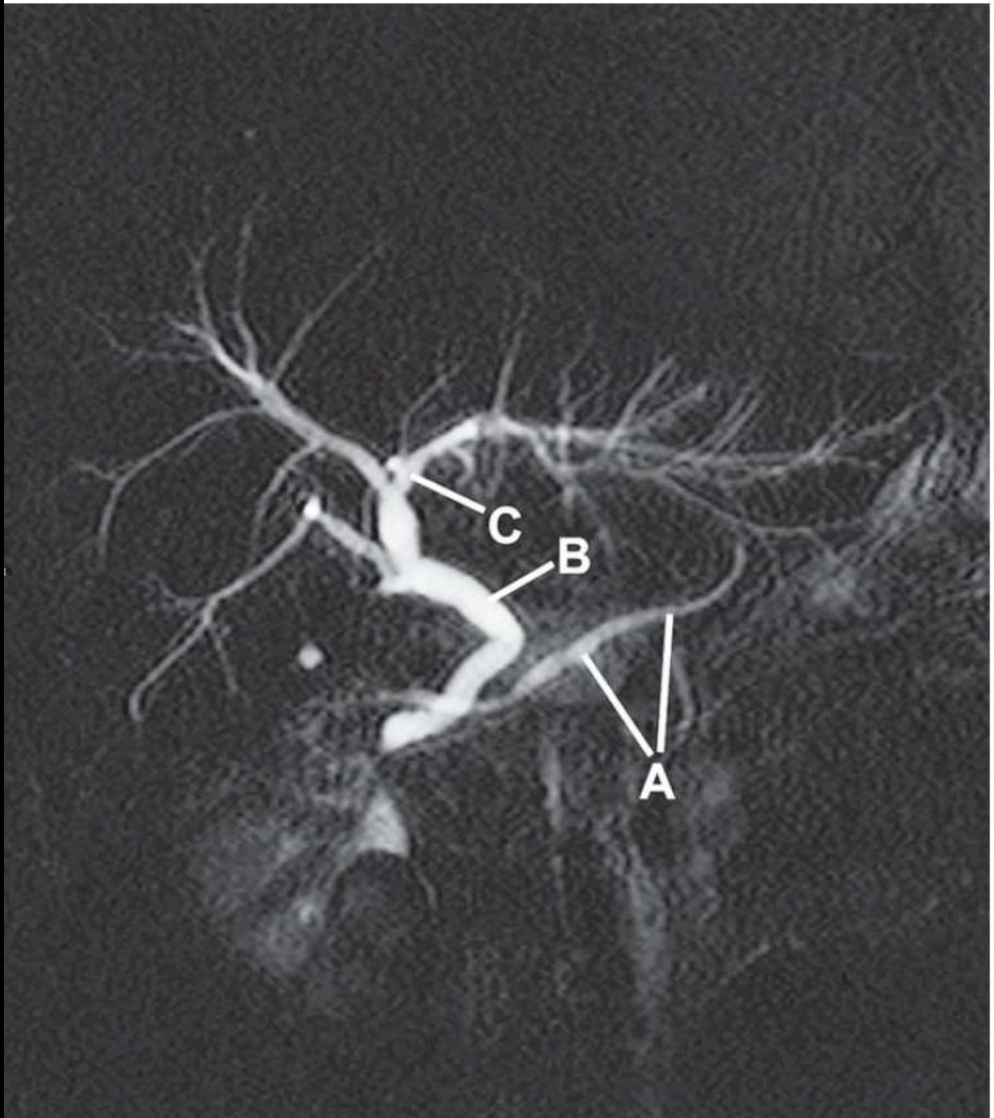
Question 48: MR cholangiopancreatogram

Answer: Cystic duct

- The cystic duct connects the gallbladder with the rest of the biliary tree.
- It is of variable length and joins the common hepatic duct to form the common bile duct at a variable point either proximally (close to the liver) or distally (near the pancreas). A low insertion is important to mention in reports because this has consequences for surgeons if they perform a cholecystectomy.

Q20

a Name the structure labelled A
b Name the structure labelled B
c Name the structure labelled C
d Name the major biliary structure not seen in this image
e Name the pancreatic anatomical variant demonstrated in this image



Q20 Answers

a Dorsal pancreatic duct (of Santorini)
b Common bile duct
c Left hepatic bile duct
d Gallbladder
e Pancreas divisum

MRCP

Bile drained from the hepatocytes runs in bile duct tributaries which pass alongsid portal venous and hepatic arterial vessels in 'portal triads'. All three systems conform to the segmental divisions of the liver. The segmental and sectoral ducts typically unite to form the right and left hepatic ducts which then converge at the porta hepatis to become the common hepatic duct. The cystic duct from the gallbladder usually drains into the common hepatic duct, after which it becomes the common bile duct (CBD). The location of cystic duct insertion and therefore the length of the common bile duct can vary, however an average length is approximately 8cm.

There are numerous variations in the configuration and course of the intra-hepatic biliary ducts and in approximately 50% the anatomy is not 'typical' (as in this image). In this case the main confluence at the porta hepatis is formed by a right sectoral duct and the left hepatic duct, with the remaining right sectoral duct inserting more distally into the CBD. This is one of the convergence étagée or shelved confluence variations seen in approximately 20% of the population. This variation is of interest to surgeons as an aberrant posterior sectoral duct can be mistaken for the cystic duct during gallbladder surgery.

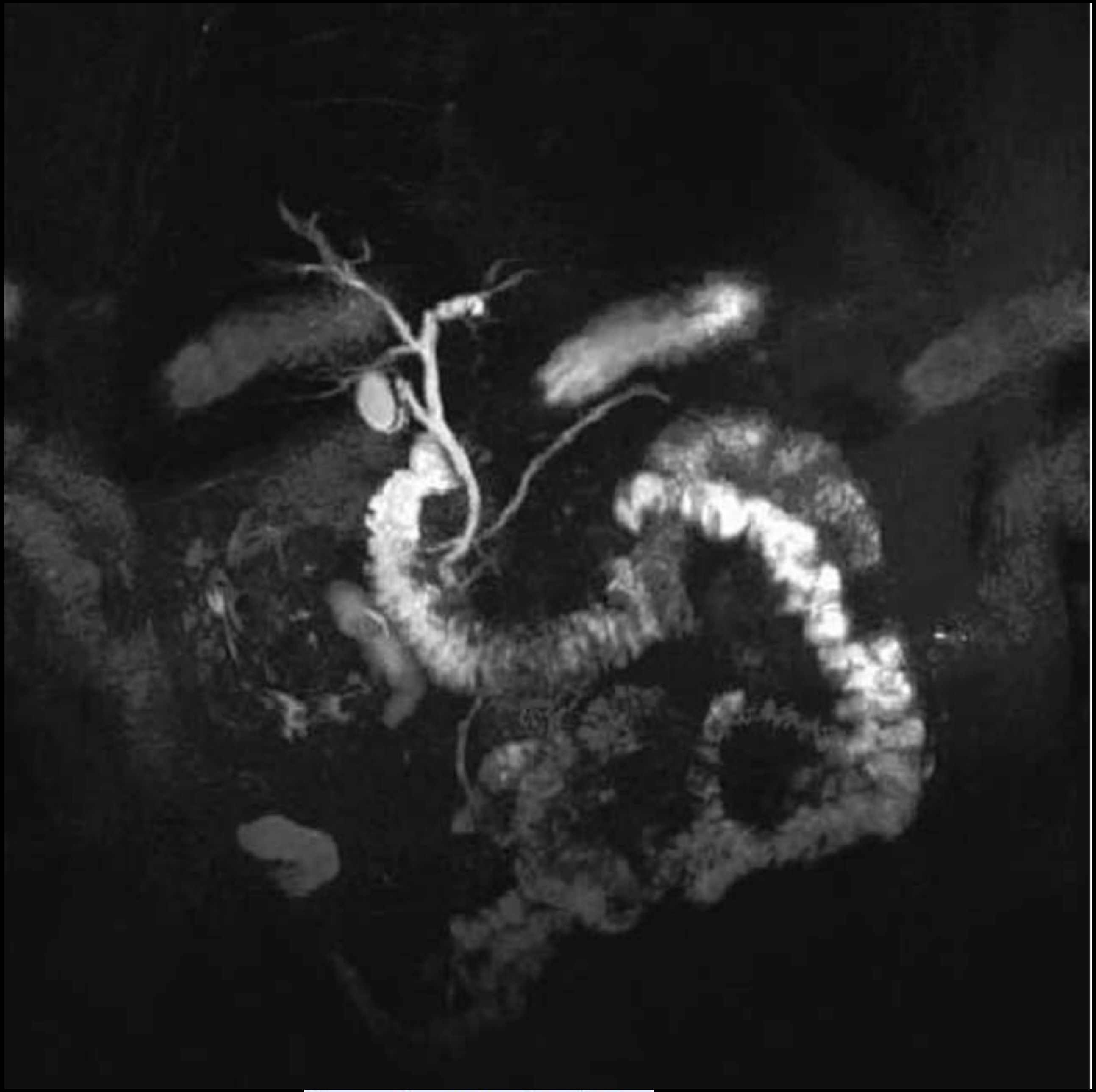
The gallbladder is not visible on this image. There can be a number of reasons for this which include: previous cholecystectomy (common), chronic cholecystitis, cholelithiasis and agenesis (rare).

Normally the pancreatic duct combines with the common bile duct to form the ampulla of Vater. This then drains into the second part of the duodenum, with the flow being controlled by a muscular sphincter (of Oddi). The main pancreatic duct is formed in-utero from fusion of the embryological dorsal and ventral ducts. It is common for some communication to persist between the pancreatic ductal systems but in approximately 6% of individuals these ducts remain entirely separate in what is termed pancreas divisum. In this anatomical variant the main dorsal duct (of Santorini) drains the tail and body of the pancreas and empties into the duodenum proximally via a separate opening – the minor papilla. The smaller ventral duct (of Wirsung), which serves the pancreatic head, then joins the distal CBD to drain into the duodenum via the major papilla. The ventral duct is seen on this image running inferior and parallel to the distal CBD.

Healy JE, Schroy PC. Anatomy of the Biliary Ducts Within the Human Liver: Analysis of the Prevailing Pattern of Branchings and the Major Variations of the Biliary Ducts. *AMA Arch Surg* 1953; 66:599–616.

Bismuth H, Vibert E. Chapter 90: Surgical Anatomy of the Liver and Biliary Ducts. In *Master Volume of Surgery, Volume 1* (eds Fischer JE, Bland KI), Lippincott Williams & Wilkins 2007.

Khan MA, Aktar A. Pancreas Divisum. *Radiology* 2010; eMedicine: www.emedicine.medscape.com



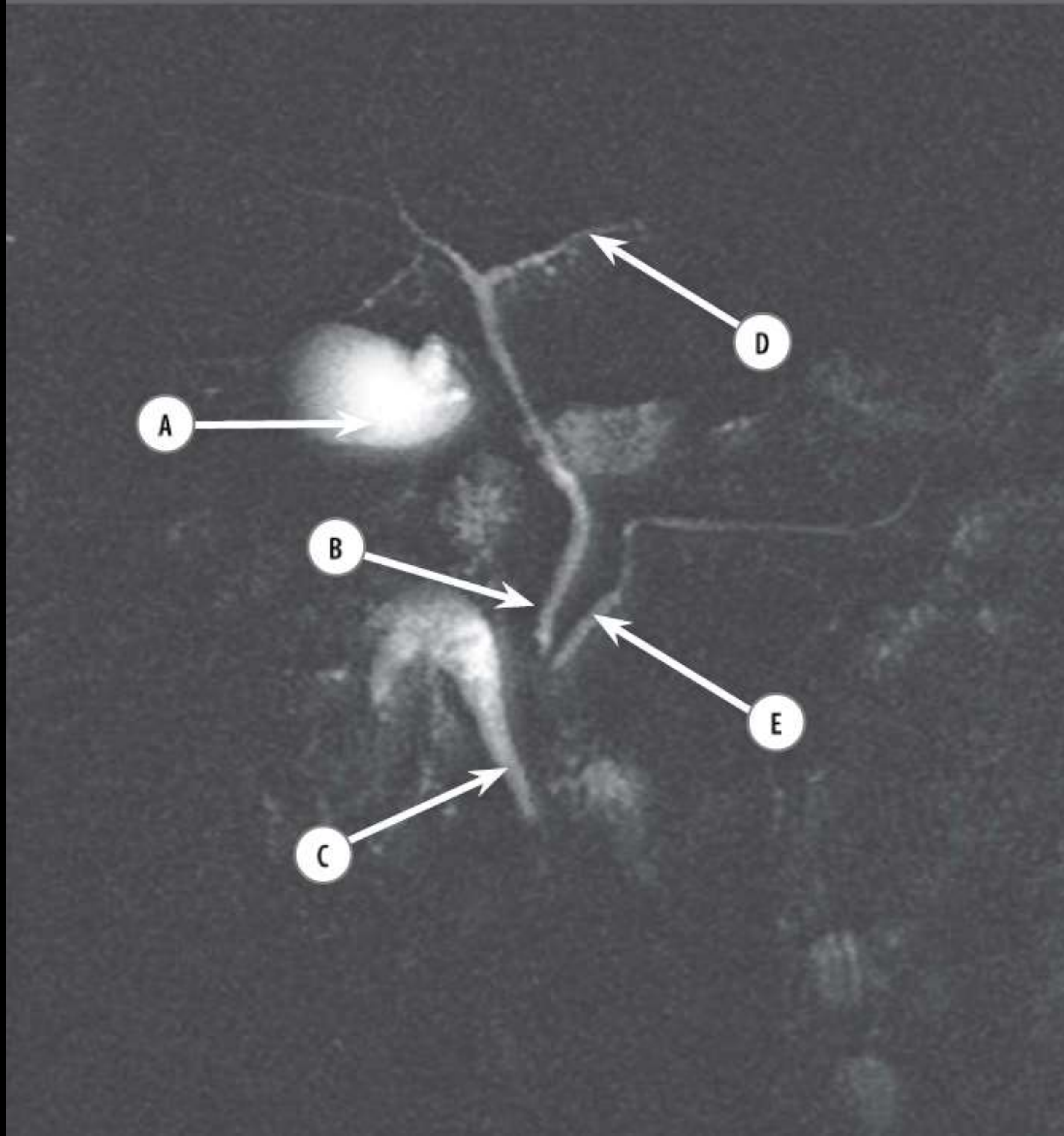
Name the normal variant

MRCP

Pancreas divisum

Failure of fusion of the dorsal and ventral moieties of the pancreas results in the anterosuperior part of the head and the body and tail draining via the accessory papilla, with the posteroinferior part of the head draining to the ampulla.

Case 3.20



Case 3.20

A Gallbladder

B Common bile duct

C Right proximal ureter

D Left hepatic duct

E Main pancreatic duct

MR cholangio-pancreatogram (MRCP).

This is a heavily T2-weighted sequence, meaning that only fluid containing structures are visualised. This can help to identify the anatomy that is demonstrated, e.g. the urine within the right renal pelvis and ureter returns a high signal on this sequence.

The gallbladder is a small pear shaped structure, which stores bile – its contents can therefore be seen on MRCP. It measures approximately 10 cm in length, and 3 cm in diameter. The gallbladder fossa is found on the visceral surface of the right lobe of liver, anterior to the porta hepatis. The gallbladder fundus protrudes from under the liver to lie against the deep surface of the anterior abdominal wall. The body of the gallbladder continues posterosuperiorly under the liver, where it begins to narrow to form the gallbladder neck. The neck is connected with the cystic duct, which joins the common hepatic duct to form the common bile duct.

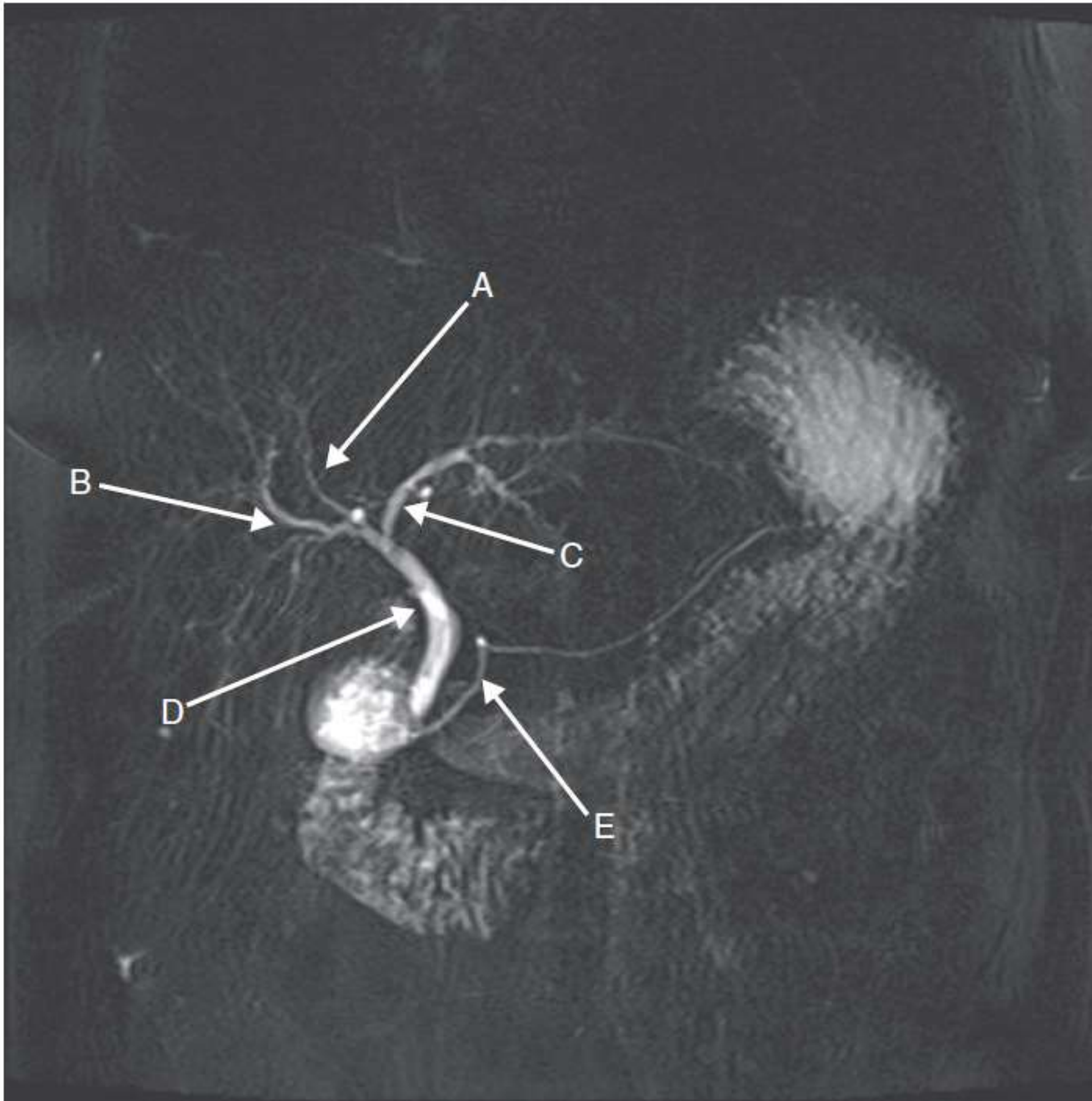
The pancreatic secretions are drained via the pancreatic duct. Small branch ducts converge with it at right angles as it travels along the length of the pancreas from the tail towards the neck. Once it reaches the neck, it takes a downward turn, angled backwards and to the right, it then joins the common bile duct to form the ampulla of Vater before draining into the duodenum via the papilla.

As MRCP studies are heavily T2-weighted and only demonstrate fluid-containing structures, the biliary tree and pancreatic ducts are shown. Other fluid filled structures within the field of view, e.g. the renal collecting system and CSF within the spinal column, may also be seen on MRCP studies.

Butler P, Mitchell AM, Ellis H. Applied Radiological Anatomy. Cambridge: Cambridge University Press, 1919: 252.

Ryan S, McNicholas M, Eustace SJ. Anatomy for Diagnostic Imaging, 3rd edn. Edinburgh: Saunders, 2010: 182–192

Case 6.4



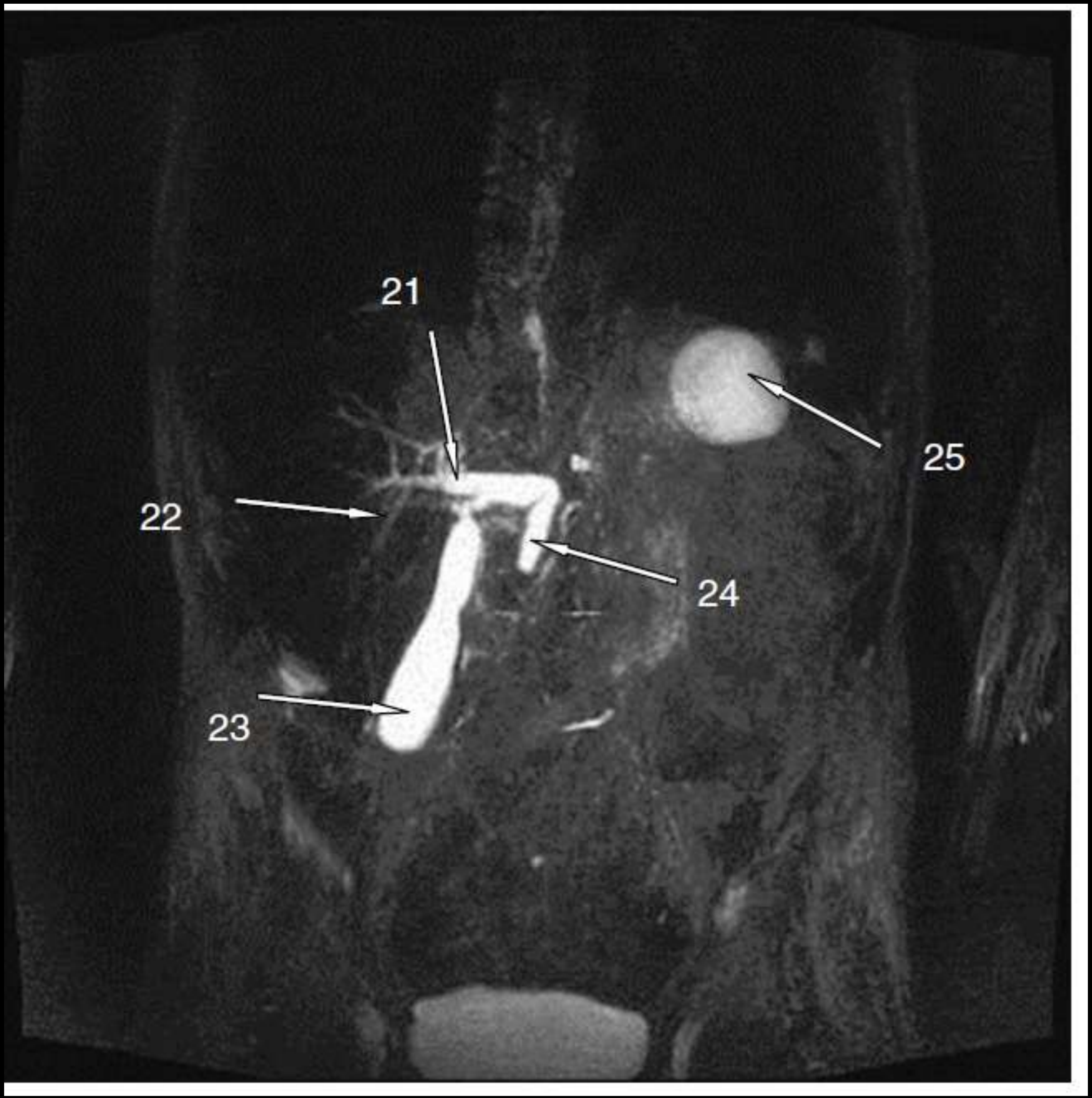
6.4 MRCP (magnetic resonance cholangiopancreatography)

MRCP of a post-cholecystectomy patient. Heavily T2-weighted maximum intensity projection (MIP) image of the biliary tree.

(a) Right anterior hepatic duct.
(b) Right posterior hepatic duct.
(c) Left hepatic duct.
(d) Common bile duct.
(e) Pancreatic duct.

Classical biliary tree anatomy occurs in about 58% of the population. The normal anatomy is the right hepatic duct and left hepatic duct draining the right and left lobes of the liver. The right hepatic duct branches into posterior duct draining segments VI and VII. The right posterior duct runs horizontally and posterior to the anterior duct and fuses to form the right hepatic duct. The anterior duct drains segments V and VIII. The left duct drains II–IV.

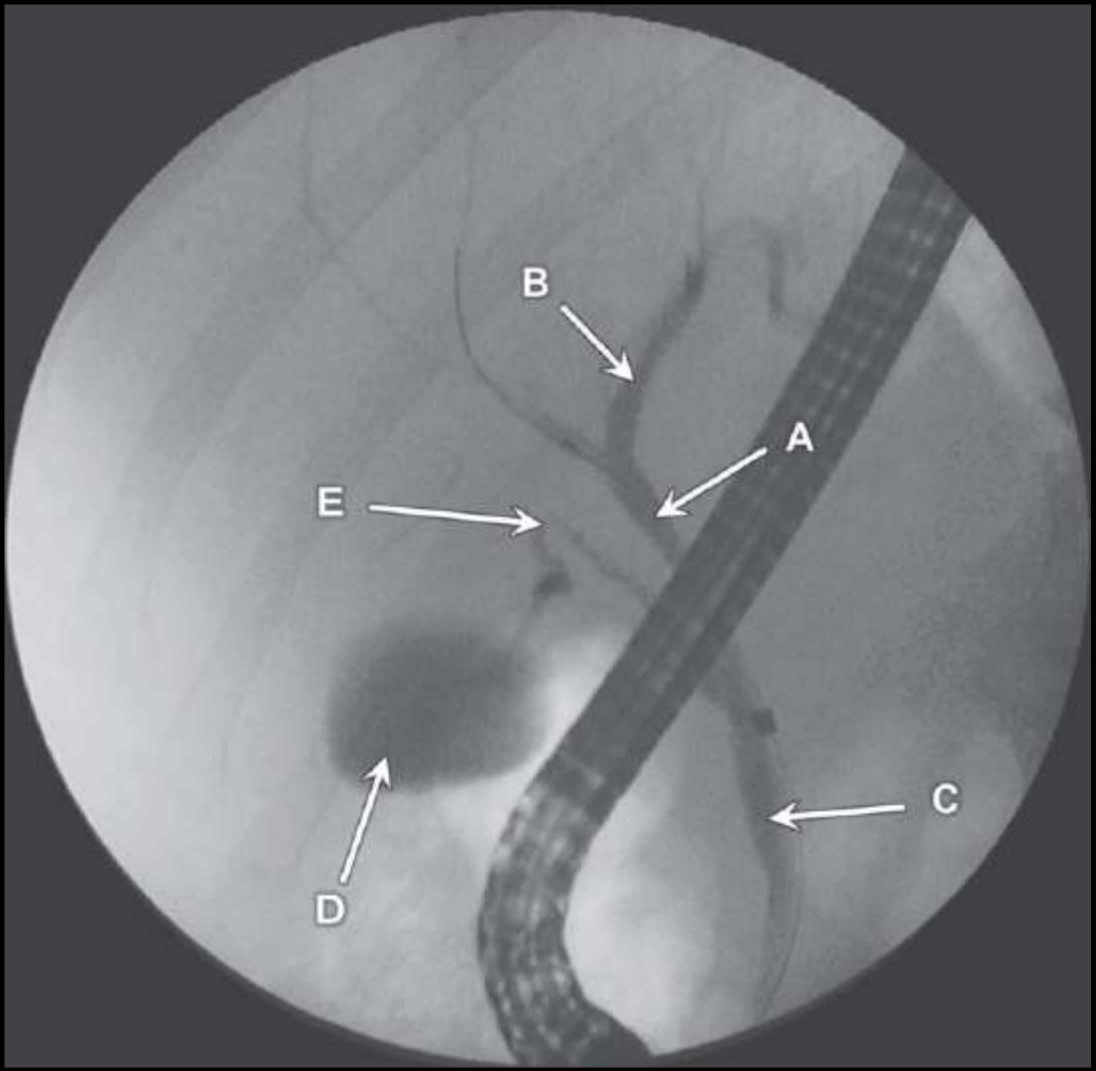
The commonest variant, in 15.6% of the population, is the right posterior duct draining into the left hepatic duct. The right anterior and posterior ducts fuse with the left to form a trifurcation in some people.


21
22
23
24
25

MRCP

21. Common hepatic duct
22. Right hepatic duct
23. Gallbladder (fundus of)
24. Common bile duct
25. Fluid in fundus of stomach

Tips: MRCP uses heavily T2-weighted sequences to utilise the properties of bile. It is a relatively quick investigation, involves no radiation and is noninvasive (compare with ERCP). Look for anatomical variations including accessory hepatic ducts, pancreas divisum and annular pancreas. The pancreatic duct should be clearly seen on MRCP.

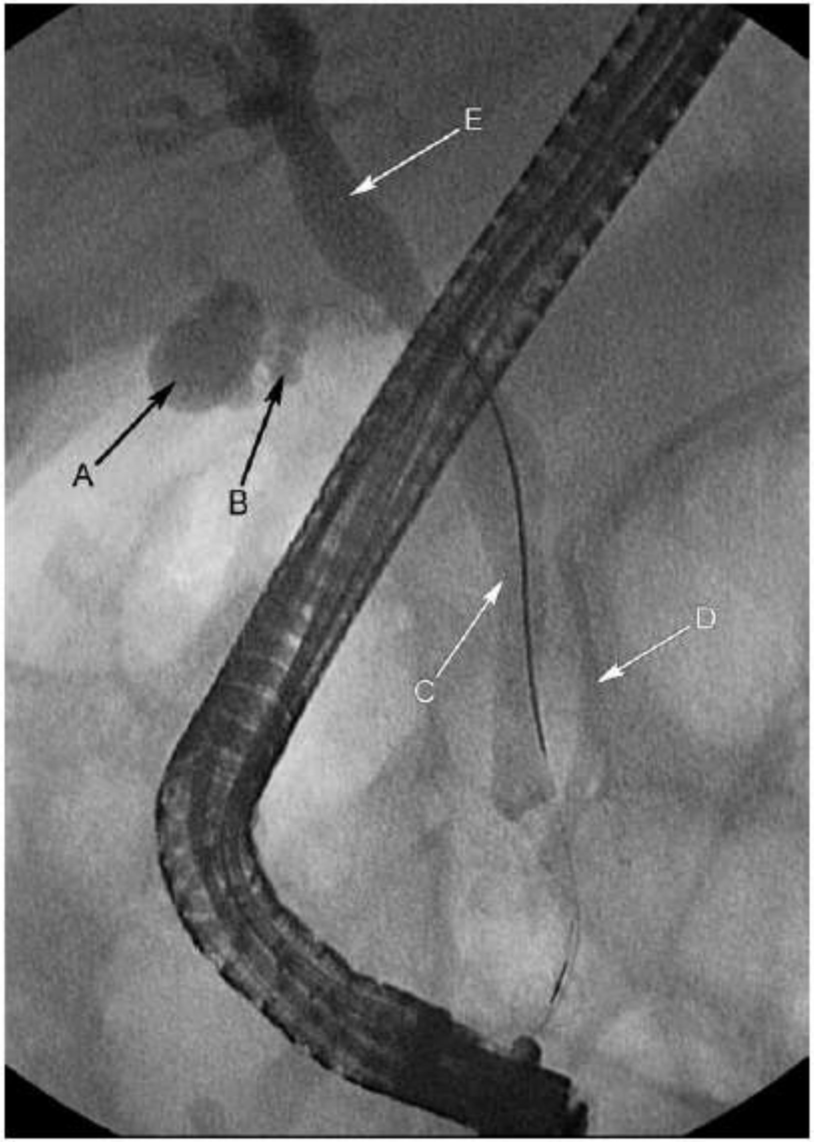

B
A
E
C
D

Case 7

ERCP.

1. Common hepatic duct
2. Left hepatic duct
3. Common bile duct
4. Gallbladder
5. Cystic duct

Question 9.12



Name the structures labelled **A** to **E**.

9.12 ERCP

A Gallbladder.
B Cystic duct.
C Common bile duct.
D Pancreatic duct.
E Common hepatic duct.

The cystic duct is normally 2–4 cm long with a variable diameter from 1 to 5 mm. Its insertion into the extrahepatic bile duct marks the change from the common hepatic duct to the common bile duct. This point is usually halfway between the porta-hepatis and the ampulla of Vater.

The normal pancreatic diameter is up to 3 mm at the head of the pancreas, and around 2 mm distally.

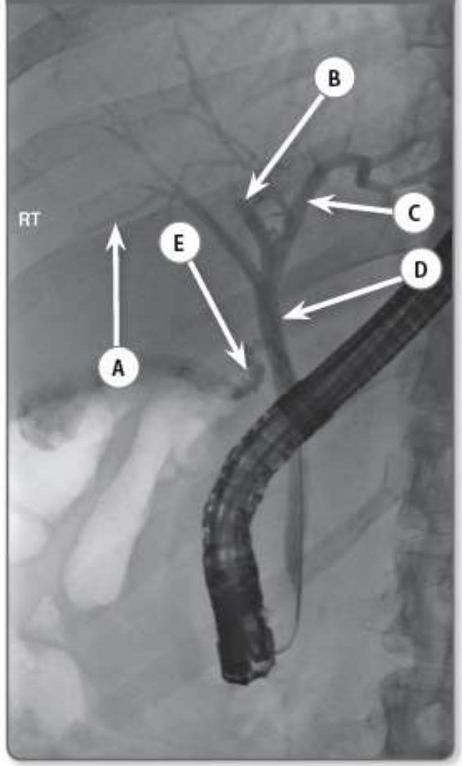

3
1
4
2
5

ERCP

1. Right hepatic duct
2. Spinous process L2 vertebra
3. Left hepatic duct
4. Common bile duct
5. Second part of duodenum (D2)

The ampulla of Vater is located in the posteromedial wall of the second part of the duodenum, which is selectively cannulated during ERCP.

Case 2.7



Case 2.7

QUESTION		WRITE YOUR ANSWER HERE
A	Name the structure labelled A.	
B	Name the structure labelled B.	
C	Name the structure labelled C.	
D	Name the structure labelled D.	
E	Name the structure labelled E.	

Case 2.7

A Right intrahepatic duct

B Right posterior sectoral duct

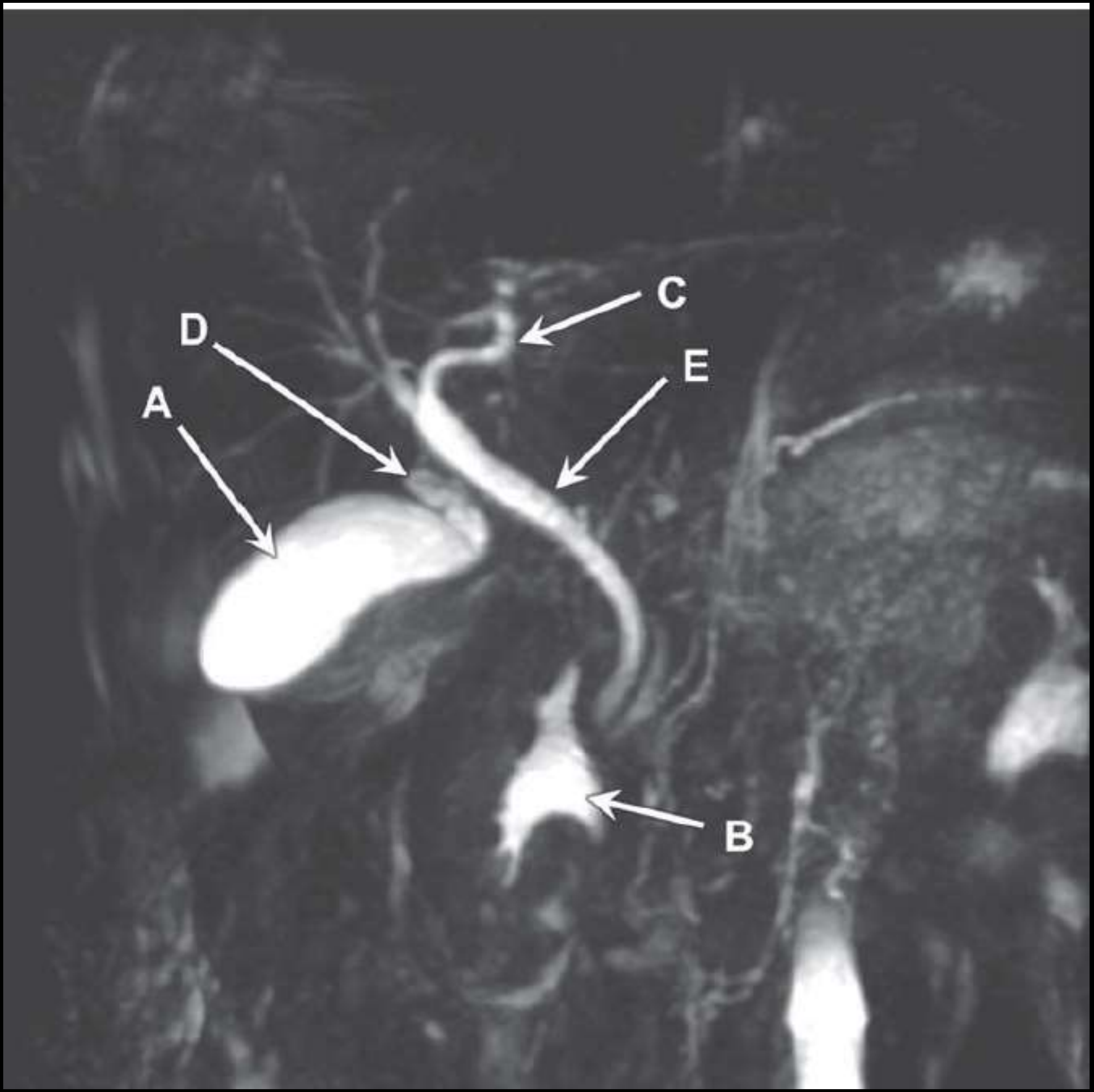
C Left hepatic duct

D Common hepatic duct

E Cystic duct

Answers

This is a single image from an ERCP examination (fluoroscopic imaging of the biliary tract from percutaneous transhepatic cholangiography [PTC] could be shown in the FRCR examination and would look identical, aside from the endoscope). Biliary anatomy is highly variable, with the normal configuration – right anterior and posterior sectoral ducts joining to form right hepatic duct, left hepatic duct joining right hepatic duct to form common hepatic duct, with common bile duct arising when the cystic duct joins the common hepatic duct – present in less than 60% of the population. There is also faint opacification of the gallbladder and filling defects within it, in keeping with gallstones.



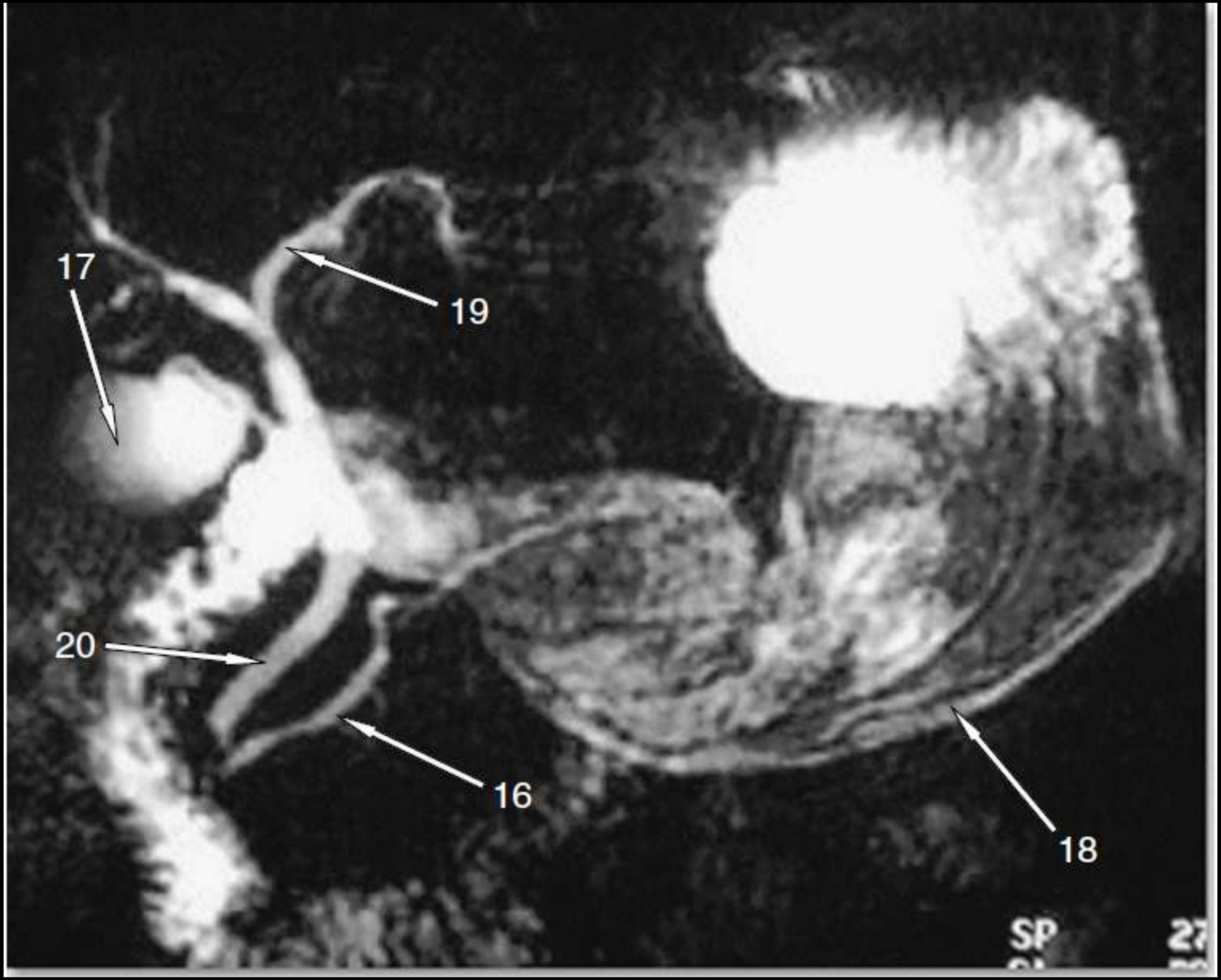
C
D
E
A
B

Case 2

MRCP

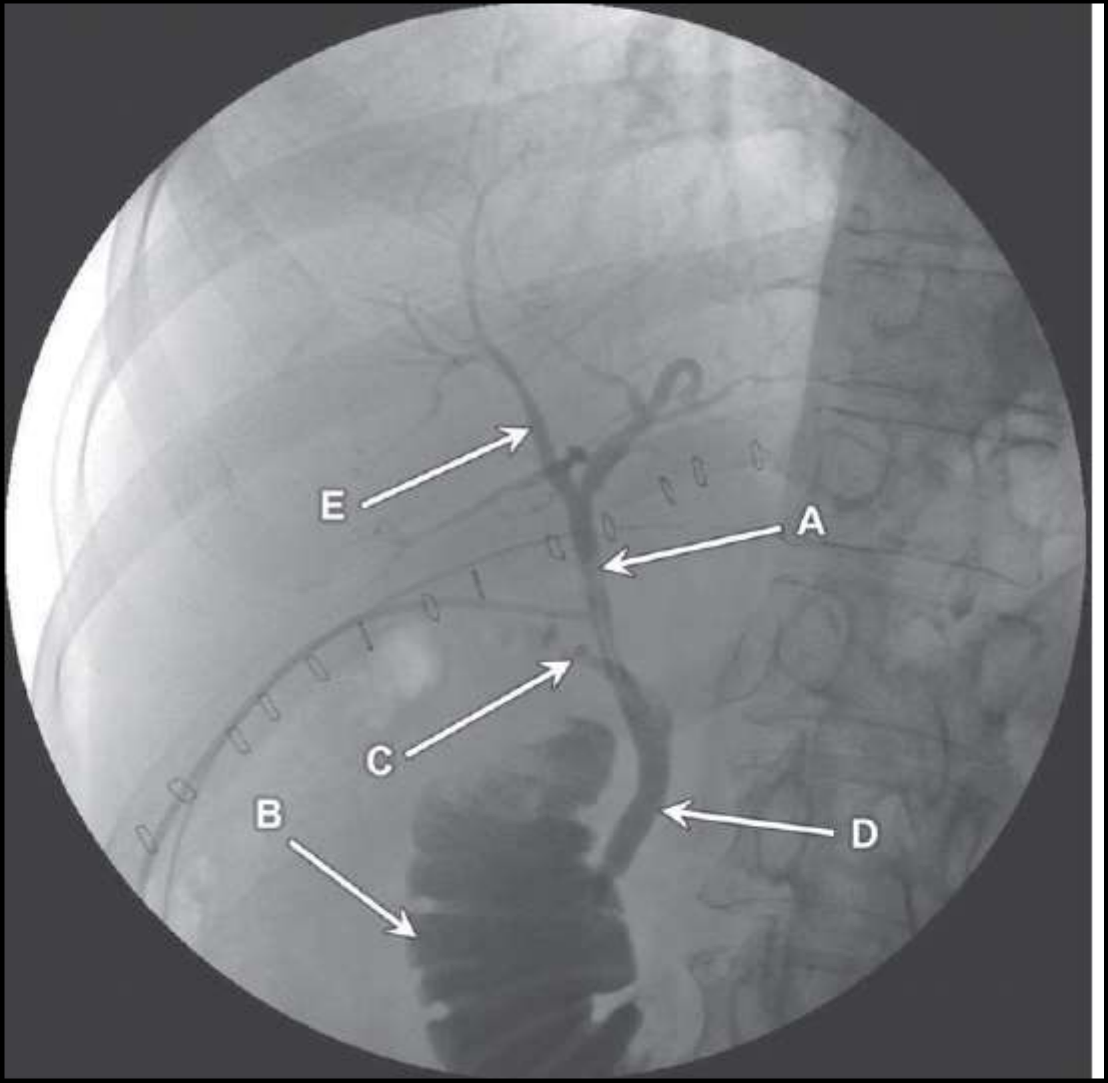
1. Gallbladder
2. Right renal pelvis
3. Left hepatic duct
4. Cystic duct
5. Common bile duct

It is important to remember that structures other than the organs in question are often revealed in these focused examinations. On this image, both renal collecting systems are visible. The other white structure at the bottom right-hand side of the image is the spinal canal.


17
19
20
16
18
SP

MRCP

16. Main pancreatic duct (of Wirsung)
17. Gallbladder
18. Greater curvature of stomach
19. Left hepatic duct
20. Common bile duct


E
A
C
B
D

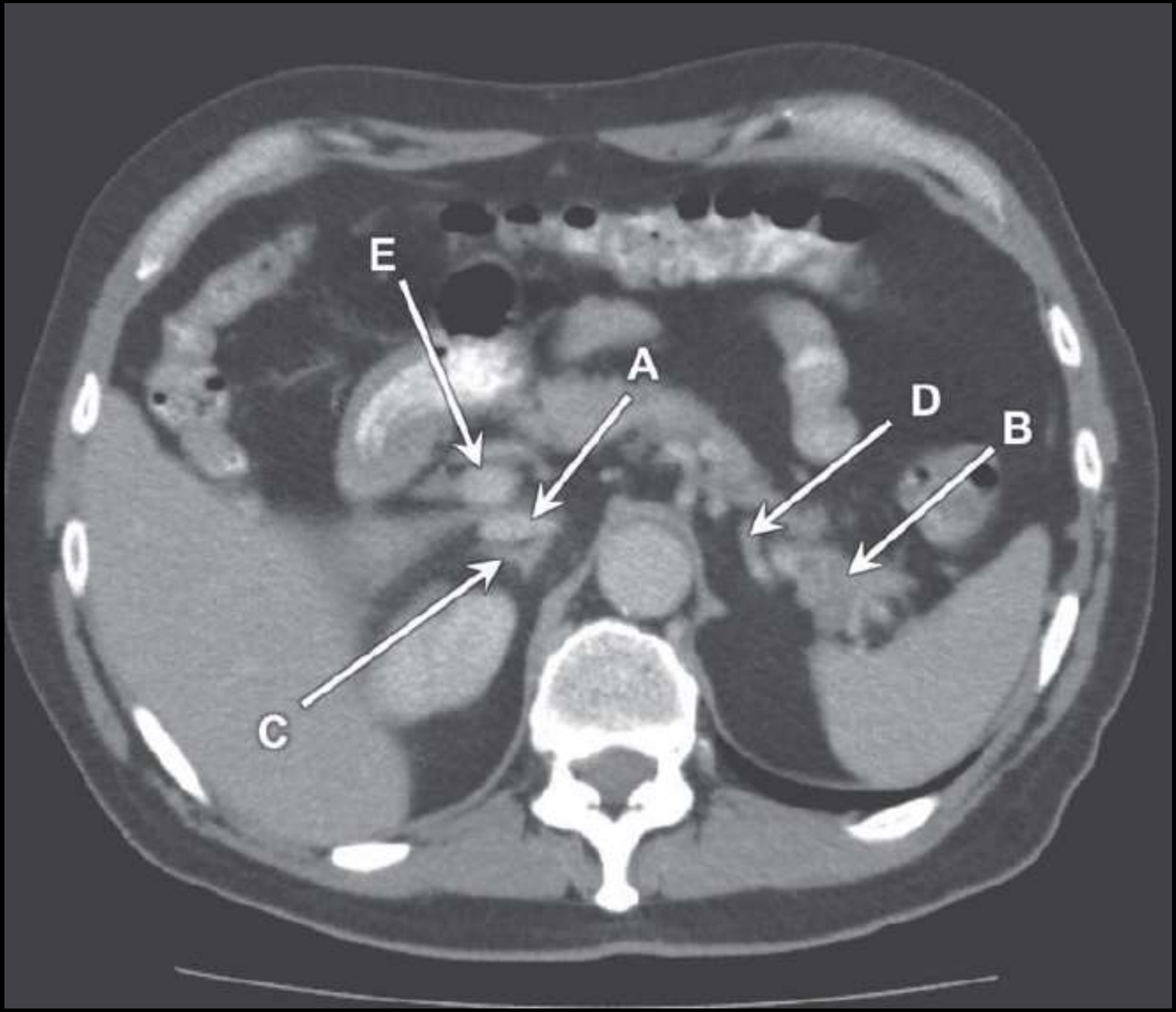
Case 14

T-tube cholangiogram (post cholecystectomy).

1. Common hepatic duct
2. Duodenum
3. Cystic duct remnant
4. Common bile duct
5. Right hepatic duct

The line extending from the common hepatic duct to the left of the image is the tube leading to the external drain. Surgical staples can be seen projected over the image giving further clue that this is a postoperative study.

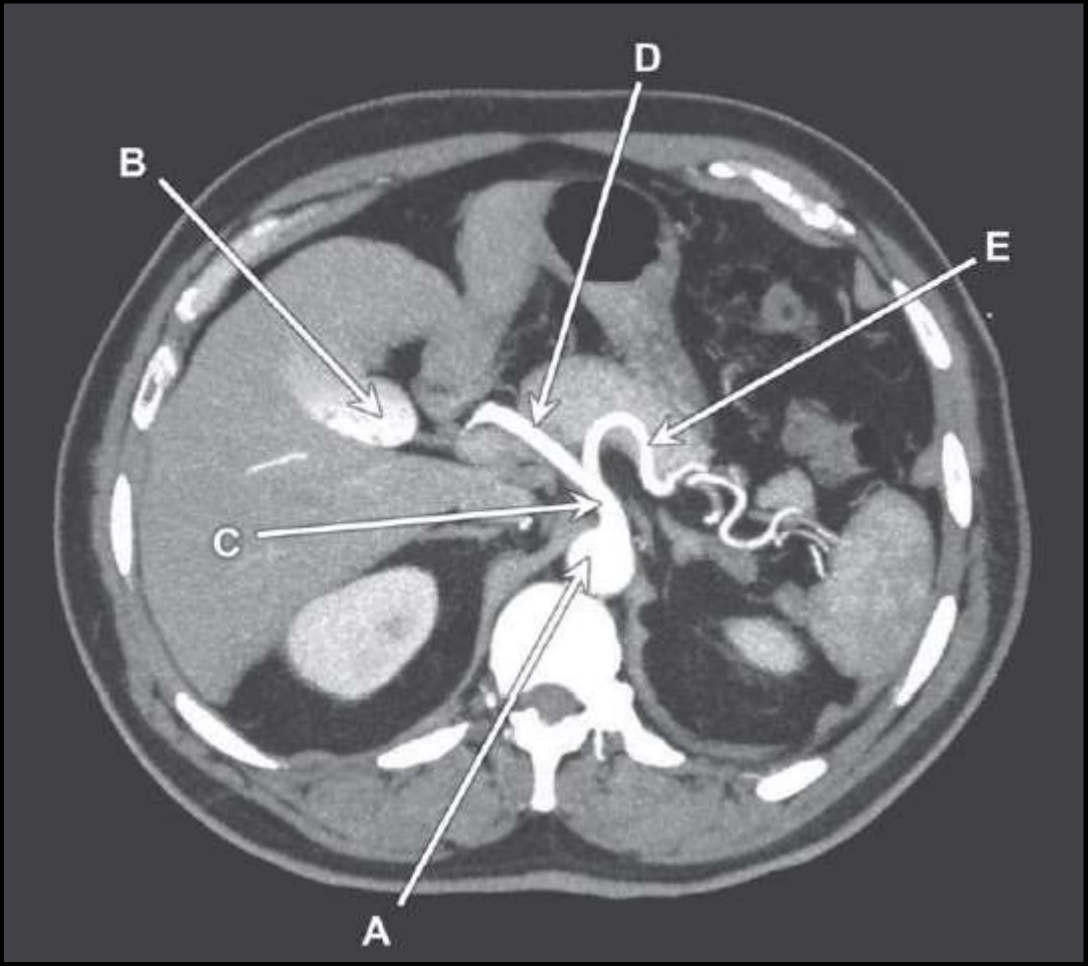
CROSS-SECTIONAL


E
A
D
B
C

Case 13

CT abdomen. Axial section

1. Inferior vena cava
2. Tail of the pancreas
3. Right adrenal gland
4. Splenic artery
5. Portal vein

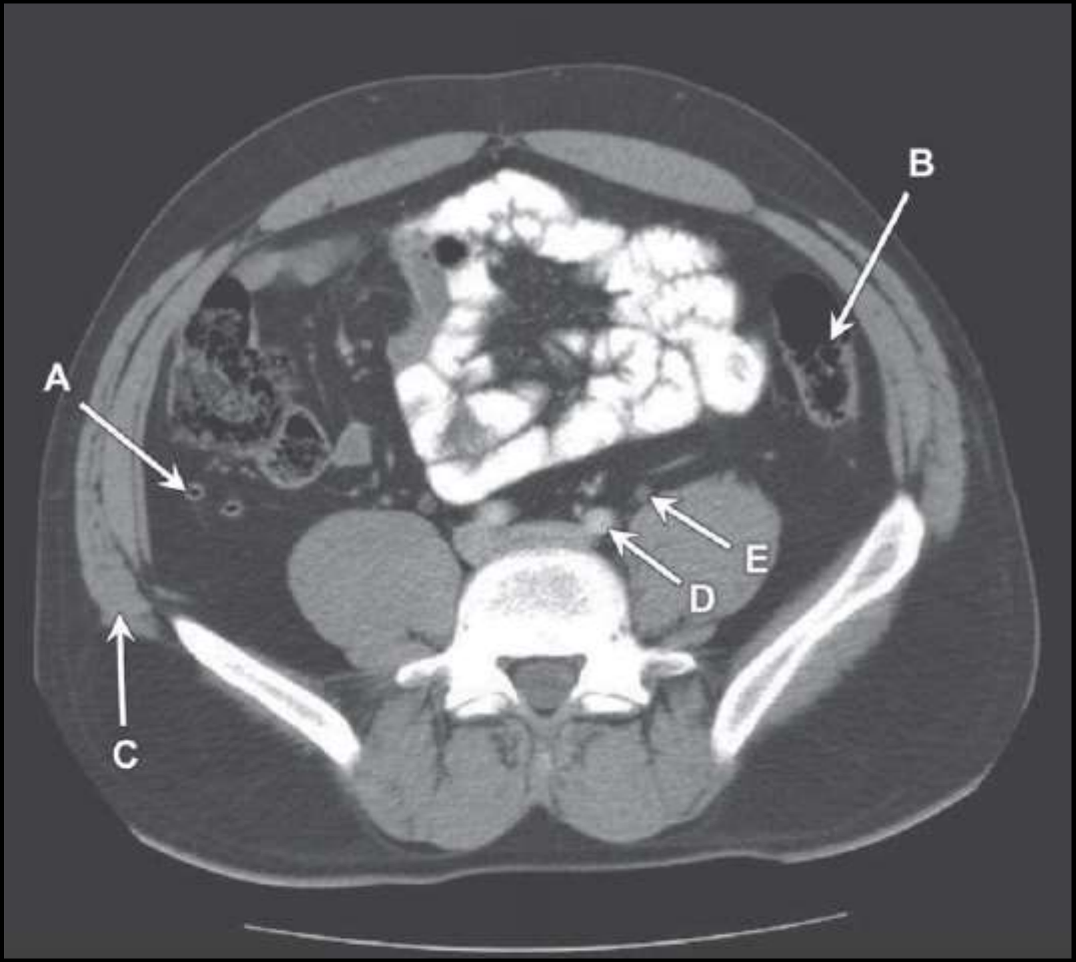

D
B
E
C
A

Case 2

CT aortogram, abdomen. Axial section.

1. Abdominal aorta
2. Gallbladder
3. Coeliac trunk
4. Common hepatic artery
5. Splenic artery

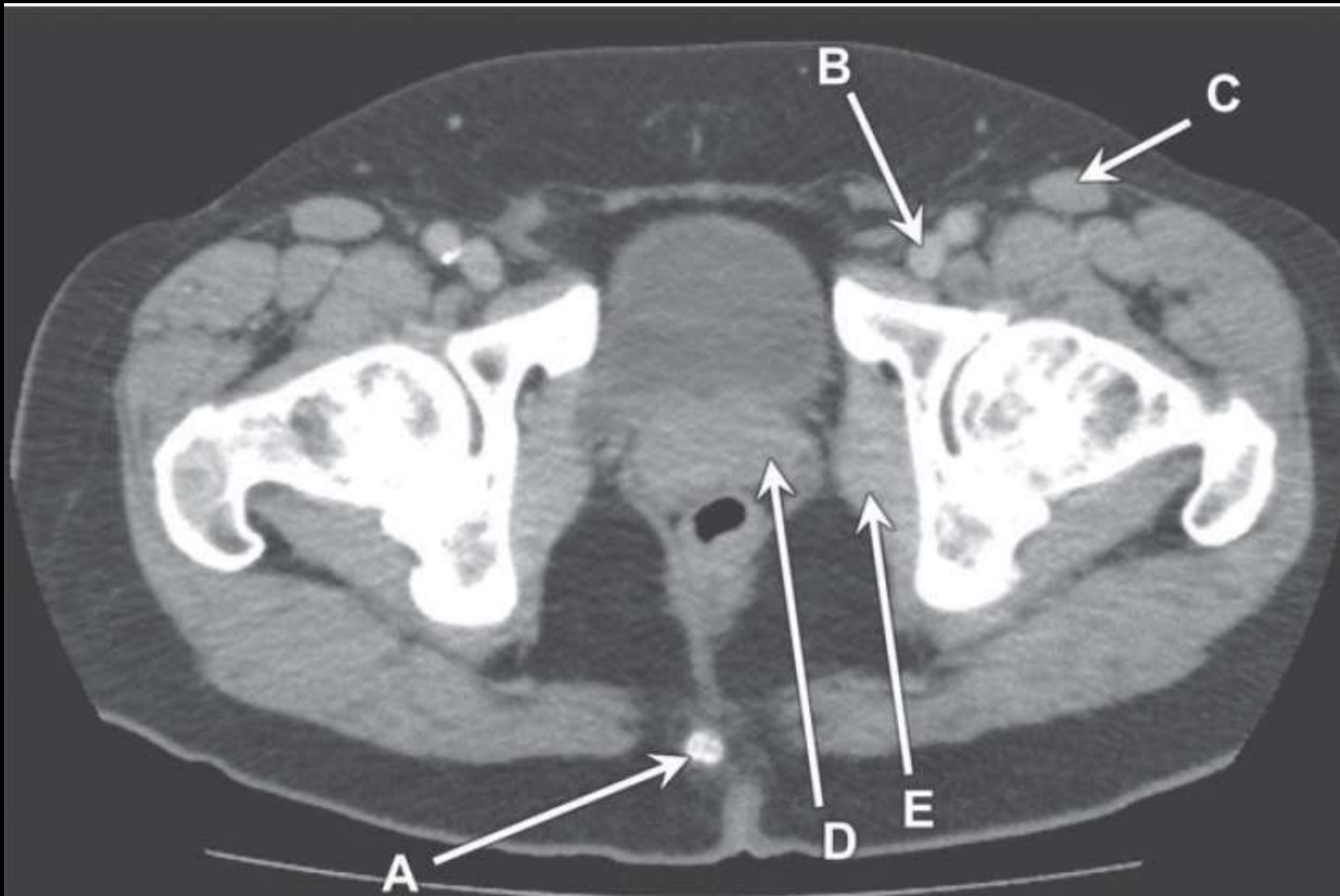
There are several normal variants of the arterial anatomy of the coeliac axis and superior mesenteric artery. Candidates are advised to familiarize themselves with these.


A
B
C
D
E

Case 2

CT abdomen with iv and oral contrast. Axial section.

1. Appendix
2. Descending colon
3. Right external oblique
4. Left common iliac artery
5. Left ureter

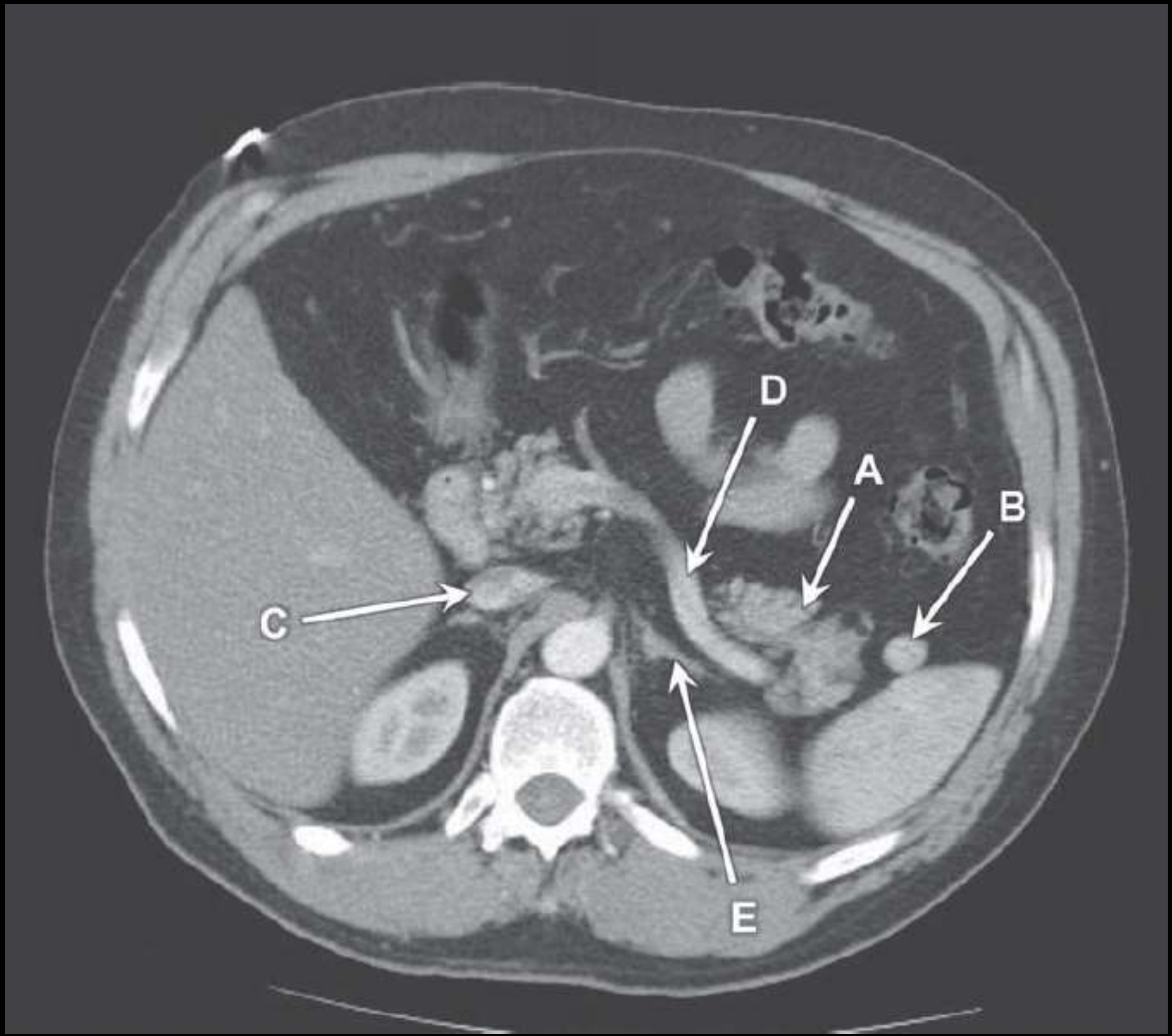


B
C
D
E
A

Case 19

CT pelvis. Axial section.

1. Coccyx
2. Left common femoral vein
3. Left sartorius muscle
4. Prostate
5. Left obturator internus muscle



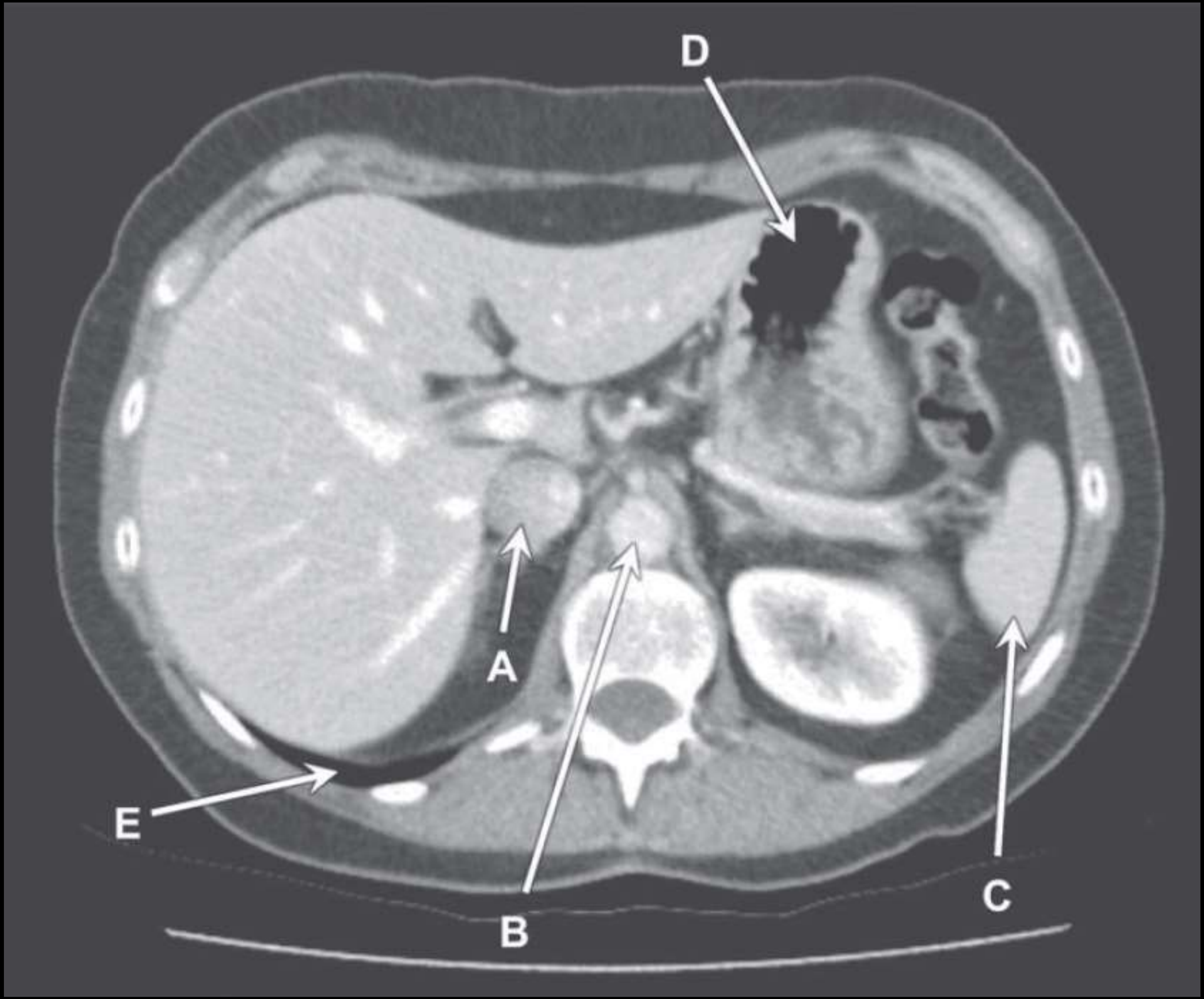
D
A
B
C
E

Case 9

CT abdomen. Axial section.

1. Tail of pancreas
2. Splenunculus
3. Inferior vena cava
4. Splenic vein
5. Left adrenal gland

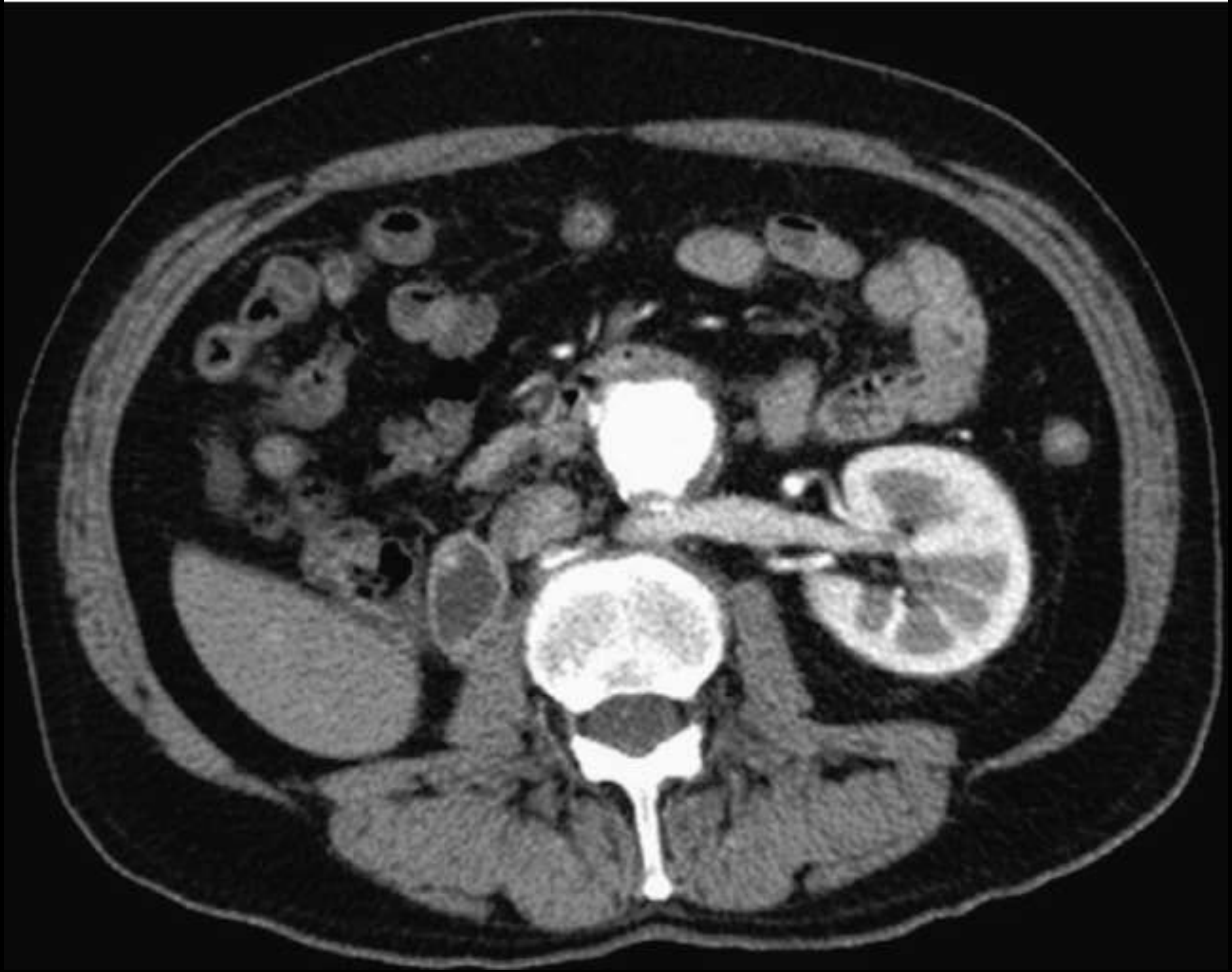
Splenunculi are small nodules of spleen, detached from the rest of the organ. They are seen in between 15 and 30% of people and are of no clinical significance.


D
A
E
B
C

Case 1

CT abdomen. Axial section.

1. Inferior vena cava
2. Abdominal aorta
3. Spleen
4. Stomach
5. Right lung base (lower lobe)



Name the normal variant

CT Abdomen

Retroaortic left renal vein

Retroaortic left renal vein occurs as part of the complex development of the inferior vena cava. The exact incidence is unknown (estimated 3 %), but it is increasingly being reported with high resolution images on CT and MRI.

Patients are usually asymptomatic, but compression of the left renal vein may cause haematuria, flank pain and varicoceles. It is important to report a retroaortic left renal vein if a patient is going to have a nephrectomy, either for malignancy or as a living kidney donor.

Name the normal variant

CT Abdomen

Duplex left kidney

Duplex kidney is seen in 4 % population. It is in the most common normal variant in the urinary tract. On ultrasound, a band of tissue is seen to separate the two moieties, and if there is distension of the kidney, two ureters may be visualised.

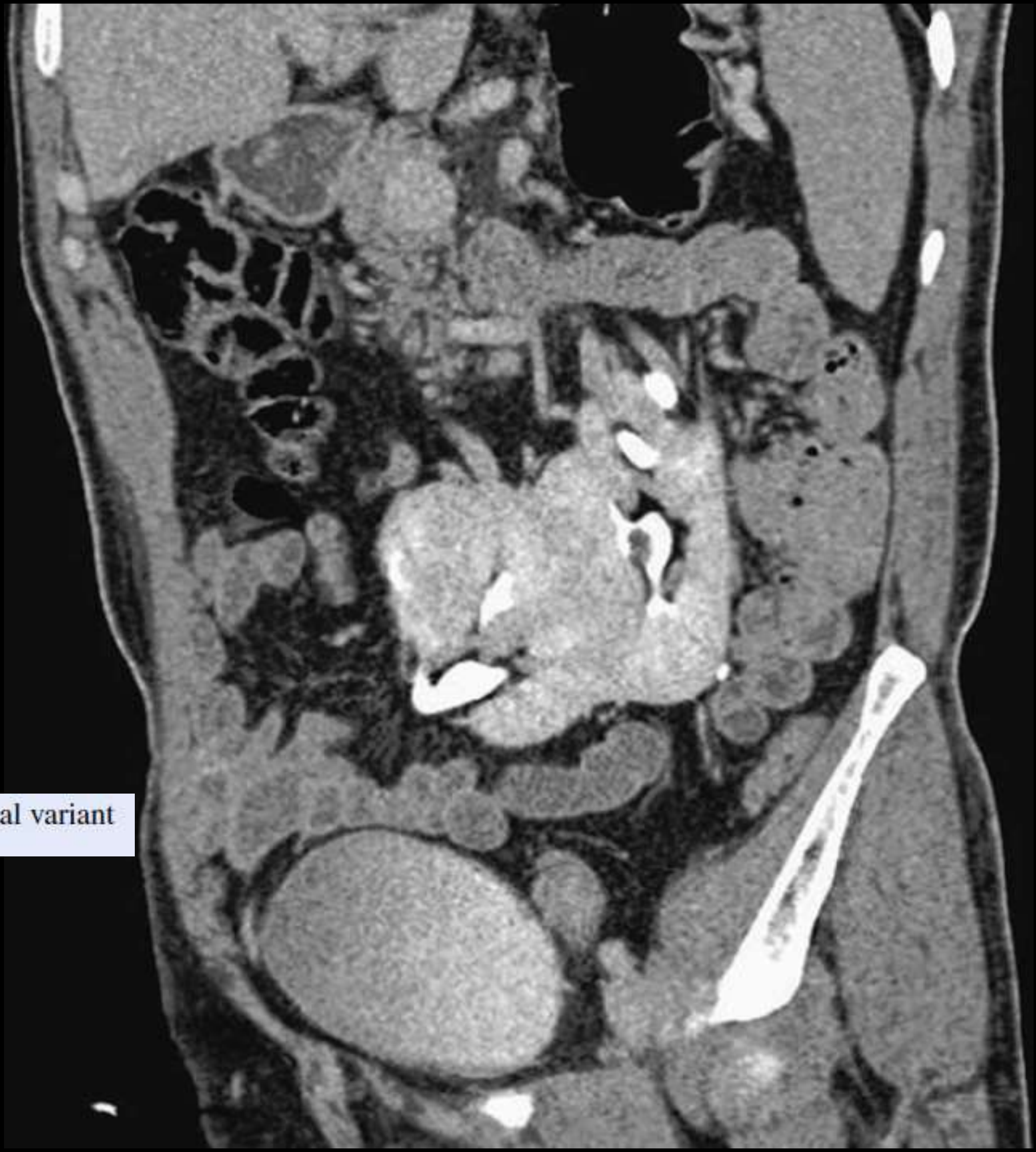
Name the normal variant

CT Abdomen

Horseshoe kidney

Kidneys may fuse during development leading to a horseshoe kidney. This is seen in 1 in 700 births and is the most common fusion anomaly. The kidney is fused across the midline. The isthmus, joining the kidneys, may be composed of functioning renal tissue or just fibrous tissue. A horseshoe kidney is more prone to injury than usual as it lies across the vertebral column.

The axis of the kidneys is abnormal, with the lower pole more medial than the upper pole. The isthmus lies anterior to the aorta and IVC but behind the IMA.

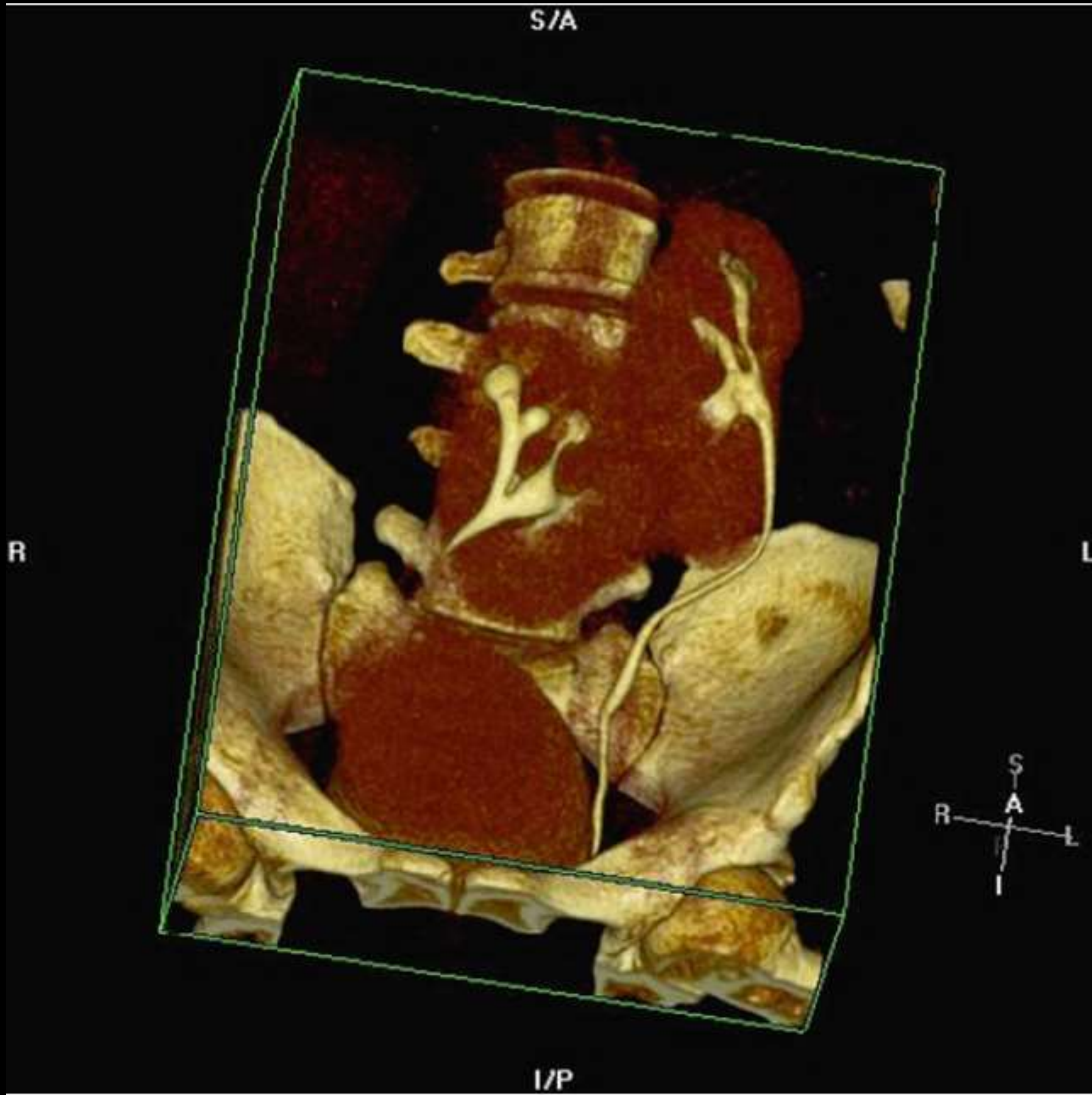


Name the normal variant

CT Abdomen

Crossed fused renal ectopia

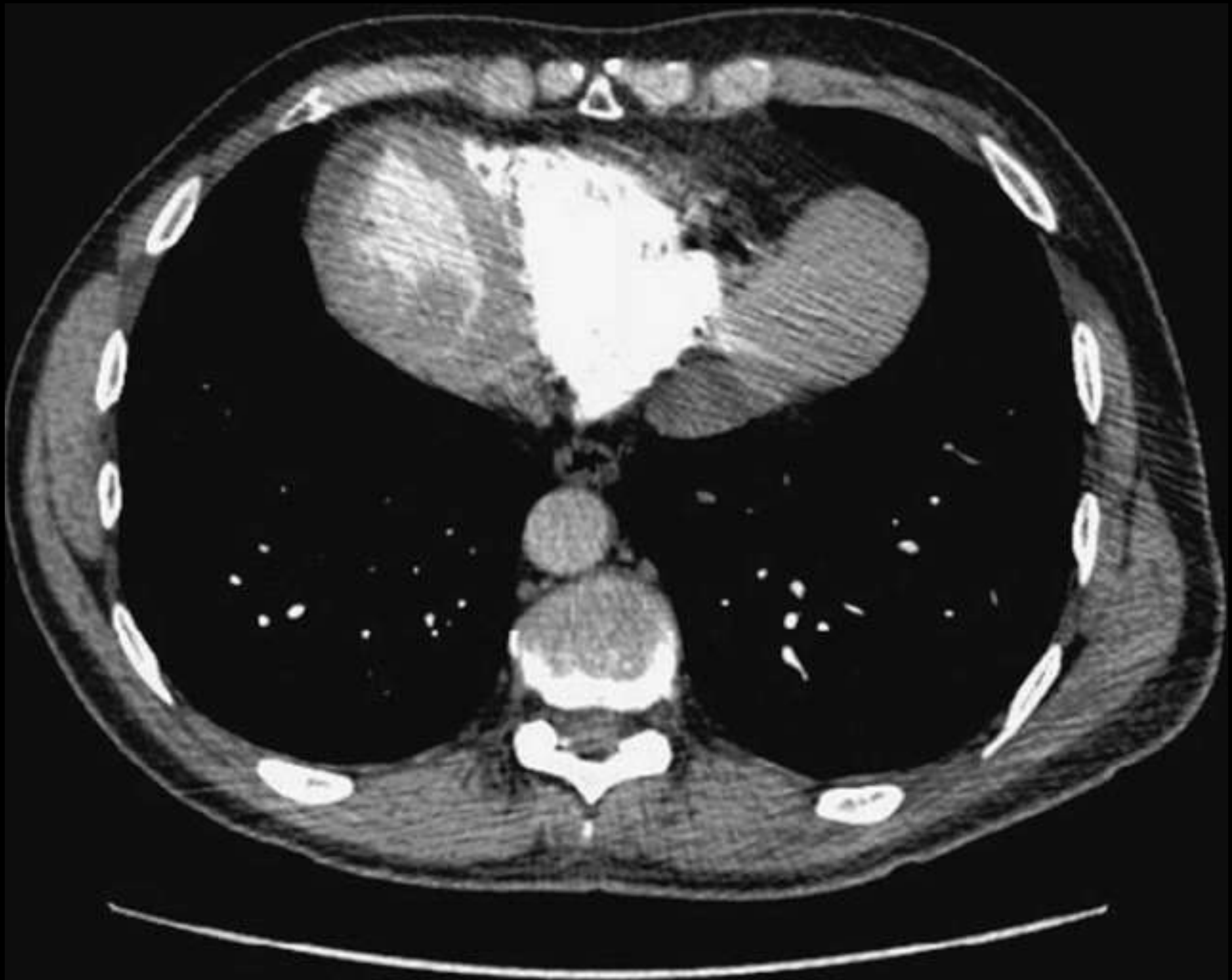
The lower kidney is usually the one that is ectopic. Abnormal rotation is present, and renal pelvises may face opposite directions. This is seen in 1/1,000 births, and the incidence of associated anomalies is low. There is a slightly increased incidence of renal calculi.



Name the normal variant

CT Abdomen

Crossed fused renal ectopia
The lower kidney is usually the one that is ectopic. Abnormal rotation is present, and renal pelvises may face opposite directions. This is seen in 1/1,000 births, and the incidence of associated anomalies is low. There is a slightly increased incidence of renal calculi.



Name the normal variant

CT Abdomen

Crossed fused renal ectopia

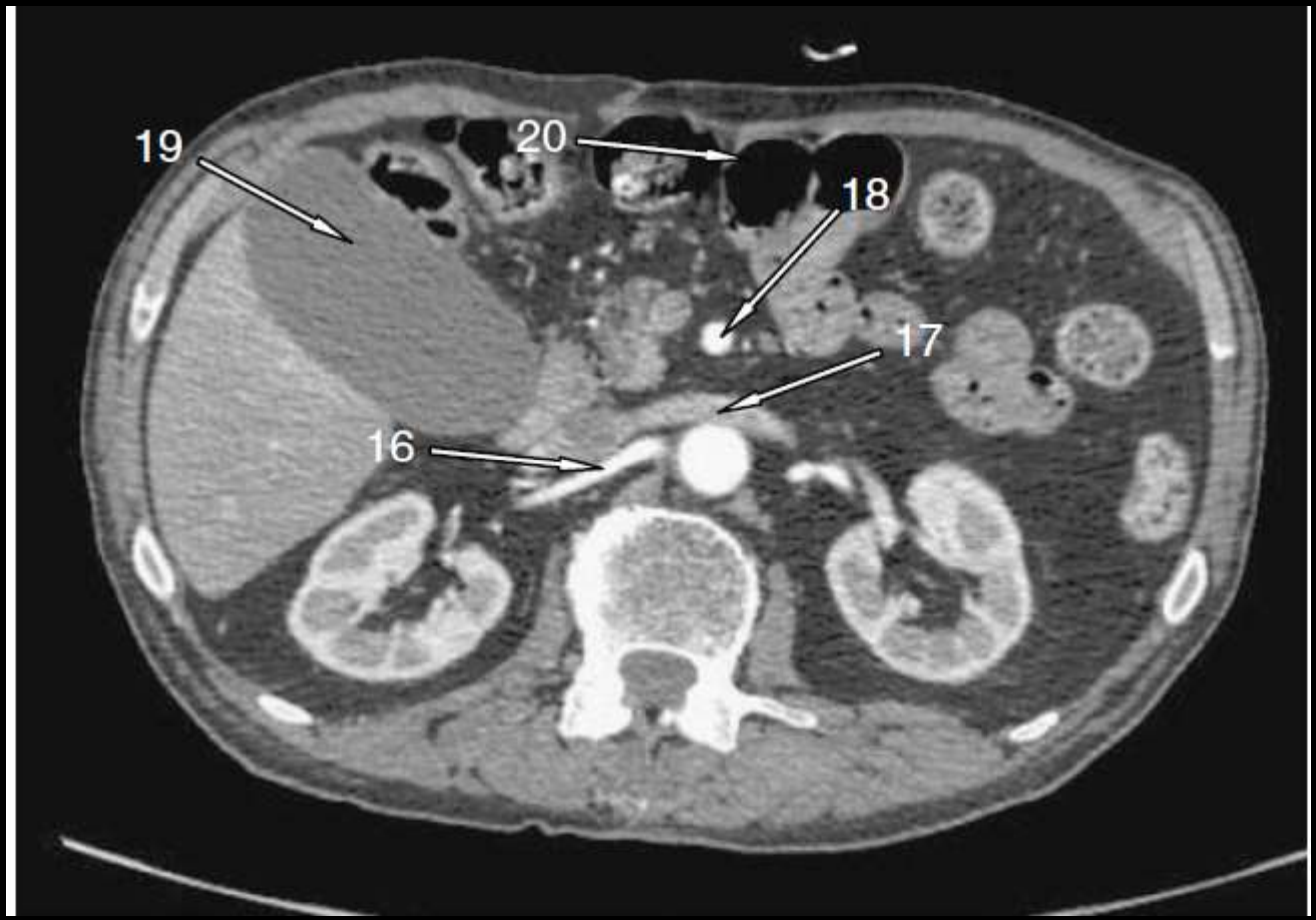
The lower kidney is usually the one that is ectopic. Abnormal rotation is present, and renal pelvises may face opposite directions. This is seen in 1/1,000 births, and the incidence of associated anomalies is low. There is a slightly increased incidence of renal calculi.

Name the normal variant

CT Abdomen

Left-sided inferior vena cava

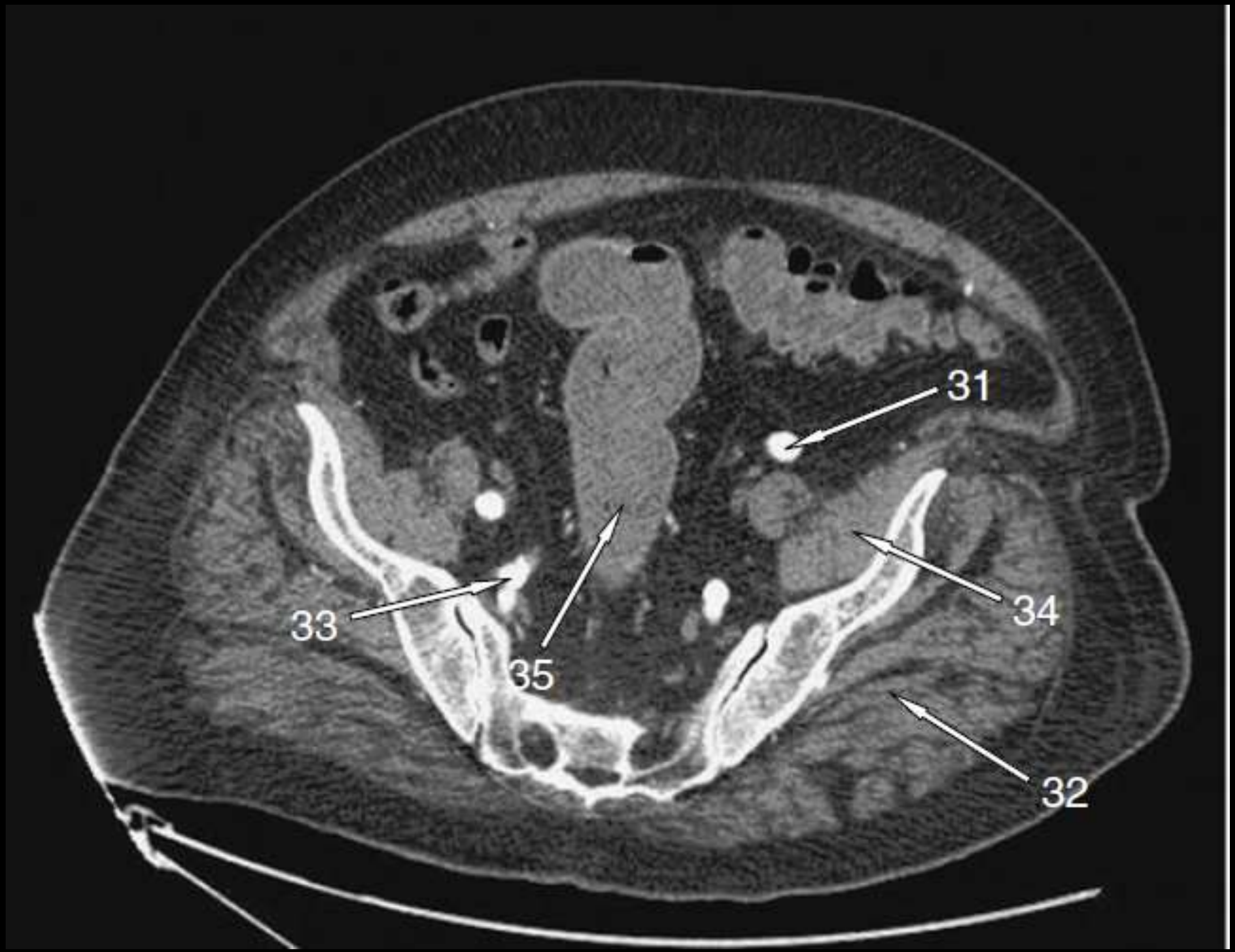
Seen in 0.2–0.5 % people due to persistence of the left and regression of the right supracardinal vein. The left IVC usually joins the left renal vein.


19
20
18
17
16

CT Abdomen

16. Right renal artery
17. Left renal vein
18. Superior mesenteric artery
19. Gallbladder
20. Transverse colon

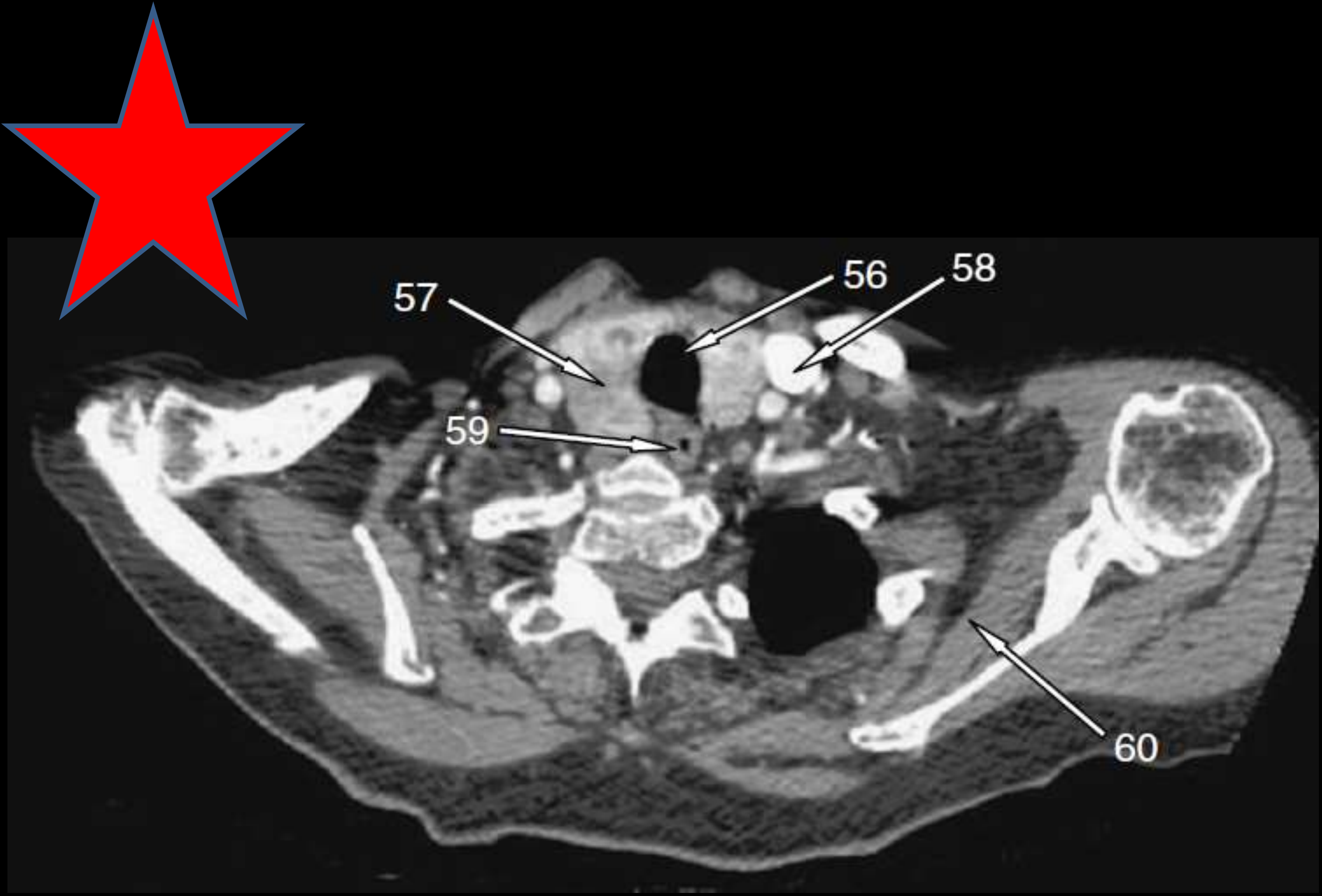
This is an arterial phase CT at L1/L2; the superior mesenteric vein lies to the left of its corresponding artery. The renal medullary pyramids are seen in their full length at the level of the hilum. The gastroduodenal artery is visible just lateral to the pancreas in this image.


31
34
33
35
32

CT Pelvis

31. Left external iliac artery
32. Left gluteus maximus muscle
33. Right internal iliac artery
34. Left iliacus muscle
35. Rectum

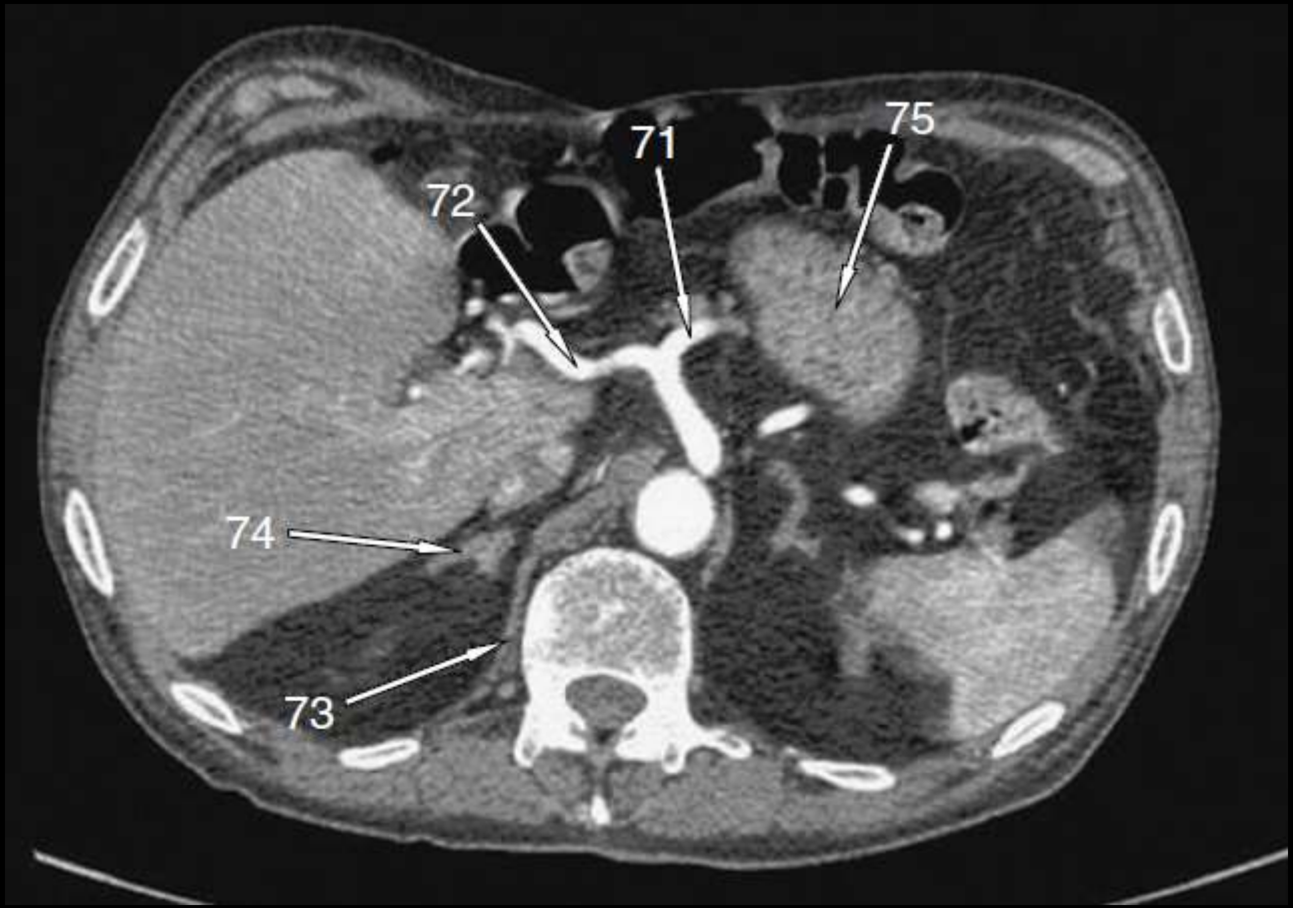
This is a CT angiogram axial view showing the division of the right internal iliac artery into its anterior and posterior trunk. The internal iliac artery arises in front of the sacroiliac joint at the level of L5/S1. Remember that the aorta normally bifurcates at the level of L4.


57
56
58
59
60

MRI Head

61. Third ventricle
62. Right Sylvian fissure
63. Basilar artery
64. Right lateral ventricle (body of)
65. Body of corpus callosum

The Sylvian fissure divides the frontal and parietal lobe above from the temporal lobe below. It appears around the 14th week of gestation and is one the most prominent fissures of the brain. The M1 segment of the middle cerebral artery lies within this fissure.



75
71
72
74
73

CT Abdomen

71. Splenic artery
72. Common hepatic artery
73. Right crus of diaphragm
74. Right adrenal gland
75. Stomach

The coeliac artery arises ventrally from the abdominal aorta at T12. This image depicts the 'seagull sign' with the ceoliac trunk dividing into the splenic and hepatic arteries. The left gastric artery isn't demonstrated in this plane.

Also note that the suprarenal glands have a linear 'V' (right) or a triangular or 'Y' shape (left).

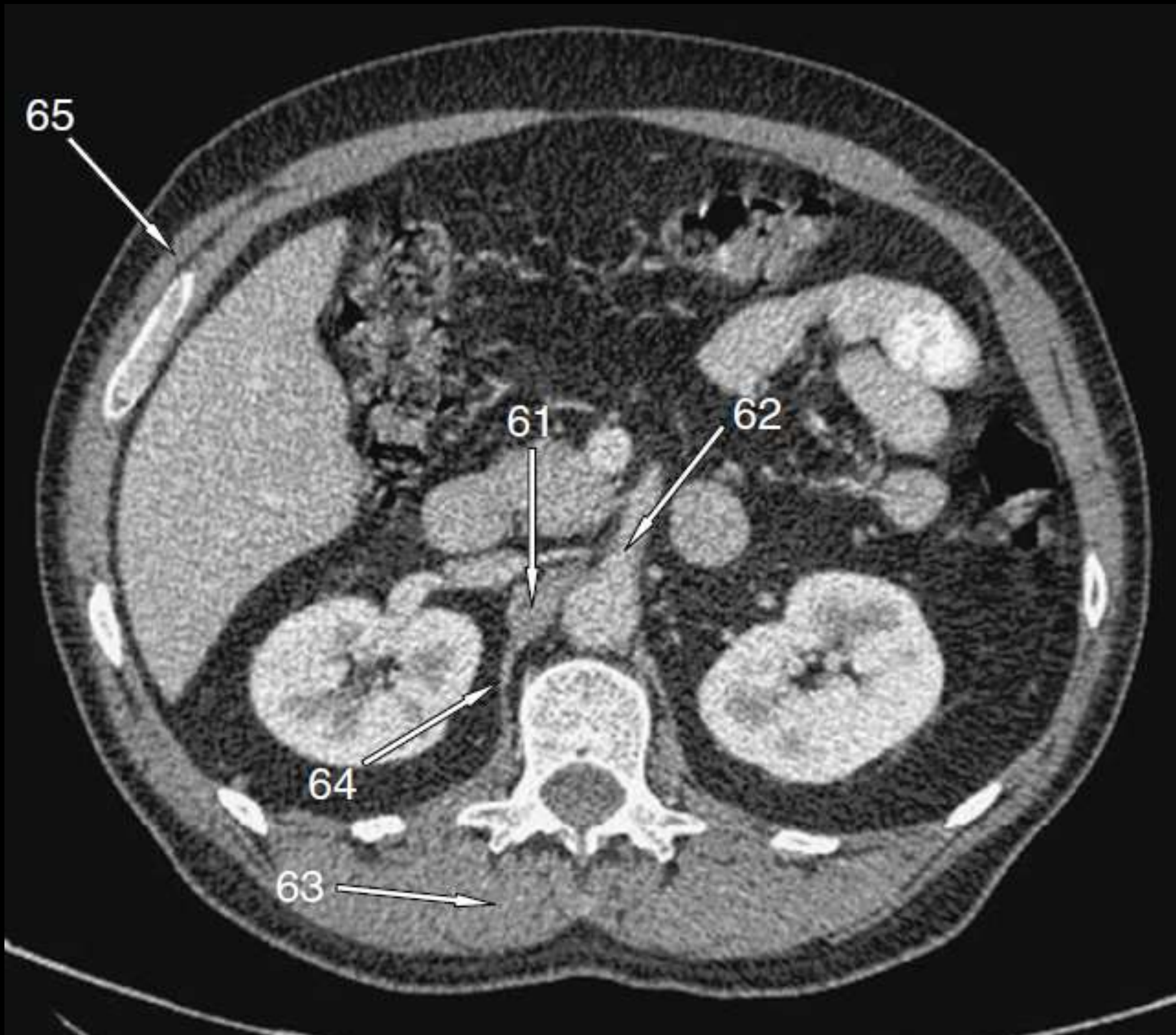
The right adrenal gland lies posterior to the IVC, medial to the right lobe of the liver and lateral to the right diaphragmatic crus.


52
51
54
55
53

CT Pelvis

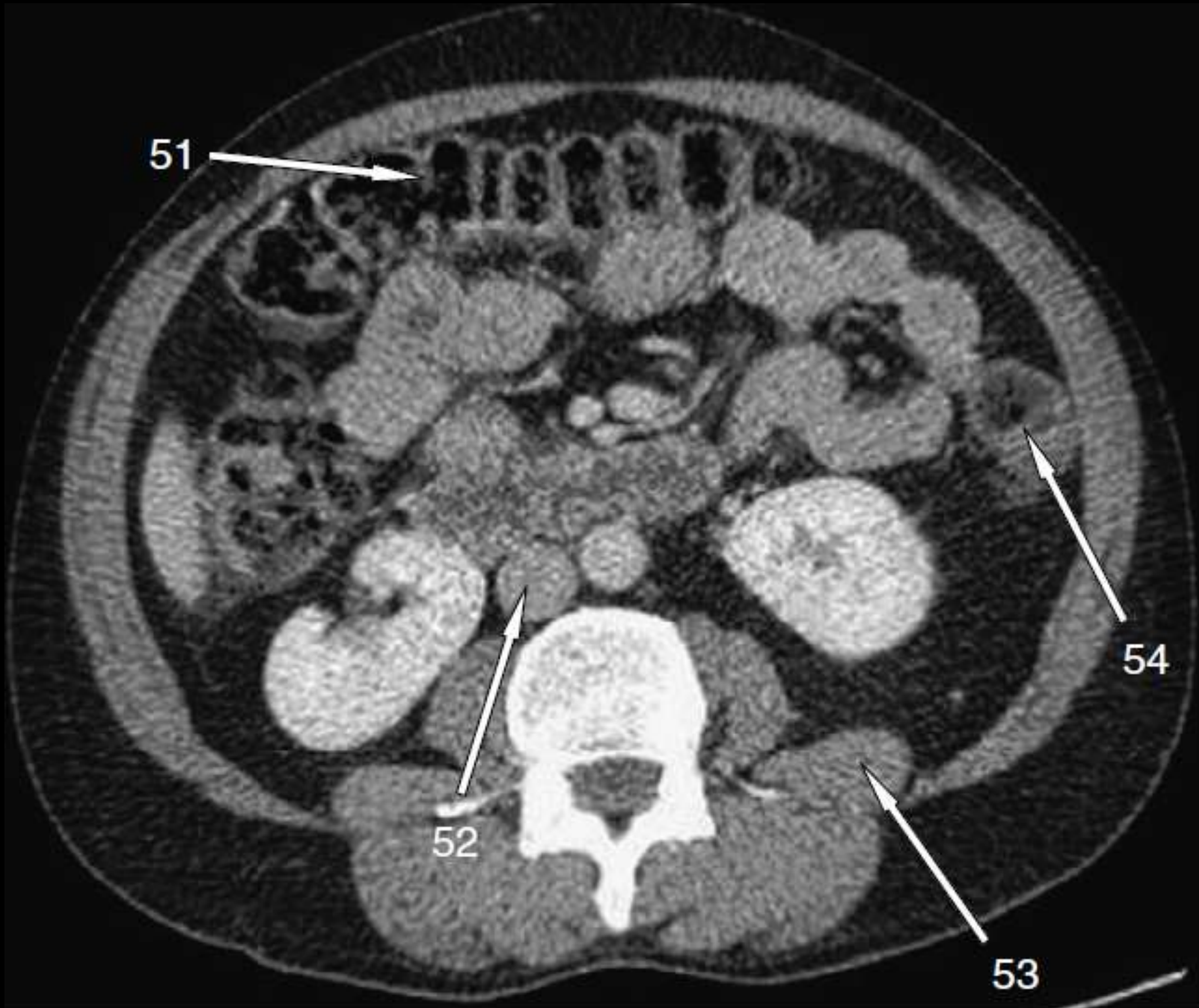
51. Left superficial femoral artery
52. Right pectineus muscle
53. Rectum
54. Right profunda femoris artery
55. Right gluteus maximus

This axial CT is at the level of the bifurcation of the CFA. Profunda (deep) femoral artery gives off the medial and lateral circumflex arteries and perforating branches to the deep muscles of the thigh.


65
61
62
64
63

CT Abdomen

61. Inferior vena cava
62. Superior mesenteric artery
63. Right erector spinae muscle
64. Right crus of diaphragm
65. Right external oblique muscle



What anatomical variant is present?

CT Abdomen

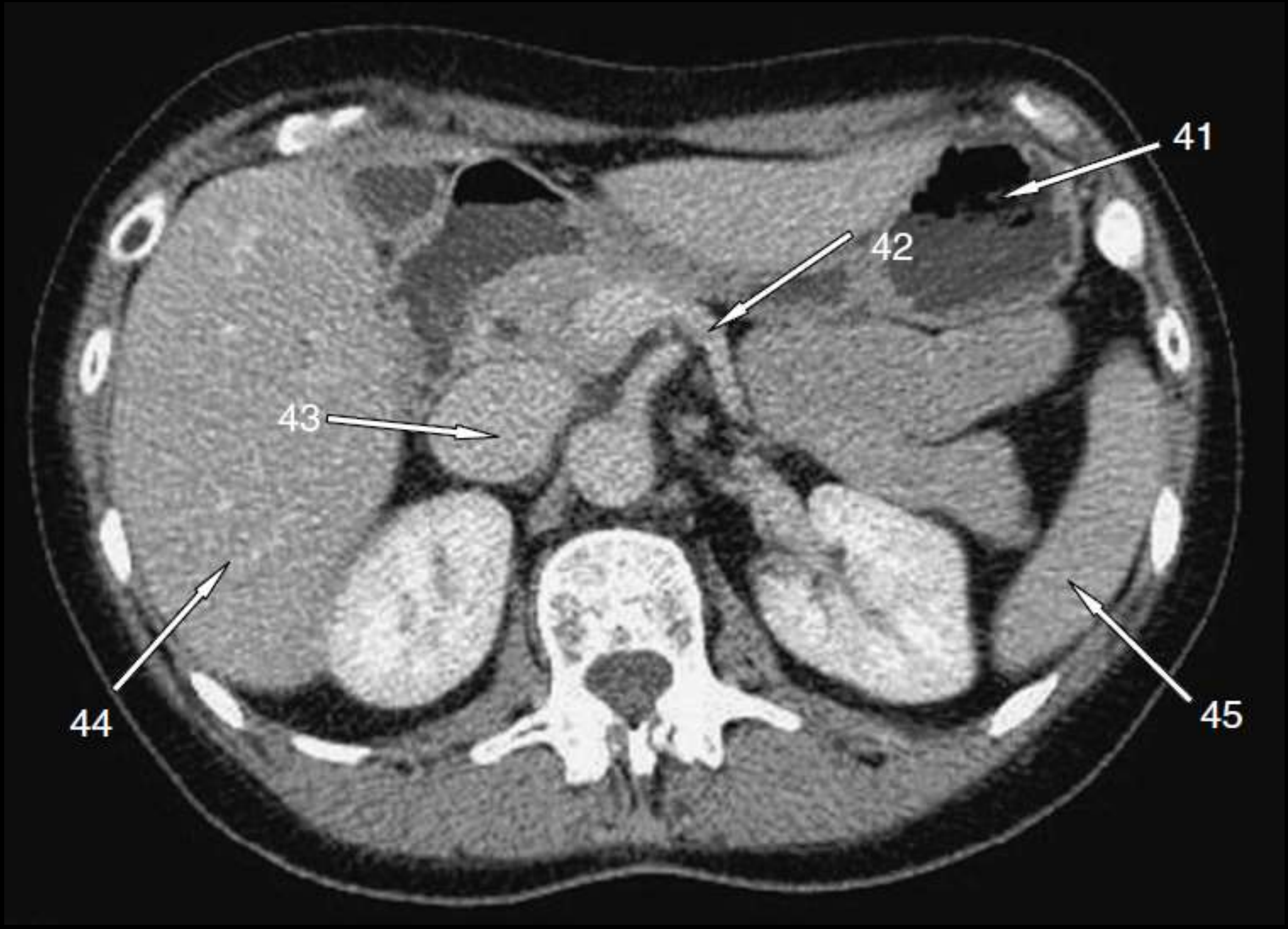
51. Transverse colon
52. Inferior vena cava
53. Left quadratus lumborum muscle
54. Descending colon
55. Malrotated right kidney

Note how the right renal pelvis faces laterally.


71
72
73
74
75

CT Abdomen

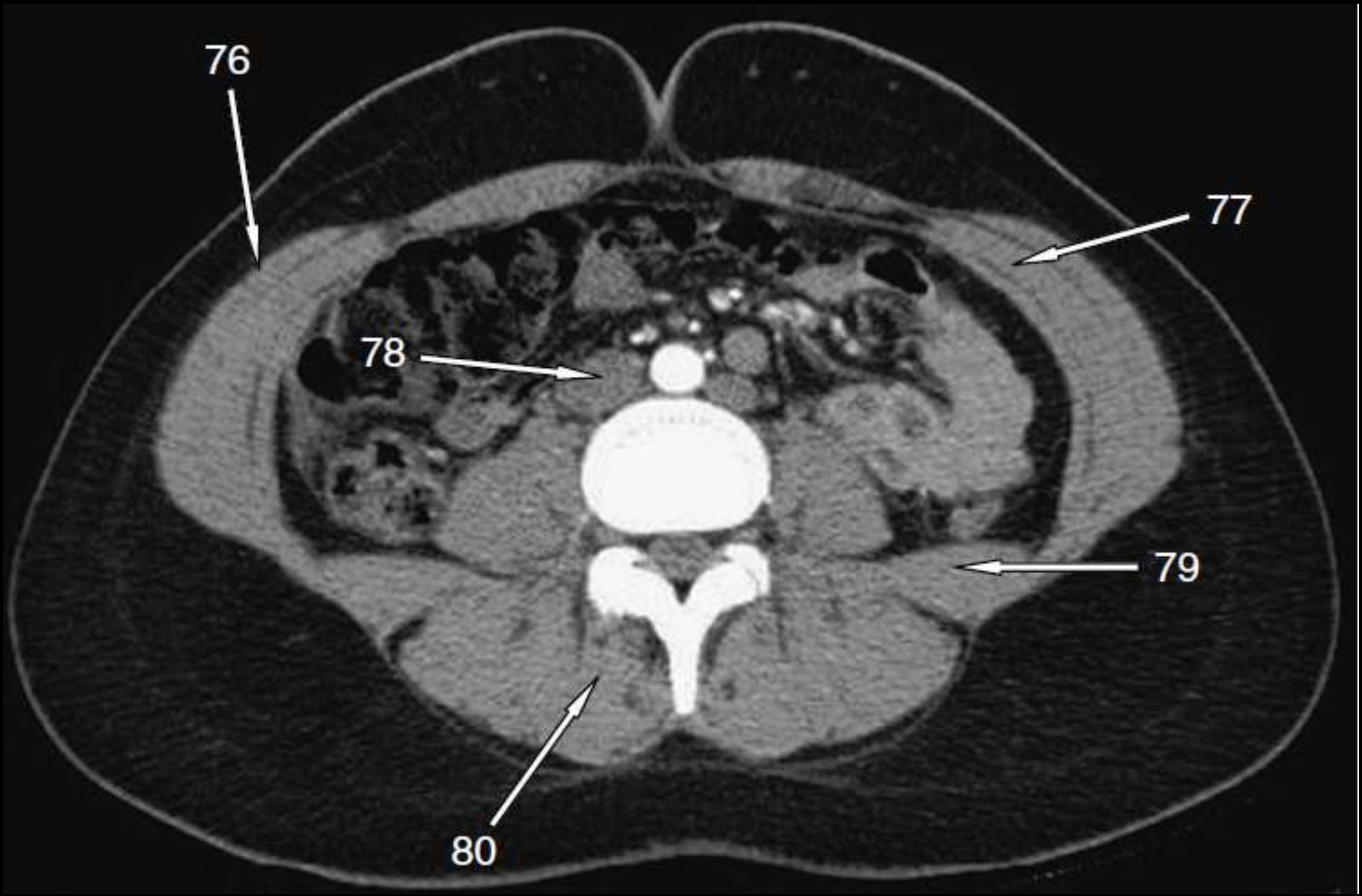
71. Gall bladder
72. 2nd part duodenum (D2 segment)
73. Tail of pancreas
74. Splenic flexure of large intestine (descending colon)
75. Splenic vein


41
42
43
44
45

CT Abdomen

41. Stomach
42. Splenic vein
43. Inferior vena cava
44. Right lobe of the liver (segment VI)
45. Spleen

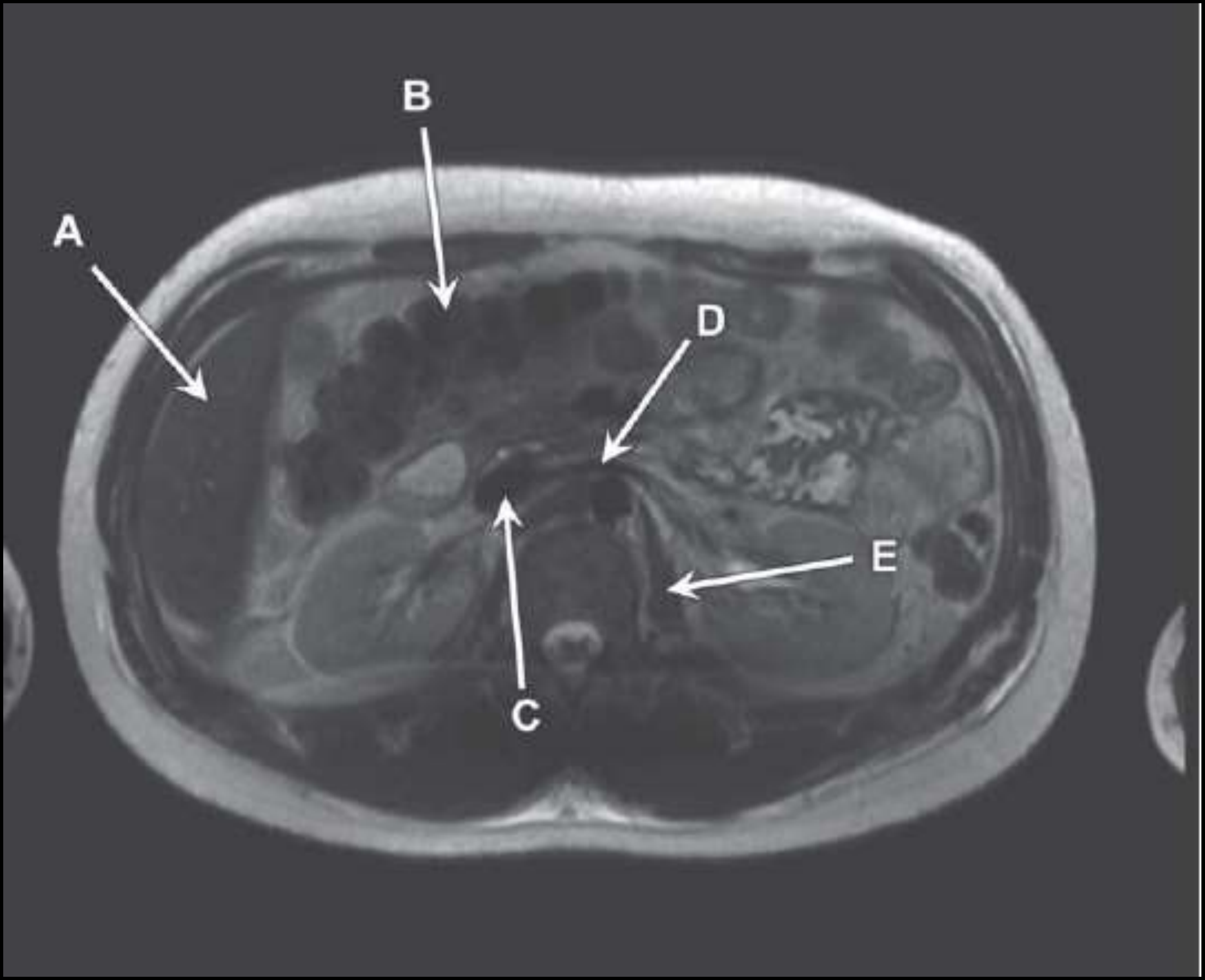
Look for the tadpole sign of the splenic vein (tail) going to join the inferior mesenteric vein to form the portal vein (head).


76
77
78
79
80

CT Abdomen

76. Right external oblique muscle
77. Left internal oblique muscle
78. Inferior vena cava
79. Left quadratus lumborum muscle
80. Right erector spinae muscles

This axial CT is taken in the arterial phase of contrast enhancement. Notice how the aorta and other arteries are enhancing. Determining the phase of a CT examination is important when identifying vascular structures and pathology.

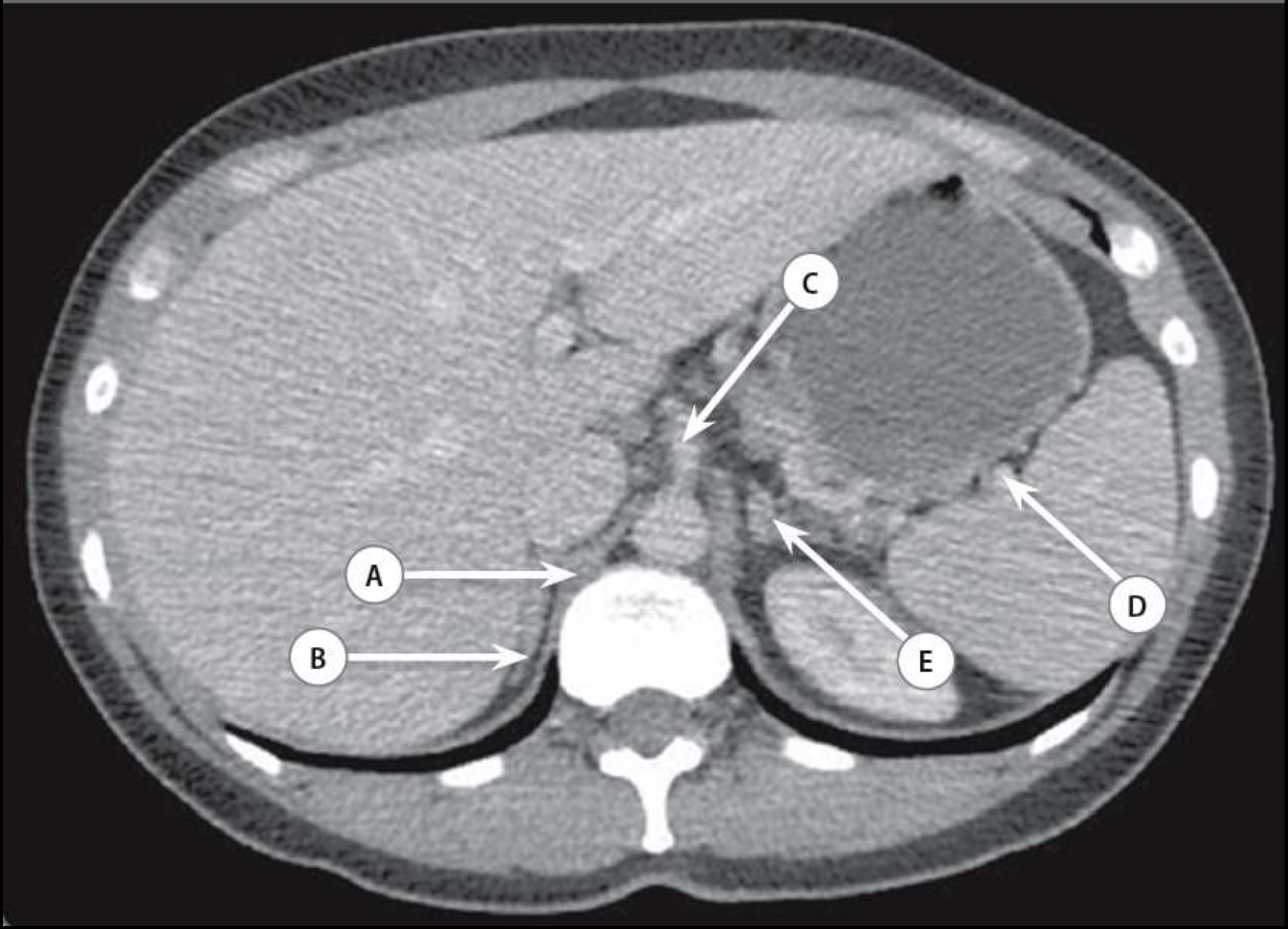

A
B
C
D
E

Case 16

MRI abdomen. T2W axial section.

1. Right lobe of liver
2. Transverse colon
3. Inferior vena cava
4. Left renal vein
5. Left crus of the diaphragm

Case 5.4



Case 5.4

A Right diaphragmatic crus

B Right adrenal gland

C Coeliac axis

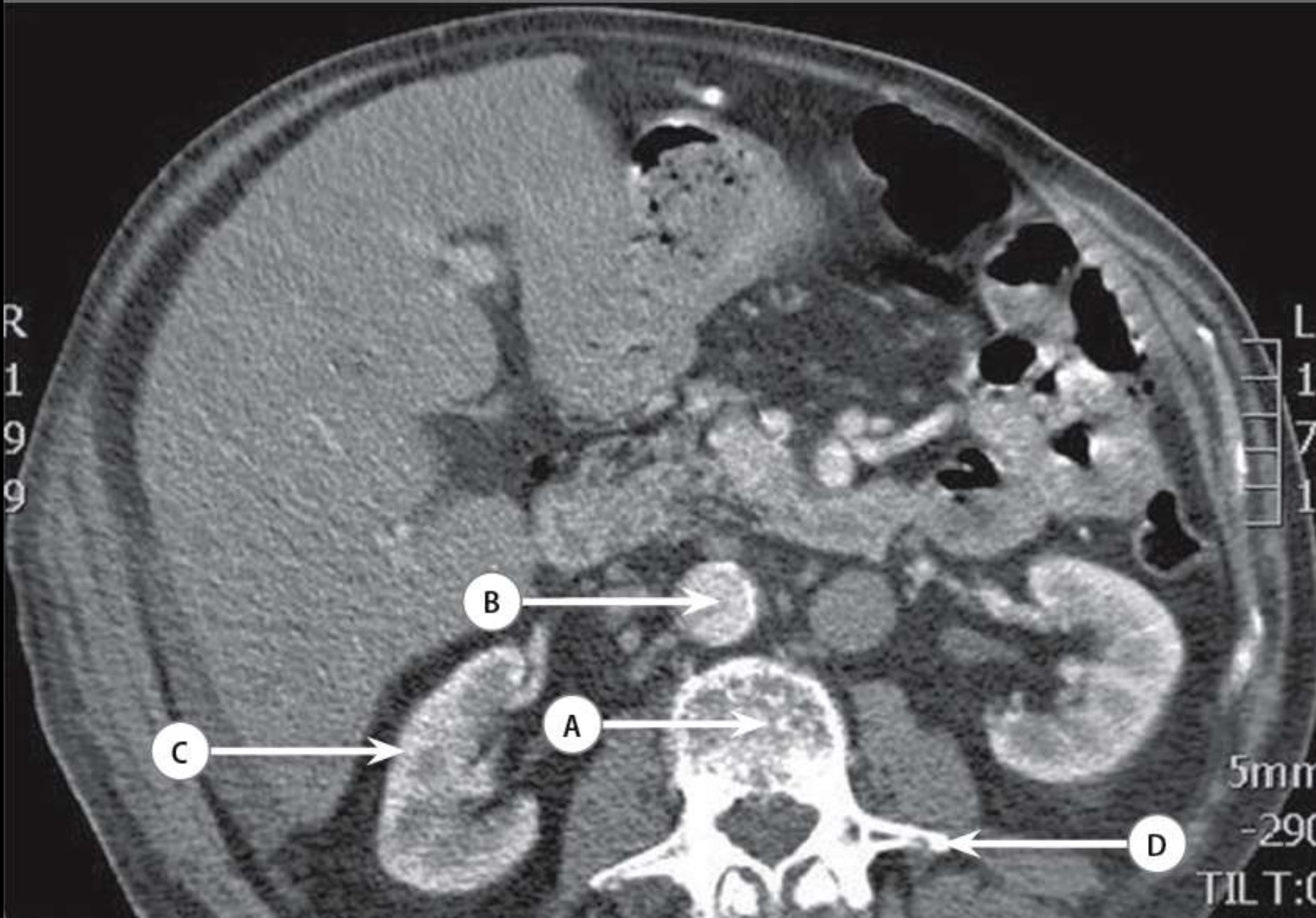
D Vessels at splenic hilum (splenic artery)

E Left adrenal gland

Axial contrast-enhanced CT.

For further discussion see Chapter 3, Cases 3.14, 3.48 and 3.49.

Case 5.17



What anatomical variant is present?

Case 5.17

A Vertebral body

B Aorta

C Cortex of right kidney

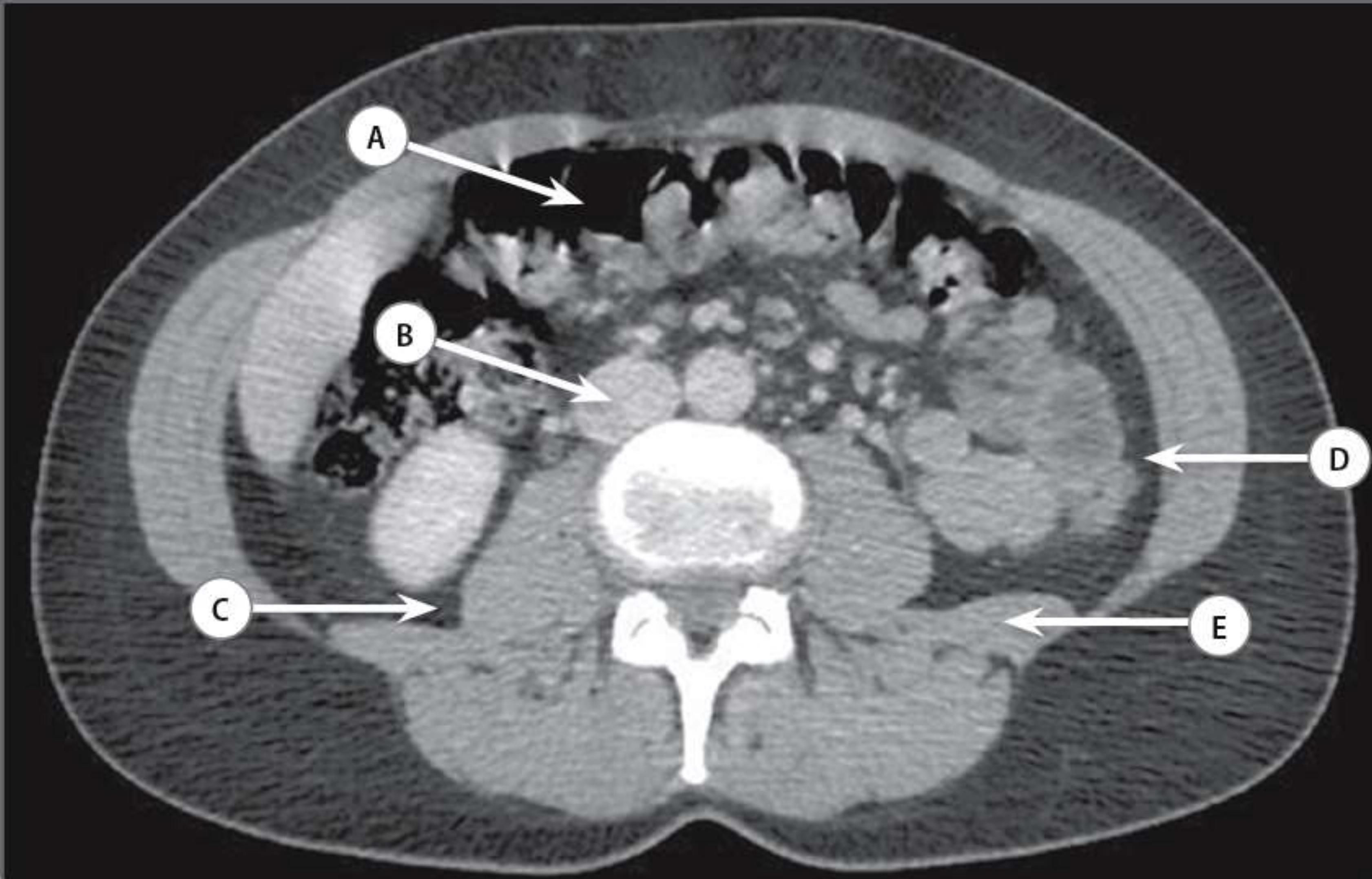
D Left transverse process

E Name the normal variant: left inferior vena cava

Axial CT at the level of the kidneys.

For further discussion see Chapter 4, Cases 4.1 and 4.2.

Case 5.18



Case 5.18

A Transverse colon

B Inferior vena cava

C Right posterior pararenal space

D Left paracolic gutter

E Left quadratus lumborum

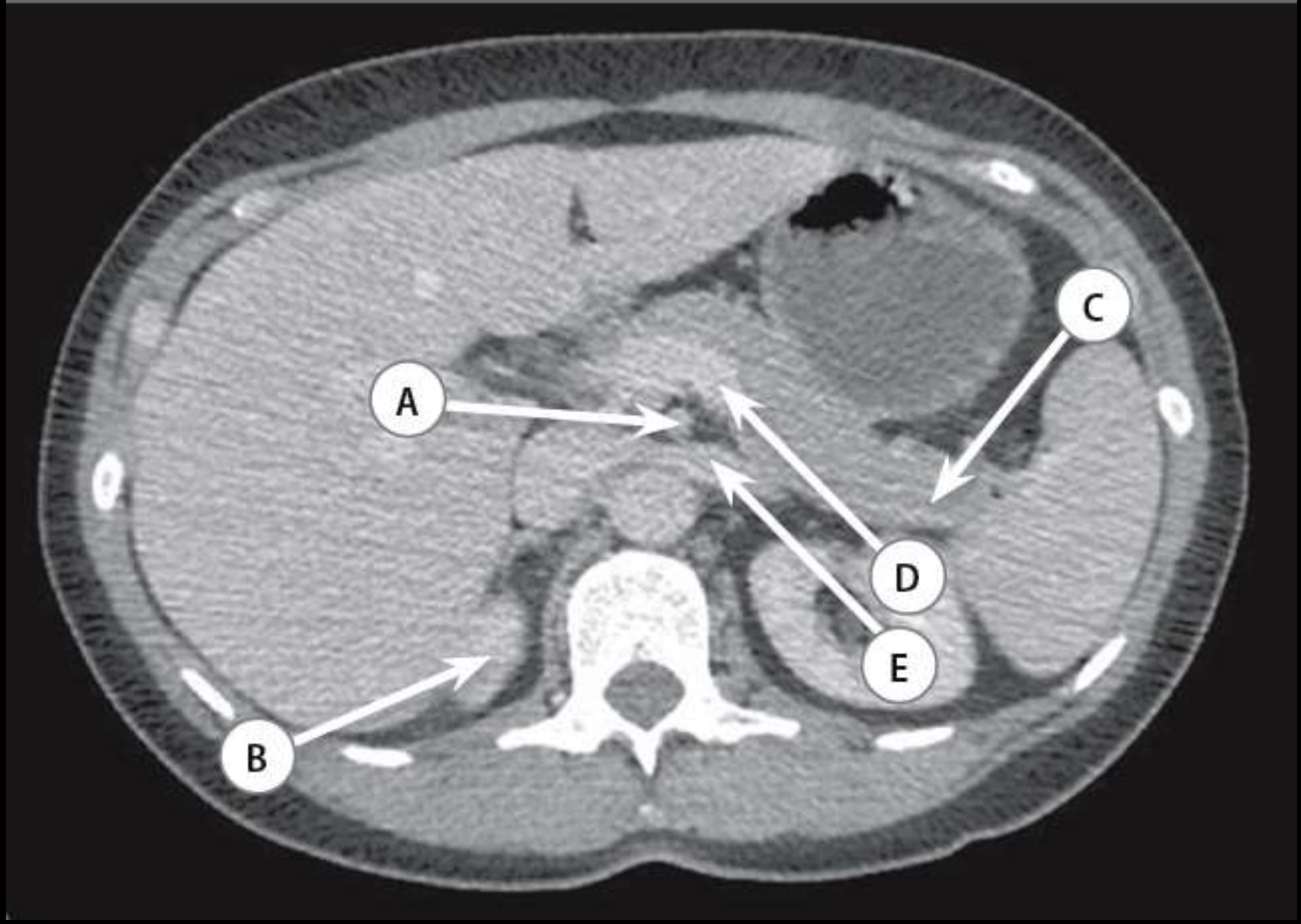
Axial contrast-enhanced CT of the abdomen.

The paracolic gutters (also known as the paracolic recesses) are found lateral to the ascending and descending colon. They are formed by two peritoneal recesses which run adjacent to the ascending and descending colon. Both paracolic gutters are continuous with the rectouterine and rectovesical spaces in the pelvis. The right paracolic gutter tends to be larger than the left, and is in communication with the right subphrenic and subhepatic spaces. The phrenicocolic ligament forms a partial barrier between the left paracolic gutter and the subphrenic spaces on the left.

Quadratus lumborum is one of the muscles of the posterior abdominal wall. It has attachments to the 12th ribs, the transverse processes of the lumbar vertebrae, the iliolumbar ligament, and the iliac crest. The arcuate ligament is formed from a focal thickening of the fascial covering of quadratus lumborum superiorly. The iliolumbar ligament is formed from a thickening of this fascial layer inferiorly, and runs between the transverse processes of L5 to the iliac crests.

Butler P, Mitchell AM, Ellis H. Applied Radiological Anatomy. Cambridge: Cambridge University Press, 1999: 193, 277.

Case 6.3



Case 6.3

A Superior mesenteric artery

B Upper pole of right kidney

C Pancreatic tail

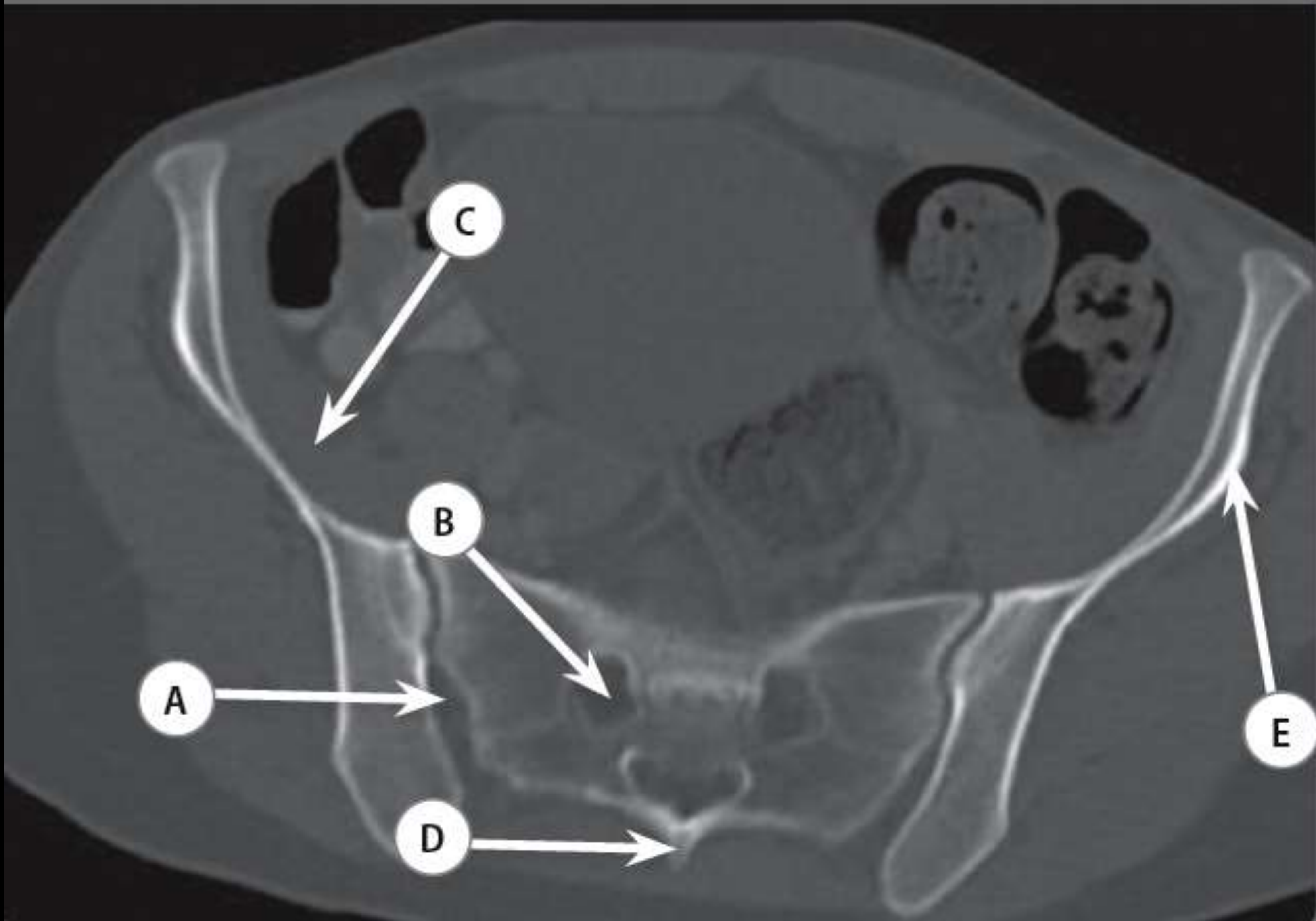
D Splenic vein

E Left renal vein

Axial contrast-enhanced CT.

For further discussion, see Chapter 3, Case 3.3.

Case 6.9



Case 6.9

A Right sacroiliac joint

B Right sacral foramen

C Right iliacus

D Spinous process of S1

E Left iliac blade

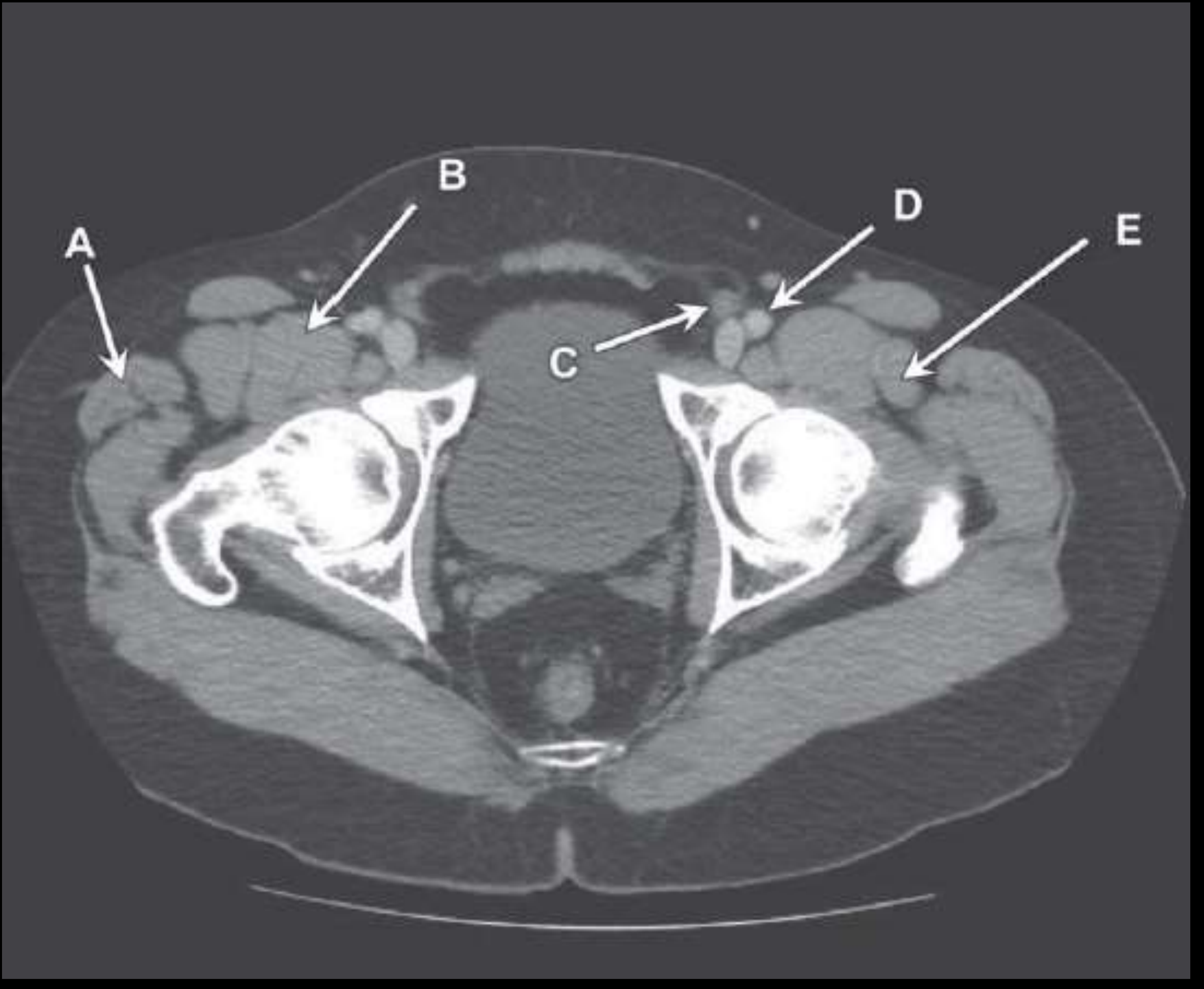
Axial CT of the sacroiliac joint.

The sacroiliac joint is a synovial joint formed by the articular surface of the sacrum and the articular surface of the iliac bone. Unlike most synovial joints, the surfaces that make up the sacroiliac joint are irregular.

The sacrum is composed of five vertebrae which are fused together in the mature skeleton. The sacral foramina represent the intervertebral foramina. The bone is expanded laterally to these foramina to form the lateral masses of the sacrum.

Iliacus arises from the inner surfaces of the ileum and fuses with the psoas to form the iliopsoas which inserts into the lesser trochanter of the femur.

Ryan S, McNicholas M, Eustace SJ. Anatomy for Diagnostic Imaging, 3rd edn. Edinburgh: Saunders, 2010: 290–291.


A
B
C
D
E

Case 2

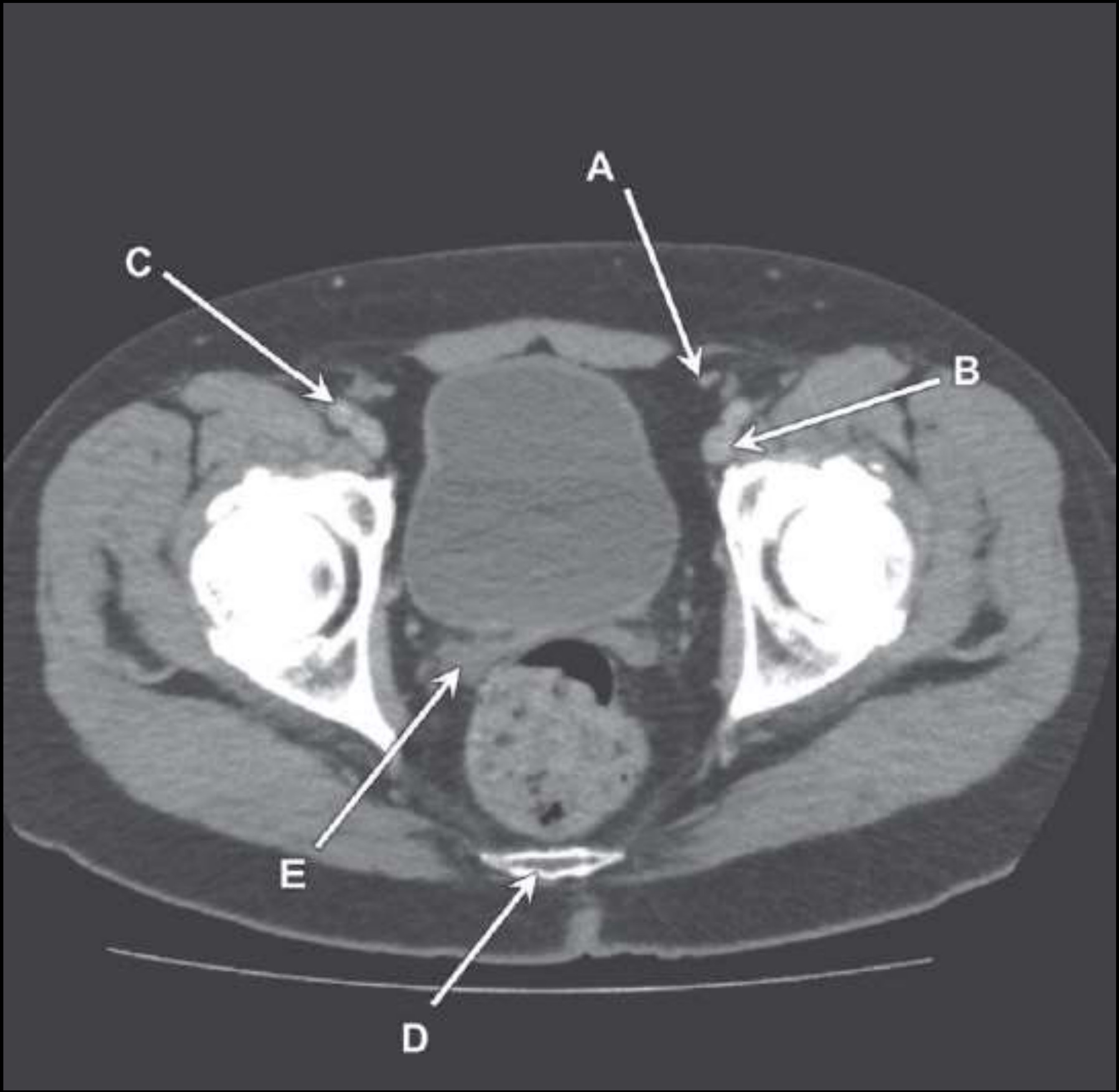
CT pelvis (male) with intravenous contrast. Axial image.

1. Right tensor fascia lata muscle
2. Right iliopsoas muscle
3. Left spermatic cord
4. Left common femoral artery
5. Left rectus femoris muscle


91
92
93
94
95

CT Pelvis

91. Left sartorius muscle
92. Right pectineus muscle
93. Right femur (right neck of femur)
94. Right rectus abdominis muscle
95. Right obturator internus muscle

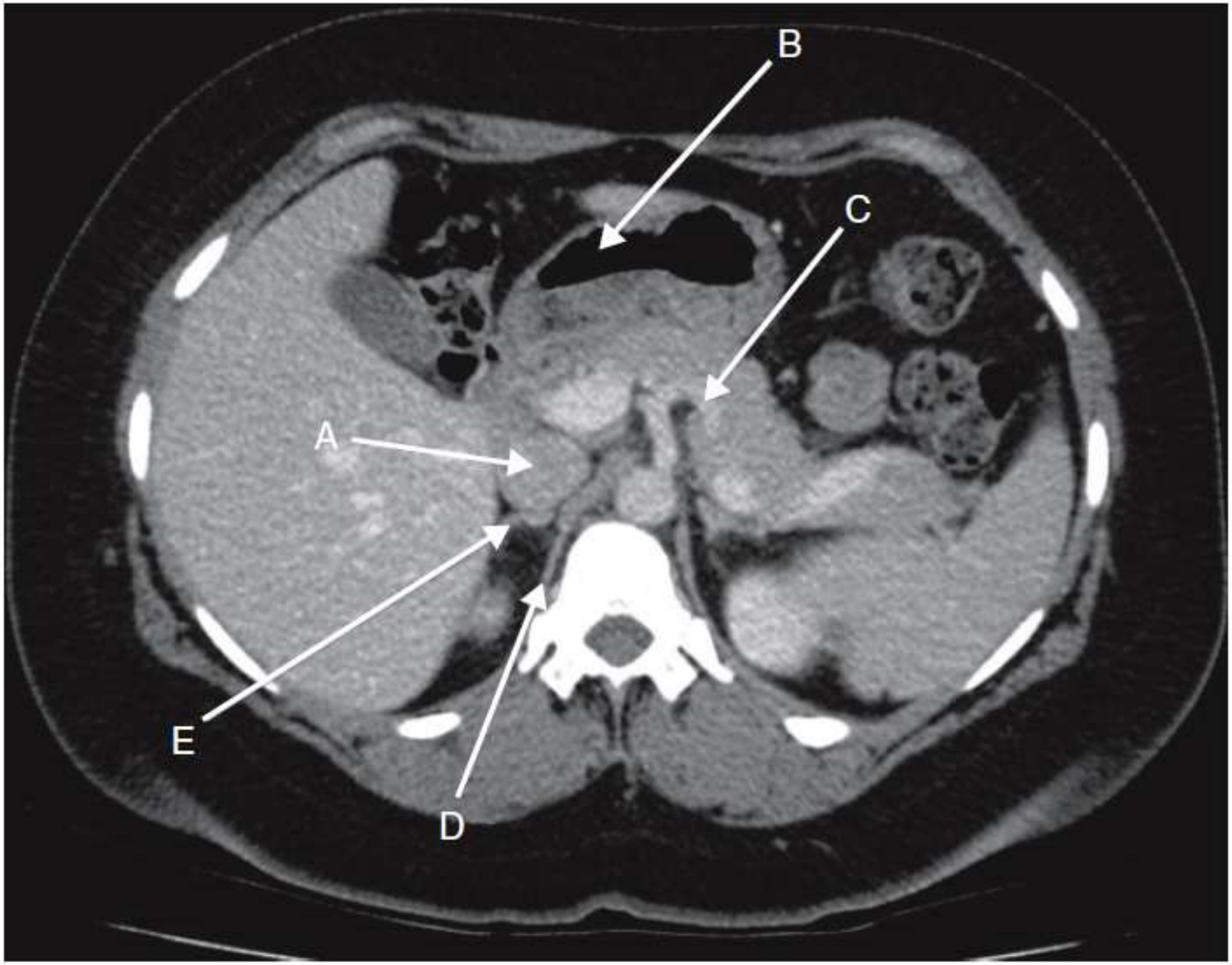

A
B
C
D
E

Case 16

CT pelvis. Axial section.

1. Left inferior epigastric vessels
2. Left external iliac vein
3. Right external iliac artery
4. Sacrum
5. Right seminal vesicles

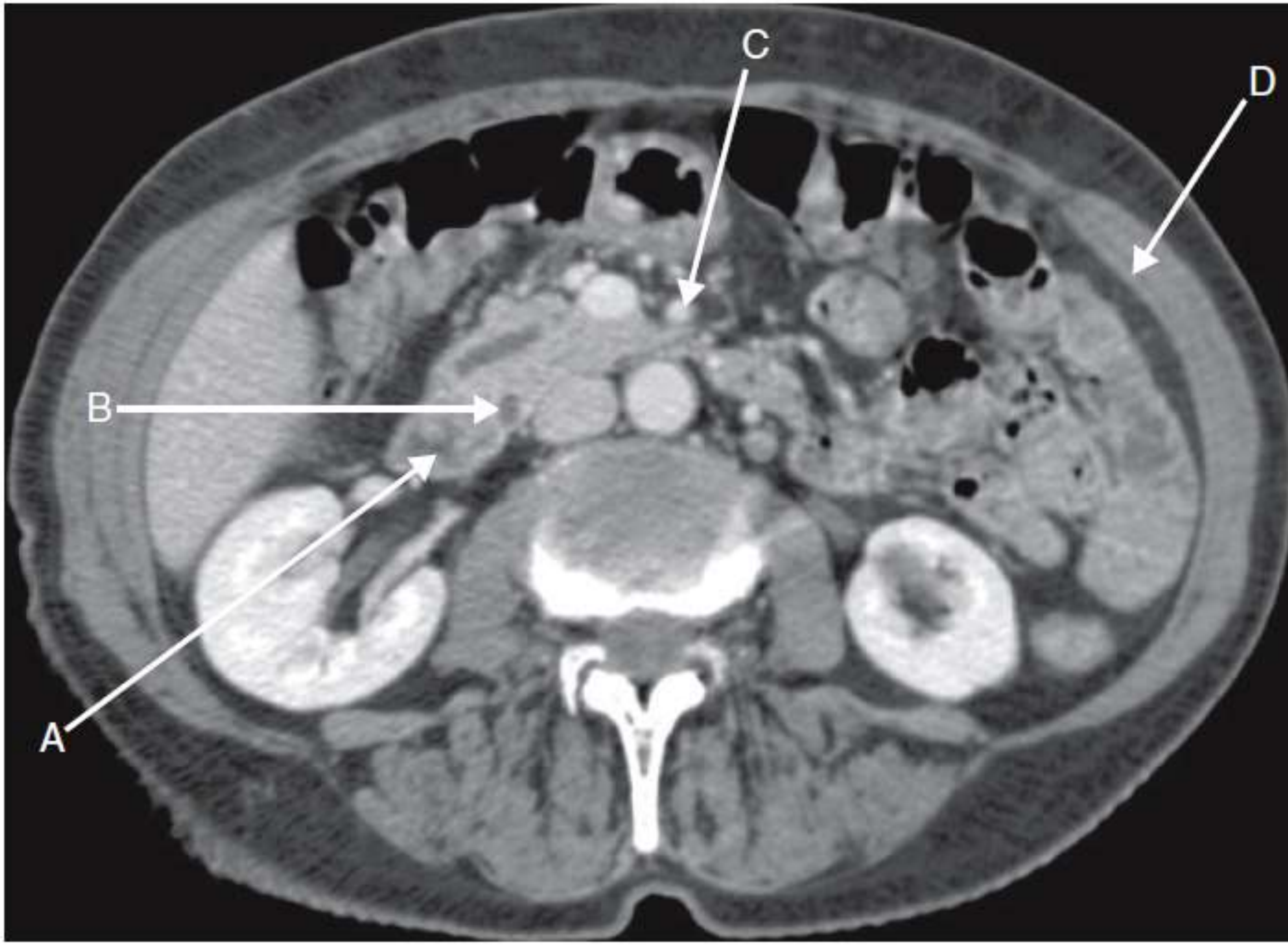
Case 8.14



8.14 Axial portal venous phase abdominal CT

(a) Inferior vena cava.
(b) Gastric antrum.
(c) Splenic artery.
(d) Crus of the right hemidiaphragm.
(e) Lateral limb of the right adrenal gland.

Case 7.8

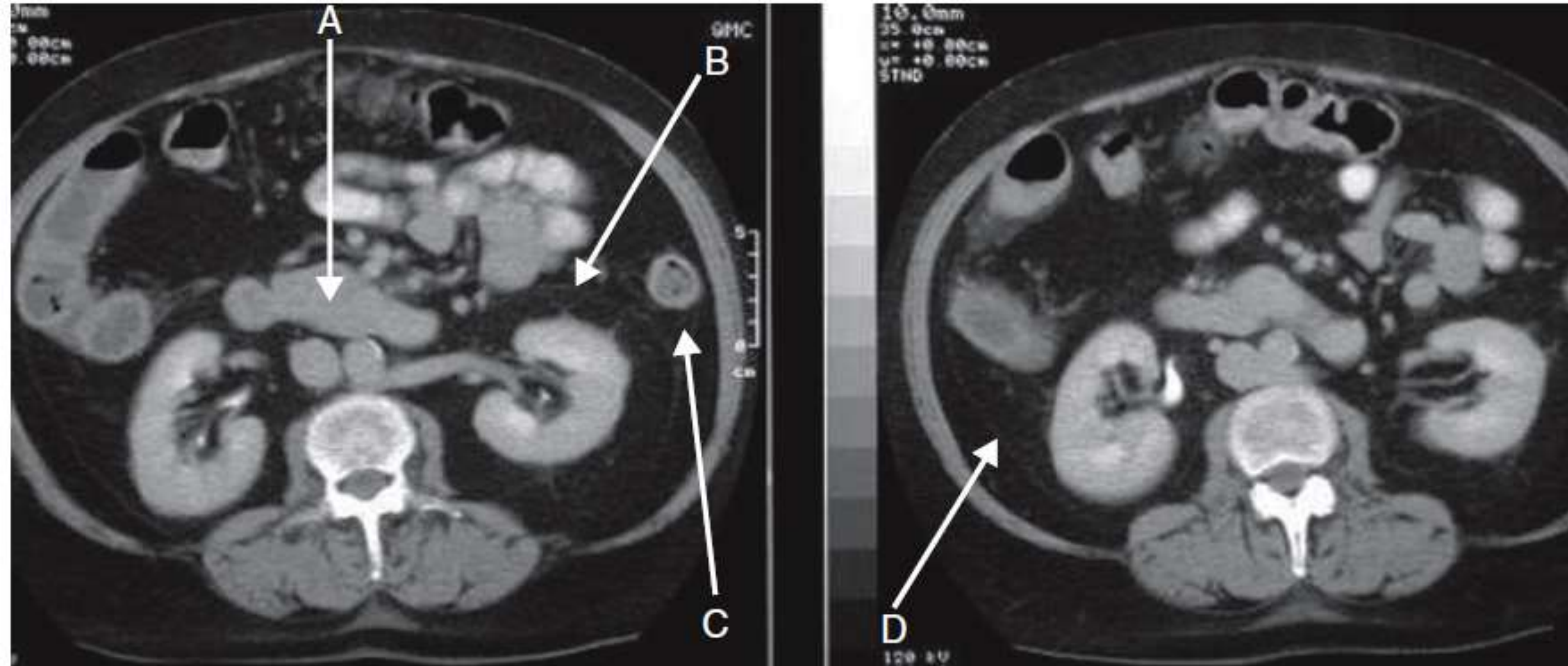


What anatomical variant is present?

7.8 Axial enhanced abdominal CT

(a) Second part of duodenum.
(b) Common bile duct (CBD).
(c) Superior mesenteric artery.
(d) Left internal oblique muscle.
(e) Pancreas divisum. This anomaly is present in up to 14% of the population (in autopsy series). Normally the shorter ventral duct (Wirsung), which drains the head of the pancreas, joins the CBD (labelled B) to drain via the major papilla into the duodenum. There is failure of fusion of the ventral duct with the main dorsal pancreatic duct (Santorini), which drain the body of the pancreas. The dorsal duct drains into the duodenum via the minor papilla. There is an unproven suggestion that this anomaly predisposes to pancreatitis.

Case 6.20



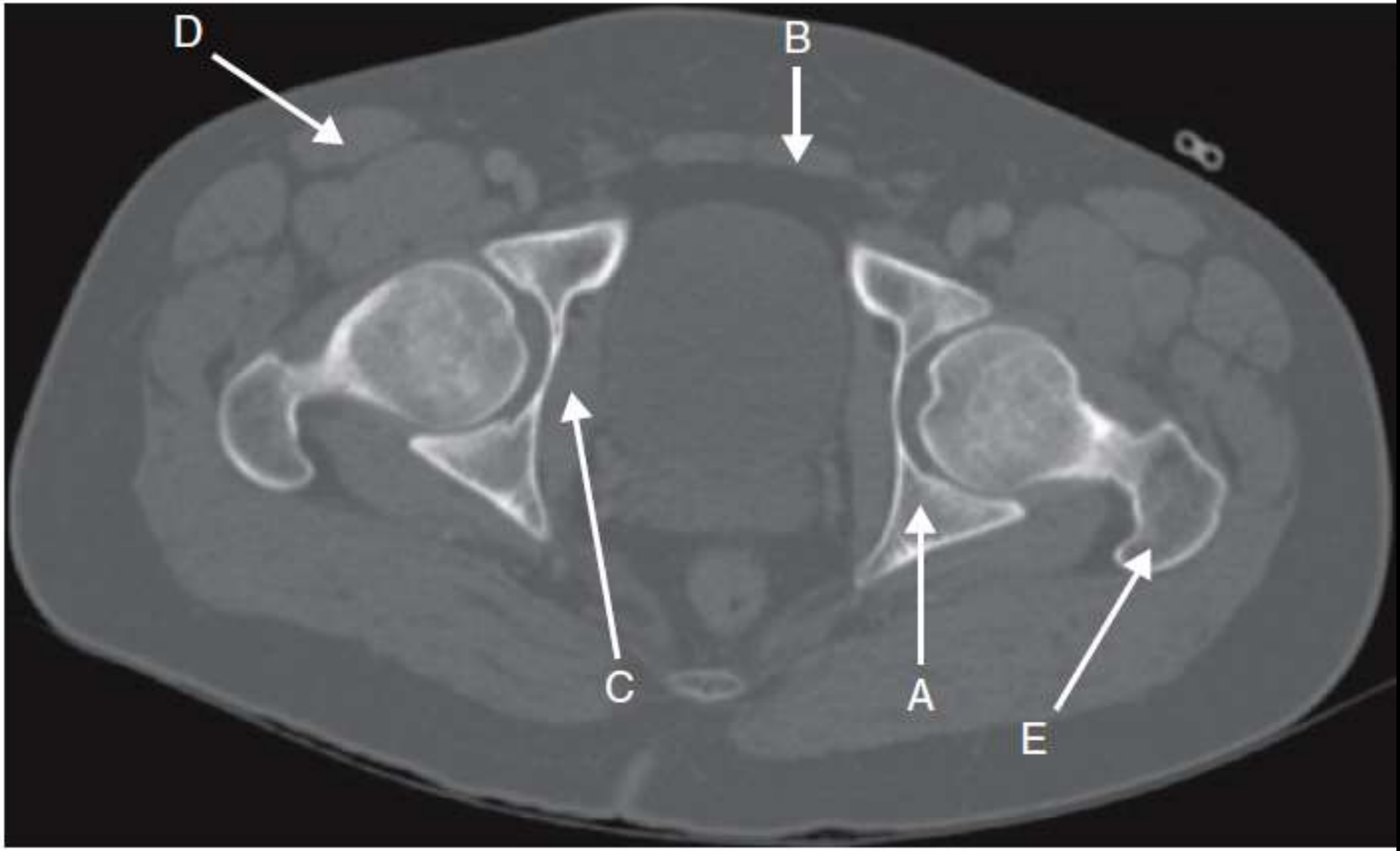
What anatomical variant is present?

6.20 Axial enhanced CT abdomen

(a) Duodenum – third part.
(b) Left anterior renal fascia.
(c) Left lateral conal fascia.
(d) Right posterior renal fascia.
(e) Retro-aortic left renal vein. A retro-aortic left renal vein is seen in about 2% of the population. In some situations the vein is posterior to the artery at the renal hilum. The anomalous vein may receive tributaries from the lumbar veins and can be associated with a higher incidence of left-sided varicoceles in males.

A circumaortic left renal vein occurs in about 8% of cases. There are two left renal veins – the superior component receives blood from the left adrenal vein and is anterior to the aorta. The inferior component is posterior to the aorta and receives blood from the gonadal vein. It is important in pre-operative planning of nephrectomy and in misdiagnosing lymphadenopathy.

Case 7.1



7.1 Axial CT pelvis (bone windows)

(a) Posterior column of the left acetabulum. The posterior and anterior columns of acetabulum provide the dominant load-bearing support of the hip joint. It is important to evaluate the integrity of the acetabular columns in the setting of pelvic trauma as fracture involvement of these structures is integral to all classification systems of acetabular fractures.

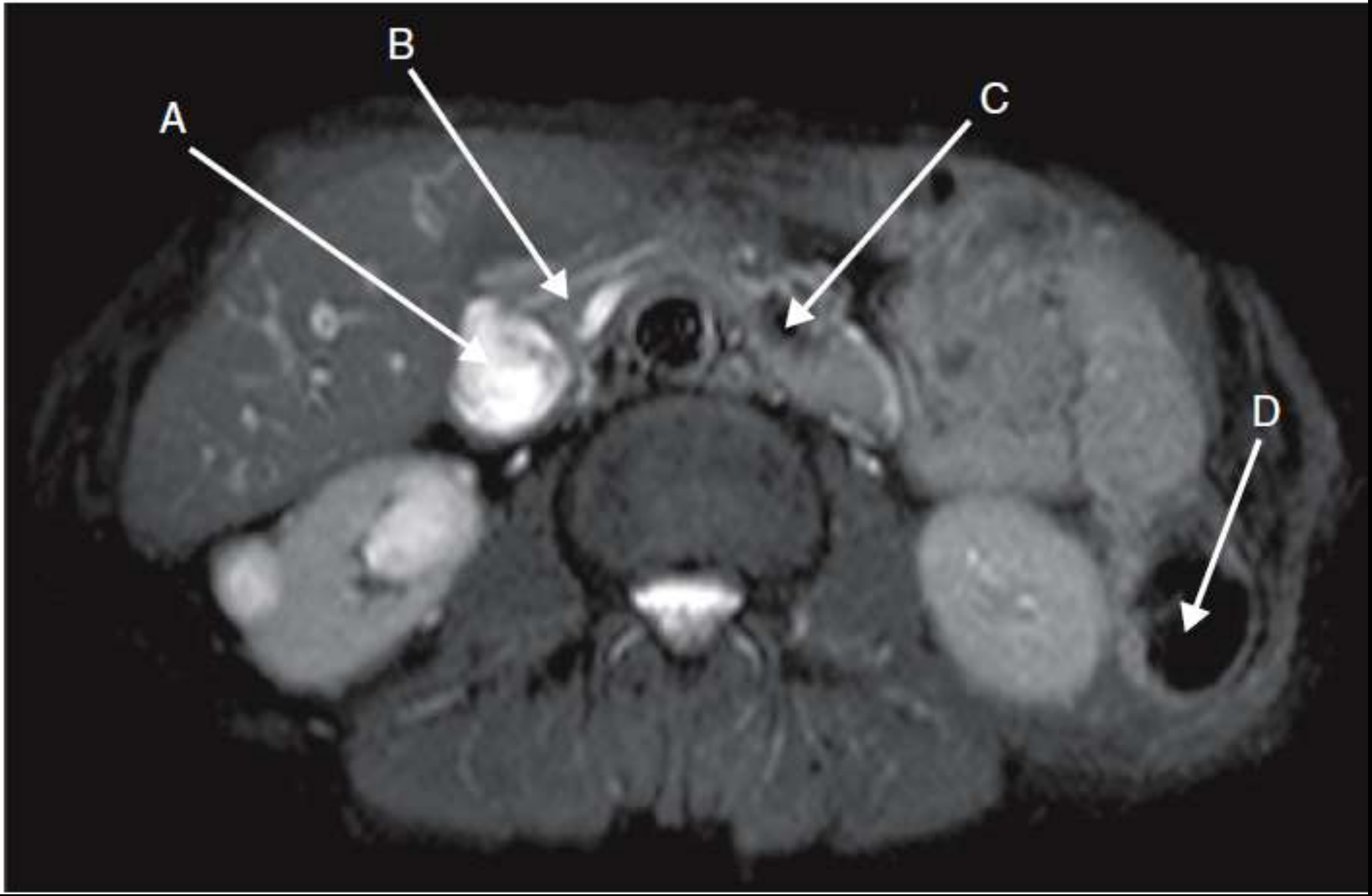
(b) Left rectus abdominis muscle. This is a strap-like muscle encased in a fascial sheath. It inserts onto the anterior surface of the pubic symphysis and has an aponeurosis which is continuous with that of the gracilis and adductor longus muscles.

(c) Right obturator internus. This arises from the internal surface of the medial acetabulum and inserts on the greater trochanter of the femur. Its action is to produce external rotation of the hip.

(d) Right sartorius muscle. This arises from the anterior superior iliac spine. It has a long muscle belly directed distally and medially spanning the hip and knee joints with an insertion on the antero-medial aspect of the tibia as one of the pes anseurinus tendon group.

(e) Greater trochanter of the left femur.

Case 5.7



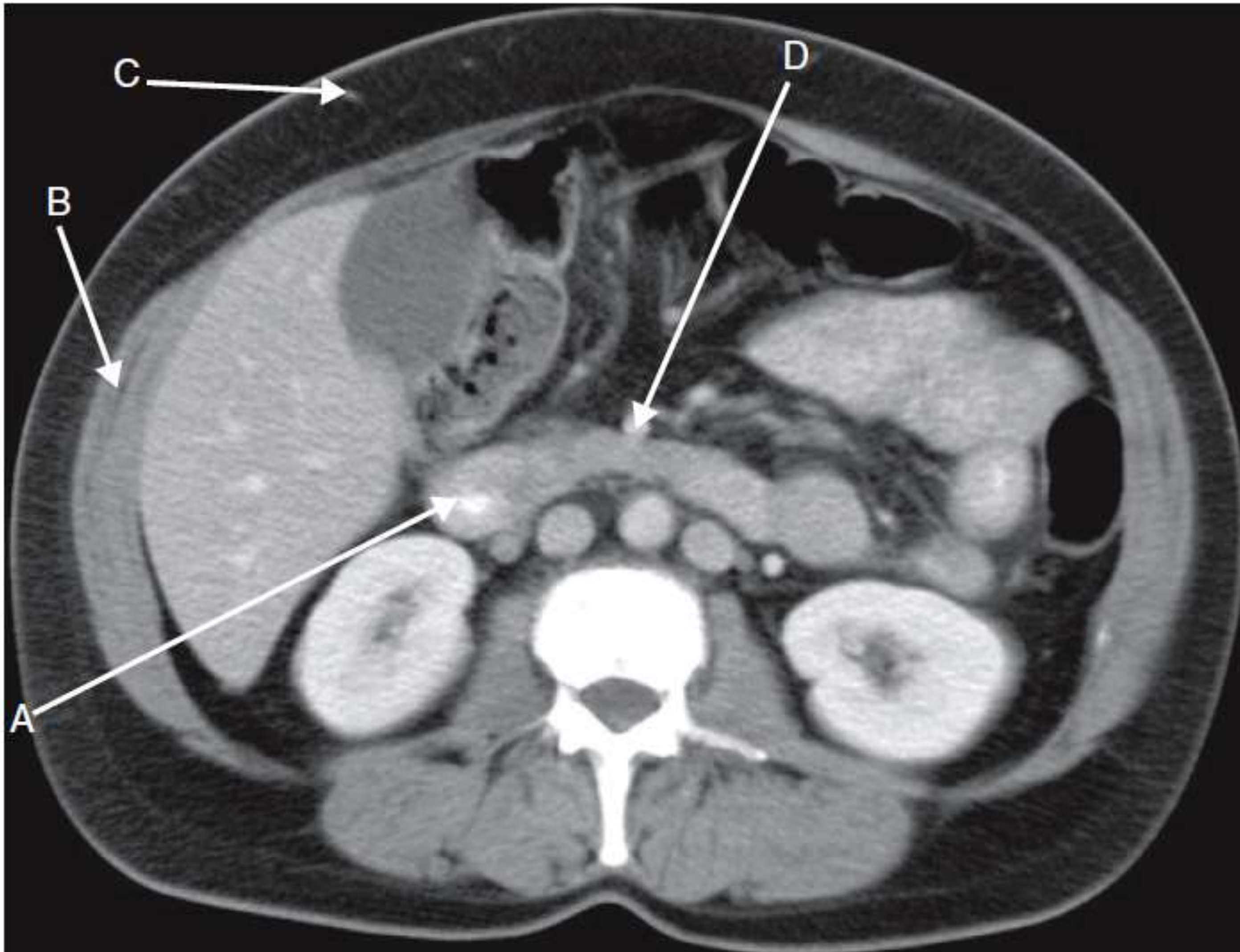
What anatomical variant is present?

5.7 Axial T2-weighted abdominal MR (fat-suppressed sequence)

(a) Second part of duodenum (or D2). The pancreatic head has a constant relationship with the duodenum. The right lateral border is nestled in the duodenal sweep.
(b) Dorsal pancreatic duct (of Santorini).
(c) Superior mesenteric artery (SMA). Flow void is seen in the SMA as it courses over the uncinate process of the pancreas. It arises 1–2 cm below the coeliac axis typically at the level of L1.
(d) Descending colon.
(e) Pancreatic divisum. This is the most common variant of pancreatic ductal fusion and drainage anomalies. It is caused by failure of fusion of the dorsal and ventral buds. The short ventral duct of Wirsung drains the head and uncinate process, with the long dorsal pancreatic duct of Santorini draining the body and tail. It is typically seen in up to 6% of the population and up to 25% of patients with idiopathic pancreatitis, though it is not proven to be a causative mechanism.

Incidentally, there are two high signal cysts seen in the right kidney.

Case 4.12



What anatomical variant is present?

4.12 Axial portal venous phase abdominal CT

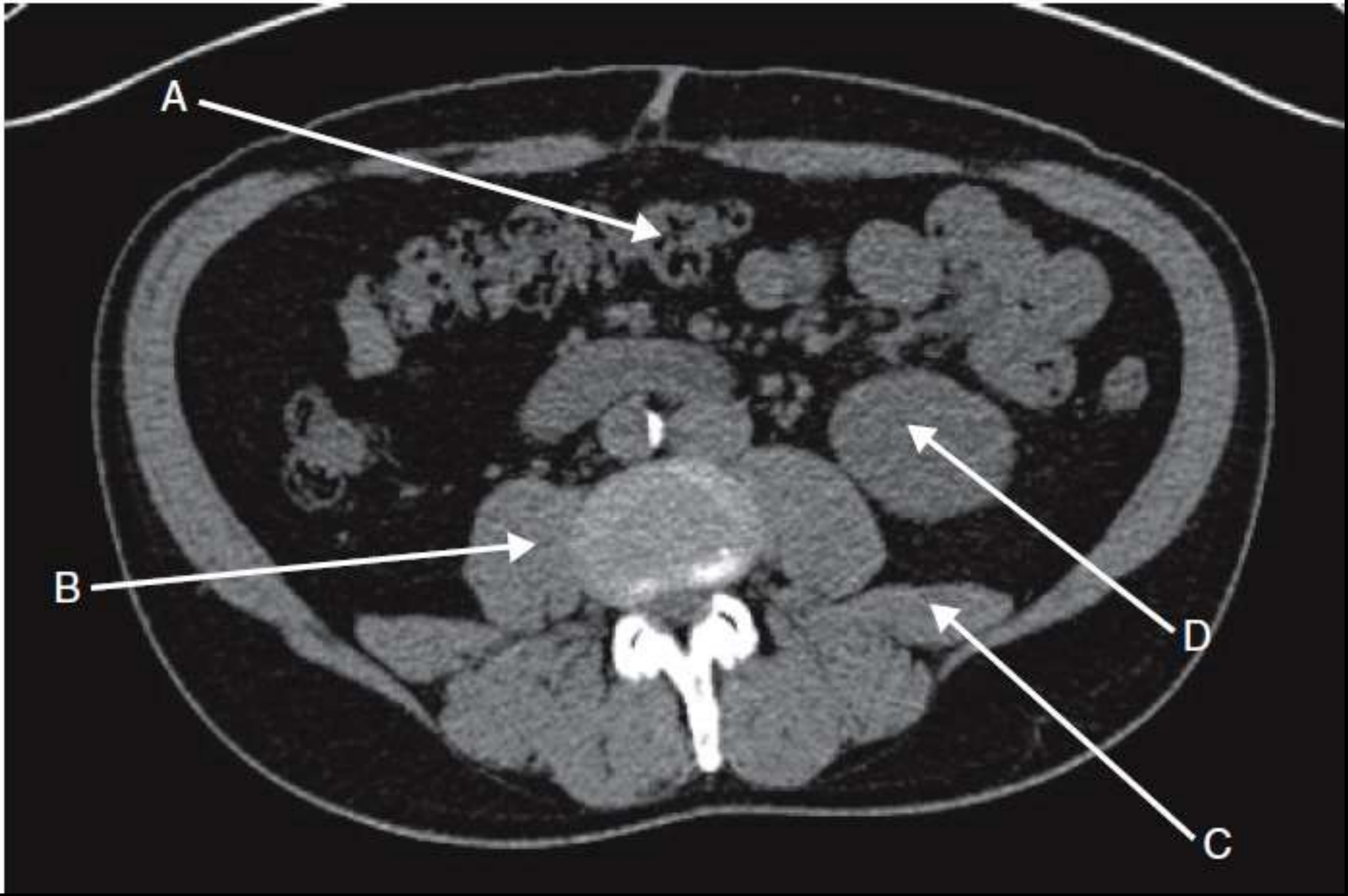
(a) Duodenum – second part.
(b) Right external oblique muscle.
(c) Right inferior epigastric artery.
(d) Superior mesenteric artery.
(e) Left-sided component of a duplicated inferior vena cava (IVC).

A double IVC has a prevalence of up to 3% and comprises a right- and left-sided IVC, which occur below the level of the renal veins. The two cavae join when the left-sided component crosses the midline, usually anterior to the aorta to join the left renal vein, which drains into the right-sided IVC. Occasionally the right renal vein may be retro-aortic.

A left-sided infra-renal IVC is described, having a prevalence of up to 0.5%. As it ascends, it crosses the midline anterior to the aorta as it joins the left renal vein.

The most important clinical problem in both anomalies is a tendency for misdiagnosis as left para-aortic lymphadenopathy. It can rarely assume relevance in IVC filter placement in which case bilateral iliac filters can be considered.

Case 1.8



What anatomical variant is present?

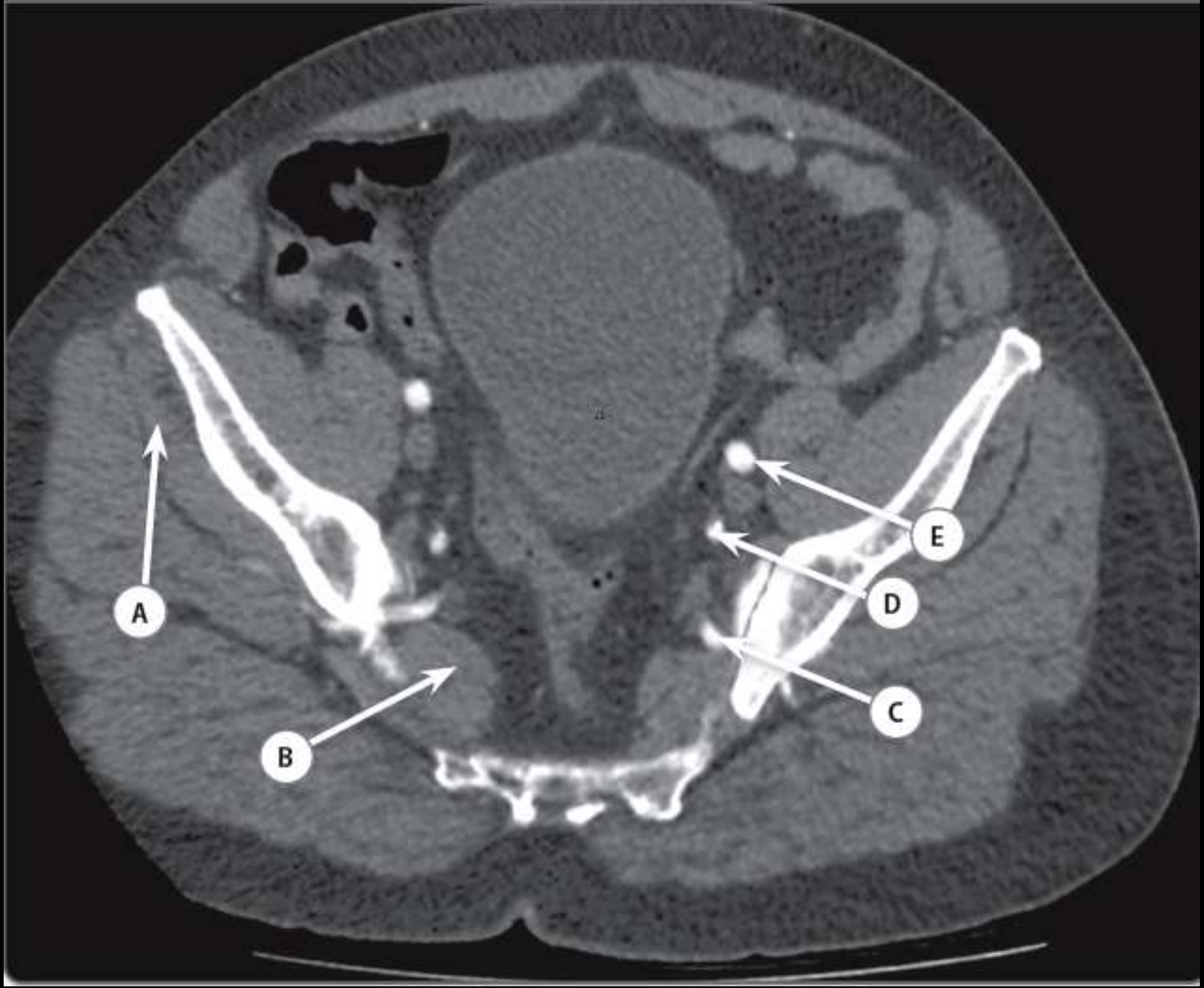
1.8 Axial unenhanced abdominal CT

(a) Transverse colon. This can be seen to cross the midline anteriorly on axial CT. It has a mesentery, the mesocolon, which attaches it to the posterior abdominal wall and on which it hangs between the fixed points of the hepatic and splenic flexures.
(b) Right psoas muscle. The psoas muscles are paired and lie lateral to the lumbar vertebrae, descending anteriorly to fuse with the iliacus muscle. A psoas abscess can develop due to the close proximity of structures to the muscle. Common origins of these abscesses include the vertebral column, expanding perinephric abscesses and bowel-related complications, such as diverticulitis.
(c) Left quadratus lumborum muscle.
(d) Left kidney. The kidneys are retroperitoneal. The hilum of the left kidney normally lies at L1 vertebral level, with the right renal hilum at the level of L1/L2 due to the liver lying superior to it. Anterior relations of the left kidney include stomach, pancreas, spleen, splenic flexure and small bowel loops.
(e) Left-sided inferior vena cava (IVC).

Normal variants are relatively common in the abdomen and include variants in vascular anatomy. Although this image is unenhanced, the IVC can be seen to lie on the left of the aorta. The aorta calcifies whereas the IVC does not, as can be seen in this image.

It is important to include any variants in vascular anatomy when constructing a radiological report as a surgeon needs to know this prior to embarking on a renal or other retroperitoneal procedures.

Case 13.18



Case 13.18

A Right gluteus minimus muscle

B Right piriformis muscle

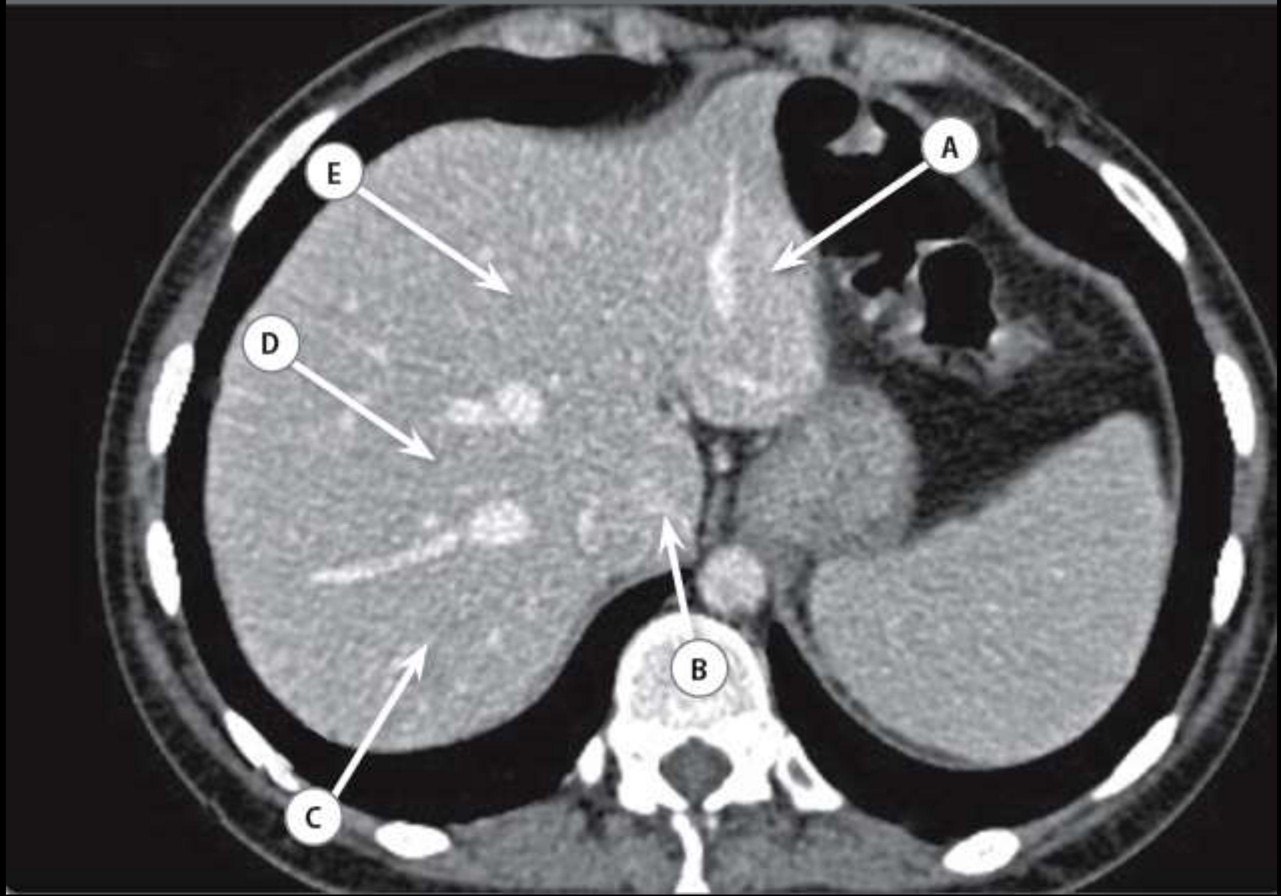
C Left inferior gluteal artery

D Left internal iliac artery

E Left external iliac artery

This is an axial view of a male pelvis taken during a CT angiogram examination. The external and internal iliac vessels are seen in the axial plane. Also note the inferior gluteal artery as it passes through the greater sciatic foramen to supply the muscles of the buttock. The piriformis muscle originates from the sacrum, exits via the greater sciatic foramen and attaches to the greater trochanter of the femur, acting as a lateral rotator of the hip.

Case 13.20



Case 13.20

A Segment II

B Segment I

C Segment VII

D Segment VIII

E Segment IVa

The Couinaud classification divides the liver anatomy into eight segments, all of which function independently (**Figure 13.1**). Each segment is centred on branches of the portal vein, hepatic artery and bile duct. In the periphery of each segment, vascular outflow is provided via the hepatic veins.

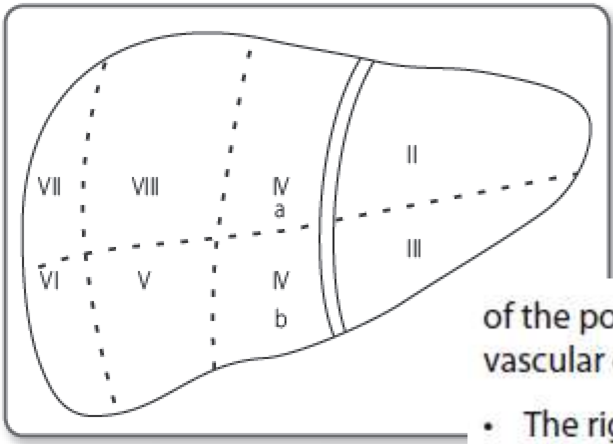
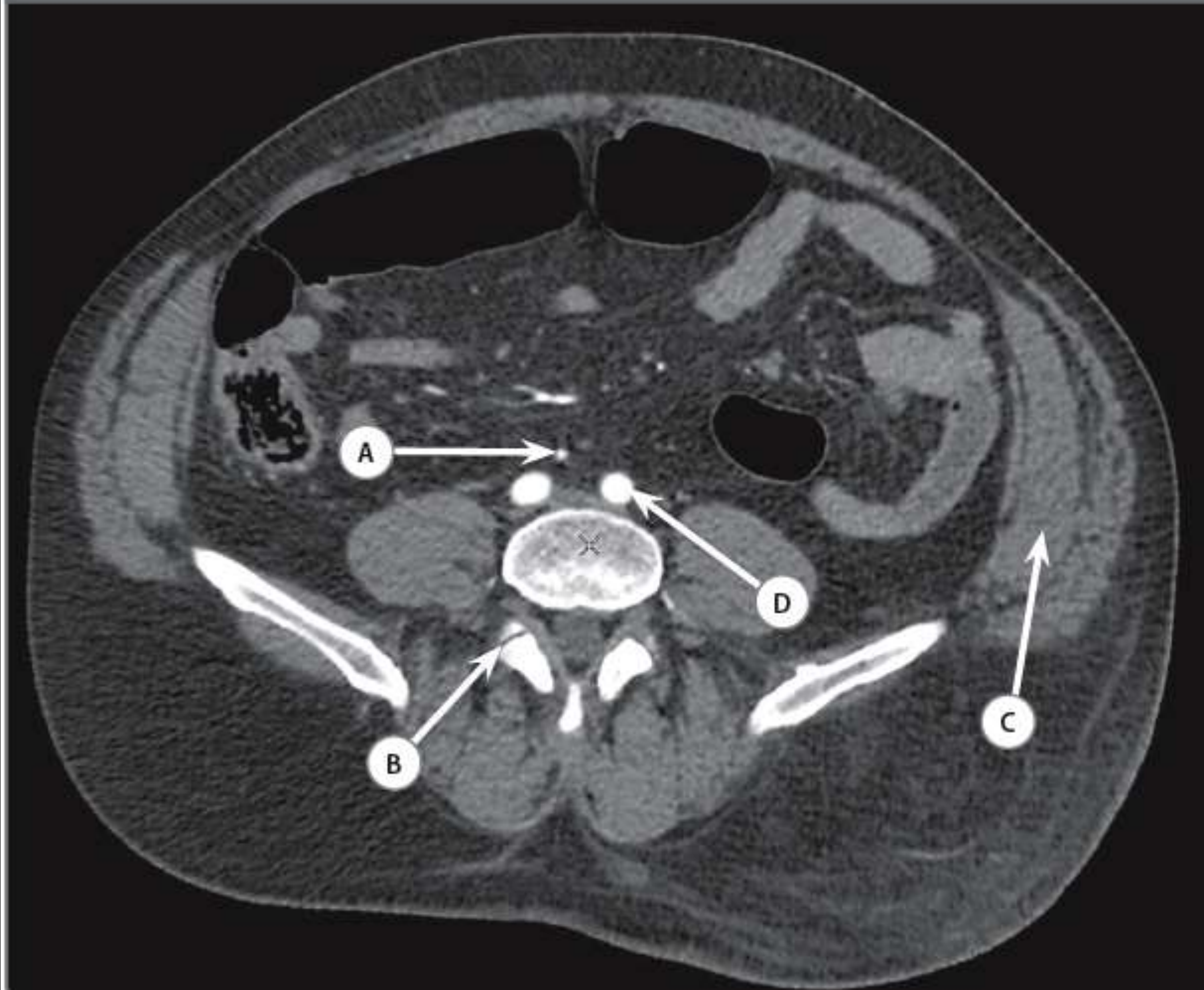


Figure 13.1 Segments of the liver.

- The right hepatic vein divides the right lobe into anterior and posterior segments
- The middle hepatic vein divides the liver into right and left lobes
- The left hepatic vein divides the left lobe into medial and lateral segments
- The portal vein divides the liver into upper and lower segments
- Segment IV is also divided to segments IVa and IVb
- Segment I is a posterior structure which drains directly into the IVC and is not seen on an anterior view
- Segments II, IVa, VII and VIII lie above the portal vein
- Segments III, IVb, V and VI lie below the portal vein

Case 12.3



E	What is the usual maximum diameter of the common iliac arteries in an adult patient?	

Case 12.3

A Inferior mesenteric artery (IMA)

B Right facet joint

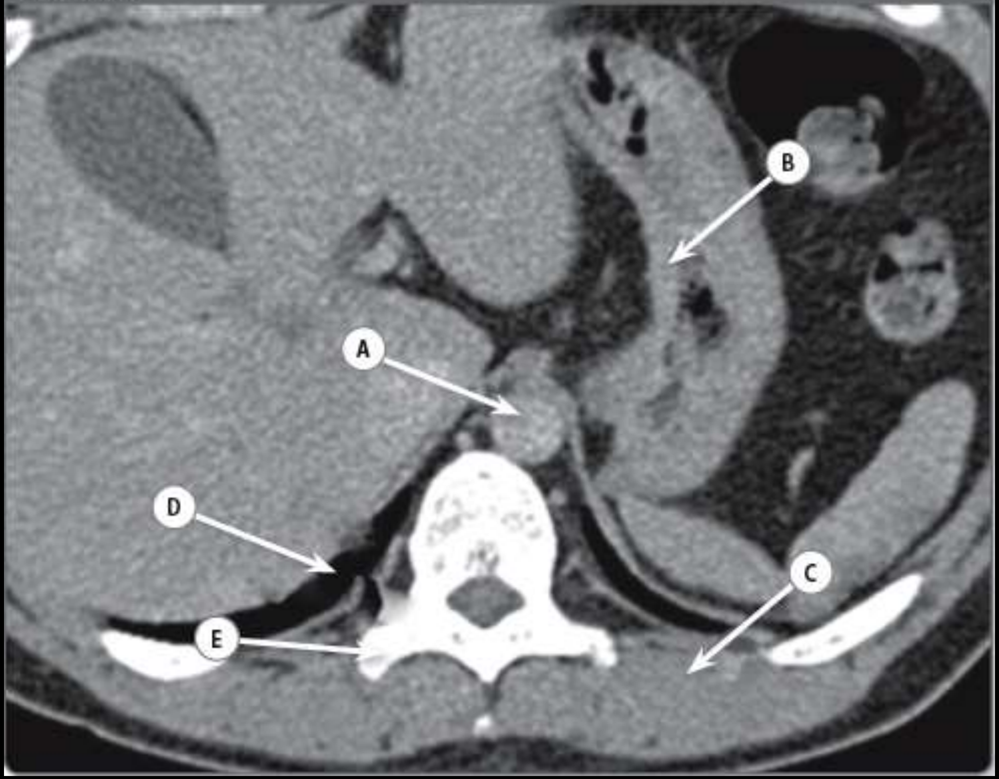
C Left internal oblique muscle

D Left common iliac artery

E 2 cm

The IMA is seen anterior to the common iliac arteries. The IMA arises from the anterior aorta at the level of L3 and supplies the colon from the distal transverse colon to the rectum. Major branches include the left colic artery, sigmoid artery and superior rectal branches.

Case 11.10



Case 11.10

A Aorta

B Lesser curve of stomach

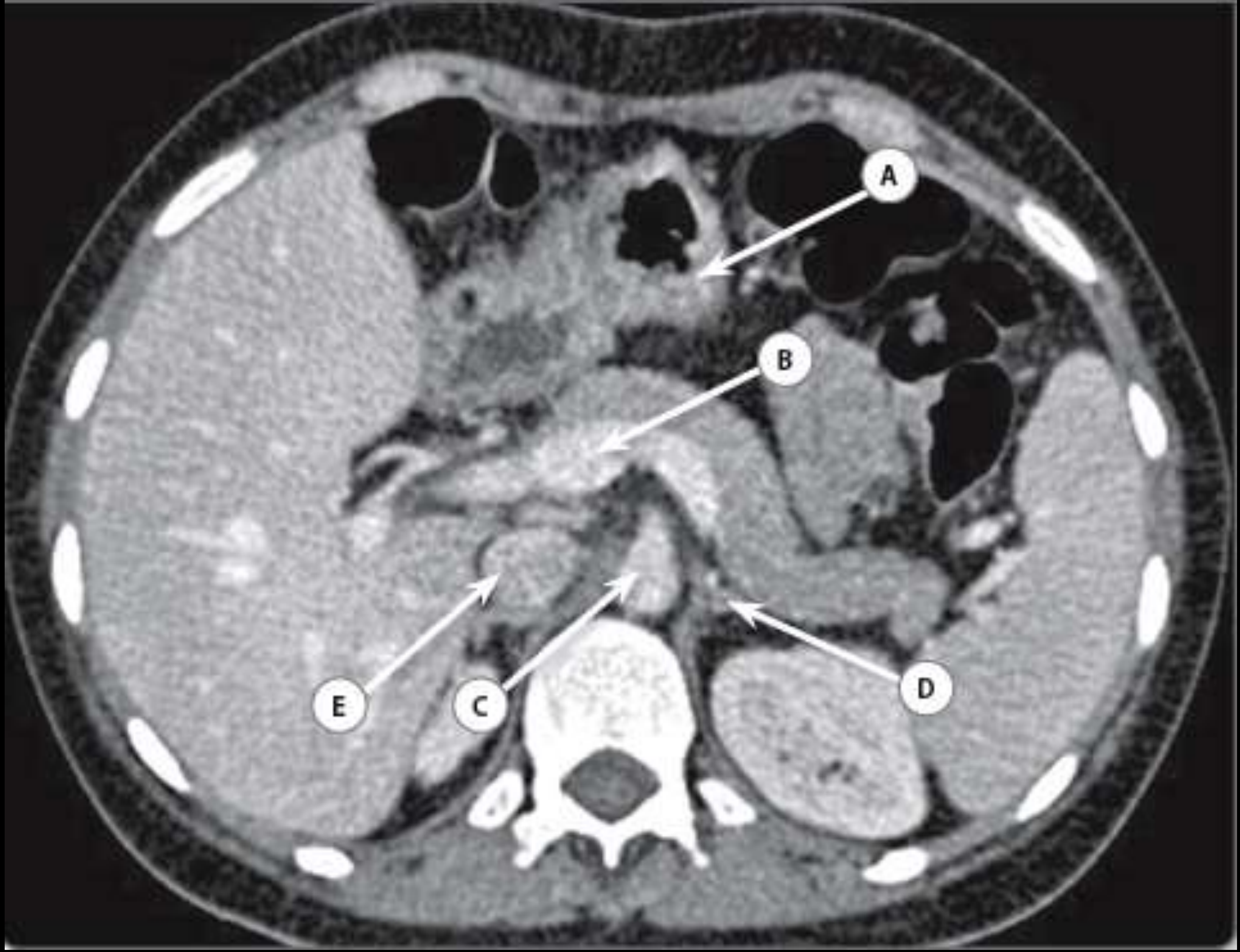
C Left erector spinae muscle

D Lower lobe of the right lung

E Right transverse process of T12

Familiarise yourself with axial views of CTs at various levels. Note the low attenuatio gallbladder which lies anterolaterally and is surrounded by liver parenchyma. Views at L1 and L2 are particularly important as an examination favourite for depicting the upper abdominal solid viscera, unpaired aortic branches and upper gastrointestinal tract.

Case 10.2



Case 10.2

A Gastric wall

B Portal vein (portal venous confluence)

C Aorta

D Left adrenal gland

E Inferior vena cava

The thickness of the gastric wall on CT examinations is very variable and it is better not to comment on abnormal 'thickness' unless the stomach has been deliberately distended by the patient drinking sufficient fluid. The splenic vein lies immediately posterior to the head, neck and body of the pancreas – without intravenous contrast, differentiation between the two is often impossible. At this level, you will often see areas of altered attenuation within the inferior vena cava (IVC) due to different veins in this vicinity containing varying levels of contrast. These flow artefacts should not be misinterpreted as thrombus.

Case 8.15

Case 8.15

A Right rectus abdominis muscle

B Left external oblique muscle

C Left internal oblique muscle

D Left transversus abdominis muscle

E Left erector spinae muscles

The abdominal wall can be divided into three parts – anterior, lateral and posterior. Each part of the abdominal wall comprises the following layers (from deep to superficial):

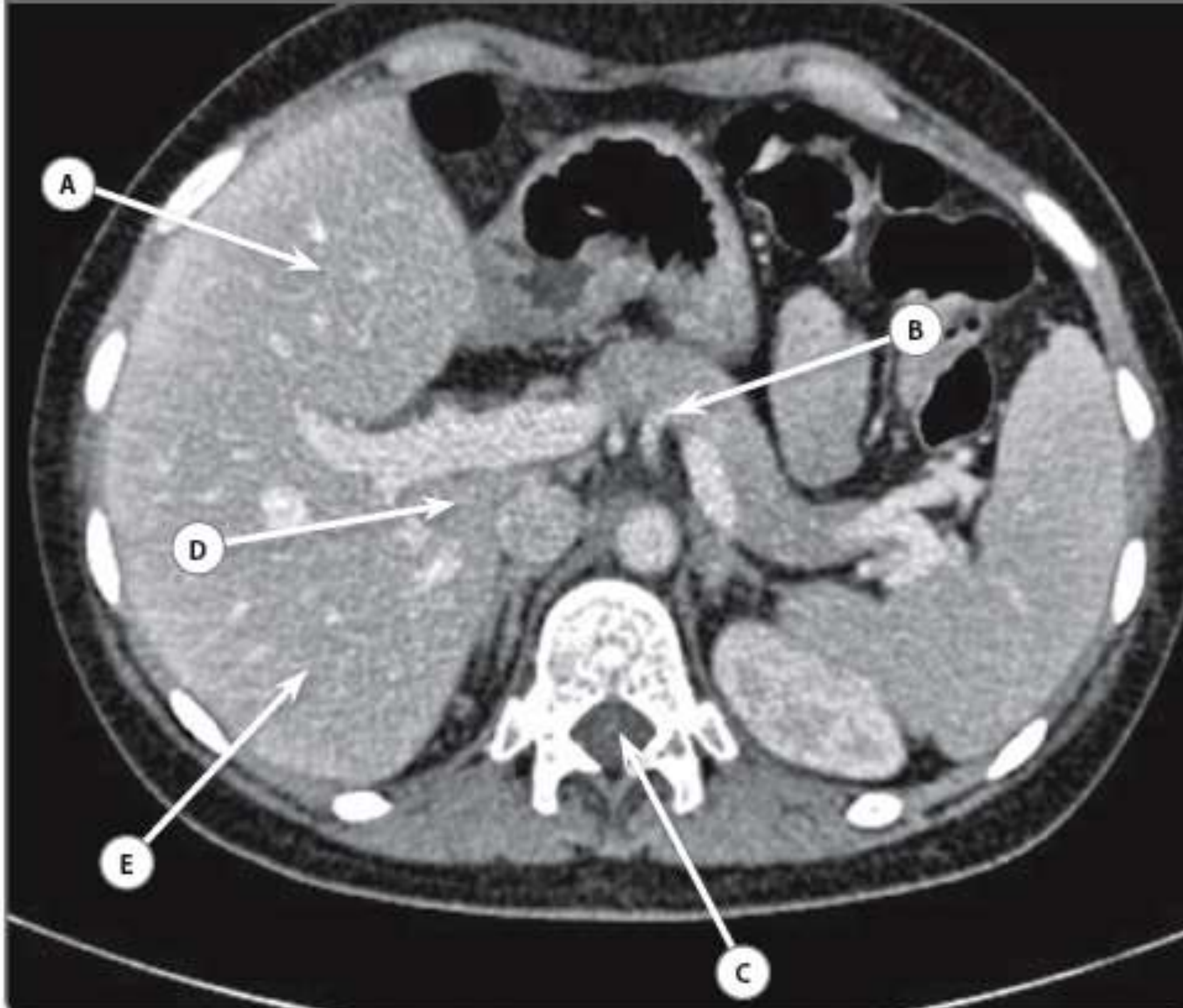
- the extraperitoneal fat
- the parietal peritoneum
- the fascial layer – the name of which is derived from the structures it covers. In the anterior abdominal wall it is called the fascia transversalis.
- the muscular layer – which is not present in the posterior abdominal wall
- the subcutaneous fat layer
- the superficial fascia
- the skin.

The muscular layer of the anterior and lateral abdominal wall consists of four muscles, which lead into the fibrous linea alba in the midline:

- paired paramedian rectus abdominis muscles, forming the most anterior wall
- three muscles forming each of the anterolateral walls, from superficial to deep:
  - external oblique muscle
  - internal oblique muscle
  - transversus abdominis muscle

Each of these muscles can be separately identified on abdominal CT or MRI due to the presence of intermuscular fat and connective tissue. They originate from the lower lateral ribs and their aponeuroses terminate in the inguinal regions, where they form the inguinal ligaments.

Case 7.14



Case 7.14

A Segment IVb

B Splenic artery

C Spinal cord

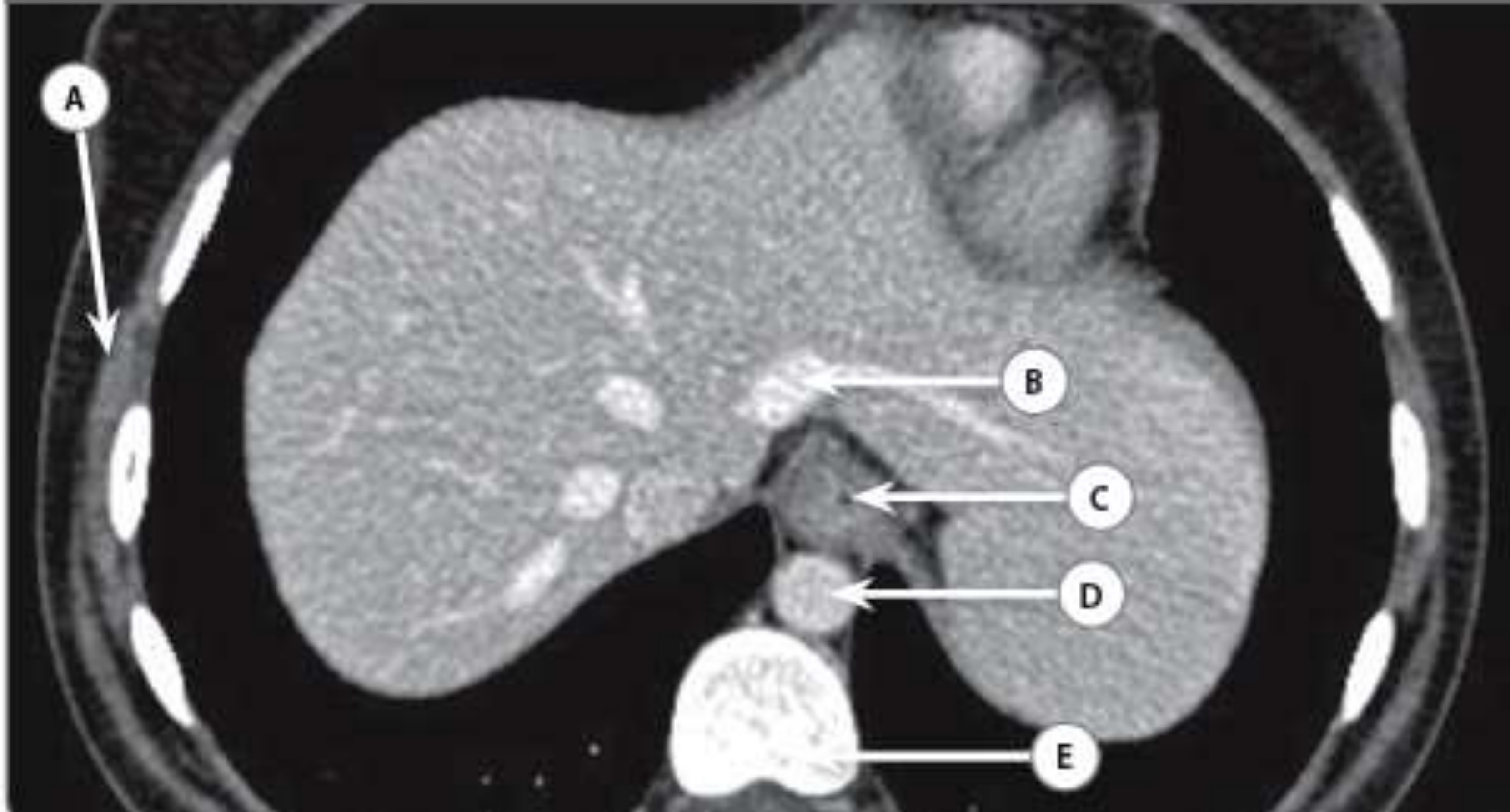
D Segment I (caudate lobe)

E Segment VI

The Couinaud classification divides the liver anatomy into eight segments, all with independent function. Each segment is centred on branches of the portal vein, hepatic artery and bile duct. In the periphery of each segment vascular outflow is provided via the hepatic veins.

Segment I is anatomically different from the other segments. It drains directly in the IVC. Note that the caudate lobe lies between the portal vein and the IVC.

Case 8.11



Case 8.11

A Right serratus anterior muscle

B Left hepatic vein

C Distal oesophagus

D Aorta

E Body of T10

The relationship of the aorta posterior to the oesophagus is well seen. Just lateral to this, the azygos and hemiazygos venous systems are visible. It is important to be able to recognise the anatomical levels of significant structures such as the gastro-oesophageal junction. Questions may ask you to identify the axial level for each image.

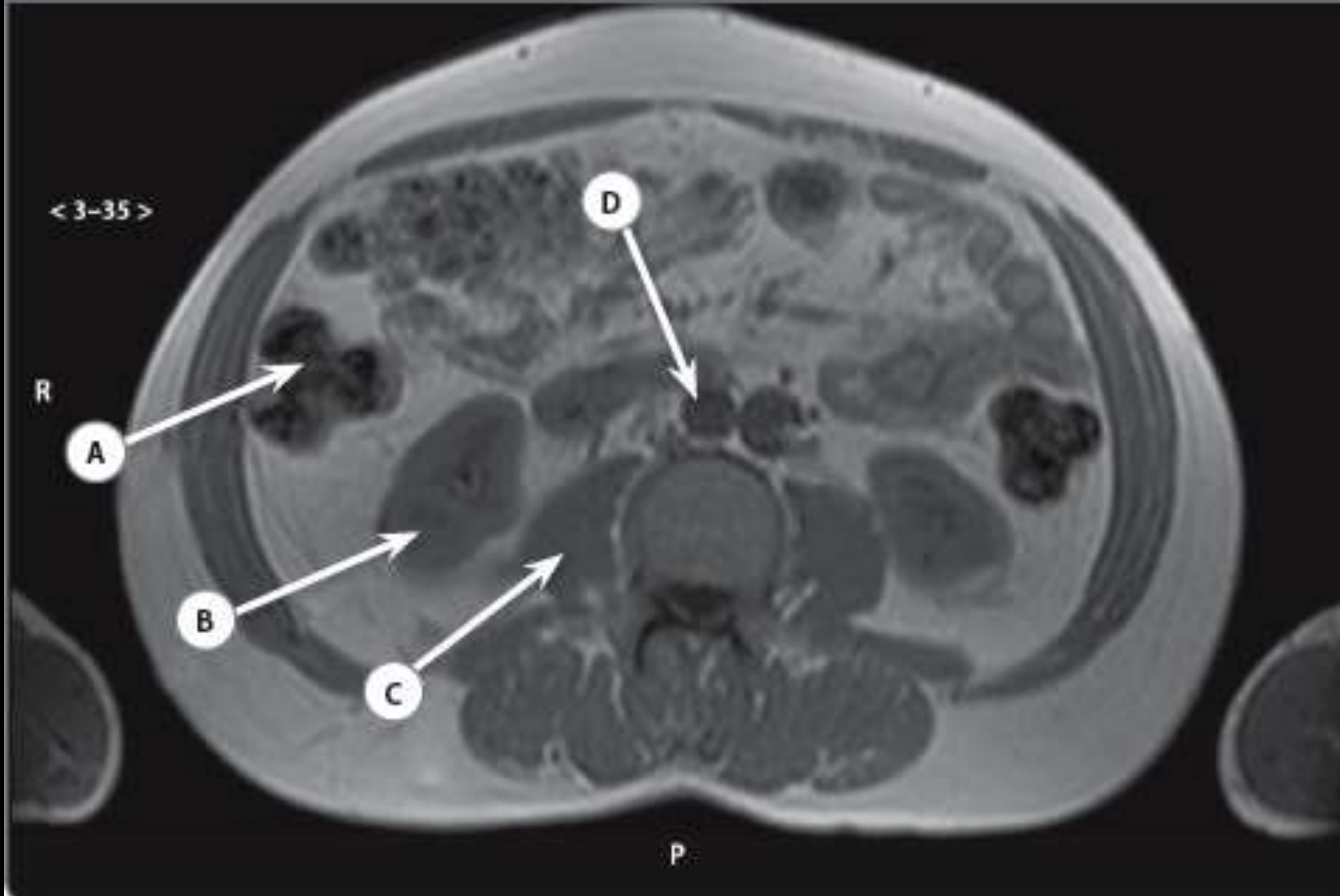
Further important levels include: entry of aorta, IVC and oesophagus through the diaphragm. An aide-mémoire to help memorise these levels is listed below:

Aortic hiatus = **12** letters = T12

Oesophagus = **10** letters = T10

Vena cava = **8** letters = T8

Case 7.11



A	Name the structure labelled A.	
B	Name the structure labelled B.	
C	Name the structure labelled C.	
D	Name the arterial structure labelled D.	
E	Which anatomical variant is present on this image?	

Case 7.11

A Ascending colon

B Right kidney

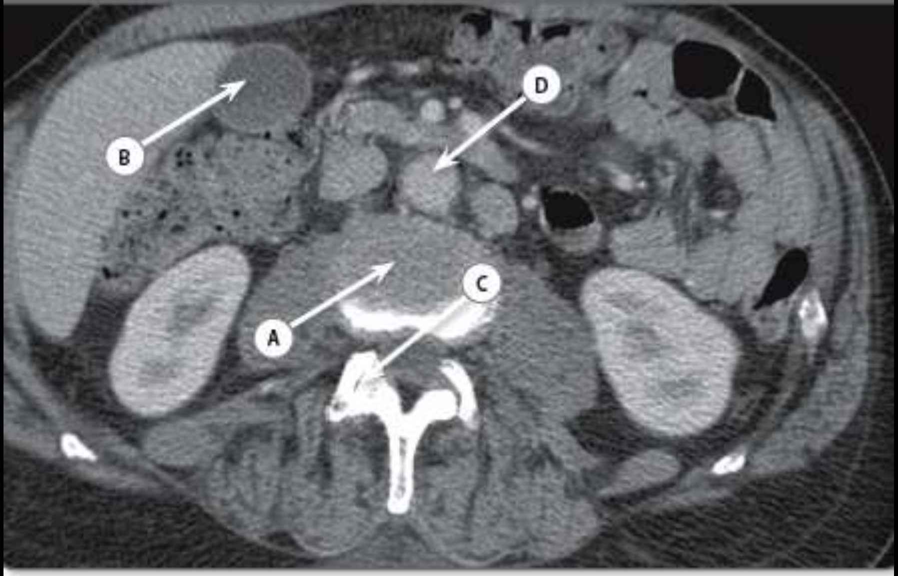
C Right psoas muscle

D Aorta

E Left-sided inferior vena cava

This is a T1-weighted axial sequence at the level of L2, in which the inferior vena cava (IVC) lies to the left of the aorta. This is a variation of normal and is a congenital variant. Several types exist but typically the left IVC terminates at the left renal vein and then crosses at the usual position to the right of the aorta. The IVC usually has a larger diameter than the aorta, a useful hint when trying to accurately label and identify the central vasculature on a single cross-sectional slice.

Case 5.8



Case 5.8

	QUESTION	WRITE YOUR ANSWER HERE
A	Name the structure labelled A.	
B	Name the structure labelled B.	
C	Name the structure labelled C.	
D	Name the structure labelled D.	
E	Which anatomical variant is present on this image?	

Case 5.8

A Intervertebral disc

B Gallbladder

C Right facet joint

D Abdominal aorta

E Double inferior vena cava

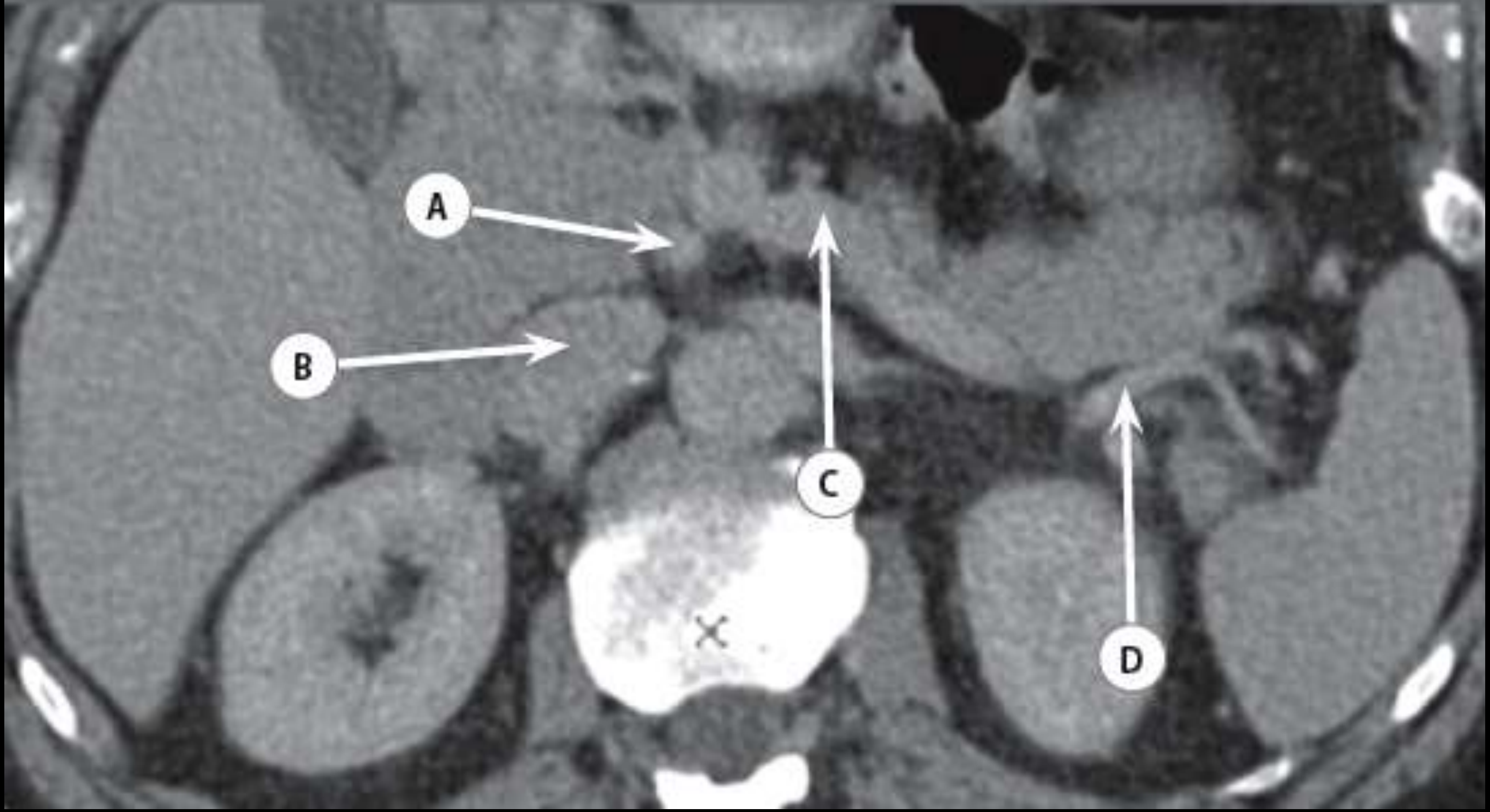
The double inferior vena cava (IVC) has a prevalence of 0.2–3.0% and is a result of the persistence of both sacrocardinal veins. The left IVC typically drains into the left renal vein, although numerous other variations have been described.

The aorta was purposely labelled to focus attention on the rather symmetrical coursing of the IVC on either side of it. The exam will not necessarily point out what variant is present and it will be up to you to identify and correctly label it.

The following venous variants may show up:

- Double IVC
- Retroaortic left renal vein
- Left IVC
- Azygous continuation of the IVC (absence of the hepatic segment of the IVC with azygous continuation)
- Circumaortic left renal vein

Case 3.14



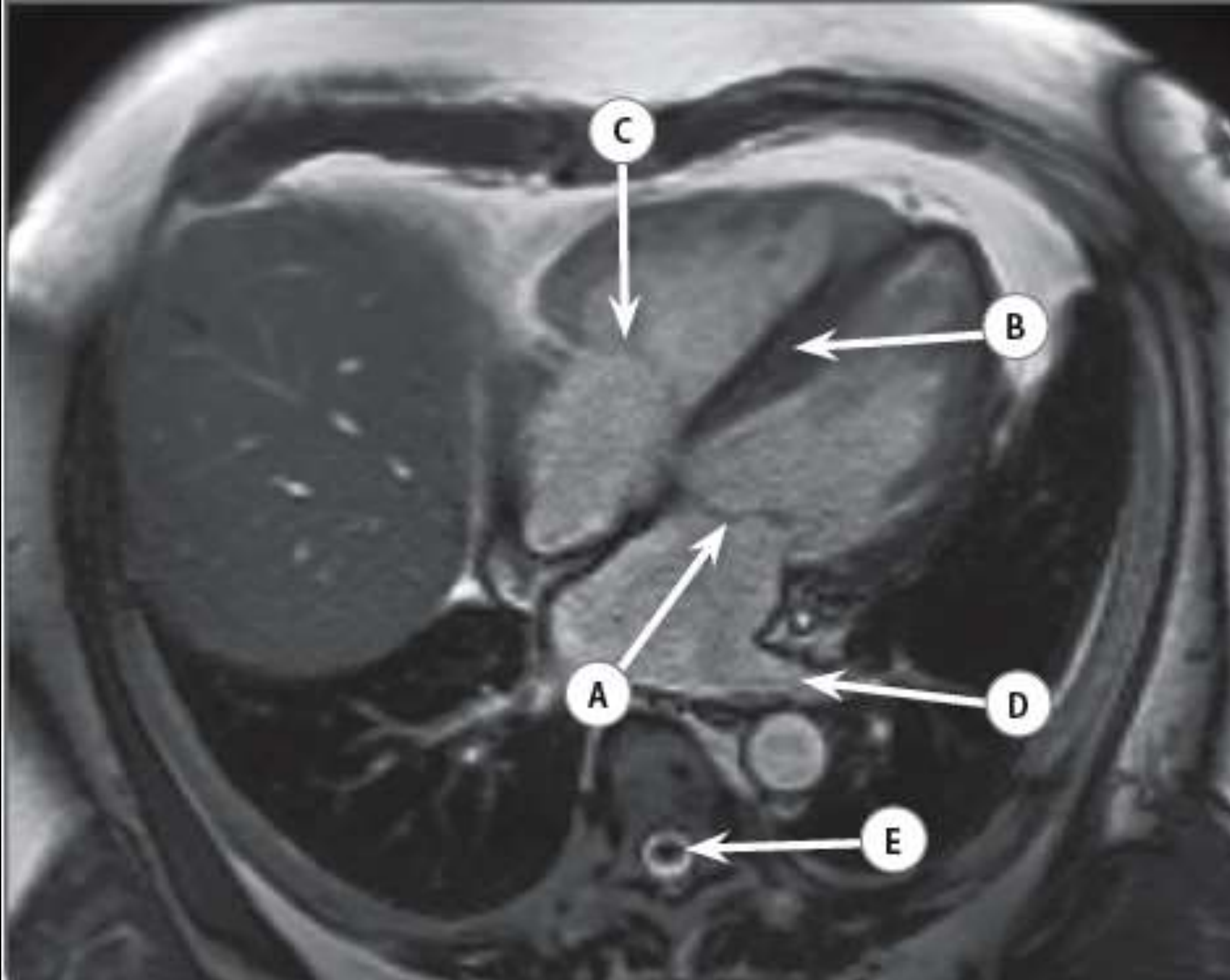
A	Name the structure labelled A.
B	Name the structure labelled B.
C	Name the structure labelled C.
D	Name the structure labelled D.
E	Which anatomical variant is present on this image?

Case 3.14

- **A** Superior mesenteric artery
- **B** Inferior vena cava
- **C** Splenic vein
- **D** Splenic artery
- **E** Partial midgut malrotation

At the level of L1/L2 the splenic vein is seen travelling towards its confluence with the superior mesenteric vein to form the portal vein. At that level, the superior mesenteric artery is expected to lie to the left of the portal confluence. However, here it is seen to be to the right and slightly posterior. This is a case of a partial midgut malrotation. The incidence of this variation is thought to be around 1/500 births and patients may be asymptomatic or present with midgut volvulus, which this variation predisposes to.

Case 1.15



Case 1.15

A Mitral valve (anterior leaflet)

B Muscular portion of interventricular septum

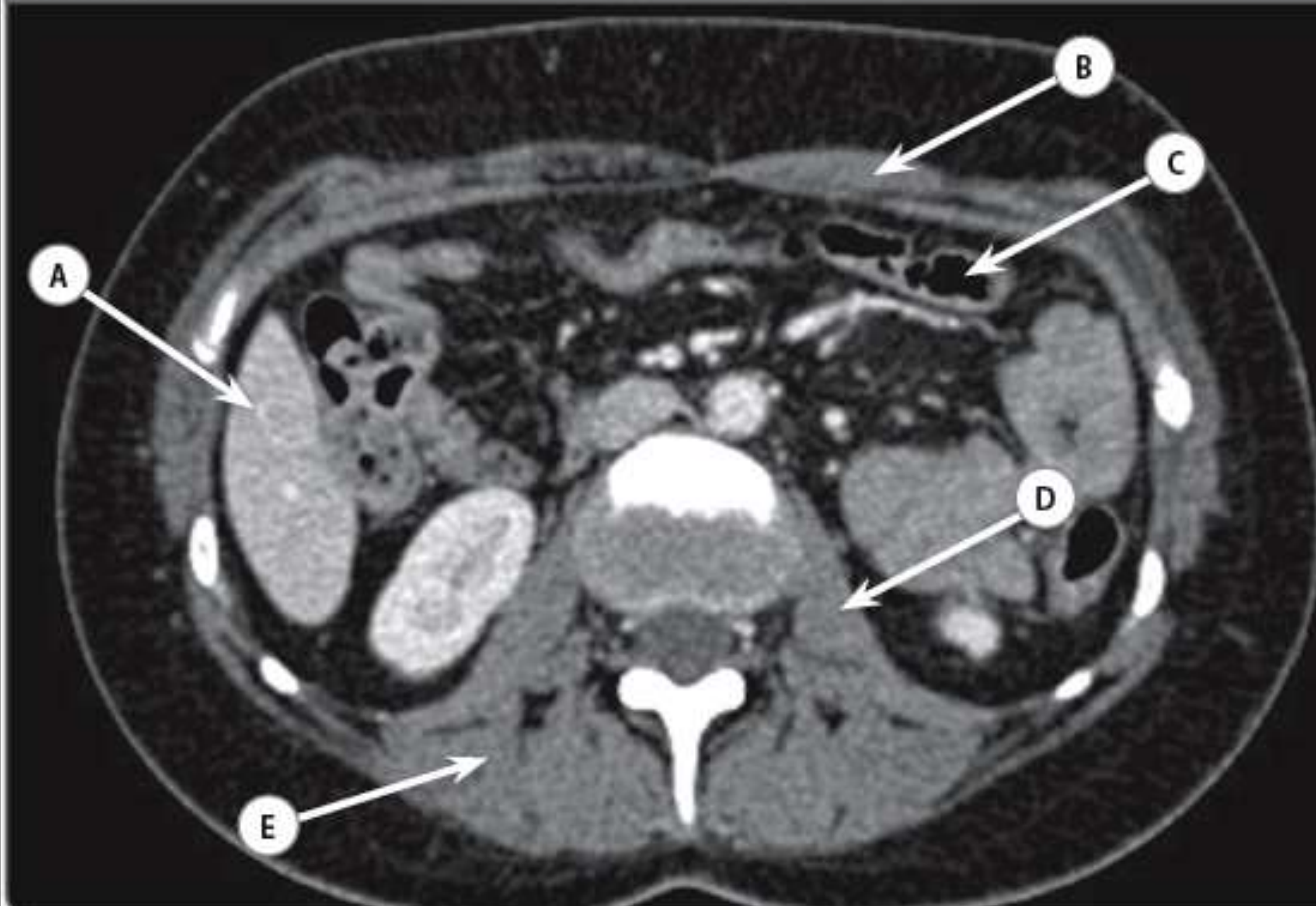
C Tricuspid valve (anterior leaflet)

D Left inferior pulmonary vein

E Spinal cord

Note that the septal leaflet of the mitral valve inserts into the septum at a different level to the septal leaflet of the tricuspid valve, being located more inferiorly towards the right ventricle. This is an important normal anatomical relationship and this offset should be looked for when performing a fetal heart scan at 18 weeks gestation. Tricuspid and mitral leaflets at the same level are often an indication of serious septal defects, e.g. atrioventricular defects. Also note that with this normal offset relationship, there is the potential for a septal defect to occur between the left ventricle and the right atrium, a rare occurrence known as a Gerbode defect.

Case 1.7



Case 1.7

A Right lobe of liver

B Left rectus abdominis muscle belly

C Transverse colon

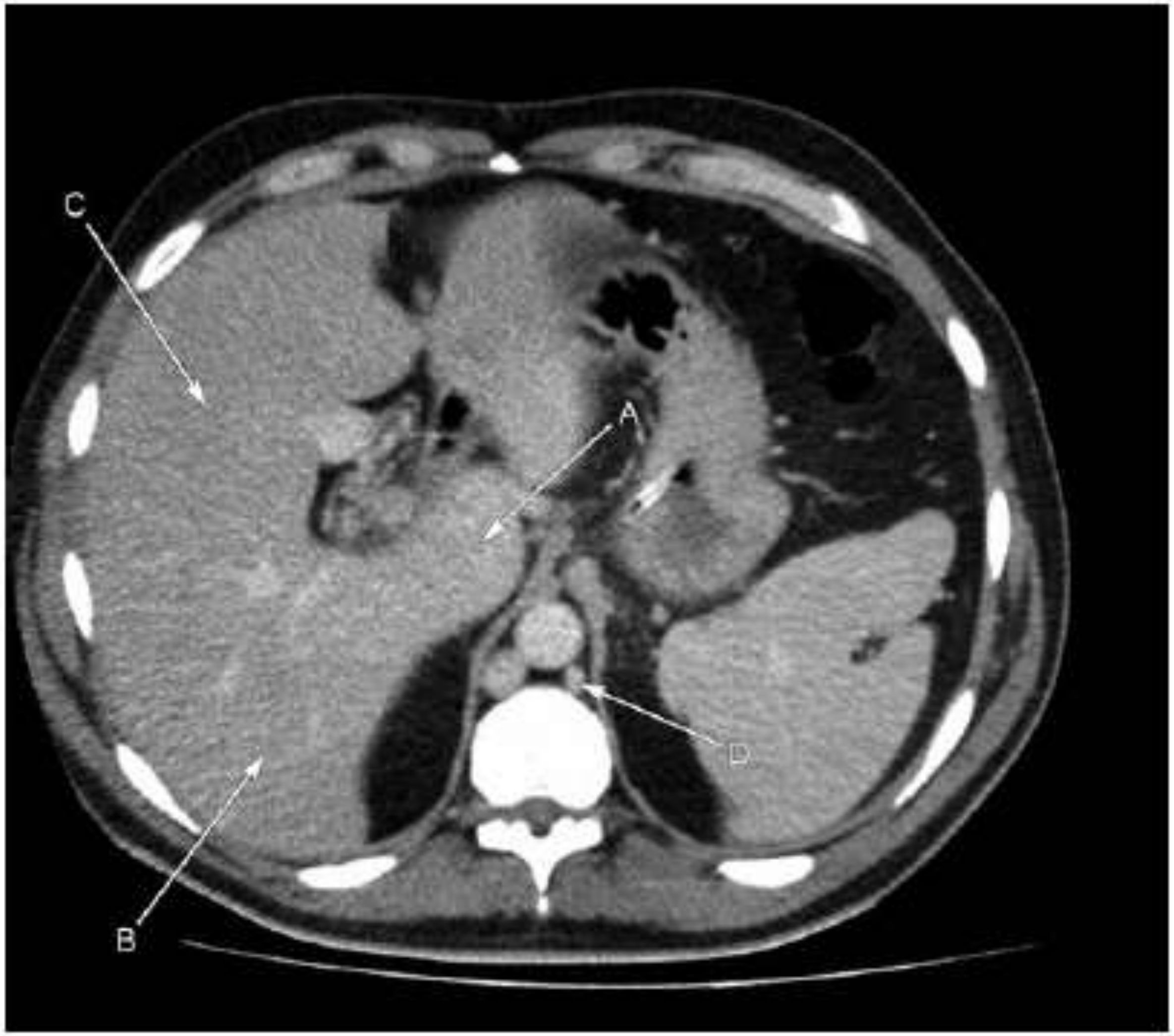
D Left psoas major muscle

E Right quadratus lumborum muscle belly

The abdominal wall can be divided into three parts: anterior, lateral and posterior. Each part of the abdominal wall is comprised of multiple layers, including skin, subcutaneous fat, fascial and muscular layers and parietal peritoneum. The muscular layer of the posterior abdominal wall consists of the following muscles:

- psoas major and minor muscles medially
- quadratus lumborum and erector spinae muscles laterally
- iliacus muscle inferiorly
- diaphragm superiorly

Question 10.5



Name the structures labelled **A** to **D**.

E What normal variant is present?

10.5 Axial CT contrast of the abdomen with IV contrast

A Segment I (caudate lobe) of the liver.
B Segment VI of the liver.
C Segment V of the liver.
D Hemiazygos vein.
E Azygos continuation of the inferior vena cava.

Couinaud was a French surgeon who divided the liver into eight functional segments, each with its own vascular and biliary drainage. (Figure 10.2). Bismuth further subdivided segment IV into IVA and IVB. The portal vein divides the liver into superior and inferior segments. The hepatic veins further subdivide these segments. The numbering of the segments can be remembered as they are numbered in approximate clockwise order, with segment II in the top left corner of the liver.

This image depicts an azygos continuation of the inferior vena cava. This anatomical variant occurs when the suprarenal inferior vena cava fails to form during embryological development. Associated situs anomalies are often present, but are not seen in this case.

See Question 8.19 for a further description of the liver segmental anatomy.

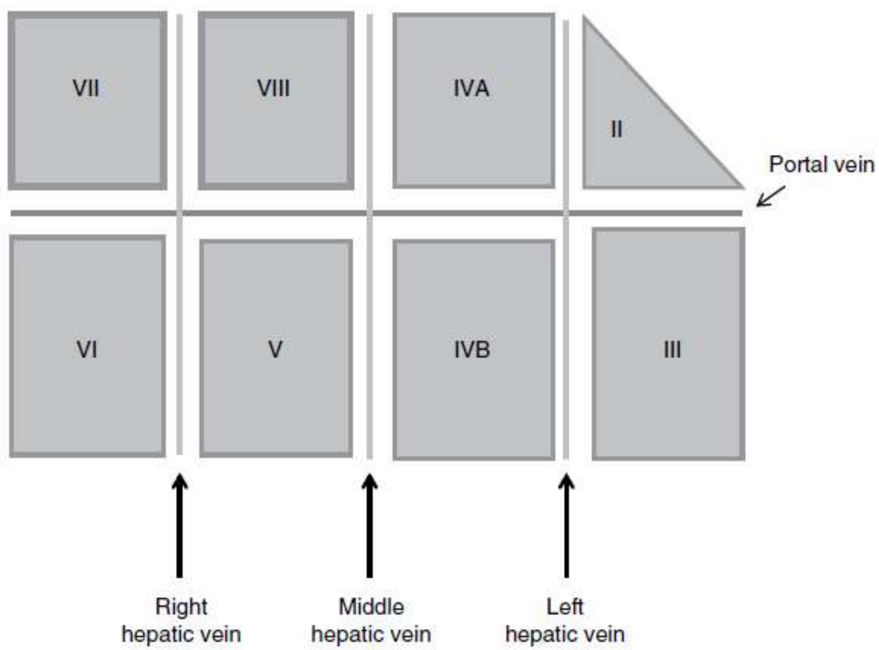
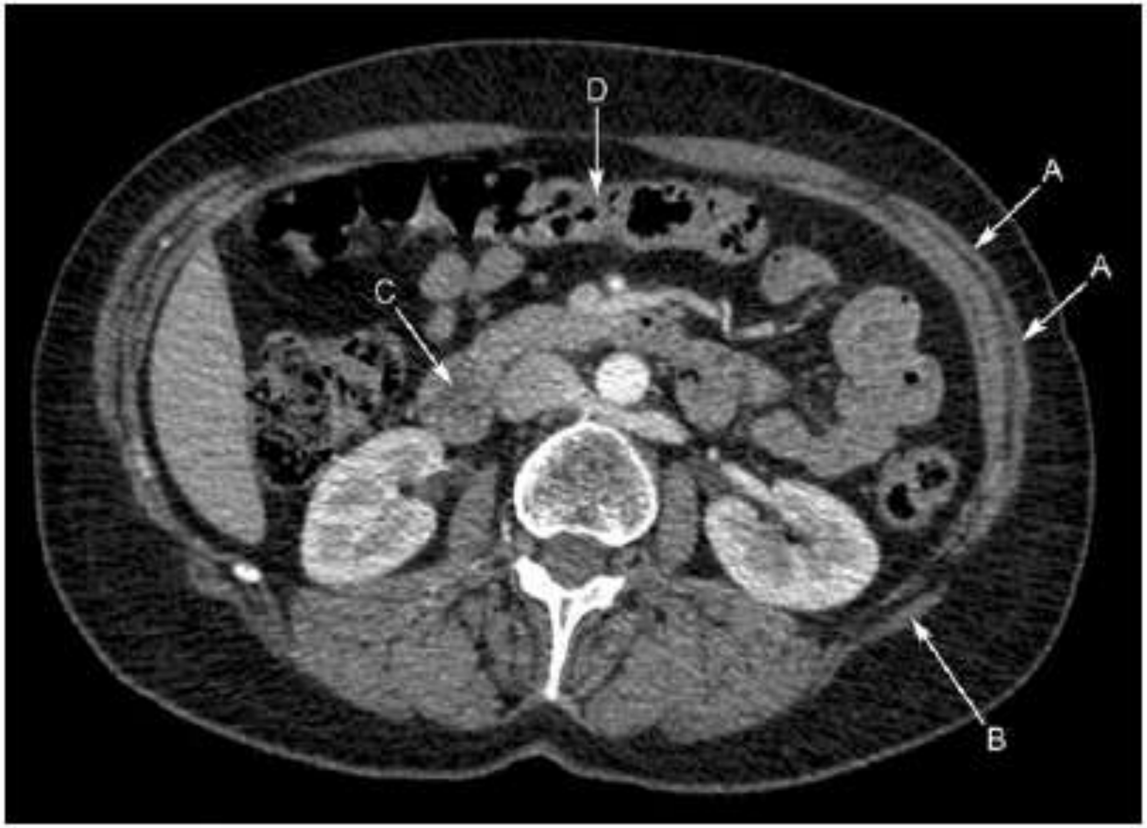


Figure 10.2 The segments of the liver

Question 10.8



Name the structures labelled **A** to **D**.
E What normal variant is present?

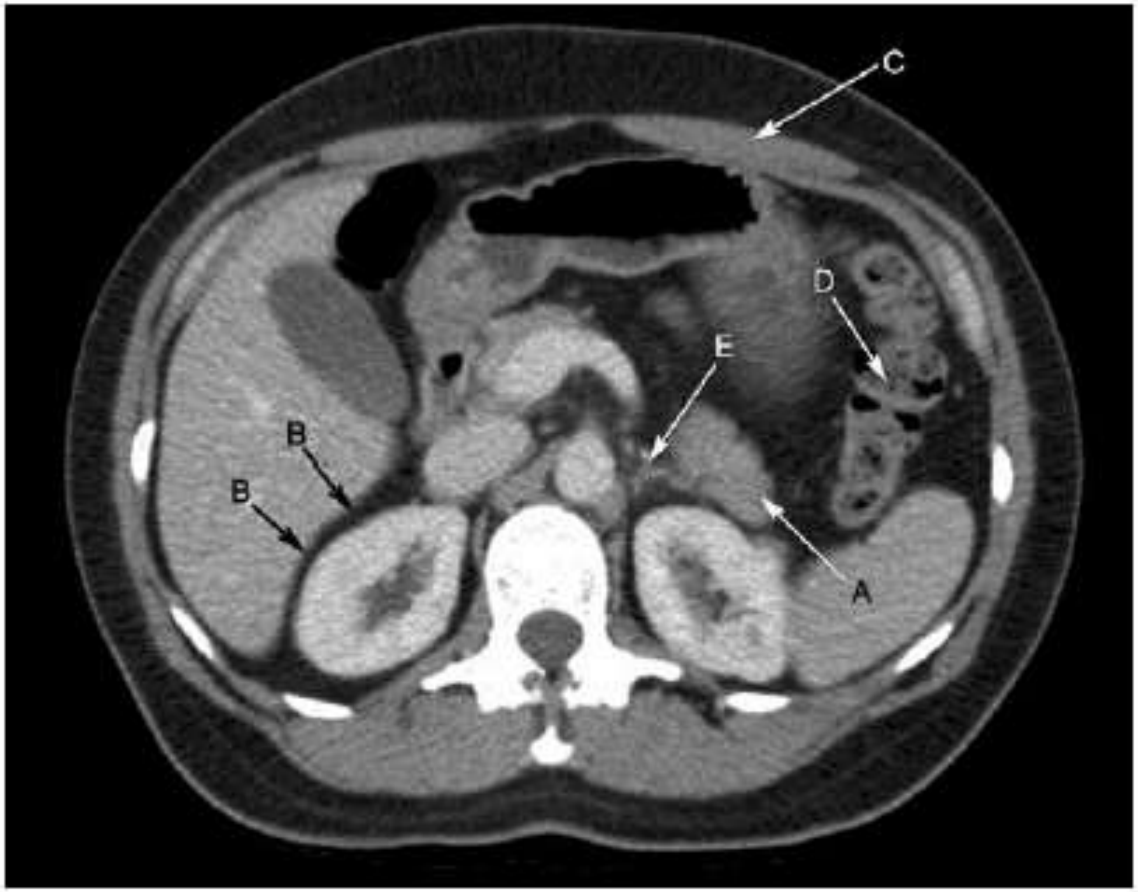
10.8 Axial CT of the abdomen with IV contrast

A Left external oblique muscle.
B Left latissimus dorsi muscle.
C Second part of the duodenum.
D Transverse colon.
E Retro-aortic left renal vein.

There are several common anatomical variants of the renal vasculature. This image depicts a retro-aortic left renal vein, which is seen in approximately 2–4% of the population. Although normally entirely asymptomatic, it can be implicated in 'posterior nutcracker syndrome', where the retro-aortic left renal vein is compressed between the aorta and the vertebrae leading to left renal venous hypertension. The symptoms of this include haematuria and flank pain.

The most common variant of the left renal venous system is the circumaortic renal vein (5–15% prevalence), in which the left renal vein bifurcates into a dorsal and ventral branch to encircle the aorta.

Question 9.13



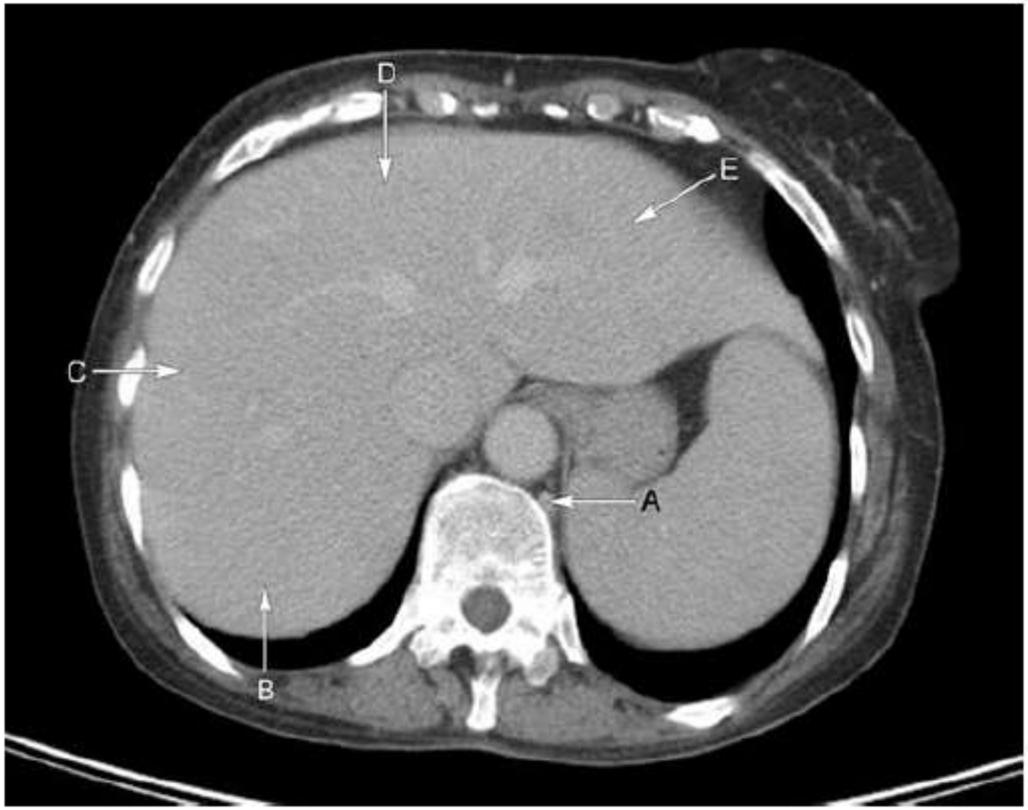
Name the structures labelled **A** to **E**.

9.13 Axial CT of the abdomen with IV contrast

A Tail of the pancreas.
B Hepatorenal recess (Morison's pouch).
C Left rectus abdominis muscle.
D Transverse colon.
E Left adrenal gland.

Morison's pouch is the eponymous name for the hepatorenal recess, a potential space separating the liver from the right kidney. It was described by a British surgeon named James Rutherford Morison (1853–1939). The hepatorenal recess is clinically important as fluid can collect here in the presence of ascites and haemoperitoneum. For this reason it is routinely assessed during FAST scanning of trauma patients.

Question 8.19



Name the structures labelled A to E.

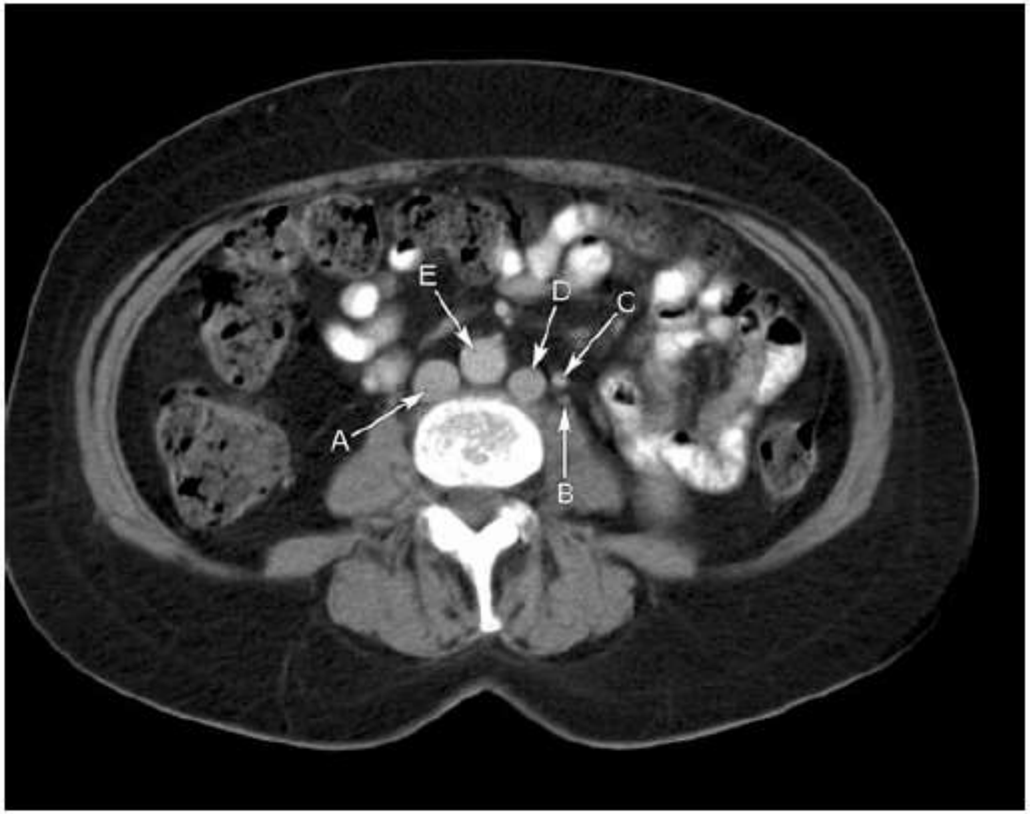
8.19 Axial CT of the abdomen with IV contrast

A Hemiazygos vein.
B Segment VII of the liver.
C Segment VIII of the liver.
D Segment IVa of the liver.
E Segment II of the liver.

In 1957, Couinaud described the liver as containing eight discrete functionally independent segments. Each segment has its own vascular inflow (branch of the portal vein), outflow (branch of the hepatic vein) and biliary drainage. The portal vein divides the liver into upper and lower segments. The caudate lobe is segment I. Segment IV is often subdivided into IVa (superior) and IVb (inferior).

For a diagram of the liver segments, please see Question 10.5.

Question 8.20



Name the structures labelled **A** to **E**.

8.20 Axial CT of the abdomen with IV and oral contrast

A Right inferior vena cava.
B Left ureter.
C Left gonadal vein.
D Left inferior vena cava.
E Aorta.

This patient has a double inferior vena cava, which is an uncommon abnormality with a prevalence of 0.2–3%. It results from persistence of both supracardinal veins during embryogenesis (normally the left supracardinal vein regresses or fuses with the right supracardinal vein). A double inferior vena cava should be suspected in cases of recurrent pulmonary embolism despite the deployment of a caval filter.

Question 7.12

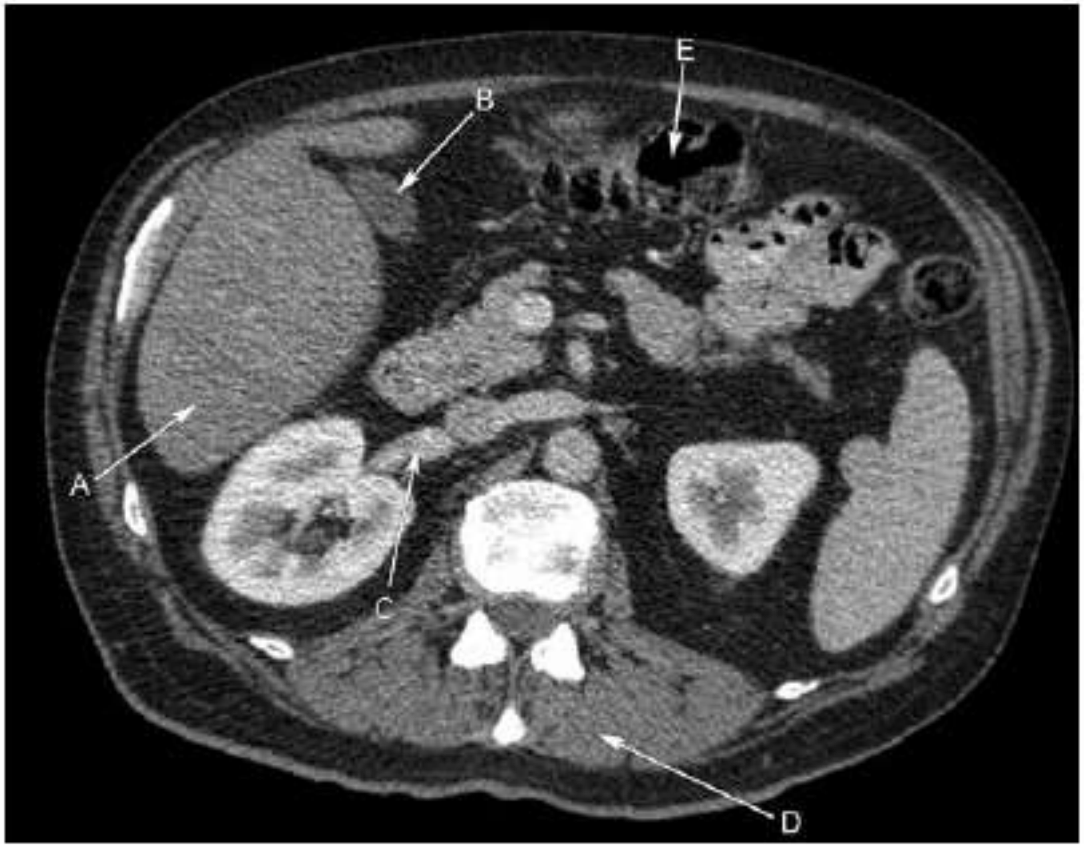
Name the structures labelled **A** to **E**.

7.12 Axial CT of the abdomen with IV contrast

A Superior pole of the right kidney.
B Superior mesenteric artery.
C Splenic vein.
D Tail of pancreas.
E Left renal vein.

The superior mesenteric artery arises at L1 just below the coeliac axis. It supplies the pancreas and bowel from the distal duodenum to two-thirds of the transverse colon. The splenic vein is the primary venous drainage of the spleen and runs along the posterior surface of the pancreas. It joins with the superior mesenteric vein to become the portal vein at the porto-splenic confluence. The left renal vein is longer than the right renal vein, owing to the right-sided position of the inferior vena cava in relation to the aorta, and passes anterior to the aorta at the level of L1.

Question 6.6



Name the structures labelled **A** to **E**.

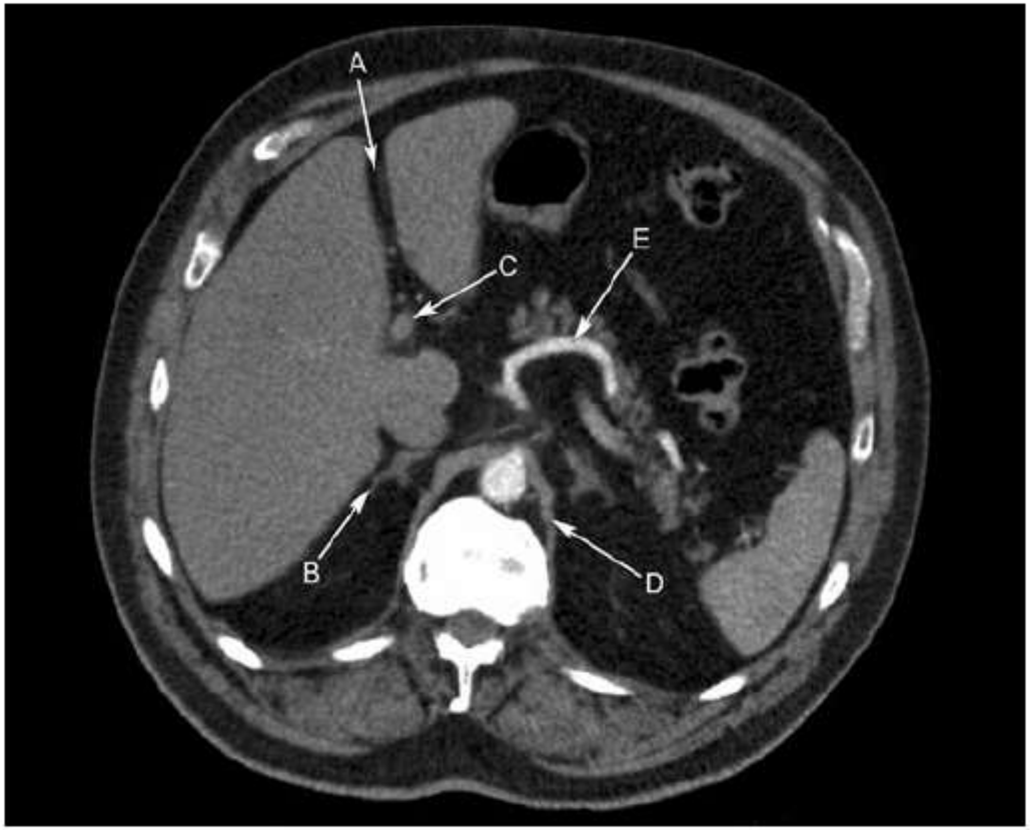
6.6 Axial CT of the abdomen with IV contrast

A Right lobe of the liver (segment VI).
B Gallbladder.
C Right renal vein.
D Left erector spinae muscle.
E Transverse colon.

The liver is traditionally divided into anatomical right and left lobes. These are demarcated on the anterior surface by the falciform ligament and on the posterior surface by the grooves for the ligamentum teres and ligamentum venosum. There are two further described lobes that are part of the right liver lobe – the quadrate lobe and caudate lobe. The quadrate lobe is situated anteroinferiorly between the gallbladder bed and the fissure for the ligamentum teres. The caudate lobe lies posteriorly between the inferior vena cava and the fissure for the ligamentum venosum. In addition to this anatomical classification, the liver is also described as consisting of eight functionally discrete segments. For further information about segmental anatomy of the liver, see Questions 8.19 and 10.5.

The gallbladder lies within the gallbladder fossa. The posterior surface is covered by visceral peritoneum and the anterior surface is adherent to the liver.

Question 3.15



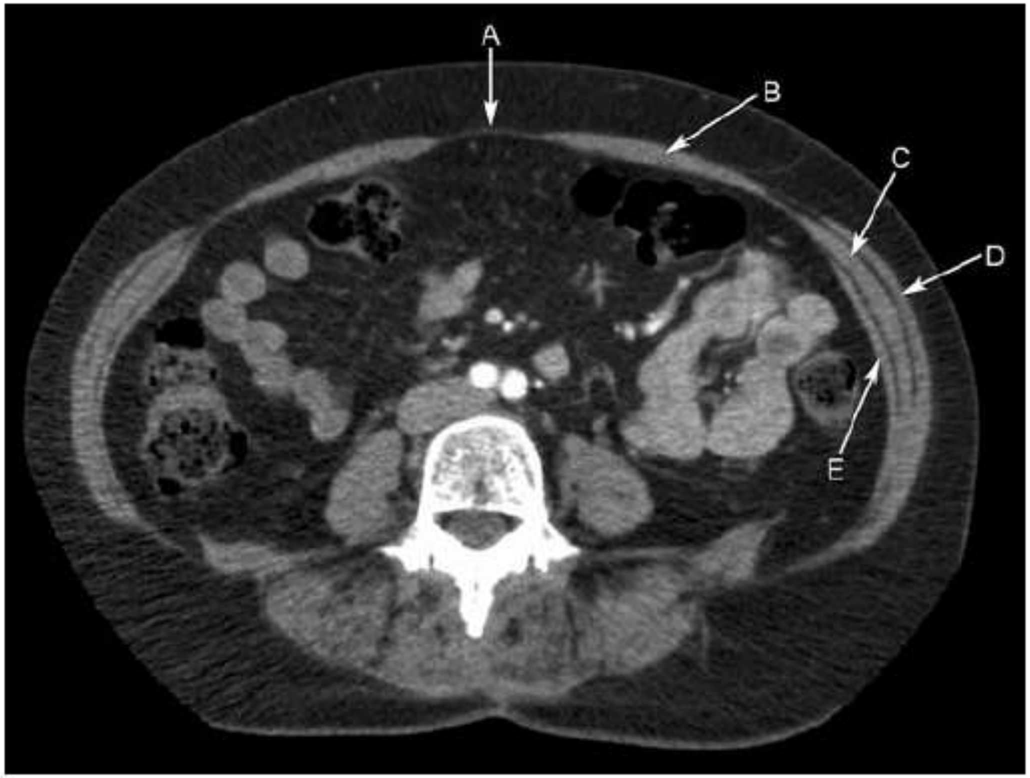
Name the structures labelled A to E.

3.15 Axial CT of the abdomen with IV contrast

A Fissure of the falciform ligament.
B Lateral limb of right adrenal gland.
C Portal vein.
D Left diaphragmatic crus.
E Splenic artery.

The falciform ligament is a thin peritoneal fold that attaches the left lobe of the liver to the peritoneum of the anterior abdominal wall. The adrenal glands are retroperitoneal structures that lie superior to the kidneys and are found at the level of T12/L1. They are not visualized on routine ultrasound in adults but can be seen in neonates. CT and MRI are the best forms of imaging for the glands. They are composed of a body and a medial and lateral limb.

Question 3.18



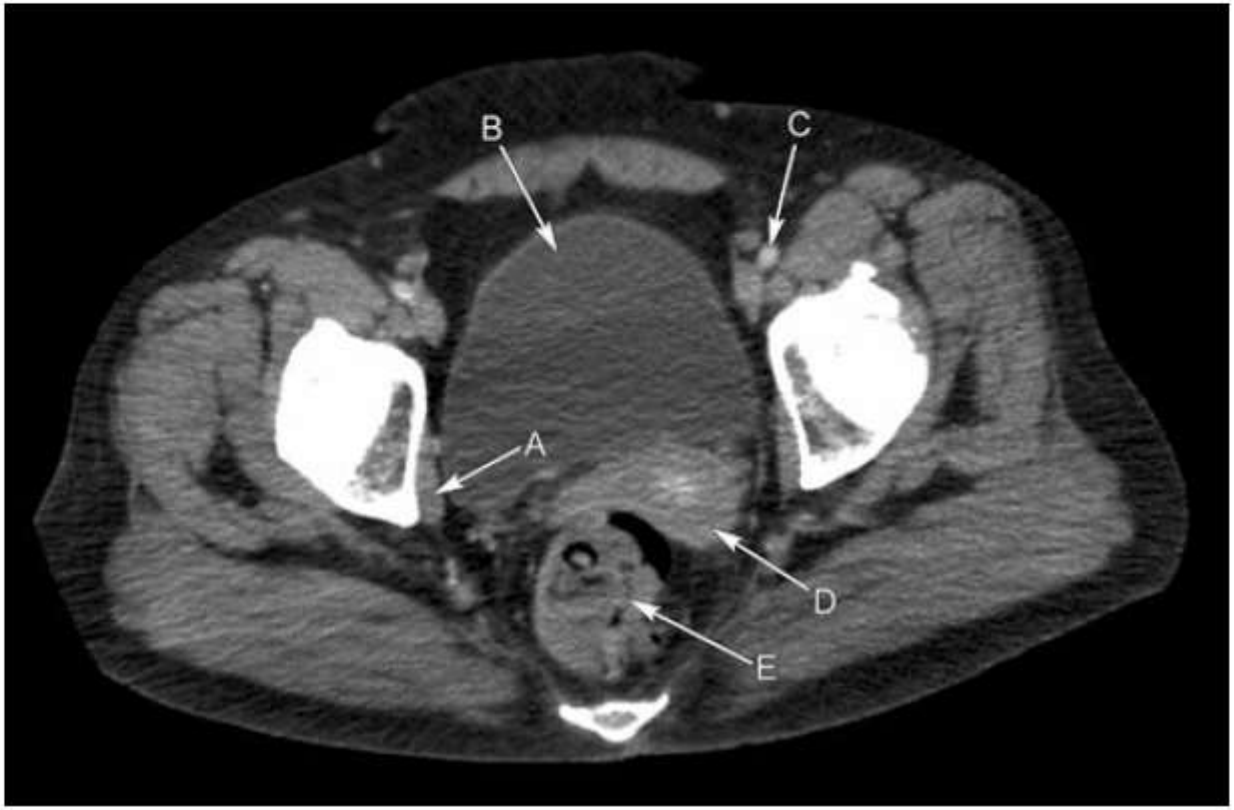
Name the structures labelled A to E.

3.18 Axial CT of the abdomen with IV contrast

A Linea alba.
B Left rectus abdominis muscle.
C Left internal oblique muscle.
D Left external oblique muscle.
E Left transversus abdominis muscle.

The rectus abdominis runs vertically down the centre of the abdomen and is divided in its midline by the linea alba. It is enclosed by the rectus sheath, which is formed by the aponeurosis of the external oblique, internal oblique and transversus abdominis (from anterior to posterior).

Question 3.11



Name the structures labelled **A** to **E**.

3.11 Axial CT of the female pelvis with IV contrast

A Right obturator internus muscle.
B Bladder.
C Left external iliac artery.
D Uterus.
E Rectum.

The bladder can be recognized on CT not only by its anterior relation to the other pelvic structures but also by its central low (fluid) attenuation.

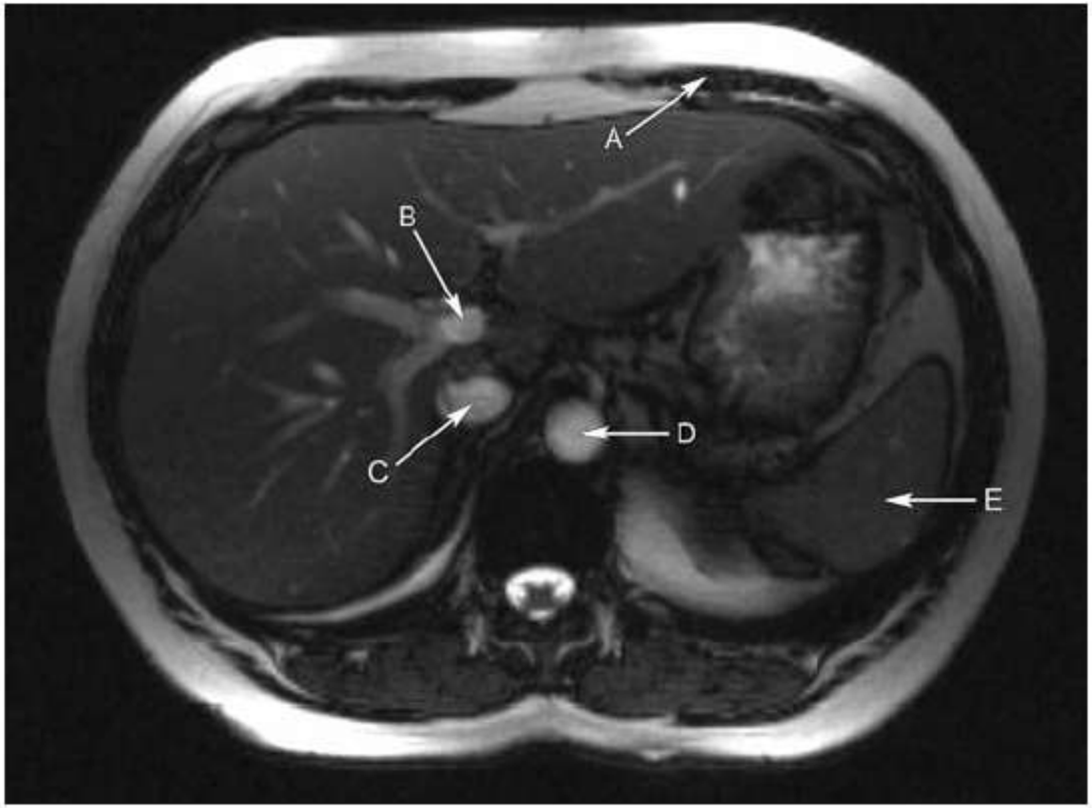
The obturator internus can be recognized as it 'lines' the pelvic sidewalls. The obturator internus muscle arises from the inner surface of the anterolateral wall of the pelvis. It exits the pelvis through the lesser sciatic foramen to attach to the greater trochanter of the femur.

The rectus abdominis can still be visualized within the anterior abdominal wall and the level of the inguinal ligament has therefore not been reached. It is only when the external iliac artery passes underneath the inguinal ligament that it becomes the common femoral artery. The mnemonic **NAVY** (**N**erve, **A**rtery, **V**ein, **Y**-fronts) can also be applied to the iliac vessels and nerves, with the external iliac artery lying lateral to the vein.

The rectum is the final part of the colon and is located posterior to the bladder in males and the vagina and uterus in females (the uterus can be seen between the bladder and the rectum in this image).

The sartorius originates from the anterior superior iliac spine and crosses two joints (the hip and the knee) to insert into the medial surface of the tibia. It can be recognized not only as an anterior thigh muscle but because it has a characteristic triangular shape with the tip of the triangle orientated posteriorly.

Question 2.14



Name the structures labelled **A** to **E**.

2.14 Axial T2 MRI of the abdomen

- **A** Left rectus abdominis muscle.
- **B** Portal vein.
- **C** Inferior vena cava.
- **D** Aorta.
- **E** Spleen.

The rectus abdominis are paired abdominal muscles extending vertically down the length of the anterior abdominal wall from the xiphisternum to the pubic symphysis. They are separated by a midline band of connective tissue called the linea alba. The spleen is located in the left upper quadrant of the abdomen beneath the ninth and twelfth ribs. In general it has a maximum normal length of 13 cm in adults.

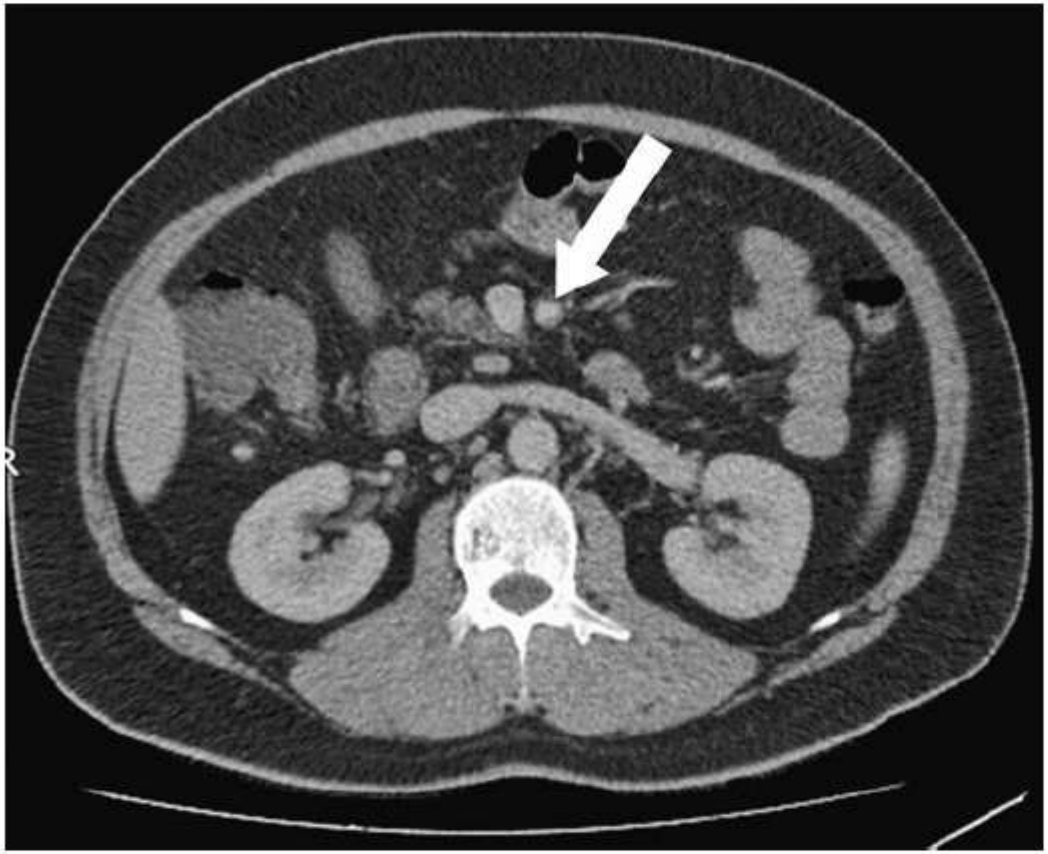
- **Question 44:**

Question 44: Axial CT of the pelvis

Answer: Left gluteus medius muscle

- The gluteus medius muscle is the middle of the three gluteal muscles.
- Because gluteus maximus, the most superficial of the three muscles, originates more inferiorly, gluteus medius appears to be the most superficial in the superior sections of the pelvis, as on the image.
- It inserts distally on the anterolateral aspect of the greater trochanter of the femur.

- Question 45:



■ Question 45: Axial CT of the abdomen

Answer: Superior mesenteric artery

- The superior mesenteric artery is the second anterior branch of the abdominal aorta and supplies the midgut.
- It runs parallel to, and to the left of, the superior mesenteric vein (SMV). It enhances synchronously with the aorta in the arterial phase and may show calcification, which helps to distinguish it from the SMV in axial images.
- It passes anterior to the left renal vein, the third part of the duodenum, and the uncinate process of the pancreas.

Question 29:

Question 29: Axial CT of the abdomen

Answer: Left renal vein

- The left renal vein is longer than the right renal vein and crosses under the origin of the superior mesenteric artery.
- The left renal vein usually crosses anterior to the aorta.
- It may, however, pass behind the aorta (a retroaortic left renal vein) or have elements anterior and posterior to the aorta (a circumaortic left renal vein). When present, the retroaortic component is always caudal to the preaortic component.

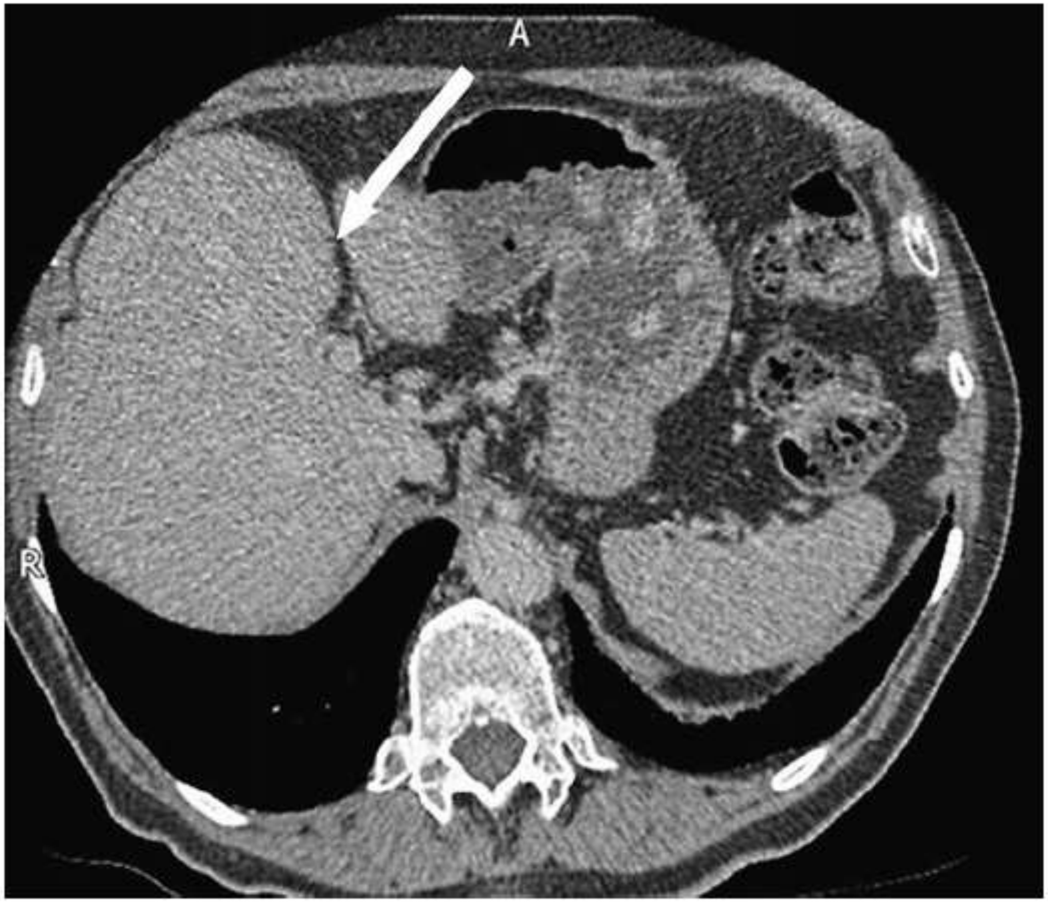
Question 30:

Question 30: Axial CT urogram

Answer: Right ureter

- There is usually one ureter on either side, but they can be double in duplex kidneys.
- Ureters are easy to see on delayed phase renal scans (usually acquired more than 10 minutes after intravenous contrast medium injection).
- As the kidneys do not lie at the same level, one ureter may be seen in cross section while the other ureter is imaged at the level of the renal pelvis. Excreted intravenous contrast within the ureter may help to identify it.

■ Question 25:



Question 25: Axial CT of the abdomen

Answer: Fissure of falciform ligament

- The falciform ligament is attached to the diaphragm and separates the medial and lateral segments of the left lobe of the liver.
- The falciform ligament is composed of two layers of peritoneum closely united together.
- Inferiorly, the falciform ligament contains the round ligament (the obliterated umbilical vein) between its layers.
- The round ligament (also known as the ligamentum teres) is found on the inferior aspect of the liver anterior to the caudate lobe.
- It merges with the fissure of the ligamentum venosum, which contains the obliterated ductus venosus that connects the left portal vein to the left hepatic vein.

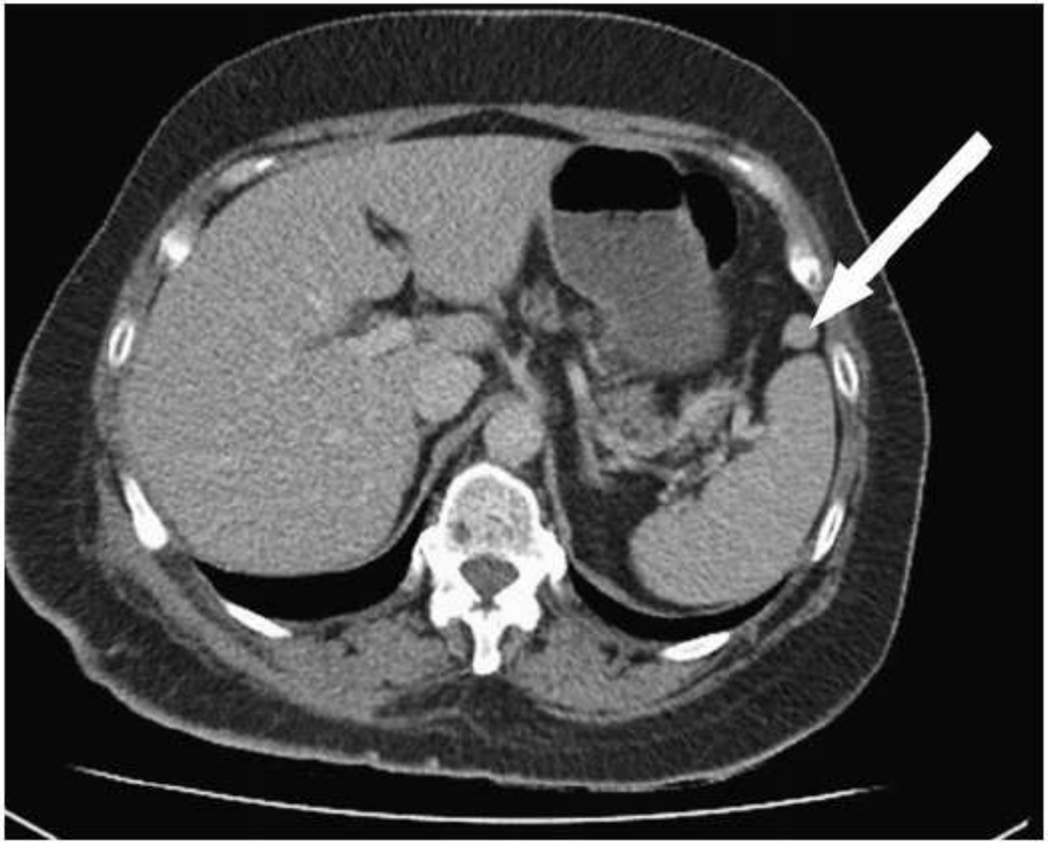
Question 26:

Question 26: Axial CT of the abdomen

Answer: Splenic vein

- The splenic vein runs alongside the splenic artery and the pancreas to form the portal vein at its confluence with the superior mesenteric vein.
- Differentiation from the splenic artery can be difficult. It is useful to consider the intravenous contrast phase of the scan. In this study, the contrast is in the arterial phase (because the aorta is enhanced). Therefore, the splenic artery will be bright, whereas the vein will be of lower attenuation.
- As the splenic artery is tortuous, it is rarely imaged whole in one axial slice.

Question 18:

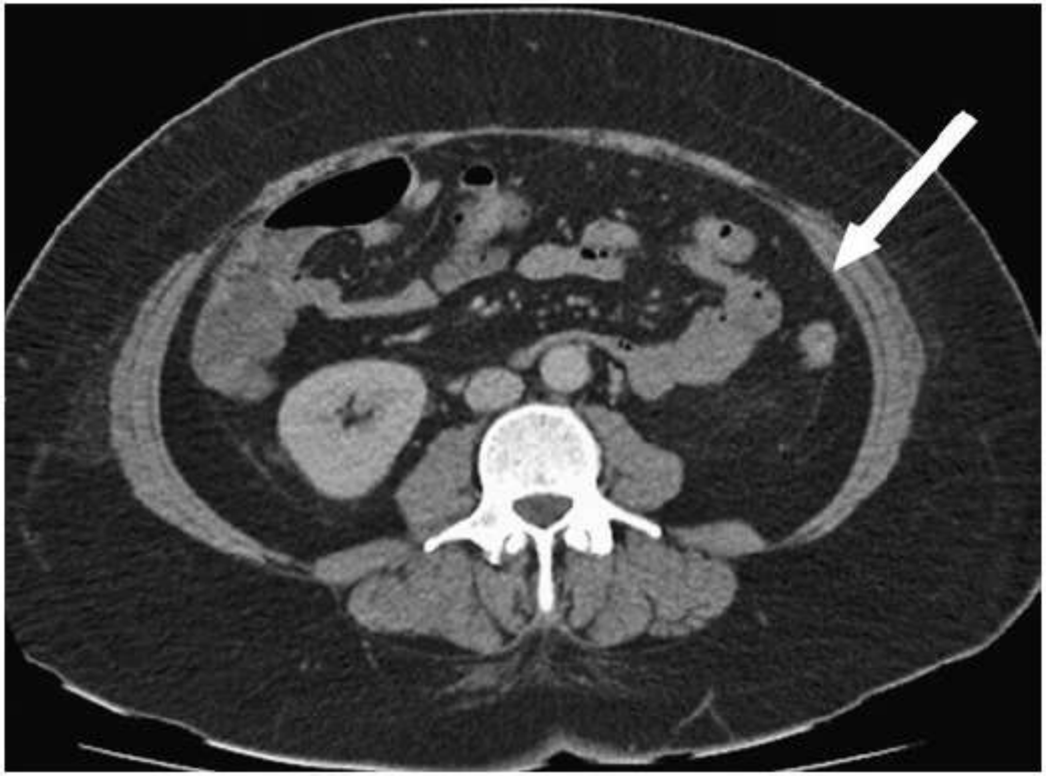


Question 18: Axial CT of the abdomen

Answer: Splenunculus

- Splenunculus is a very common normal variant that can be confused with disease such as lymphadenopathy.
- It is often seen as a small, rounded structure near the hilum of the spleen of isointensity/equal reflectivity/isodensity to the spleen on MRI/US/CT, respectively.
- A splenunculus should follow the enhancement characteristics of the spleen in all phases of enhancement.

- **Question 10:**



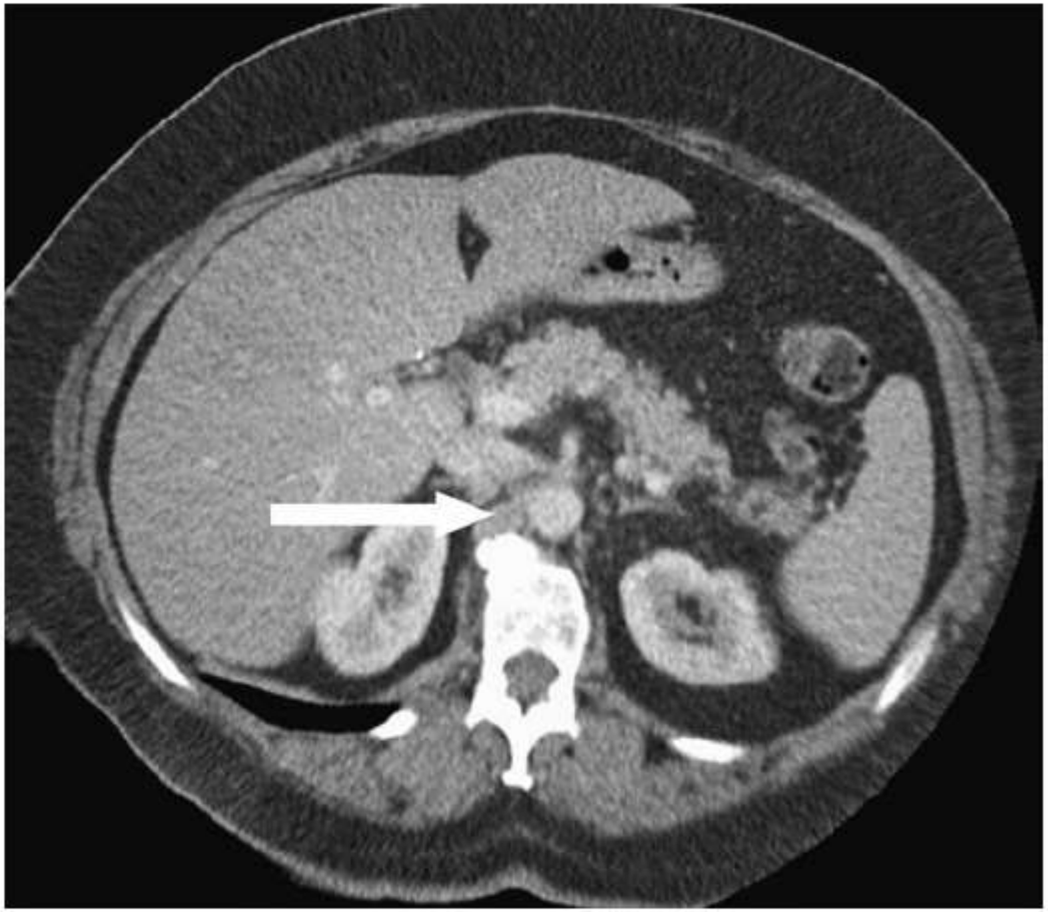
Question 10: Axial CT of the abdomen

Answer: Left transversus abdominis muscle

- The left transversus abdominis muscle is the innermost of the lateral abdominal muscles. Its fibres run transversely from lateral to medial.
- On its inferior border, it forms a tendinous fold, part of which is the roof of the inguinal canal.

■ Question 11:

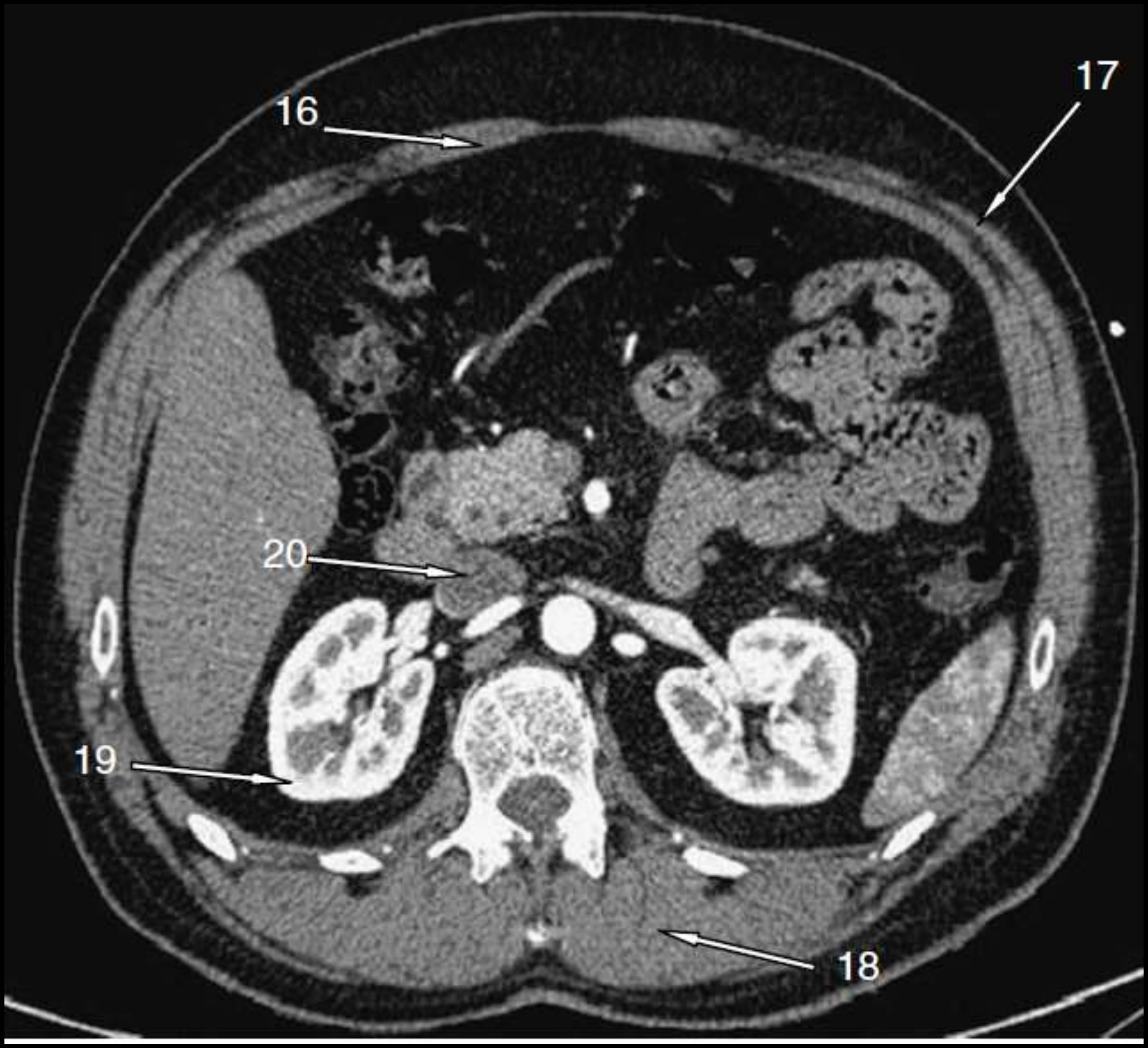
Question 13:



Question 13: Axial CT of the abdomen

Answer: Right crus of the diaphragm

- The diaphragmatic crura are a paired structure; however, the right crus extends more inferiorly to L3 and may be confused with other structures.
- The left crus inserts onto L2.


16
17
20
19
18

CT Abdomen

16. Right rectus abdominis muscle
17. Left external oblique muscle
18. Left erector spinae muscle
19. Right kidney (cortex)
20. Inferior vena cava

It is important to recognise the phase of contrast to correctly identify the vascular structures.

Question 1.13

Name the structures labelled **A** to **E**.

1.13 Axial CT abdomen with IV contrast

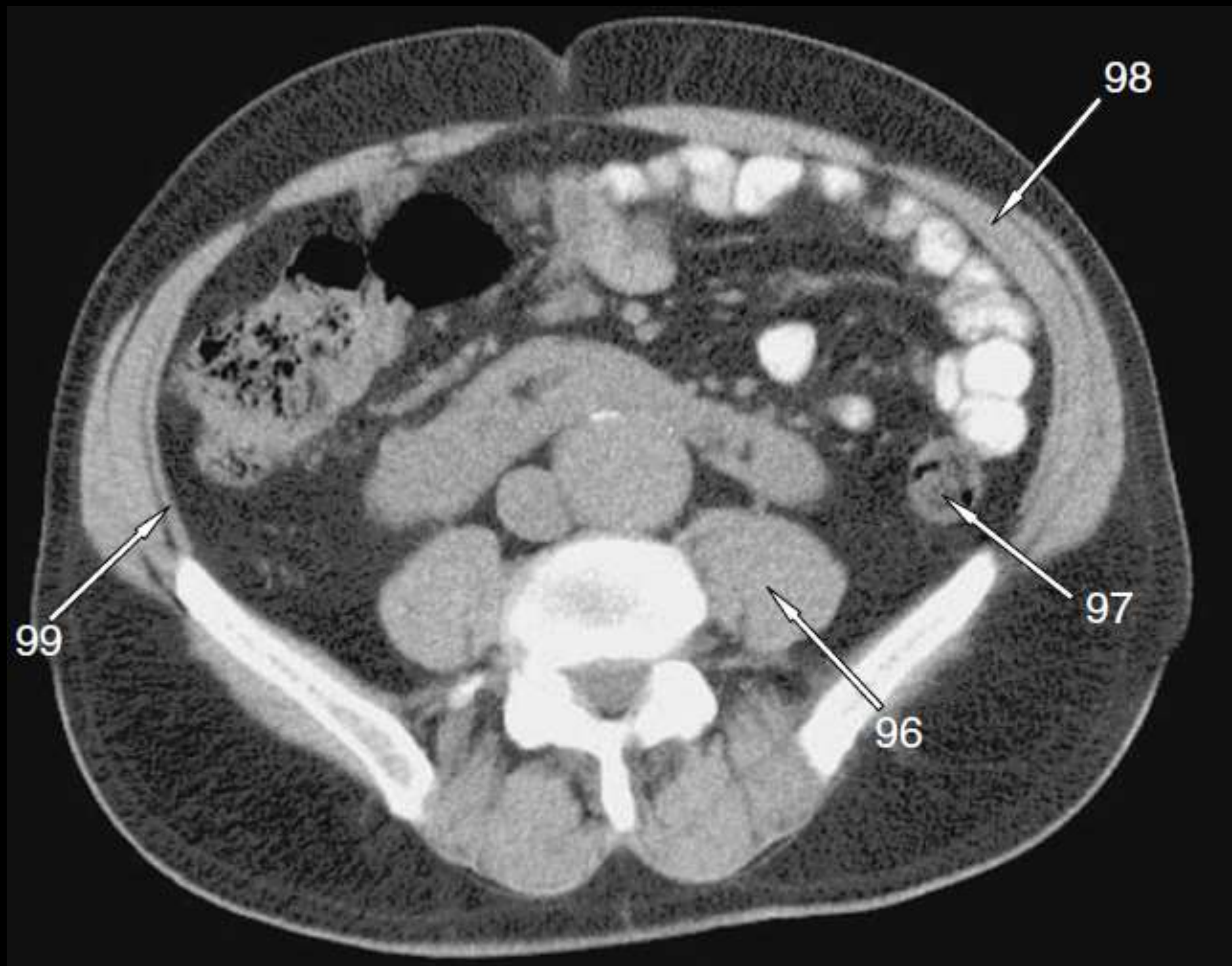
A Right crus of the diaphragm.
B Inferior vena cava.
C Superior mesenteric artery.
D Splenic vein.
E Left renal vein.

The crura of the diaphragm are tendinous structures that attach the diaphragm to the vertebral column. The right crus is larger and longer than the left and is attached to L1, L2 and L3. Because the inferior vena cava is on the right of the aorta, the left renal vein is longer than the right and passes anterior to the aorta. The left renal vein receives:

- Gonadal vein (testicular in males, ovarian in females).
- Left inferior phrenic vein.
- Left suprarenal vein.
- Left second lumbar vein.

These vessels drain directly into the inferior vena cava on the right side.

The superior mesenteric artery arises from the anterior surface of the aorta, just inferior to the origin of the coeliac trunk, at the vertebral level of L1. It supplies the intestine from the distal duodenum to the distal two-thirds of the transverse colon. The splenic vein runs posterior to the body and neck of the pancreas to join the superior mesenteric vein that together form the portal vein.

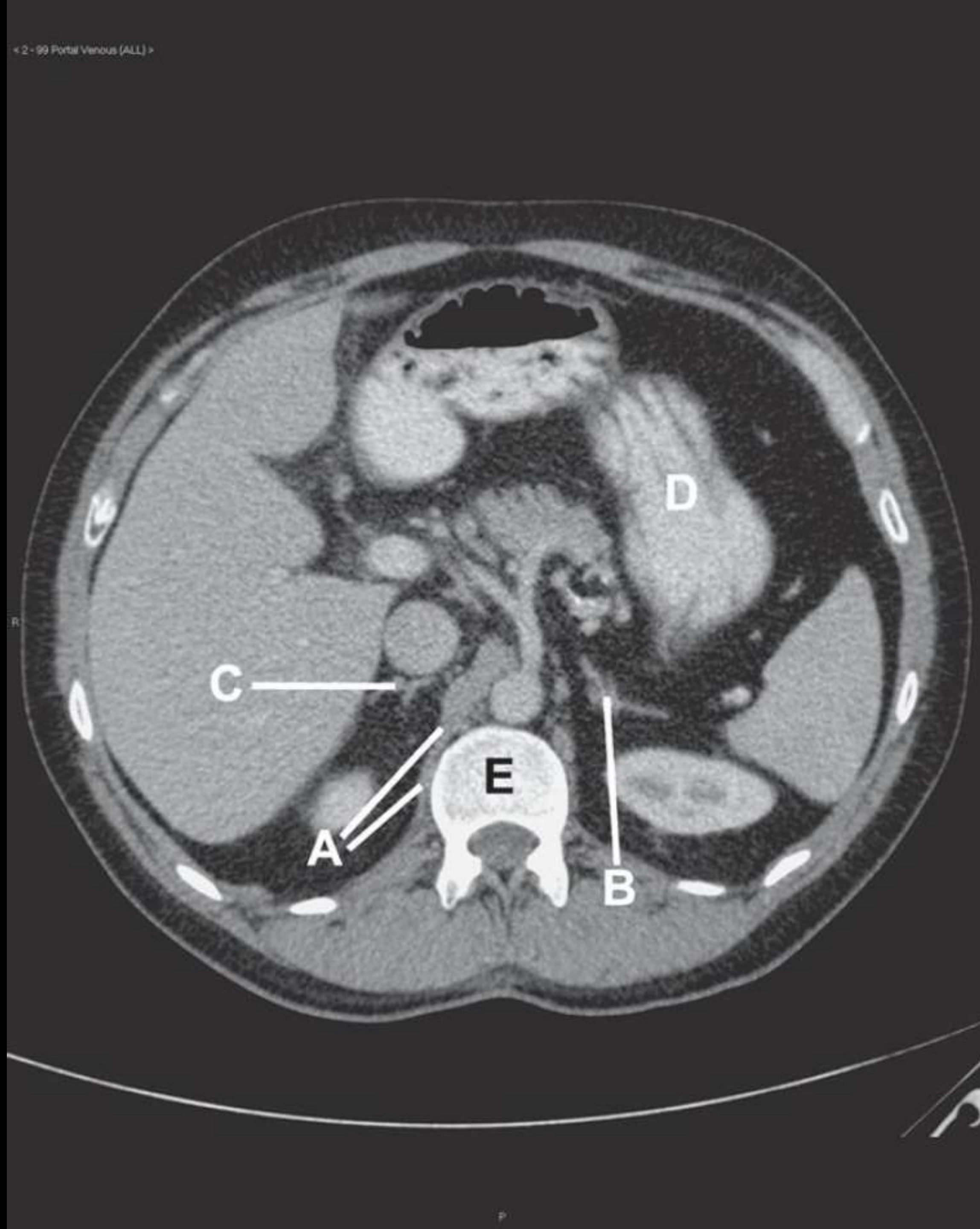


Name the anatomical variant

CT Abdomen

96. Left psoas major muscle
97. Descending colon
98. Right internal oblique muscle
99. Right transversus abdominis muscle
100. Horseshoe kidney

Horseshoe kidney is a congenital anomaly affecting about 1 in 400 people. The central portion of the kidney is found below the inferior mesenteric artery.


< 2 - 99 Portal Venous (ALL) >
D
C
E
A
B
R
P

Q10 Answers

a Crus of right hemi-diaphragm
b Left adrenal gland
c Right adrenal gland
d Body of the stomach
e T12 vertebral body

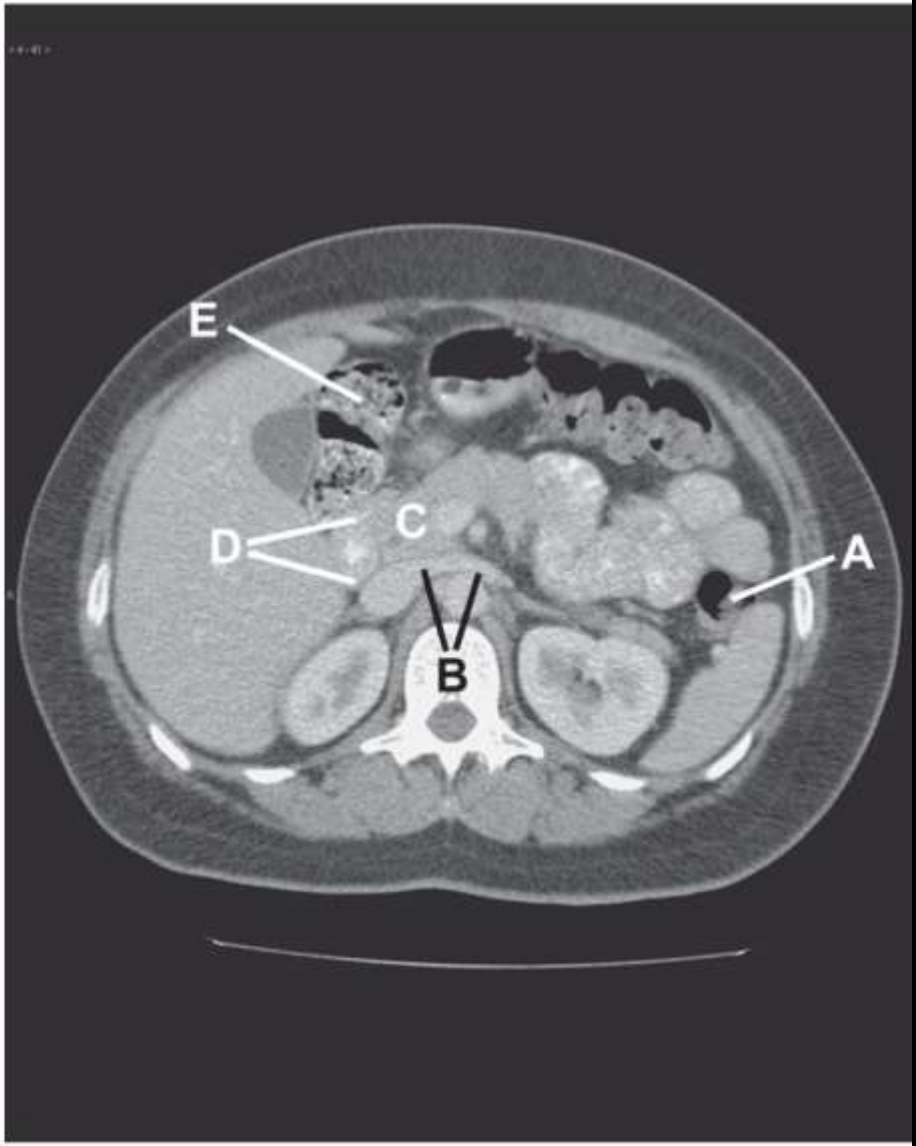
CT of the upper abdomen with oral and intravenous contrast, in the portal venous phase, axial section

The adrenal glands lie retroperitoneally and above the kidneys with the position of the gland on the right being more consistent. It lies posterior to the inferior vena cava, medial to the right lobe of the liver and lateral to the right diaphragmatic crus. It is lower and more medial in relation to the spine than the left adrenal.

The stomach is J-shaped and shows much variation in size and shape between individuals. It has two curvatures – the greater and lesser curves. The incisura is an angulation towards the pyloric end of the lesser curve. There are two orifices, the cardia (upper) and pylorus (lower). The part above the cardia is called the fundus. Between the cardia and the incisura is the body of the stomach and distal to the incisura is the gastric (pyloric) antrum. The stomach is lined by mucosa which forms into temporary folds called rugae. These can be seen in this image as lines running the length of the gastric body.

Q11

a Name the peritoneal ligament arising from structure A
b Name the structure labelled B
c Name the structure labelled C
d Name the structure labelled D
e Name the peritoneal ligament arising from structure E



Q11 Answers

a Phrenicocolic ligament
b Left renal vein
c Head of pancreas
d Second part of duodenum
e Duodenocolic ligament

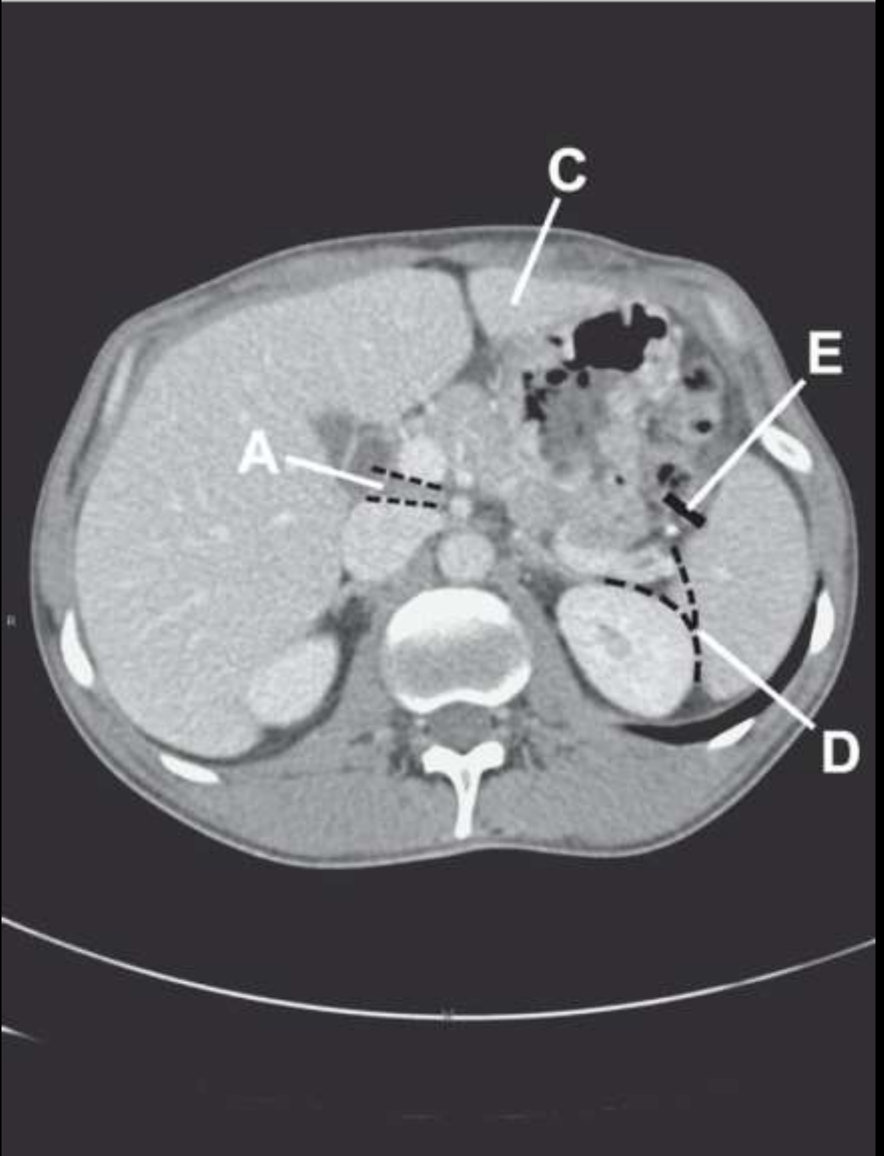
Porto-venous CT at the level of the L2 vertebra, axial section

The ascending and descending colon are both retroperitoneal structures which are fixed anteriorly and on both sides by peritoneum. At the hepatic flexure, the peritoneum extends to form the duodenocolic ligament which is continuous with the transverse mesocolon and contains the lymphatic vessels draining the right colon. The phrenicocolic ligament is a similar structure on the left side which extends from the splenic flexure to the diaphragm at the level of the 11th rib. This is continuous with both the transverse mesocolon and splenorenal ligament and provides additional support to the spleen as well as forming a barrier between the infracolic and supracolic compartments.

The left renal vein is five times longer than the right and passes anterior to the aorta from the renal hilum to drain into the IVC. It receives the inferior phrenic, gonadal and suprarenal veins on the left. The right renal vein receives no extrarenal tributaries.

Q12

a Name the opening outlined and labelled A
b Name the cavity into which A opens
c Name the structure labelled C
d Name the peritoneal structure indicated by the lines labelled D
e Name the peritoneal structure indicated by the line labelled E



Q12 Answers

a Foramen of Winslow/epiploic foramen
b Lesser sac
c Left lobe of the liver
d Splenorenal ligament
e Gastrosplenic ligament

CT abdomen at the level of L1, axial section

The lesser sac of the peritoneum lies between the pancreas and the posterior wall of the stomach, duodenum, lesser omentum and hepatoduodenal ligament. It extends for a variable extent superiorly to the diaphragmatic crus and inferiorly to the root of the transverse mesocolon. A fold of peritoneum surrounding the left gastric artery forms a division between two recesses in the lesser sac. The sac is formed from the embryological liver migrating from a central position into the right upper abdomen. This causes stretching of the visceral peritoneal covering and the creation of a space along its path.

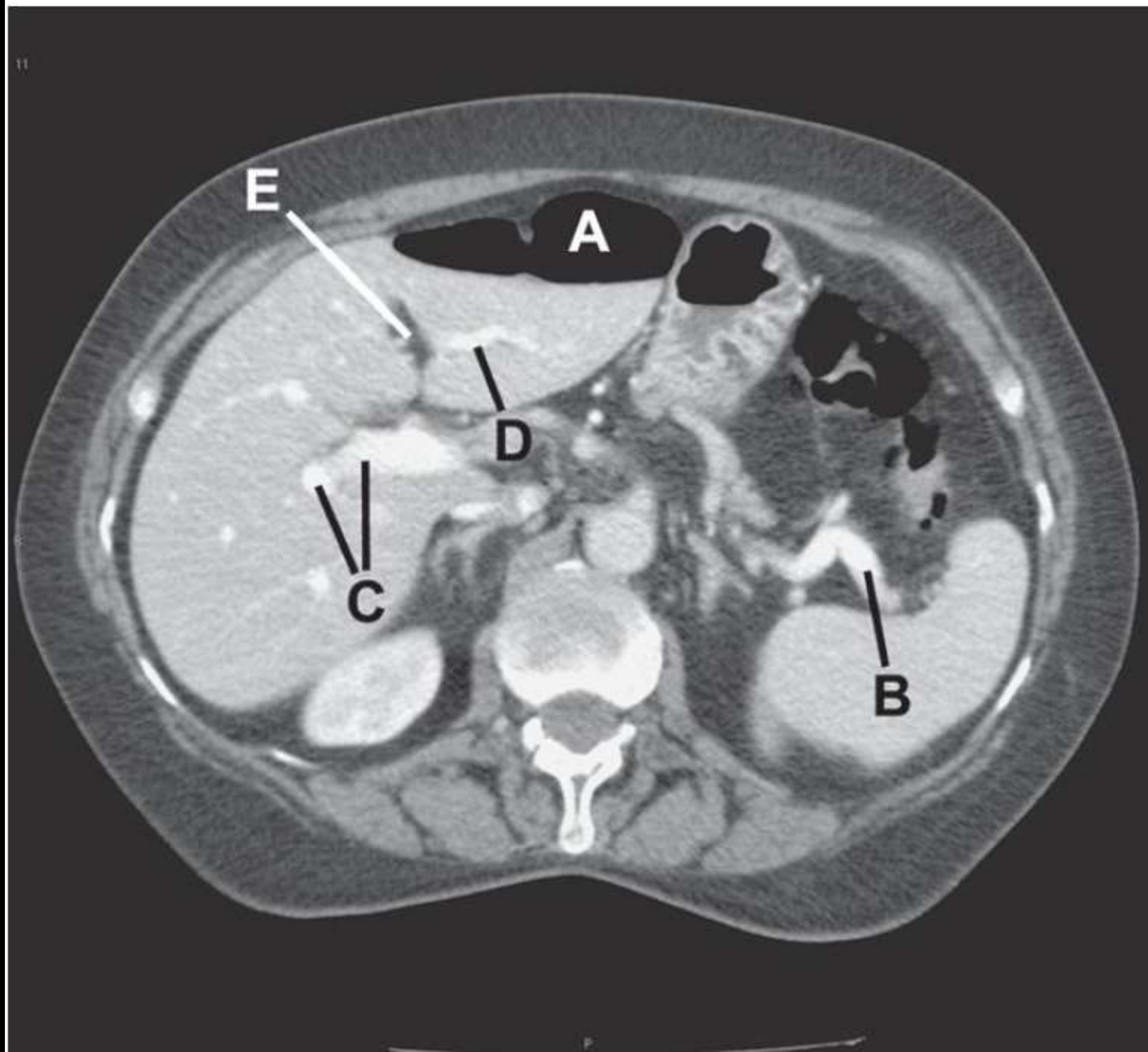
The foramen of Winslow, or epiploic foramen, is a communication under the free bottom edge of the lesser omentum between the greater sac and lesser sac. It measures 25mm and is located between the IVC and free margin of the ligament containing the portal triad of vessels – the hepatoduodenal ligament.

The splenorenal, or lienorenal, ligament connects the posterior aspect of the spleen to the anterior para-renal space and contains the splenic vessels, tail of the pancreas and surrounding fat. The gastrosplenic ligament connects the greater curve of the stomach with the splenic hilum and contains left gastroepiploic and short gastric vessels. Together these two ligaments comprise the lateral boundary of the lesser sac.

DeMeo JH, Fulcher AS, Austin RF Jr *et al.* Anatomic CT demonstration of the peritoneal spaces, ligaments, and mesenteries: normal and pathologic processes. *Radiographics* 1995; 15:755–770.

Q13

a Name the gas filled structure labelled A
b Name the structure labelled B
c Name the structure labelled C
d Name the structure labelled D
e Name the embryological vascular remnant located at site E



Q13 Answers

a Transverse colon
b Splenic vein
c Right portal vein
d Left portal vein
e Umbilical vein

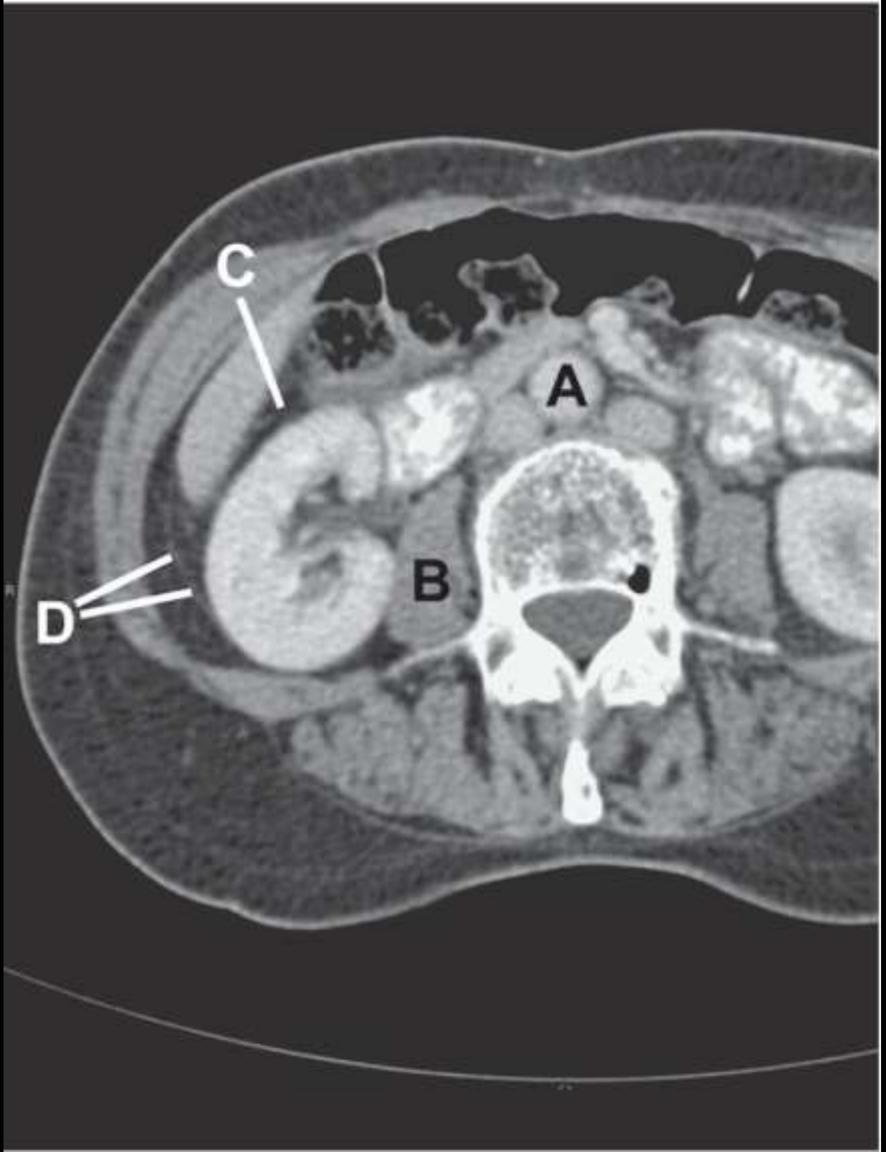
Upper abdominal CT with contrast (portal venous phase), axial section

The portal venous system serves to channel the blood drained from the gut and spleen into the liver prior to it entering the systemic circulation. The main portal vein is approximately 7cm long and is a direct continuation of the SMV, coursing anterior to the IVC towards the porta hepatis. Portal venous tributaries are the splenic (into which drains the inferior mesenteric vein), cystic, gastric and superior pancreatoduodenal veins. The portal vein divides into right and left limbs which in turn supply branches to the various hepatic segments. The portal vein supplies approximately 75% of the blood to the liver with the remainder being supplied via the hepatic arterial system.

Flow in the umbilical vein usually ceases following birth, but it remains a potential site of porto-systemic anastomoses. Other sites of porto-systemic anastomoses are at the lower oesophagus, upper anal canal, bare area of liver and retroperitoneal areas.

Q14

a Name the structure labelled A
b Name the structure labelled B
c Name the space labelled C
d Name the structure labelled D
e Name the anatomical variant demonstrated in this image



Q14 Answers

a Abdominal aorta
b Psoas muscle
c Hepato-renal (Morison's) pouch
d Posterior renal fascia (fascia of Zuckerlandl)
e Double IVC

Abdominal CT with oral and IV contrast, axial section

The IVC is normally formed from the confluence of the common iliac veins at the L5 level, behind the right common iliac artery and it travels up the posterior abdominal wall on the right of the midline. Developmental anomalies of one or more of the caval segments (hepatic, supra-renal, renal and infra-renal) are occasionally present. Duplication of the infra-renal IVC ('Double-IVC') is a developmental anomaly of the infra-renal segment resulting in persistence of both embryological supracardinal veins and is seen in 0.2–3% of the population. In these cases the left IVC typically drains into the left renal vein, which in turn joins the right-sided IVC as normal. Variations in the configuration of the renal segment (right suprasubcardinal and postsubcardinal anastomoses) are most common anomalies encountered, with retro-aortic and circum-aortic left renal veins present in approximately 8% and 2% of the population, respectively.

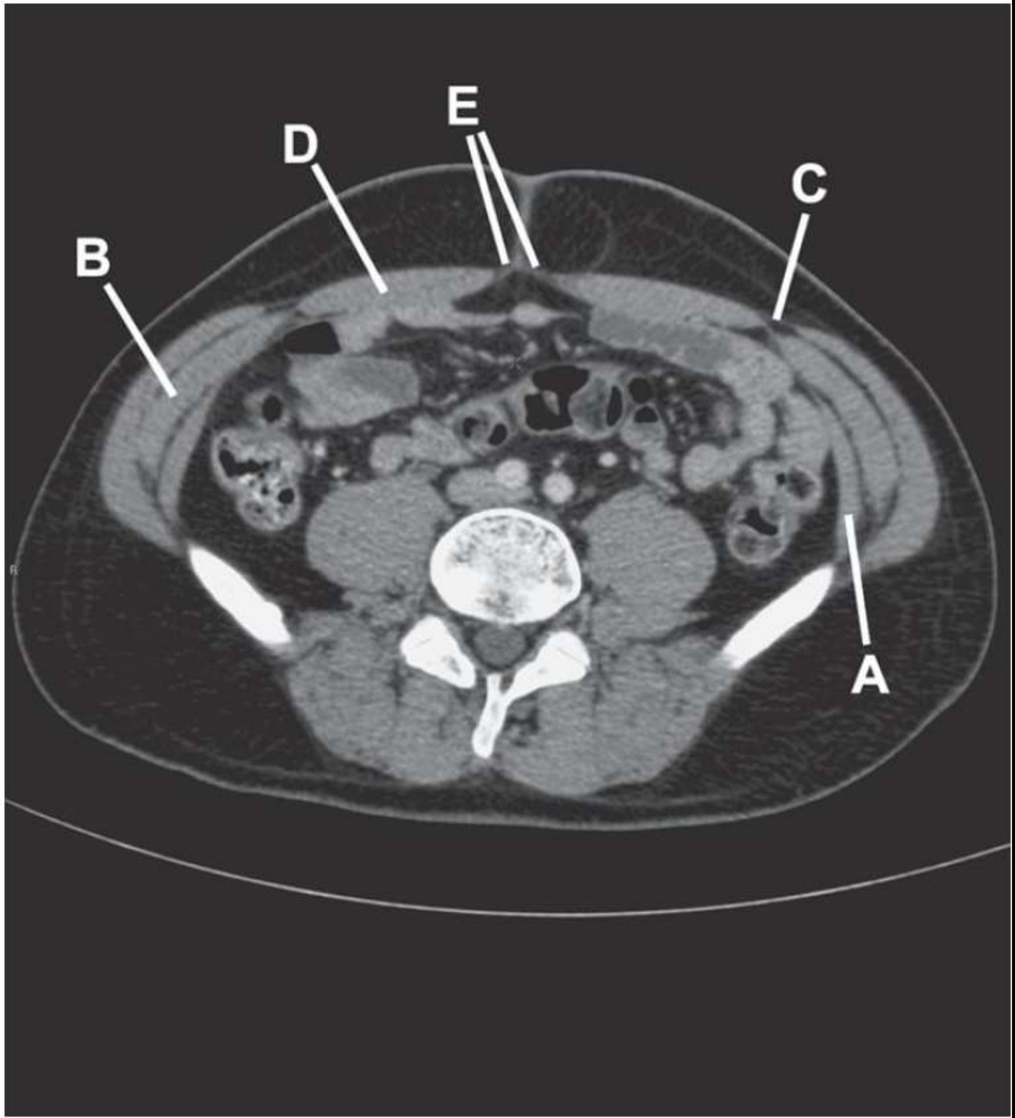
The kidneys are surrounded by perirenal fat which in turn is surrounded by the anterior and posterior leaves of renal fascia. The anterior leaf is Gerota's fascia and the posterior leaf is the fascia of Zuckerlandl. These divide the retroperitoneal space into three compartments: the peri-renal, anterior para-renal and posterior-para-renal spaces.

Morison's pouch lies at the posterior aspect of the right sub-hepatic space anterior to the right kidney and is the most dependant position of the peritoneal cavity in a supine patient. Its importance as a potential site of fluid accumulation within the abdomen was described by Morison in 1894.

Bass JE, Redwine MD, Kramer LA *et al.* Spectrum of Congenital Anomalies of the Inferior Vena Cava: Cross-sectional Imaging Findings. *RadioGraphics* 2000; 20:639–652.

Q16

a Name the structure labelled A
b Name the structure labelled B
c Name the structure labelled C
d Name the structure labelled D
e Name the structure labelled E



Q16 Answers

a Transversus abdominis
b Internal oblique
c Aponeurosis of external oblique
d Rectus abdominis
e Linea alba

CT at the level of the iliac crest, axial section

The musculature of the anterior and lateral abdominal wall consists of four main muscles; rectus abdominis, external oblique, internal oblique and transversus abdominis.

The two recti lie either side of the midline and extend from the 5th, 6th and 7th costal cartilages to the pubis. They are interconnected by the linea alba and invested within a thick fascial covering known as the rectus sheath which is formed by the aponeuroses of the external oblique, internal oblique and transversus abdominis muscles.

The external oblique is the largest and most superficial of the three antero-lateral muscles. It arises from ribs 4–12 and interdigitates with slips of muscle from serratus anterior and latissimus dorsi. As it passes anteriorly it becomes an aponeurosis which forms part of the anterior rectus sheath, anterior to rectus abdominis. The free lower edge of the external oblique is attached between the anterior superior iliac spine and the pubic tubercle and forms the inguinal ligament.

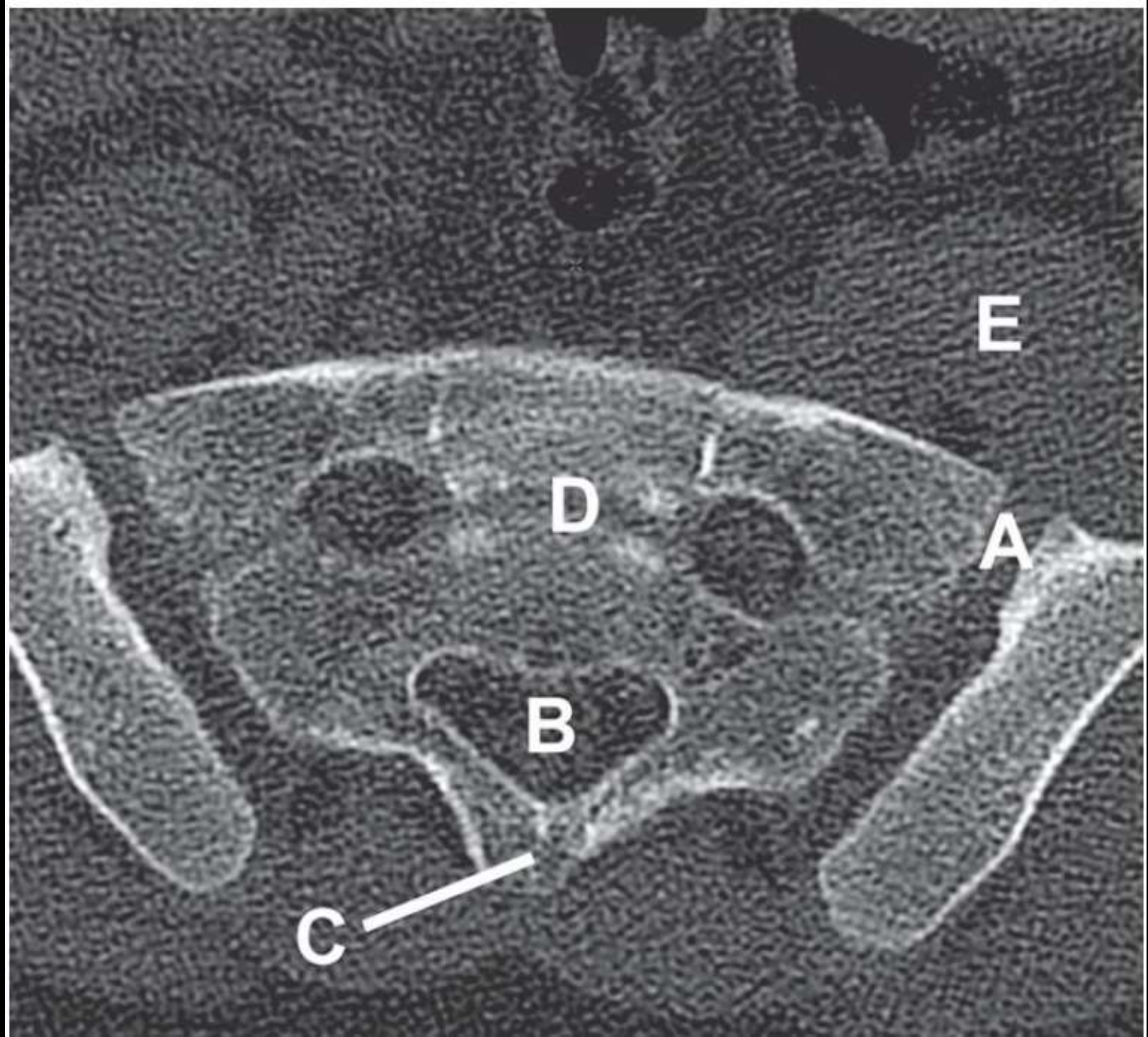
The internal oblique lies deep to and is smaller than the external oblique. It arises from the costal margin and thoracolumbar fascia and is inserted into the inguinal ligament below. As it passes anteriorly it becomes an aponeurosis which, above the umbilicus, splits around the rectus abdominis and contributes to both the anterior and posterior layers of the rectus sheath.

The transversus abdominis is the deepest of the three muscles, arising from the costal margin, thoracolumbar fascia, iliac crest and inguinal ligament. It also becomes an aponeurosis which, above the umbilicus contributes to the posterior layer of the rectus sheath.

Below the umbilicus, all three aponeuroses pass anterior to the rectus abdominis. This produces a whitening of the anterior wall where the rectus passes deep to all three layers and is known as the arcuate line.

Q7

a Name the structure labelled A
b Name the structure labelled B
c Name the structure labelled C
d Name the structure labelled D
e Name the muscle group labelled E



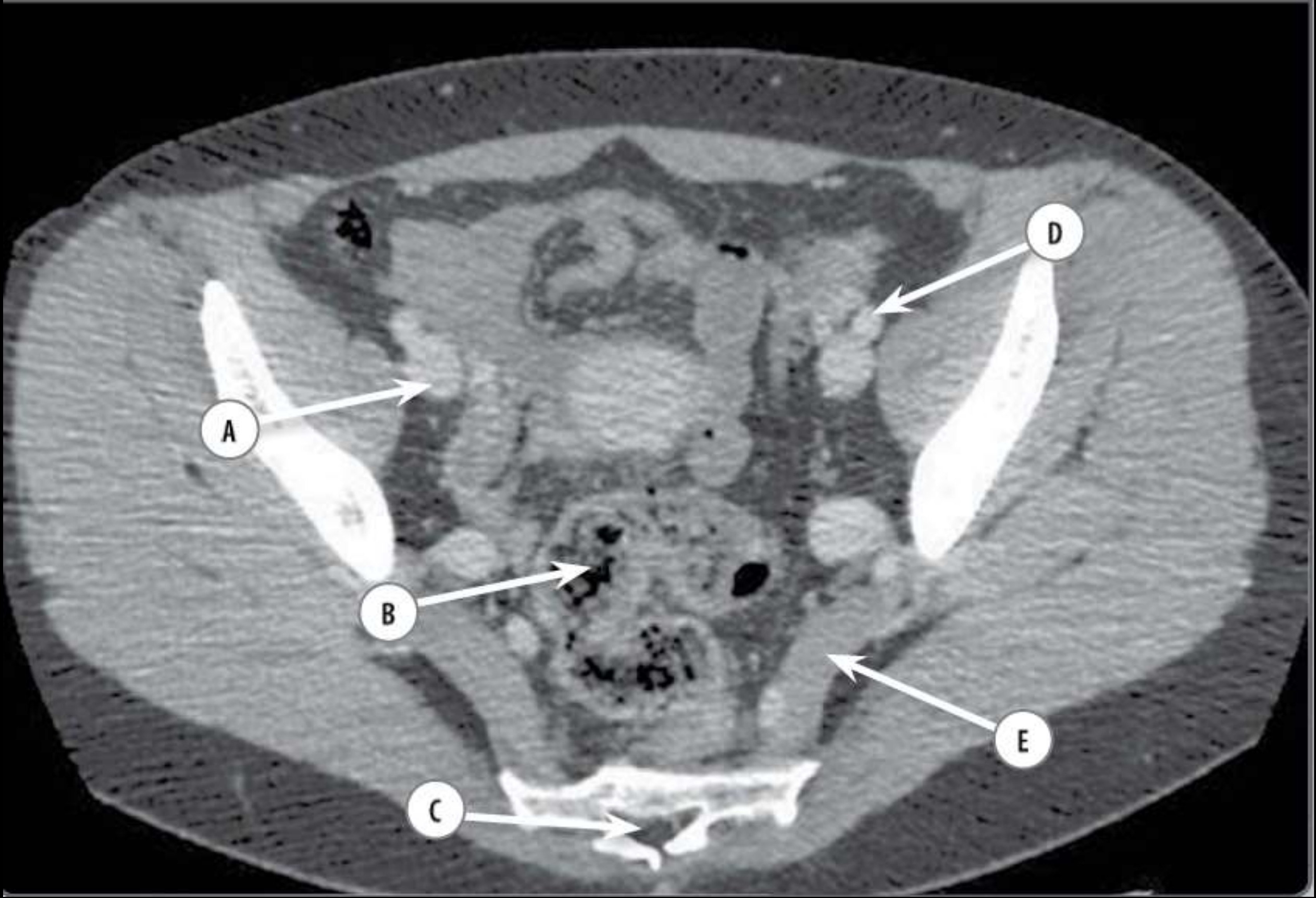
Q7 Answers

- **a** Sacro-iliac (SI) joint
- **b** Sacral canal
- **c** Median sacral crest
- **d** Unfused S1–S2 joint
- **e** Iliopsoas (hip flexors)

Oblique view of paediatric sacrum from CT study presented in bone windows

The sacrum forms from fusion of the five sacral vertebrae; this process is not complete until adulthood. Fusion of the spinous processes of the sacral vertebrae creates the median sacral crest. The sacral canal is a continuation of the vertebral canal and transmits the sacral nerve roots (cauda equina) which subsequently exit the sacrum via the anterior or posterior sacral foramina.

Case 3.14



Case 3.14

A Right external iliac vein

B Sigmoid colon

C Sacral canal

D Left external iliac artery

E Left piriformis

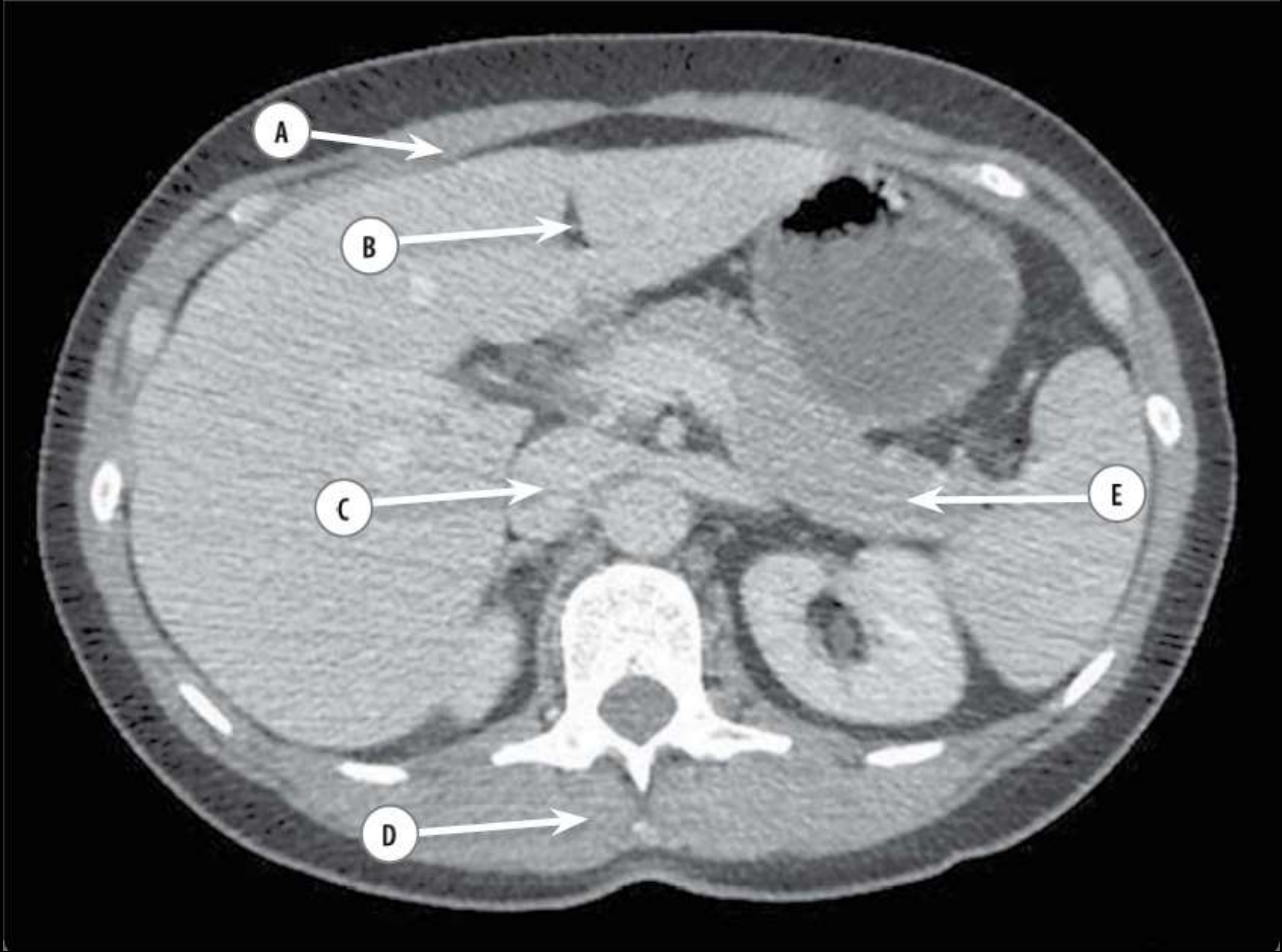
Axial contrast-enhanced CT of the pelvis.

The sacrum is made up of five sacral vertebrae which are fused together. It has a triangular shape, with its base lying superiorly, articulating with L5. Anteriorly, it has a concave surface, which forms the posterior wall of the pelvis. In the central part of the sacrum runs the sacral canal, which is continuous with the spinal canal above. There are four pairs of anterior sacral foramina and four pairs of dorsal sacral foramina, which transmit the anterior and dorsal rami of S1–S4 respectively. On the dorsal surface, running longitudinally, between the dorsal foramina is the median sacral crest. The four sacral tubercles project from this crest in the midline. There are also two lateral sacral crests, which are found laterally to the dorsal foramina. Occasionally, there are transverse tubercles which arise from these crests – these represent vestigial transverse processes.

The sigmoid colon is found in the pelvis, and is quite variable in length. It begins at the pelvic brim, and extends to its junction with the rectum. It is surrounded by peritoneum, which also ends at the rectosigmoid junction. The sigmoid colon is attached to the posterior pelvic wall by the sigmoid mesocolon, the root of which is shaped like an inverted 'V'. The sigmoid vessels, arising from the inferior mesenteric vessels, are transmitted in the sigmoid mesocolon.

Butler P, Mitchell AM, Ellis H. Applied Radiological Anatomy. Cambridge: Cambridge University Press, 1999: 218, 354.

Case 3.16



Case 3.16

A Right rectus abdominis

B Ligamentum teres

C Inferior vena cava

D Right erector spinae

E Pancreatic tail

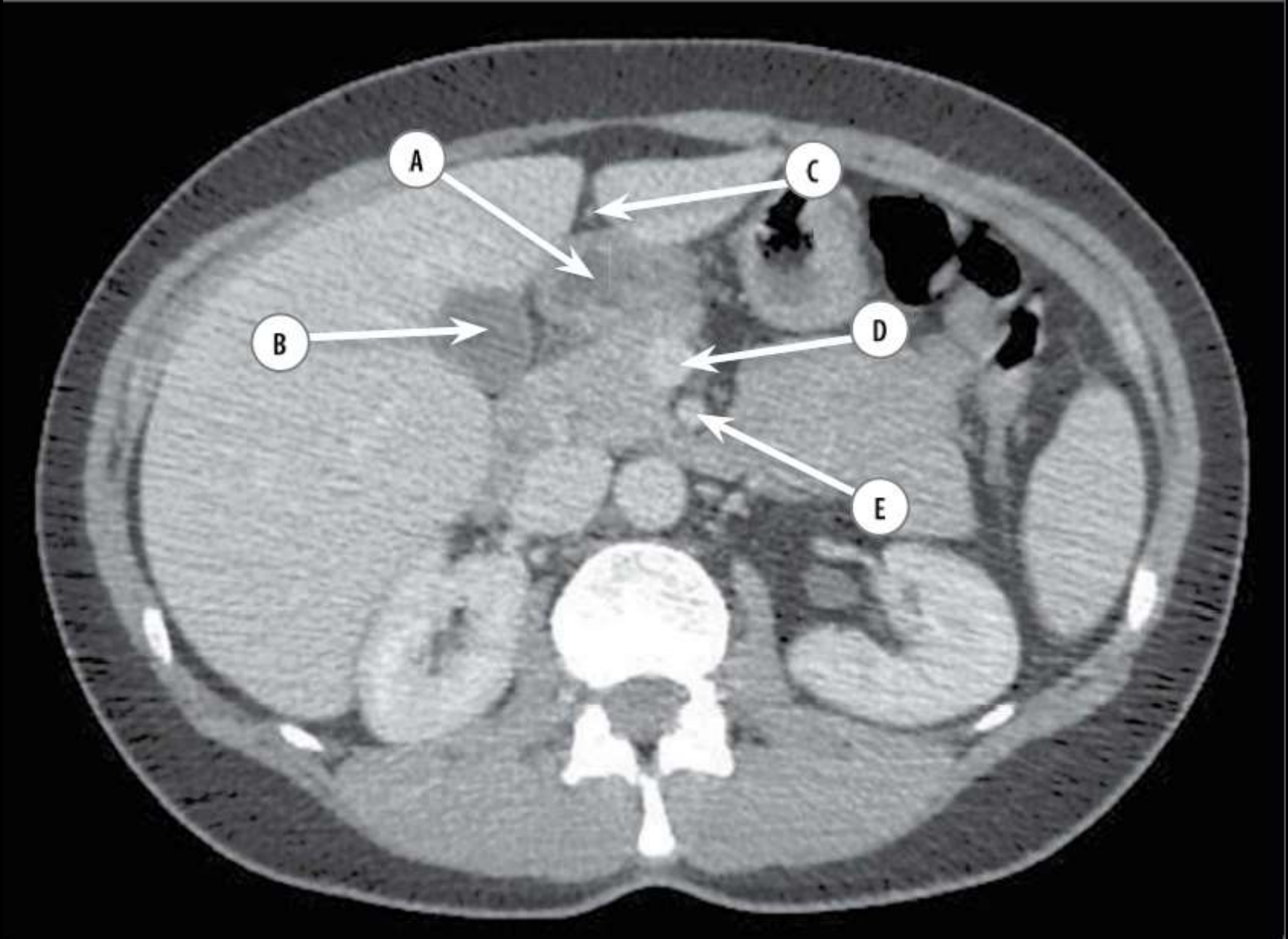
Coronal contrast-enhanced CT of the abdomen in the portal venous phase.

The ligamentum teres (also known as the round ligament) is formed by the obliterated left umbilical vein. It runs in the falciform ligament (a peritoneal fold) from the umbilicus to the liver. The falciform ligament divides the liver into right and left lobes. In this image the ligamentum teres appears as a soft tissue density structure surrounded by fat.

The extensors of the spine can be described by their location – deep, intermediate and superficial. Erector spinae is the most powerful of these groups, and is made up by the superficial extensors. These muscles lie in the groove either side of the spinal column and run the length of the spine.

Ryan S, McNicholas M, Eustace SJ. Anatomy for Diagnostic Imaging, 3rd edn. Edinburgh: Saunders, 2011: 175.
Butler P, Mitchell AM, Ellis H. Applied Radiological Anatomy. Cambridge: Cambridge University Press, 1999: 308.

Case 3.19



Case 3.19

A First part of duodenum

B Gallbladder

C Ligamentum teres

D Superior mesenteric vein

E Superior mesenteric artery

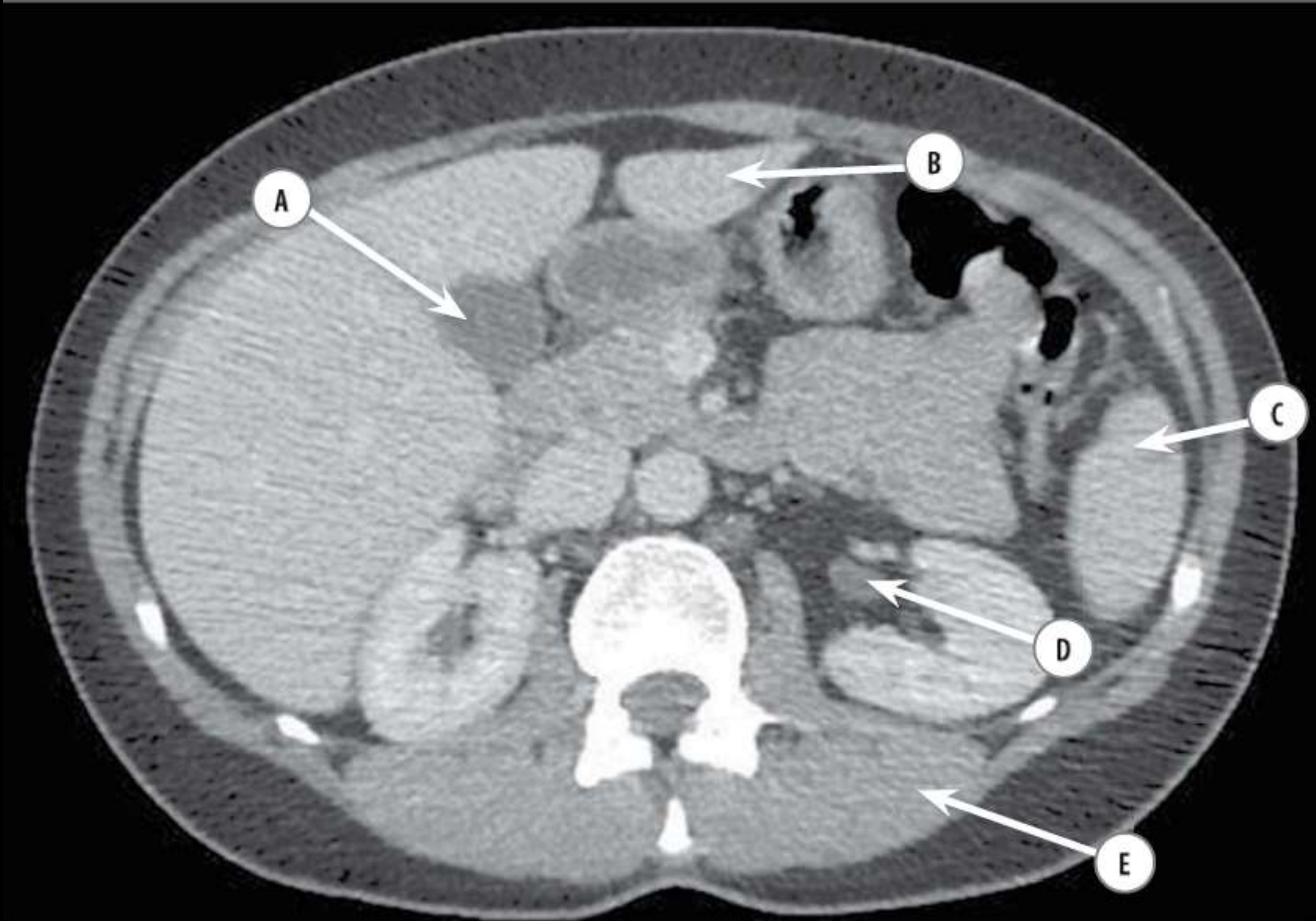
Axial contrast-enhanced CT through the upper abdomen.

The superior mesenteric vein (SMV) is located to the right of the superior mesenteric artery (SMA). The SMA is typically surrounded by a 'halo' of fat. On an ultrasound image, this appears as an echo-bright area surrounding the vessel; on this CT scan the fat can also be seen, but it appears dark due to its low density relative to the intravascular contents. The other differentiating feature between the SMA and SMV is their calibre. The SMV is of a larger calibre than the SMA, as is demonstrated on this image.

The ligamentum teres (also known as the round ligament) is the obliterated remnant of the left umbilical vein. It travels in the free edge of the falciform ligament between the umbilicus and the inferior border of the liver. The point where the falciform ligament meets the liver marks the division of the right and left lobes of the liver. The ligamentum teres continues, to the left side of the porta hepatis, where it attaches to the left main portal vein.

Ryan S, McNicholas M, Eustace SJ. Anatomy for Diagnostic Imaging, 3rd edn. Edinburgh: Saunders, 2011: 173–175.

Case 3.21



Case 3.21

A Gallbladder

B Left lobe of liver

C Lower pole of spleen

D Left proximal ureter

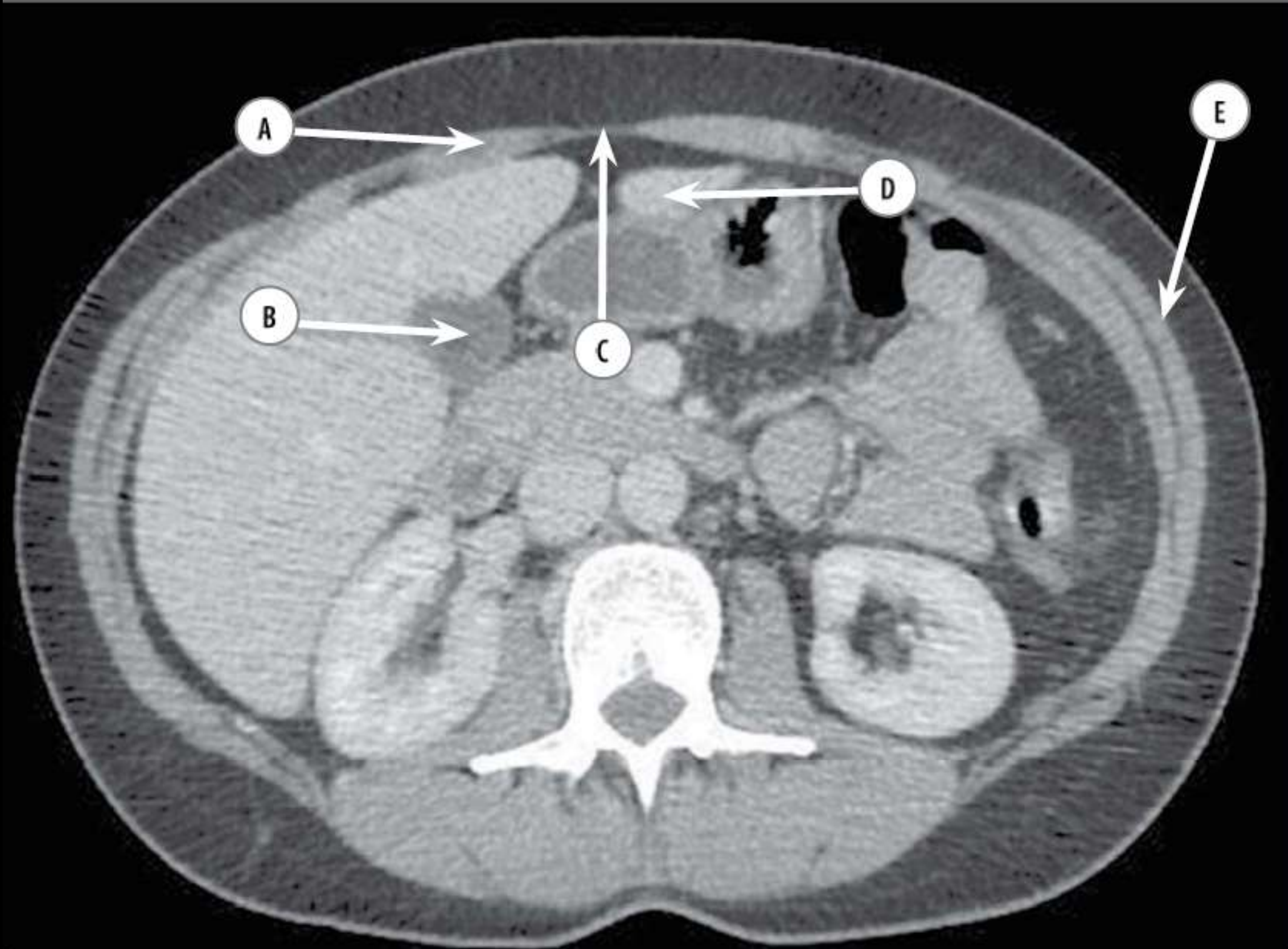
E Left erector spinae

Axial contrast-enhanced CT of the abdomen.

The spleen is found in the left upper quadrant of the abdomen, and measures up to 12 cm in length, 7 cm in width and 4 cm in breadth. It is attached from its hilum to the posterior abdominal wall via the splenorenal and phrenicosplenic ligaments. The gastrosplenic ligament attaches the spleen to the stomach, and separates the lesser sac from the greater sac anteriorly. The splenic surface which abuts the diaphragm is smooth and rounded, and it is protected in this position by the 9th–11th ribs which overly it. The 'visceral' surface is contoured where it abuts the adjacent organs. This surface has impressions from the left kidney posteriorly, the splenic flexure inferiorly, the pancreatic tail at the splenic hilum, and an anterior impression from the stomach. The splenic vessels enter at the hilum between the gastric and renal impressions. The red and white pulps of the spleen enhance at different rates, and can therefore cause a mottled appearance particularly in the arterial phase.

Ryan S, McNicholas M, Eustace SJ. Anatomy for Diagnostic Imaging, 3rd edn. Edinburgh: Saunders, 2011: 192–193.

Case 3.23



Case 3.23

A Right rectus abdominis

B Gallbladder

C Linea alba

D Left lobe of liver

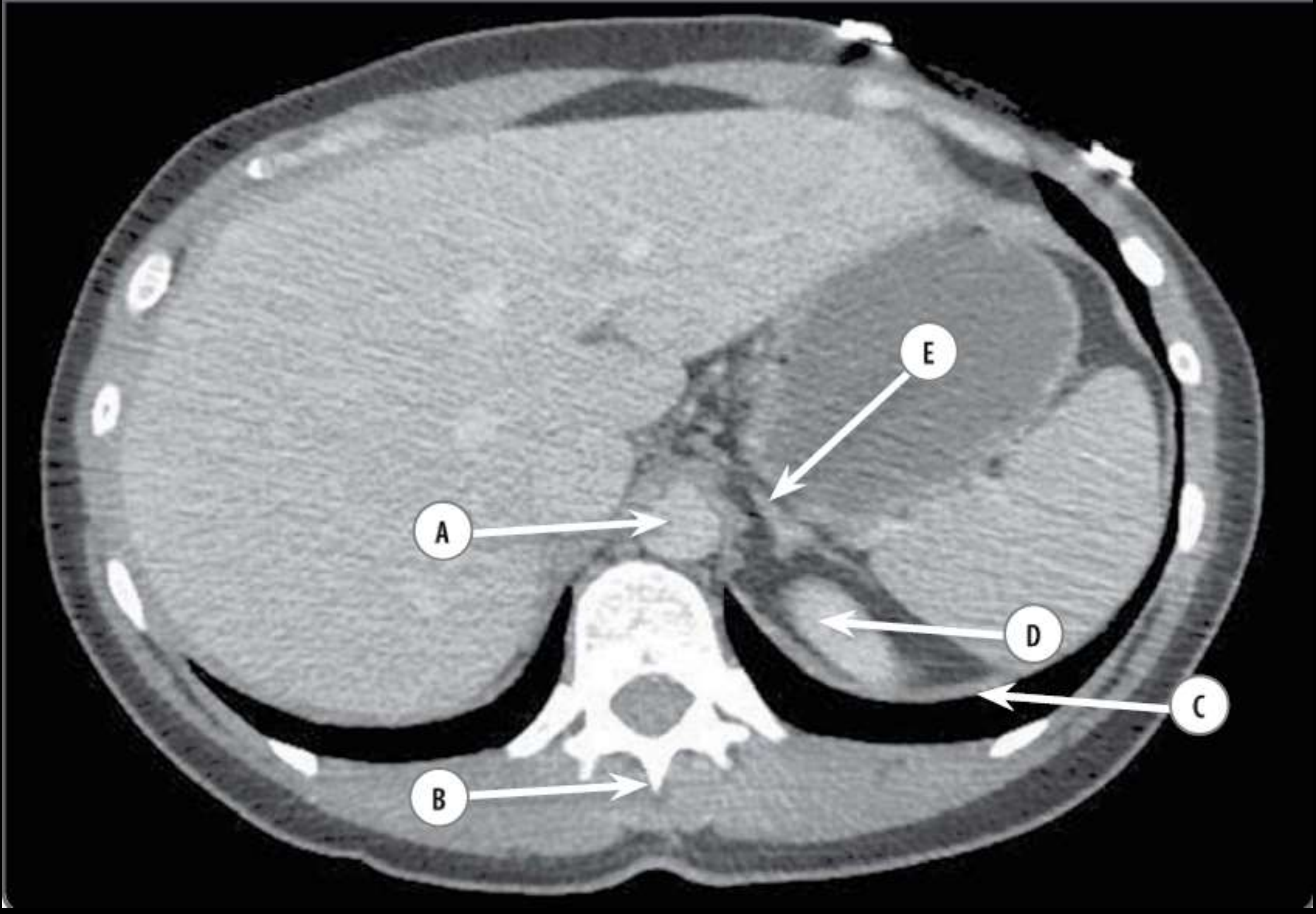
E Left external oblique

Axial contrast-enhanced CT scan.

The rectus abdominis muscles are two strap muscles which run either side of the midline, from the costal cartilages to the pubis. The rectus muscles are surrounded by the rectus sheath, which is formed from the aponeuroses of the external and internal obliques as well as transversus abdominis. The rectus sheath is then attached to the linea alba, which is a strip of fibrous connective tissue separating the two recti in the midline. Above the umbilicus, the linea alba is approximately 4–6mm wide, and is thin in its anteroposterior (AP) dimension. Below the umbilicus it becomes narrower from left to right, but thicker in the AP dimension. Laterally, the rectus sheath is bound by the linea semilunaris (spigelian fascia), which is also formed from the aponeuroses of the lateral abdominal muscles.

Butler P, Mitchell AM, Ellis H. Applied Radiological Anatomy. Cambridge: Cambridge University Press, 1999: 200.

Case 3.24



Case 3.24

A Abdominal aorta

B Spinous process of lower thoracic vertebra

C Left hemi-diaphragm

D Upper pole of left kidney

E Anterior limb of left adrenal gland

Axial contrast-enhanced CT in the portal venous phase.

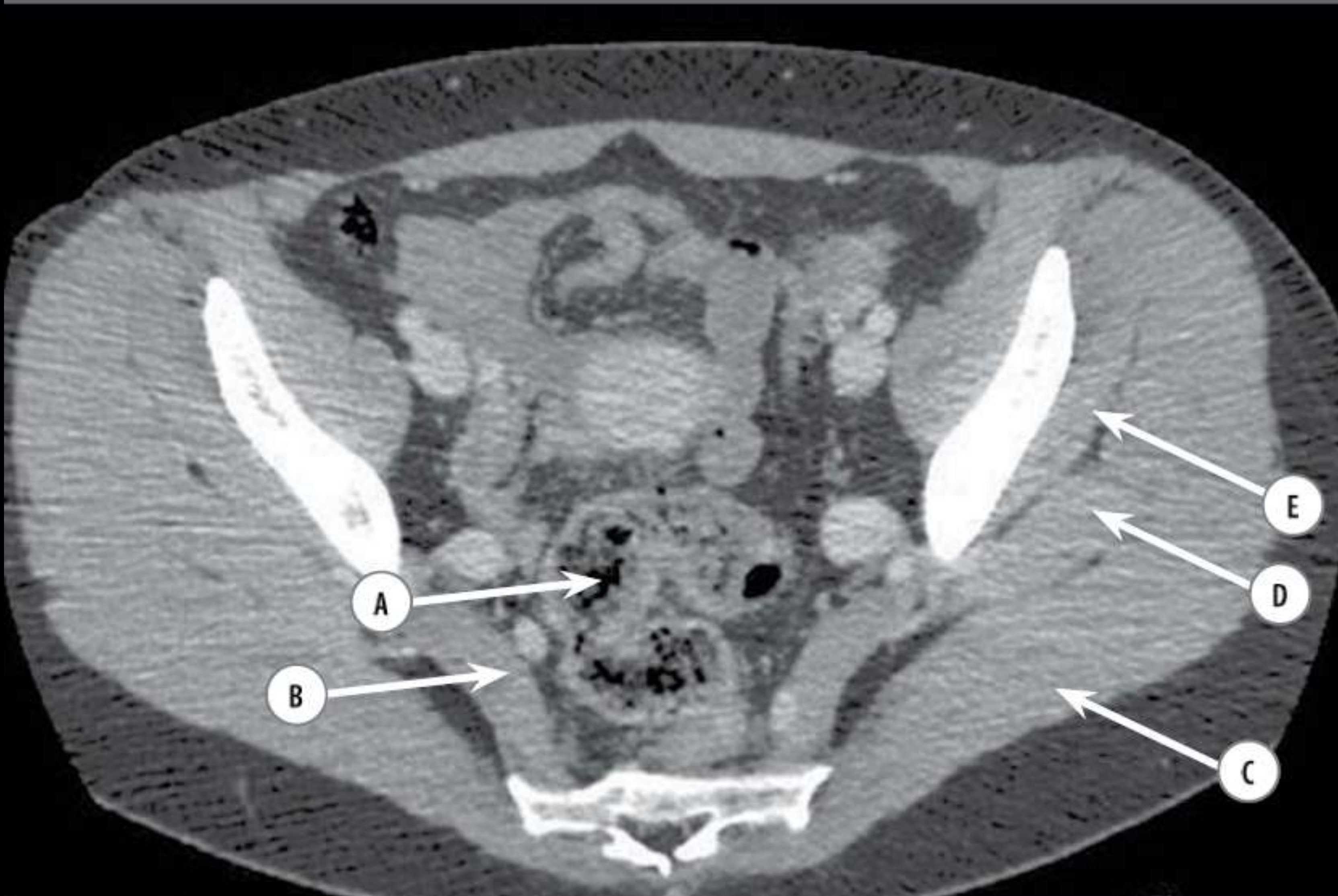
The diaphragm is a strong muscular sheet which forms the floor of the thorax. It has origins arising from the sternum, ribs and vertebrae, as well as the central tendon. The central tendon is fused with the pericardium at its midportion, and posteriorly it extends towards the paraspinal gutters. The sternal attachment is via two small slips, which extend to the posterior aspect of the xiphisternum. There are further diaphragmatic slips which arise from the six lower costal cartilages to form the costal attachments.

From the lower thoracic and upper lumbar vertebrae arise the crura and arcuate ligaments. The right crus is attached to the bodies of L1–3, whereas the smaller left crus extends only from L1–2. The median arcuate ligament is formed by a fibrous thickening of the medial aspects of both crura. Lateral to this, are found the medial arcuate ligaments, which overlie the psoas muscles, and are formed from a thickening of the psoas fascia. Lastly, the lateral arcuate ligament is found overlying the quadratus lumborum muscles, and is formed by a thickening of its fascia.

Ryan S, McNicholas M, Eustace SJ. Anatomy for Diagnostic Imaging, 3rd edn. Edinburgh: Saunders, 2011: 117–119.

Butler P, Mitchell AM, Ellis H. Applied Radiological Anatomy. Cambridge: Cambridge University Press, 1999: 270.

Case 3.25



Case 3.25

A Sigmoid colon

B Right piriformis

C Left gluteus maximus

D Left gluteus medius

E Left gluteus minimus

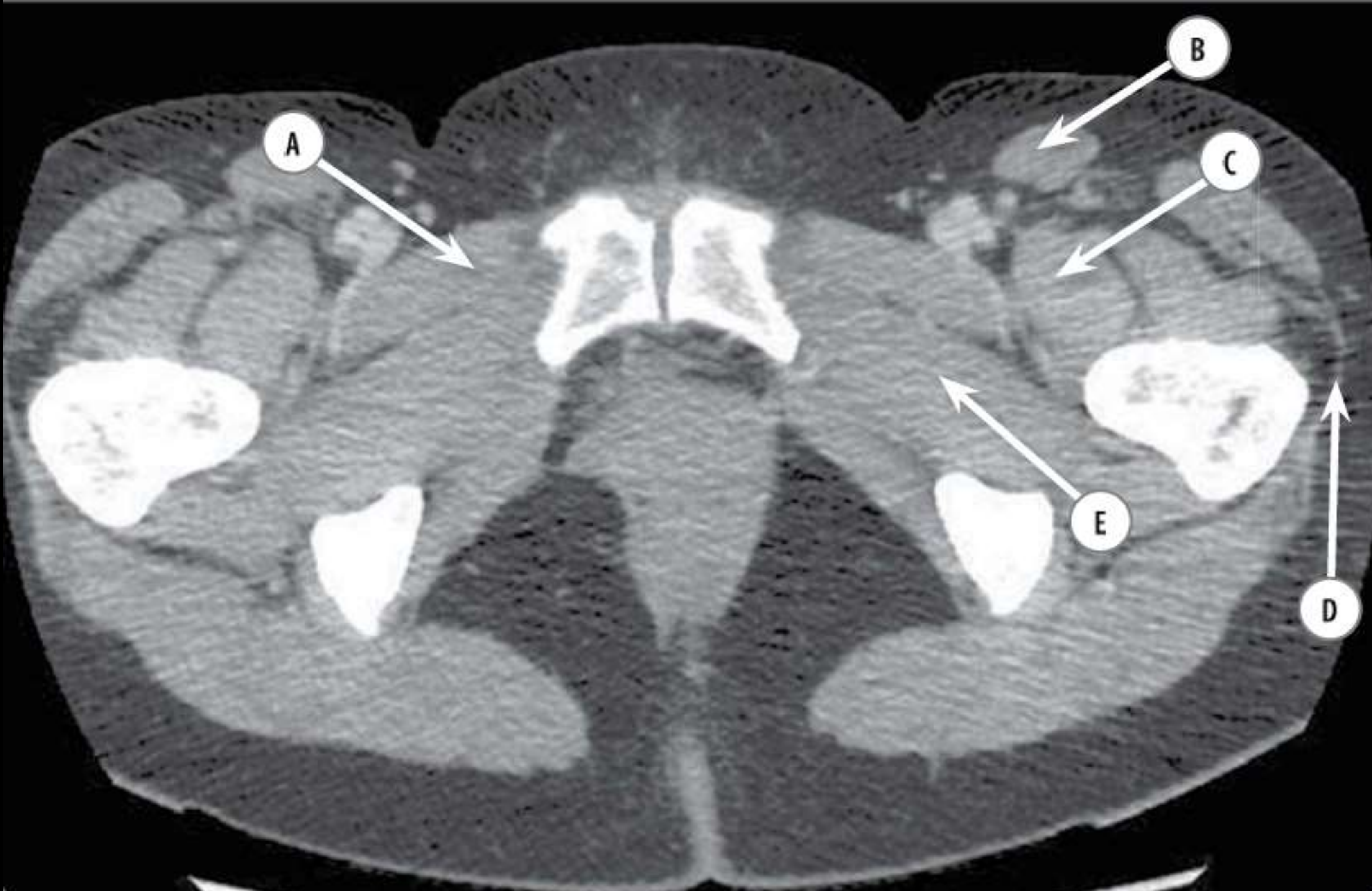
Axial contrast-enhanced CT scan.

The gluteal muscles arise from the iliac bones and pass around the outside of the pelvis, to insert into the proximal femur. Gluteus maximus is the largest and most superficial of the gluteal muscles. Of the three, gluteus maximus arises most posteriorly with its origin from the posterior surface of the ilium, including the sacrum, coccyx and sacrotuberous ligament. The muscle fibres from gluteus maximus converge to form a tough tendinous sheath which becomes part of the iliotibial tract. The deep fibres then attach to the gluteal tuberosity on the proximal femur. Gluteus medius arises anteriorly and deep to gluteus maximus, and inserts onto the greater trochanter. Gluteus minimus is the smallest and deepest of the gluteal muscles, arising below gluteus medius. It too inserts onto the greater trochanter.

Piriformis arises from the anterior surface of the sacrum and passes through the greater sciatic foramen to insert into the greater trochanter.

Ryan S, McNicholas M, Eustace SJ. Anatomy for Diagnostic Imaging, 3rd edn. Edinburgh: Saunders, 2011: 220.

Case 3.26



Case 3.26

A Right pectineus

B Left sartorius

C Left iliopsoas

D Left iliotibial tract

E Obturator externus

Axial contrast-enhanced CT of the pelvis.

The iliotibial tract is a thickened band of connective tissue, that is part of the fascia lata (the deep fascia of the lateral thigh), and inserts into the lateral tibial condyle. The tensor fascia lata is one of the anterior thigh muscles, arising from the anterior superior iliac spine, and inserts into the iliotibial tract.

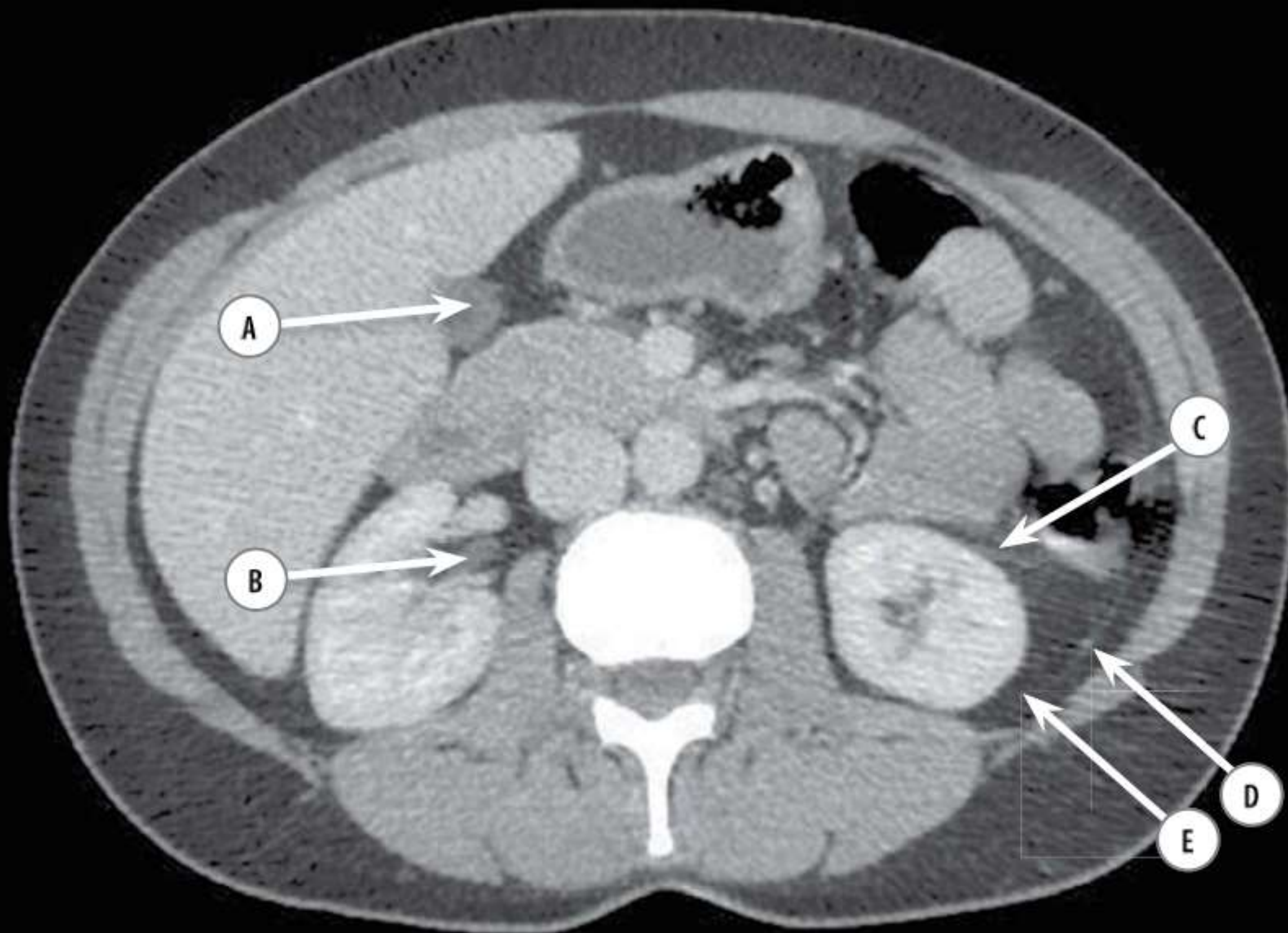
Sartorius is the longest muscle in the human body. It is a thin strap muscle which runs along the anterior thigh, from the anterior superior iliac spine to the medial tibial condyle, where it inserts as part of the pes anserinus. It acts to flex the hip and knee, as well as rotate the femur laterally.

Obturator externus is one of the muscles of the pelvic girdle. It arises from the outer aspect of the obturator membrane, and runs inferiorly to the hip joint to insert onto the posterior aspect of the greater trochanter. When flexed, it acts to externally rotate the femur.

Pectineus is one of the hip adductors. It is a flat muscle, which has its origin on the superior surface of the pubis. It then passes posterolaterally to insert into the femur, from the lesser trochanter to the linea aspera.

Butler P, Mitchell AM, Ellis H. Applied Radiological Anatomy. Cambridge: Cambridge University Press, 1999: 355, 362.
Wheeless, CR. Wheeless' Textbook of Orthopaedics, 2011. http://www.wheelessonline.com/ortho/sartorius Accessed July 2011.

Case 3.28



Case 3.28

A Gallbladder

B Right proximal ureter

C Left Gerota's fascia

D Left fascia of Zuckerkandl

E Left perirenal space/perirenal fat

Axial contrast-enhanced CT scan.

Each kidney is invested in fascia, which has an anterior and posterior leaf; these are referred to as Gerota's and Zuckerkandl's fascia, respectively. These fascial layers are approximately 1 mm thick, and are best seen on CT when they are at right angles to the beam. Laterally, Gerota's and Zuckerkandl's fascias merge to form the lateral conal fascia, which runs along the lateral abdominal wall and is continuous with the fascial covering of transversus abdominis.

The perirenal space is bounded by the renal fascia which contains the kidneys, their vessels, fat and the adrenal glands (the adrenal glands are found within the perirenal fascia, but are separate from the kidney as they are contained within their own compartment).

The anterior pararenal space lies between Gerota's fascia and the posterior peritoneum. It contains the duodenum, ascending and descending colon, and pancreas. The posterior pararenal space lies between Zuckerkandl's fascia and the muscles of the posterior abdominal wall. This space is bounded medially by the attachment of the renal fascia to the fascia of psoas muscle and laterally is continuous with the extraperitoneal fat, below transversus abdominis; it contains only fat.

The right ureter is nicely demonstrated on this image, with its water density helping to differentiate it from the surrounding vessels at the renal hilum.

Figure 3.2 demonstrates the relationships of the retroperitoneal fascial planes and spaces.

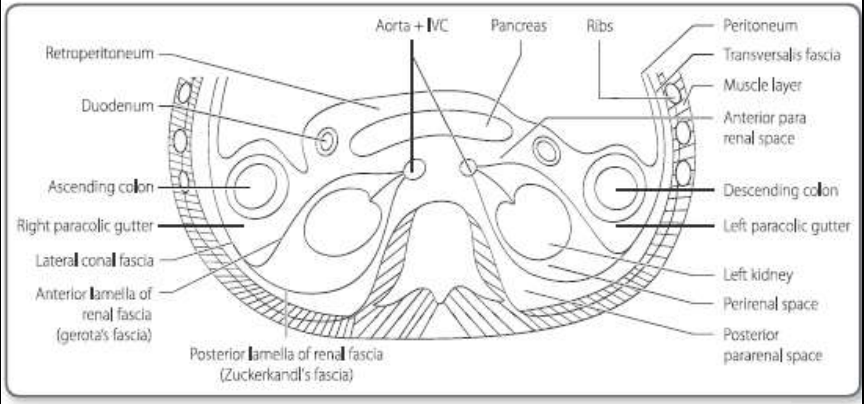
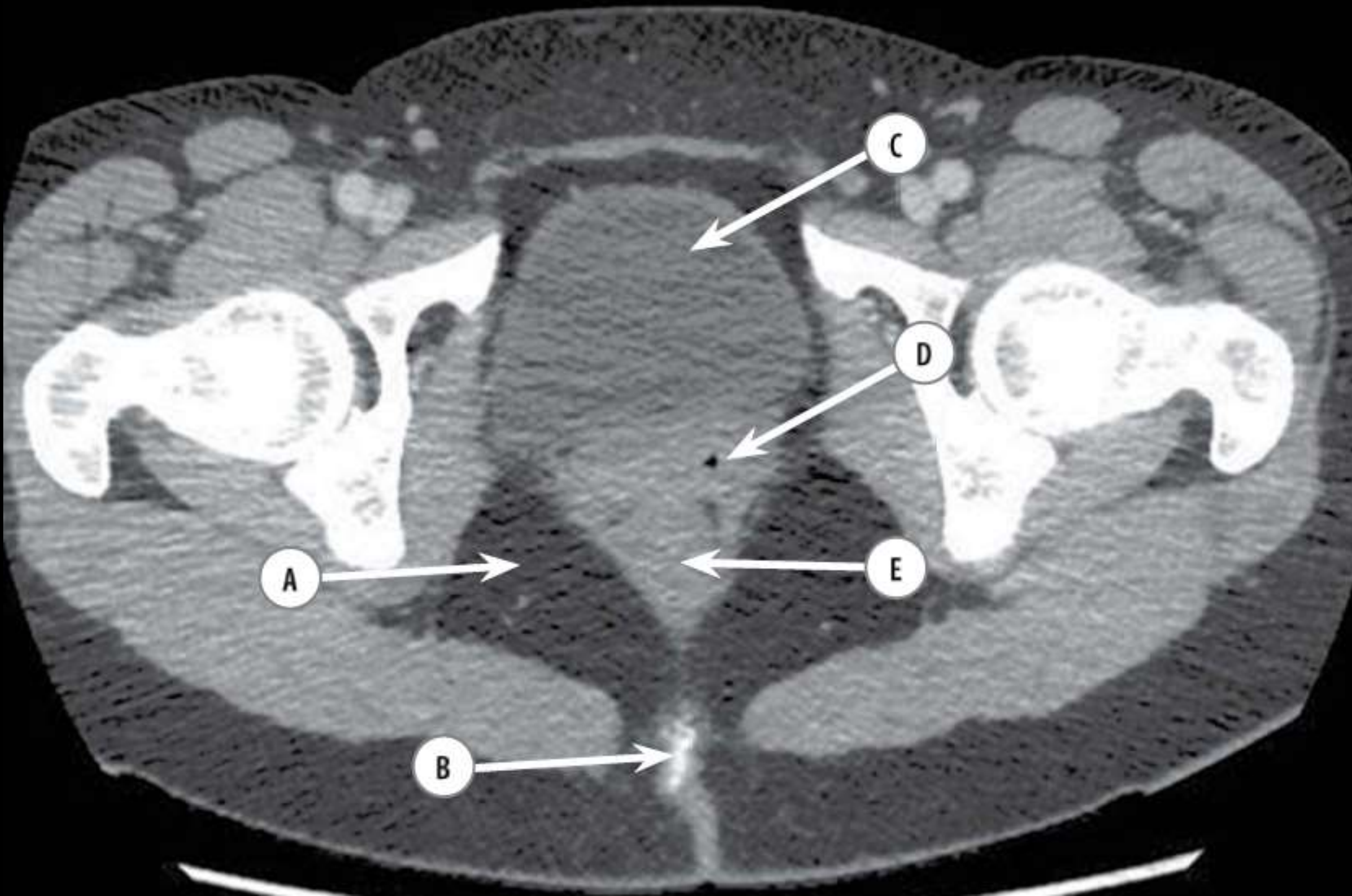


Figure 3.2 Fascial planes and anatomical spaces of the retroperitoneum.

Ryan S, McNicholas M, Eustace SJ. Anatomy for Diagnostic Imaging, 3rd edn. Edinburgh: Saunders, 2011: 196–199.

Case 3.31



Case 3.31

A Fat within the right ischiorectal fossa

B Coccyx

C Bladder

D Vagina

E Rectum

Axial contrast-enhanced CT of the pelvis.

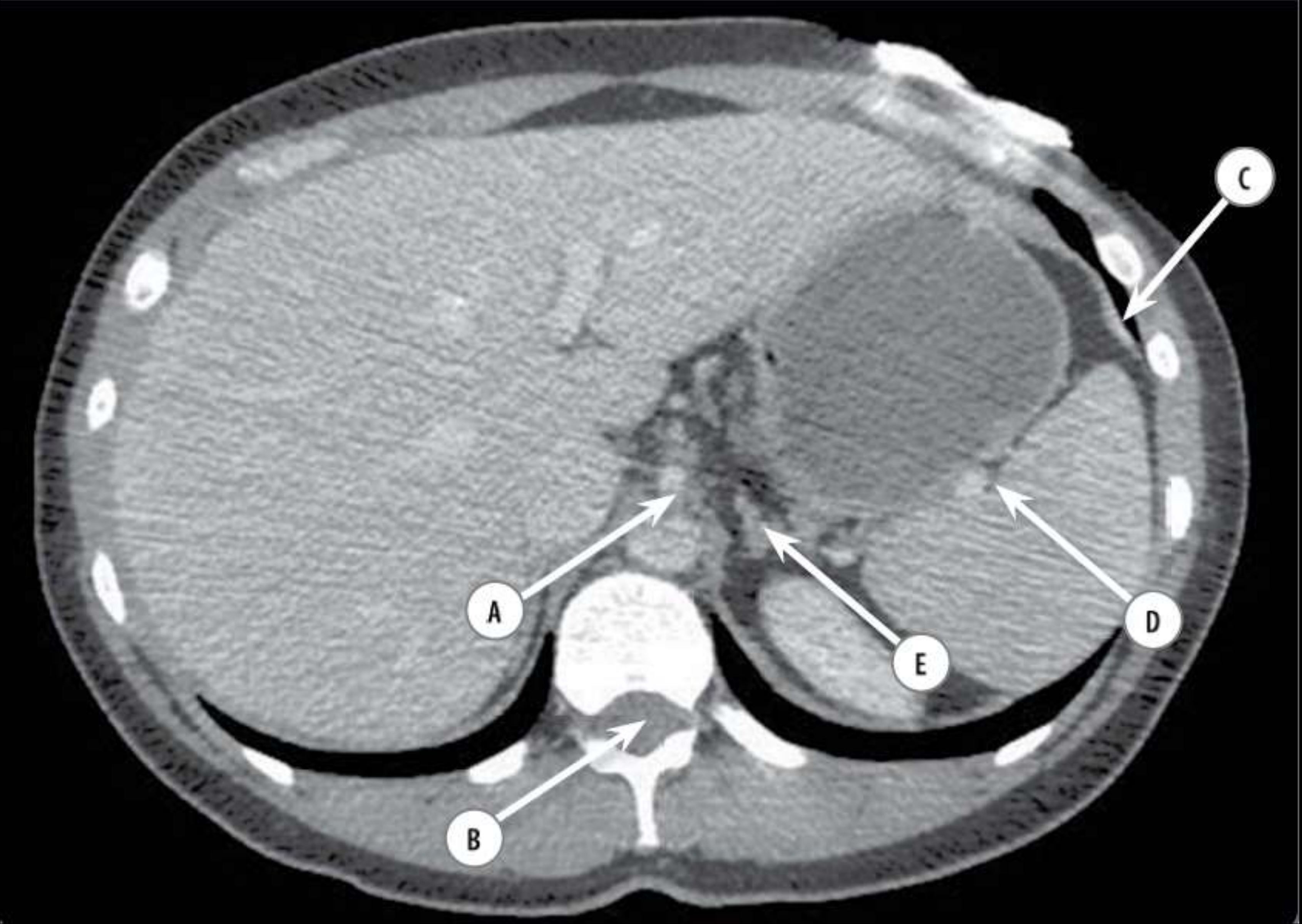
The ischiorectal fossa is found below the posterior fibres of levator ani and anterior to the sacrotuberous ligaments and gluteus maximus. The urogenital perineum forms its anterior border and the lateral border reaches to the fascia overlying obturator internus. This space is important due to its propensity for sepsis, via the rectum or anal canal, and the subsequent development of ischiorectal abscesses.

The vagina is found between the bladder and urethra anteriorly, and the rectum posteriorly. There is a small bubble of air visible on this section within the vaginal vault, which may help to identify it. Between the upper third of the vagina and the rectum is found the pouch of Douglas, or recto-uterine pouch. This is the most dependent part of the peritoneal cavity when a person is in an erect position.

The urethra, vagina and rectum are all parallel to the pelvic brim, and to each other. The vagina is a muscular tube which extends from the vulva superiorly and posteriorly, piercing the urogenital diaphragm to surround the cervix. Anterior to the cervix is a shallow anterior vaginal fornix. The lateral and posterior fornices of the vagina are deeper in comparison.

Butler P, Mitchell AM, Ellis H. Applied Radiological Anatomy. Cambridge: Cambridge University Press, 1999: 281, 295.

Case 3.36



Case 3.36

A Coeliac axis

B Spinal cord within spinal canal

C Left hemi-diaphragm

D Splenic hilum

E Left adrenal gland

Axial contrast-enhanced CT in the portal venous phase.

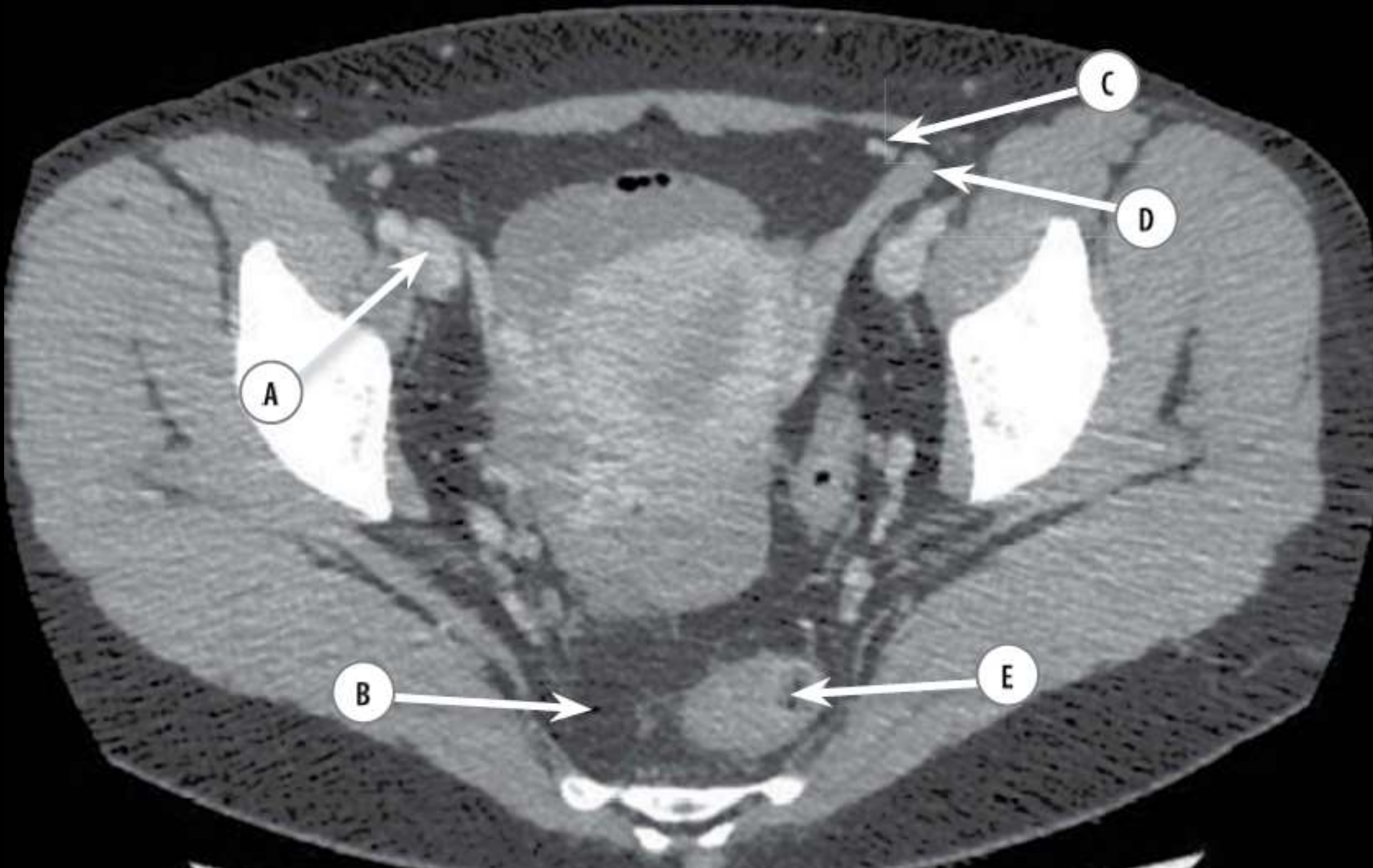
The adrenal glands are retroperitoneal structures which lie above the kidneys. They are found within the perirenal fascia but are separated from the kidney, as they are enclosed within their own compartment. The adrenal glands are composed of a body and two limbs (medial and lateral). The left adrenal gland can be described as having three limbs: anterior, posteromedial and posterolateral. The left adrenal gland has a slightly more variable position than the right. It tends to have a 'Y' shape on cross sectional images, and is found behind the splenic vein, extending towards the hilum of the left kidney. The right adrenal gland tends to be more 'V' shaped on cross section, and has a more consistent position. It is found medial to the right lobe of liver, behind the inferior vena cava, with the right diaphragmatic crus to its medial side. It lies more inferior and medial compared to the left adrenal gland.

The diaphragm forms deep recesses where it attaches to the ribs – these are known as the costophrenic angles. Due to the domed shape of the diaphragm, some of the lung base extends into the costophrenic angles, and this can be seen on the same sections as the upper abdominal viscera.

The coeliac axis arises between T12 and L1 from the anterior surface of the aorta. Its initial course may be horizontal or vertically upwards. On this section it can be seen to pass forwards in the plane of the image initially. It is found below the left lobe of the liver, and above the level of the pancreas and splenic vein. After approximately 1–2 cm, the coeliac axis divides into the common hepatic, splenic and left gastric arteries.

Ryan S, McNicholas M, Eustace SJ. Anatomy for Diagnostic Imaging, 3rd edn. Edinburgh: Saunders, 2011: 203–205.
Butler P, Mitchell AM, Ellis H. Applied Radiological Anatomy. Cambridge: Cambridge University Press, 1999: 225, 270.

Case 3.45



Case 3.45

A Right external iliac vein

B Perirectal fat

C Left inferior epigastric vessels

D Left round ligament

E Rectum

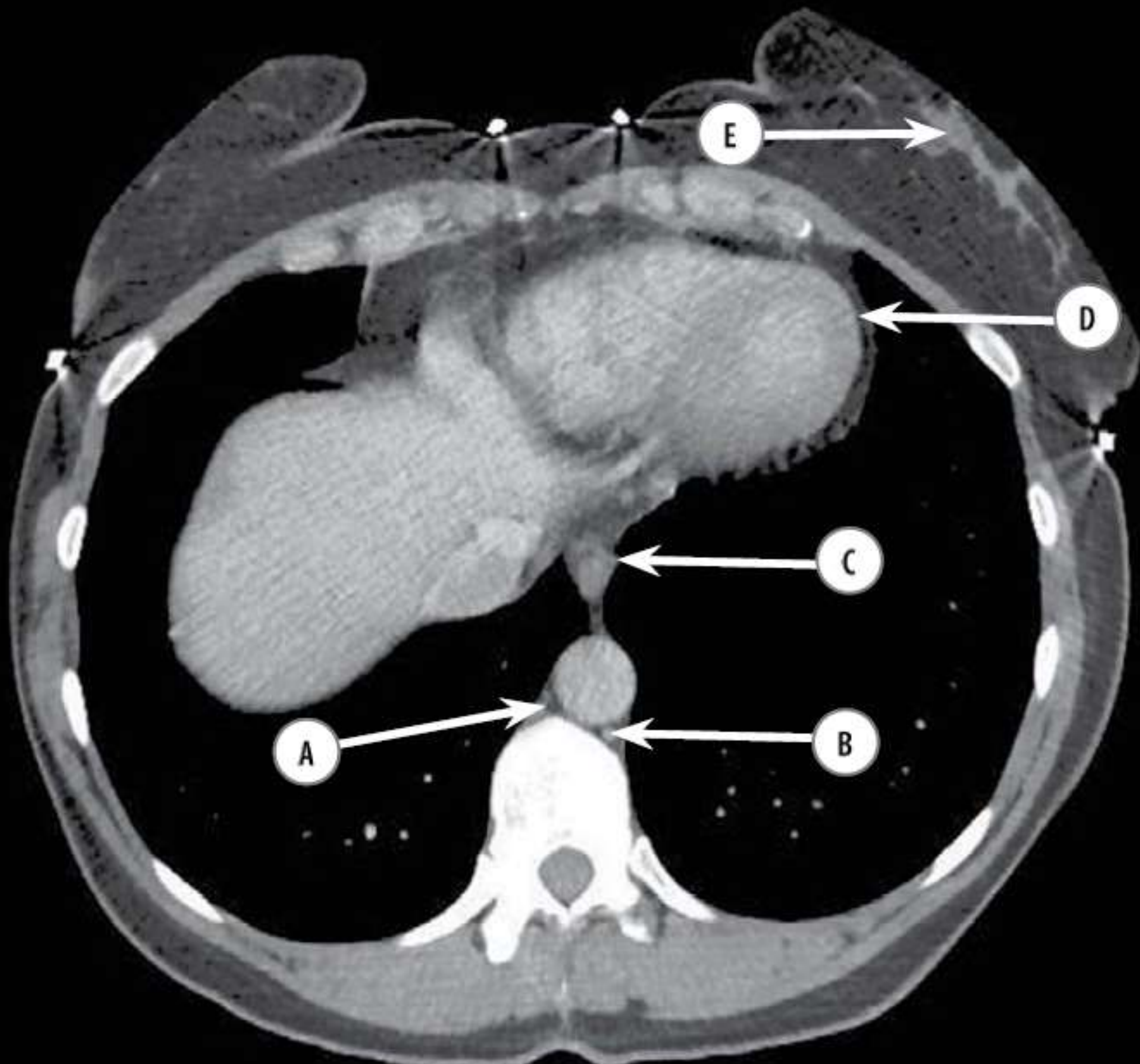
Axial contrast-enhanced CT.

The round ligament is one of the suspensory ligaments of the uterus. It runs from the superolateral aspect of the uterus, anteriorly through the inguinal canal, and ends as its fibres become part of the tissue of the mons pubis. The round ligament acts to keep the uterus in a position of anteversion and is stretched during pregnancy, which can cause pain.

The common iliac arteries bifurcate at the level of the pelvic brim, in front of the lower sacroiliac joints. The external iliac artery then runs along the surface of psoas before passing under the inguinal ligament, where it becomes the common femoral artery. The inferior epigastric artery arises from the external iliac artery just before it passes under the inguinal ligament. It then takes a path up the internal surface of the anterior abdominal wall to enter the rectus sheath.

Hirsch HA. Atlas of Gynaecological Surgery. New York: Thieme Medical Publishers, 1997: 114.
Ryan S, McNicholas M, Eustace SJ. Anatomy for Diagnostic Imaging, 3rd edn. Edinburgh: Saunders, 2011: 226–228, 240.
Butler P, Mitchell AM, Ellis H. Applied Radiological Anatomy. Cambridge: Cambridge University Press, 1999: 282.

Case 3.55



Case 3.55

- **A** Azygos vein
- **B** Hemiazygos vein
- **C** Oesophagus
- **D** Left ventricular wall
- **E** Left breast – fibroglandular tissue

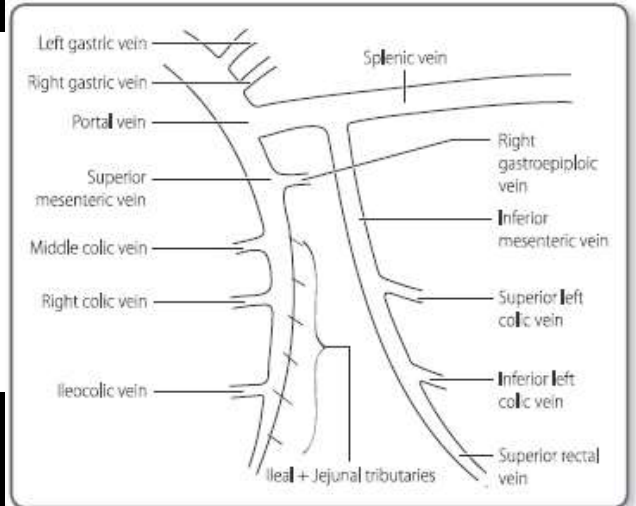


Figure 3.8 Portal venous system.

Axial contrast-enhanced CT.

The azygous venous system drains deoxygenated blood from the posterior thorax and abdomen into the superior vena cava (SVC). It is made up of the right sided azygos vein, and the left sided hemiazygos and accessory hemiazygos veins.

The azygous vein can arise either as a branch of the inferior vena cava (IVC), or as a confluence between the right ascending lumbar vein and the right subcostal vein, at the level of L2. It rises up behind the right diaphragmatic crus and follows a path anterior to the bodies of T12–5, with the aorta and thoracic duct to its left. Once it reaches the level of the pulmonary hilum it arches anteriorly over the right main bronchus, to drain into the SVC. The 'azygos arch' can occasionally be displaced laterally. It is invested in four layers of pleura to create an accessory fissure, which delineates an azygos lobe, separate from the upper lobe.

The accessory hemiazygos vein drains the 4th to 8th posterior intercostal veins and may also drain the left bronchial veins. It follows a path to the left of the vertebral column until it reaches the midthoracic level, where it crosses the midline and passes behind the aorta to drain into the azygos vein.

The hemiazygos vein arises on the left, below the diaphragm and similarly to the azygos vein can have a variable origin. It may arise from the left renal vein, or as a confluence of the left ascending lumbar and left subcostal veins. It rises on the left of the vertebral column and passes across the midline, behind the aorta at the midthoracic level, to drain into the azygos vein. **Figure 3.9** demonstrates the anatomy of the azygous venous system.

Ryan S, McNicholas M, Eustace SJ. Anatomy for Diagnostic Imaging, 3rd edn. Edinburgh: Saunders, 2011: 147–149.

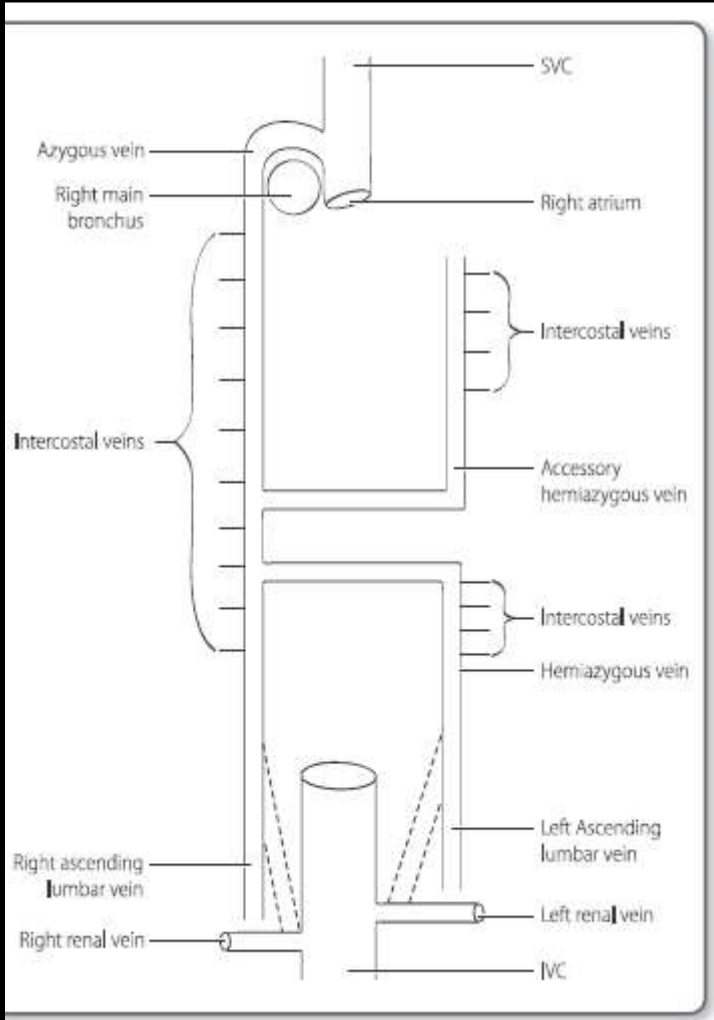


Figure 3.9 Anatomy of the azygous venous system.

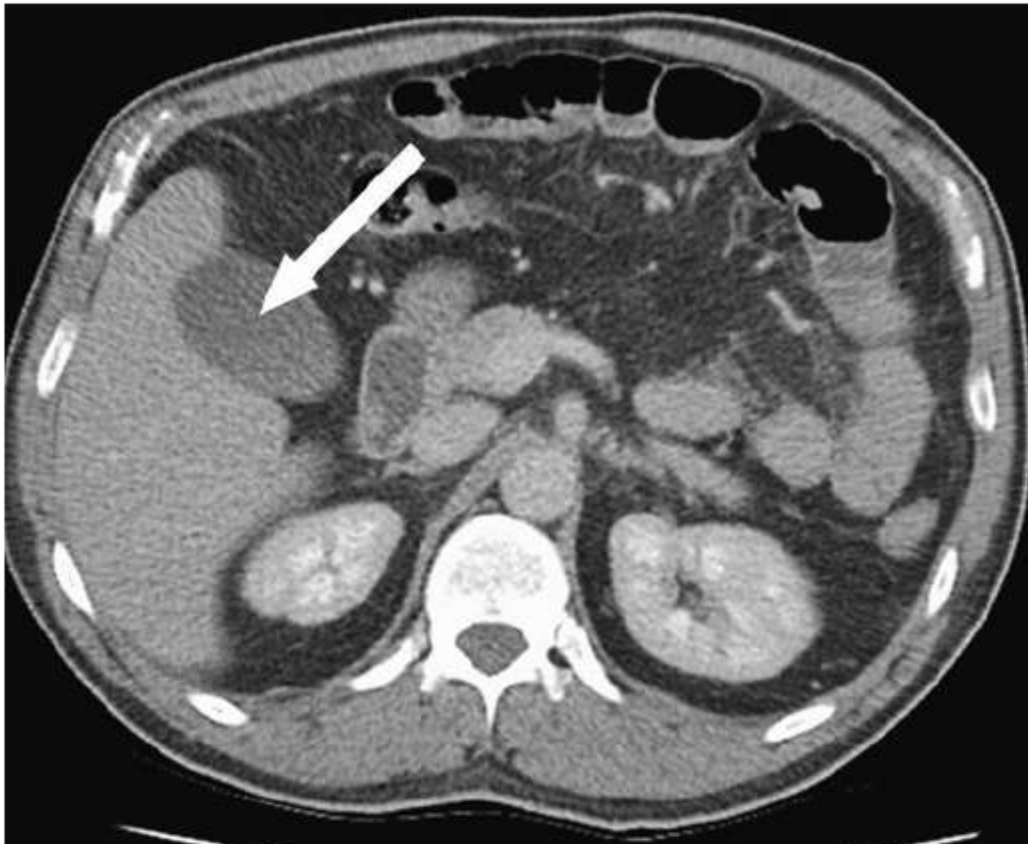
Question 1:

Question 1: Axial CT of the abdomen

Answer: Inferior vena cava

- The inferior vena cava (IVC) passes adjacent to to the posterior part of the liver.
- The IVC has a short intrathoracic course. This may be important when it comes to answering the question in the examination, 'intrathoracic inferior vena cava', if the marker points to the IVC above the diaphragm.
- In the image, the IVC is distended and appears larger than the aorta. Sometimes it can appear slitlike when it is collapsed; it varies with the phase of respiration and intravascular volume. Be sure to familiarise yourself with both appearances.
- A bilateral/double IVC is a well-described normal variant.

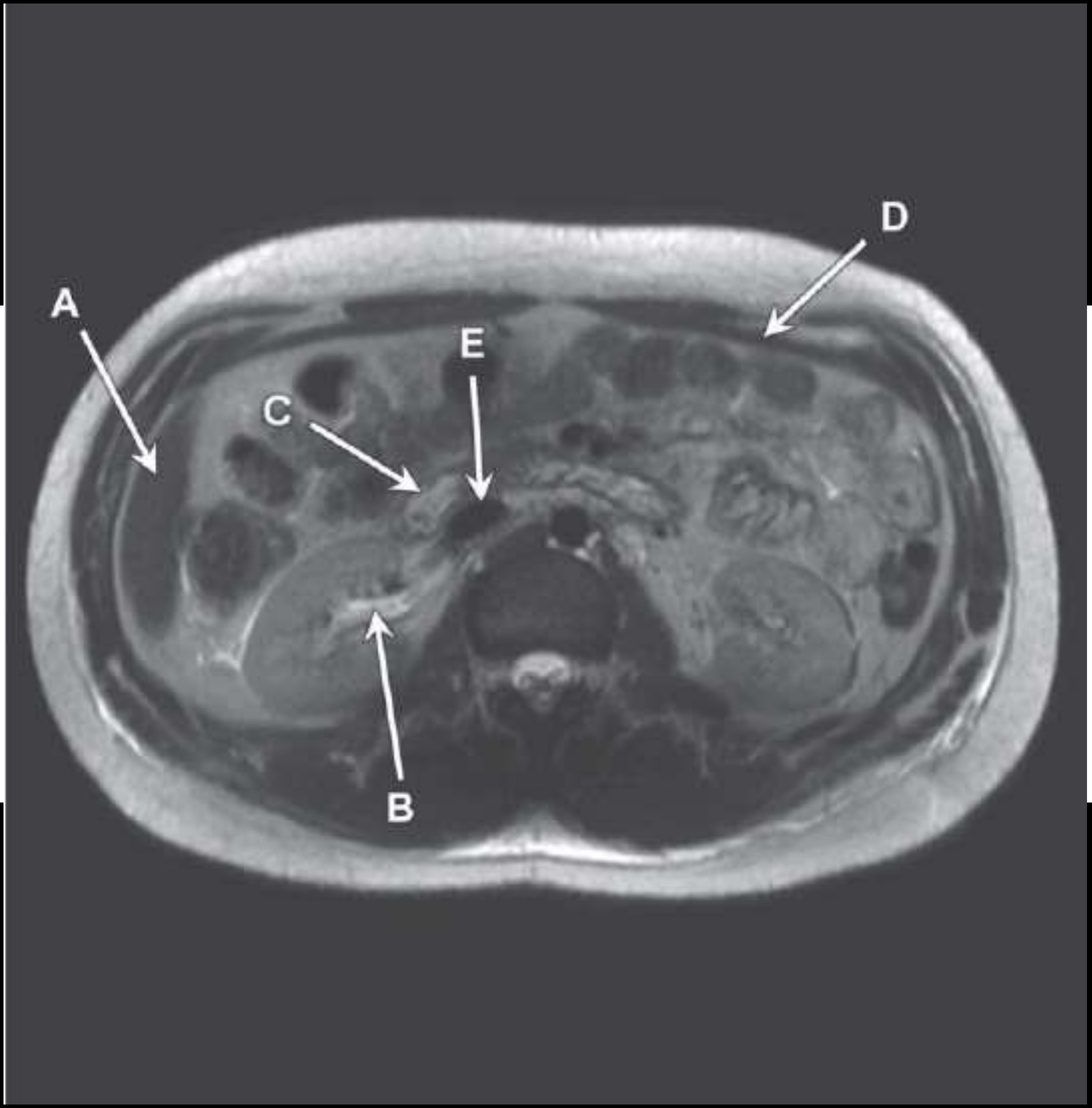
- **Question 2:**



Question 2: Axial CT of the abdomen

Answer: Gallbladder

- The gallbladder is a fluid-filled structure and therefore has a lower attenuation than the adjacent liver.
- Rarely, it may be intrahepatic, surrounded by liver parenchyma rather than on the undersurface of the liver.
- Its wall should be less than 3 mm in thickness.
- Gas within the gallbladder may be a normal finding shortly after sphincterotomy or biliary stent insertion.


A
B
C
D
E

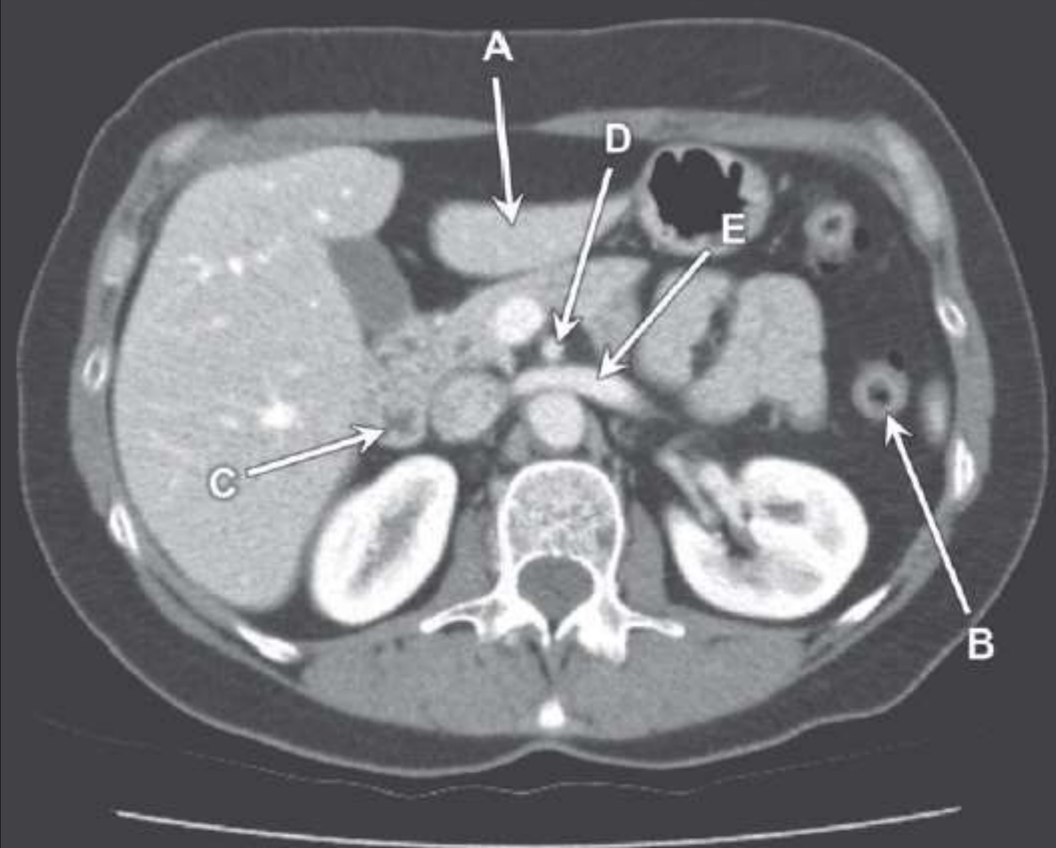
Case 1

MRI abdomen. T2W axial section

1. Liver
2. Right renal pelvis
3. Duodenum (second part)
4. Left transversus abdominis muscle
5. Inferior vena cava

The blood vessels show flow void artefact and are black on this image. B, therefore is not a vessel.

1. Name the segment of the liver labelled A.



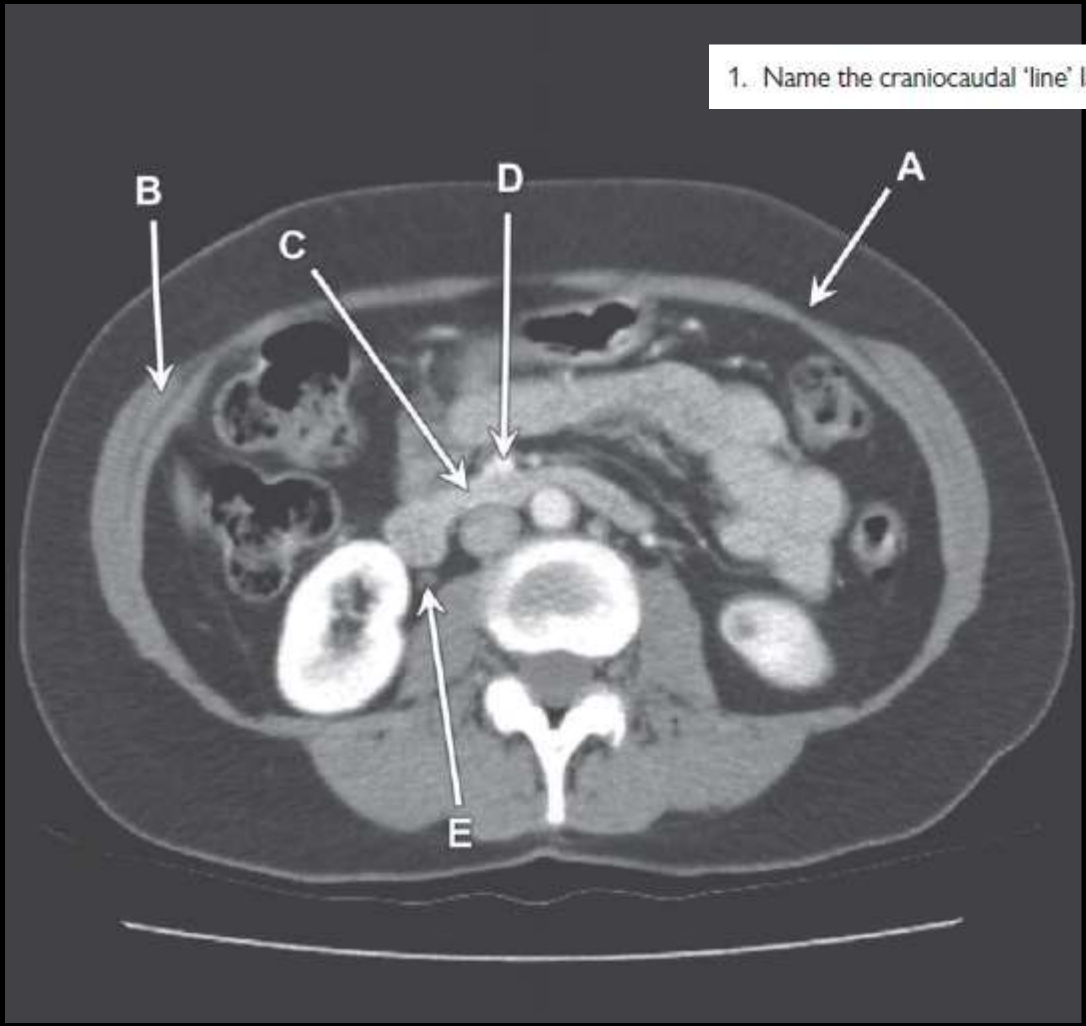
Case 3

CT abdomen. Axial section

1. Segment 3
2. Descending colon
3. Duodenum (second part)
4. Superior mesenteric artery
5. Left renal vein

The candidate should be familiar with the liver segments. Segments 2 and 3 make up the left lobe, 2 superiorly and 3 inferiorly, divided at the level of the portal vein.

1. Name the craniocaudal 'line' labelled A.

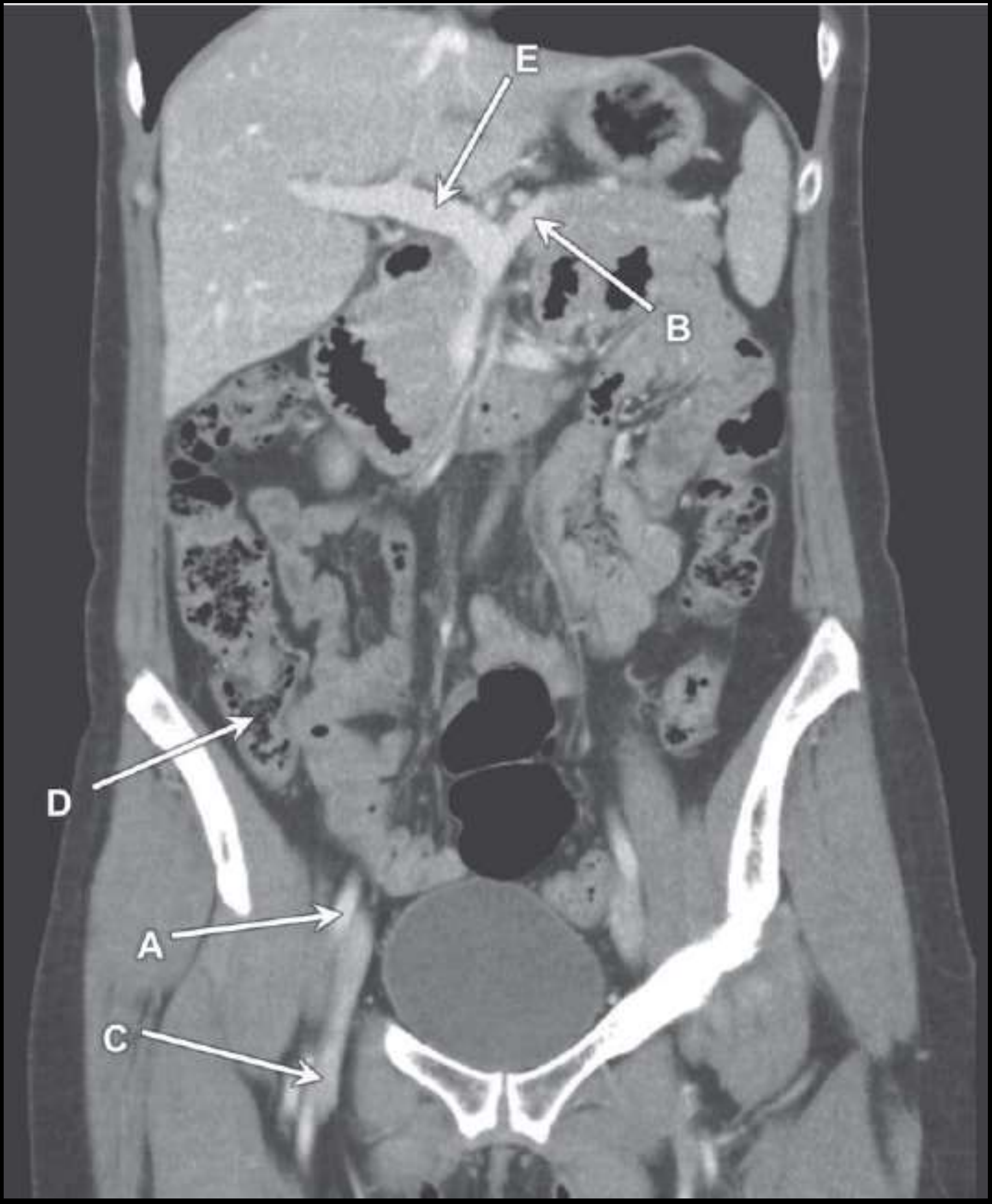


Case 8

CT abdomen. Axial section.

1. Linea semilunaris
2. Right internal oblique muscle
3. Duodenum (third part)
4. Superior mesenteric artery
5. Right ureter

The linea semilunaris is also known as 'Spiegel's line' and is the site of Spiegelian herniae (through the Spiegelian fascia).


E
B
D
A
C

Case 6

CT abdomen. Coronal section.

1. Right external iliac artery
2. Splenic vein
3. Right common femoral vein
4. Caecum
5. Portal vein

Remember that the blood vessels change their name from 'external iliac' to 'femoral' as they pass the inguinal ligament.

CT Abdomen

Left-sided inferior vena cava

Seen in 0.2–0.5 % people due to persistence of the left and regression of the right supracardinal vein. The left IVC usually joins the left renal vein.


1
2
3
4
5
10.00mm/

CT Abdomen

1. Stomach
2. Splenic vein
3. Gall bladder
4. Superior mesenteric vein
5. Left kidney

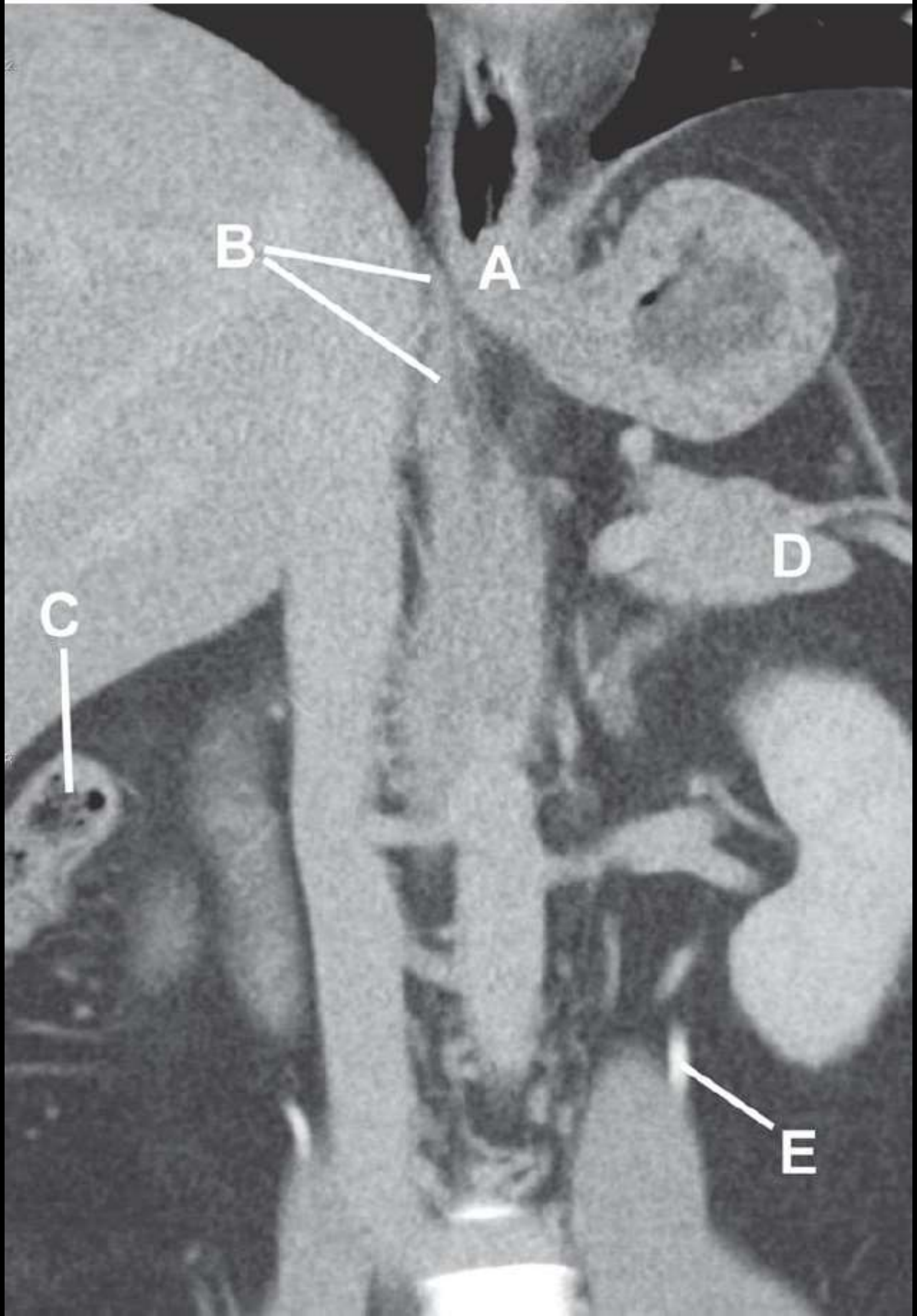
The portal vein is formed by the union of the splenic vein and the superior mesenteric vein behind the neck of the pancreas. It drains blood from the lower 1st/3rd of the oesophagus to halfway down the anal canal.


37
36
38
39
40

MRI Abdomen

36. Right lobe of liver
37. Right hemidiaphragm
38. Spleen
39. Right renal pelvis
40. Thecal sac

The plane of this MRI section is such that the thecal sac is exposed in the lower lumbar segments.


B
A
C
D
E

Q3 Answers

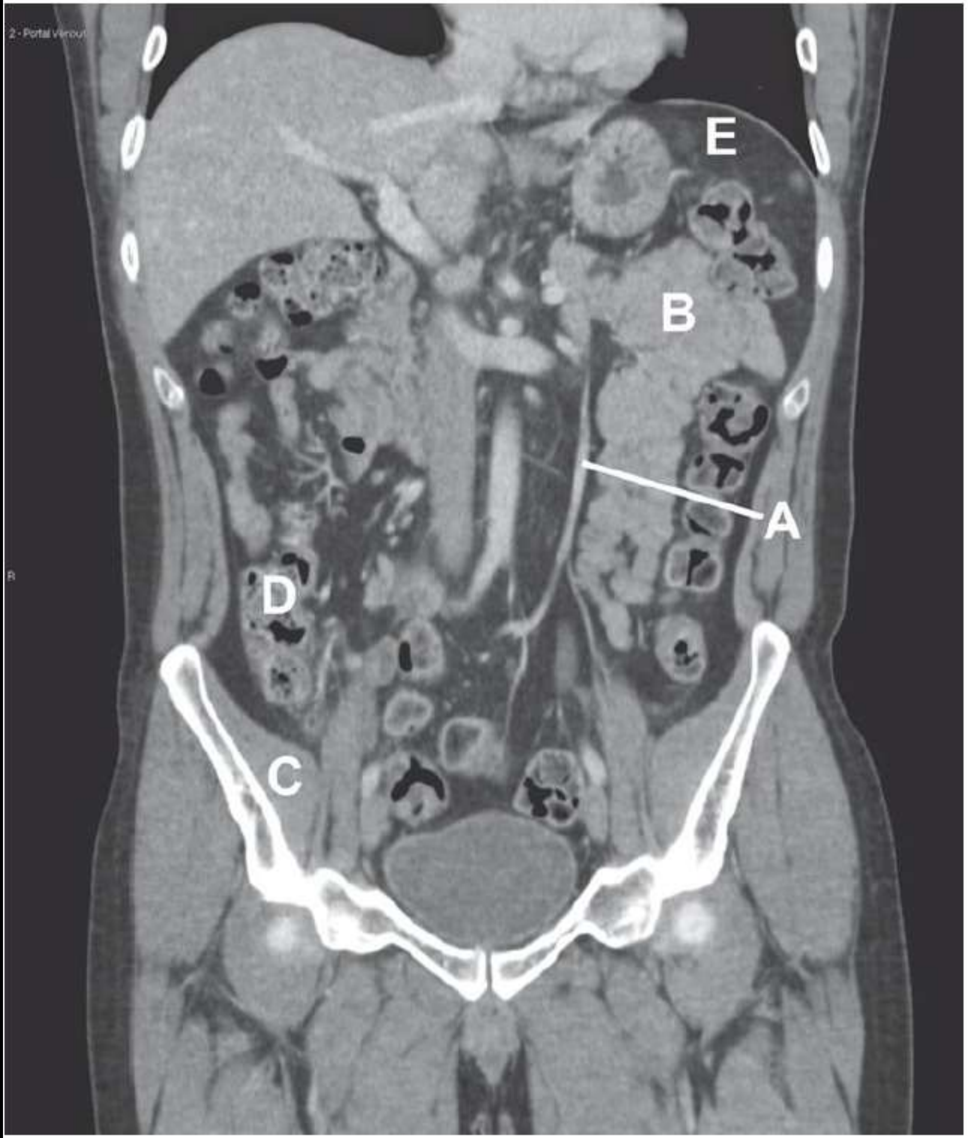
- **a** Gastro-oesophageal junction
- **b** Crus of right hemi-diaphragm
- **c** Right colic flexure (hepatic flexure)
- **d** Tail of the pancreas
- **e** Left ureter

CT of upper abdomen with contrast, oblique coronal section

The two diaphragmatic crura arise from the upper lumbar vertebrae (L1/2/3 on the right and L1/2 on the left) and arch superiorly and anteriorly to form the margins of the aortic and oesophageal hiatuses. They are connected anteriorly by the median arcuate ligament which forms the anterior border of the aortic hiatus (T12). Anterior to this is the oesophageal hiatus (T10). The third and most anterior diaphragmatic hiatus is for the IVC (T8) which is situated immediately inferior to the right atrium within the large central tendon of the diaphragm.

Q13

a Name the structure labelled A
b Name the structure labelled B
c Name the structure labelled C
d Name the artery supplying the structure labelled D
e Name the space labelled E



Q13 Answers

a Left gonadal (testicular) vein
b Jejunum
c Iliacus
d Ileo-colic artery
e Left sub-phrenic space

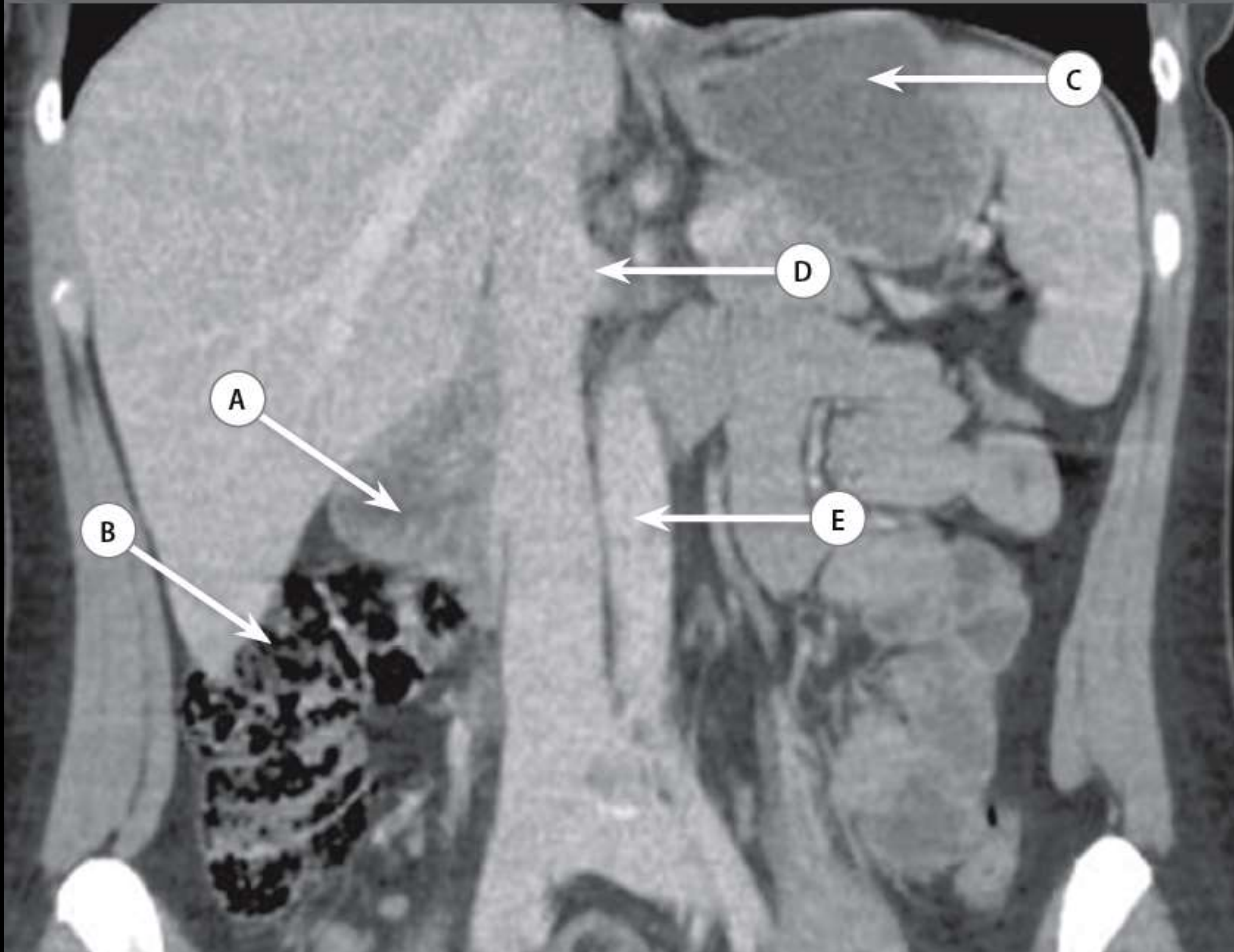
CT abdomen with contrast, coronal section

In males, the testicular veins enter the abdominal cavity through the inguinal canal and run along the anterior aspect of the psoas muscle, usually in a pair either side of the testicular artery. The vein on the right empties into the IVC but on the left it usually inserts at a right angle into the left renal vein.

The superior mesenteric artery supplies the mid-gut structures, which includes bowel from half way along the 2nd part of duodenum to the distal two thirds of the transverse colon. Three branches of the SMA provide the colonic supply – the ileo-colic, right colic and middle colic arteries.

The left sub-phrenic space is separated from the right sub-phrenic space by the falciform ligament of the liver.

Case 5.5



Case 5.5

A Duodenum, junction of D2 and D3

B Hepatic flexure of large bowel

C Gastric fundus

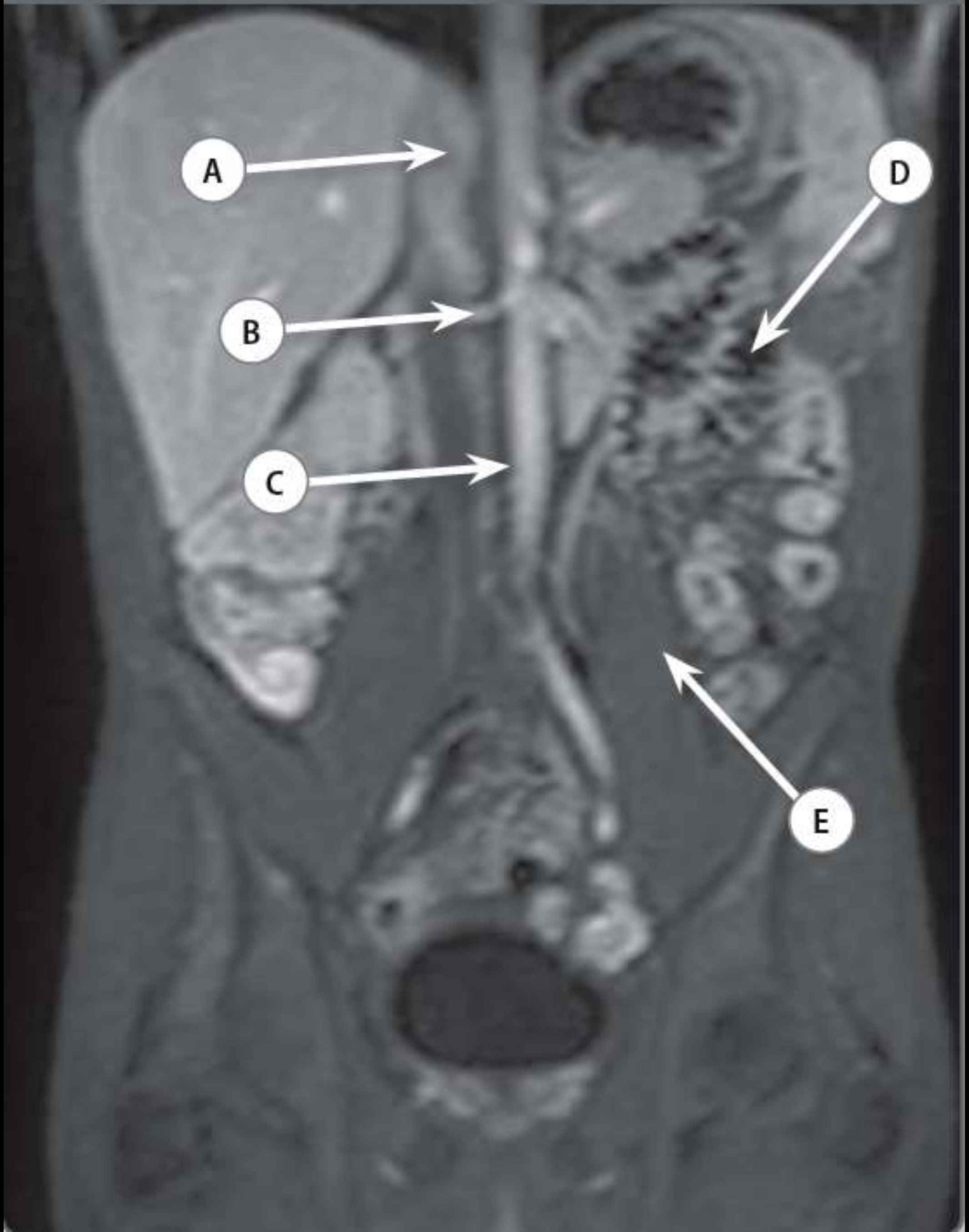
D Left renal vein

E Abdominal aorta

Coronal contrast-enhanced CT of the abdomen and pelvis.

For further discussion see Chapter 3, Cases 3.6 and 3.12.

Case 6.2



Case 6.2

A Intrahepatic inferior vena cava

B Right renal artery

C Abdominal aorta

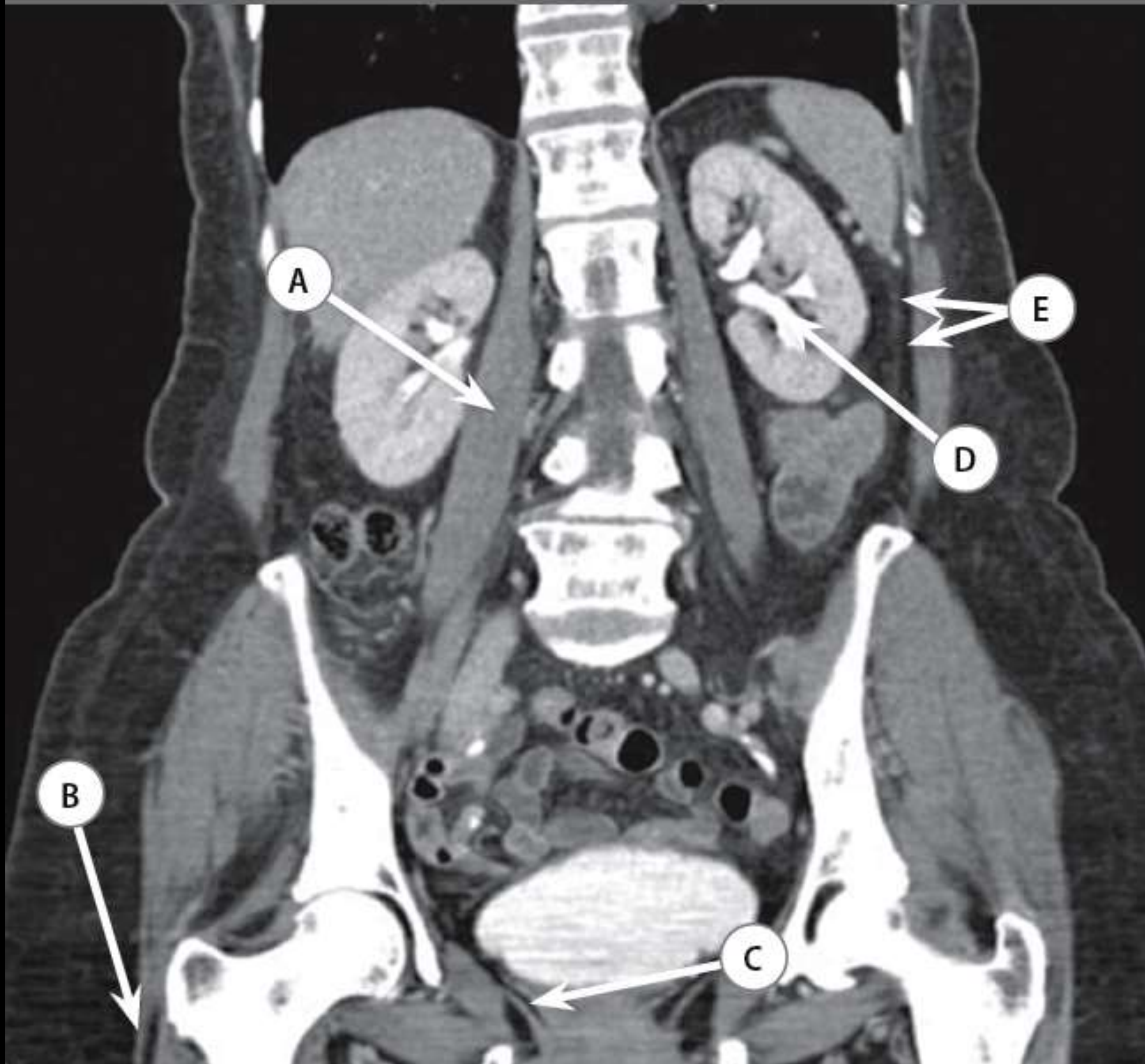
D Jejunal loop

E Left psoas major

Coronal abdominal MRI.

For further discussion, see Chapter 3, Cases 3.10 and 3.12.

Case 6.16



Case 6.16

A Right psoas

B Right iliotibial tract

C Right levator ani

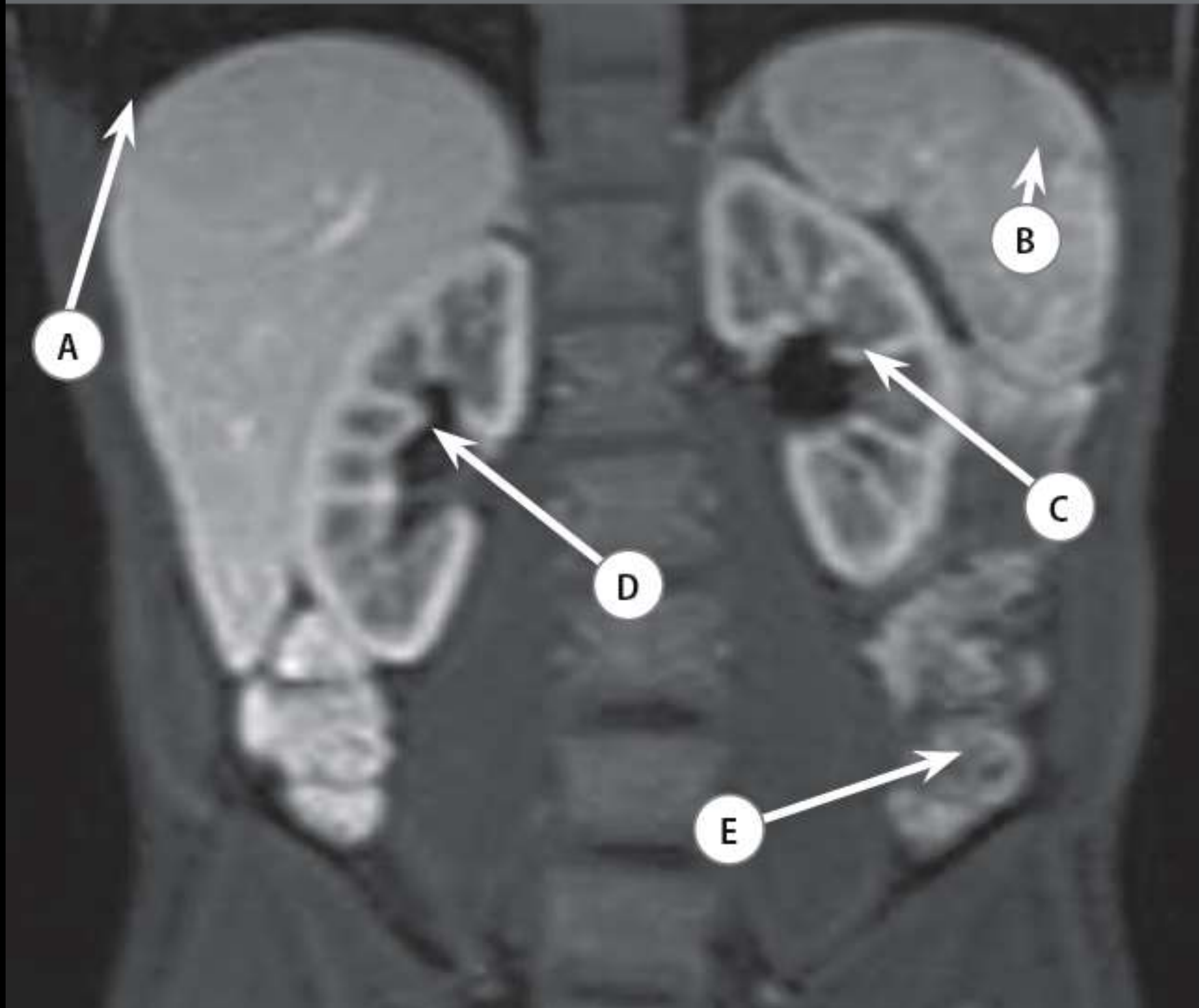
D Infundibulum of left lower pole calyx

E Left lateral conal fascia

Coronal CT urogram.

For further discussion see Chapter 3, Cases 3.13 and 3.53.

Case 6.18



Case 6.18

A Right costophrenic angle

B Spleen

C Column of Bertin, interpolar region left kidney

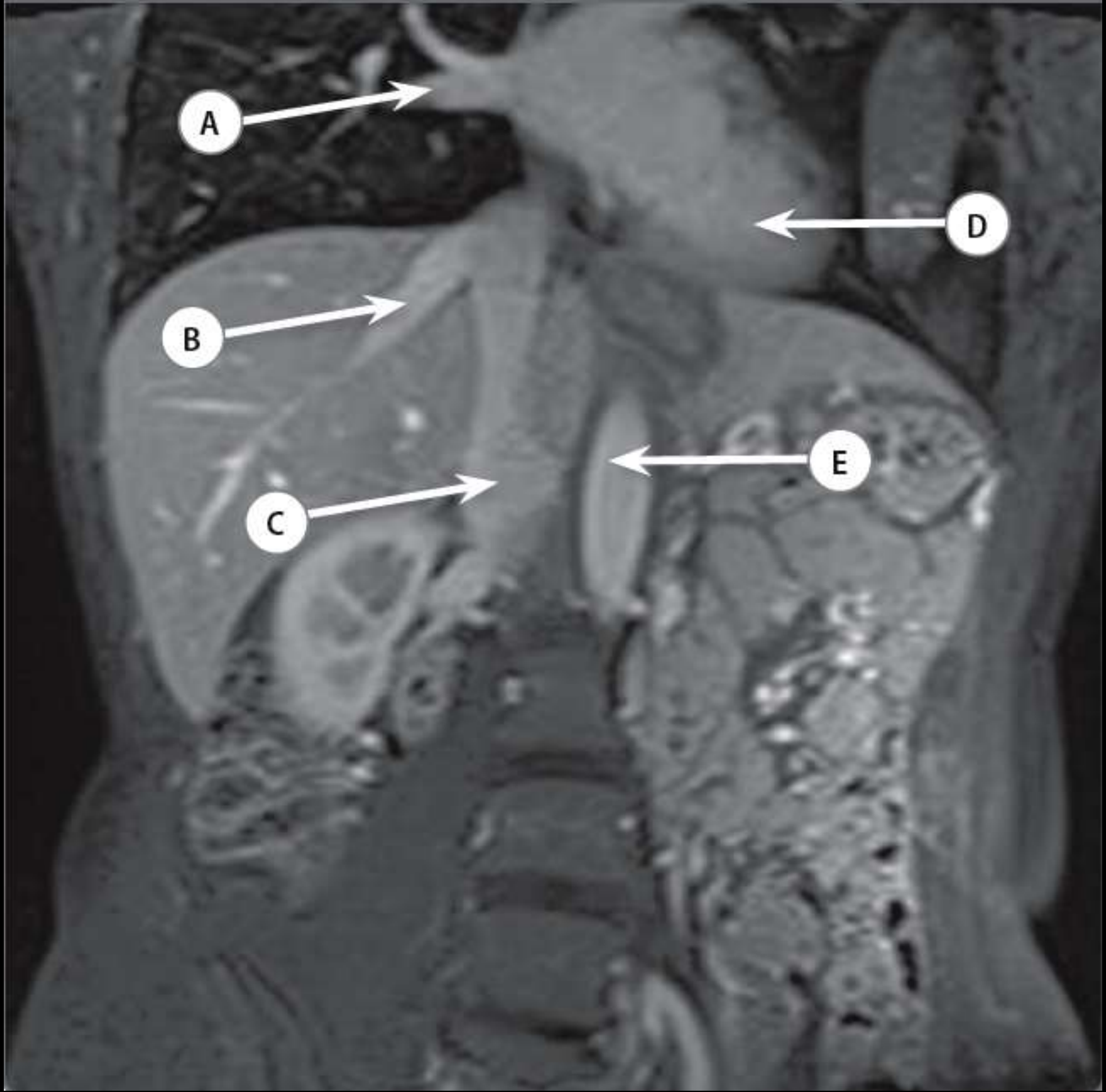
D Right renal pelvis

E Descending colon

Fat-sat coronal MRI of the abdomen.

For further discussion see Chapter 3, Case 3.9.

Case 6.20



Case 6.20

A Right inferior pulmonary vein

B Right hepatic vein

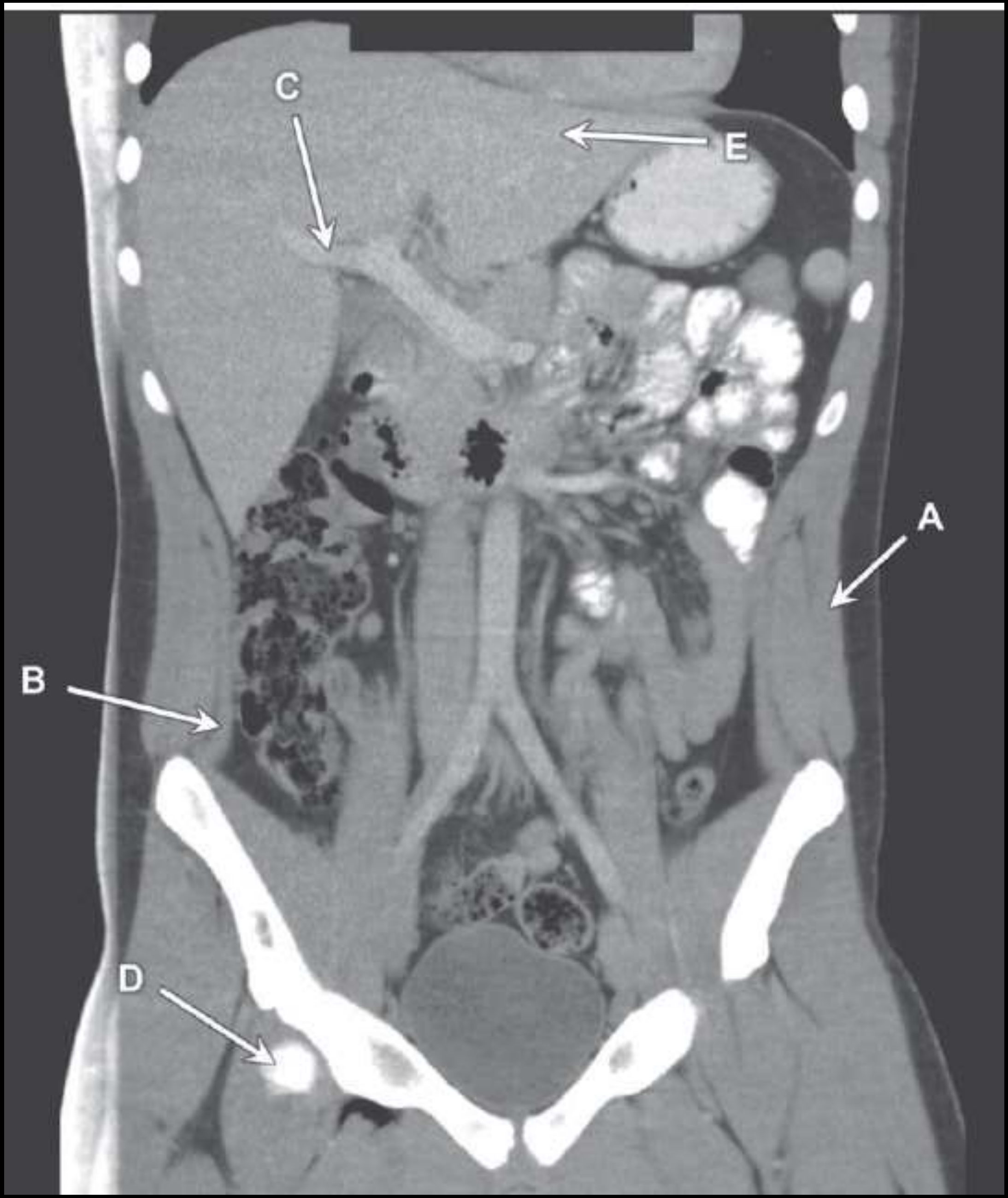
C Intrahepatic inferior vena cava

D Left ventricle

E Abdominal aorta

Coronal MRI of the abdomen.

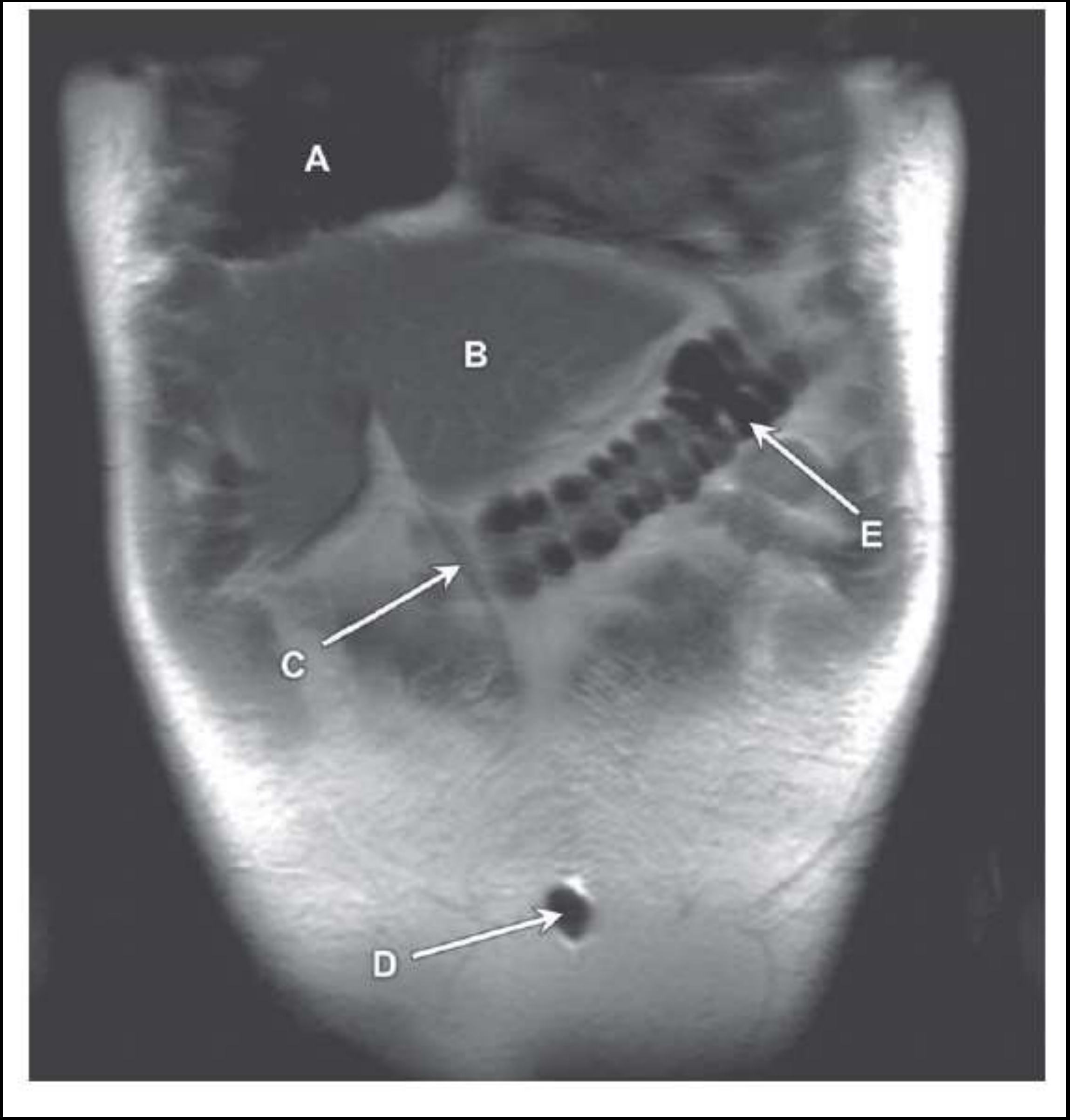
For further discussion see Chapter 3, Case 3.39.


C
E
A
B
D

Case 5

CT abdomen and pelvis with intravenous contrast. Coronal reconstruction.

1. Left external oblique muscle
2. Right transversus abdominis muscle
3. Right portal vein
4. Head of right femur
5. Left lobe of liver

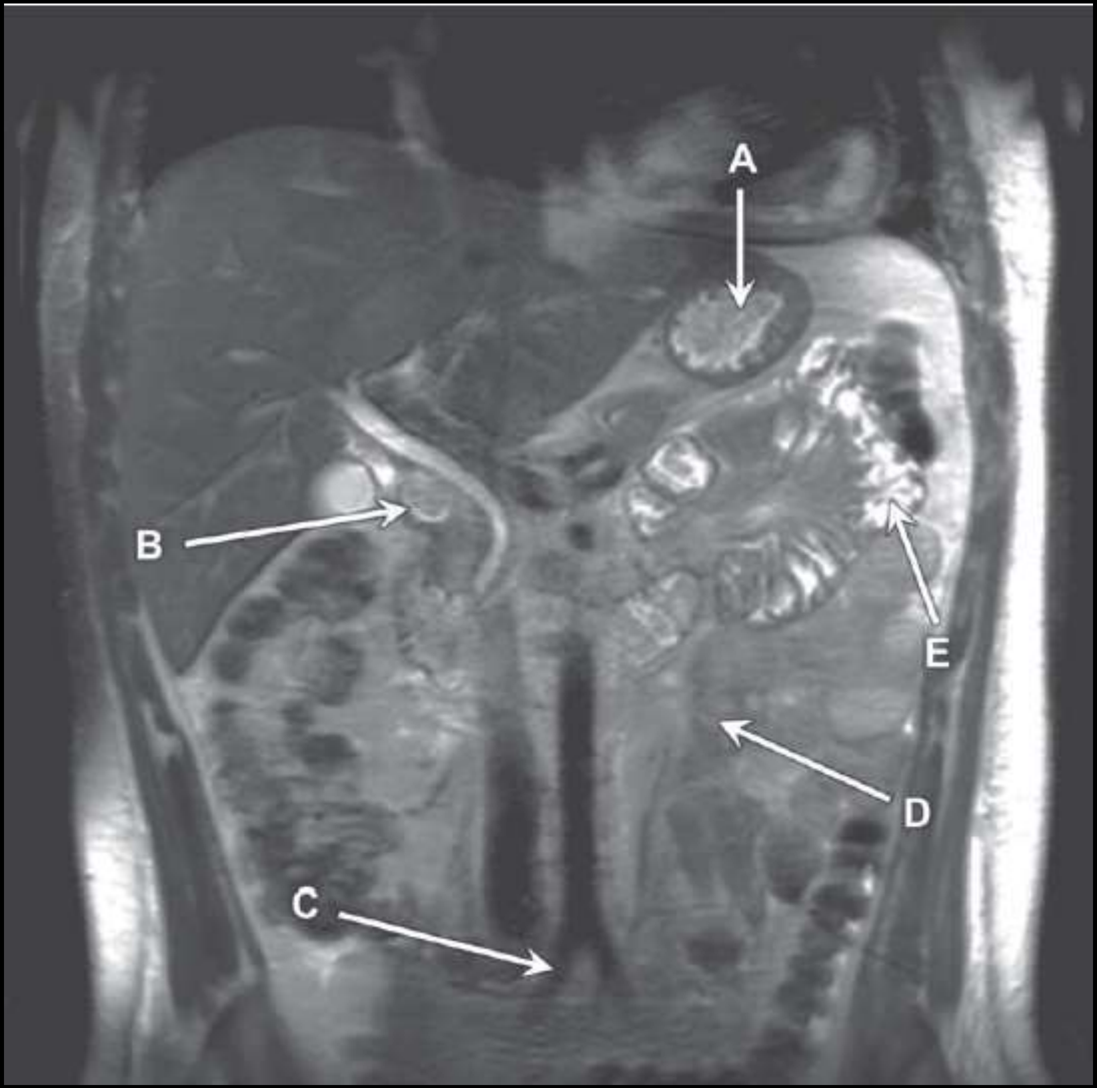

A
B
C
D
E

Case 18

MRI abdomen. T1W coronal section.

1. Right lung
2. Left lobe of the liver
3. Falciform ligament
4. Umbilicus
5. Transverse colon

As elsewhere, once one has recognized that this is an anterior slice of the abdomen, the rest should be straightforward.


A
B
C
D
E

Case 7

MRI abdomen. T2W coronal section.

1. Stomach
2. Duodenum
3. Right common iliac artery
4. Ileum
5. Jejunum

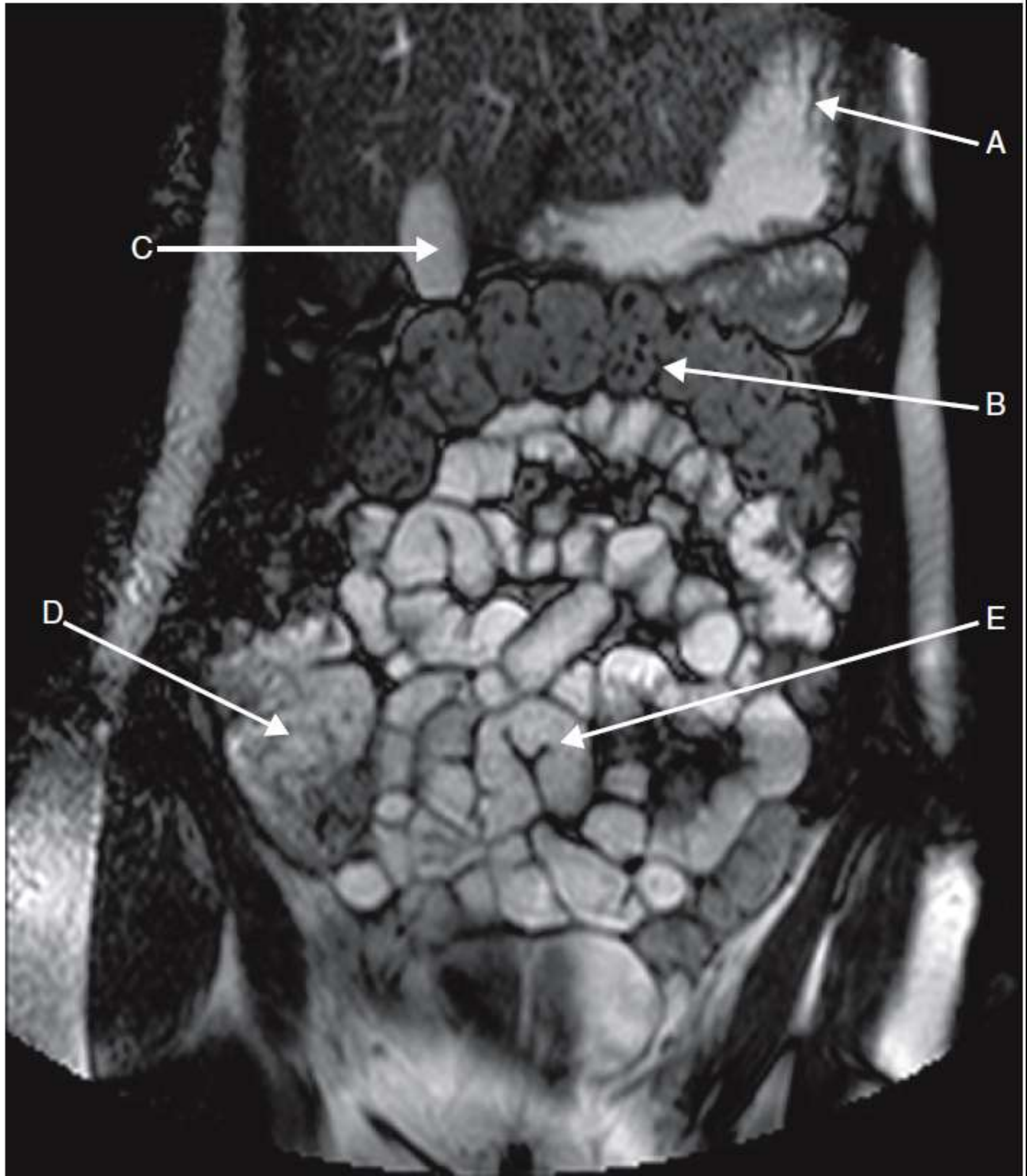
Questions	
66.	At what vertebral level does structure 66 traverse the diaphragm?

CT Abdomen

66. T8
67. Right psoas major muscle
68. Spleen
69. Left renal vein
70. Small intestine (loops of)

The IVC traverses the diaphragm at T8. The levels at which important structures traverse the diaphragm can be remembered as follows: vena cava (8 letters, T8), oesophagus (10 letters, T10) and aortic hiatus (12 letters, T12).

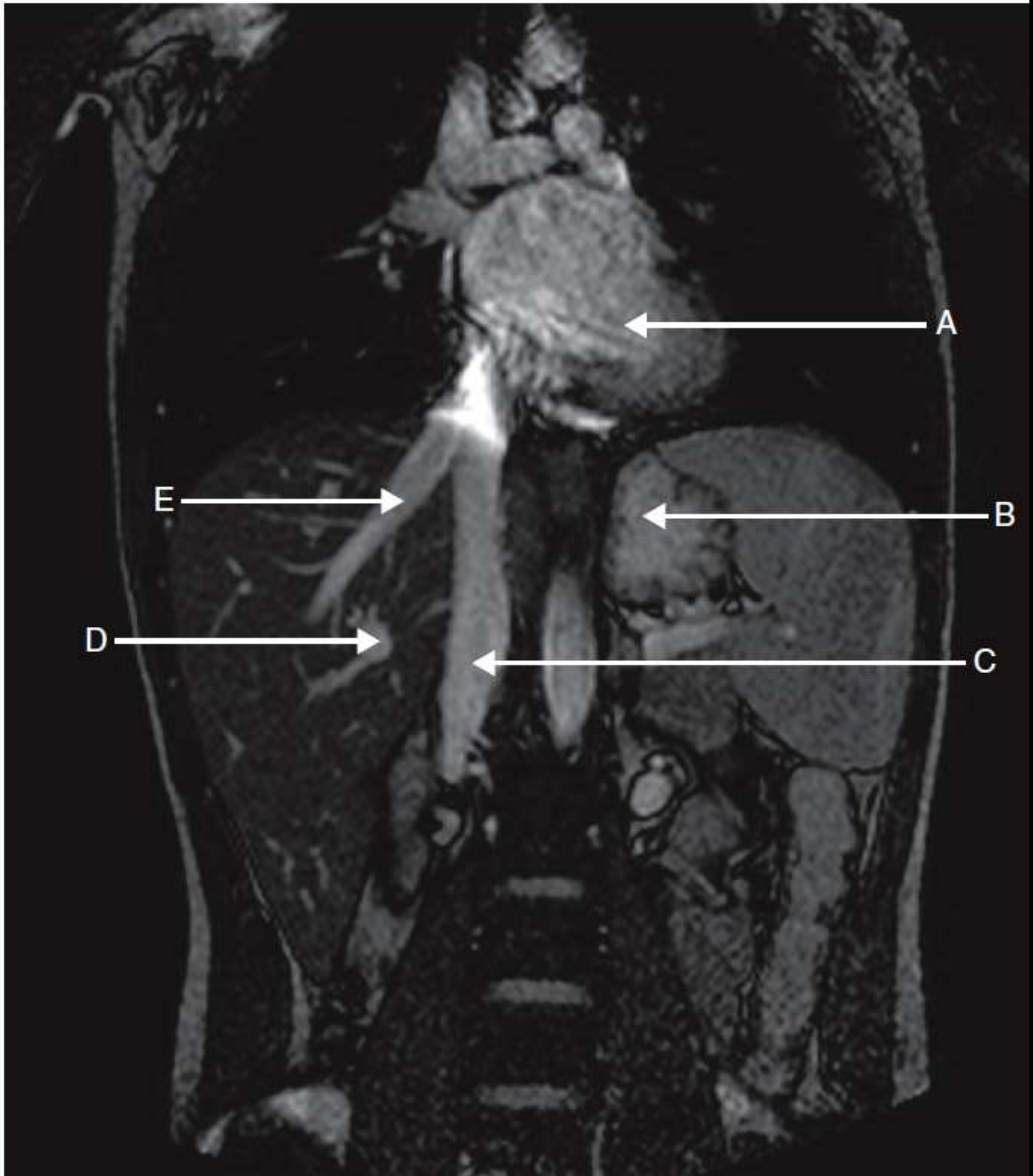
Case 6.6



6.6 Coronal T2-weighted MR enteroclysis image

(a) Rugal folds of the stomach. When contracted the gastric mucosa is thrown into longitudinal ridges. They are most marked in the pyloric region and along the lesser curve.
(b) Transverse colon. Contains solid faecal matter and therefore on this T2-weighted fast field echo image appears of low signal mixed with air.
(c) Gallbladder. The bile shows as high signal on this T2-weighted image.
(d) Caecum. It appears high signal as there is still a certain amount of fluid within the faeces at this stage.
(e) Ileum. Note the wall is smooth and shows no obvious thickening or change in the surrounding tissue.

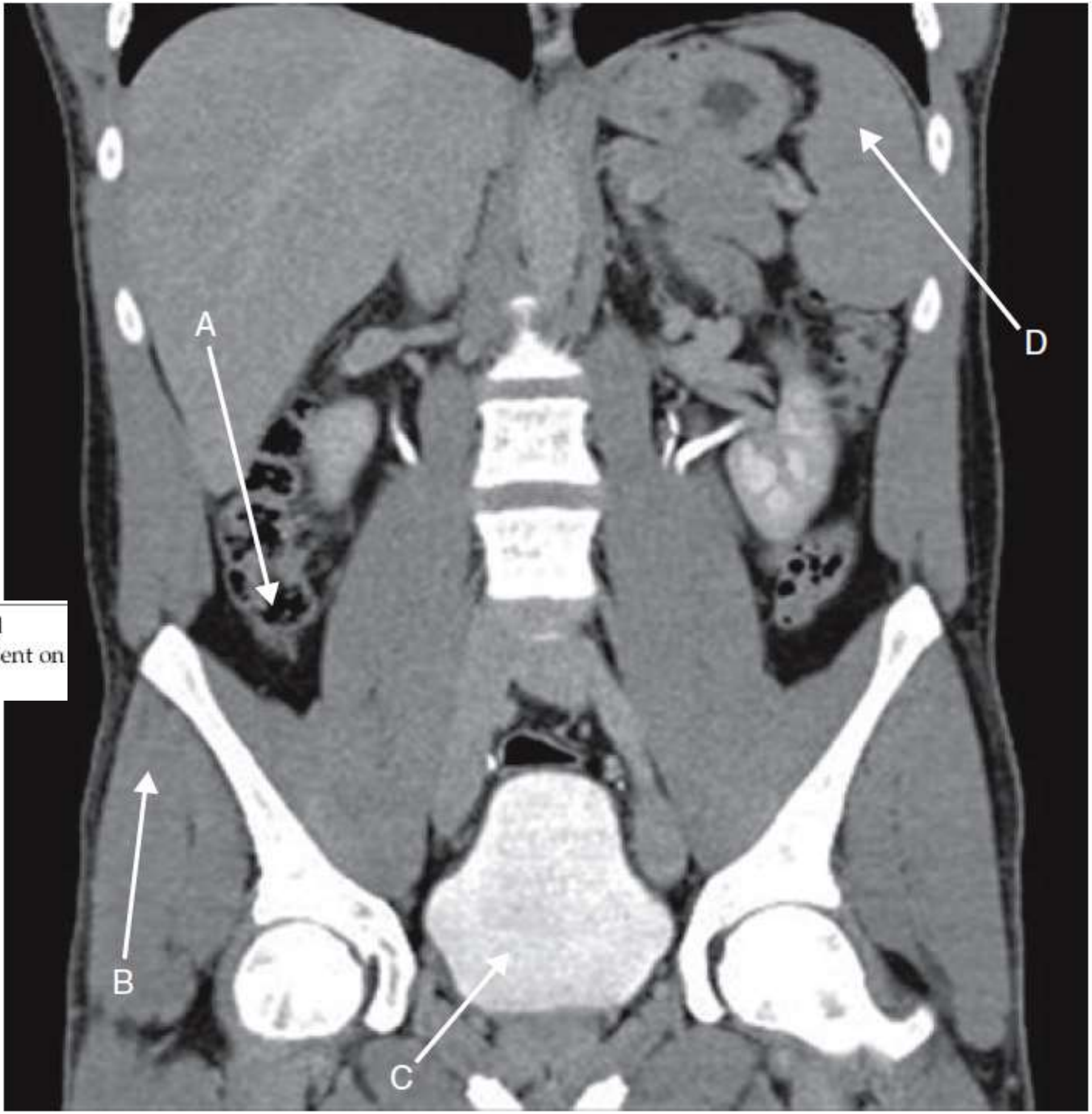
Case 4.14



4.14 Coronal T2-weighted MR through thorax and abdomen

(a) Left ventricle.
(b) Fundus of stomach.
(c) Inferior vena cava (IVC). The IVC passes through the central tendon of the diaphragm at T8 together with the right phrenic nerve. The oesophagus passes through the diaphragm at T10 together with the right vagus nerve posteriorly and the left vagus nerve anteriorly. The aortic opening is at T12 through which also passes the thoracic duct. Other structures which pass through the diaphragm are the left phrenic nerve, splanchnic nerves and the sympathetic chain behind the arcuate ligaments.
(d) Right portal vein. The proximity of the portal vein to the hepatic vein allows for a Transjugular Intrahepatic Porto-systemic Shunt (or TIPSS) procedure. With cirrhosis of the liver there is raised venous pressure in the liver bed which transmits to the portal circulation and collateral pathways develop. In particular, there is risk of catastrophic gastrointestinal haemorrhage from oesophogeal varices. A TIPSS procedure shunts blood into the systemic circulation thereby reducing portal pressure. It involves placing a covered stent between the right portal vein and right hepatic vein via a jugular approach.
(e) Right hepatic vein.

Case 3.9



(e)	Which normal variant is present on this image?

3.9 Coronal enhanced abdominal CT

(a) Ascending colon.
(b) Right gluteus medius muscle.

(c) Urinary bladder.
(d) Spleen.
(e) Left duplex kidney.

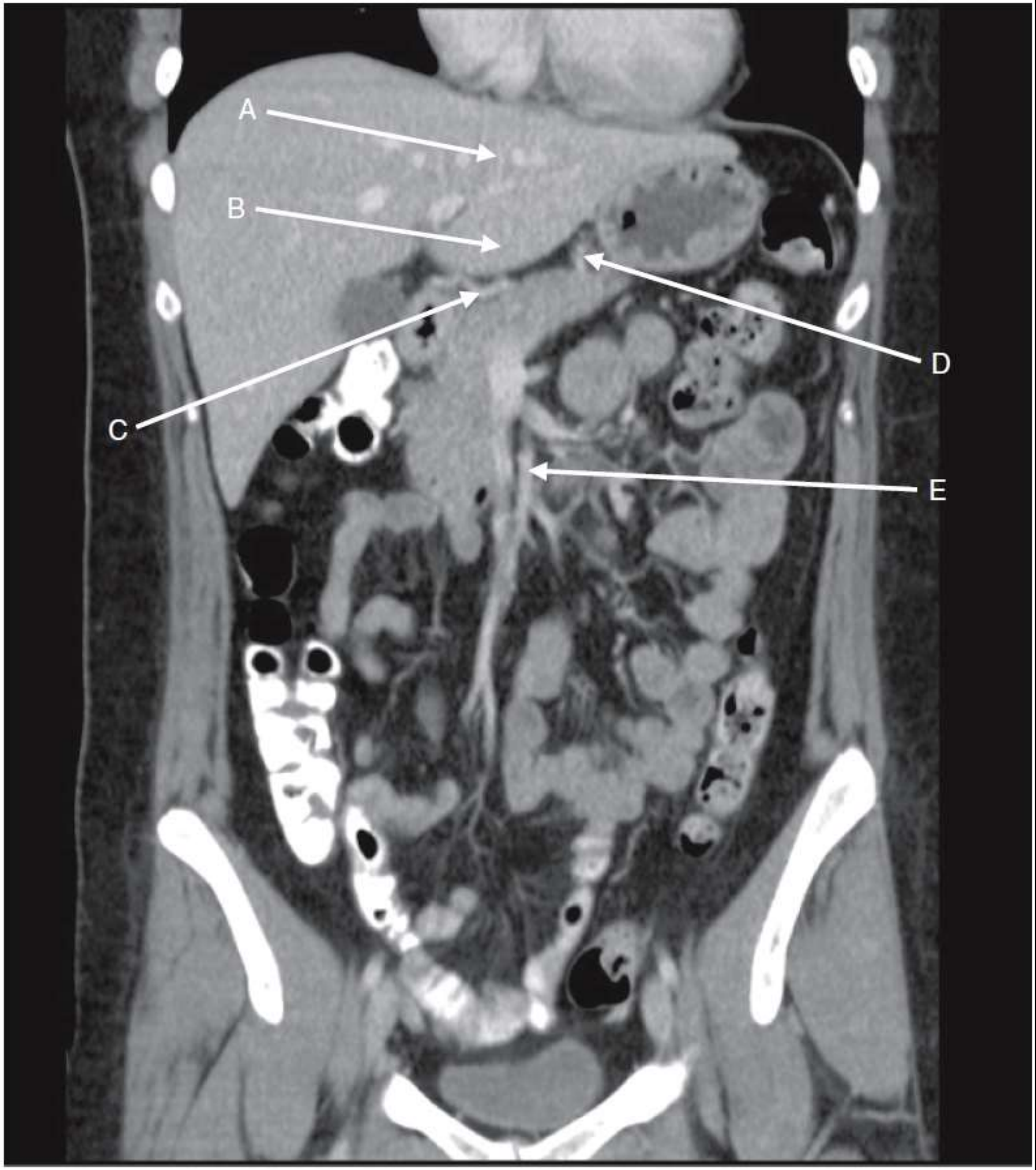
CTU is now a widely accepted modality used for the investigation of haematuria. Depending on local policy, different phases of imaging are obtained, which must include a urographic phase.

Images should be interpreted using axial, sagittal and coronal planes to ensure both ureters have been adequately assessed in their entirety.

The commonest anomaly of the kidney is duplication of the collecting system, which occurs in 1% of the population. This is more common in females than males and varies from a bifid renal pelvis to complete duplication of the ureter. In this case, the ureter draining the upper pole moiety inserts lower into the bladder than that draining the lower moiety. The upper ureter is more likely to obstruct and the lower pole ureter more likely to reflux.

When evaluating CTU, look carefully for any anomaly in ureteric anatomy as one ureter may be involved in tumour or with renal calculi, and the other may be normal.

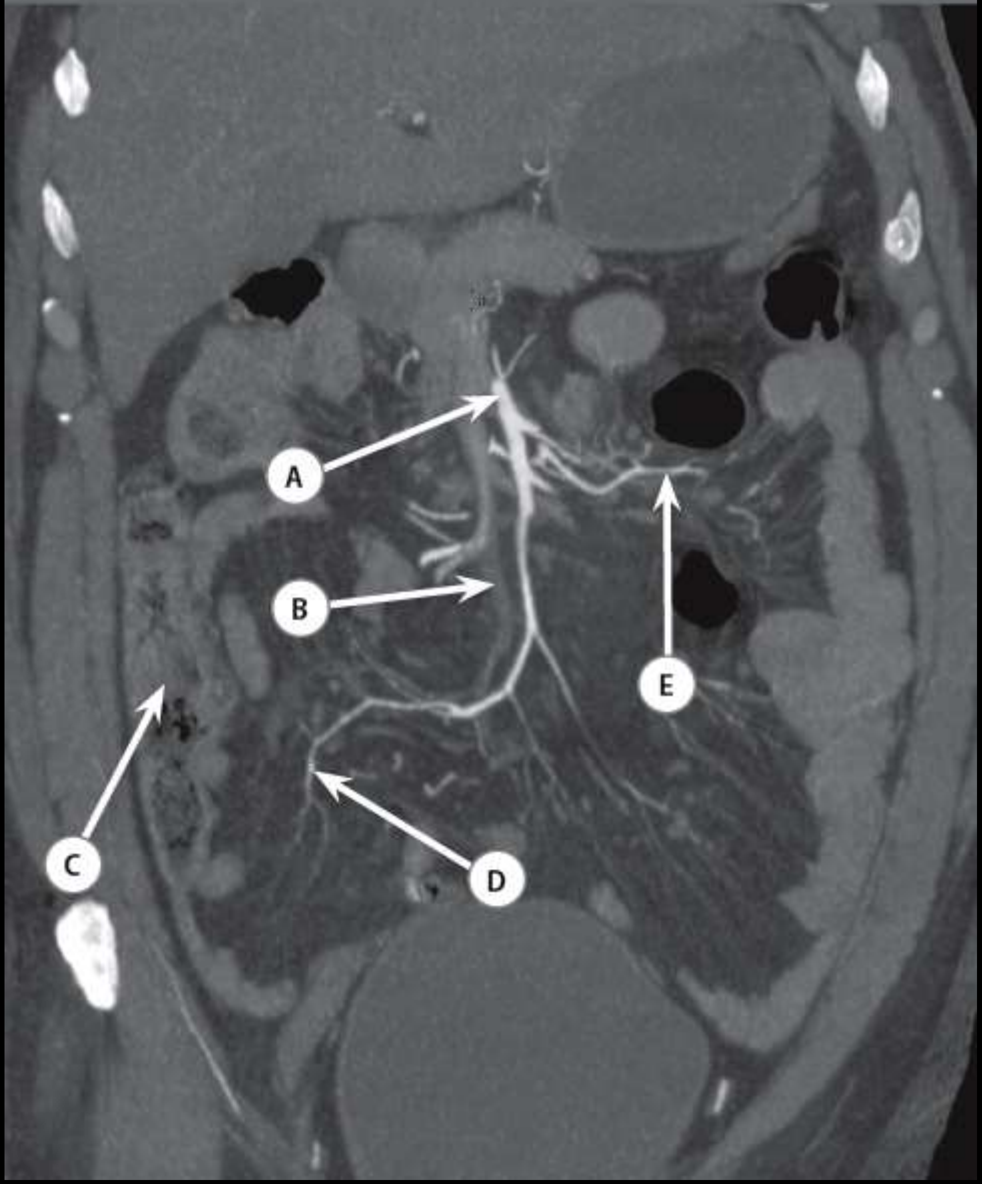
Case 2.9



2.9 Portal venous phase coronal CT abdomen

(a) Liver segment 2.
(b) Liver segment 3. The commonest classification used was first proposed by Couinaud in 1957. This partitions the liver into segments divided by the left and right branch of the portal vein and the three hepatic veins. The caudate lobe is named as segment 1.
(c) Common hepatic artery, arises from the coeliac artery into the lesser omentum ascending in front of the portal vein.
(d) Left gastric artery. This arises from the coeliac artery and passes upwards and left to reach the oesophagus. It ascends along the lesser curve of the stomach, supplying the lower third of the oesophagus and upper part of stomach.
(e) Superior mesenteric artery. This arises below the coeliac artery and descends over the uncinate process of the pancreas. It enters the root of the mesentery supplying the small intestine.

Case 15.13



Case 15.13

A Superior mesenteric artery (SMA)

B Superior mesenteric vein

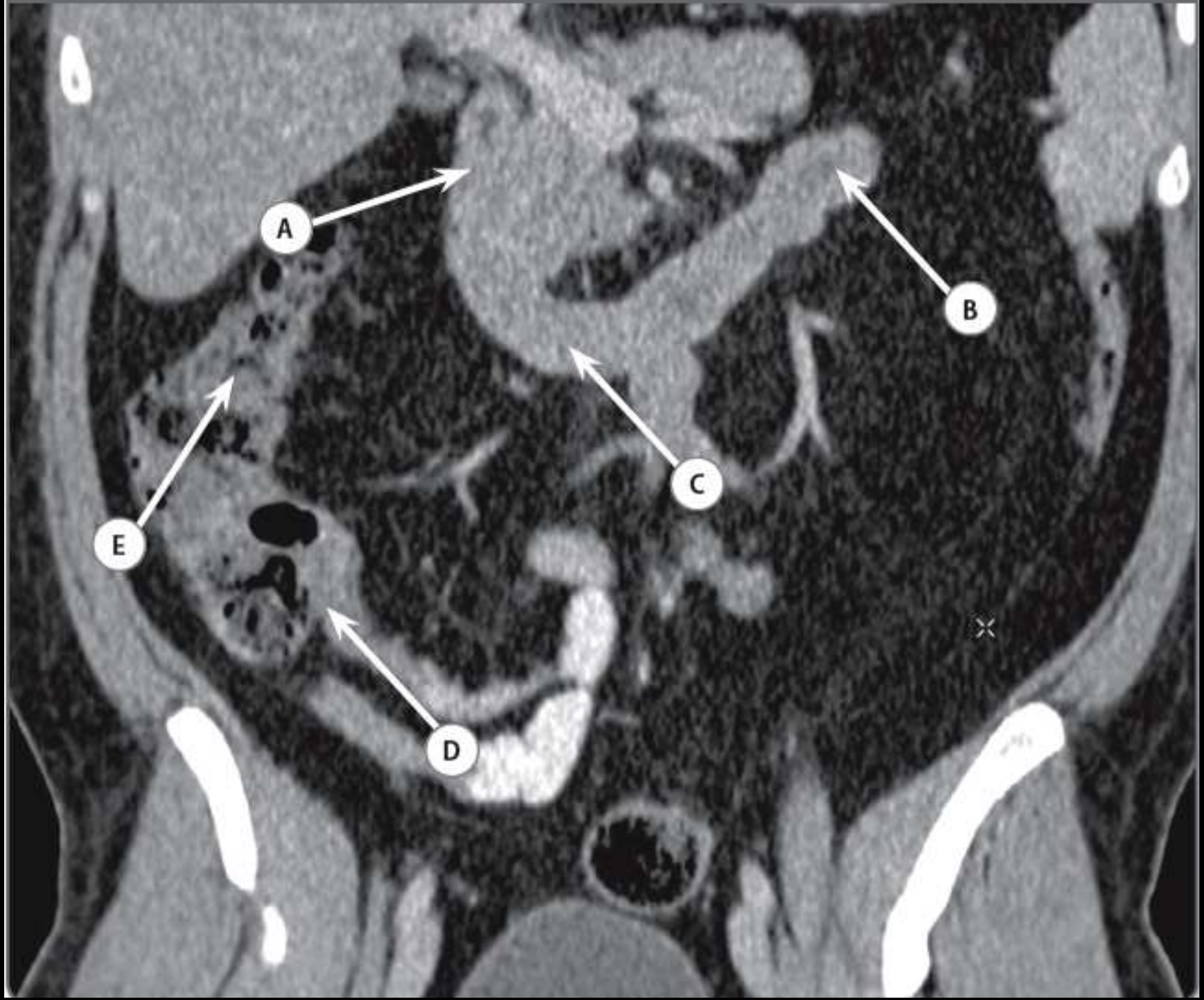
C Ascending colon

D Ileocolic branch

E Jejunal branch

The SMA and major branches are depicted. Note the normal anatomical position of the superior mesenteric vein (B), to the right of the artery. Reversal of this indicates gut malrotation. The SMA supplies the small bowel from the mid point of the second part of the duodenum to the mid/distal transverse colon. The inferior mesenteric artery (IMA) supplies the remainder of the colon. The colon at the region of the splenic flexure is considered a watershed area in terms of vascularity and is a common site of ischaemia.

Case 13.4



Case 13.4

A Second part of duodenum

B Fourth part of duodenum

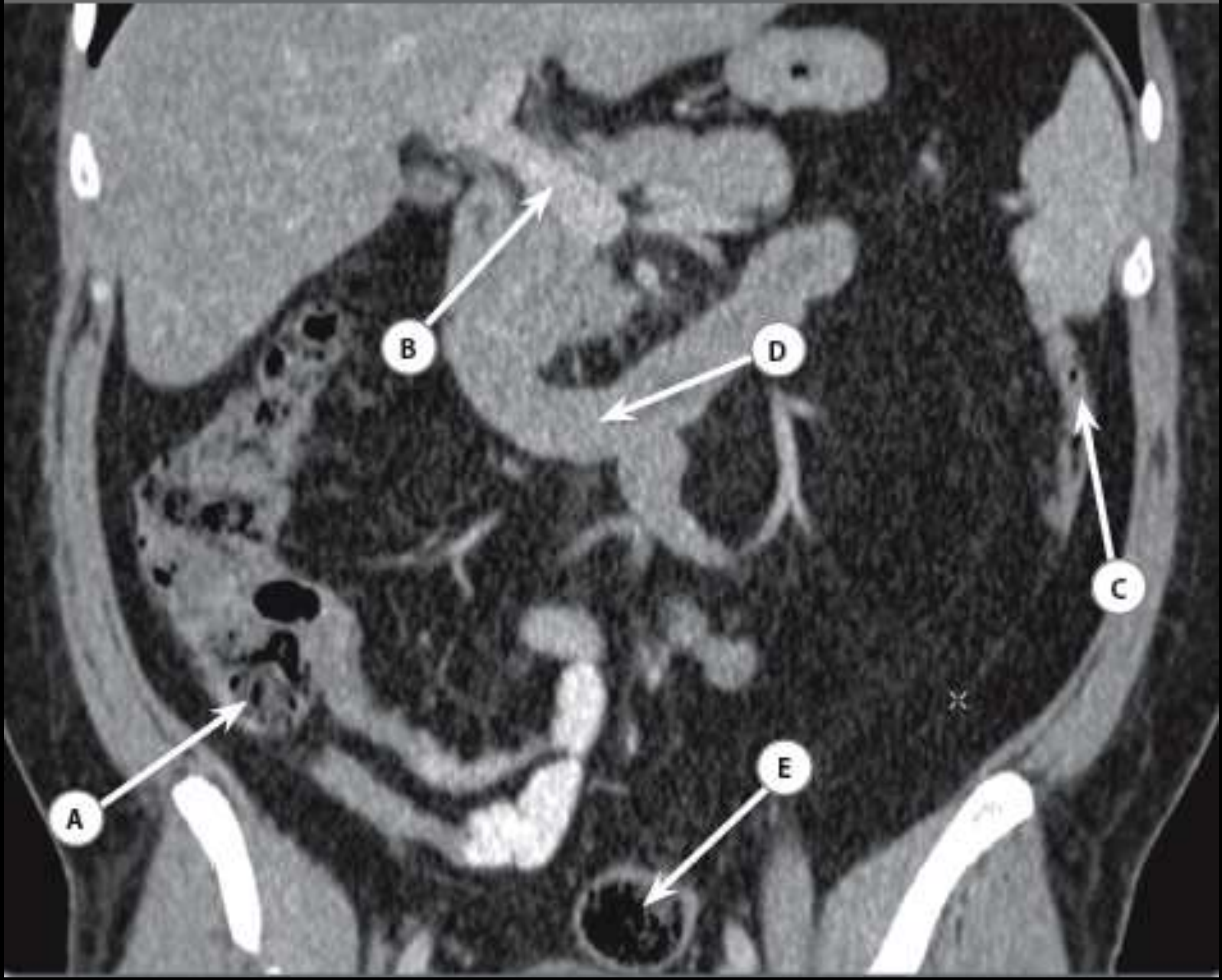
C Third part of duodenum

D Ileocecal junction (valve)

E Ascending colon

The duodenum is the proximal part of the small bowel. For descriptive purposes it is divided into four parts, which in the coronal plane form an approximate 'C' shape, as illustrated on this image. The second (descending) part is the location of the ampulla, through which the biliary tree drains into the duodenal lumen. Only the first part of the duodenum is intraperitoneal, with the rest of the duodenum lying in the retroperitoneum. Blood supply to the duodenum is from branches of the coeliac axis and superior mesenteric artery (superior and inferior pancreaticoduodenal arteries respectively).

Case 7.17



Case 7.17

A Caecum

B Portal vein

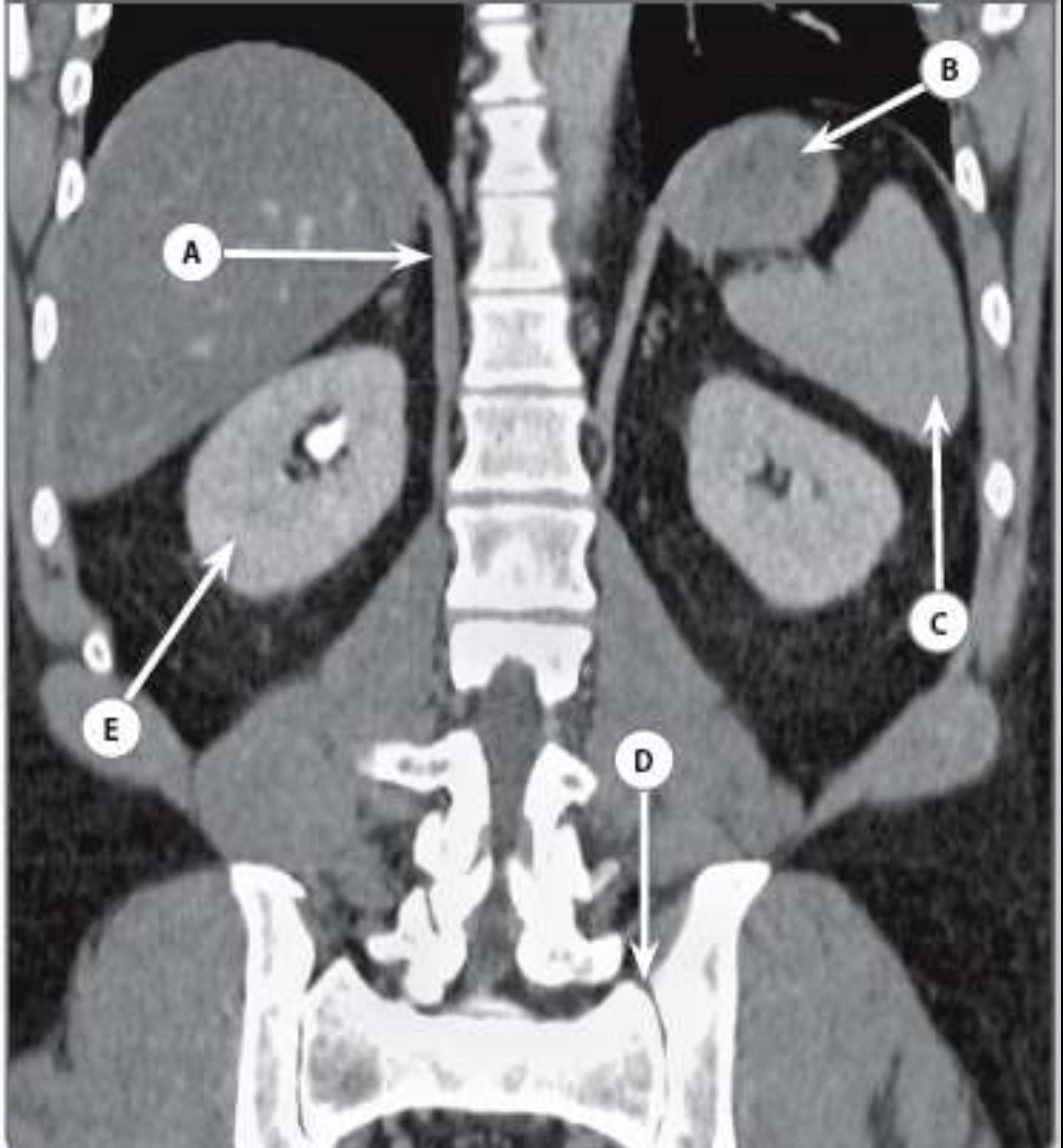
C Descending colon

D Third part of the duodenum

E Gas in sigmoid colon

The portal vein is responsible for draining the blood from the gastrointestinal system into the liver. It is formed by the confluence of the superior mesenteric and splenic veins, behind the neck of the pancreas. At the porta hepatis it branches into right and left intrahepatic portal veins to supply the corresponding hepatic lobes.

Case 6.5



Case 6.5

A Crus of right hemidiaphragm

B Gastric fundus

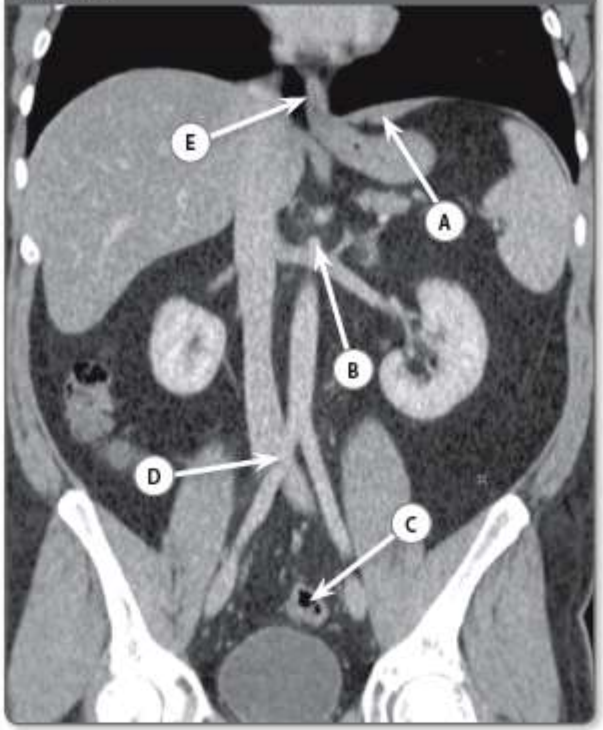
C Spleen

D Left sacroiliac joint

E Right kidney

The crura of the diaphragm are fibrous bands that originate from the central tendon of the diaphragm and insert to either side of the upper lumbar vertebrae. They act as tethers for the muscular contraction of the diaphragm. The spleen has a marked variability of normal shape, particularly noticeable on CT, with small splenunculi again being a common CT finding.

Case 5.20



Case 5.20

QUESTION		WRITE YOUR ANSWER HERE
A	Name the structure labelled A.	
B	Name the structure labelled B.	
C	Name the structure labelled C.	
D	Name the structure labelled D.	
E	Name the structure labelled E.	

Case 5.20

A Left hemidiaphragm

B Superior mesenteric artery

C Sigmoid colon

D Right common iliac artery

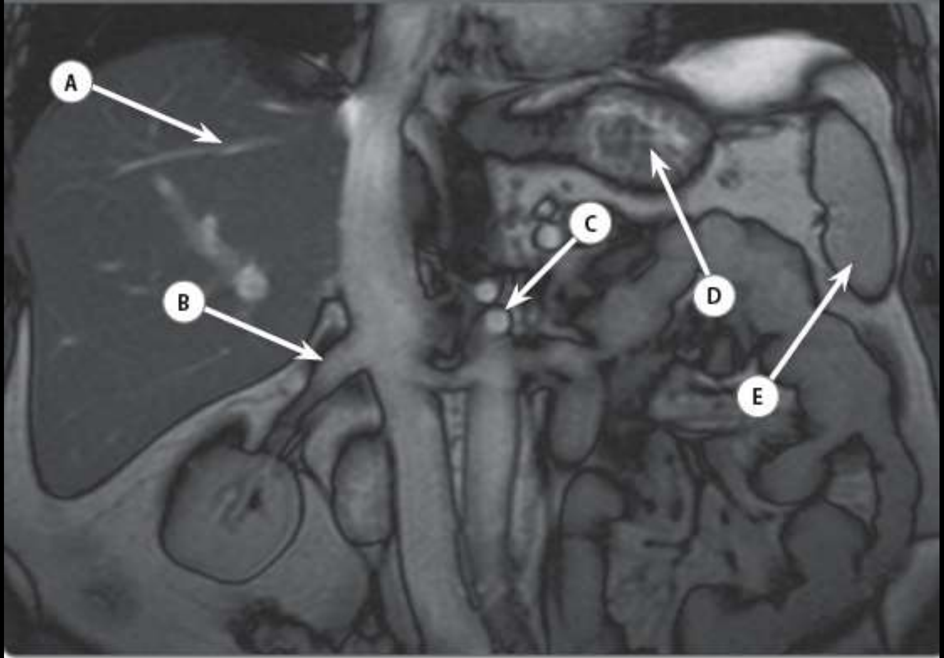
E Gastro-oesophageal junction

The inferior vena cava (IVC) is the largest abdominal vein which drains blood from the lower limbs and trunk into the right atrium. The IVC runs alongside the vertebral column to the right of the abdominal aorta. It is formed by the confluence of the common iliac veins at the level of L5 and traverses the diaphragm at T8. The main tributaries of the IVC are as follows:

- Hepatic veins (T8 level)
- Inferior phrenic vein (T8)
- Suprarenal vein and renal veins (L1)
- Gonadal vein (L2)
- Lumbar veins (L1)

Note the position of the superior mesenteric artery anterior to the left renal vein. Also note how the right common iliac artery passes anterior to the left common iliac vein.

Case 4.15



Case 4.15

QUESTION		WRITE YOUR ANSWER HERE
A	Name the structure labelled A.	
B	Name the structure labelled B.	
C	Name the structure labelled C.	
D	Name the structure labelled D.	
E	Name the structure labelled E.	

Case 4.15

A Right hepatic vein

B Right renal vein

C Origin of superior mesenteric artery

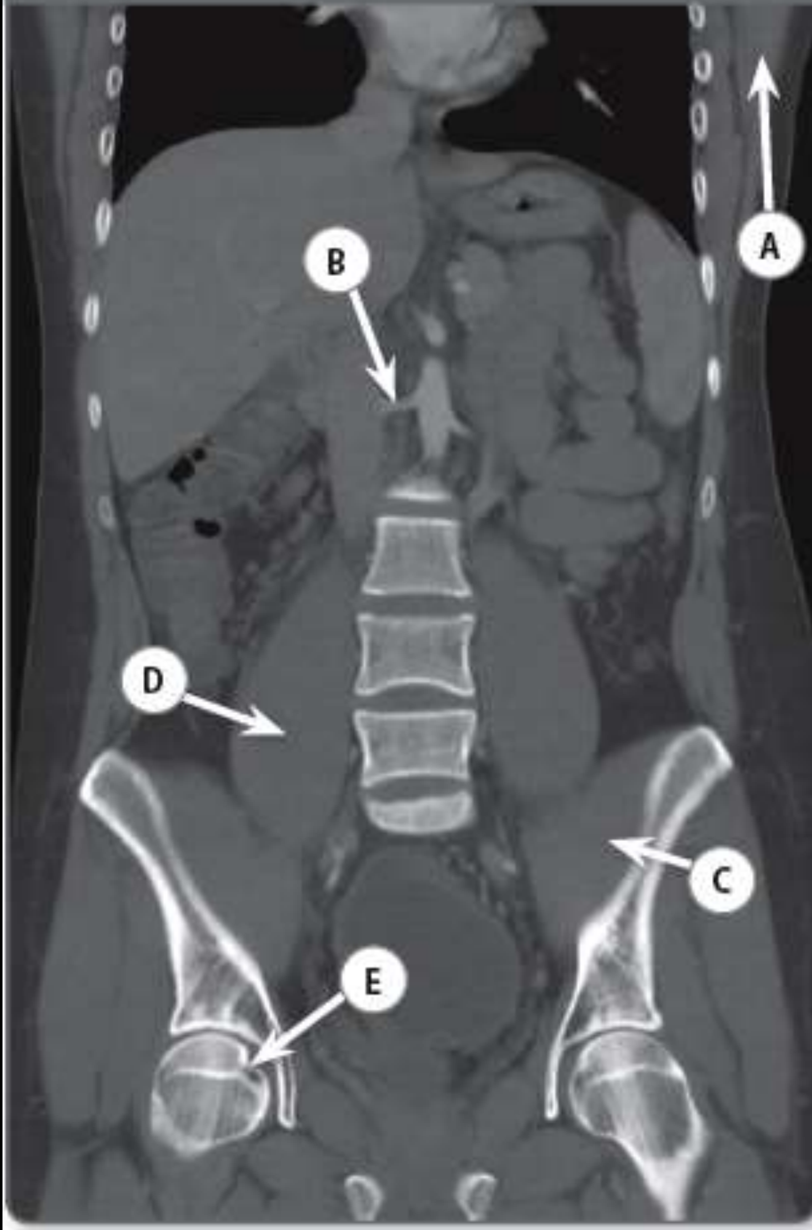
D Stomach

E Spleen

The inferior vena cava (IVC) most commonly lies to the right of the aorta, although variations of this do exist, e.g. a left IVC draining into the left renal vein.

The coeliac axis and superior mesenteric artery (SMA) are anterior branches of the aorta and arise at the levels of T12 and L1 respectively.

Case 3.19



A	Name the structure labelled A.
B	Name the structure labelled B.
C	Name the structure labelled C.
D	Name the structure labelled D.
E	What structure inserts at E (fovea)?

Case 3.19

A Left latissimus dorsi muscle

B Right renal artery

C Left iliacus muscle

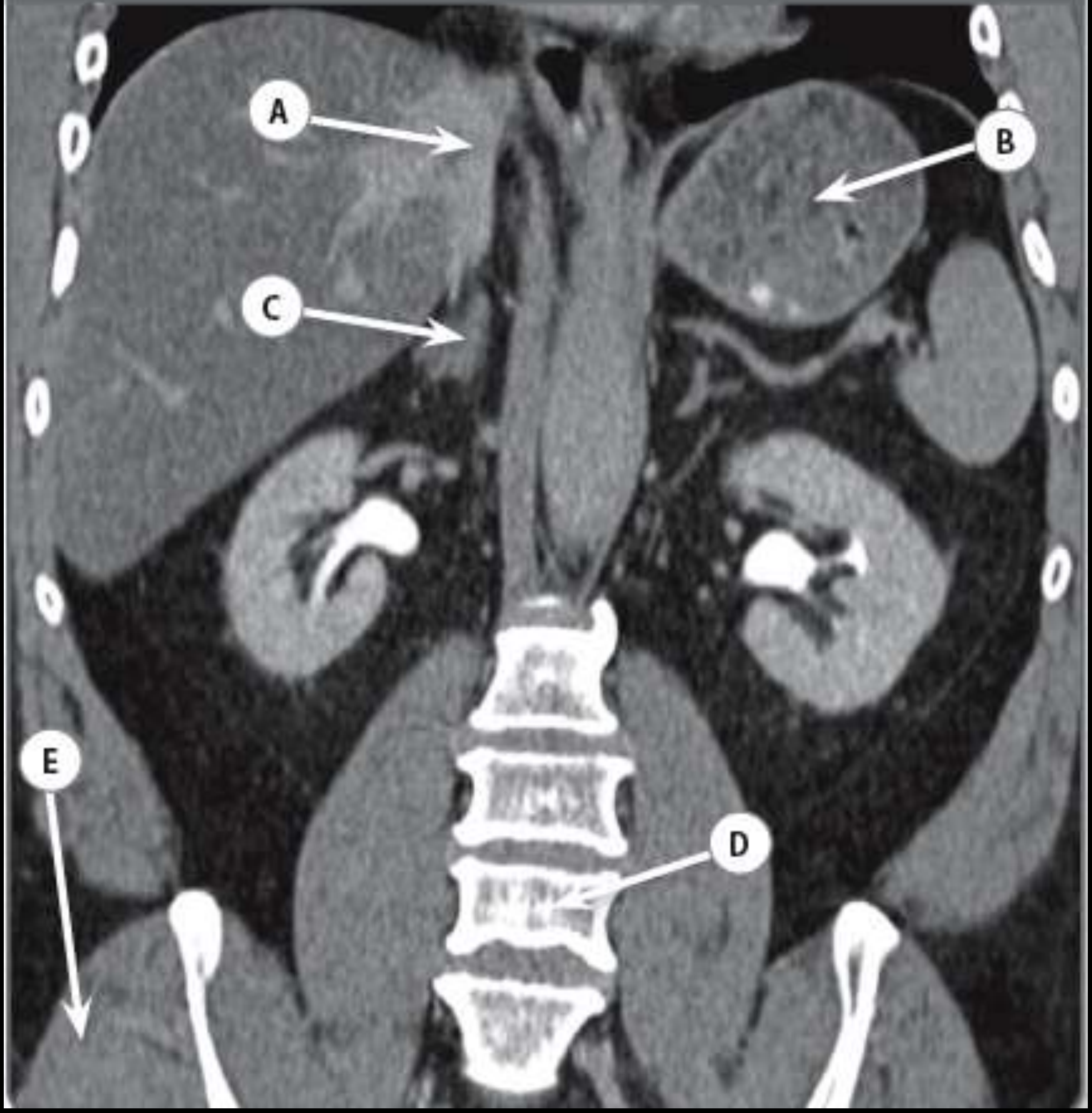
D Right psoas major muscle

E Right ligamentum teres

The iliacus muscle arises from the iliac fossa within the pelvis and converges with the psoas major muscle to insert as a unified tendon into the lesser trochanter of the femur. The latissimus dorsi muscle is the broadest muscle of the back and lies on the dorsolateral aspect of the trunk.

The fovea of the femoral head is an indentation which provides the insertion site for ligamentum teres – a stabilising ligament in childhood but a transmitter of arterial supply throughout life.

Case 1.11



Case 1.11

A Intrahepatic inferior vena cava

B Gastric lumen

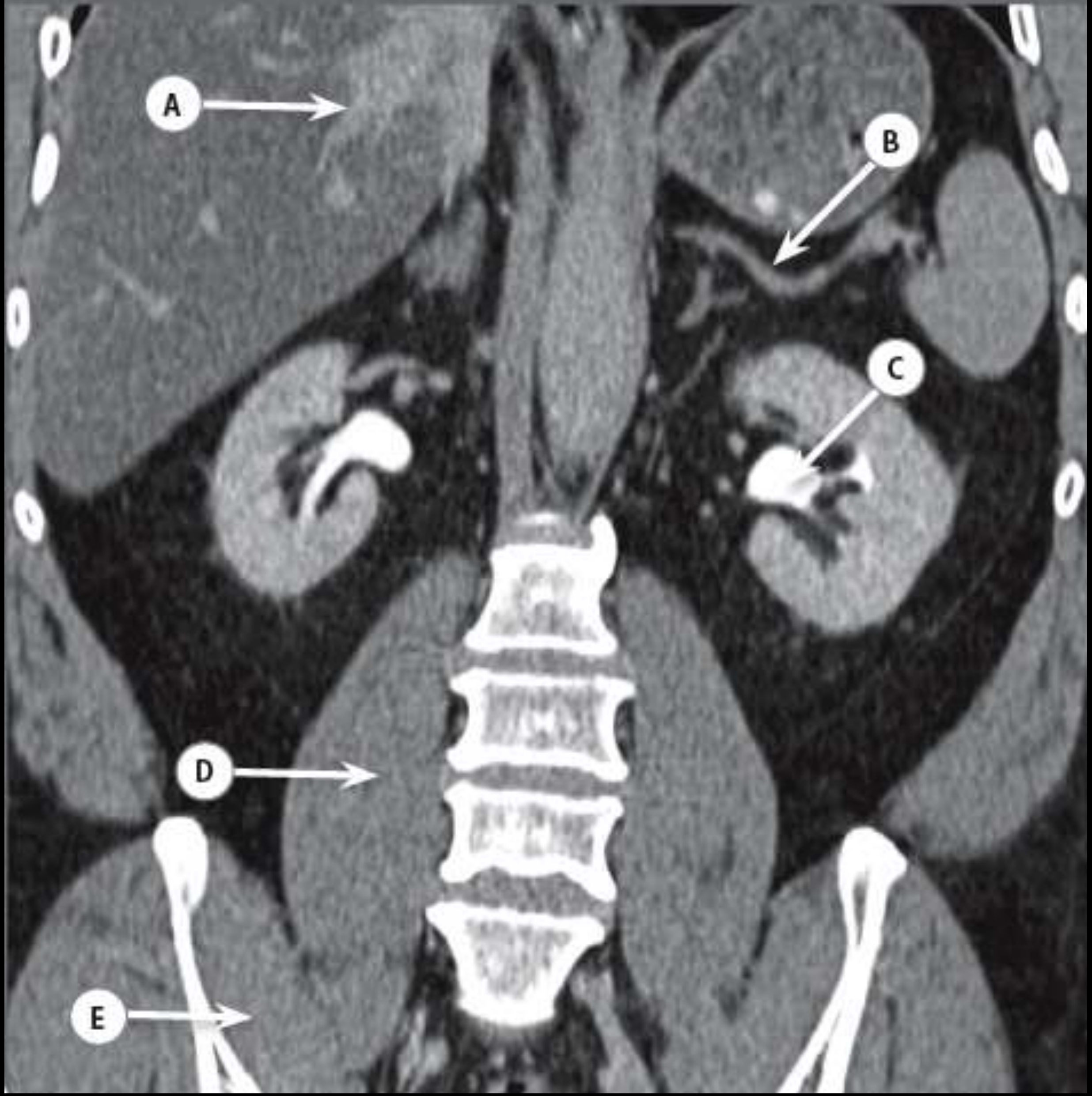
C Right suprarenal gland

D Body of L4 vertebra

E Gluteus medius muscle

Both triangular shaped suprarenal (adrenal) glands can usually be identified lying superior to the upper pole of each kidney. Note the relation of the right suprarenal gland superior and medial to the right kidney. The left suprarenal gland may not be visible at the same axial level as it is often found in a slightly more superior position compared to the right.

Case 2.3



Case 2.3

A Right hepatic vein

B Splenic artery

C Left renal pelvis

D Right psoas muscle

E Right iliacus muscle

In many institutions, the CT urogram has completely replaced the conventional IVU. The patient is scanned approximately 10–12 minutes after the administration of the intravenous contrast, allowing adequate time for the kidneys to excrete the administered contrast. The excreted contrast can then be seen in the renal collecting systems, ureters and bladder, with tumours being evident as filling defects.

Question 10.12

Name the structures labelled **A** to **E**.

10.12 Coronal MRA of the kidneys

A Right renal capsule, right kidney.
B Right renal artery.
C Left lumbar artery.
D Left renal cortex.
E Left renal medulla.

The kidneys are encased by a tough fibrous capsule known as the renal capsule. The kidneys comprise an outer cortex and an inner medulla. The medulla contains the pyramids, named after their shape, and contains the functional unit of the kidney – the nephron. MRA of the renal arteries is commonly performed to assess for renal artery stenosis or in the assessment of a patient's vasculature prior to kidney donation.

Question 8.15

Name the structures labelled **A** to **E**.

8.15 Coronal CT of the abdomen with IV contrast

A Second part of the duodenum.
B Common hepatic artery.
C Pancreas.
D Splenic artery.
E Superior mesenteric artery.

The duodenum forms a C shape around the head of the pancreas and is divided anatomically into four parts. The first part (duodenal cap) passes superiorly, to the right and posterior of the pylorus. It may be indented by the gallbladder. The second part is roughly vertical and is the site of insertion of the ampulla of Vater. The third part curves anteriorly around the inferior vena cava, aorta and L3 vertebra. The head of the pancreas is in contact with its superior border. It is indented by the aorta posteriorly and the superior mesenteric artery and vein superiorly. The fourth part of the duodenum continues to pass to the left of midline to reach the duodenal-jejunal junction. The ligament of Treitz lies at the highest part of the fourth part of duodenum.

The common hepatic artery and splenic artery both arise from the coeliac trunk. The superior mesenteric artery lies to the left of the superior mesenteric vein.

See Question 1.14 for further descriptions of the duodenal anatomy.

Question 6.11

Name the structures labelled **A** to **D**.

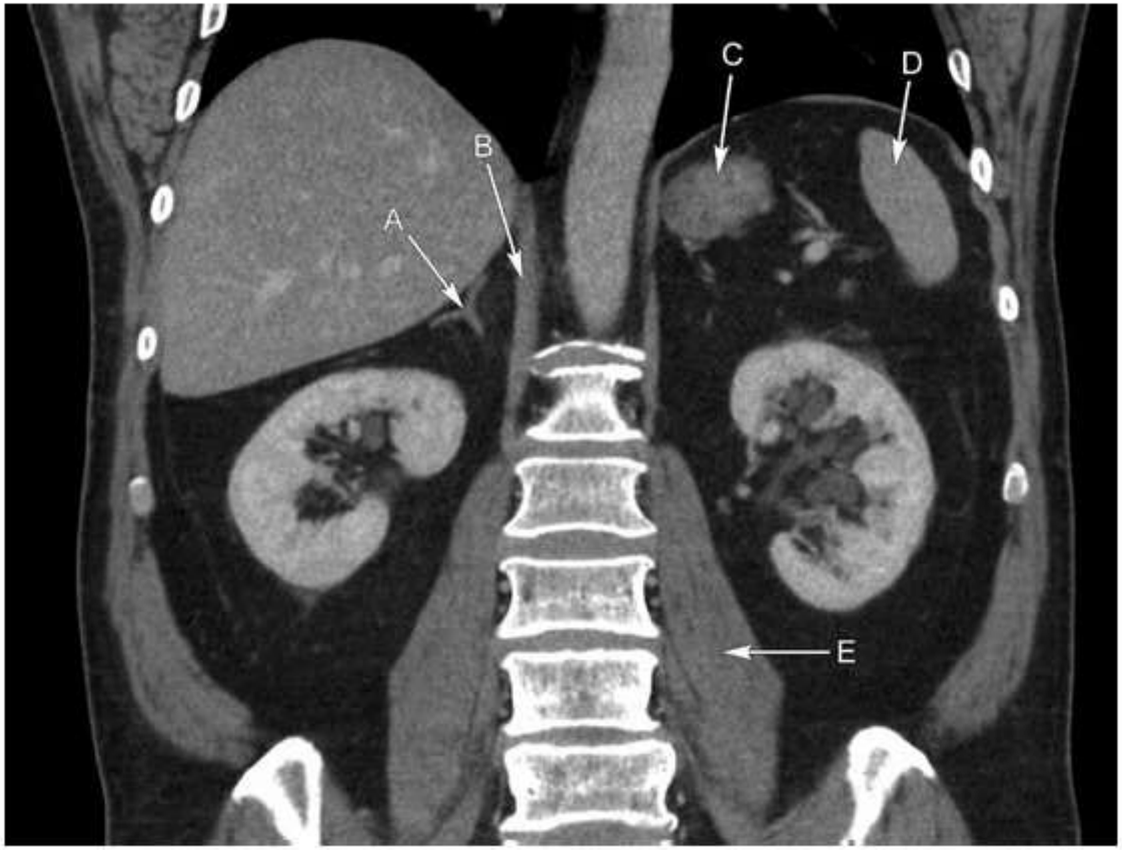
E Which artery or arteries supply the structure labelled **A**?

6.11 Coronal CT of the abdomen with IV contrast

A Ascending colon.
B Left psoas major muscle.
C Left iliacus muscle.
D Symphysis pubis.
E Right colic artery and ileocolic artery.

The caecum is the first part of the large bowel and lies in the right iliac fossa. It does not have a mesentery. The terminal ileum enters it medially and obliquely, forming a valve known as the ileocaecal valve. The arterial supply of the caecum is the ileocolic artery (a branch of the superior mesenteric artery). The arterial supply of the ascending colon and hepatic flexure is via the ileocolic and right colic arteries.

Question 5.12



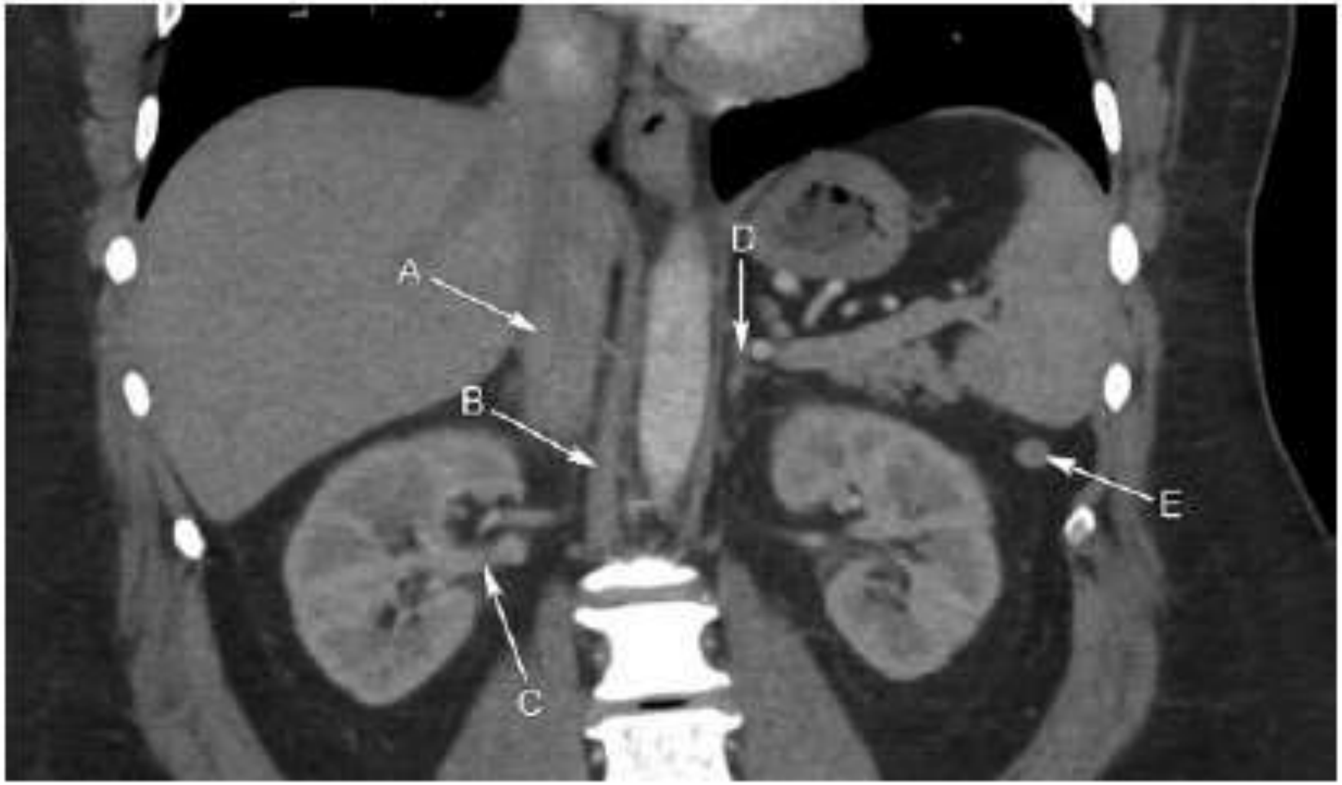
Name the structures labelled **A** to **E**.

5.12 Coronal CT of the abdomen with contrast

A Right adrenal gland.
B Right diaphragmatic crus.
C Stomach.
D Spleen.
E Left psoas major muscle.

There are three main paired muscles in the posterior abdominal wall – psoas major, quadratus lumborum and iliacus. The psoas major runs from the sides of the T12–L5 vertebrae (including transverse processes and discs) to the lesser trochanter of the femur, where it joins with the psoas minor and iliacus to act as a flexor of the hip. This confluence of muscles is generally known as iliopsoas.

Question 3.10



Name the structures labelled **A** to **E**.

3.10 Coronal CT abdomen with IV contrast

A Inferior vena cava.
B Right crus of the diaphragm.
C Right renal vein.
D Left adrenal gland.
E Splenunculus.

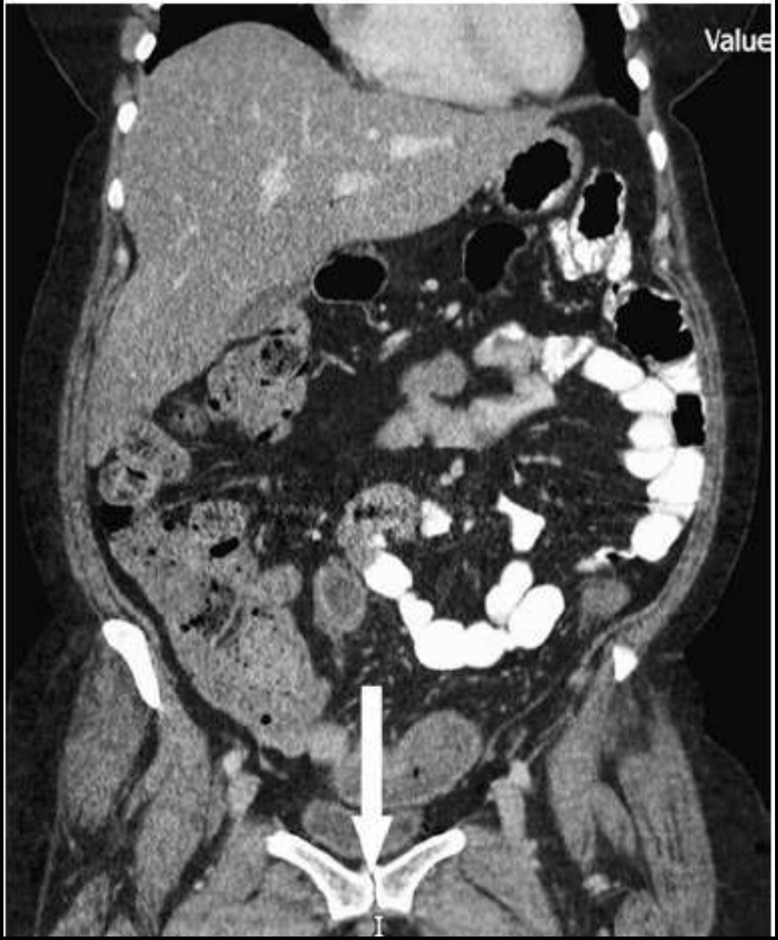
The inferior vena cava lies to the right of the aorta and the left renal vein is therefore longer than the right. The left renal vein passes in front of the aorta and the left renal artery. The left renal vein is the drainage pathway for the following veins:

- Left gonadal vein (left testicular vein in males and left ovarian vein in females).
- Left suprarenal vein.
- Left inferior phrenic vein.
- Left second lumbar vein.

The equivalent veins on the right side drain directly into the inferior vena cava.

A splenunculus is a small accessory spleen and commonly appears as a small rounded nodule located near the spleen.

Question 43:



Question 43: Coronal CT of the abdomen and pelvis

Answer: Symphysis pubis

- The symphysis pubis is a non-synovial cartilaginous joint in the midline between the paired pubic bones.
- The bladder lies immediately deep to the pubic symphysis.

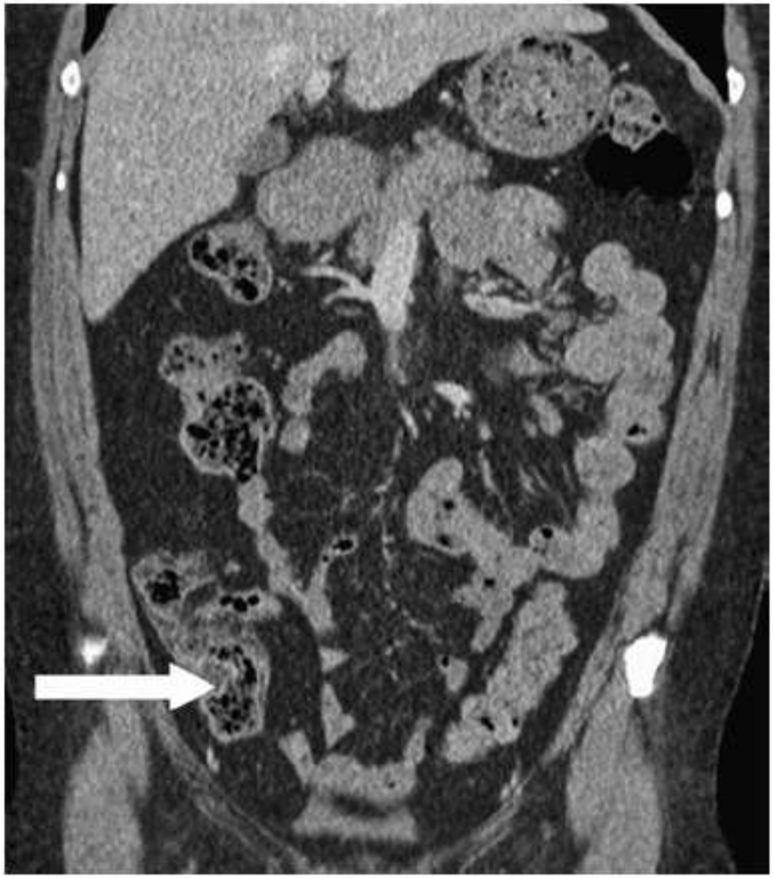
Question 40:

Question 40: Coronal T2-weighted MRI of the abdomen

Answer: Right ureter

- The ureter drains the renal collecting system and connects the kidney to the bladder.
- The ureter starts at the pelviureteric junction and ends at the vesicoureteric junction distally. These two points are common areas of obstruction.
- The ureters are lined by urothelium, which is prone to field change—the concept of multicentric cancer producing multiple transitional (urothelial) cell cancers.

Question 31:

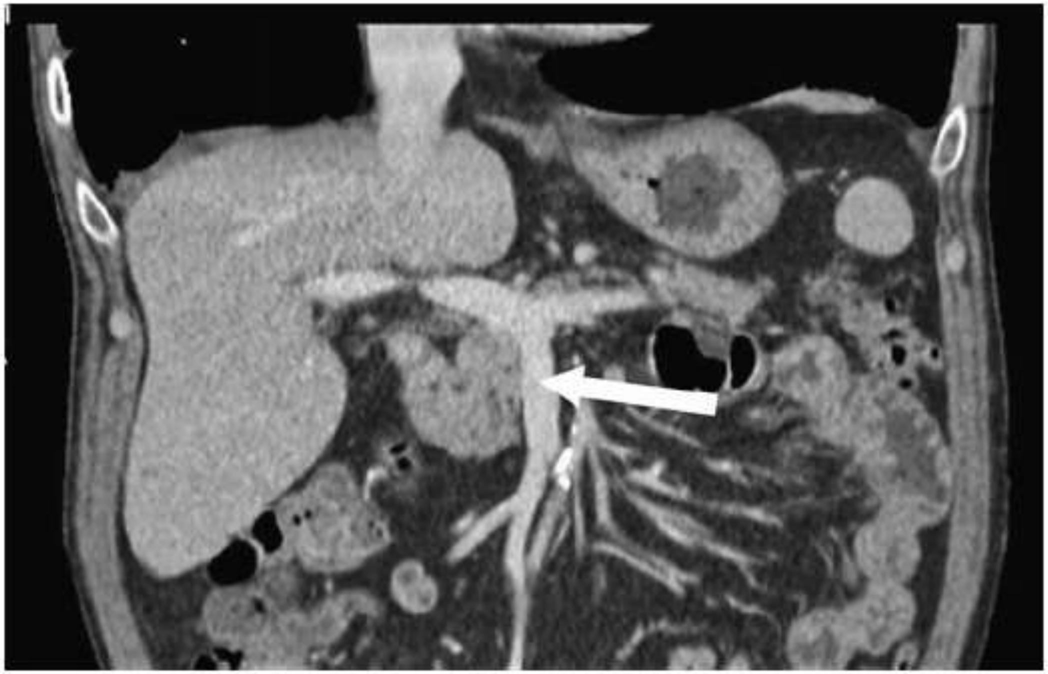


Question 31: Coronal CT of the abdomen and pelvis

Answer: Caecum

- The caecum is the first part of the colon.
- It becomes the ascending colon just superior to the ileocaecal junction.
- The appendix can often be seen arising from the caecum proximal to the ileocaecal junction.
- The caecum is a common site of disease and should always be reviewed. The maximum diameter on an abdominal radiograph is 9 cm.

Question 17:



Question 17: Coronal CT of the abdomen

Answer: Superior mesenteric vein

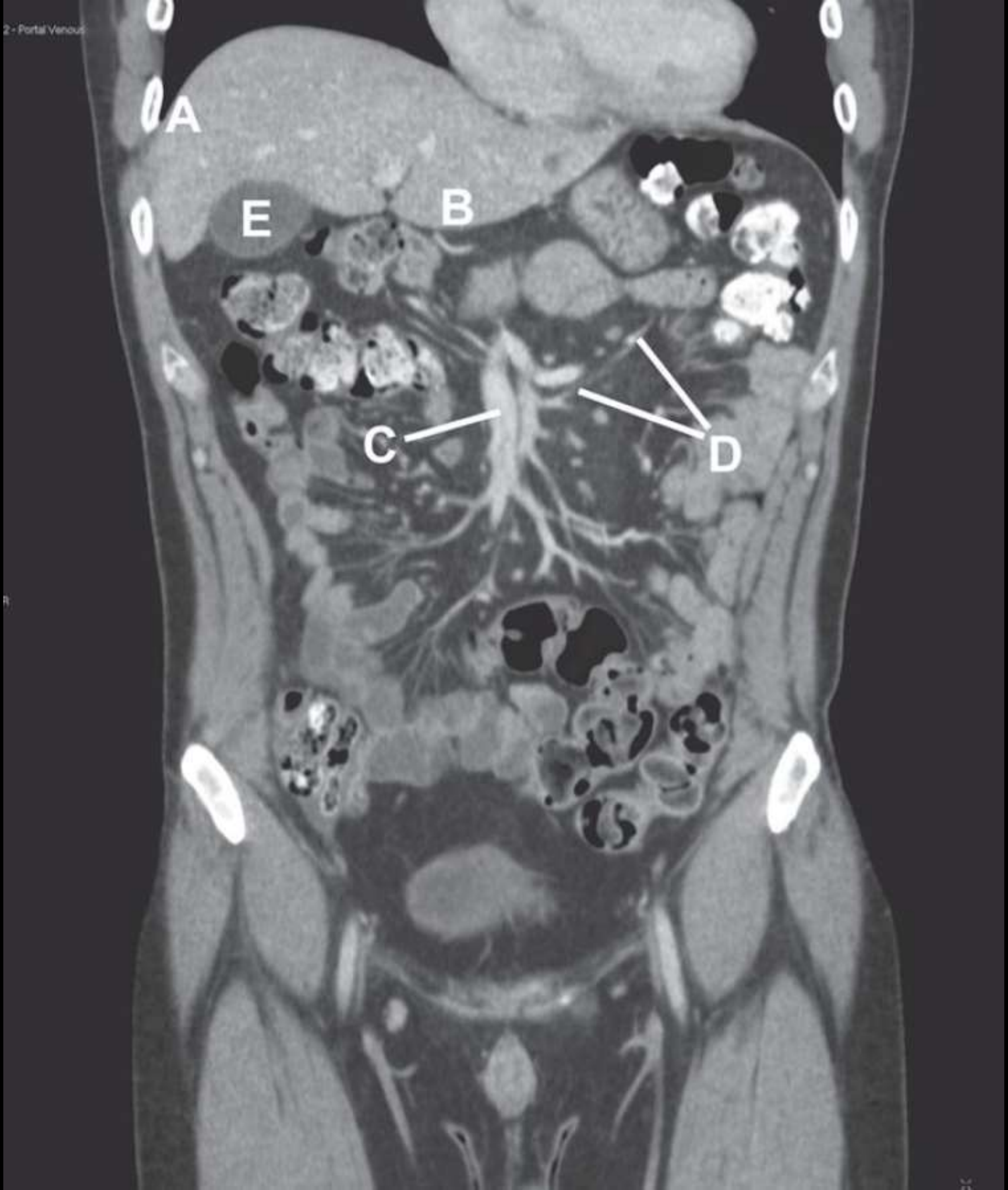
- The superior mesenteric vein (SMV) is the principal venous drainage of the bowel. It joins the splenic vein to form the portal vein.
- The SMV runs to the right of the superior mesenteric artery (SMA). Reversal of the SMA/SMV relationship is a feature of intestinal malrotation.
- The confluence of the SMV and splenic vein defines the neck of the pancreas.

- **Question 4:**

Question 4: Coronal CT of the abdomen

Answer: Medial limb of the right adrenal gland

- The right adrenal gland is usually found cranial to the right kidney, whereas the left adrenal gland lies anteromedial to the upper pole of the left kidney.
- The normal thickness of a limb of the adrenal gland is approximately the same thickness as the adjacent diaphragm.
- The adrenal gland is composed of the body and the medial and lateral limbs. If in doubt as to how specific you should be in the examination, you should provide more information and specify the part of the adrenal gland that is labeled.


2 - Portal Venous
A
B
E
C
D
R

Q9 Answers

a Right lateral superior (VII)
b Left medial inferior (III)
c Superior mesenteric vein
d Jejunal branch of the superior mesenteric artery
e Gallbladder

CT of abdomen and pelvis at the level of the superior mesenteric vessels, coronal section

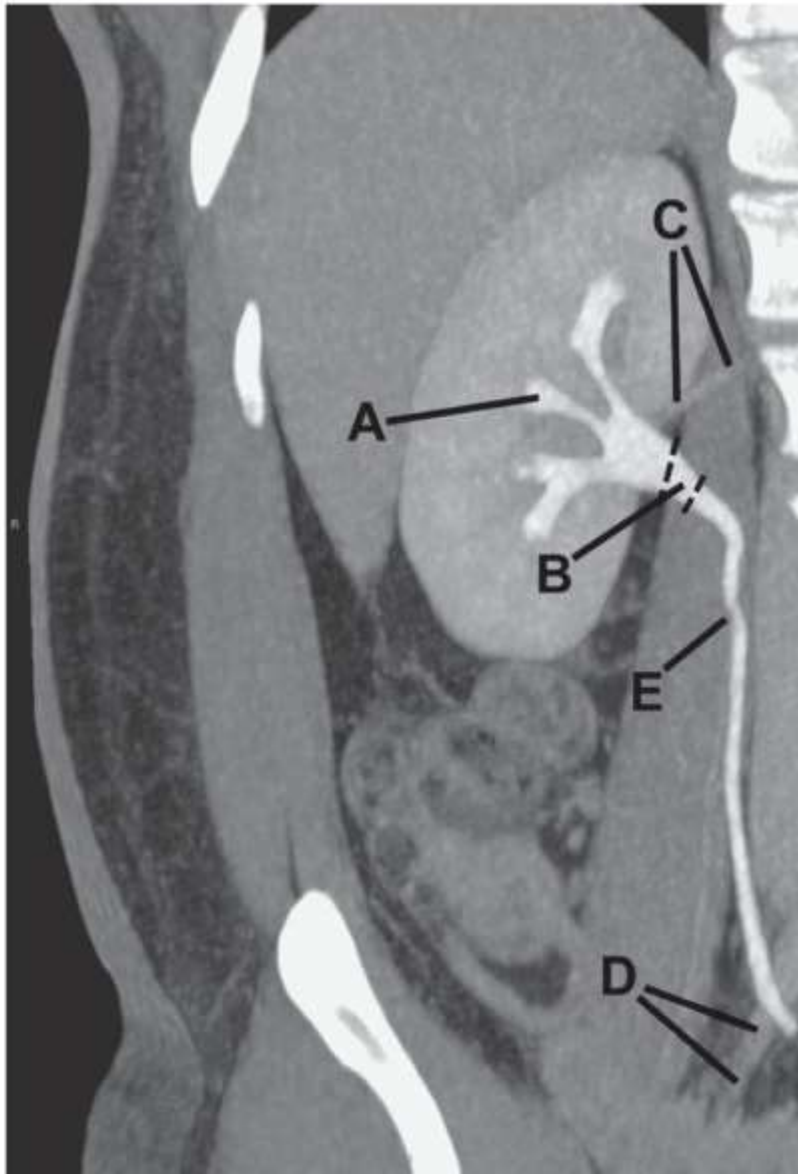
The superior mesenteric artery arises just proximal to the origins of the renal arteries. The artery courses anteriorly and then inferiorly, running alongside and to the left of the superior mesenteric vein. From the left lateral aspect of the SMA, a total of 4–6 jejunal branches arise, with each artery dividing into two and joining to form an arcade of vessels which parallels the orientation of the intestine. A branch of the dorsal pancreatic artery may arise from the SMA just proximal to the first jejunal branch. The middle colic branch and right colic branch arise from the right side of the SMA, and supply the transverse colon and ascending colon respectively. Occasionally a second artery accompanies the middle colic artery in the transverse mesocolon before coursing inferiorly to connect with the left colic artery. This is known as an artery of Riolan and, if present, forms a communication between the superior mesenteric and inferior mesenteric arterial systems. The ileocolic artery arises from the distal SMA and supplies branches to the caecum, terminal ileum and appendix. A total of 9–13 ileal branches arise from the terminal SMA and form into arcades (in a similar fashion to the jejunal branches) to supply the ileum. The distal ileal branch forms an anastomosis with the ileocolic artery.

Hepatic segments are regions of the liver that share a common blood supply (both hepatic arterial and portal venous) and biliary drainage. There are eight segments in total and they were first described by Couinaud, a French hepatobiliary surgeon, in 1957. The liver is divided by the principal plane into two anatomical halves and these are further sub-divided into four segments. The planes of segmental division are marked by the hepatic veins in the longitudinal axis and the portal vein in the transverse axis. Segment IV is different in that it extends either side of the portal vein and can be given the suffix (a) for the superior part and (b) for the inferior part. When the liver is viewed from the front the segments are numbered in an approximately clockwise fashion beginning at the caudate lobe which is segment I. Segments VII, VIII, IV(a) and II run right-to-left superior to the portal vein and segments VI, V, IV(b) and III run in a similar manner inferior to the portal vein.

Claude Couinaud. *Le Foie: Études anatomiques et chirurgicales (The Liver: Anatomical and Surgical Studies)*, Masson, Paris, 1957.

Q15

a Name the structure labelled A
b Name the region outlined and labelled B
c Name the structure labelled C
d Name the structure labelled D
e Name the structure responsible for the indentation at position E



Q15 Answers

a Major calyx
b Pelvi-ureteric junction
c Renal artery
d External iliac artery
e Gonadal artery

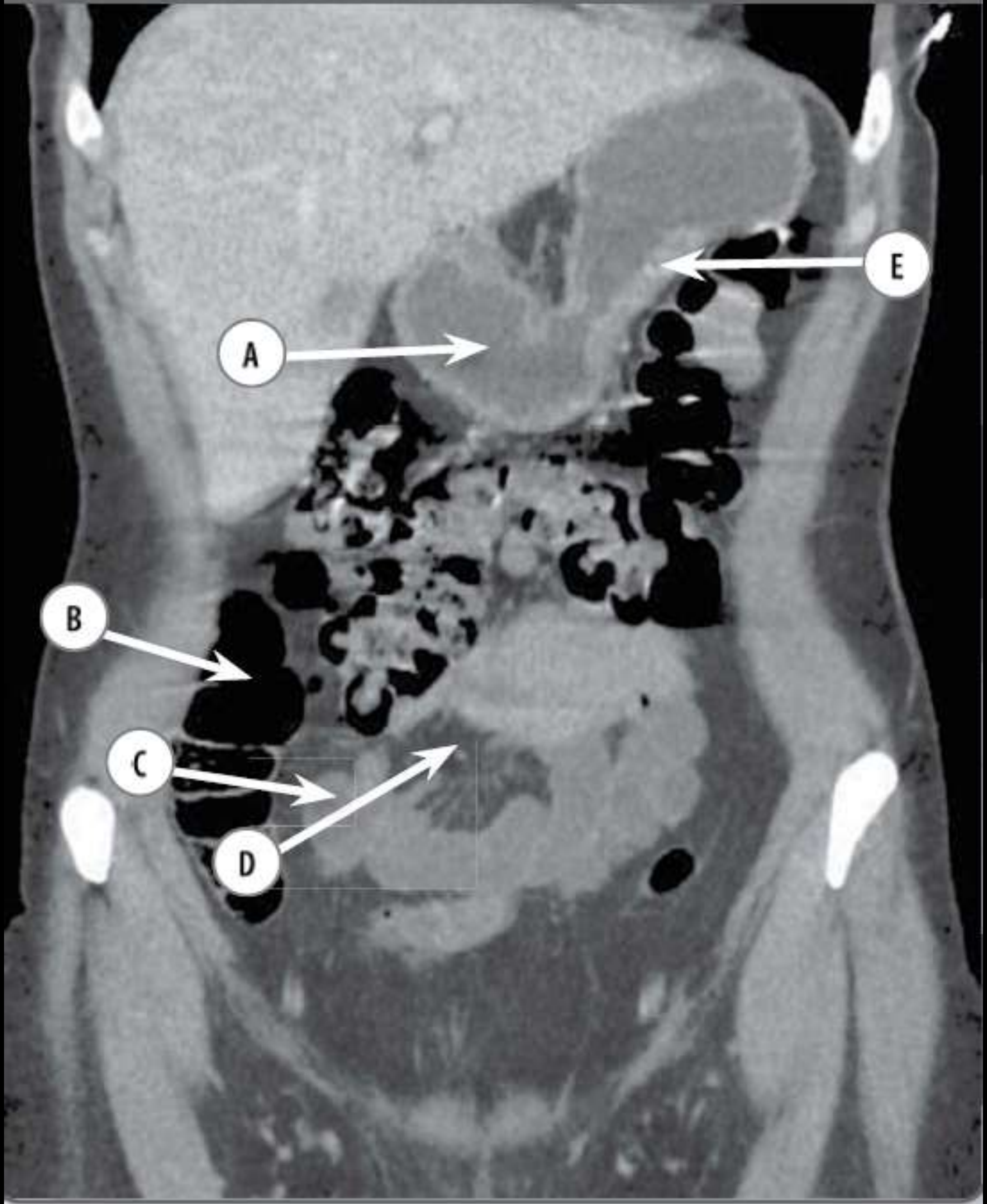
CT urogram of the right kidney, maximum intensity projection, coronal section

The renal collecting system consists of several minor calyces which form two or three major calyces. These then drain into the renal pelvis, which is a conical structure located at the hilum of the kidney. It is usually the most posterior of the hilar structures. The right renal artery is longer than the left and the opposite is true with the renal veins. The kidney consists of five segments (apical, posterior, lower, upper and middle) which are each supplied by a segmental artery and vein.

The transition between renal pelvis and ureter is the pelvi-ureteric junction, which along with the vesico-ureteric junction are the narrowest segments of the upper renal tract.

The ureter passes inferiorly along the anterior border of psoas major muscle. It is crossed by the gonadal artery which arises from the anterior aorta (L2 vertebral level) and travels obliquely down towards the testis or ovaries. Inferiorly the right ureter is crossed by the ileo-colic and right colic vessels as well as the root of the mesentery. It deviates medially from the psoas muscle and crosses anterior to the bifurcation of the common iliac artery (where the iliac artery is positioned anterior to the iliac vein) prior to passing into the pelvis.

Case 3.11



Case 3.11

A Gastric antrum

B Gas within ascending colon

C Small bowel loop; ileum

D Small bowel mesentery

E Stomach wall, greater curve

Coronal contrast-enhanced CT in the portal venous phase.

The small bowel mesentery is made up of two folds of peritoneum, which connect the small bowel to the posterior abdominal wall. The mesentery is fan-shaped and within it run the blood vessels, nerves and lymphatics which supply the small bowel. The blood vessels can be easily appreciated on this image as fine linear branching structures, containing contrast, and outlined by fat. The root of the small bowel mesentery runs from the duodenojejunal flexure in the left upper quadrant, to the superior aspect of the right sacroiliac joint in the right lower quadrant.

The ileum makes up approximately 60% of the length of the small bowel. It forms the distal small bowel, running from the jejunum to the caecum via the ileocaecal valve. The ileum tends to lie in the right lower quadrant, whereas the jejunum tends to be located in the left upper quadrant. Other differences between jejunum and ileum include the diameter of the loops and the number of valvulae conniventes they contain; both being greater in the jejunal loops. **Table 3.2** summarises the differences in the appearance of jejunal and ilial loops.

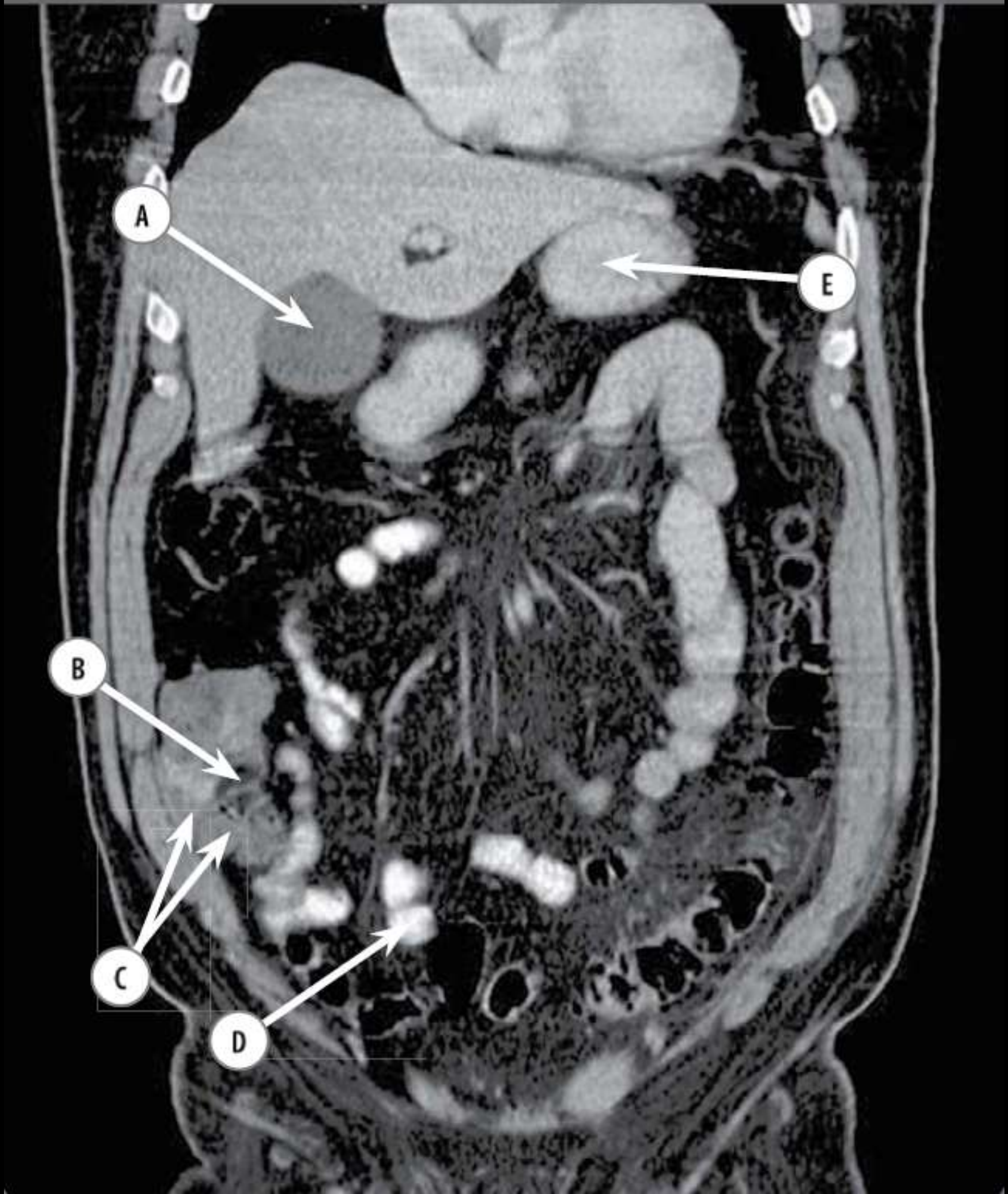
Table 3.2 Anatomical features to differentiate jejunal from ilial loops

	Jejunum	Ileum
Location	Left upper quadrant	Right lower quadrant
Diameter	Wider (~ 3.5 cm)	Narrower (~ 2.5 cm)
Thickness of wall	Thicker	Thinner (1mm)
Valvulae conniventes	More numerous	Less numerous
	Thicker (2mm)	Thinner (1mm)

Butler P, Mitchell AM, Ellis H. Applied Radiological Anatomy. Cambridge: Cambridge University Press, 1999: 196.

Ryan S, McNicholas M, Eustace SJ. Anatomy for Diagnostic Imaging, 3rd edn. Edinburgh: Saunders, 2011: 167–169.

Case 3.12



Case 3.12

A Gallbladder

B Iliocaecal valve

C Caecum

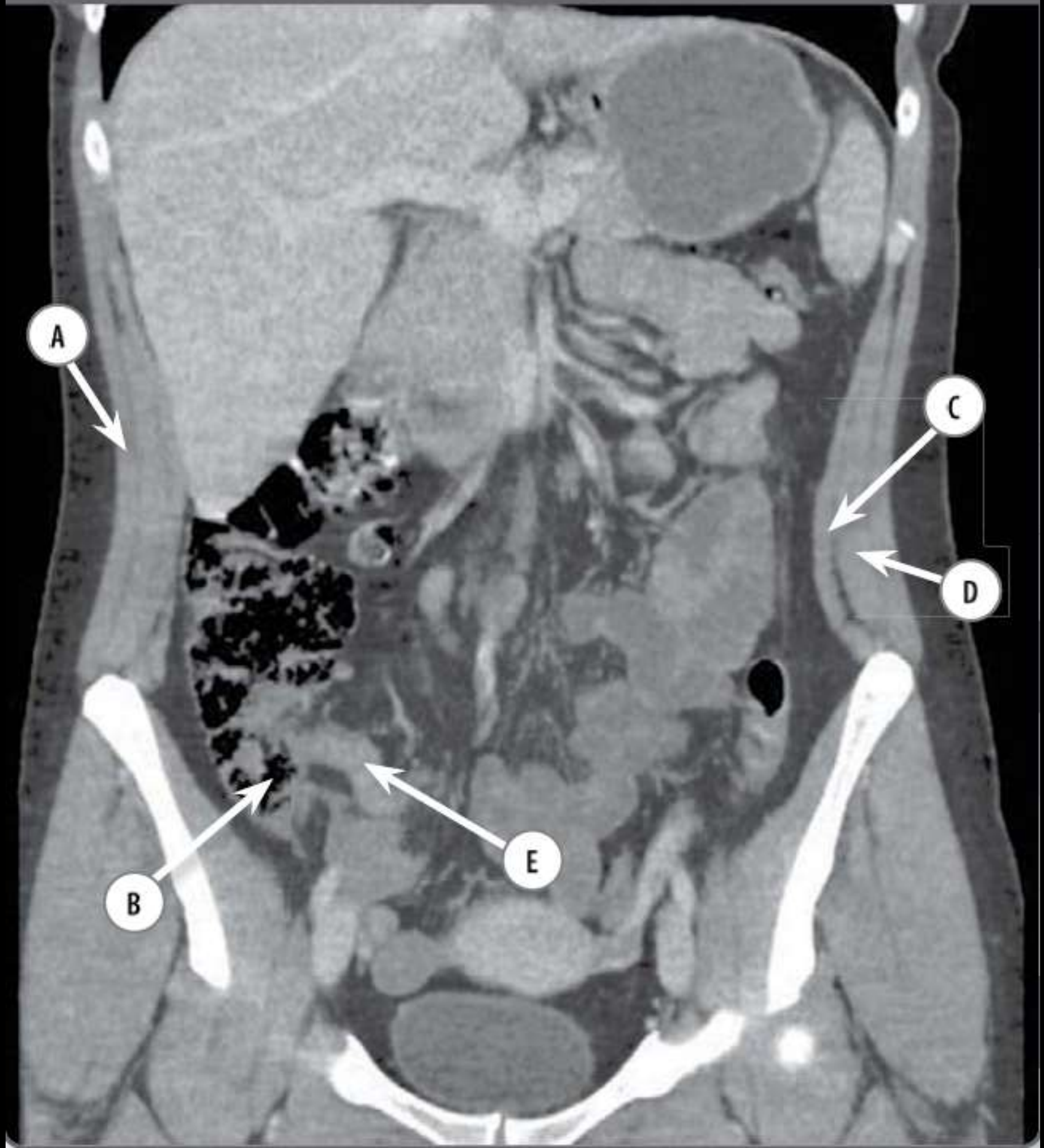
D Ileal loop

E Stomach

Coronal contrast-enhanced CT.

The iliocaecal valve is found in the right iliac fossa, and is the point at which the small bowel joins the large bowel. The ileocaecal valve opens into the postero-medial aspect of the large bowel, at the level of the first complete transverse haustral fold. This fold thickens posteriorly to become the frenula of the valve – these are typically up to 3 mm in thickness. Below this level is found the caecum, and above, the ascending colon. The appendix joins the caecum approximately 2cm below the ileoceacal valve. The valve has an upper and a lower fold, and helps to prevent reflux of bowel contents from the large bowel into the terminal ileum due to thickening of the circular muscle at this point. It projects slightly into the lumen of the large bowel, and may be seen as a filling defect on barium enema. There is often some fat around the valve, which makes it easily identifiable on CT studies.

Case 3.13



Case 3.13

A Right external oblique muscle

B Caecum

C Left transversus abdominis

D Left internal oblique

E Terminal ileum

Coronal contrast-enhanced CT of the abdomen.

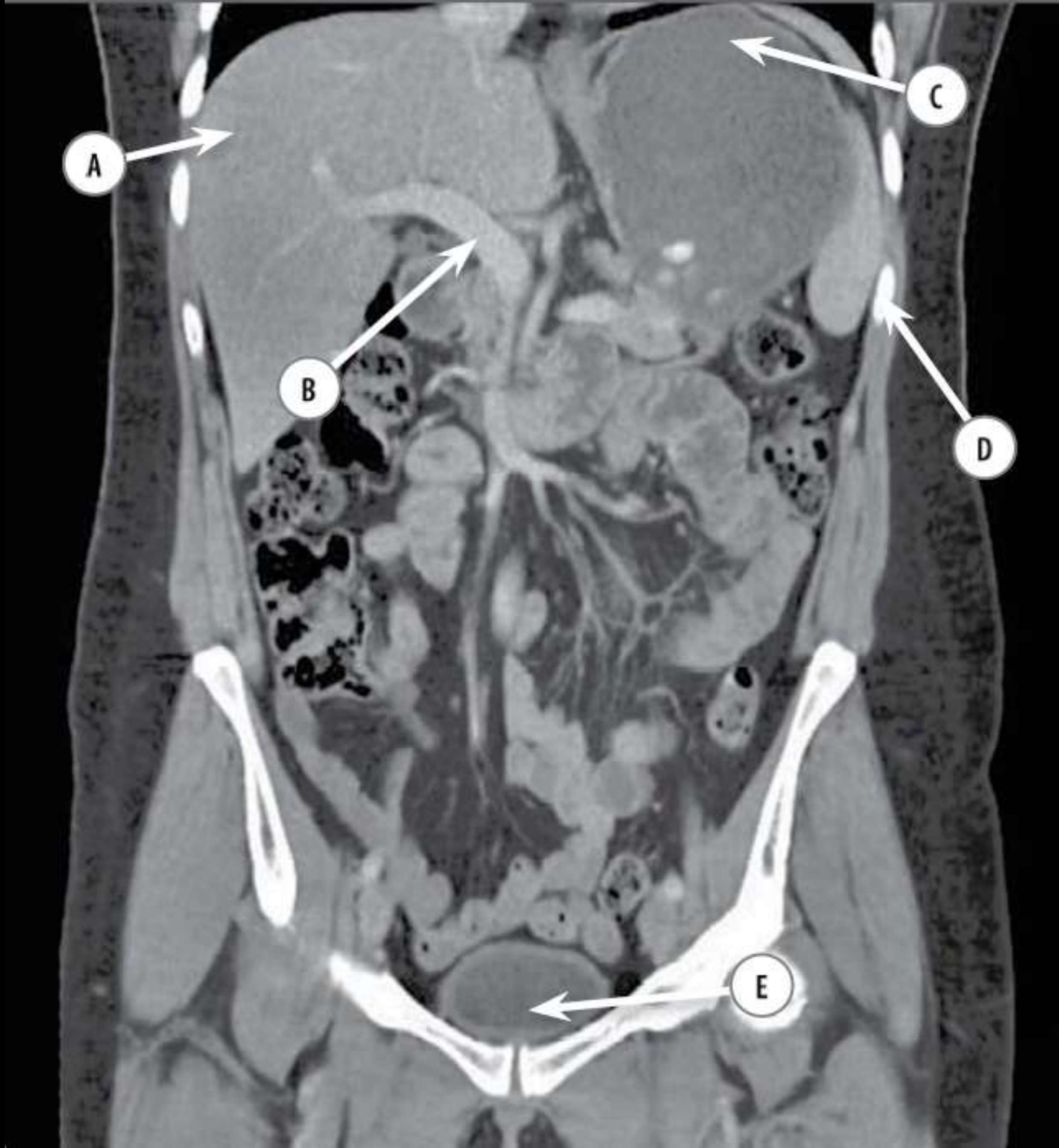
The terminal ileum is the most distal part of the small bowel, and joins the large bowel at the junction of the caecum and the ascending colon via the ileocaecal valve. There are few valvulae conniventes in this part of the small bowel, and it tends to have a thinner and smaller calibre wall than the more proximal jejunum.

The ileocaecal valve opens into the posteromedial aspect of the large bowel, where it projects into the lumen somewhat. There is usually some fat around the ileocaecal valve, which makes it easily identifiable on CTs.

The muscles of the anterolateral abdominal wall are external oblique, most superficially, with internal oblique deep to this, and transversus abdominis as the third, and deepest muscle layer. All three form an aponeurosis that becomes the rectus sheath, surrounding the rectus abdominis muscles before inserting into the linea alba in the midline.

Ryan S, McNicholas M, Eustace SJ. Anatomy for Diagnostic Imaging, 3rd edn. Edinburgh: Saunders, 2011: 157, 167–169.

Case 3.15



Case 3.15

A Right lobe of liver

B Portal vein

C Gastric fundus

D Left 12th rib

E Urinary bladder

Coronal contrast-enhanced CT of the abdomen in the portal venous phase.

The liver is divided into right and left lobes, and further subdivided into 8 segments by the portal and hepatic veins. **Figure 3.1** illustrates the segmental anatomy of the liver.

The portal vein is formed by the confluence of the superior mesenteric vein and the splenic vein, behind the pancreatic neck, just to the right of midline. It travels superiorly, within the hepatoduodenal ligament, towards the porta hepatis, where it divides into right and left branches. The right portal vein divides further into anterior

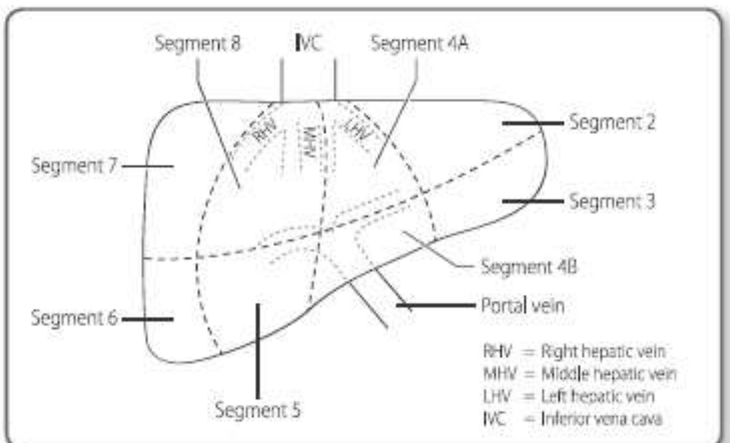
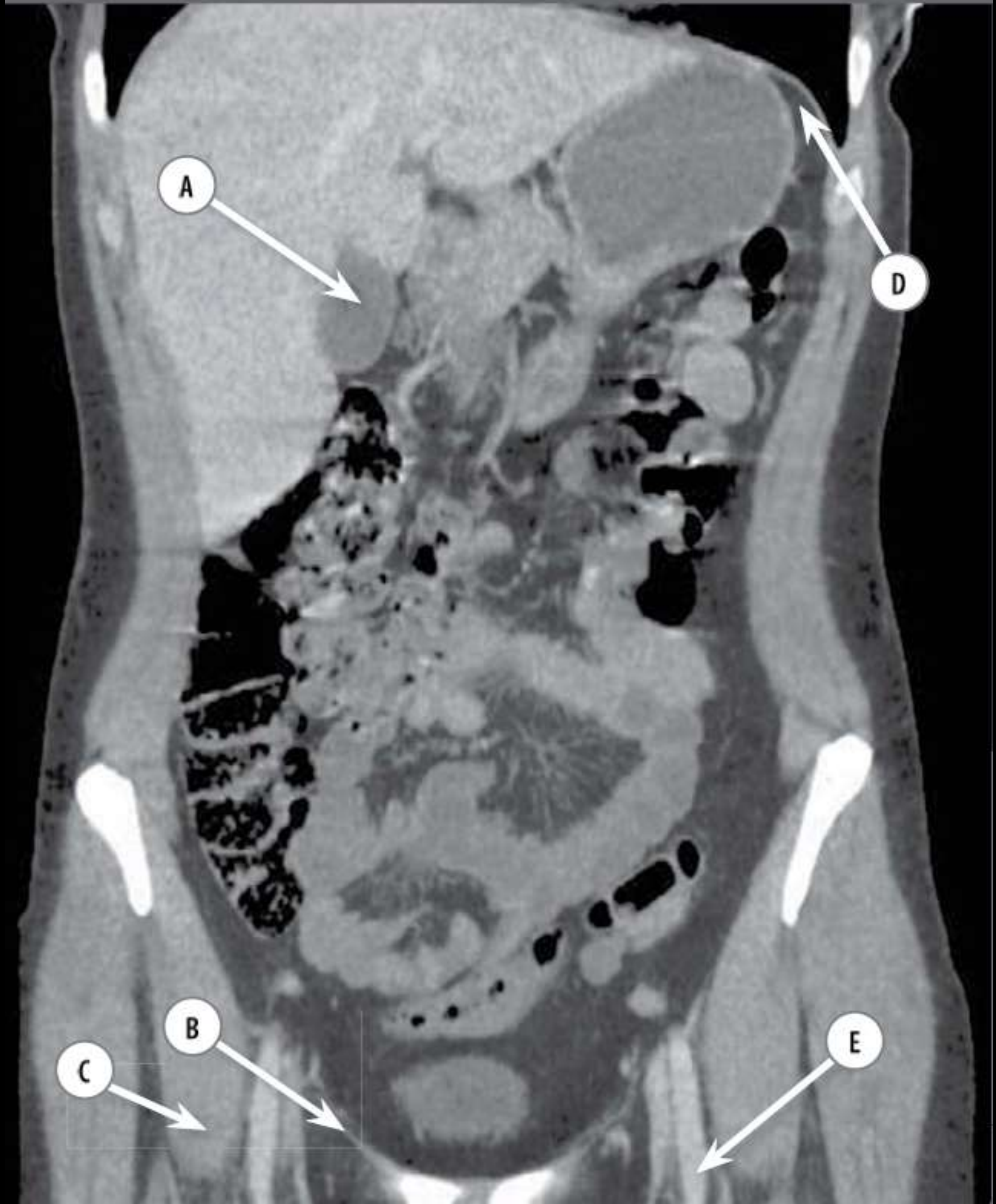


Figure 3.1 Segmental anatomy of the liver.

and posterior branches. The left portal vein gives off branches to the caudate and quadrate lobes (segments I and IV), before going on to divide into superior and inferior branches more distally. The superior and inferior branches supply segments II, III and the inferior aspect of segment IV.

Butler P, Mitchell AM, Ellis H. Applied Radiological Anatomy. Cambridge: Cambridge University Press, 1999: 234–235.

Case 3.27



Case 3.27

A Gallbladder

B Right inguinal ligament

C Right iliopsoas

D Fat in the left subphrenic space

E Left common femoral artery

Coronal contrast-enhanced CT of the abdomen and pelvis in the portal venous phase.

The aponeurosis of the external oblique muscle is thickened inferiorly at its free edge to form the inguinal ligament. This ligament runs from the pubic tubercle superolaterally to the anterior superior iliac spine. Its fibres continue inferiorly to merge with the fascia lata. The inguinal ligament forms the base of the inguinal canal, and forms the medial wall of the femoral ring.

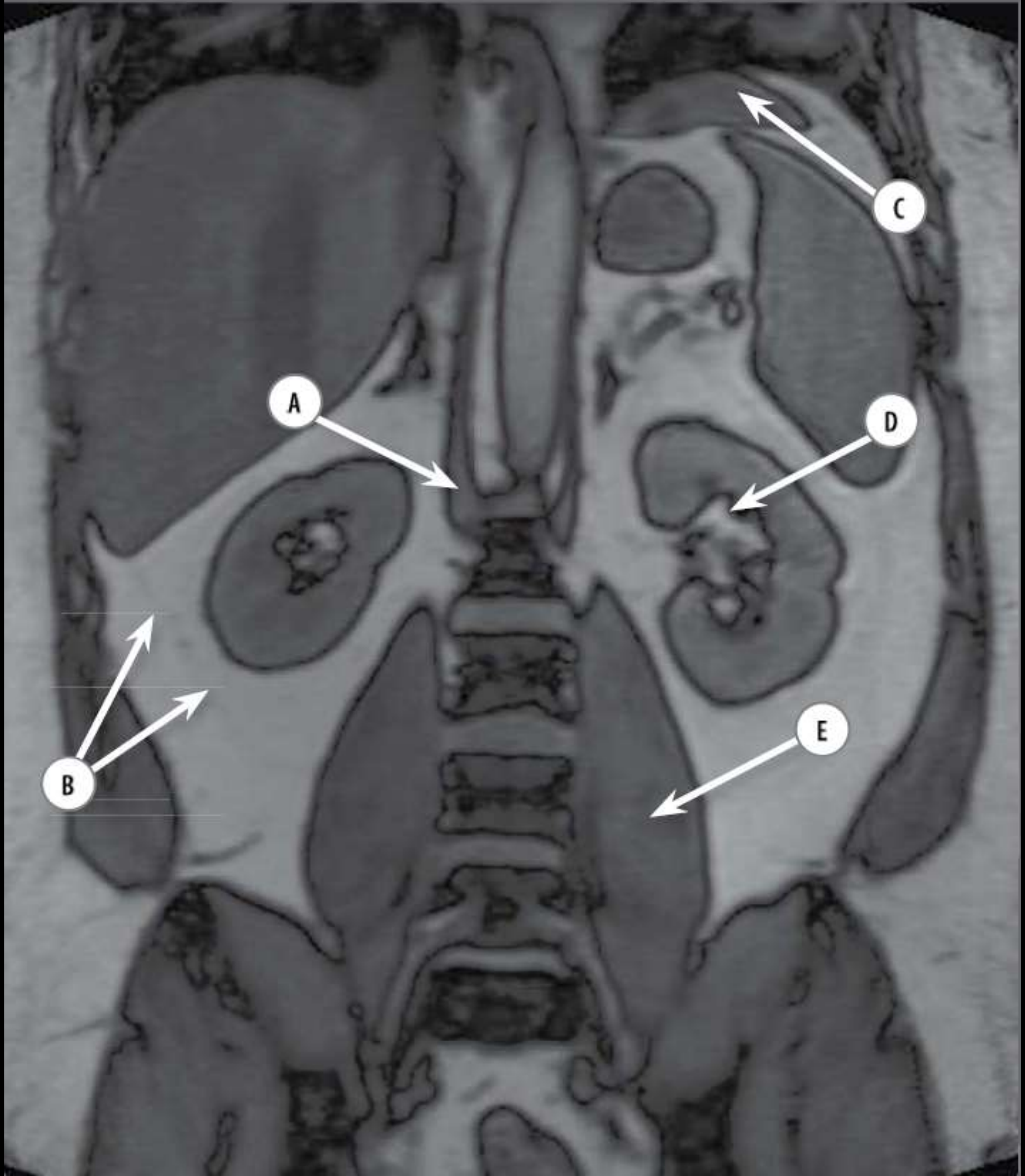
The external iliac artery becomes the common femoral artery as it passes under the mid-point of the inguinal ligament (the midinguinal point). The common femoral artery enters the thigh below the inguinal ligament, and is found laterally to the common femoral vein at this point. As it enters the thigh it gives off four superficial branches:

- **superficial epigastric artery** passes superomedially through the rectus sheath to run in the anterior abdominal wall
- **superficial circumflex iliac artery** runs laterally on a course towards the anterior superior iliac spine
- **superficial external pudendal artery** passes medially and supplies the superficial portions of the external genitalia and skin
- **deep external pudendal artery** also passes medially and supplies the skin overlying the external genitalia.

From here, the common femoral artery continues a course inferiorly through the femoral triangle, below sartorius to enter the adductor canal. The main branch of the common femoral is the profunda femoris artery, which arises approximately 5 cm distal to the inguinal ligament, and takes an inferoposterior course and comes to lie behind the femoral artery.

Butler P, Mitchell AM, Ellis H. Applied Radiological Anatomy. Cambridge: Cambridge University Press, 1999: 201, 387.

Case 3.29



Case 3.29

A Right diaphragmatic crus

B Right Zuckerkandl's fascia

C Left lobe of liver

D Left renal sinus fat

E Left psoas

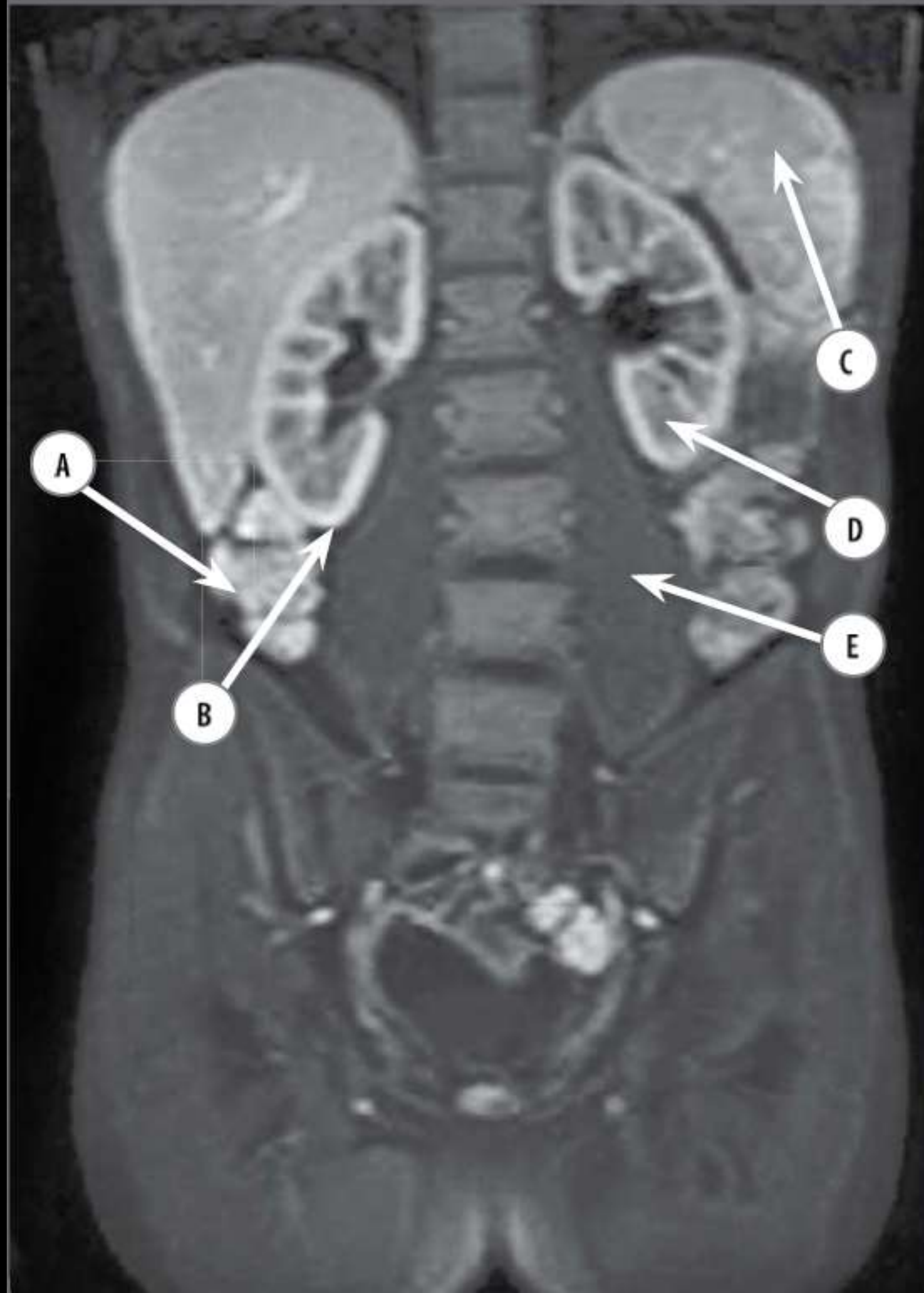
Coronal T1-weighted, out of phase MRI through the posterior abdomen.

Out of phase imaging gives this 'India ink' appearance. This is due to signal drop out from voxels which contain both fatty and non-fatty tissue. Therefore, it tends to occur at interfaces of fat with soft tissue. This sequence is often used to characterise adrenal lesions.

The kidney is surrounded by a fibrous capsule and the space immediately surrounding this is known as the perirenal space. This space is filled with perirenal fat and is bounded by the renal fascia. This fascia can be seen as a fine low signal line running around the kidney and is best visualised on images where the plane intersects it at right angles. On this image it is outlined nicely on either side by the high signal fat surrounding it. The renal fascia has an anterior and a posterior leaf, which merge laterally to become the lateral conal fascia. The posterior pararenal space is found behind the posterior leaf of the renal fascia, which is also known as Zuckerkandl's fascia. The anterior pararenal space is found posterior to the peritoneum, in front of the anterior renal fascia, which is also known as Gerota's fascia. The retroperitoneum is therefore divided into three compartments by the renal fascias.

Ryan S, McNicholas M, Eustace SJ. Anatomy for Diagnostic Imaging, 3rd edn. Edinburgh: Saunders, 2011: 198–199.

Case 3.35



Case 3.35

A Ascending colon

B Right kidney, lower pole cortex

C Spleen

D Left kidney, lower pole medullary pyramid

E Left psoas

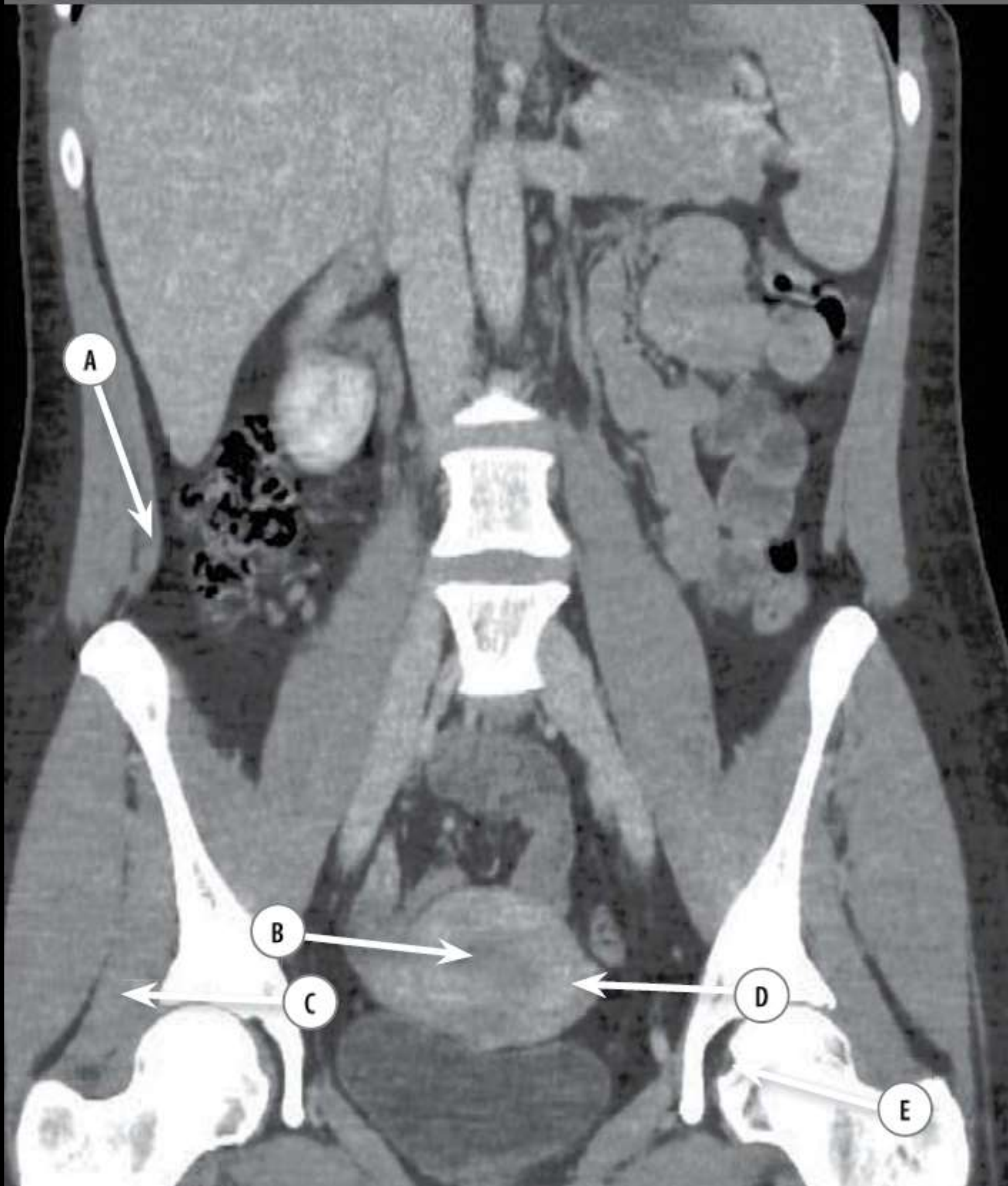
Coronal contrast-enhanced, fluid attenuated abdominal MRI.

The kidney is made up of an outer cortex, and an inner medulla. In contrast-enhanced imaging the cortex enhances first, followed by the medulla. Excretion of contrast then results in enhancement of the pelvicalyceal system. The renal medulla is made up of multiple pyramids, separated by columns of cortex (columns of Bertin). The apices of the pyramids form the renal papillae – these have a convex contour, cupped by the adjacent draining calyx. There are typically seven pairs of minor calyces (anterior and posterior). These join into two or three major calyces, which drain via their infundibula to the renal pelvis.

The psoas muscles are retroperitoneal structures, medial to the lower poles of the kidneys. They lie to either side of the lumbar spine and act as flexors and stabilisers. They originate from the transverse processes of L1–5 and, more superficially, from the bodies of T12–L5. As they descend they fuse with iliacus to form iliopsoas, which runs under the inguinal ligament and attaches to the lesser trochanter of the femur.

Ryan S, McNicholas M, Eustace SJ. Anatomy for Diagnostic Imaging, 3rd edn. Edinburgh: Saunders, 2011: 196–201, 220.
Butler P, Mitchell AM, Ellis H. Applied Radiological Anatomy. Cambridge: Cambridge University Press, 1999: 308.

Case 3.42



Case 3.42

A Right transversus abdominis

B Endometrial cavity

C Right gluteus minimus

D Myometrium

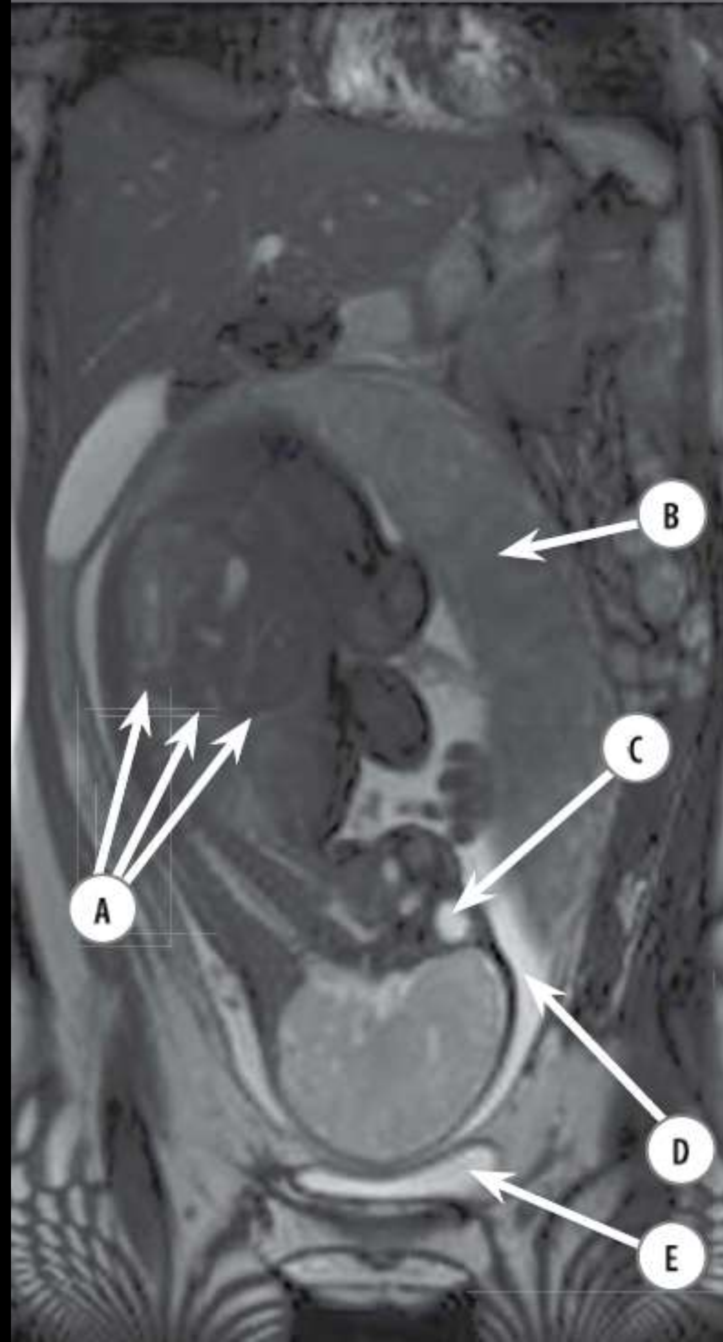
E Fovea of left femoral head

Coronal contrast-enhanced CT of the abdomen and pelvis.

The uterus is usually anteverted and anteflexed; therefore, the uterus is seen in transverse section on this image. Enhancement of the uterus on CT is variable, but both the myometrium and endometrium can show enhancement, especially mid-cycle. This enhancement helps to differentiate the uterus from other soft tissue structures within the pelvis, such as pelvic small bowel loops. During the secretory phase of the menstrual cycle there may be non-enhancing fluid visualised within the endometrial cavity.

The fovea of the femoral head is an ovoid depression, which marks the attachment of the ligamentum teres. This ligament is attached at its base to either side of the acetabular notch. Within the ligamentum teres runs the acetabular branch of the obturator artery, which provides the blood supply to the central part of the head of femur.

Case 3.47



Case 3.47

A Fetal diaphragm

B Placenta

C Fetal globe

D Amniotic fluid

E Maternal bladder

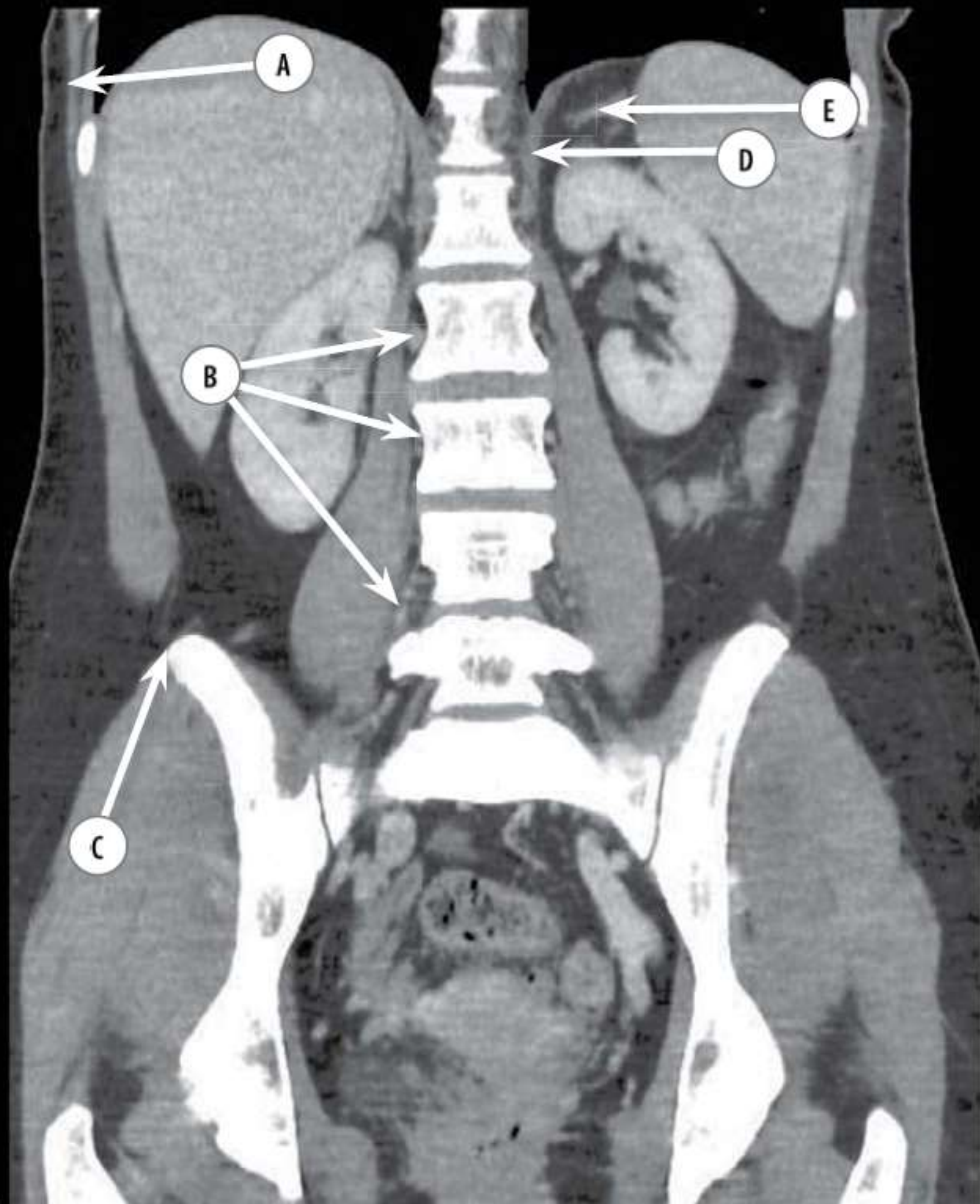
Coronal T2-weighted MRI through a pregnant uterus.

This fetus is in a cephalic presentation with a right lateral lie. The placenta is positioned to the left and returns a moderately high signal, which allows differentiation between it and the myometrium beneath. On contrast-enhanced images the placenta enhances avidly and early during the arterial phase. The myometrium enhances later and to a lesser degree. During the second trimester the placenta demonstrates a heterogenous enhancement pattern, but by the third trimester, it develops into a more lobular pattern, due to the organization of the placenta into cotyledons.

The T2 weighting means that fluid-containing structures return a high signal. Therefore, the amniotic fluid and the urine within the bladder both appear bright. The fetal globe also has a high signal on this sequence.

Prayer D. Fetal MRI. London: Springer, 2011: 407.

Case 3.52



Case 3.52

A Right intercostal muscle

B Right lumbar vessels

C Right iliac crest

D Left diaphragmatic crus

E Left adrenal gland

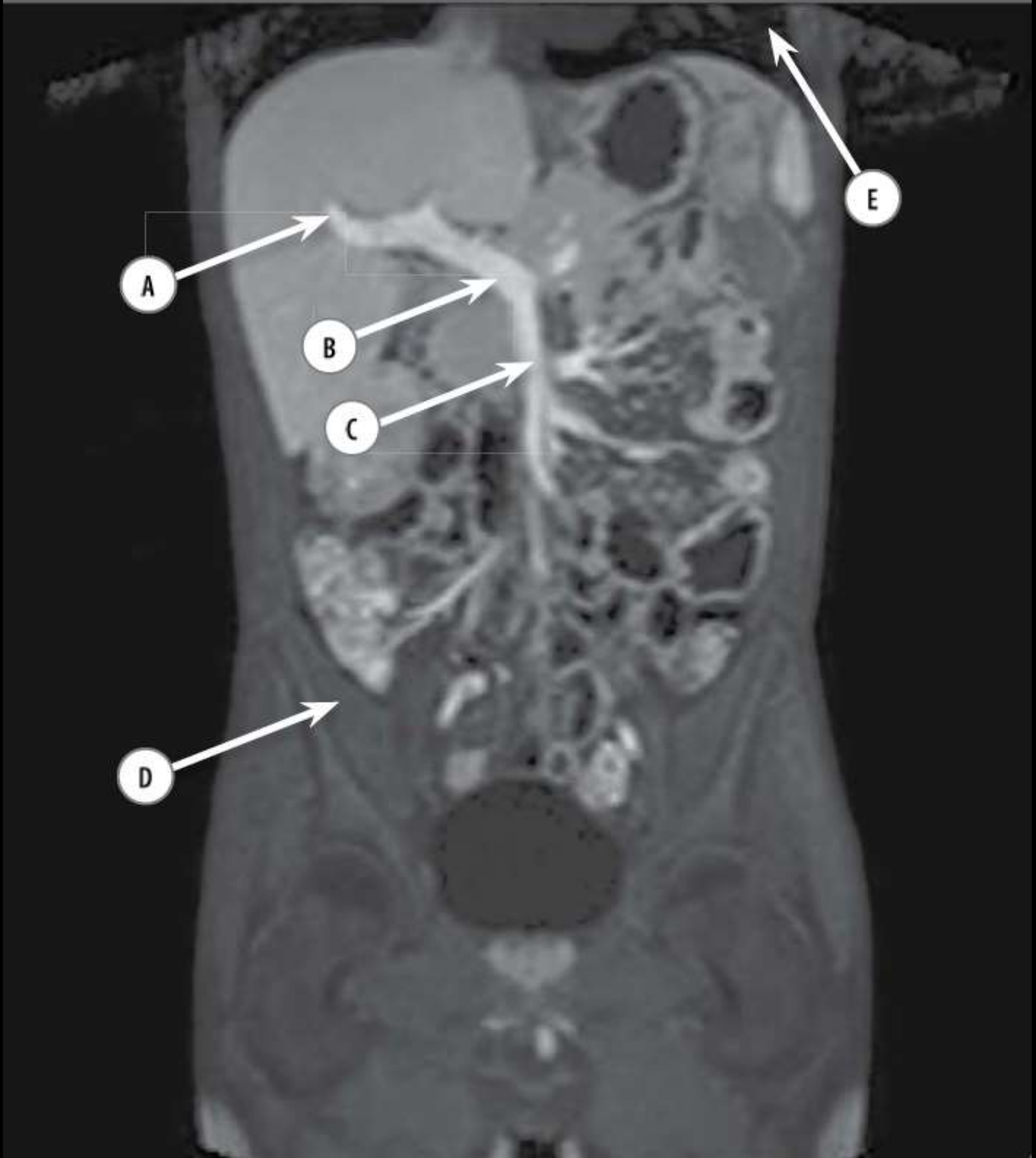
Coronal contrast-enhanced CT.

The lumbar arteries are paired vessels arising from the abdominal aorta and supply the posterior abdominal wall; they are analogous to the intercostal arteries. There are usually four pairs which have their origins from the posterolateral aspect of the aorta at the levels of the 1st to 4th lumbar vertebral bodies. A 5th pair arising from the middle sacral artery is sometimes present. The lumbar arteries pass posteriorly along the sides of the vertebral bodies beneath the psoas muscles. They course around the quadratus lumborum muscles, and then cross the posterior aponeurosis of transversus abdominis. From here, they run anteriorly between transversus abdominis and internal oblique.

There are four pairs of lumbar veins which pass along the sides of the vertebral bodies and drain into the posterior aspect of the inferior vena cava (IVC). The left sided veins have a longer course than the right, and run posteriorly to the aorta to reach the IVC. The ascending lumbar veins run longitudinally in front of the transverse processes and connect the lumbar veins together. When they reach the diaphragm, the ascending lumbar veins continue as the azygous and hemi-azygous veins.

Butler P, Mitchell AM, Ellis H. Applied Radiological Anatomy. Cambridge: Cambridge University Press, 1999: 272.

Case 3.53



Case 3.53

A Right main branch of portal vein

B Portal vein

C Superior mesenteric vein

D Right iliacus

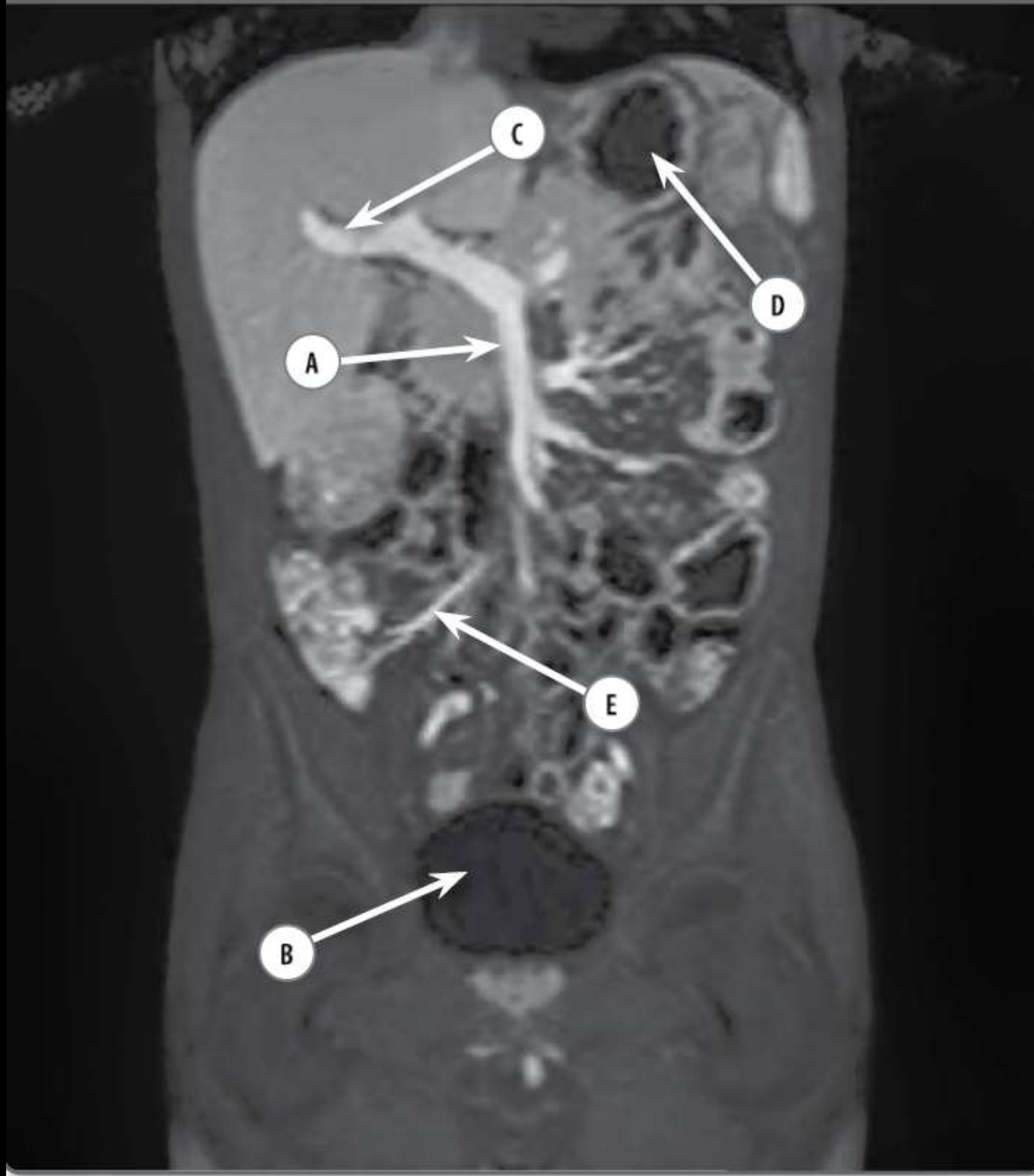
E Left lung base

Coronal contrast-enhanced T1-weighted MRI.

The portal vein arises from the confluence of the superior mesenteric and splenic veins at the level of L1/2. The portal vein drains blood from the spleen, pancreas, gallbladder and GI tract (excluding the anus). From its origin, the portal vein passes to the right behind the neck of pancreas, then behind the first part of duodenum and on towards the porta hepatis. Between the confluence and the porta, the portal vein is joined by the superior pancreaticoduodenal vein and the left and right gastric veins. Once the portal vein enters the liver at the porta hepatis it divides into right and left main branches. The branches of the hepatic artery accompany the portal veins, with the same branching pattern. The hepatic arteries, however, have a much smaller calibre than the adjacent portal veins. The cystic vein drains into the right portal vein and the paraumbilical veins into the left. The ligamentum teres (a remnant from the obliterated left umbilical vein) arises from the left portal vein and is continuous with the ligamentum venosum.

Ryan S, McNicholas M, Eustace SJ. Anatomy for Diagnostic Imaging, 3rd edn. Edinburgh: Saunders, 2011: 178–181.

Case 3.54



Case 3.54

A Superior mesenteric vein

B Urinary bladder

C Right portal vein

D Stomach

E Ileocolic vein

Coronal contrast-enhanced abdominal MRI.

The superior mesenteric vein (SMV) forms a confluence with the splenic vein to become the portal vein. The tributaries of the superior mesenteric vein are listed below.

From the right side:
- ileocolic vein
- right colic vein – drains the ascending colon
- middle colic vein – drains the transverse colon

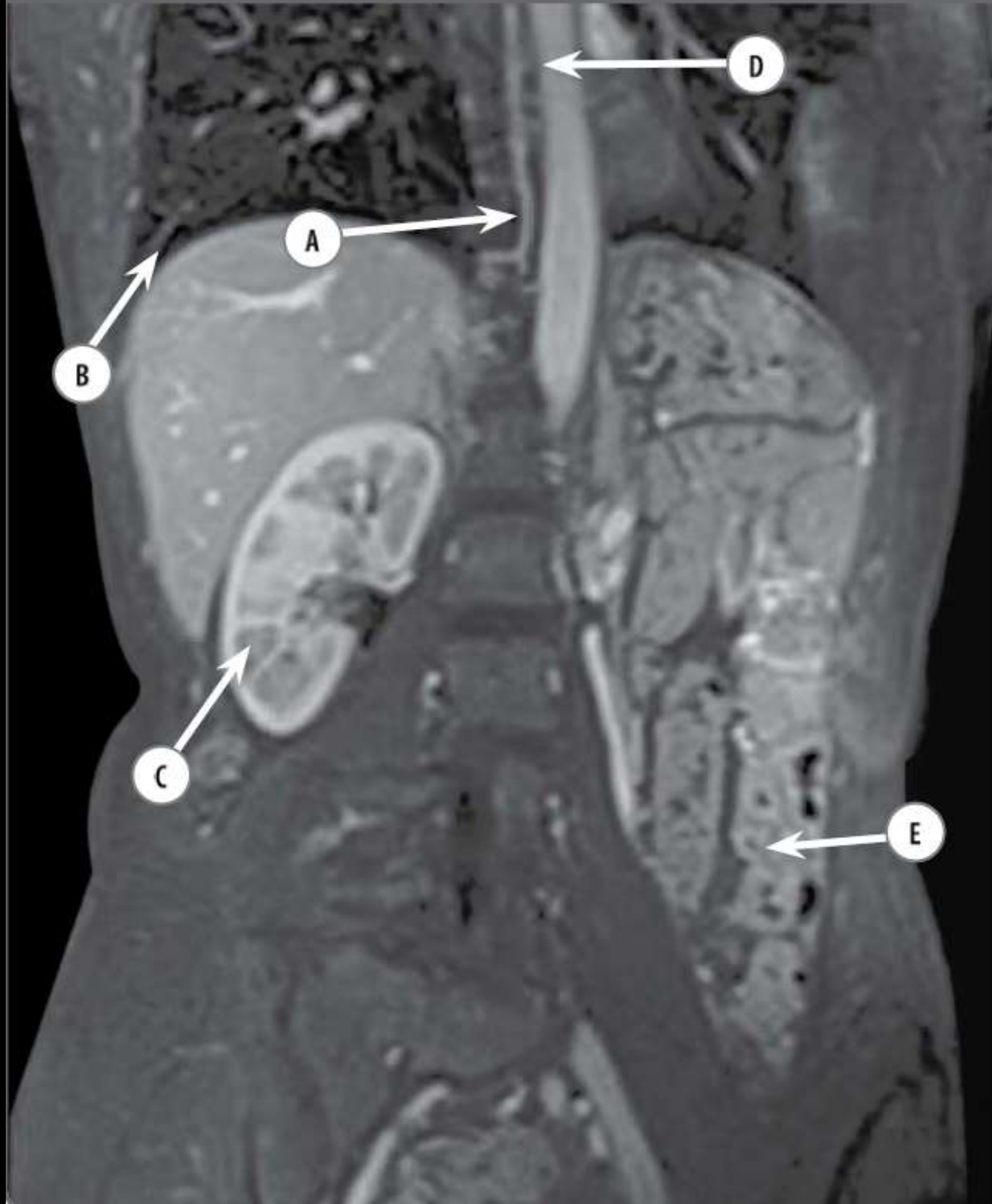
From the left side:
- ileal veins
- jejunal veins

Proximally:
- inferior pancreaticoduodenal vein
- right gastroepiploic vein

The inferior mesenteric vein drains into the splenic vein, which takes a horizontal course behind the pancreas to join the SMV to form the portal vein. The portal vein then takes an oblique course laterally towards the porta hepatis. En route it receives the superior pancreaticoduodenal vein, as it passes behind the neck of the pancreas. Next it receives the right and left gastric veins as it passes behind the first part of duodenum. The portal vein continues in the free edge of the lesser omentum, with the common bile duct and hepatic artery anterior to it. **Figure 3.8** demonstrates the anatomy of the portal venous system

Butler P, Mitchell AM, Ellis H. Applied Radiological Anatomy. Cambridge: Cambridge University Press, 1999: 235.
Ryan S, McNicholas M, Eustace SJ. Anatomy for Diagnostic Imaging, 3rd edn. Edinburgh: Saunders, 2011: 193–196.

Case 3.56



Case 3.56

A Azygous vein

B Right costophrenic angle

C Medullary pyramid, right lower pole of kidney

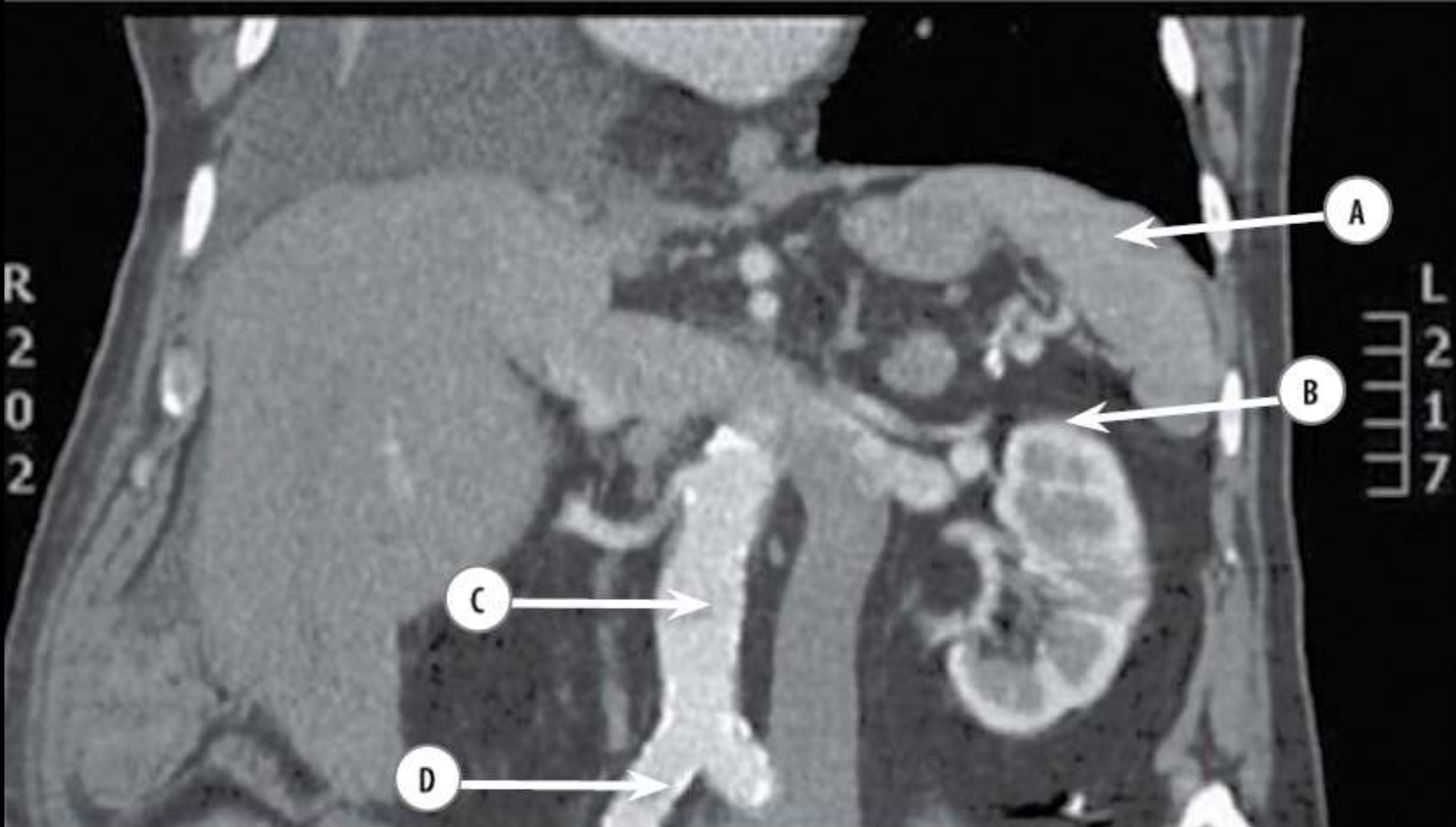
D Descending thoracic aorta

E Descending colon

Oblique coronal contrast-enhanced T1-weighted MRI.

This image demonstrates the relationship between the azygous vein and the descending aorta. The azygous vein rises from the abdomen into the thoracic cavity, to the right of the aorta and the thoracic duct and in front of the spinal column and the right posterior intercostal arteries. Its course passes just medial to the right lung, with its pleural surface adjacent to the azygous vein. When it reaches the level of T4 it takes an anterior course, arching over the hilum of the right lung, to drain into the superior vena cava.

Case 3.58



E Which normal variant is demonstrated?

Case 3.58

A Spleen

B Upper pole of left kidney, cortex

C Abdominal aorta

D Right common iliac artery

E Normal variant: left-sided inferior vena cava

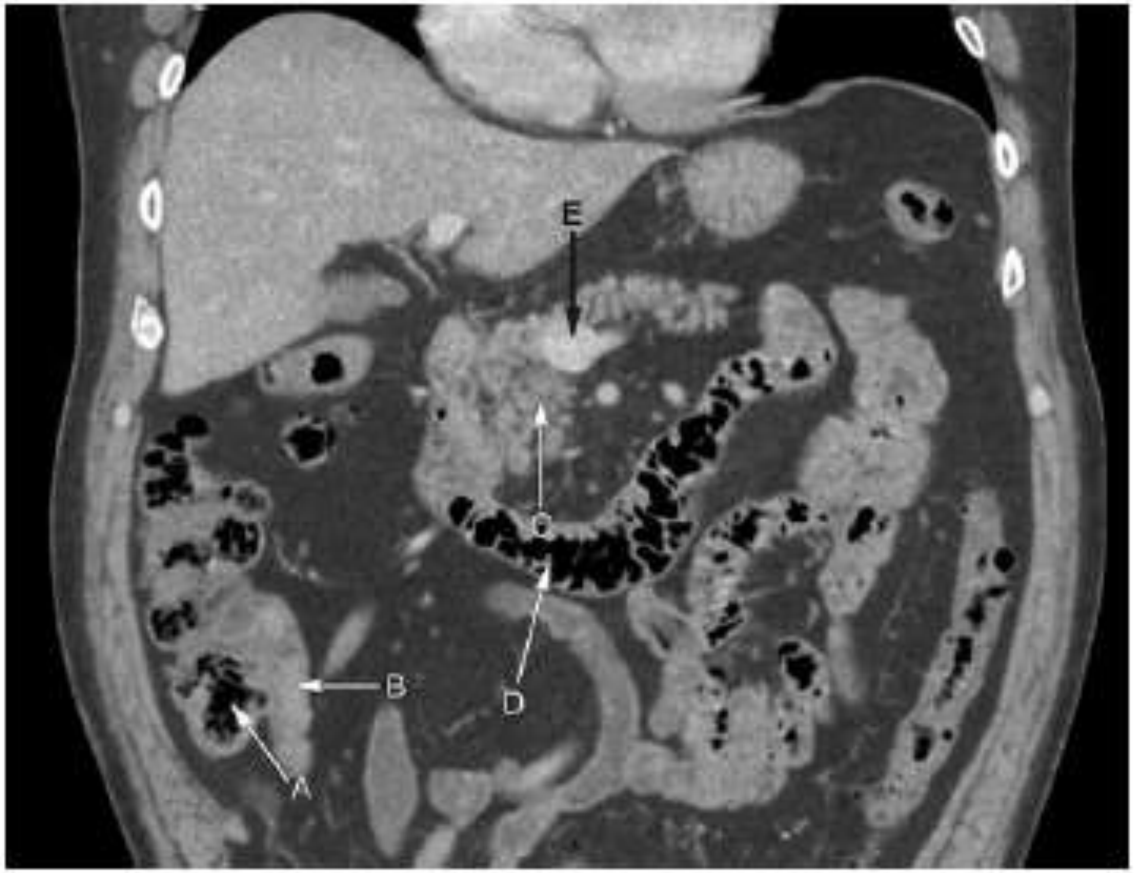
Coronal abdominal CT in the arterial phase.

A left-sided inferior vena cava (IVC) is a normal variant which occurs in approximately 0.2–0.5% of people. In this situation, the confluence of the iliac veins is found behind the left common iliac artery and the IVC ascends from here, on the left side of the abdominal aorta. Typically, once it receives the left renal vein, it crosses anterior to the aorta, towards the right hand side. At this point it receives the right renal vein and resumes a normal course.

This example demonstrates the typical course taken by a left-sided IVC, crossing in front of the aorta once the left renal vein has been received. The arterial phase of this study should help you to identify this anomaly, as the contrast has not yet reached the venous system.

Branchereau A, Jacobs M. Unexpected Challenges in Vascular Surgery. Heidelberg: Springer, 2005: 46.

Question 4.11

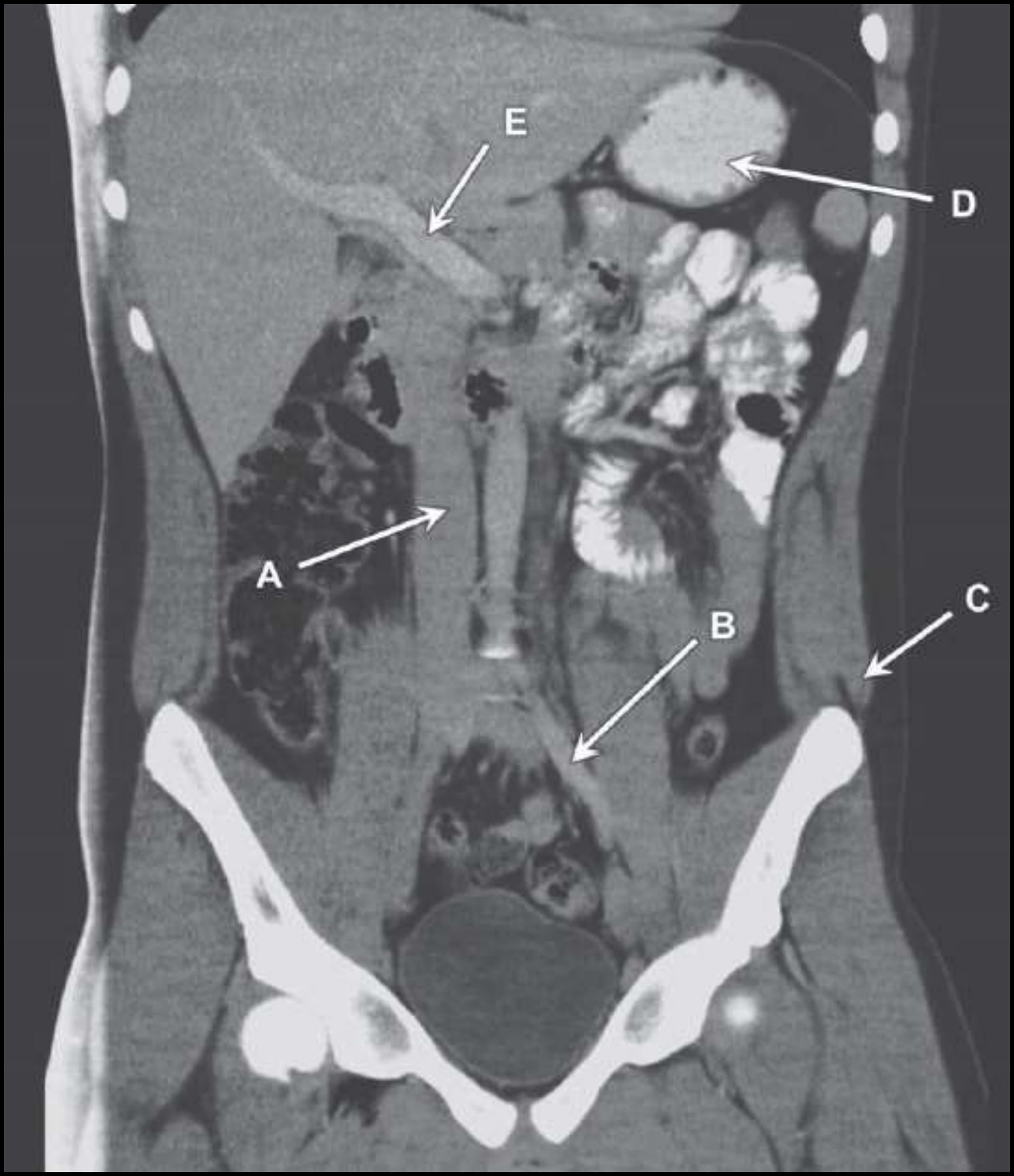


Name the structures labelled **A** to **E**.

4.11 Coronal CT of the abdomen with IV contrast

A Caecum.
B Terminal ileum.
C Uncinate process of the pancreas.
D Third part of the duodenum.
E Porto-splenic confluence; origin of portal vein.

The portal vein is formed by the union of the superior mesenteric vein and the splenic vein behind the neck of the pancreas. The uncinate process of the pancreas arises from the inferior aspect of the head of the pancreas and passes inferiorly to the portal vein and posteriorly to the superior mesenteric vessels. The head of the pancreas lies within the concavity of the second part of the duodenum. The terminal ileum is the only site for vitamin B12 and bile absorption within bowel and is commonly affected by disease processes such as Crohn's disease and TB. It enters the caecum of the colon as demonstrated in this image.

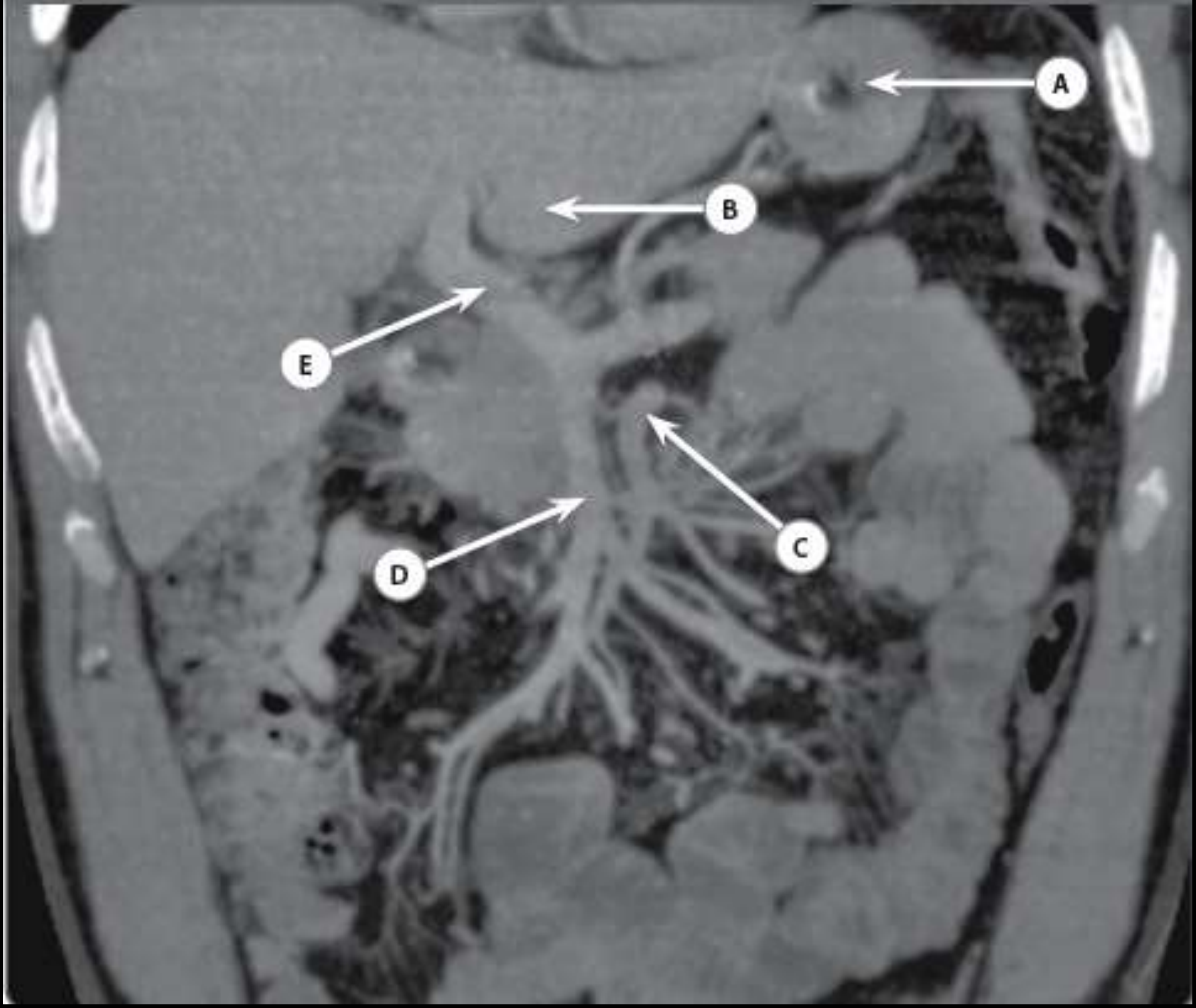

E
D
A
B
C

Case 5

CT abdomen. Coronal section.

1. Inferior vena cava
2. Left common iliac artery
3. Left external oblique muscle
4. Stomach
5. Portal vein

Case 9.5



Case 9.5

A Stomach

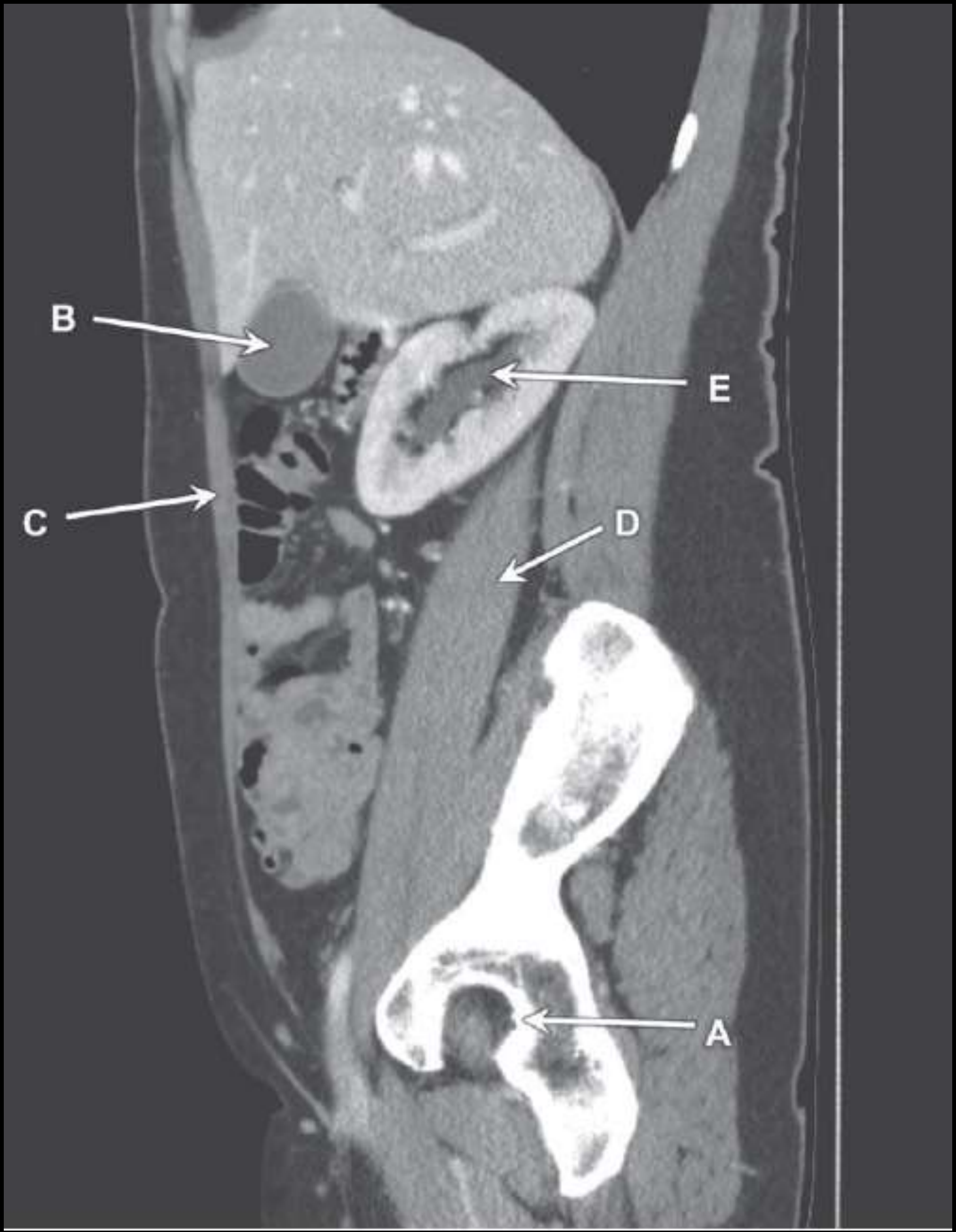
B Left lobe of liver

C Superior mesenteric artery

D Superior mesenteric vein

E Portal vein

The portal vein is formed by the confluence of the superior mesenteric vein and the splenic vein. The superior mesenteric vein lies to the right of the superior mesenteric artery and posterior to the pancreas. Note that there is a small amount of gas in the stomach and scattered throughout the large bowel, whereas the small bowel (shown on the left side of the abdomen), contains no gas. These are normal appearances.

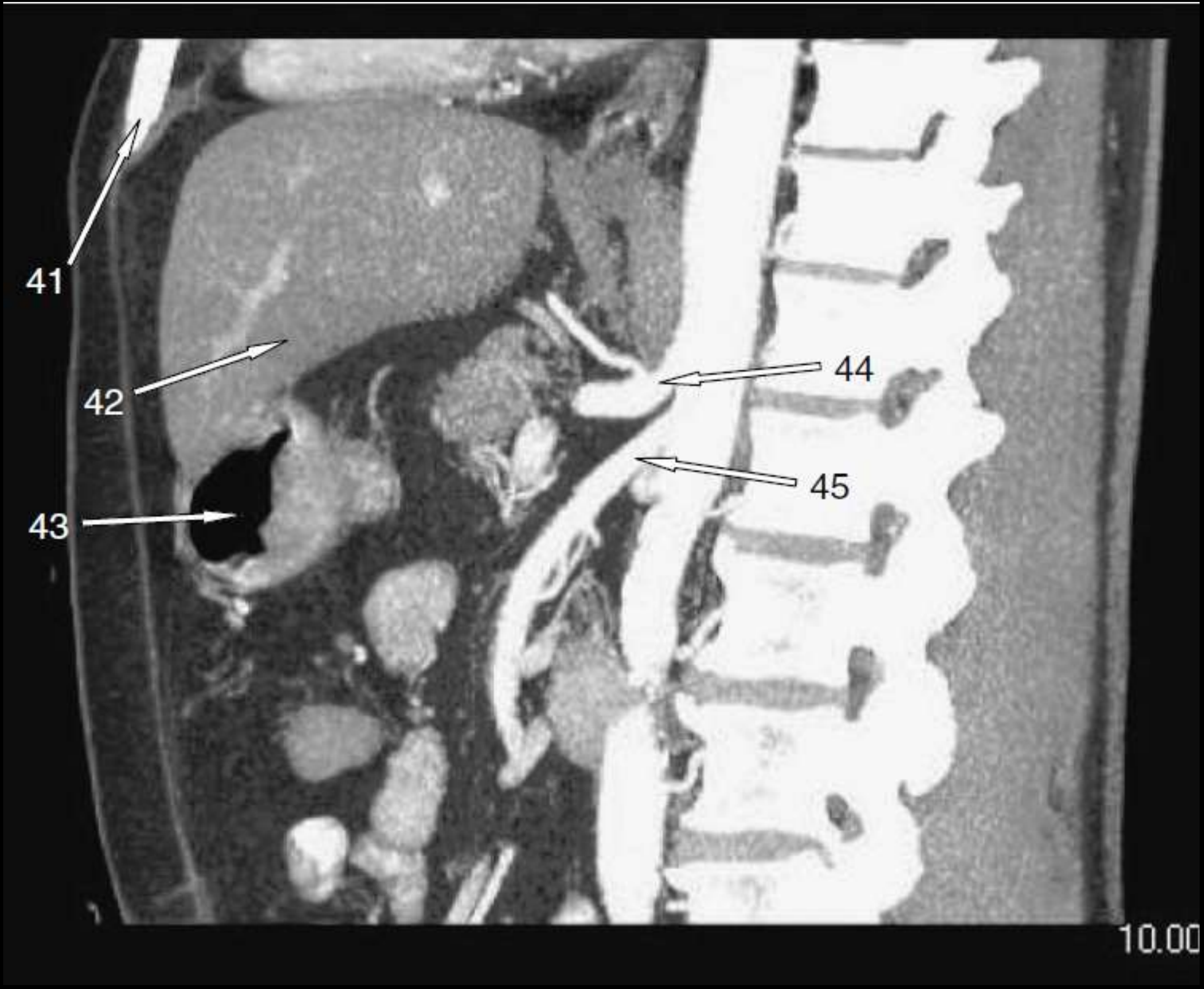

B
E
C
D
A

Case 12

CT abdomen. Parasagittal section.

1. Right acetabulum
2. Gallbladder
3. Right rectus abdominis muscle
4. Right psoas muscle
5. Right renal pelvis

This is the right side as liver and gallbladder are on the image!



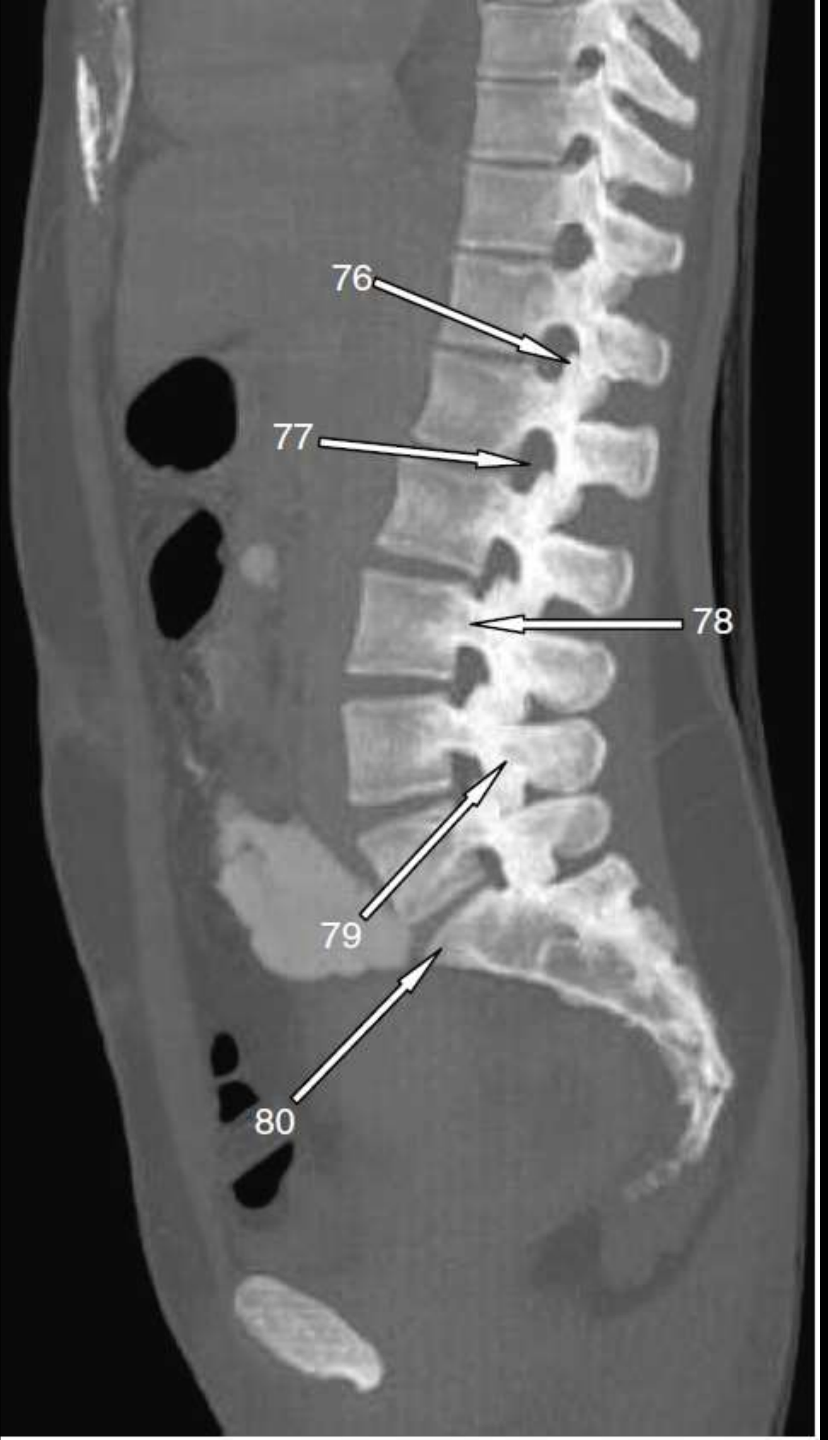
41
42
43
44
45
10.00

CT Abdomen

41. Xiphisternum
42. Liver
43. Stomach
44. Coeliac axis
45. Superior mesenteric artery

Aortic branches in the abdomen:

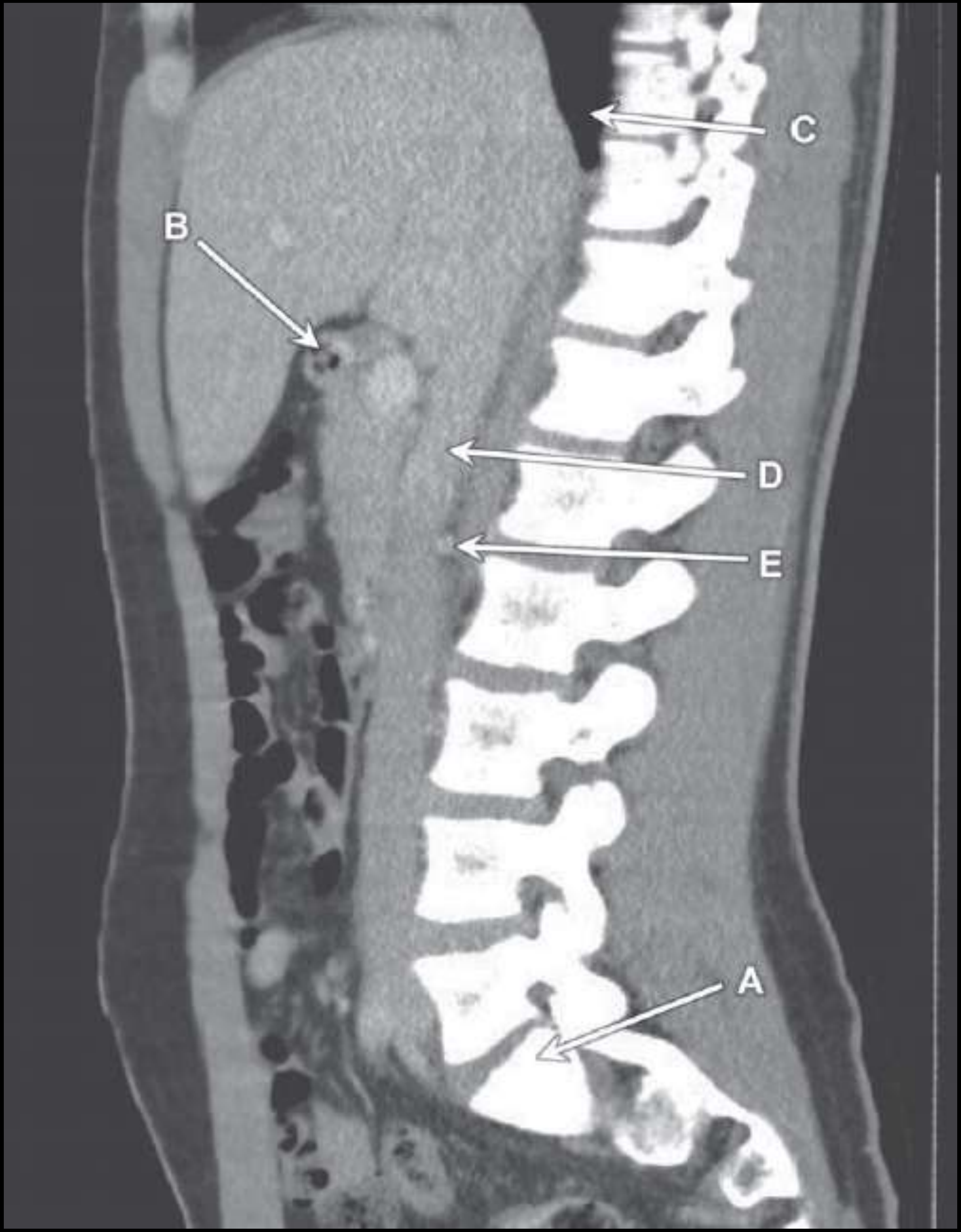
T12 – Coeliac trunk arises.
L1 – Superior mesenteric.
L2 – Renal arteries.
L3 – Inferior mesenteric artery.
L4 – Aorta divides into right and left common iliac arteries.
L5/S1 – Common iliac arteries divide into internal and external iliac arteries.


76
77
78
79
80

CT Abdomen

76. Superior articular process of L1 vertebra
77. L1/L2 intervertebral foramen
78. Pedicle L3 vertebra
79. Pars interarticularis of L4 vertebra
80. Sacral promontory

The pars interarticularis is the part of the lamina between the superior and inferior articular facets. The transverse processes are formed at the junction of the pedicle and lamina. The laminae fuse to form the spinous process posteriorly.

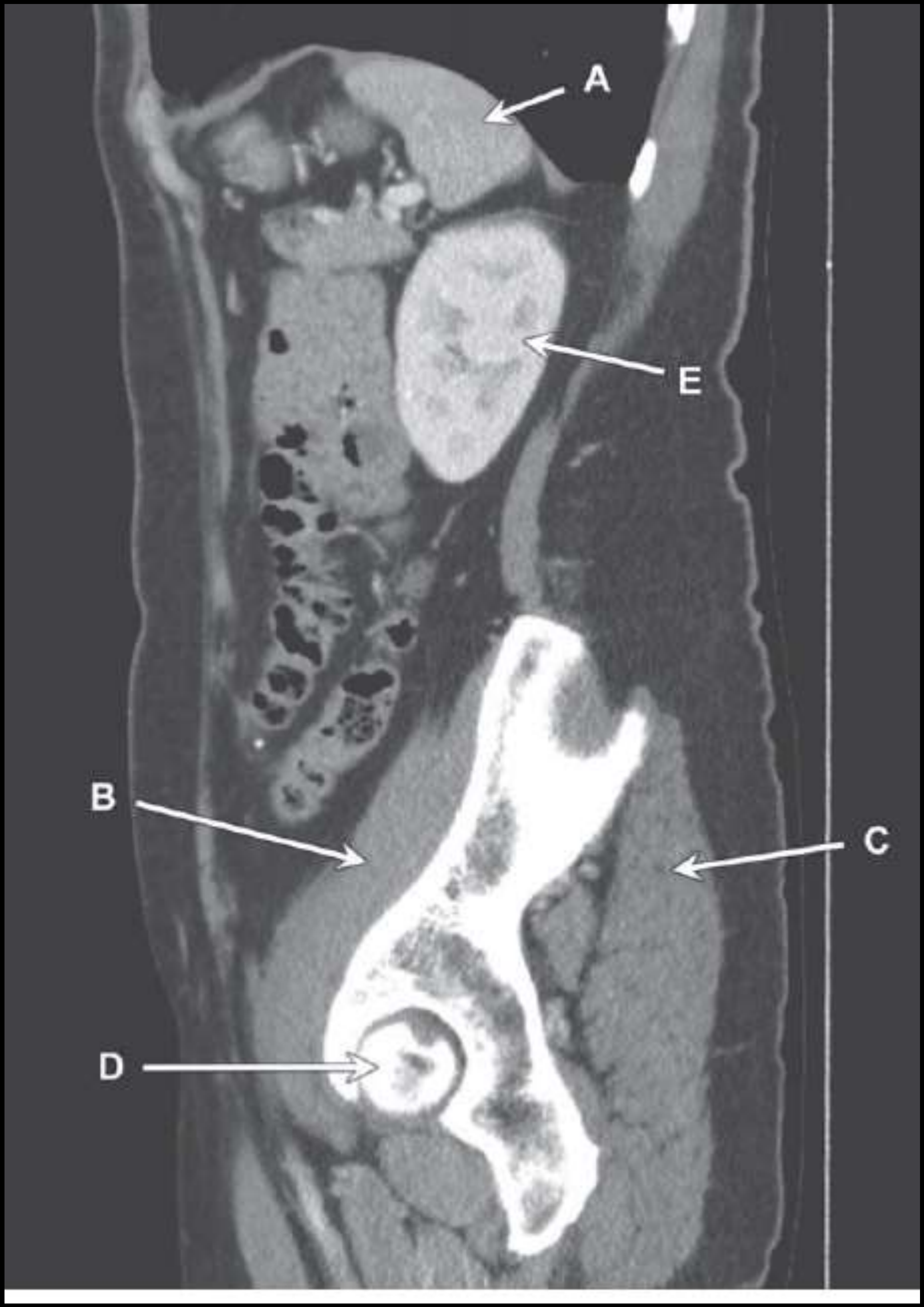

C
B
D
E
A

Case 17

CT abdomen with intravenous contrast. Parasagittal reconstruction.

1. S1 vertebral body
2. Duodenum
3. Lower lobe of right lung
4. Inferior vena cava
5. Right renal artery

'D' is clearly the IVC as this passes into the liver superiorly so we are looking at a slightly off-centre parasagittal image just right of the midline. 'E', therefore, is a vessel passing behind the IVC on the right so is the right renal artery.


A
E
B
C
D

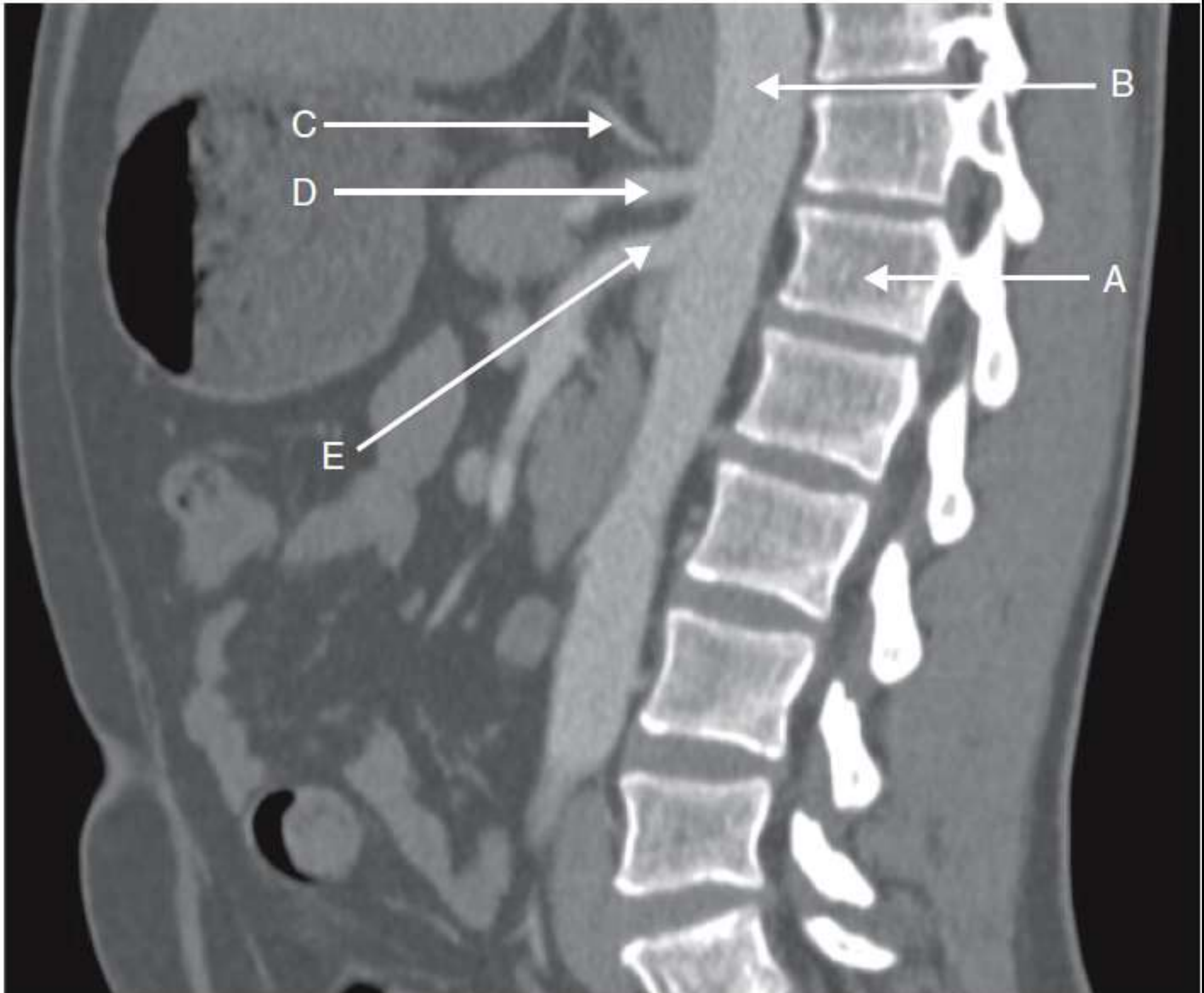
Case 20

CT abdomen. Parasagittal section.

1. Spleen
2. Left iliacus muscle
3. Left gluteus maximus muscle
4. Left femoral head
5. Left kidney

The absence of the liver and presence of the spleen make this a left parasagittal section.

Case 4.19



4.19 Sagittal minimal intensity projection (MIP) abdominal aorta

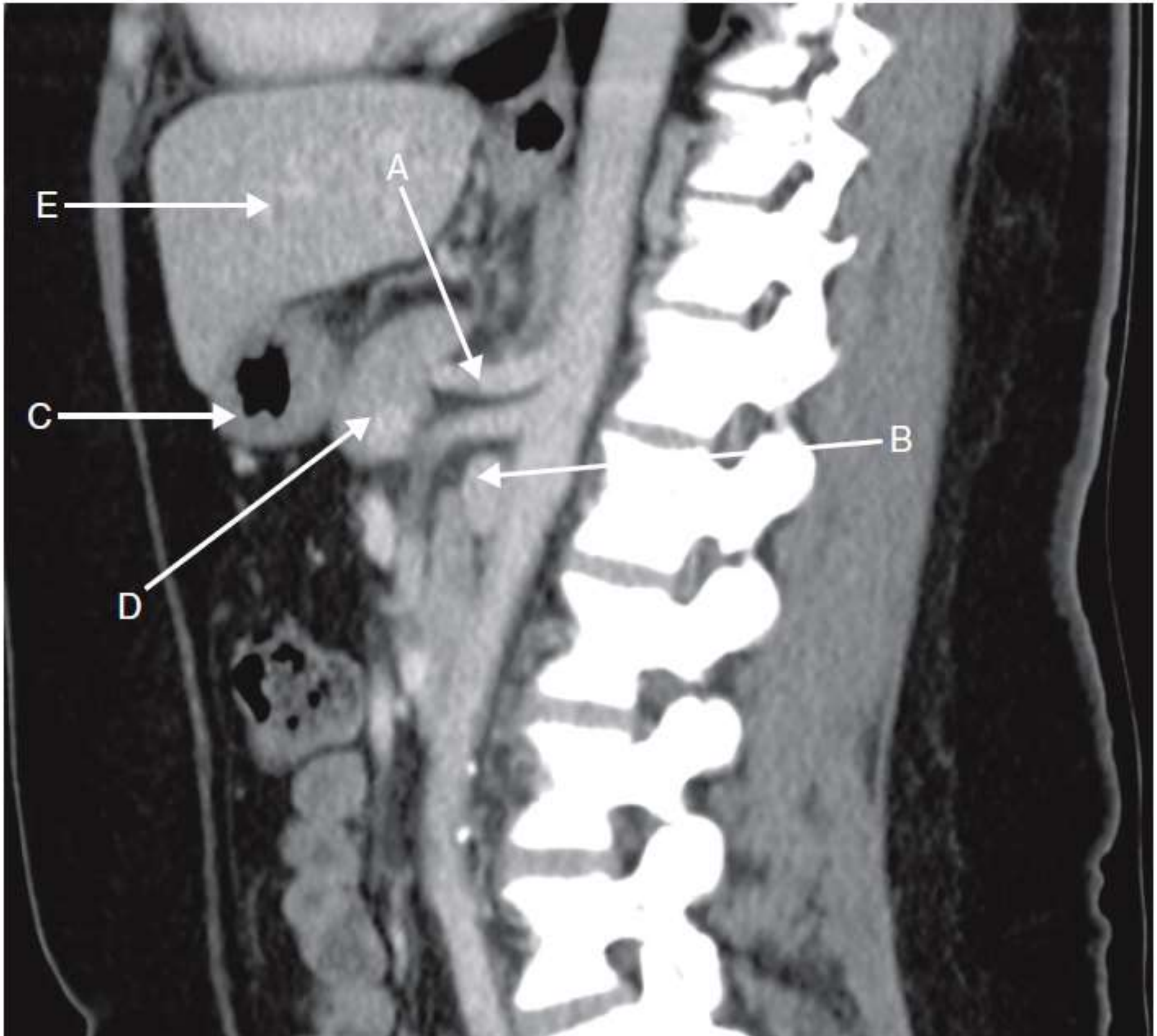
(a) T12 vertebral body.
(b) Aorta.
(c) Left gastric artery.
(d) Coeliac axis.
(e) Superior mesenteric artery (SMA). The SMA comes off at L1, which is known as the transpyloric plane of Addison. Its usefulness is in the number of structures which lie in this plane:

Pylorus of stomach
Fundus of gallbladder

Neck of pancreas
Renal pelvis
Termination of spinal cord
Ninth rib.

The lateral projection is key when working out at what levels the splanchnic branches arise as well as their cranio-caudal angulation for catheter placement. Therefore any planning for mesenteric angiography should be undertaken on a preceding CT.

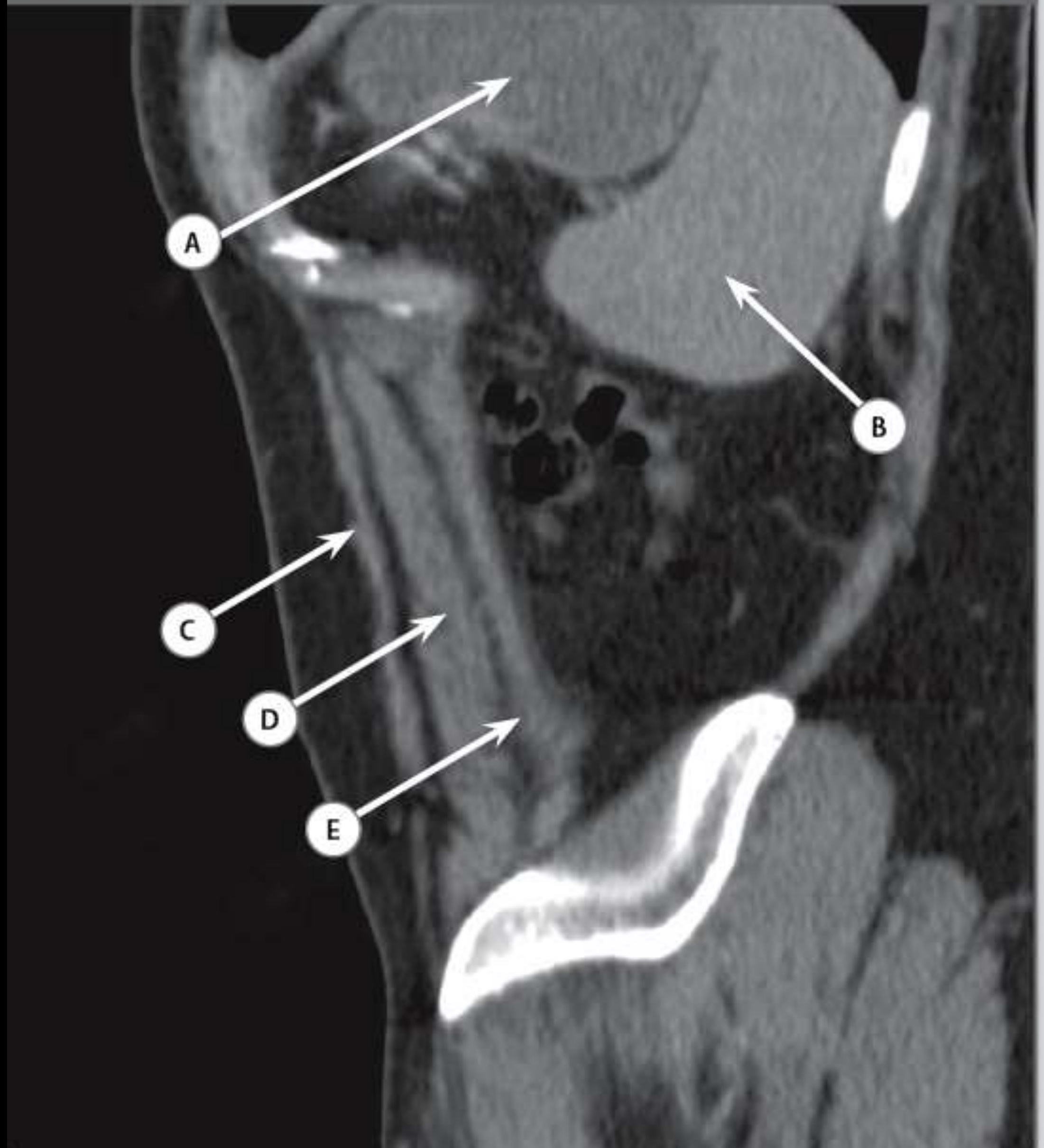
Case 2.20



2.20 CT sagittal reconstruction image of the abdominal aorta

(a) Coeliac artery.
(b) Left renal vein. The left renal vein is situated inferior to the superior mesenteric artery, anterior to the aorta.
(c) Gastric antrum. The gastric antrum is located anteriorly in contrast to the fundus, which lies more posteriorly.
(d) Head of pancreas.
(e) Left lobe of liver.

Case 15.7



Case 15.7

A Stomach

B Spleen

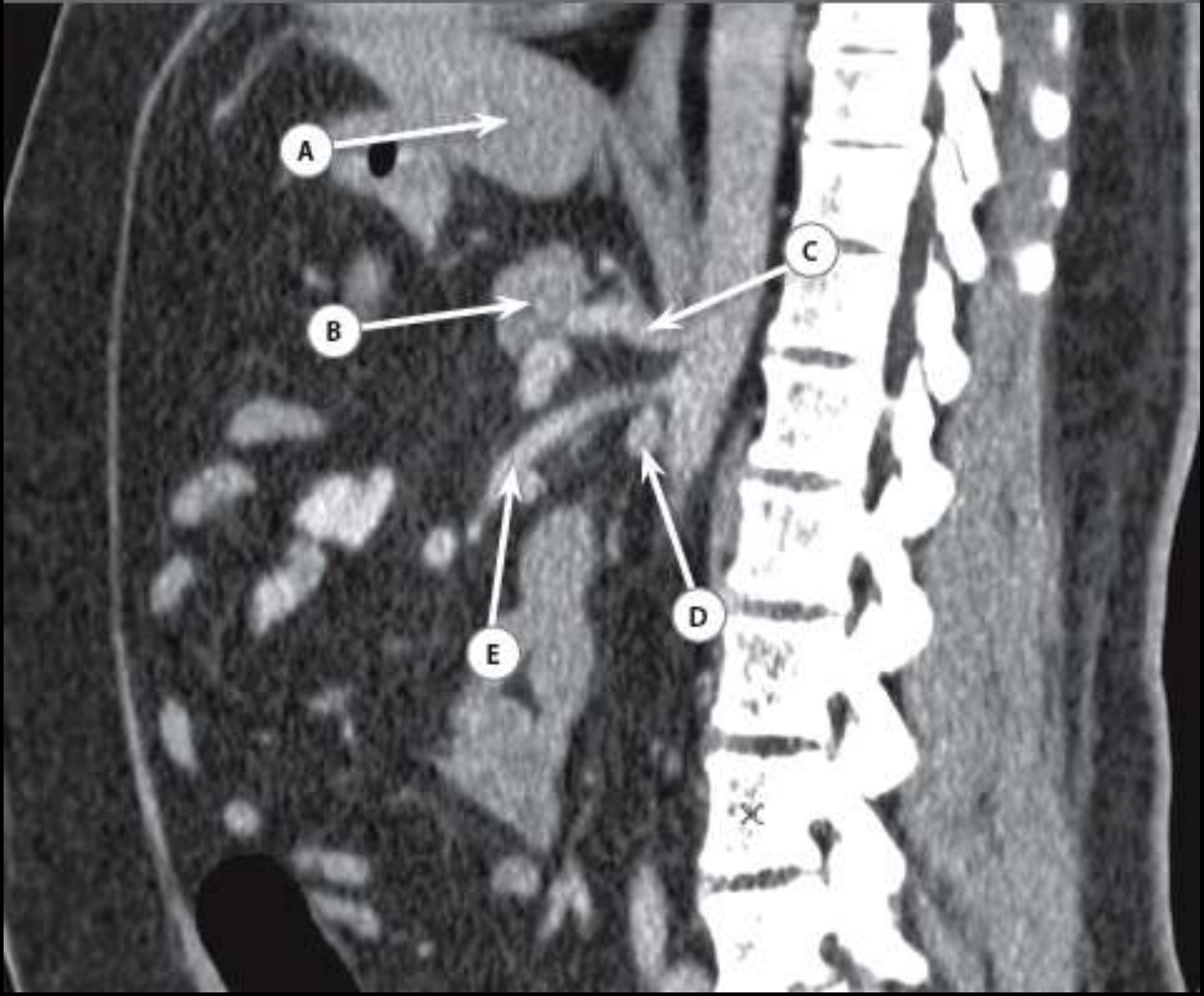
C Left external oblique muscle

D Left internal oblique muscle

E Left transversus abdominis muscle

The stomach has been filled with water, hence its distended appearance, with the left hemidiaphragm lying just above it. Parasagittal views (both CT and MRI) are ideal imaging tools for assessing diaphragmatic disease including congenital and acquired hernias, eventrations and traumatic ruptures. The diaphragm also has variable anatomical appearances and this projection will help in assessing the presence of multiple slips.

Case 9.9



Case 9.9

A Left lobe of the liver

B Body of pancreas

C Coeliac axis/trunk

D Left renal vein

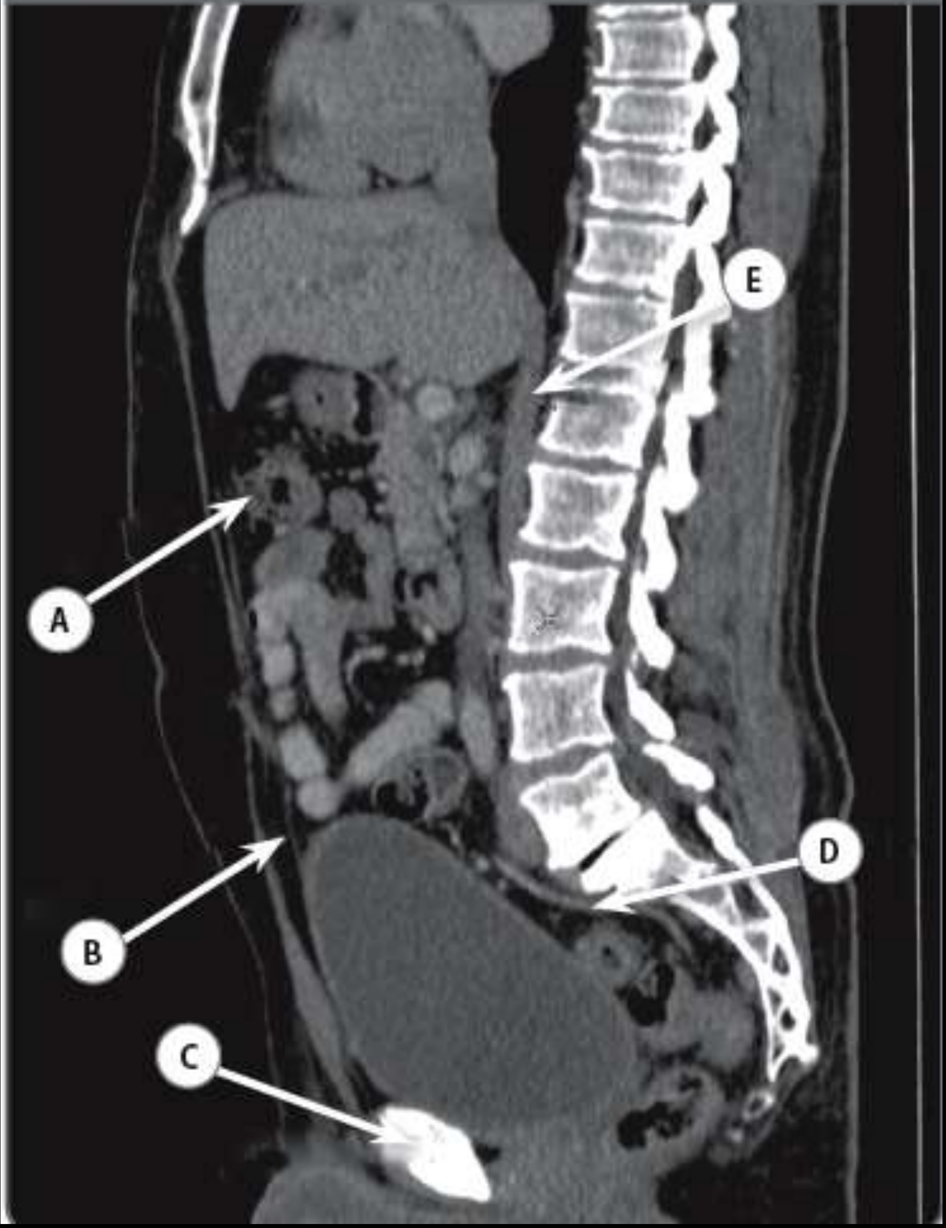
E Superior mesenteric artery

Three unpaired branches of the abdominal aorta arise from the anterior wall of the aorta between the L1 and L3 vertebral levels:

- the coeliac axis/trunk at the superior margin of L1 vertebra level
- the superior mesenteric artery (SMA) at the level of the mid-body of L1 vertebra
- the inferior mesenteric artery (IMA) at L3 level.

It is important to note the relationship between two of these three major abdomin arterial vessels and adjacent viscera, which is clearly demonstrated on this sagittal midline view. The coeliac axis lies posterosuperior to the body of pancreas and the SMA runs anterior to the left renal vein. Inferior to the SMA trunk lies the third part of the duodenum, which can be compressed between the SMA and the vertebral column in very thin individuals or after rapid weight loss in a condition known as a nutcracker syndrome.

Case 4.19



Case 4.19

A Transverse colon

B Peritoneal reflection

C Right pubis

D Superior rectal artery

E Inferior vena cava (IVC)

Orientation of abdominal and pelvic structures in the sagittal plane is easier wher you can recognise important anatomical landmarks. The IVC may serve as a good landmark when seen running anterior to the vertebral column and traversing the liver just before crossing the diaphragm to drain into the right atrium.

The superior rectal artery, a branch of the inferior mesenteric artery (IMA), can be identified coursing anteriorly to the sacrum to supply the rectum.

Question 9.11

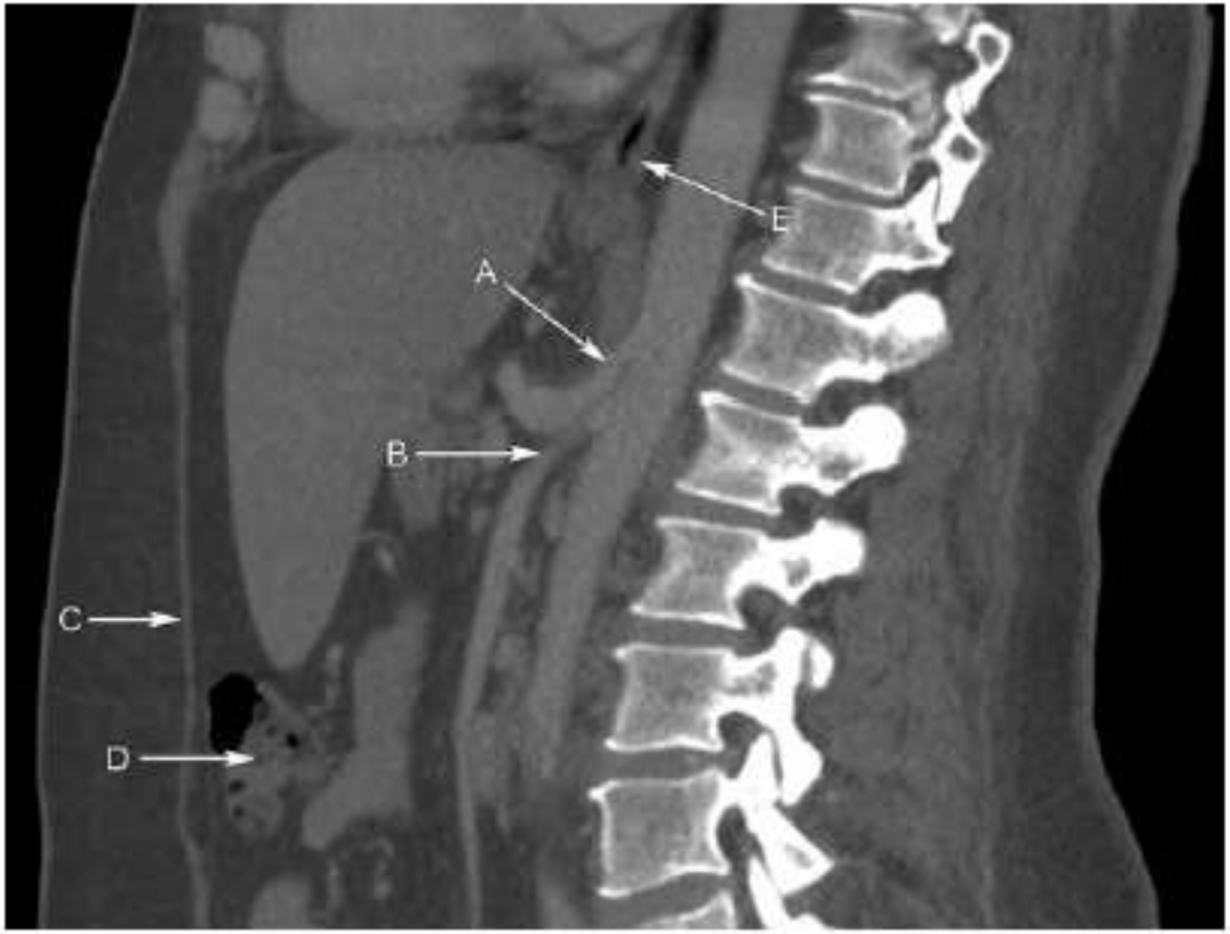
Name the structures labelled **A** to **E**.

9.11 Sagittal CT of the abdomen with IV contrast

A Portal vein.
B Gallbladder.
C Right kidney.
D Ascending colon.
E Retroperitoneal fat.

The kidneys are retroperitoneal structures lying approximately at the level of T12 to L3. The right kidney is slightly lower than the left. The right kidney sits posterior to the liver just below the diaphragm. The upper parts of the kidneys lie partially under the eleventh and twelfth ribs. The kidneys are surrounded by two layers of fat (perirenal and pararenal fat) and Gerota's fascia.

Question 7.11



Name the structures labelled **A** to **E**.

7.11 Sagittal CT of the abdomen with IV contrast

A Coeliac axis.
B Superior mesenteric artery.
C Linea alba.
D Transverse colon.
E Oesophagus.

There are three main anterior branches of the aorta supplying the abdominal viscera and bowel. These are the coeliac axis, superior mesenteric artery and the inferior mesenteric artery. The coeliac axis originates at T12 and gives rise to the common hepatic, left gastric and splenic arteries. The superior mesenteric artery arises at L1 and gives rise to the inferior pancreaticoduodenal artery, middle colic artery, right colic artery, intestinal arteries and the ileocolic artery. It typically runs to the left of the superior mesenteric vein – if it is seen to the right of the vein then suspect malrotation or volvulus.

The linea alba (white line) is the vertical midline aponeurosis of the anterior abdominal wall muscles.

For further images and explanations of the abdominal vasculature, see Questions 3.14, 6.11 and 10.18.

Question 11: Coronal CT of the abdomen

Answer: Transverse colon

- The transverse colon is the most distal part of the colon to be supplied by branches from the superior mesenteric artery.
- It is suspended from the transverse mesocolon and lies within the peritoneal cavity.
- It is of variable length and may be seen drooping as far down as the pelvis.

Question 32:

Question 32: Sagittal CT of the abdomen and pelvis

Answer: Rectus abdominis muscle

- The rectus abdominis are paired anterior abdominal wall muscles. They consist of multiple muscle bellies with intervening tendinous intersections.
- In the midline, the two muscles are separated by a tendinous structure called the linea alba. This is where the aponeuroses of the lateral abdominal muscles insert.

- **Question 33:**

■ Question 33: Sagittal T2-weighted MRI of the lumbar spine and sacrum

Answer: Fundus of uterus

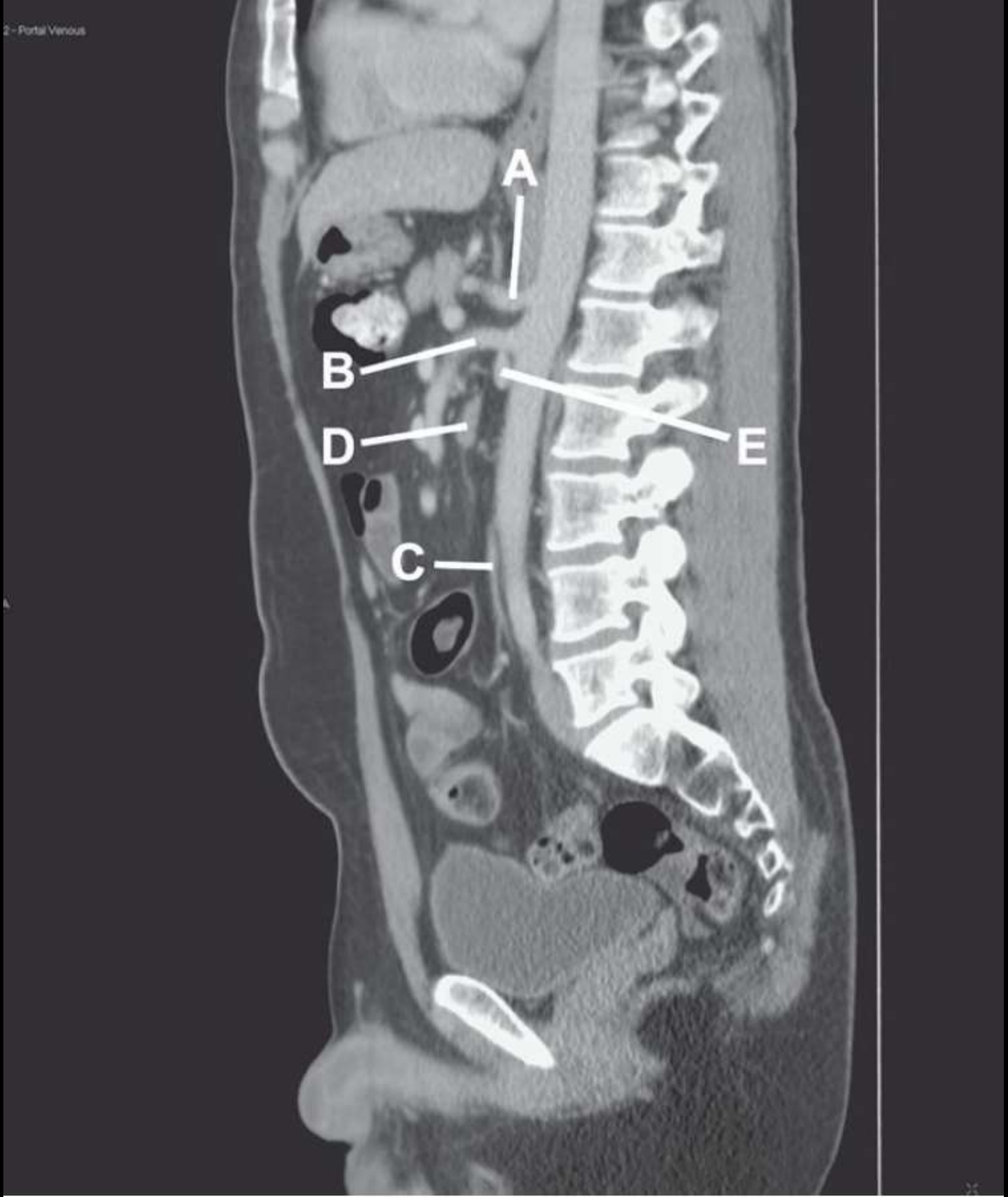
- The uterus lies between the bladder and rectum. It consists of the fundus, body, and cervix.
- The uterus has a characteristic layered appearance, especially on MRI and ultrasound.
- Endometrial thickness varies with age and stage of menstrual cycle. The upper limit of normal in an asymptomatic postmenopausal women is 10 mm.
- In the examination, it is quite common to be asked to name a structure that is not part of the main structures being imaged, so-called 'edge of film' structures.

Question 12:

Question 12: Sagittal CT of the abdomen and pelvis

Answer: Coeliac trunk

- The coeliac trunk is the first anterior branch of the abdominal aorta and supplies the foregut.
- It gives rise to the common hepatic, splenic, and left gastric arteries.



2 - Portal Venous
A
B
D
E
C

Q8 Answers

- **a** Coeliac trunk
- **b** Superior mesenteric artery (SMA)
- **c** Inferior mesenteric artery
- **d** Third part of duodenum
- **e** Left renal vein

Contrast enhanced abdomino-pelvic CT, midline sagittal section

This image demonstrates the relative positions of the three un-paired ventral aortic branches.

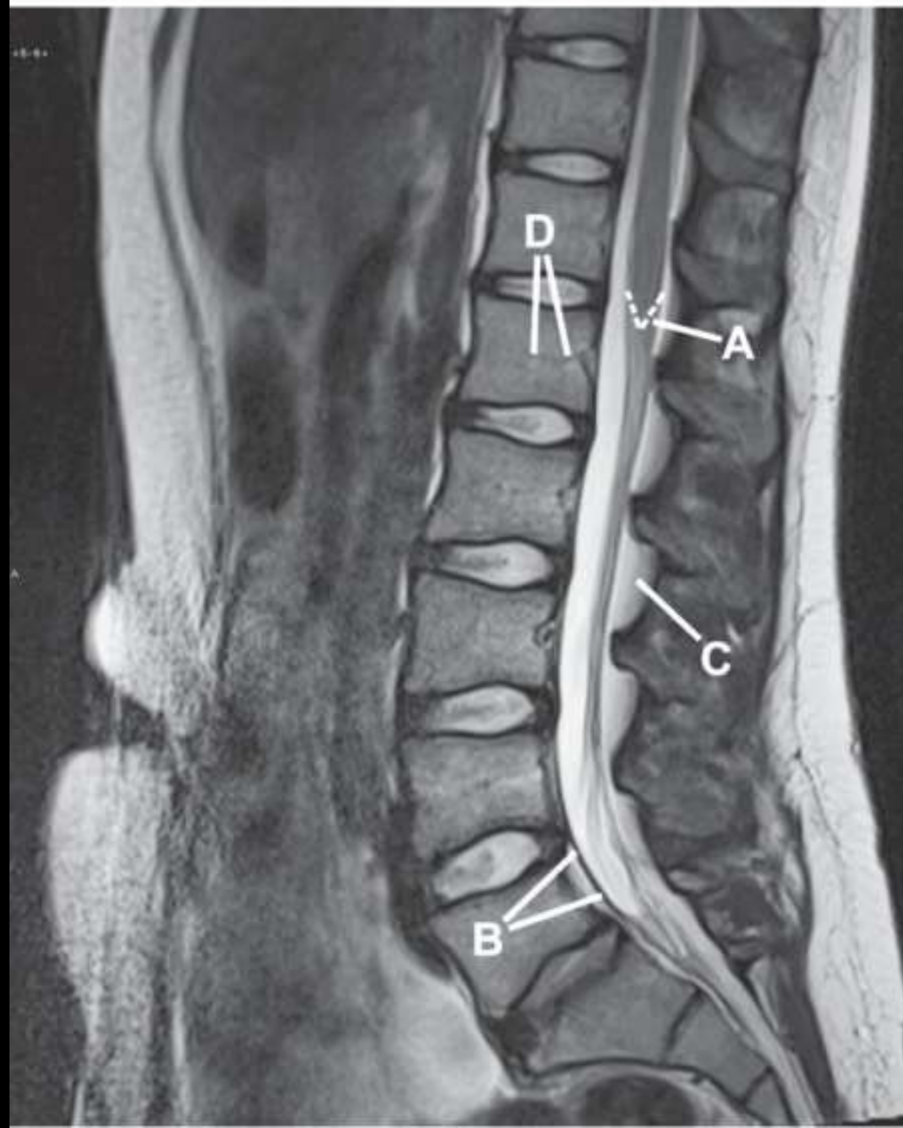
The coeliac trunk arises at the T12–L1 level and often takes a caudal course from the anterior aorta. It runs above the pancreas and the splenic vein and lies posterior to the left lobe of liver.

The SMA arises from the anterior aorta at around the level of L1. In approximately 0.5% of people the coeliac artery and SMA arise from a single (coeliacomesenteric) trunk. Running in a transverse direction deep to the SMA are the left renal vein and third part of duodenum. The pancreas and portal vein lie anteriorly. The SMA runs within the mesenteric root lying to the left of the superior mesenteric vein (SMV).

The inferior mesenteric artery (IMA) arises from the left anterior aspect of the aortic wall at the level of L3 and branches into the left colic and superior rectal arteries.

Q21

a Name the structure labelled A
b Name the structure labelled B
c Name the structure labelled C
d Name the structure labelled D
e Name the artery that supplies most of the spinal cord visible in this image (inferior to T9)



Q21 Answers

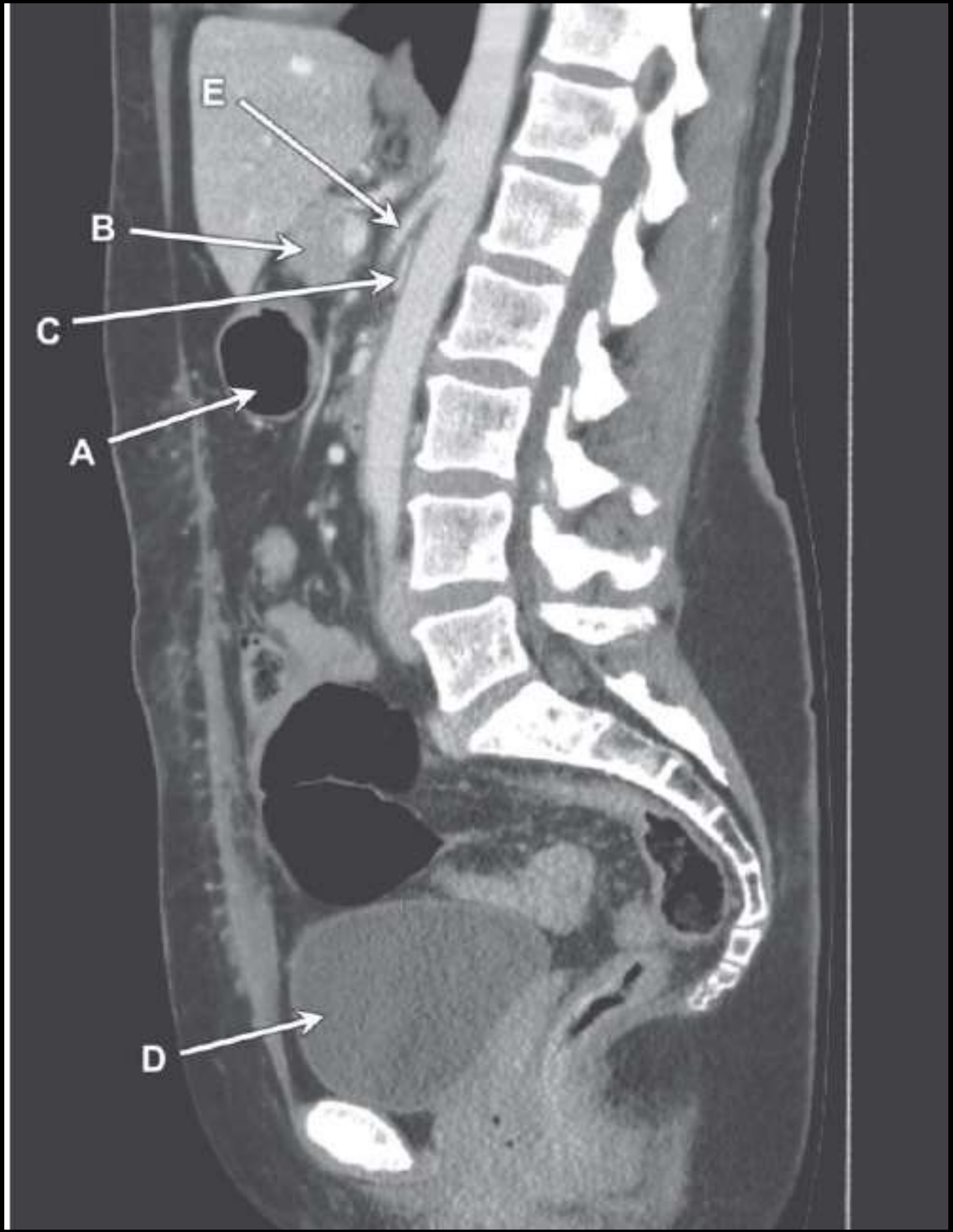
a Conus medullaris
b Posterior longitudinal ligament
c Epidural fat
d Basivertebral vein
e Artery of Adamkiewicz

T2W MRI of lower spine, midline sagittal section

The spinal cord terminates at the conus medullaris which is located opposite L1 or L2 in adults, but is positioned lower (L3) in children. This occurs because the relative growth of the spinal canal and meninges is greater than that of the spinal cord. The conus medullaris marks the termination of the cord only, as the lumbar and sacral nerve roots continue their descent within the thecal sac forming the cauda equina. There is a bulge in the spinal cord proximal to its termination, at around the level of T9–L1 vertebral bodies. This is the lumbar enlargement and is the location of the lower limb plexus (L2–S3) of nerve roots. A similar, but smaller, cervical enlargement occurs in the cord at the C3–T1 vertebral levels due to the upper limb plexus of nerve roots (C5–T1). Both of these enlargements occur as a result of a greatly increased mass of motor cells within the anterior horns of the grey matter.

The posterior longitudinal ligament provides stability to the posterior border of the vertebral bodies and intervertebral discs extending from the body of the axis (C2) to the sacrum. It is attached to the intervertebral discs but separated from the posterior wall of the vertebral bodies by the basivertebral veins and the associated venous plexus. The epidural space lies between the posterior longitudinal ligament and spinal dura. This space is more capacious in the lumbar region than elsewhere and is filled with epidural fat.

Blood supply to the spinal cord is through one anterior and two posterolateral spinal arteries. The proximal arteries supplying them vary throughout the length of the cord. Several radiculomedullary and intercostal arteries supply the upper (C1–T2) and middle (T3–T8) territories respectively, however the blood supply to the lower segment is mainly provided from a single source, the artery of Adamkiewicz. It usually arises from a radicular artery somewhere between the 9th thoracic and 1st lumbar segment and on the left side 80% of the time. The inconsistency in its location makes it susceptible to inadvertent iatrogenic damage during endovascular intervention. Two pairs of basivertebral veins drain each of the thoracic and lumbar vertebra and empty into the epidural plexus.


E
B
C
A
D

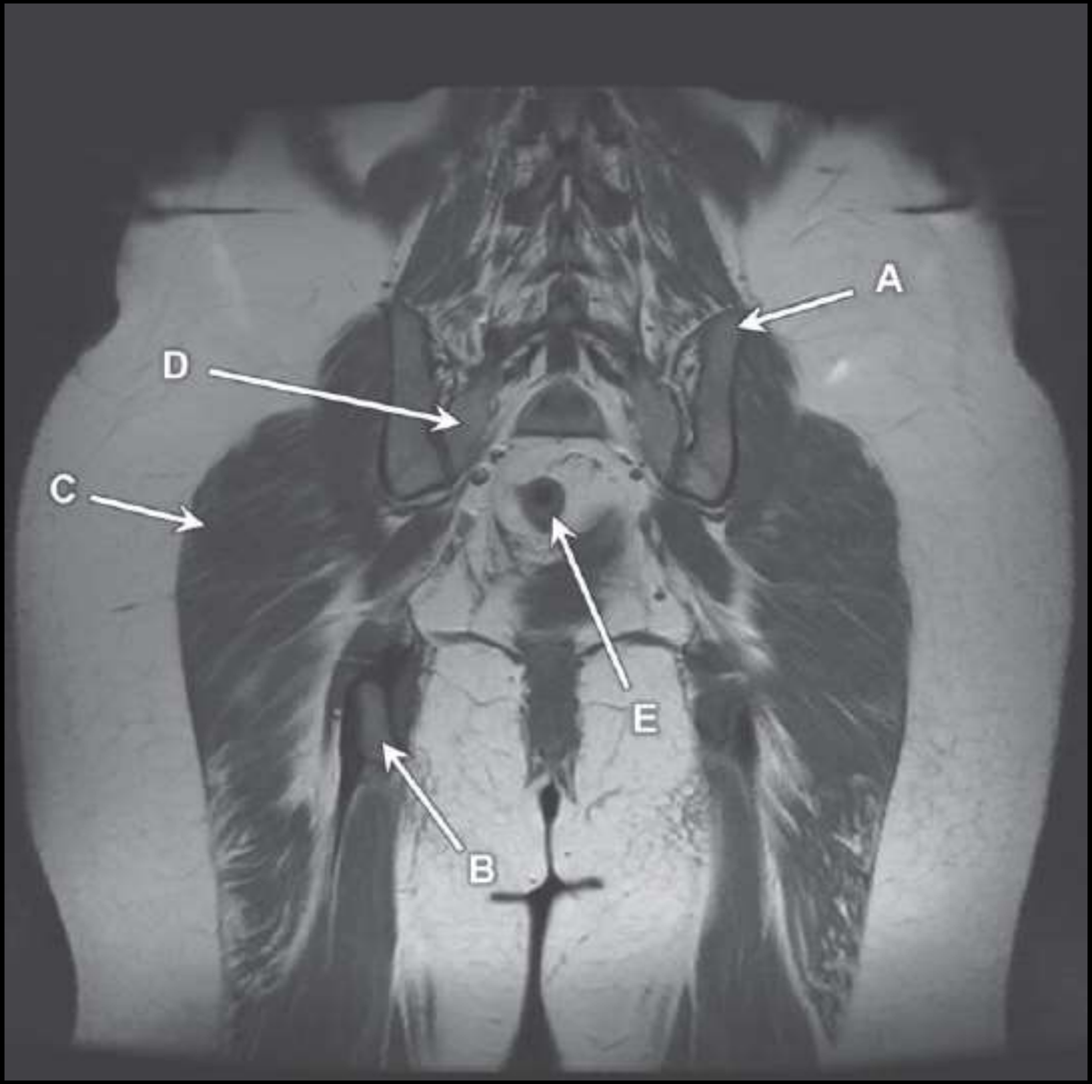
Case 12

CT abdomen. Sagittal section.

1. Stomach
2. Pancreas
3. Left renal vein
4. Urinary bladder
5. Superior mesenteric artery

'A' might be mistaken for the transverse colon but this is seen lying much lower in the abdomen near the distended loops of sigmoid. 'C' should now be familiar as the flattened left renal vein passing over the abdominal aorta. 'B' might be mistaken for a filled duodenum but this structure is clearly solid and the splenic vein can be seen at the posterior aspect.

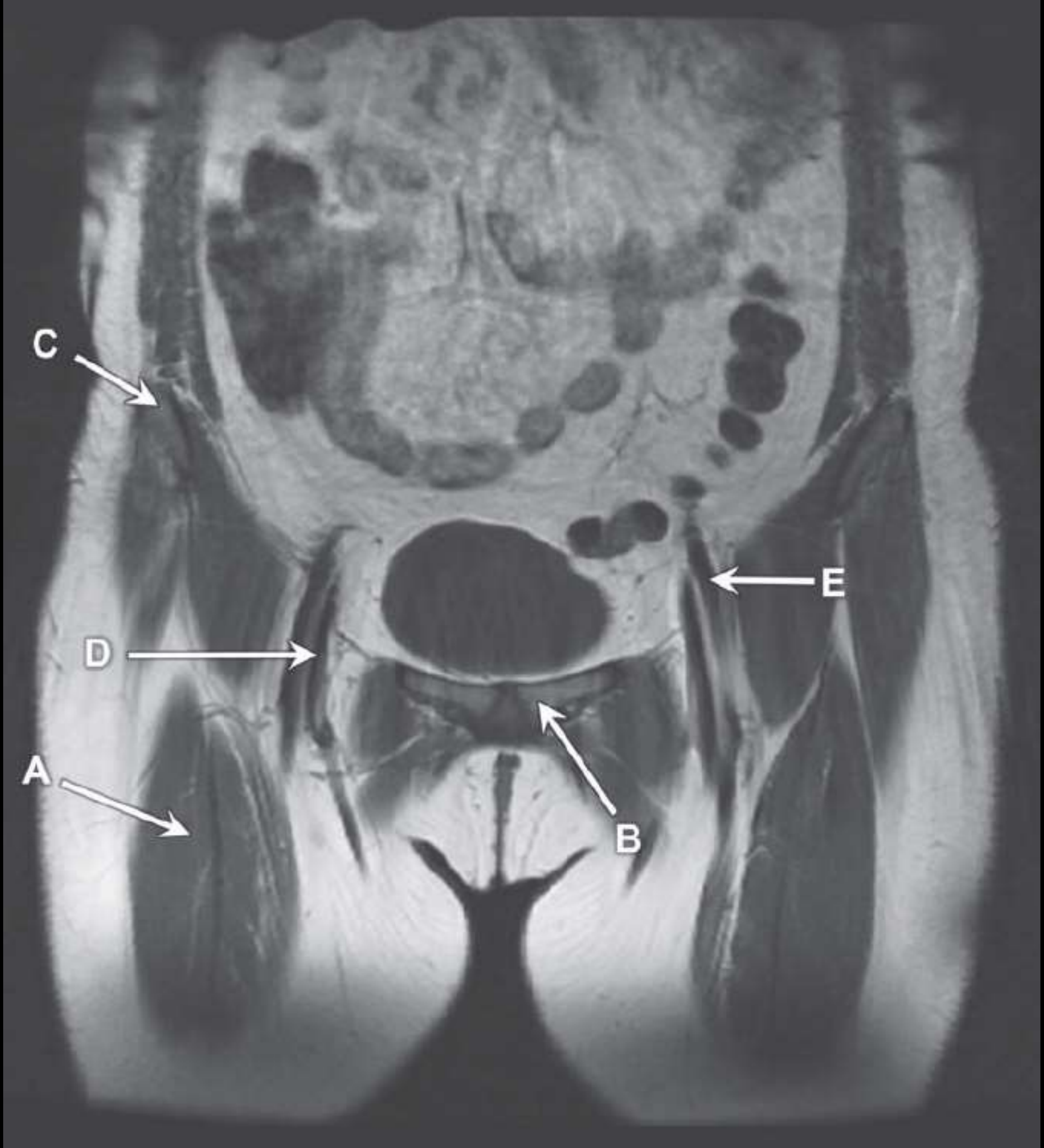
MRI PELVIS


A
D
C
E
B

Case 10

MRI pelvis. T1W coronal section.

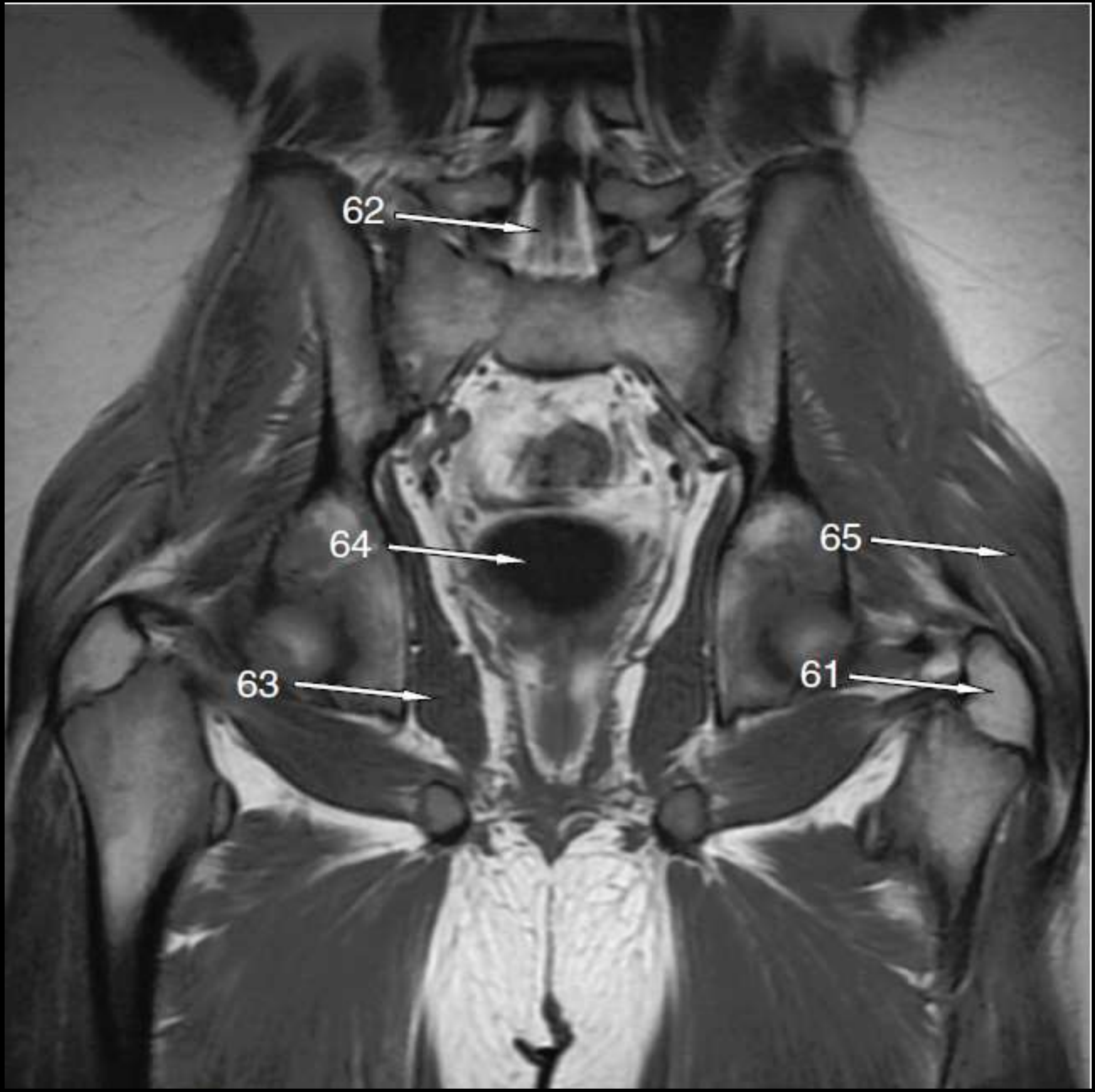
1. Left iliac crest
2. Right ischial tuberosity
3. Right gluteus maximus muscle
4. Right sacral ala
5. Rectum


C
E
D
A
B

Case 17

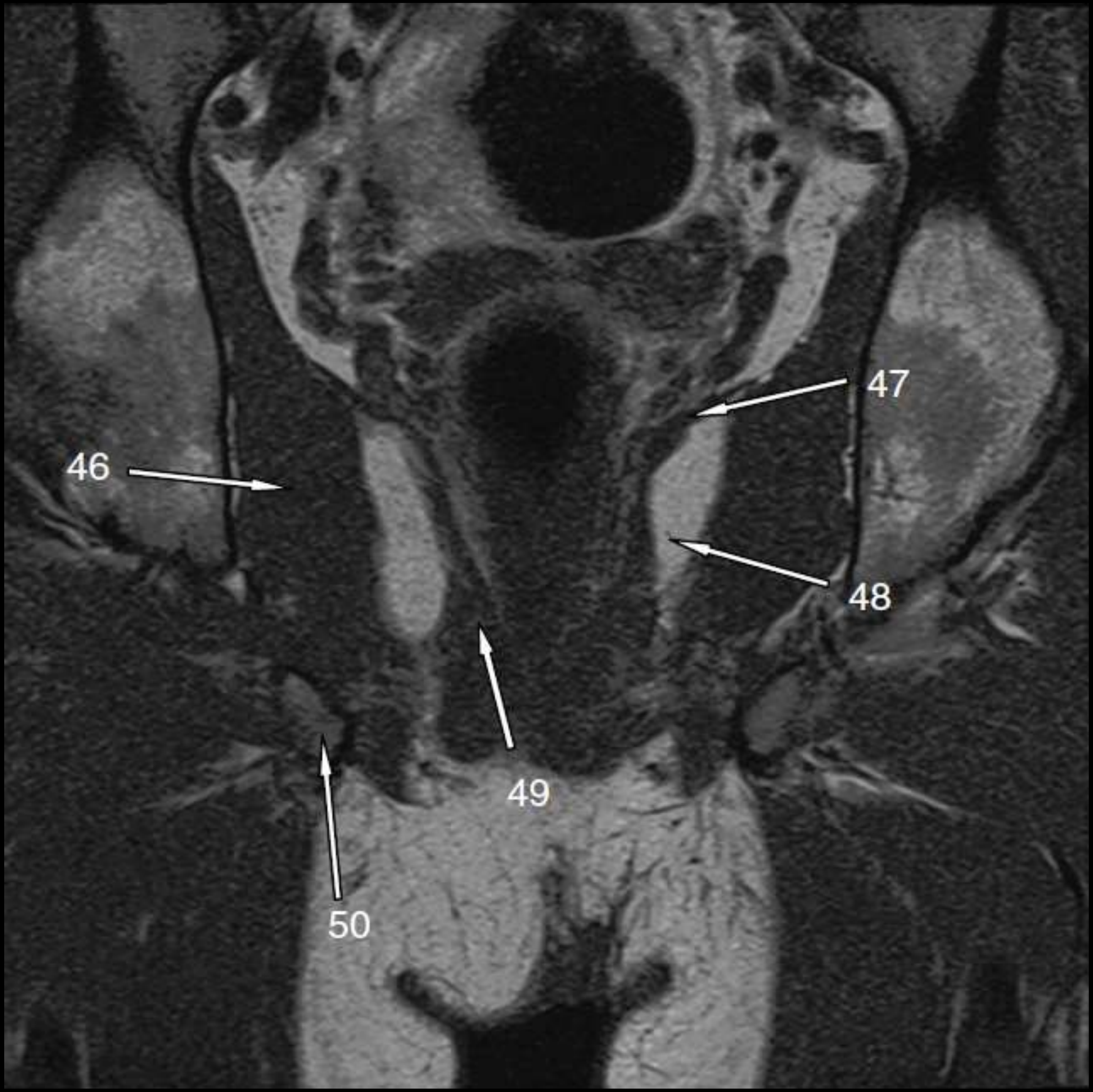
MRI pelvis. T1 weighted. Coronal section

1. Right rectus femoris muscle
2. Left pubic tubercle
3. Right anterior superior iliac spine
4. Right common femoral vein
5. Left common femoral artery


62
64
65
63
61

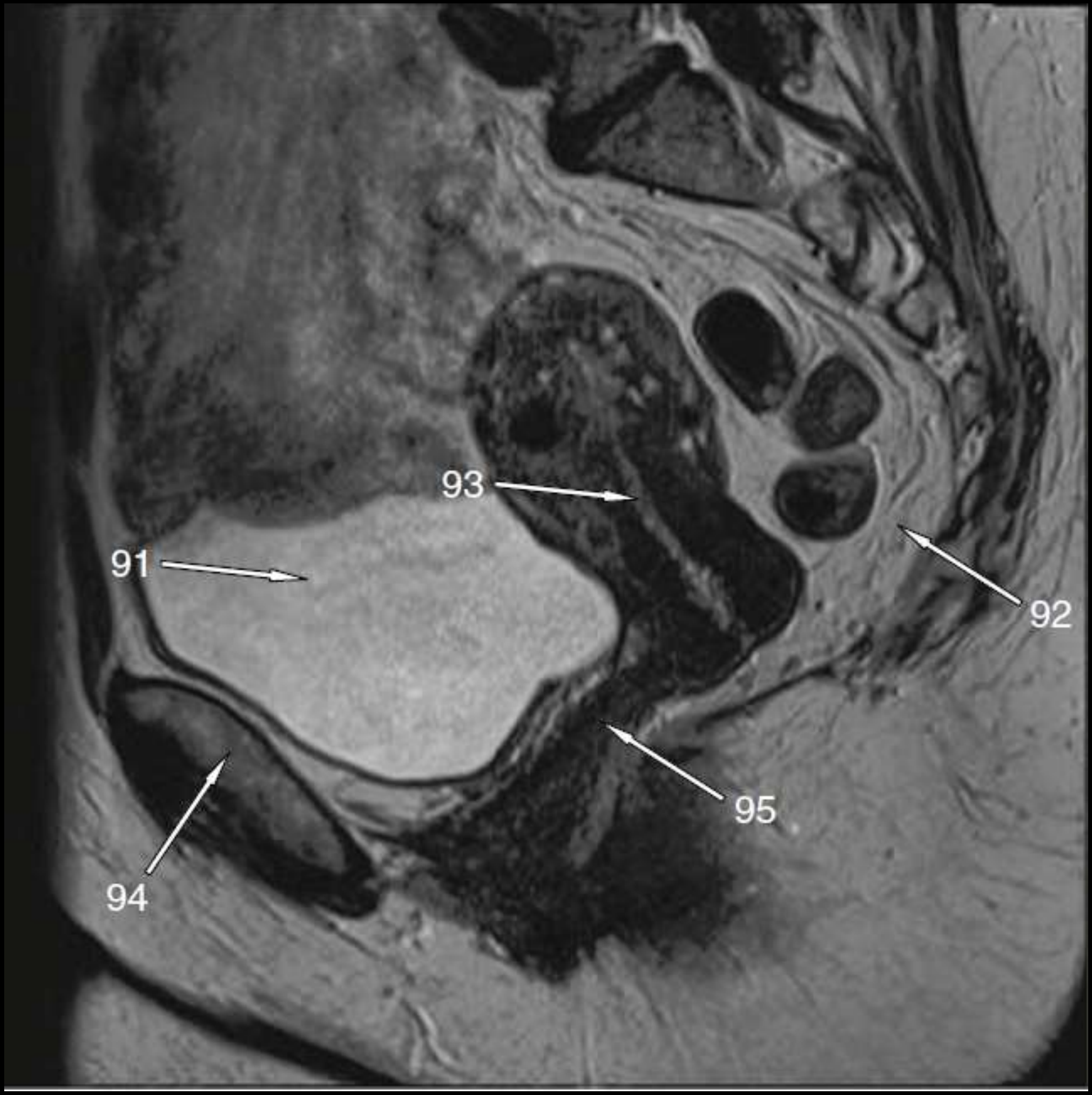
MRI Pelvis

61. Left greater trochanter
62. Cauda equina
63. Right obturator internus
64. Urinary bladder
65. Left gluteus maximus


47
46
48
49
50

MRI PELVIS

46. Right obturator internus muscle
47. Left levator ani muscle
48. Left ischioanal fossa
49. Right external anal sphincter
50. Right ischium



93
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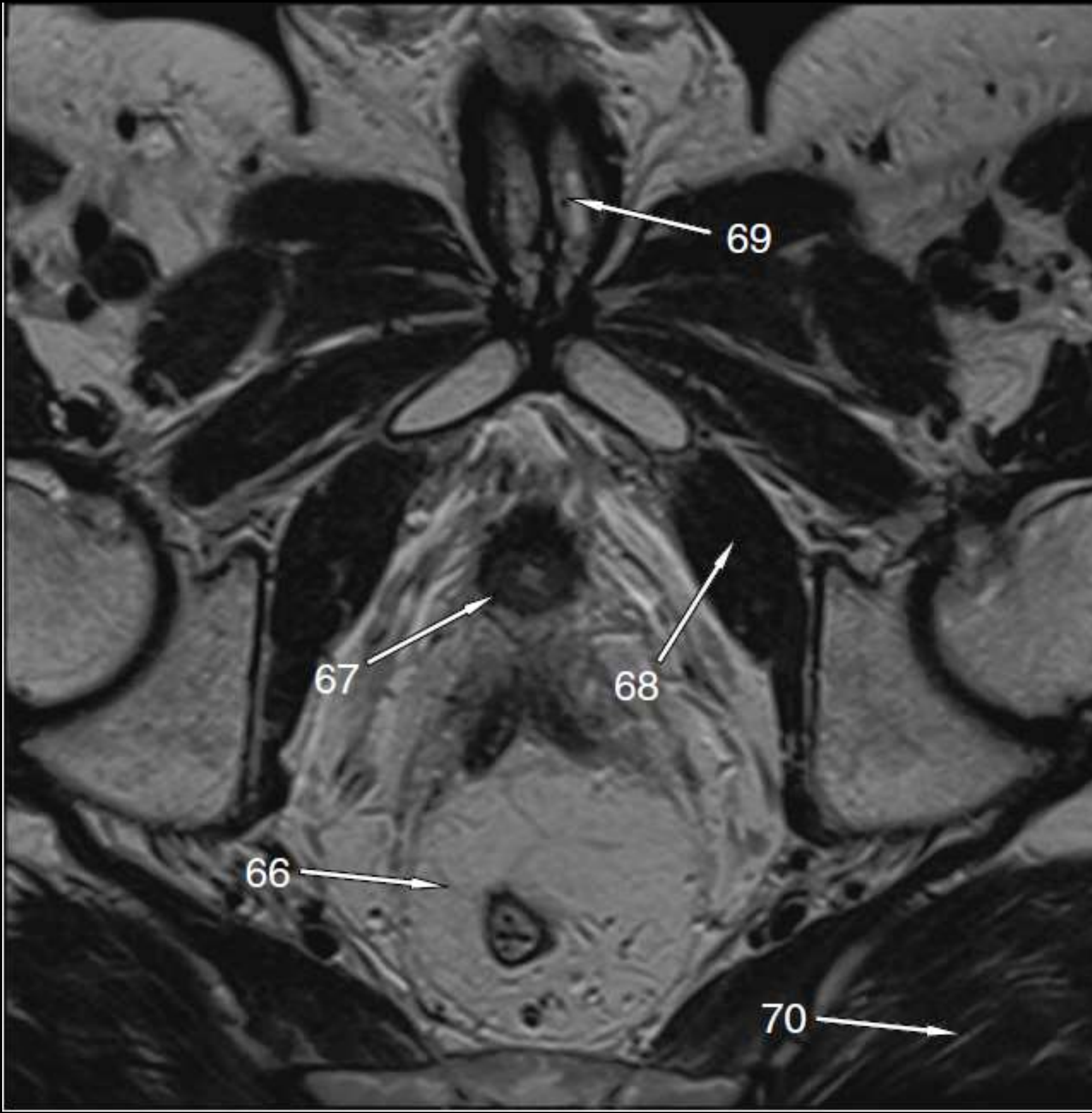
MRI Pelvis

91. Bladder
92. Mesorectum
93. Endometrium
94. Pubic symphysis
95. Vagina

The MR appearance of normal endometrium is best demonstrated on T2-weighted images because the uterus has homogeneous intermediate signal intensity with T1-weighted sequences. T2-weighted images delineate the uterine zonal anatomy. The normal endometrium is of uniformly high signal intensity, and the inner myometrium, or junctional zone, is of uniformly low signal intensity.


69
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MRI Pelvis

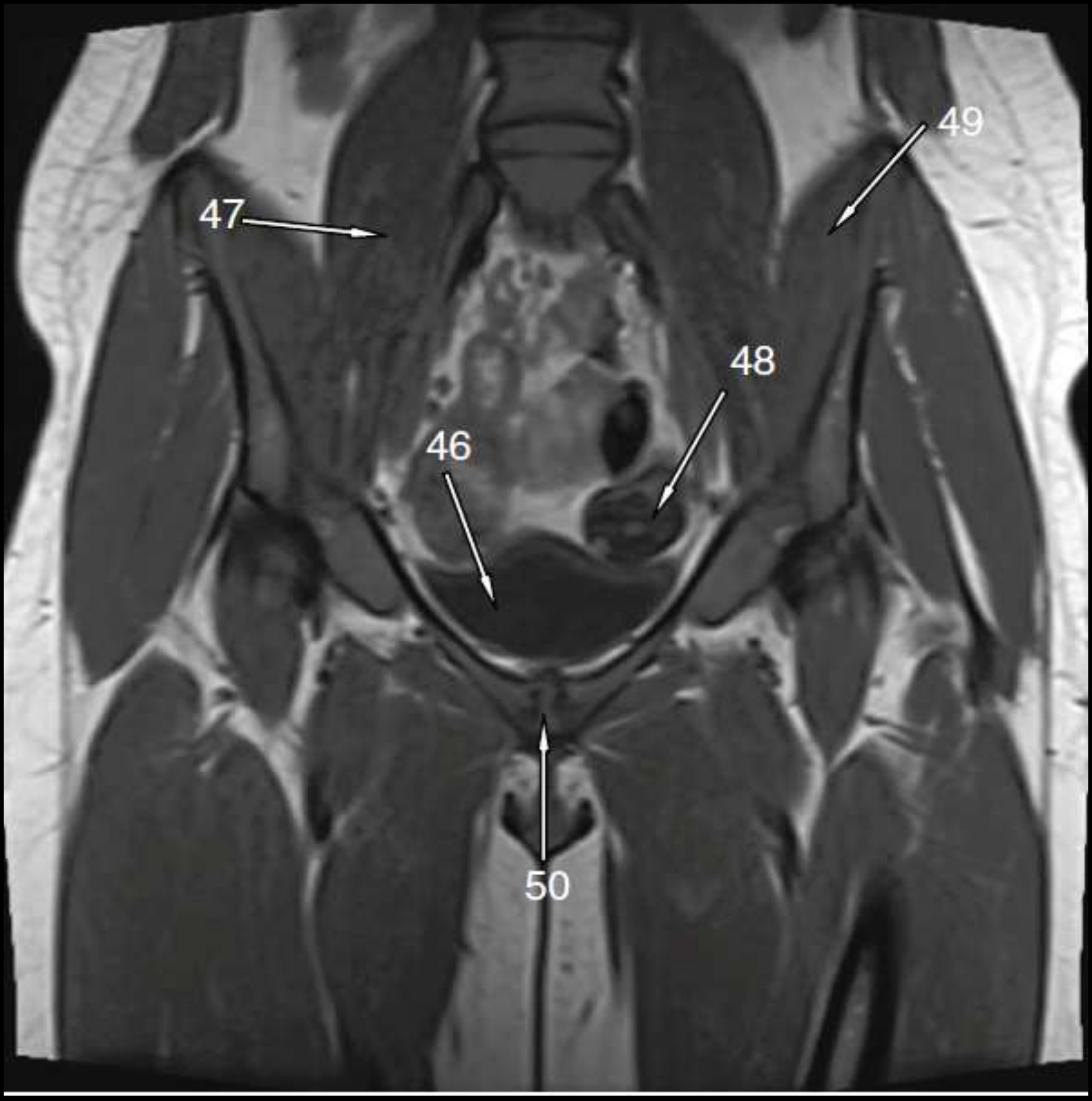
66. Mesorectal fat
67. Prostate
68. Left obturator internus
69. Corpus cavernosum (left)
70. Left gluteus maximus muscle


20
19
16
18
17

MRI Pelvis

16. Symphysis pubis
17. Ischioanal (rectal) fossa
18. Prostate (peripheral zone)
19. Left pectineus muscle
20. Left spermatic cord

The prostate is divided into three anatomical zones: transitional, central and peripheral zones. However on T2-weighted MR images only two zones can be distinguished: the peripheral and central zones. The majority of prostate cancers occur in the peripheral zone.


47
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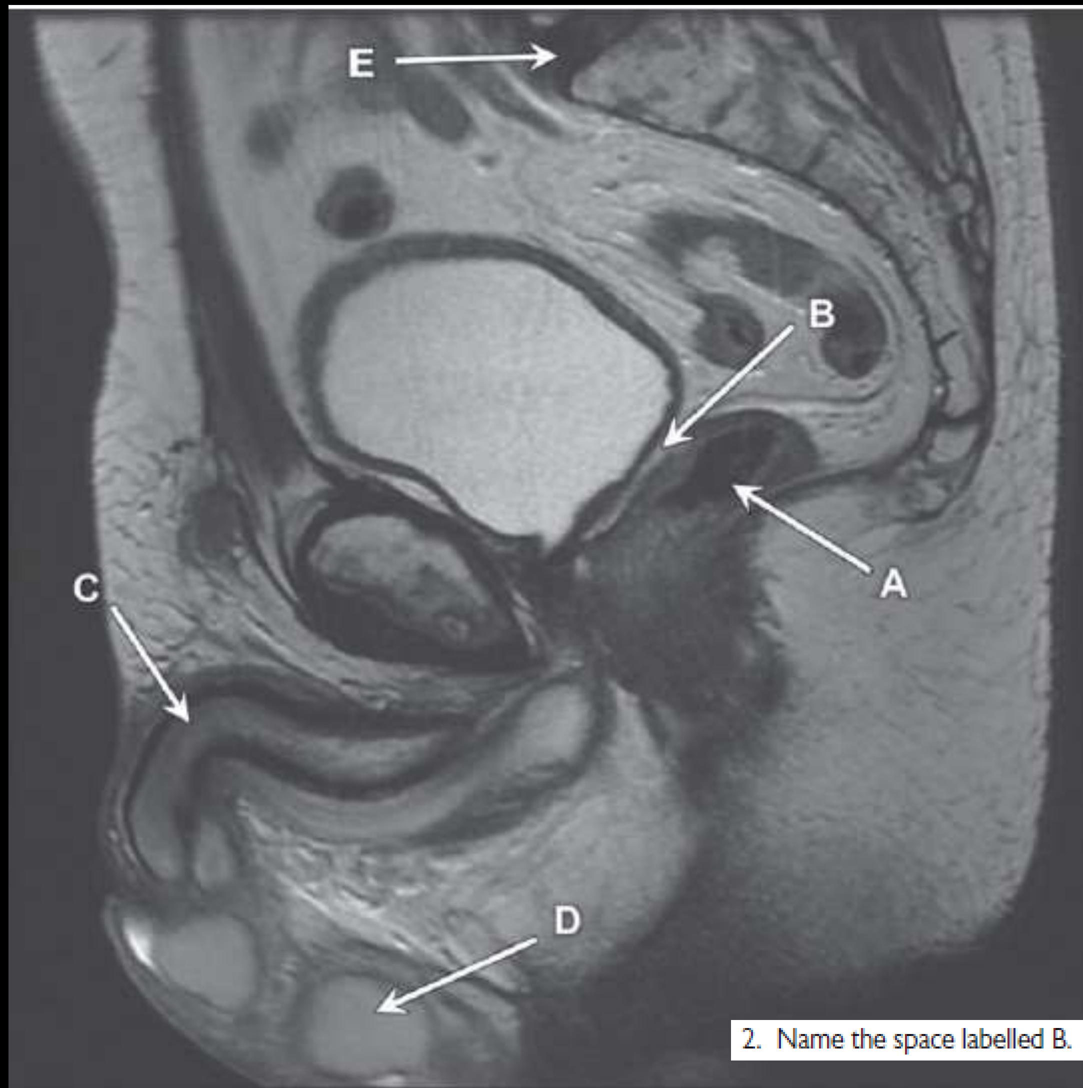
MRI Pelvis

46. Urinary bladder
47. Right psoas major muscle
48. Sigmoid colon
49. Left iliacus muscle
50. Symphysis pubis



2. Name the space labelled B.

Case 11

MRI pelvis (male). T2W sagittal section.

1. Rectum
2. Rectovesical pouch
3. Corpus cavernosum
4. Testis
5. L5/S1 intervertebral disc


A
B
C
D
E

Q1 Answers

a Sacral nerve roots in sacral canal (cauda equina)
b Fat in the presacral space
c Rectal folds (valves)
d Posterior fornix of vagina
e Junctional zone of the myometrium

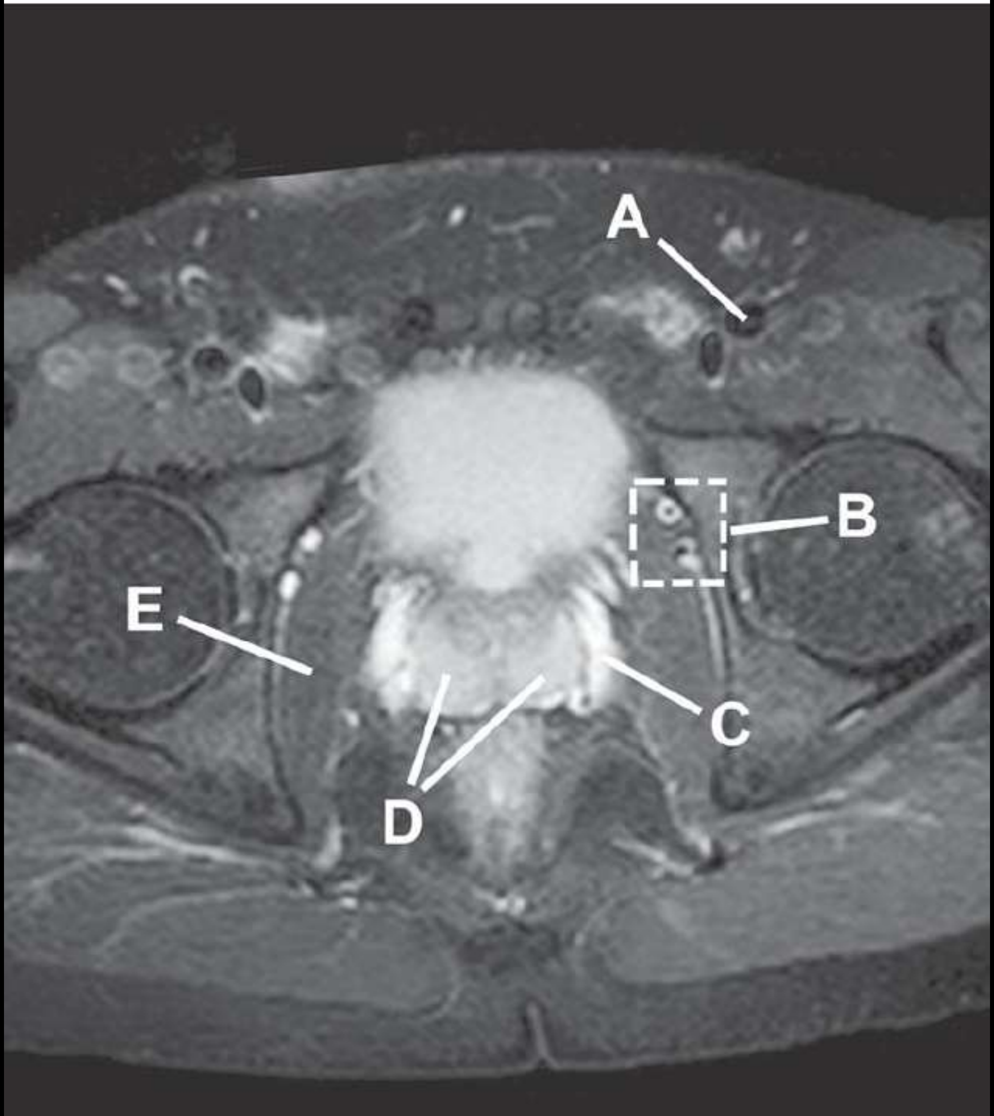
T2W MRI of female pelvis, midline sagittal section

The spinal cord terminates at the conus which is normally sited at the L1/2 level. The distal lumbar and sacral nerve roots leave the cord at the conus and collectively form the cauda equina (due to their somewhat similar appearance to a horse's tail) within the vertebral canal.

Physiological fluid and the mucosal surfaces of the uterus, cervix and vagina produce high signal on T2 which makes these collapsed cavities visible.

Q19

a Name the structure labelled A
b Name the group of neurovascular structures outlined and labelled B
c Name the structure labelled C
d Name the structure labelled D
e Name the structure labelled E



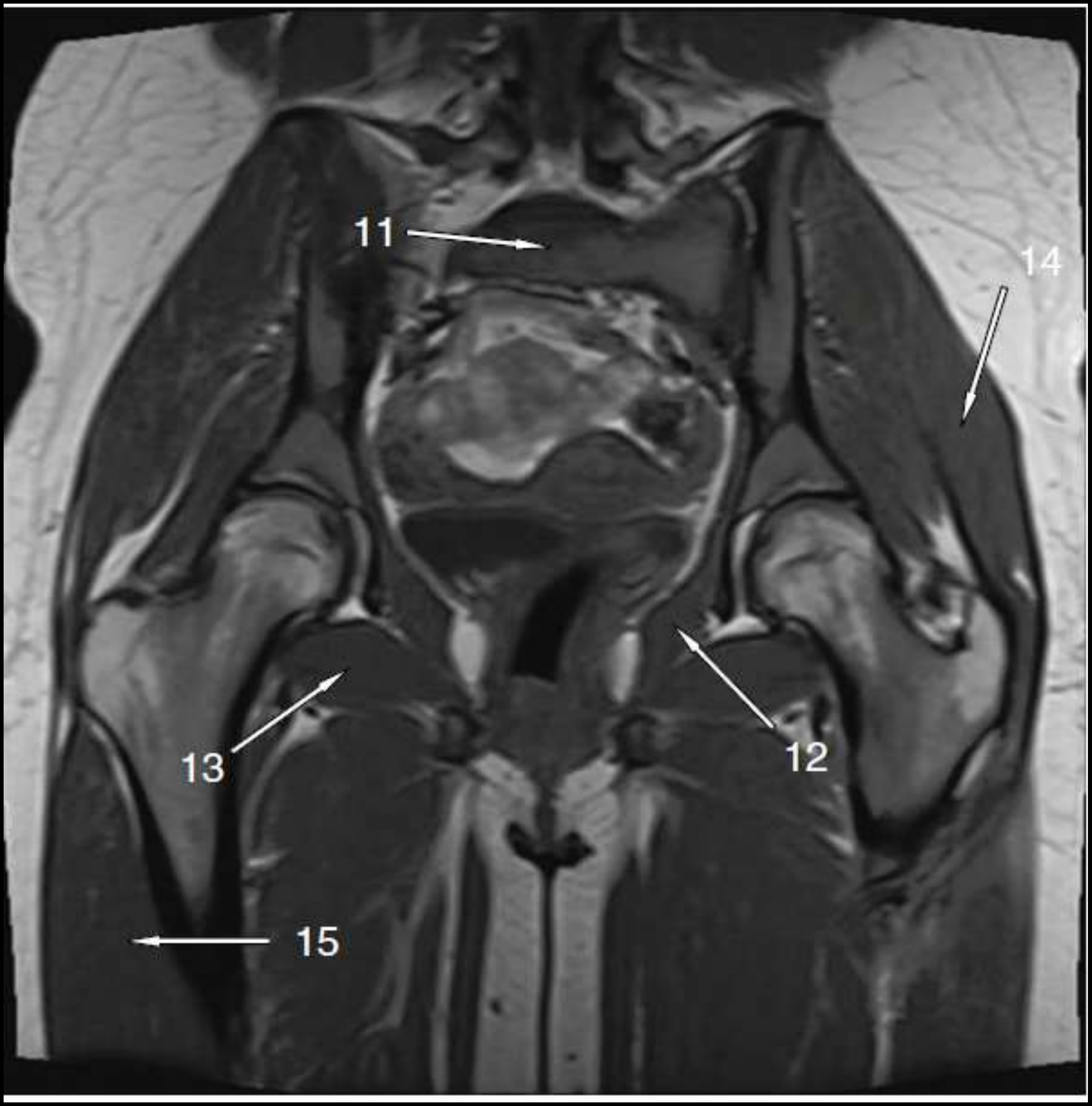
Q19 Answers

a Common femoral artery
b Obturator artery, vein and nerve
c Seminal vesicle
d Peripheral zone of prostate
e Obturator internus muscle

T2W MRI of male pelvis with fat saturation, axial section

On this image, the urinary bladder is seen in the midline with the prostate beneath. Prostatic zonal anatomy is well seen with the higher signal peripheral zone surrounding the lower signal central gland. Superior and lateral to the prostate on either side of the midline lie the seminal vesicles.

The iliac vessels are continuous distally with the common femoral vessels; the name changes as they pass under the inguinal ligament and leave the pelvis. The obturator vessels are branches of the anterior division of the internal iliac vessels. The obturator vessels run along the lateral wall of the pelvis. Initially they lie medial to the obturator internus muscle but distally they perforate this layer to reach the obturator foramen.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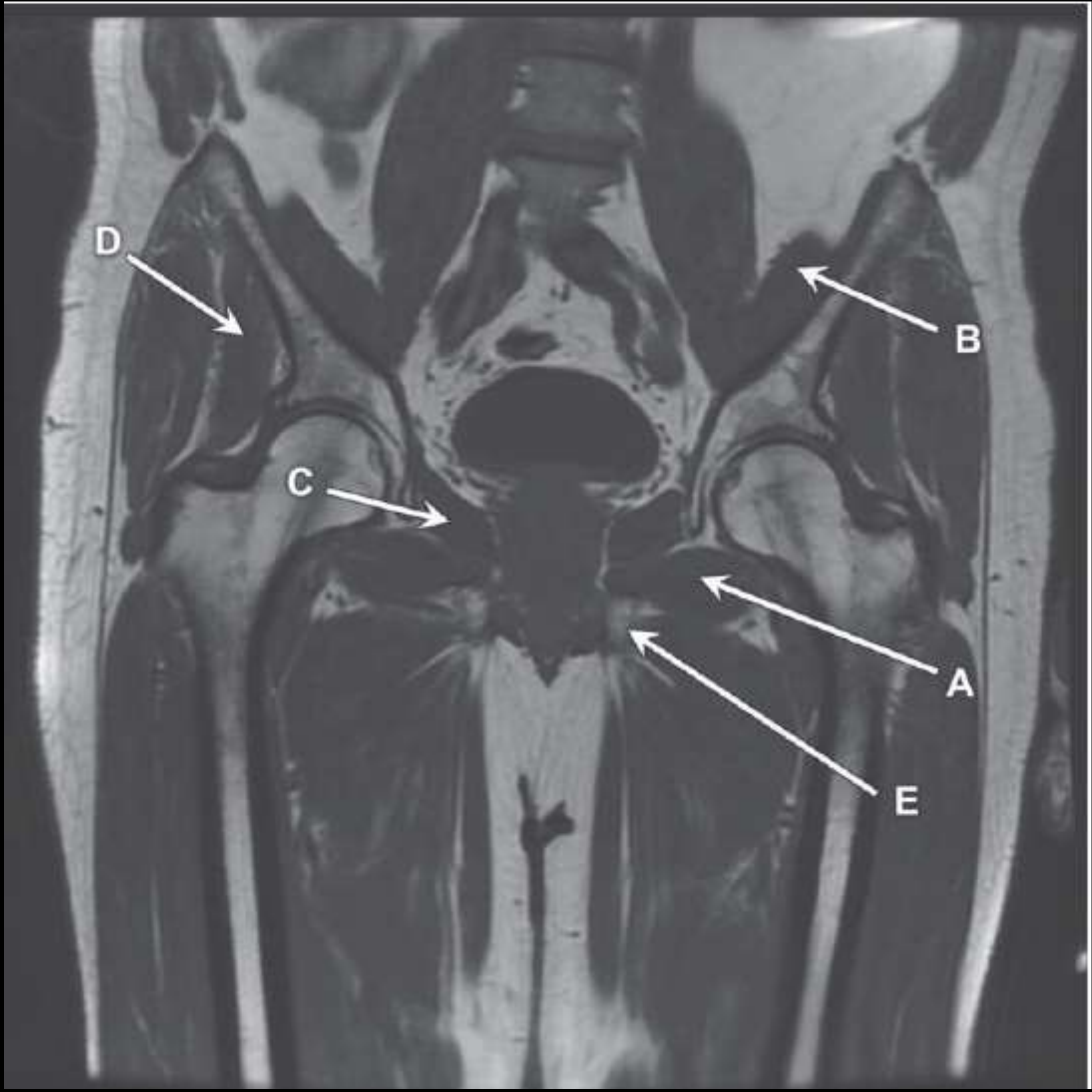
MRI Pelvis

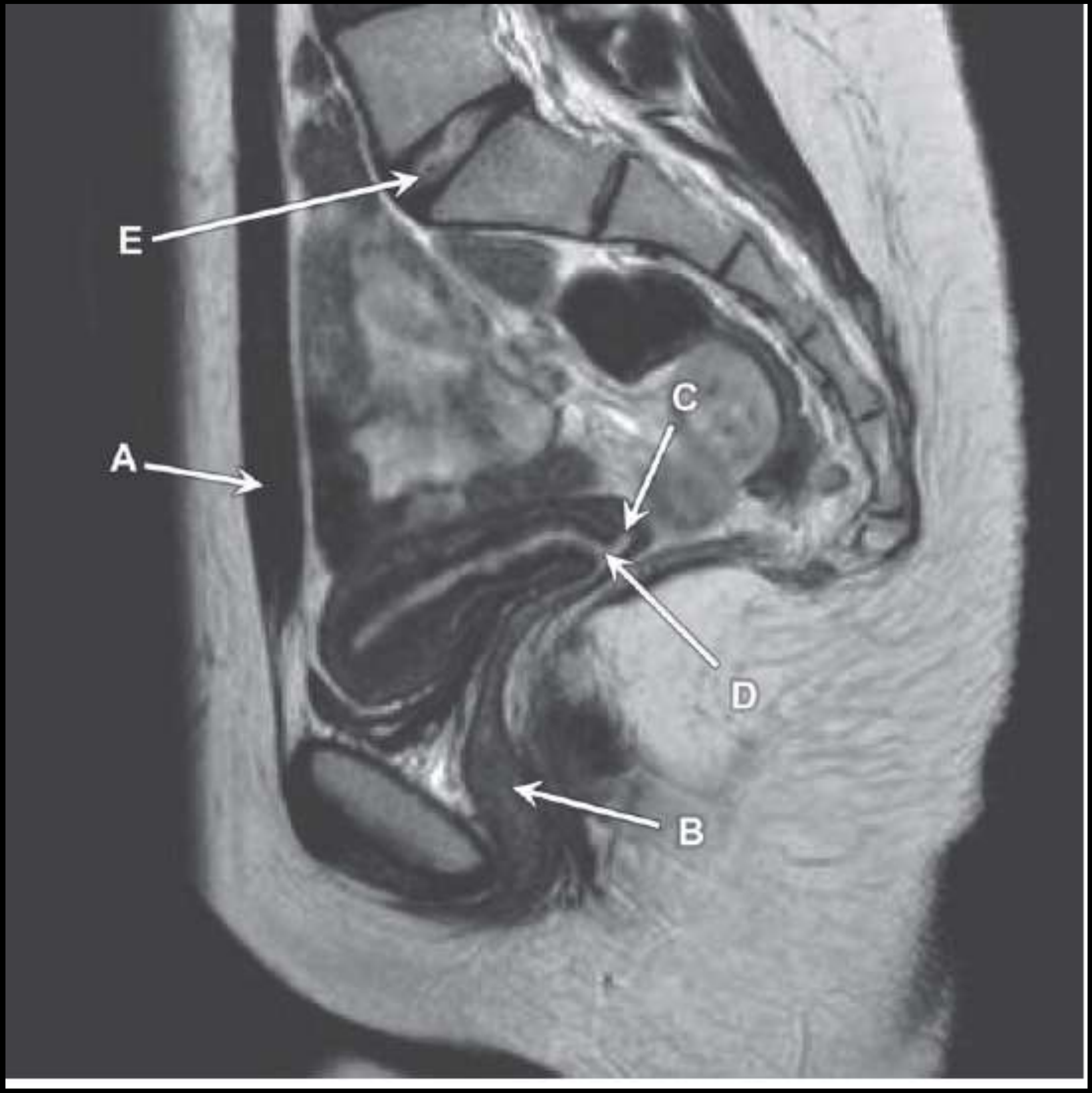
11. Sacrum/sacral promontory
12. Left obturator internus muscle
13. Right obturator externus muscle
14. Left gluteus medius muscle
15. Right vastus lateralis muscle


D
B
C
A
E

Case 2

MRI pelvis. Coronal T1W image.

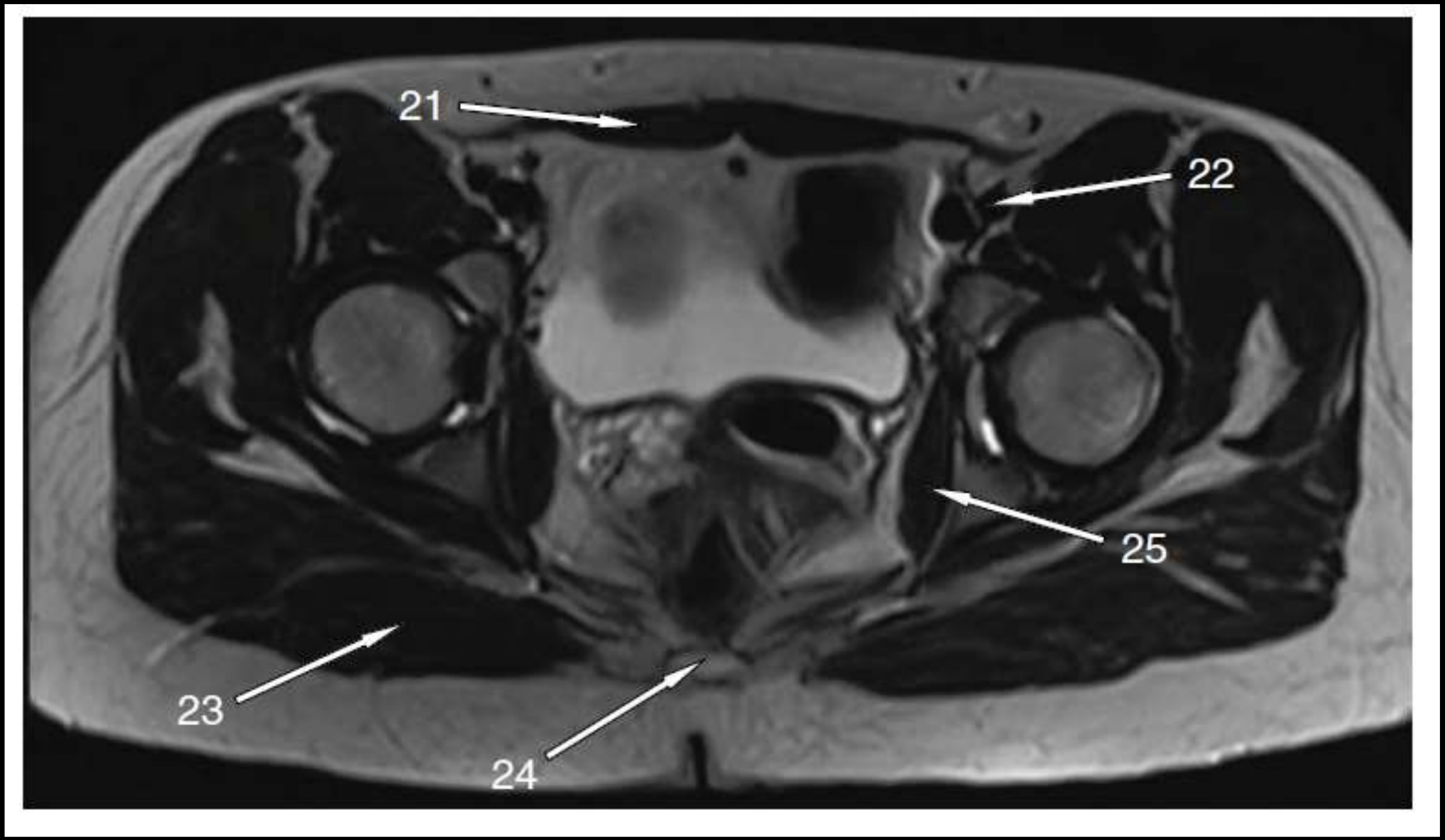
1. Left obturator externus muscle
2. Left iliacus muscle
3. Right obturator internus muscle
4. Right gluteus minimus muscle
5. Left inferior pubic ramus


E
C
A
D
B

Case 9

MRI pelvis (female). T2W sagittal section.

1. Rectus abdominus muscle
2. Vagina
3. Posterior fornix of vagina
4. External os of cervix
5. L5/S1 intervertebral disc


21
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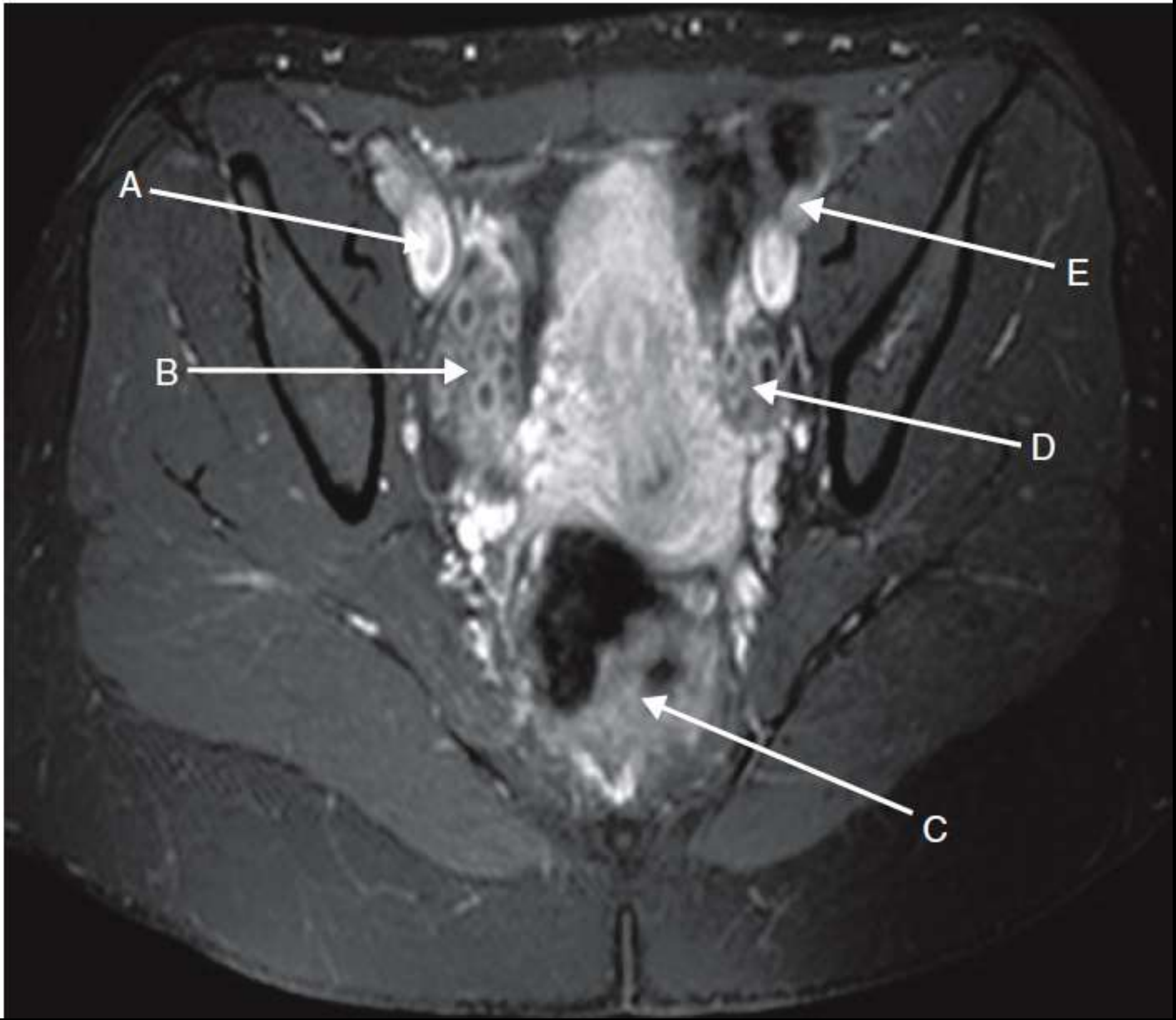
24

MRI Pelvis

21. Right rectus abdominis muscle
22. Left external iliac artery
23. Right gluteus maximus muscle
24. Coccyx
25. Left obturator internus muscle

When presented with an MRI case, firstly it is important to identify the sequence. A useful hint is to remember that fluid is bright on T2-weighted images and fat is bright on T1-weighted images.

Case 8.7

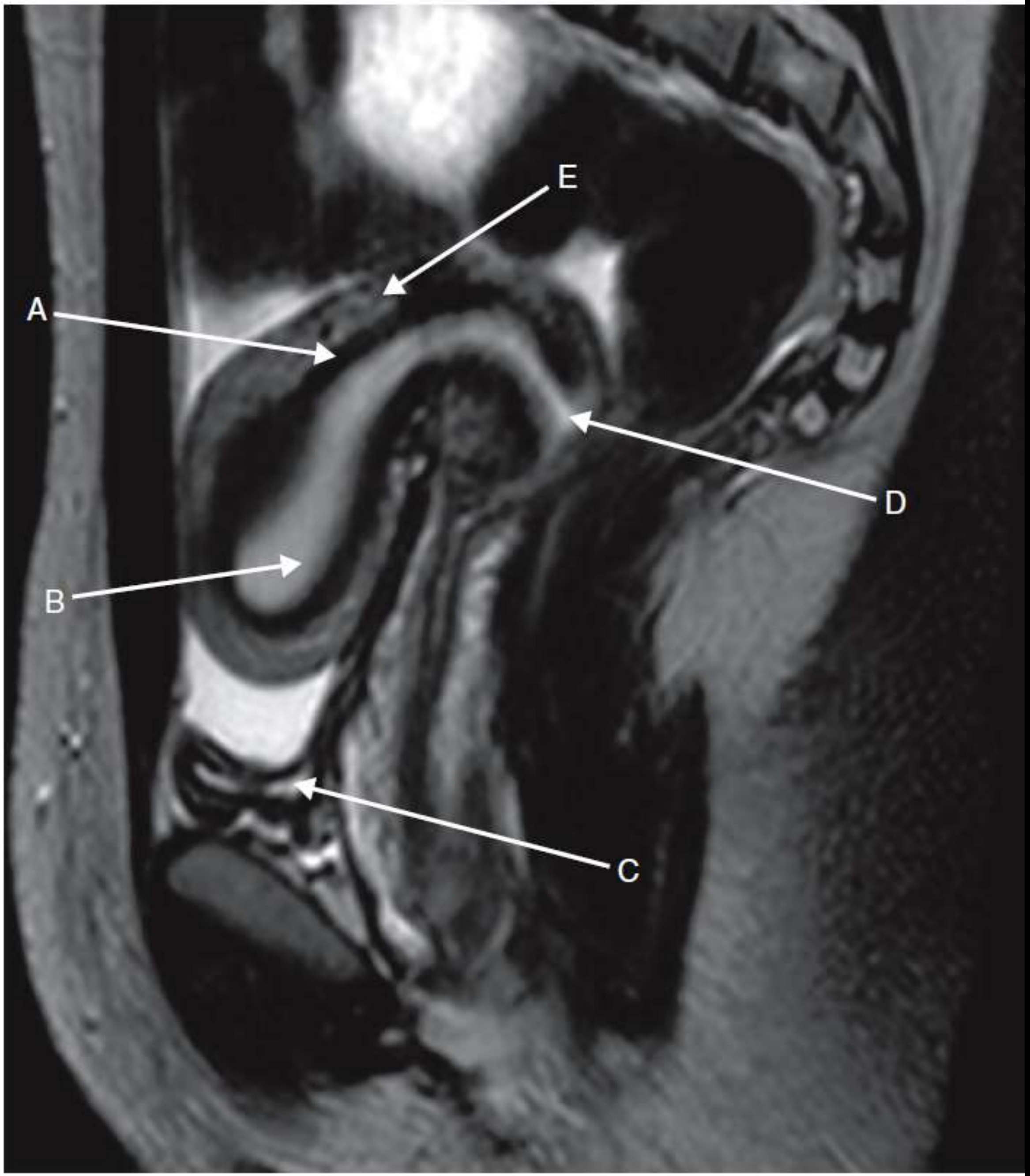


8.7 Axial T2-weighted MR pelvis (female)

(a) Right femoral vein.
(b) Right ovary.
(c) Rectum.
(d) Left ovary.
(e) Left femoral artery.

MRI is commonly used in assessing both the male and the female pelvis. Fat saturation techniques can enable the pelvic organs to be well visualized. Ovarian cysts can be seen, which are often small and multiple in pre-menopausal females.

Case 7.6



7.6 Sagittal T2-weighted MR female pelvis

(a) Junctional zone of uterus.
(b) Endometrial cavity.
(c) Urinary bladder.
(d) External os of uterus.
(e) Myometrium of uterus.

Ultrasound, both transabdominal and transvaginal, and MRI are used to assess the female pelvis. MRI has superior soft tissue contrast, and can delineate anatomy very clearly. On T2 sequences the endometrium, endocervical canal and vaginal canal are of high signal. The inner zone of the myometrium is of low signal and known as the junctional zone. This is histologically similar to the remainder of the myometrium. The outer myometrium is of intermediate signal. There is high signal pelvic fluid.

T1-weighted images of the uterus and ovaries show intermediate signal with poor contrast.

Fibroids (leiomyoma) are the most common tumour of the uterus, found in 25% of females >35 years. They arise from smooth muscle cells and can be well visualized on MRI. They are typically seen as low signal lesions relative to the remainder of the uterus on T2-weighted images and isointense to the uterus on T1-weighted images.

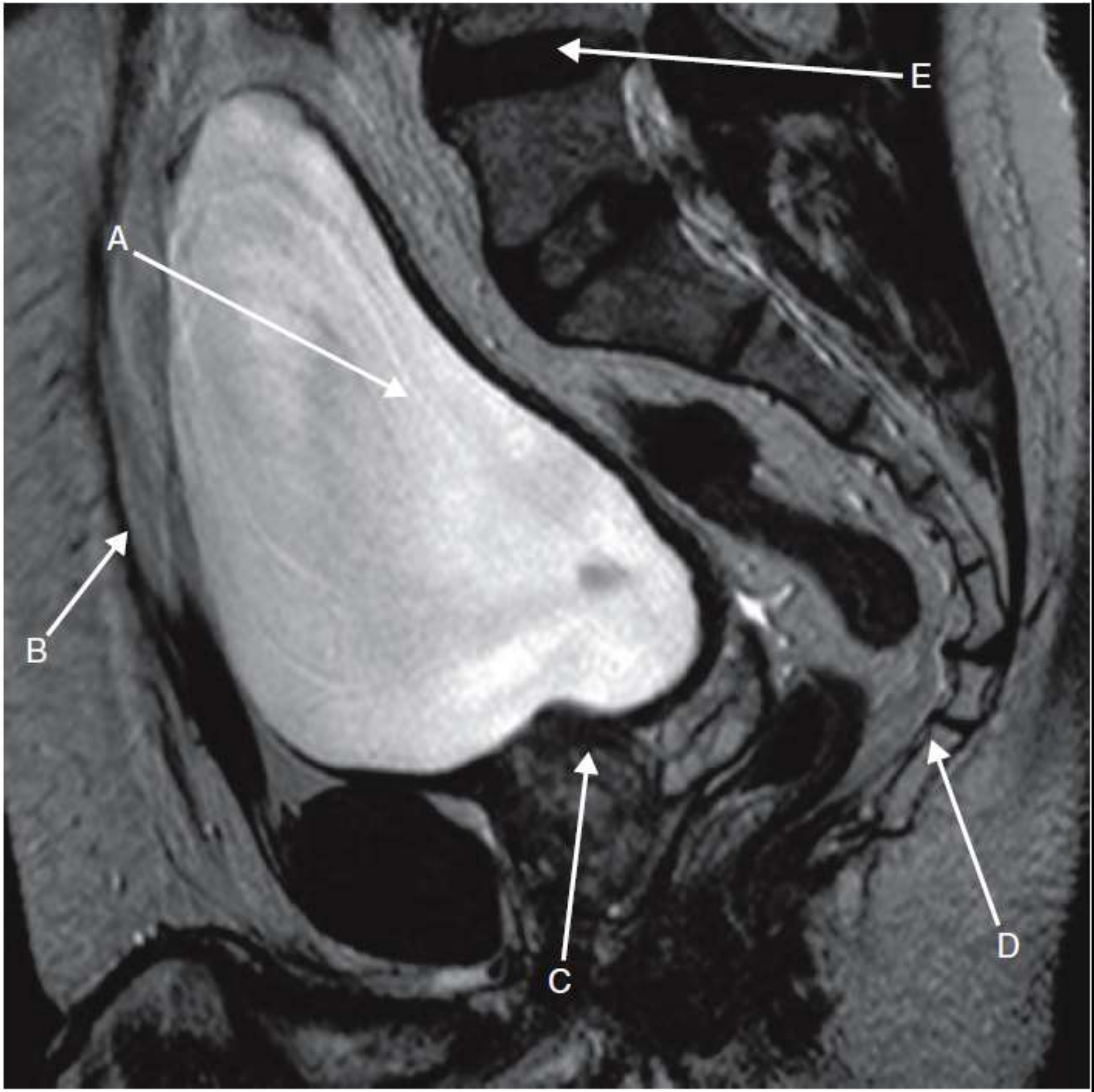
Case 6.19

6.19 Sagittal T2-weighted MR pelvis (female)

(a) Pubic bone.
(b) Bladder.
(c) Endometrium.
(d) Rectus abdominus muscle.
(e) Junctional zone between myometrium and endometrium.

On T2-weighted images the endometrium is of high signal. The junctional zone is of low signal and the myometrium of intermediate signal.

Case 6.8



6.8 Sagittal T2-weighted MR pelvis (male)

(a) Urinary bladder.
(b) Rectus abdominis muscle.
(c) Prostate.
(d) Coccyx.
(e) L4/L5 intervertebral disc.

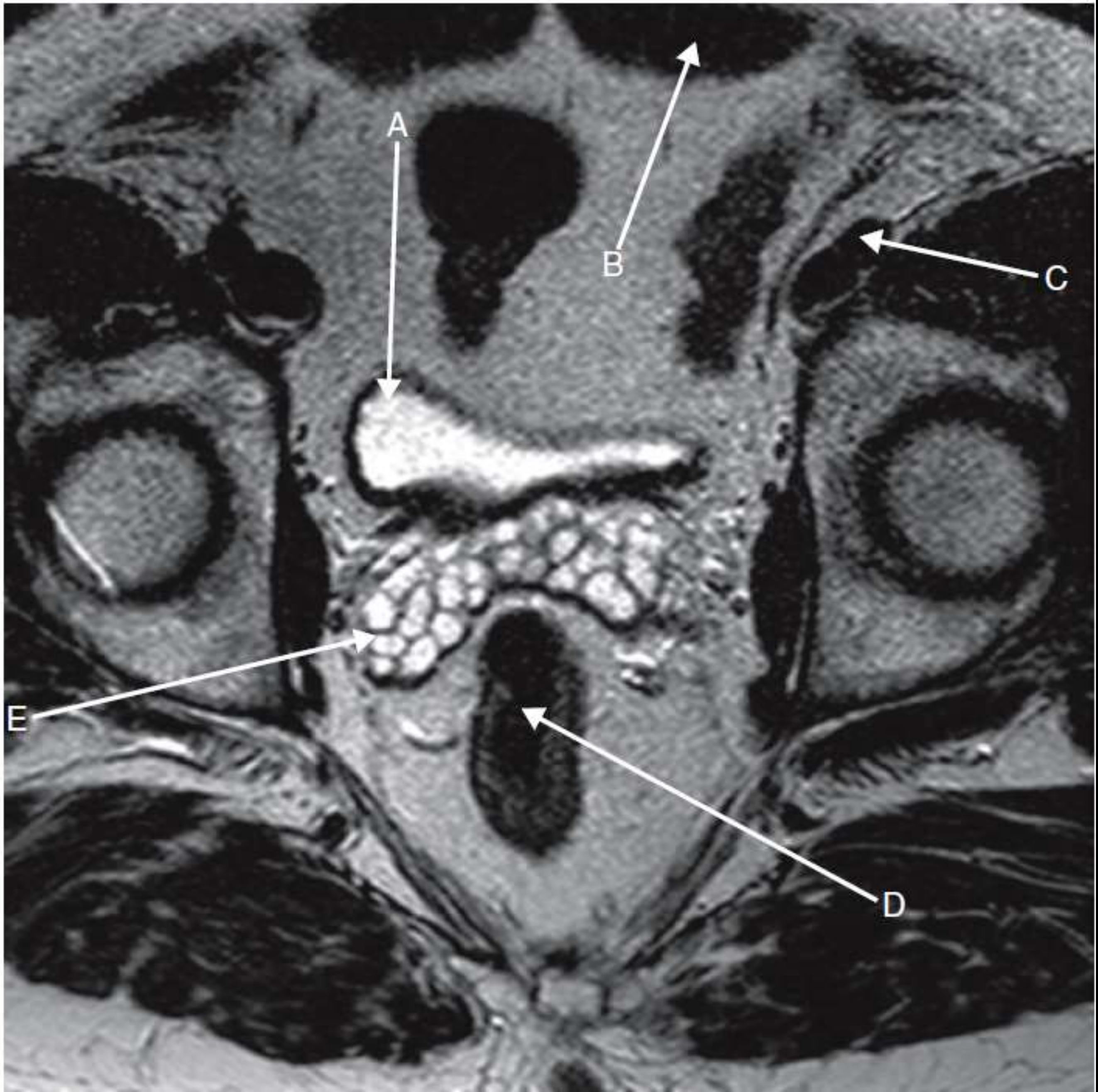
Thin sections are taken in all three planes when evaluating the prostate in order to ascertain if there is any extra-capsular disease.

MRI bladder includes dynamic, contrast-enhanced images as bladder tumours are hypervascular and show early enhancement. This ensures that correct staging can be performed. Sequences performed also include images of the upper tracts to ascertain if there is any hydronephrosis, hydroureter or ureteric tumour. CTU will often be

performed in conjunction with MRI as transitional cell tumours can occur separately, both in the bladder and the upper tracts.

It is important to look at the entire image, even though it may be centred on a specific organ. Although T1-weighted images are optimum for evaluating bone marrow, look at the vertebral alignment on any sagittal images and for any intervertebral disc disease.

Case 5.12



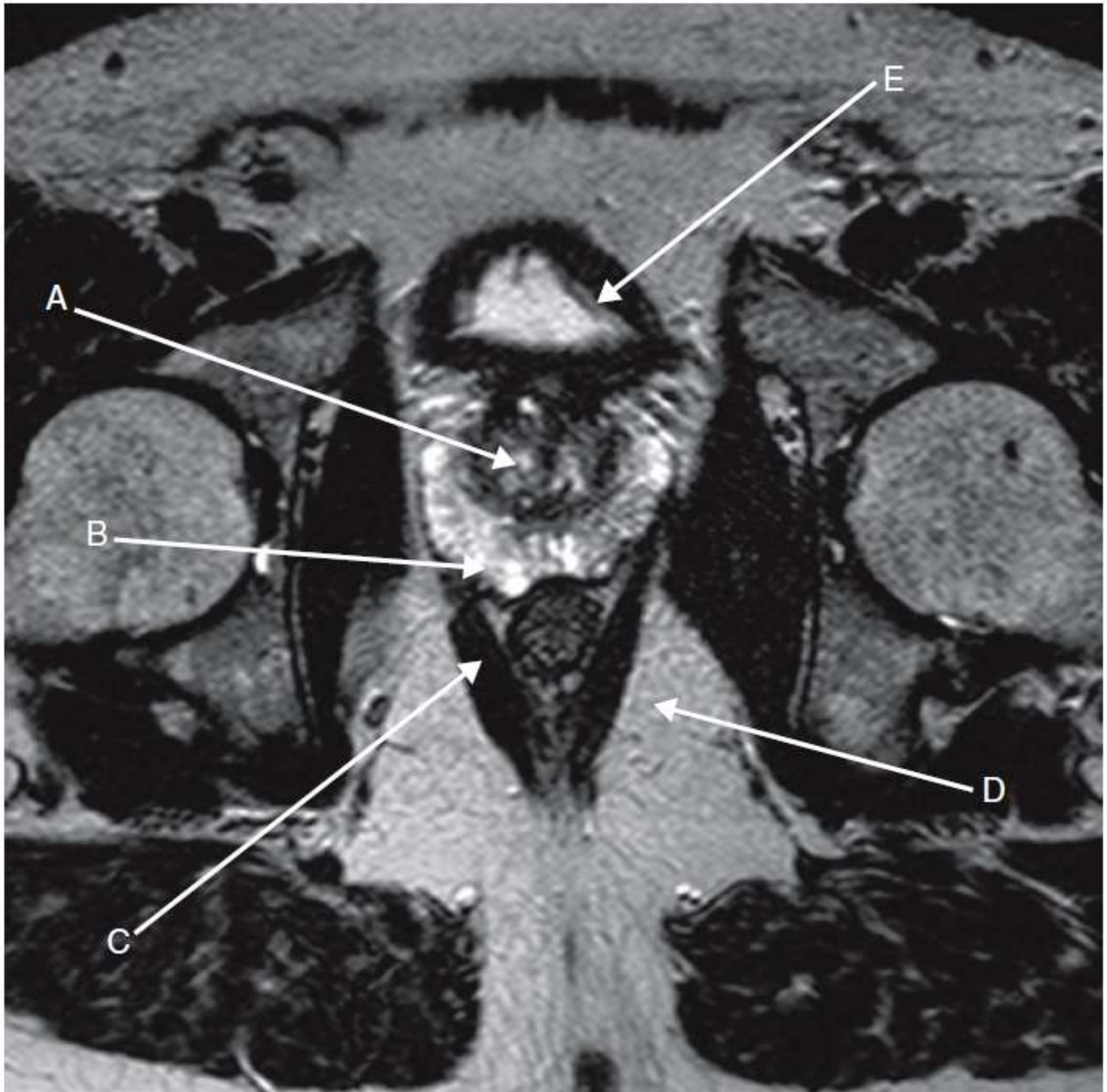
5.12 Axial T2-weighted MR male pelvis

(a) Urinary bladder. Fluid is seen as high signal on T2-weighted and low signal on T1-weighted images, unless it is haemorrhagic or proteinaceous when it will be high on T1-weighted images. The wall of the urinary bladder should be clearly defined and <5 mm in thickness when adequately distended.

(b) Left rectus abdominis muscle.
(c) Left femoral artery.
(d) Rectum.
(e) Right seminal vesicles. Seminal vesicles are seen as high signal on T2-weighted and low signal on T1-weighted images. It is essential to evaluate seminal vesicles when staging prostatic carcinoma, as disease involvement changes the staging and usually renders the patient inoperable. Tumour involvement will change the high T2 signal to low signal. When evaluating the MRI, ensure no haemorrhage is present in the seminal vesicles (from transrectal prostate biopsy) as this can lead to interpretation errors.

Seminal vesicles are paired sacculated diverticula that lie transversely posterior to the prostate and store seminal fluid. They narrow inferiorly to fuse with the vas deferens and become the ejaculatory ducts.

Case 4.10



4.10 Axial T2-weighted MR prostate

(a) Central zone of prostate.
(b) Right peripheral zone of prostate.
(c) Right levator ani muscle.
(d) Left ischio-anal fossa.
(e) Urinary bladder.

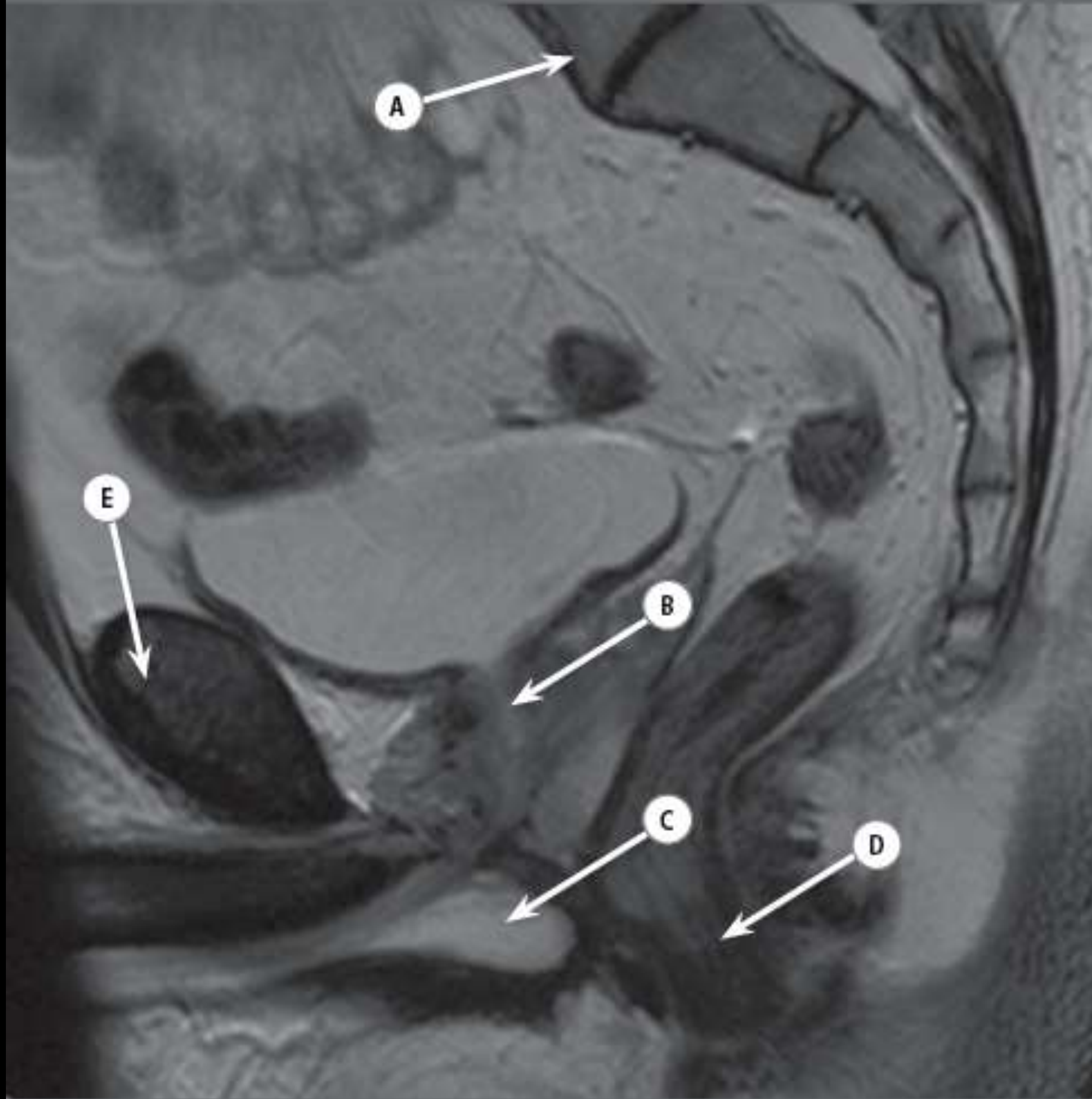
The prostate is divided into zones:

Peripheral zone contains 70% glandular tissue
Central zone contains 25% glandular tissue
Transition zone contains 5% glandular tissue.

T2-weighted MRI images depict prostatic zonal anatomy. The peripheral zone should be seen as high signal on T2-weighted images in contrast to transitional and central zones, which are of intermediate/low signal. The transitional and central zones cannot be clearly separated with imaging.

Tumours occur in the peripheral zone where low signal lesions can be seen on T2 imaging. MRI is often performed shortly after biopsy has occurred, and it is essential to note any haemorrhagic change by carefully evaluating T1-weighted images, as this can mimic tumour. If there are difficulties in MRI interpretation due to haemorrhage and it is going to make a difference in patient management, repeat MRI may be needed. Central zone hypertrophy leads to benign prostatic hyperplasia, which can cause bladder outflow obstruction and lower urinary tract symptoms. The peripheral zone will then appear compressed on MRI, and the central zone seen to contain areas of low, intermediate and high signal.

Case 11.4

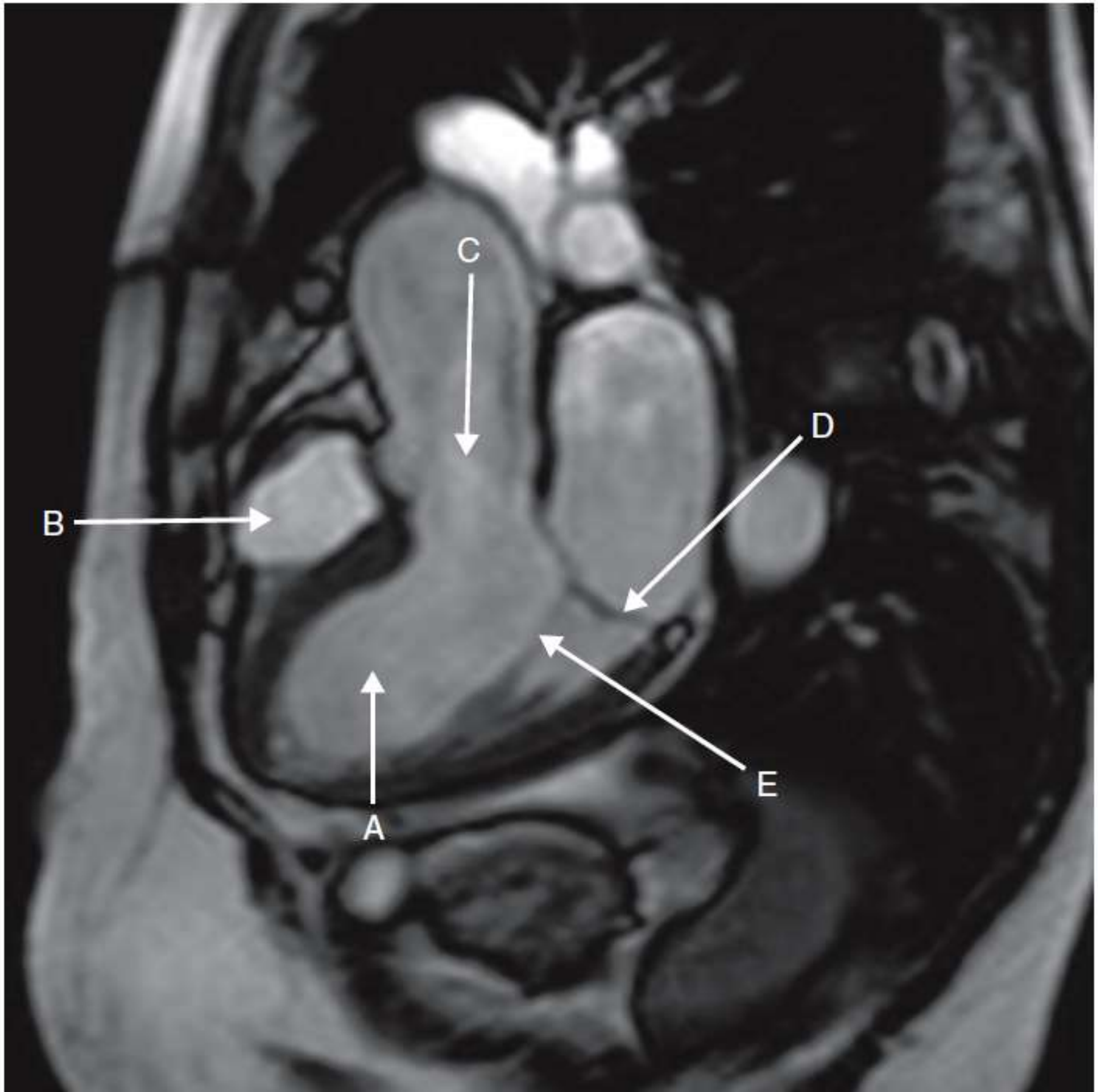


Case 11.4

- **A** Body of L5 vertebra
- **B** Prostatic urethra
- **C** Corpus cavernosum
- **D** Rectum
- **E** Symphysis pubis

The male urethra is typically around 20 cm in length. It follows an approximately S-shaped path. From proximal to distal, the named parts are: prostatic, membranous, bulbar and penile.

Case 3.8



3.9 Coronal enhanced abdominal CT

(a) Ascending colon.
(b) Right gluteus medius muscle.

(c) Urinary bladder.
(d) Spleen.
(e) Left duplex kidney.

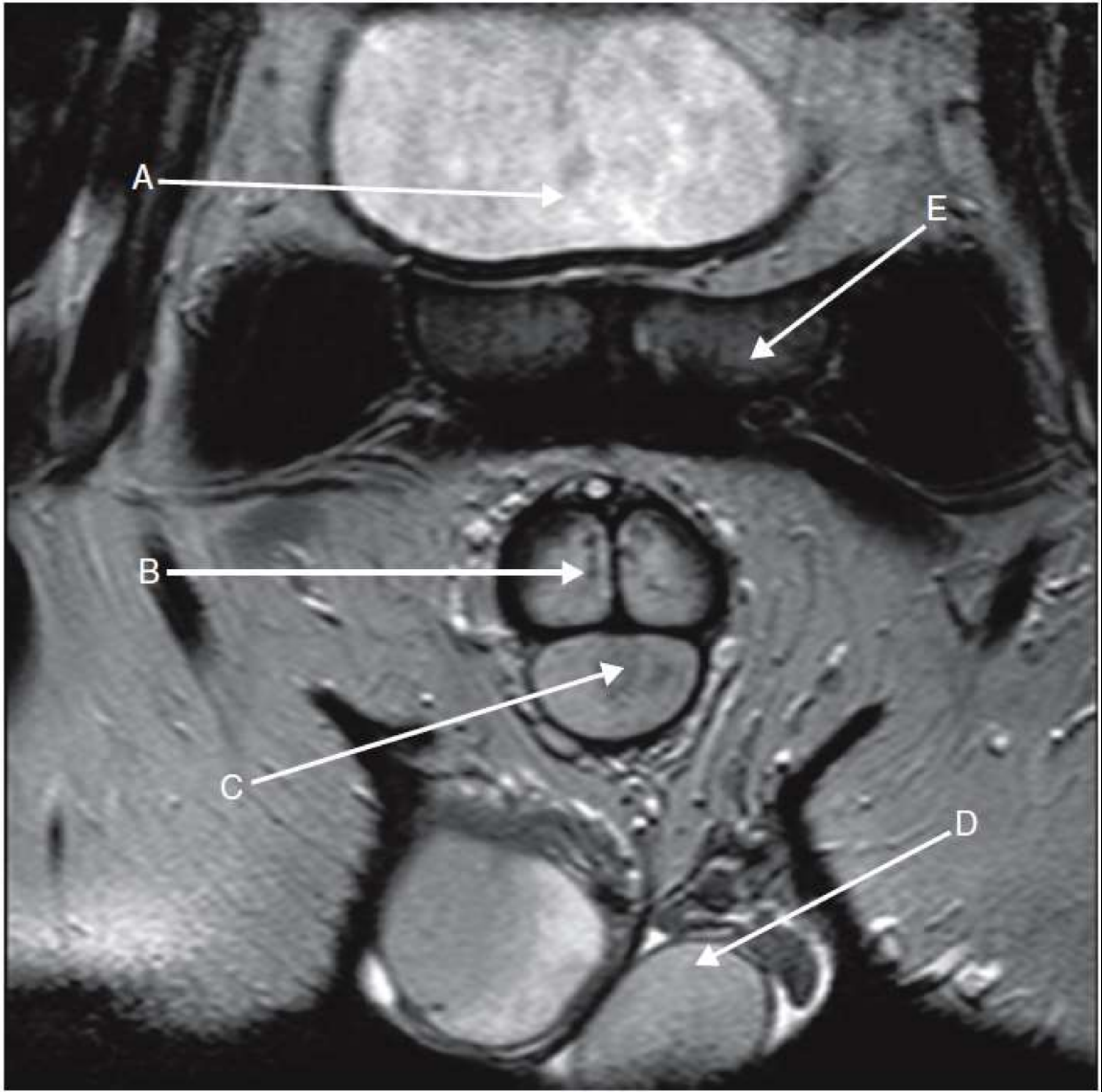
CTU is now a widely accepted modality used for the investigation of haematuria. Depending on local policy, different phases of imaging are obtained, which must include a urographic phase.

Images should be interpreted using axial, sagittal and coronal planes to ensure both ureters have been adequately assessed in their entirety.

The commonest anomaly of the kidney is duplication of the collecting system, which occurs in 1% of the population. This is more common in females than males and varies from a bifid renal pelvis to complete duplication of the ureter. In this case, the ureter draining the upper pole moiety inserts lower into the bladder than that draining the lower moiety. The upper ureter is more likely to obstruct and the lower pole ureter more likely to reflux.

When evaluating CTU, look carefully for any anomaly in ureteric anatomy as one ureter may be involved in tumour or with renal calculi, and the other may be normal.

Case 2.5



2.5 Coronal T2-weighted image of the male pelvis through the base of the penis

(a) Urinary bladder.
(b) Corpus cavernosum.
(c) Corpus spongiosum.

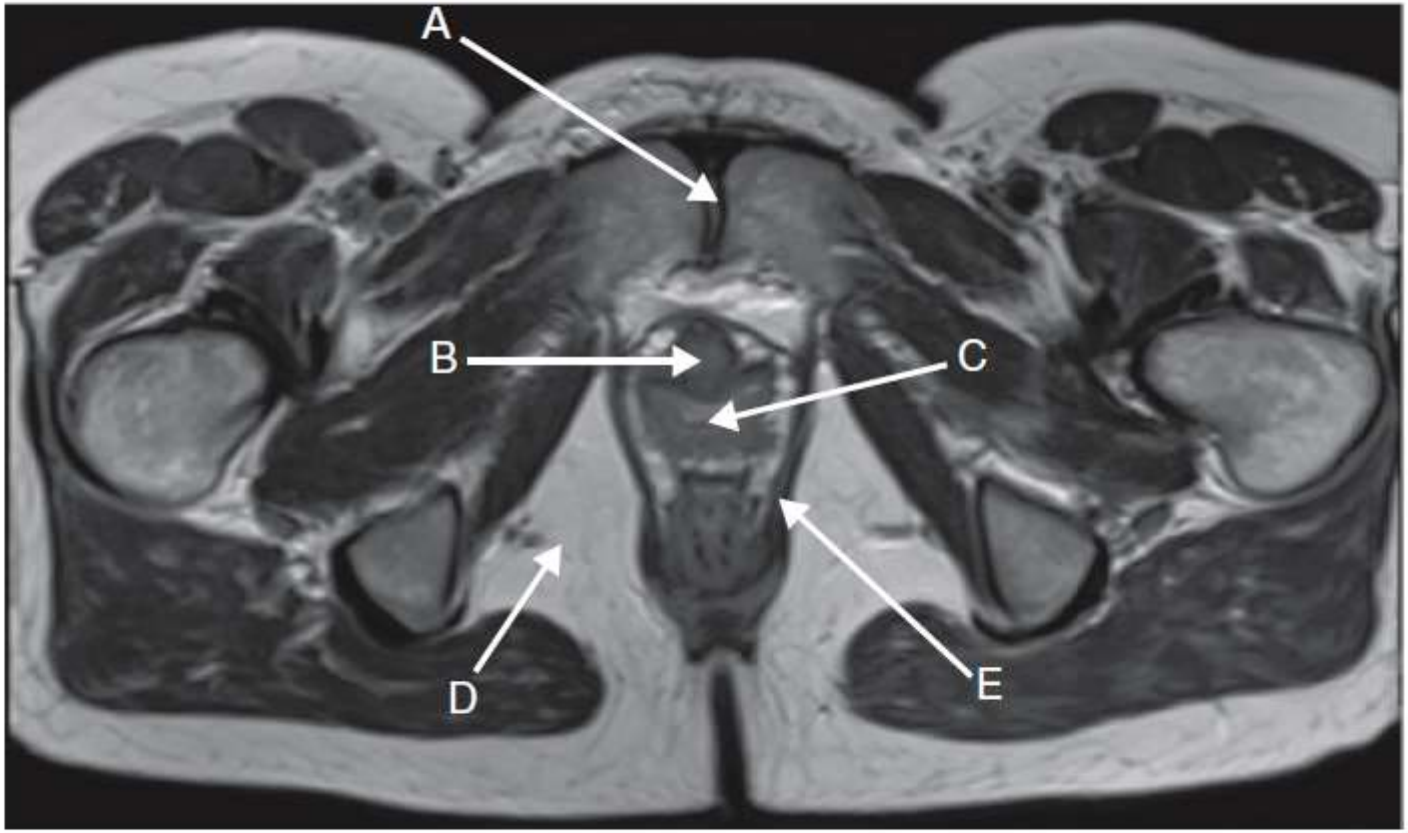
(d) Left testis. Normal testis is high signal on T2 MRI and intermediate on T1. The epididymis is isointense or hypointense relative to testis on T1 and hypointense on T2-weighted images.
(e) Left pubic bone.

There are paired dorsal corpora cavernosa, and a single ventral corpus spongiosum, which surrounds the penile urethra. These can be seen easily on MRI or ultrasound.

Arterial supply to the penis is from the internal pudendal arteries. Paired cavernosal arteries run in the corpora cavernosa. Paired deep dorsal arteries lie external to the tunica albuginea and run laterally to the deep dorsal vein, supplying skin and glans penis.

Penile carcinoma, although relatively uncommon, can be well visualized on MRI using T2 and post-contrast T1 sequences. Primary tumours are usually solitary, ill-defined lesions that are of low signal relative to the corpora on both T1- and T2-weighted images. Tumours enhance following contrast, but to a lesser degree than the corpora cavernosa.

Case 1.6



1.6 Axial T1-weighted MR female pelvis

(a) Symphysis pubis. This is a cartilaginous joint between the two pubic bones whose articular surfaces are covered by hyaline cartilage. A fibrocartilaginous disc connects two surfaces allowing virtually no movement to take place.

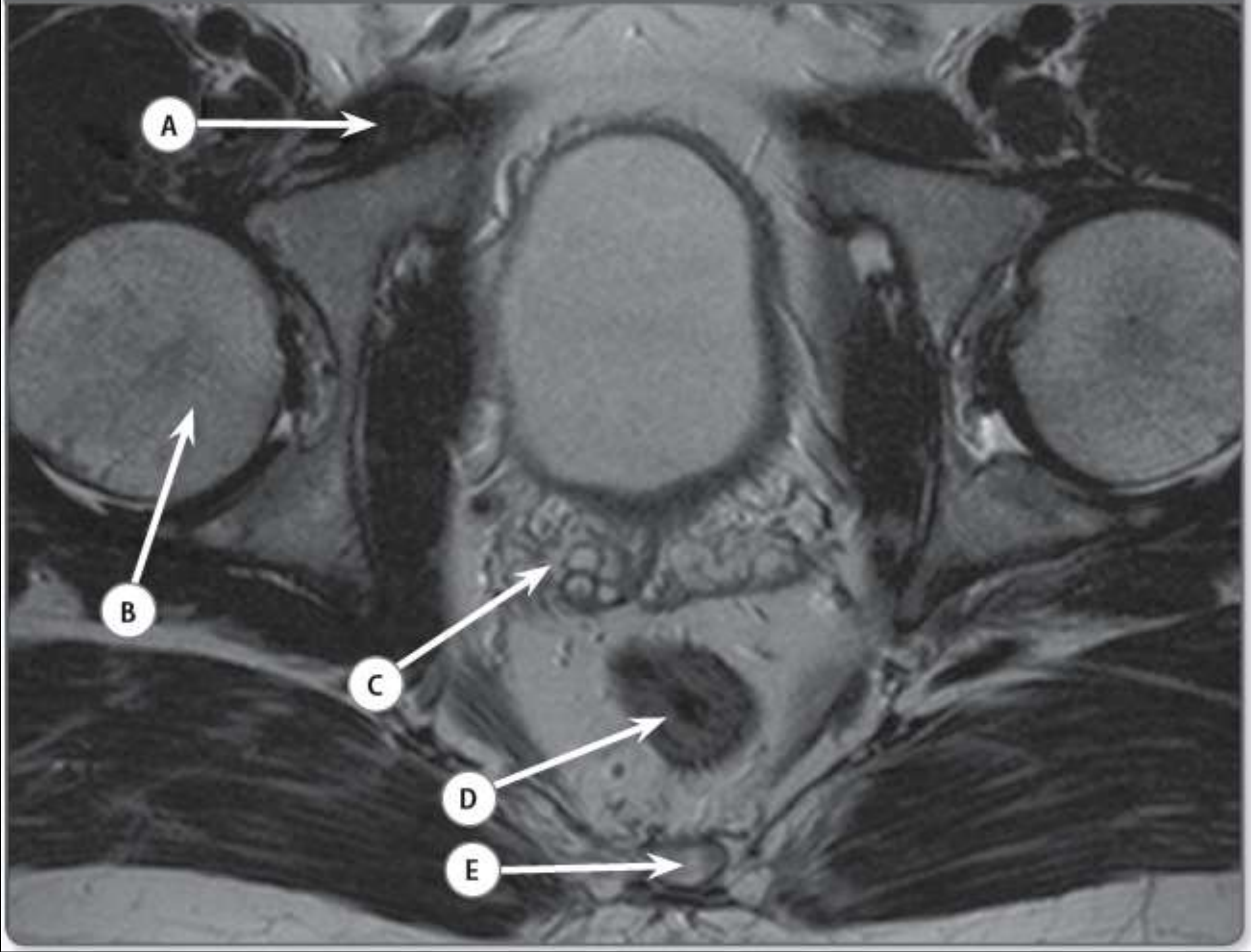
(b) Urethra. The female urethra is usually 4 cm in length. On T2-weighted images the urethra is seen as concentric rings of different signal intensities, giving the appearance of a target.

(c) Vagina. Its lower third runs parallel to the urethra. Typically it shows an H-shaped appearance on transverse MRI. The mucosal layer shows high signal intensity on T2-weighted, muscular layer shows low signal intensity on T1-weighted and the outer adventitial layer has a high signal intensity on T2-weighted imaging.

(d) Right internal pudendal artery and veins. The structure is called the (right) ischio-anal fossa (ischio-rectal fossa). It is filled with dense fat allowing the anal canal to distend during defaecation. The pudendal nerve runs inside the pudendal canal (Alcock's canal), which is situated in the lateral wall of the ischio-anal fossa. It also contains the internal pudendal artery and veins.The inferior rectal artery, vein and inferior anal nerves also cross the fossa transversely. The ischio-anal fossa is bounded laterally by obturator internus.

(e) Left levator ani muscle. This thin muscle arises from the posterior surface of the superior ramus of the pubis and forms the medial boundary of the ischio-anal fossa. It merges with the muscle from the opposite side, the coccyx and inserts into the rectum.

Case 15.18



Case 15.18

A Right pectineus muscle

B Right femoral head

C Right seminal vesicle

D Rectum

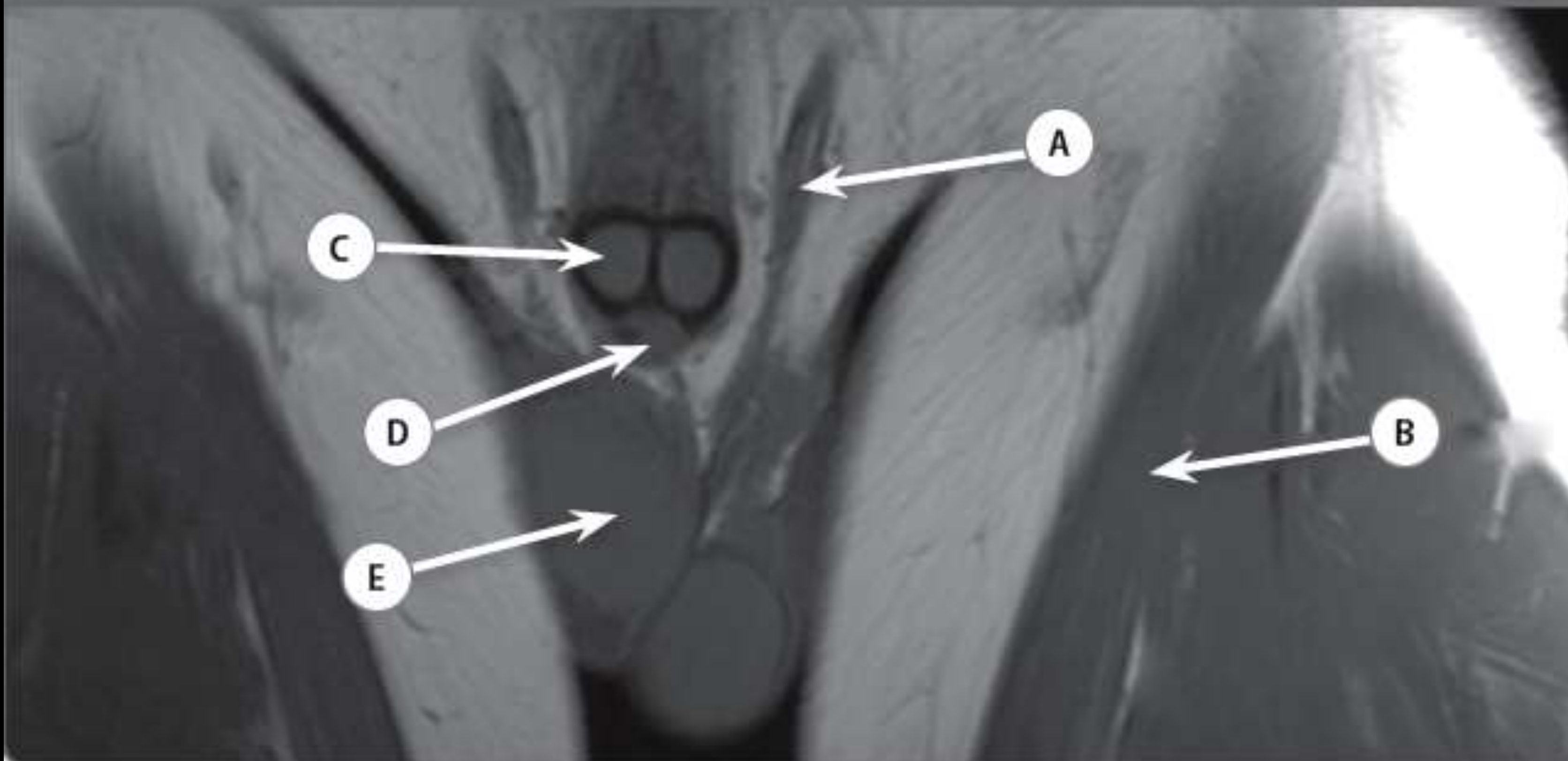
E Coccyx

The femoral canal is the space medial to the femoral vein and lateral to the lacunar ligament. The roof of the canal is the inguinal ligament and the floor is formed by the pectineus muscle.

The mnemonic **NAVY** may be used to remember the structures of the femoral canal, from lateral to medial:

Nerve, **A**rtery, **V**ein, **Y** fronts.

Case 14.20



Case 14.20

A Left spermatic cord

B Left sartorius muscle

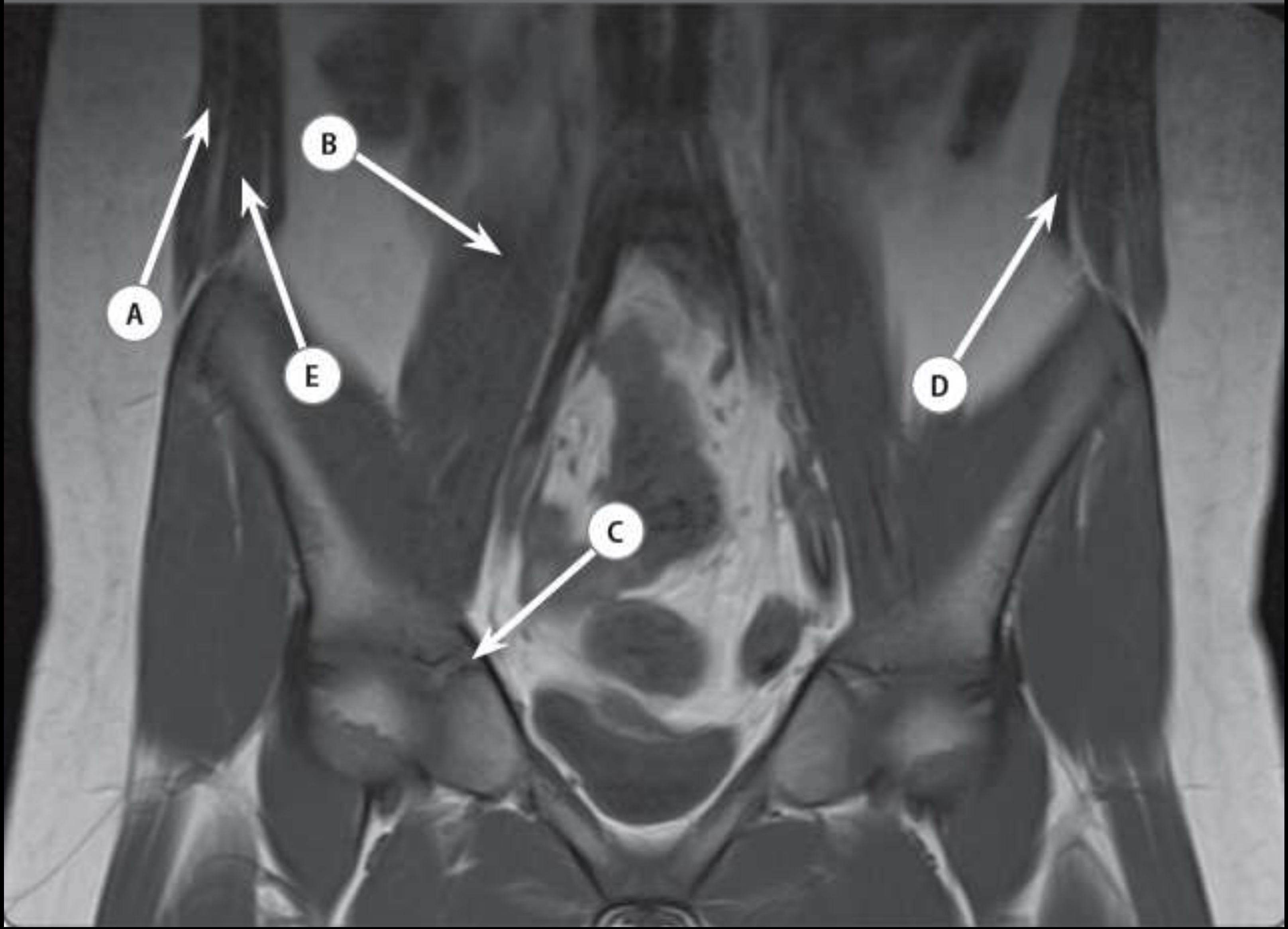
C Right corpus cavernosum

D Corpus spongiosum

E Right testis

The spermatic cord (A) descends to the testis after it exits the superficial inguinal ring. The spermatic cord is covered by the external spermatic fascia, cremasteric muscle/fascia and internal spermatic fascia. It conveys the vas deferens, nerves, arteries, lymphatics and pampiniform venous plexus.

Case 15.10



Case 15.10

A Right external oblique muscle

B Right psoas major muscle

C Right triradiate cartilage

D Left transversus abdominis muscle

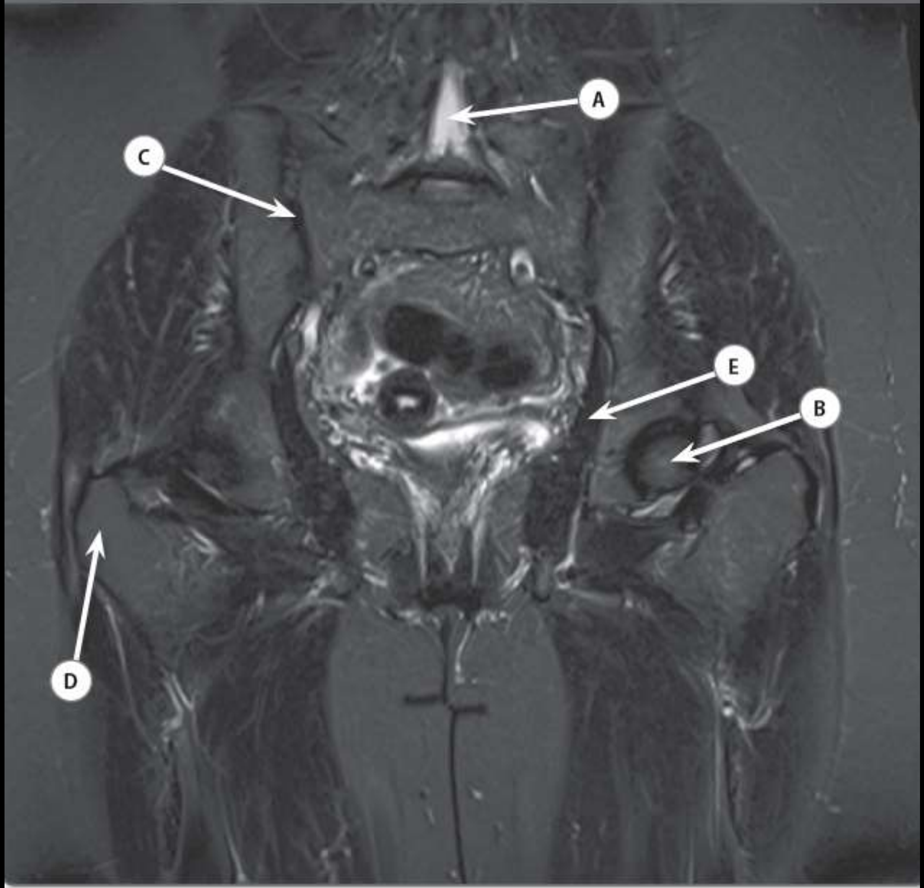
E Right internal oblique muscle

The musculature of the abdominal wall comprises the paired anterior rectus abdominis muscles and lateral wall musculature. The muscles of the lateral wall comprise, from deepest to most superficial, **TIE**:

- **T**ransversus abdominis
- **I**nternal oblique
- **E**xternal oblique

These muscles can be easily seen on both MRI and CT examinations.

Case 14.3



Case 14.3

QUESTION		WRITE YOUR ANSWER HERE
A	What accounts for the high signal labelled A?	
B	Name the structure labelled B.	
C	Name the structure labelled C.	
D	Name one muscle that inserts into the structure labelled D.	
E	Name the structure labelled E.	

Case 14.3

A Cerebrospinal fluid within the thecal sac

B Head of left femur

C Right sacroiliac joint

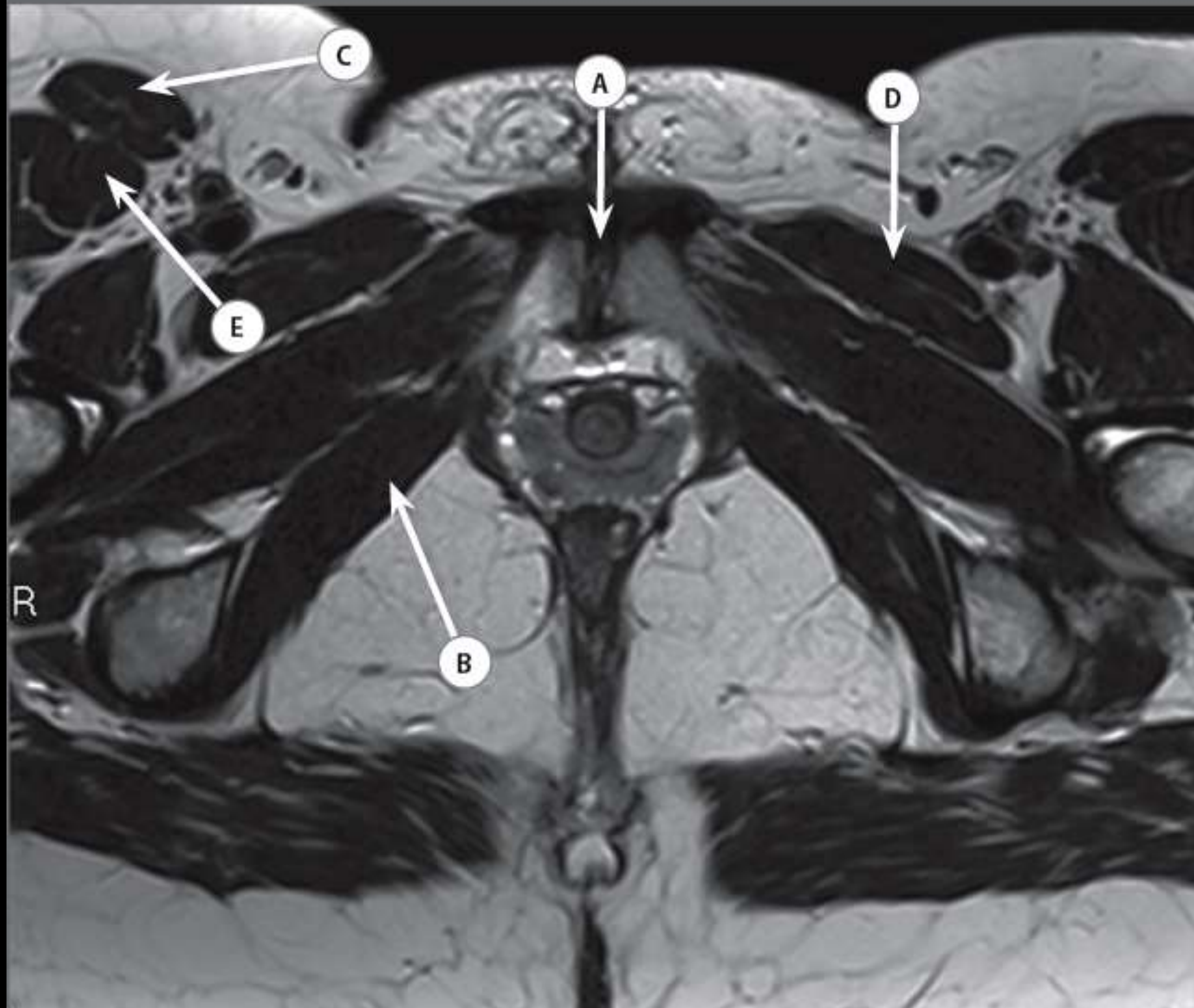
D Right gluteus medius or minimus muscle

E Left obturator internus muscle

The greater trochanter of the femur serves as the insertion site for both the gluteus minimus and gluteus medius muscles. The lesser trochanter is the insertion site for the iliopsoas tendon.

The paired obturator internus and obturator externus muscles may be easily remembered from their descriptors, with internus being inside the pelvis and externus being outwith the pelvis.

Case 13.11



Case 13.11

A Symphysis pubis

B Right obturator internus muscle

C Right sartorius muscle

D Left pectineus muscle

E Right rectus femoris muscle

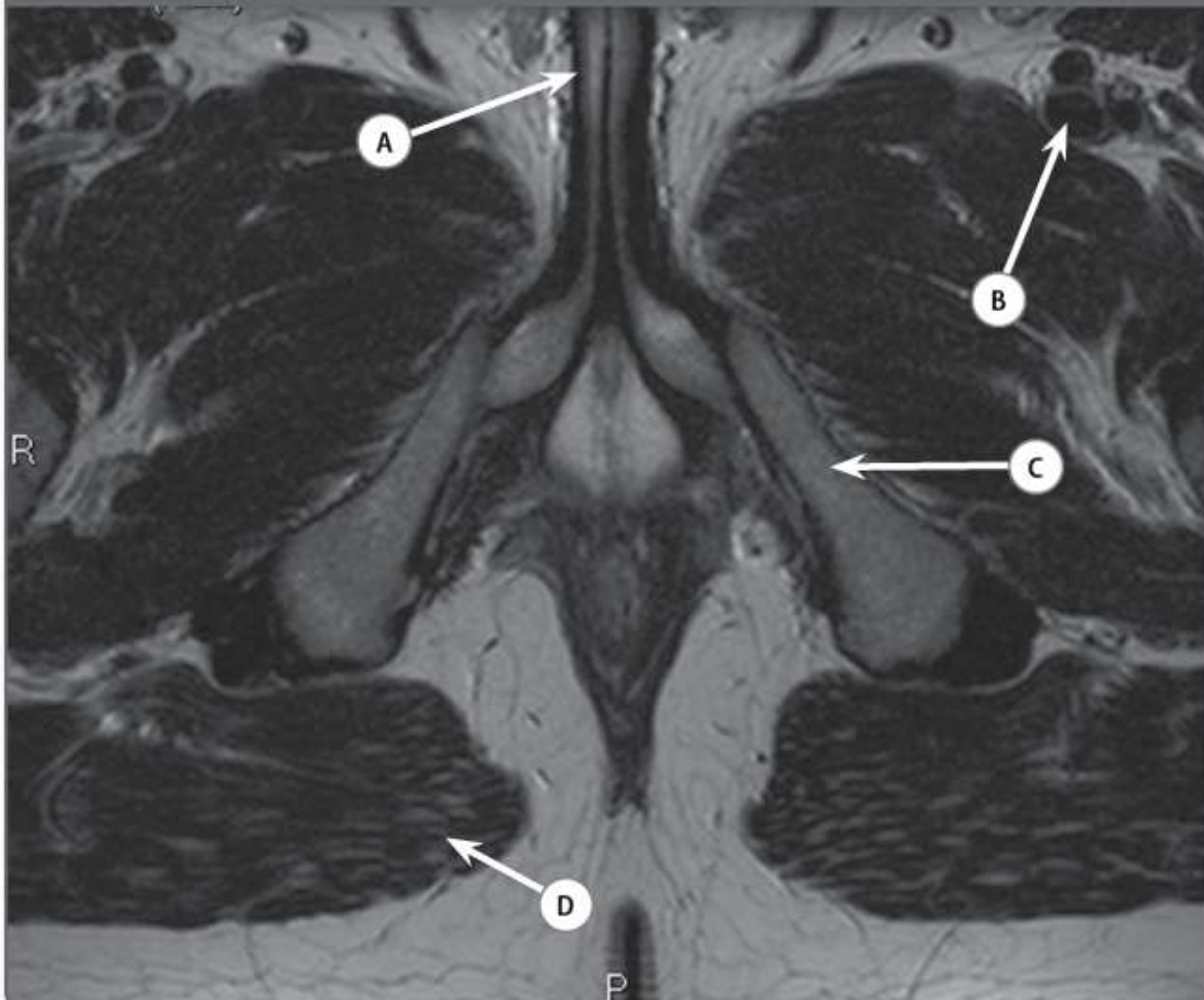
The symphysis pubis is a cartilaginous midline joint formed between the pubic bones. The pubic bones serve as an origin of multiple muscles, including:

- pectineus
- adductor magnus (shared origin)
- adductor longus
- adductor brevis
- gracilis

Another important landmark for the muscle origins includes the ischial tuberosity of the ischium. It provides the origin for the following muscles:

- long head of biceps femoris
- semitendinosus
- semimembranosus
- adductor magnus (shared origin)

Case 12.18



E	Name the non-paired erectile column of the penis.

Case 12.18

A Right corpus cavernosum

B Left femoral vein

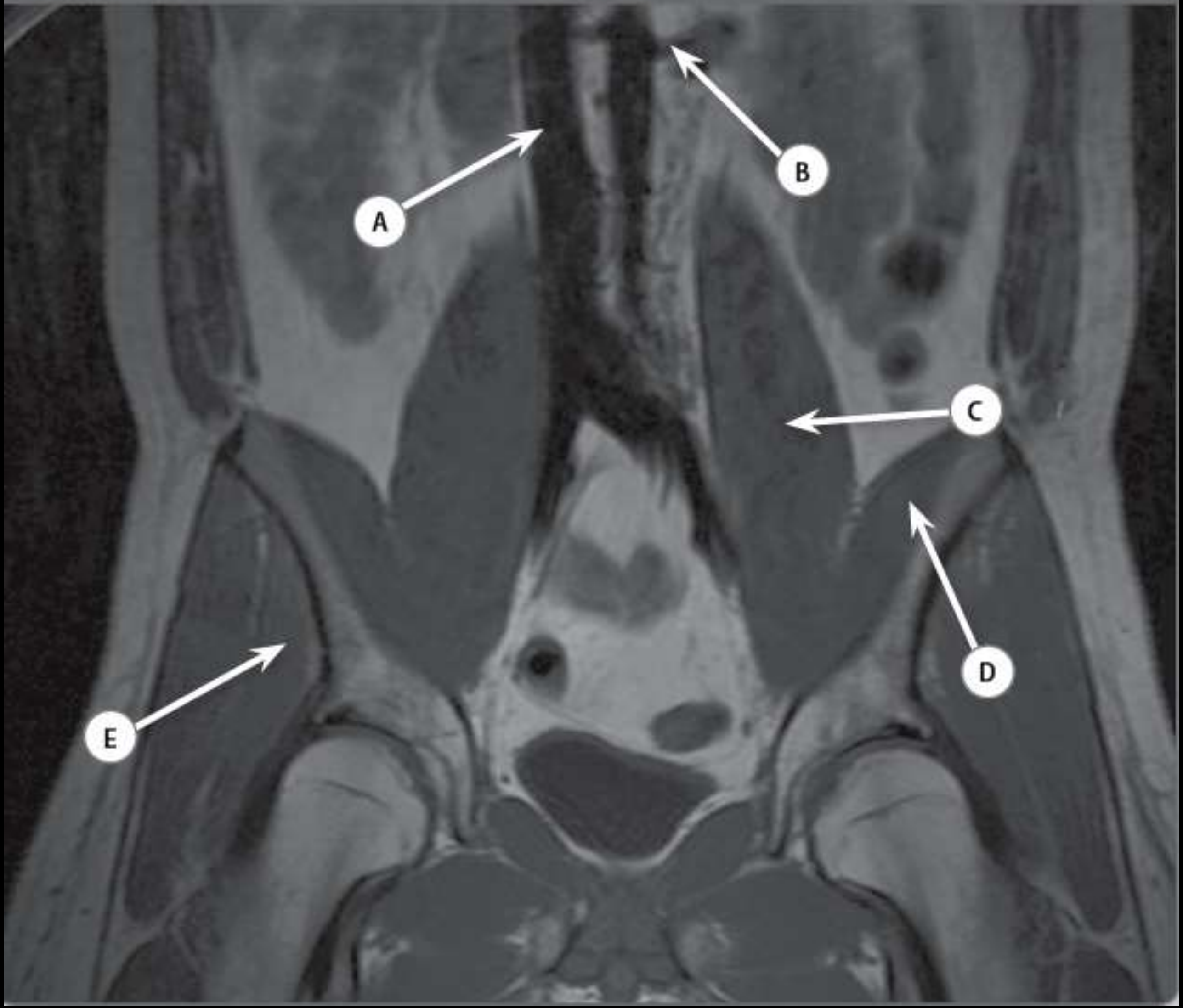
C Left inferior pubic ramus

D Right gluteus maximus muscle

E Corpus spongiosum

The two corpora cavernosa are seen anteriorly. Posteriorly, they expand bilaterally into the crura of the penis with the ischiocavernous muscles lying immediately adjacent to the bulb of the penis, anterior to the anus, on the internal aspect of the inferior pubic rami. Posterior to these structures lie the fat-filled ischioanal fossae.

Case 12.19



Case 12.19

A Inferior vena cava

B Left renal artery

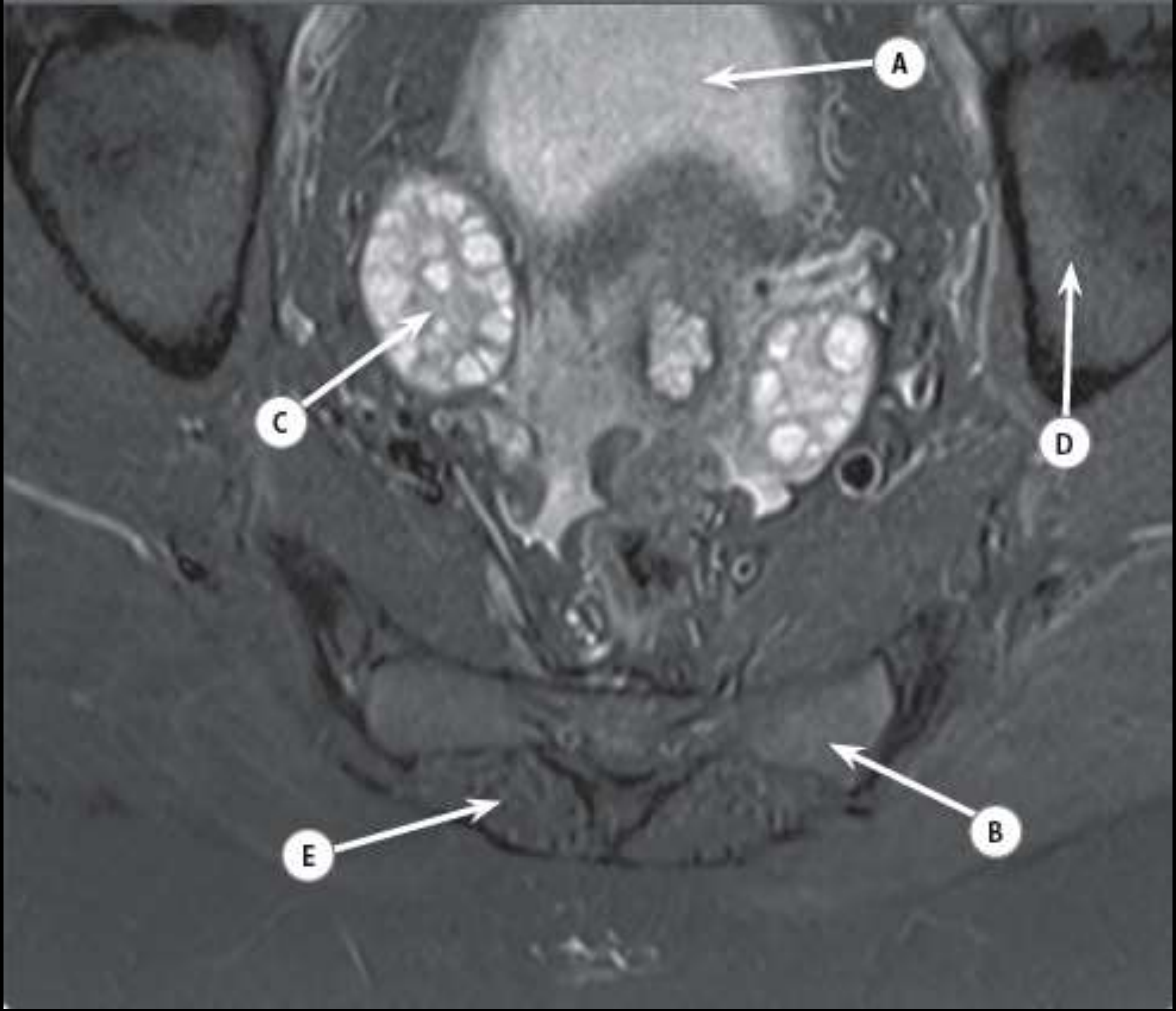
C Left psoas major muscle

D Left iliacus muscle

E Right gluteus minimus muscle

On MRI, flowing blood is depicted as dark flow voids, as seen here in the aorta and inferior vena cava (IVC). The normal configuration of aorta and IVC is shown with the aorta lying to the left of the IVC. The embryology of the IVC is complicated and congenital variations are relatively common (for example, double IVCs or absent sections at varying levels).

Case 11.20



Case 11.20

A Urinary bladder

B Left sacral alum

C Right ovary

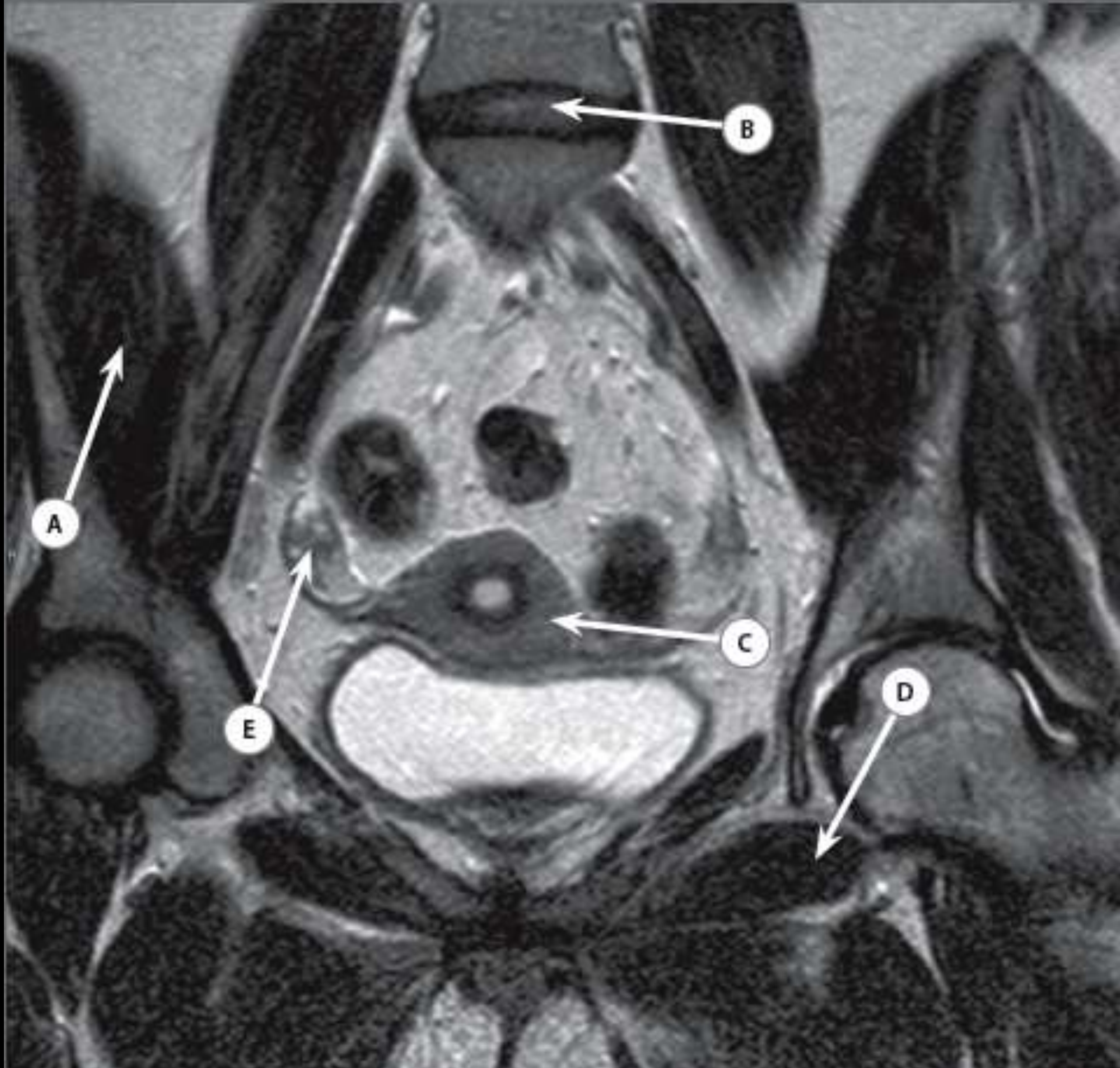
D Left (superior) acetabulum

E Right erector spinae muscle

The osseous acetabulum is composed of a triad of pelvic bones – the pubic bone, ischium and ilium. On careful examination of the image, the low signal of the cortices of the femoral heads is just visible thus allowing (D) to be identified as the superior acetabulum.

This axial oblique image clearly demonstrates the functional follicles in the paired ovaries.

Case 10.5



Case 10.5

A Right iliacus muscle

B Intervertebral disc

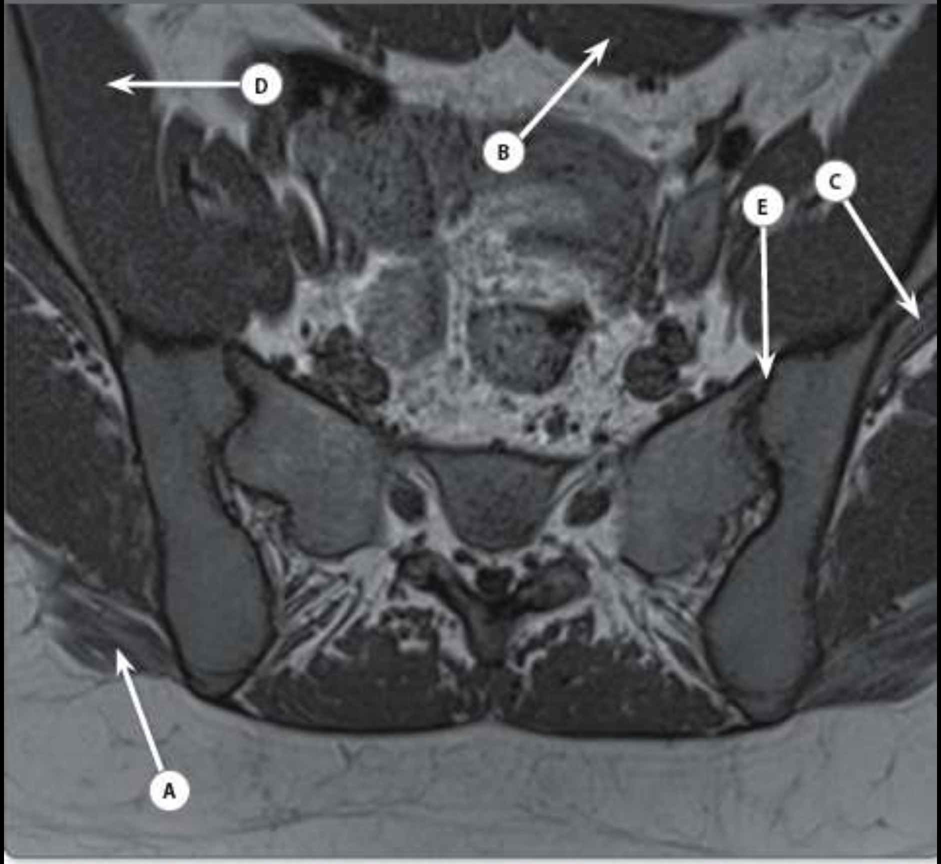
C Uterus (fundus)

D Left obturator externus muscle

E Right ovary

A doughnut-shaped fundus of the uterus is seen in the coronal plane. Note the appearance of the endometrium, the innermost histological layer of the uterus. It is under hormonal control and undergoes cyclic regeneration. The ovaries are visualised on either side of the uterus, showing characteristic high T2-weighted signal within the ovarian follicles.

Case 8.17



Case 8.17

QUESTION		WRITE YOUR ANSWER HERE
A	Name the structure labelled A.	
B	Name the structure labelled B.	
C	Name the insertion site of the structure labelled C.	
D	Name the structure labelled D.	
E	Name the structure labelled E.	

Case 8.17

A Right gluteus maximus

B Left rectus abdominis

C Greater trochanter of the left femur

D Right iliacus

E Left sacroiliac joint

Three gluteal muscles make up the buttocks and comprise (from deep to superficial):

1. gluteus minimus
2. gluteus medius
3. gluteus maximus

Gluteus medius and minimus insert into the ipsilateral greater trochanter of the femur. Gluteus maximus has a combined insertion into the iliotibial band/tract and the gluteal tuberosity of the femur.

Case 8.4

Case 8.4

A Ascending colon

B Appendix

C Ileocaecal valve/caecum

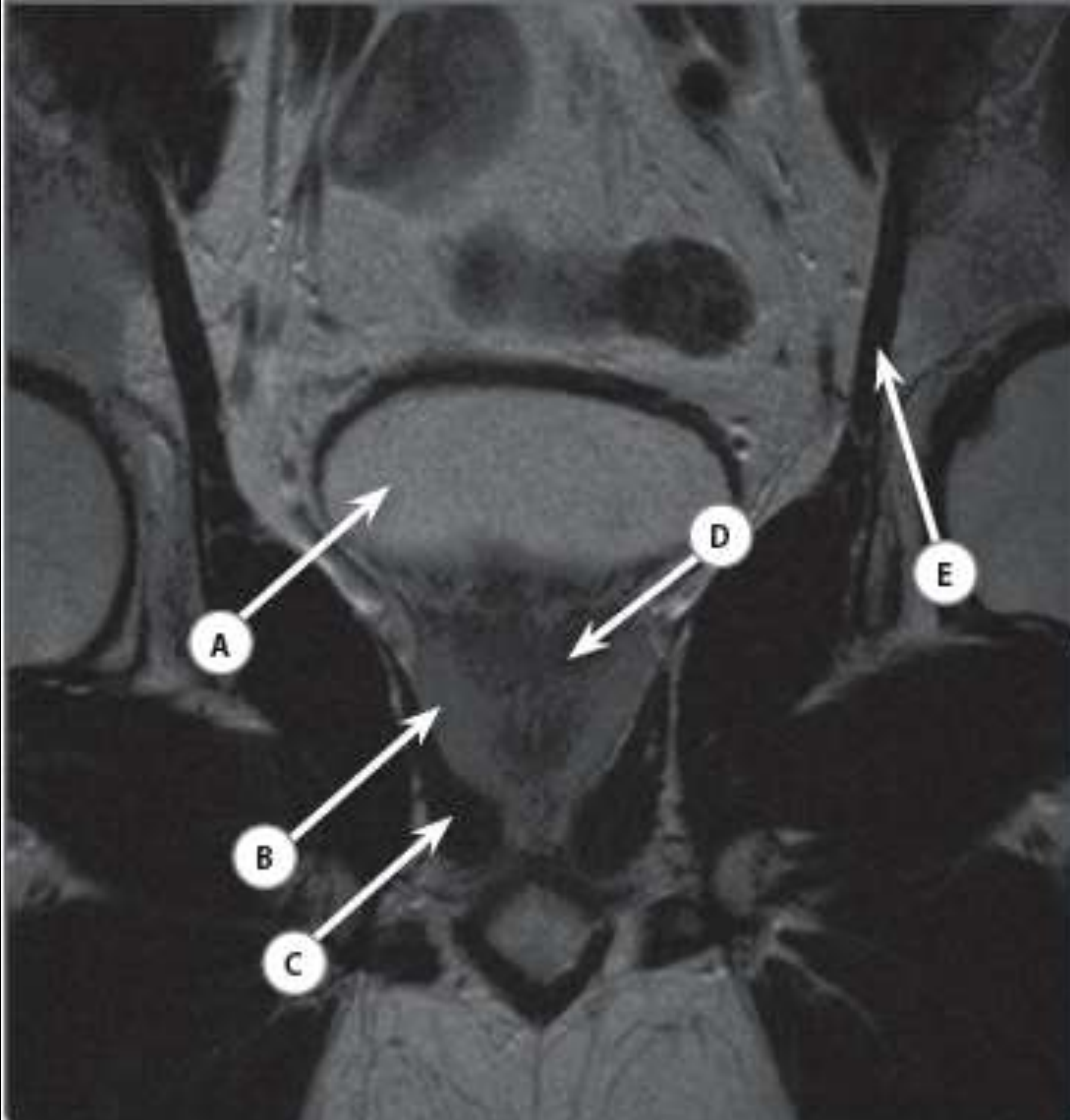
D Duodenojejunal junction

E Endometrial cavity of the uterus

Many authorities have now stated that when reviewing and reporting abdominal and pelvic CT or MRI, it is essential to include coronal assessment. Reliance on axial imaging is no longer acceptable as the extra information gained from coronal and, where necessary, sagittal imaging, is significant in many cases. The inclusion of coronal and sagittal body imaging will become more commonplace in radiological examinations, so ensure you know your way around these types of images.

This particular MRI shows the value of coronal imaging in demonstrating the peritoneal spaces, recesses and reflections.

Case 8.8



Case 8.8

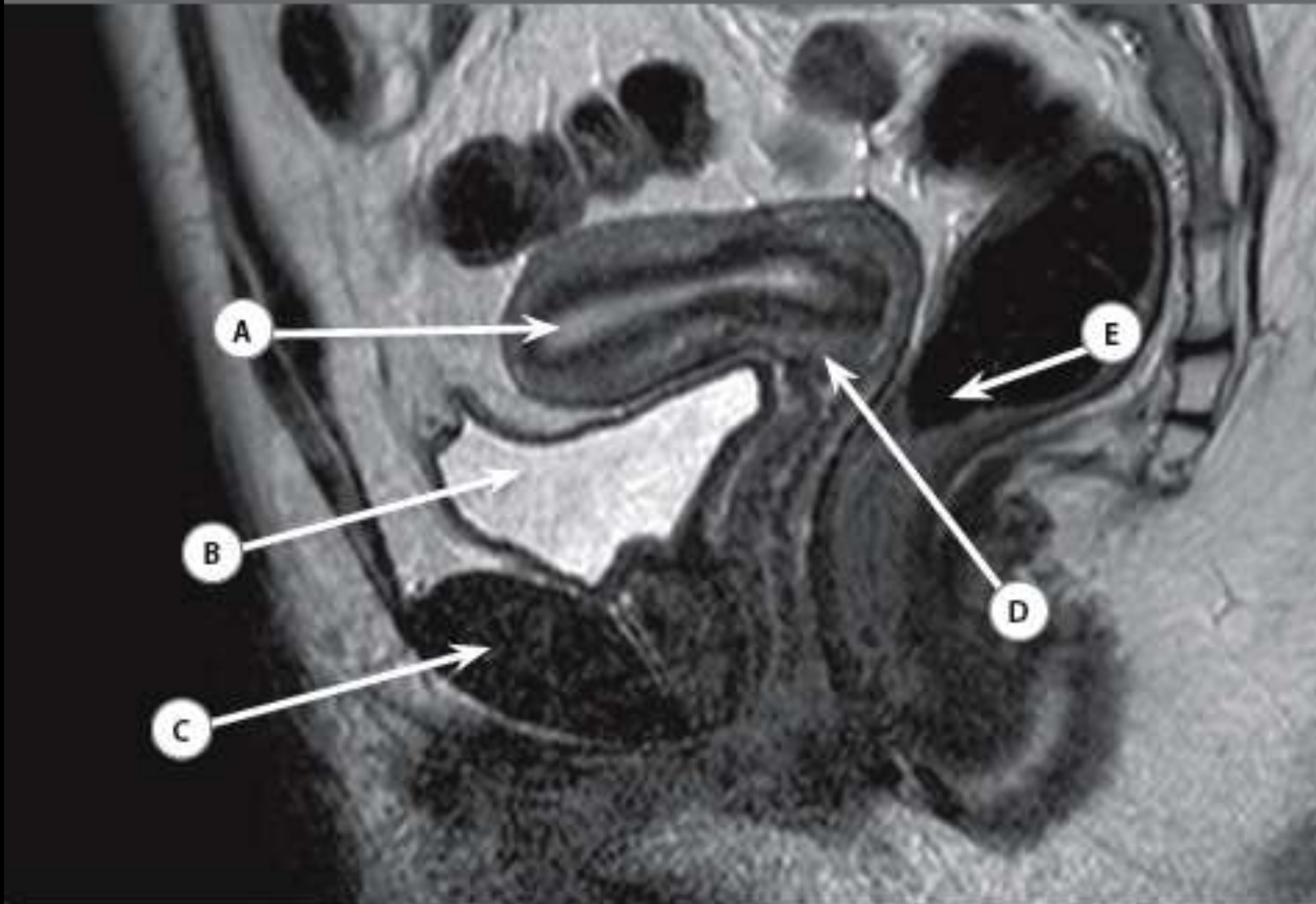
- A Bladder
- B Peripheral zone of prostate
- C Right levator ani muscle
- D Central zone of prostate
- E Left obturator internus muscle

The zonal anatomy of the prostate is well demonstrated in the coronal plane. In addition, the verumontanum is seen centrally as an area of low signal with a midline high signal vertical line. It signifies the opening of the ejaculatory ducts in the prostatic urethra and is Latin for 'mountain ridge'.

The anatomy of the levator ani muscles can be appreciated as they insert into the perineal body, a fibrous node posterior to the male urethra or the urethra and vagina in females.

The obturator internus fibres are located lateral to the levator ani group. The muscle originates from the anterolateral walls of the pelvis and covers the obturator foramen. It travels inferiorly, through the lesser sciatic foramen, to insert into the greater trochanter of the femur.

Case 7.7



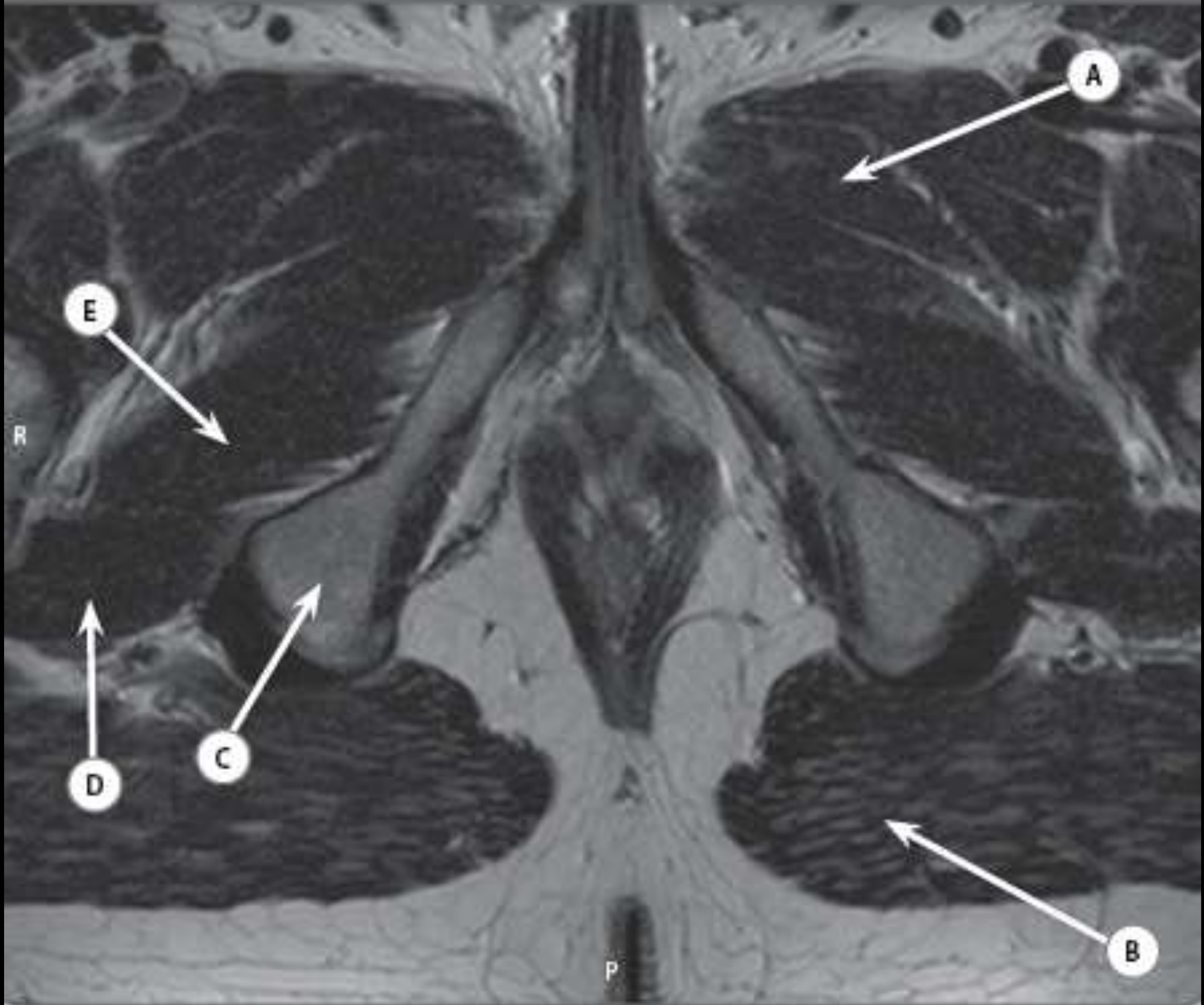
Case 7.7

- **A** Endometrial cavity
- **B** Bladder
- **C** Symphysis pubis
- **D** Cervix
- **E** Rectum

The uterus in this example is anteverted and anteflexed and demonstrates the characteristic trilaminar appearance of the endometrium. Note the relationship of the cervix which lies anterior to the rectum.

Sagittal views through the pelvis might show numerous important anatomical structures and their relationship to other pelvic organs. Candidates must be able to recognise all the major structures confidently and not just the organs relating to an individual anatomical system. Vertebral bodies, discs and nerve roots may also be visible and candidates are expected to recognise and name them.

Case 5.13



Case 5.13

A Left adductor longus muscle

B Left gluteus maximus muscle

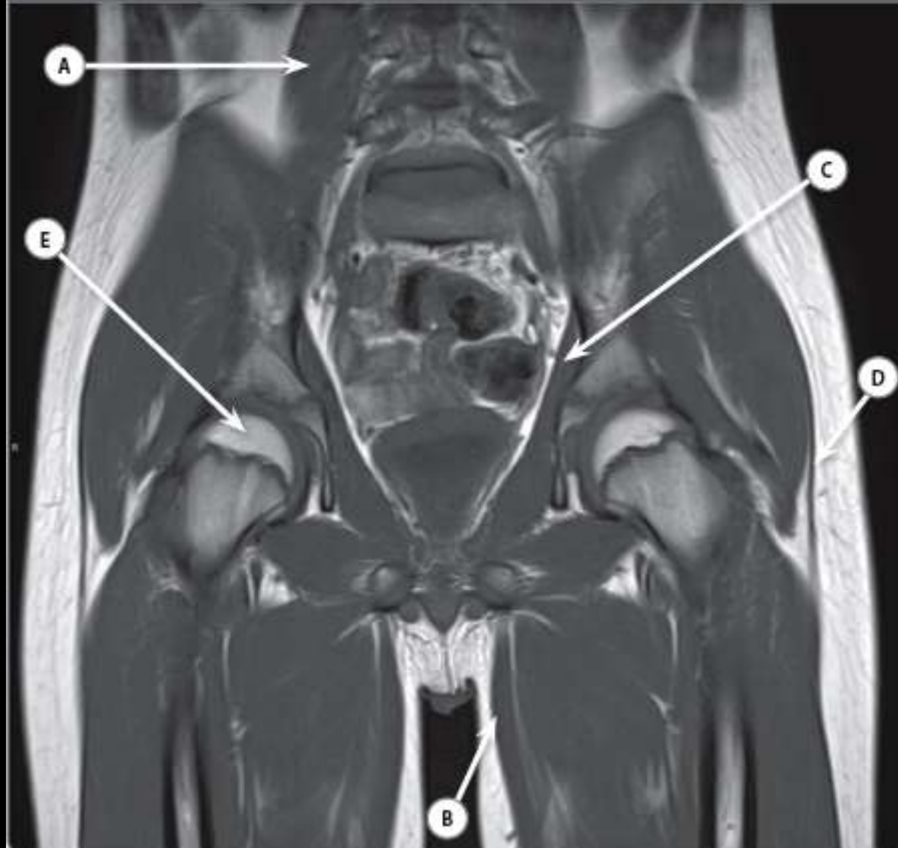
C Right ischium

D Right quadratus femoris muscle

E Right adductor magnus muscle

The three adductor muscles (magnus, longus and brevis) have a common origin site from the external surface of the pubic bone. The muscle surrounding the anus is the puborectalis which is the inferior part of the levator ani muscles. The fat-filled spaces immediately lateral to the anal complex are the ischioanal fossae. These contain small dark serpiginous structures anteriorly (as seen on this image) which are the inferior neurovascular bundles.

Case 5.6



Case 5.6

QUESTION		WRITE YOUR ANSWER HERE
A	Name the tendinous insertion site for the structure labelled A.	
B	Name the origin of the structure labelled B.	
C	Name the structure labelled C.	
D	Name the structure labelled D.	
E	Name the structure labelled E.	

Case 5.6

A Lesser trochanter of right femur

B Left inferior pubic ramus

C Left obturator internus muscle

D Left iliotibial band

E Right capital femoral epiphysis

Psoas major

- Origin – transverse processes of the L1–L5 vertebrae and lateral surfaces of the T12–L4 vertebrae
- Insertion – common iliopsoas insertion into the lesser trochanter of proximal femur.

Gracilis

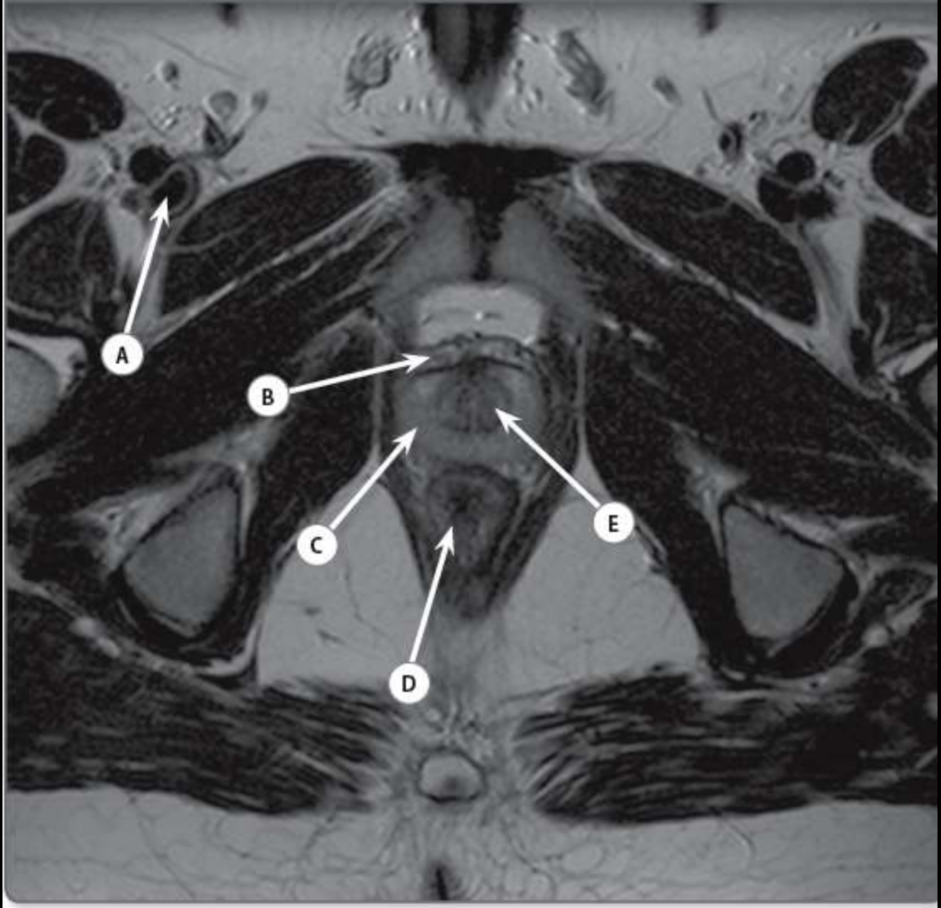
- Origin – inferior pubic ramus, arising from aponeurosis
- Insertion – pes anserinus (proximal medial tibia).

Obturator internus

- Origin – ischiopubic rami
- Insertion – Trochanteric fossa, greater trochanter of femur.

The iliotibial band is a fibrous enforcement of the fascia lata and the insertion site of gluteus maximus and tensor fascia lata.

Case 3.10



Case 3.10

QUESTION		WRITE YOUR ANSWER HERE
A	Name the structure labelled A.	
B	Name the structure labelled B.	
C	Name the structure labelled C.	
D	Name the structure labelled D.	
E	Name the structure labelled E.	

Case 3.10

A Right femoral vein

B Retropubic venous plexus

C Peripheral zone of prostate

D Rectum

E Central zone of prostate

This is an axial T2-weighted MRI through the male pelvis. The peripheral zone of the prostate has brighter signal in this sequence and the central zone is darker. Three distinct zones are described (**Table 3.1**) along with fibromuscular stroma. Structure

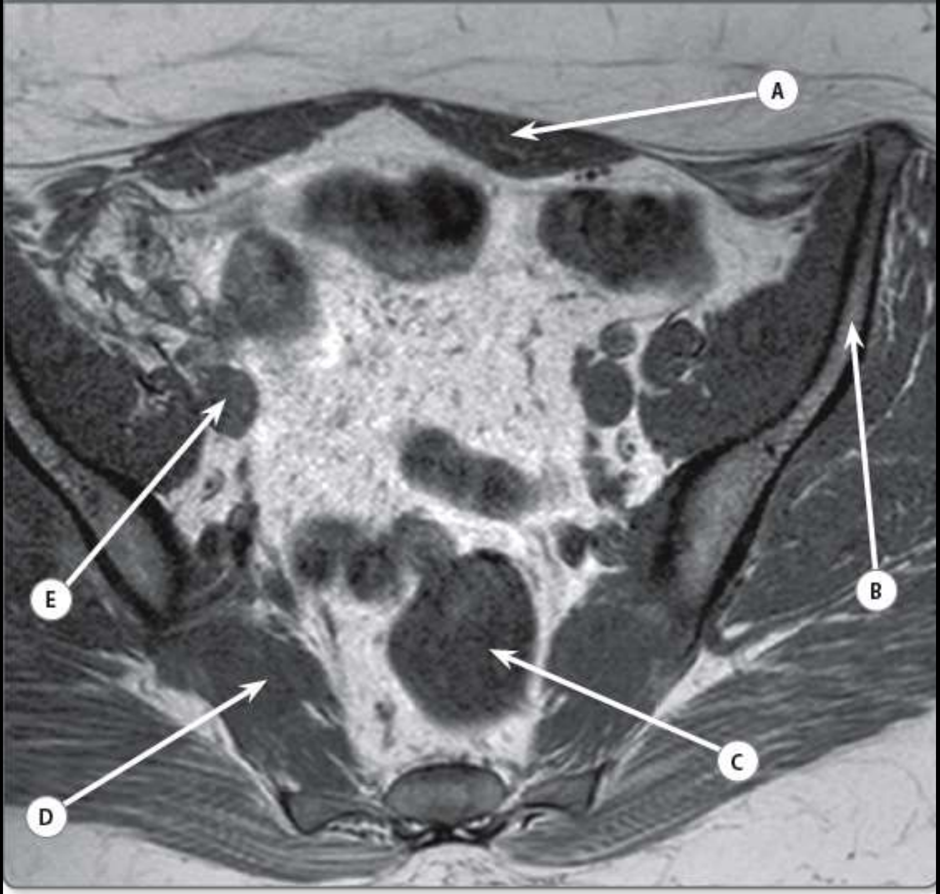
Table 3.1 Zonal anatomy of the prostate

Zone	Location	Pathology
Peripheral	Subcapsular, posterior aspect	• 70% of malignancies arise here
Central	Surrounds ejaculatory ducts	• Around of 3% malignancies arise here
Transition	Surrounds proximal urethra	• Continues to grow throughout life • Is the area in which benign prostatic hyperplasia occurs • Accounts for 20–30% malignancies

Answers

(B) is the retropubic venous plexus (of Santorini), an important structure for the urologist performing a prostatectomy.

Case 2.18



Case 2.18

QUESTION		WRITE YOUR ANSWER HERE
A	Name the structure labelled A.	
B	Name the structure labelled B.	
C	Name the structure labelled C.	
D	Name the structure labelled D.	
E	Name the structure labelled E.	

Case 2.18

A Left rectus abdominis muscle

B Left iliac wing

C Rectum

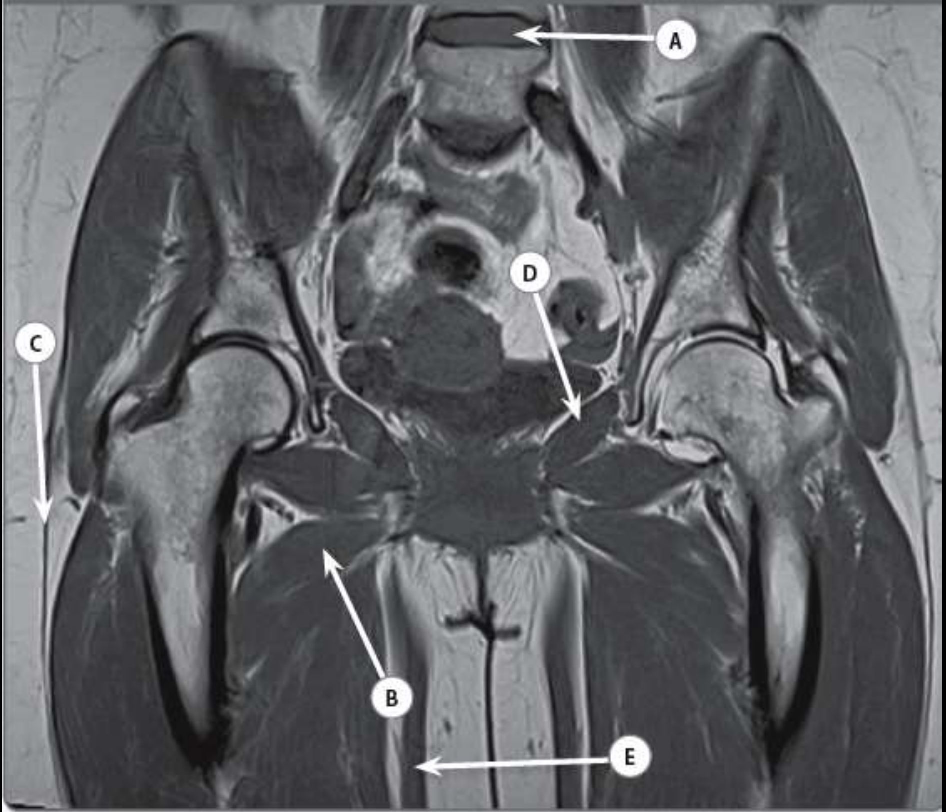
D Right piriformis muscle

E Right common iliac vein

Immediately posterior to the lateral aspect of the rectus abdominis muscles lie a collection of small round structures (three on each side in this case), the inferior epigastric vessels.

The sciatic nerve emerges from the pelvis just inferior to the piriformis muscle, via the greater sciatic notch. It descends vertically about halfway between the ischial tuberosity and the greater trochanter of the femur, deep to the gluteus maximus muscle.

Case 1.17



Case 1.17

QUESTION		WRITE YOUR ANSWER HERE
A	Name the structure labelled A.	
B	Name the structure labelled B.	
C	Name the structure labelled C.	
D	Name the structure labelled D.	
E	Name the structure labelled E.	

Case 1.17

A L4/L5 intervertebral disc

B Right pectineus muscle

C Right iliotibial band/tract

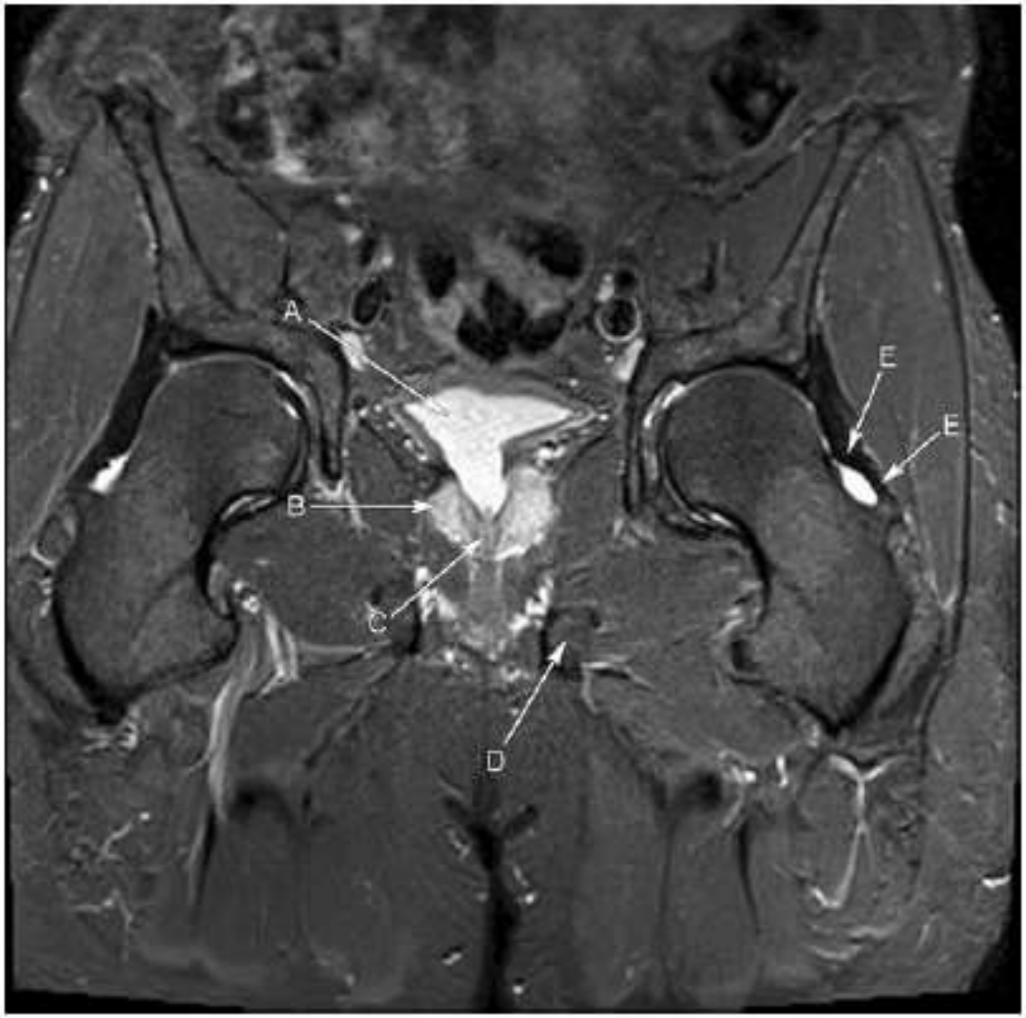
D Left obturator internus muscle

E Right gracilis muscle

The iliotibial band is a lateral fibrous tract which originates from the iliac tubercle and inserts into the lateral condyle of the tibia. Due to its fibrous nature, it is distinctively shown as a low signal band on the lateral aspect of the thigh within the subcutaneous fat.

The pectineus muscle originates from the pectineal line of the pubis and inserts into the pectineal line of the superomedial femur – remember pectineus = PPP.

Question 10.14



Name the structures labelled **A** to **E**.

10.14 Coronal STIR MRI of the prostate

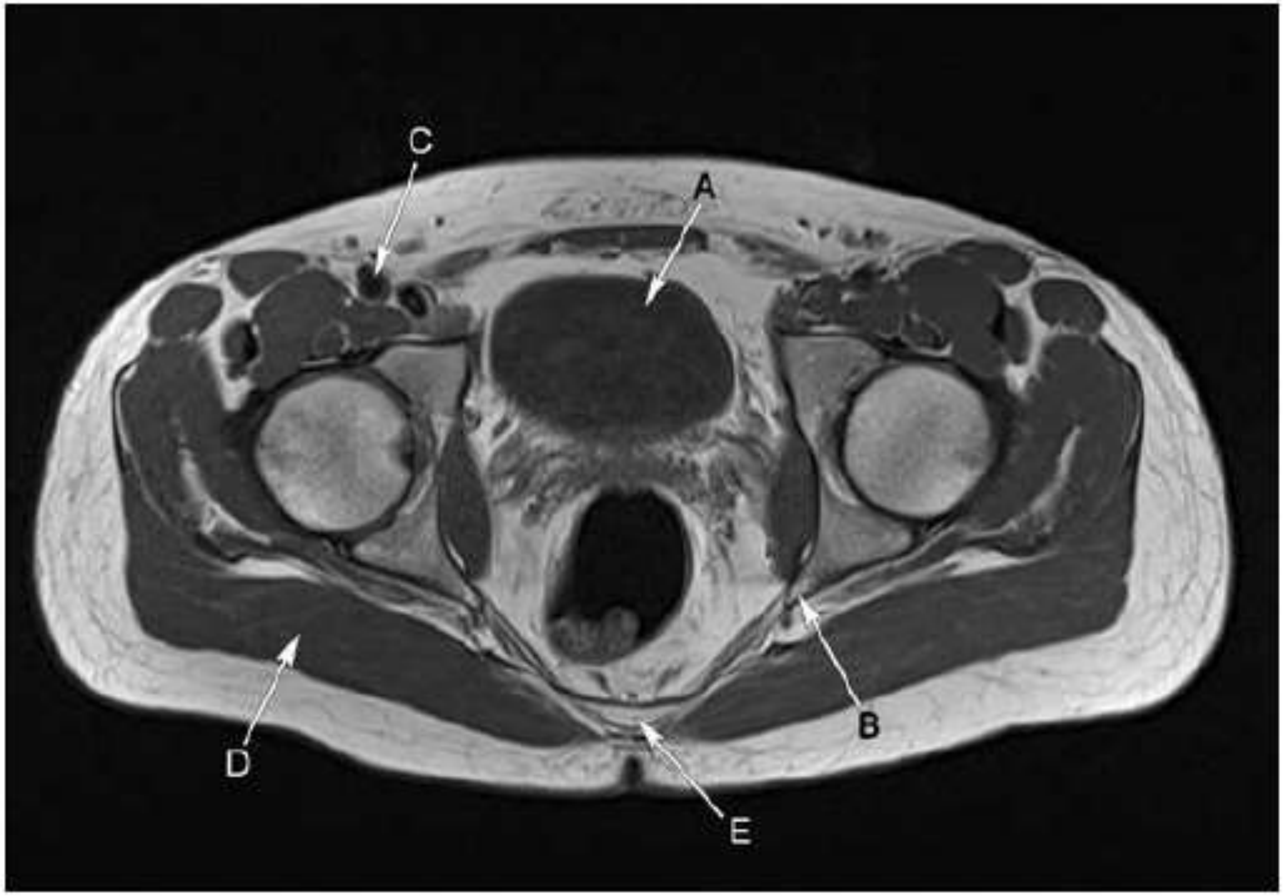
A Bladder.
B Peripheral zone of the prostate.
C Central gland of the prostate.
D Left ischial tuberosity.
E Left hip capsule.

The prostate lies inferior to the bladder and encases the prostate urethra and ejaculatory ducts. It is cone-shaped, consisting of an apex (the tip of the cone, which sits on the urogenital diaphragm) and a base (which is situated along the inferior surface of the bladder). The prostate consists of three glandular zones:

Transition zone	Narrow area that surrounds the proximal urethra at the level of the ejaculatory ducts It is hypertrophy of this zone that is responsible for benign prostatic hypertrophy
Central zone	Surrounds the urethra above the level of the ejaculatory ducts
Peripheral zone	Subcapsular peripheral portion of the prostate that surrounds the distal urethra Largest part of the prostate accounting for 70% of the gland Roughly 80% of prostate cancers originate in this zone

MRI is the primary modality for the staging of prostate cancer as it is able to differentiate between disease confined to the prostate (T2 disease) and extra-prostatic disease (T3 disease). It is unable to differentiate between the transition and central zones of the prostate and is thus termed the central gland.

Question 8.16



Name the structures labelled **A** to **E**.

8.16 Axial T1 MRI of the pelvis

A Bladder.
B Left ischial spine.
C Right femoral artery.
D Right gluteus maximus.
E Sacrum.

The ischial spine is a triangular eminence from the posterior border of the ischium. It gives rise to the superior gemellus muscle on its external surface and the coccygeus, levator ani and pelvic fascia on its internal surface. The sacrospinous ligament attaches to its pointed apex. The pudendal nerve passes dorsal to the ischial spine. For this reason the ischial spine can serve as a useful landmark for performing a pudendal nerve block.

Question 8.10

Name the structures labelled A to E.

8.10 T2 FLAIR coronal MRI of the pelvis

A Urethra.
B Left corpus cavernosum.
C Corpus spongiosum.
D Testis.
E Right superior pubic ramus.

By convention, the ventral surface of the penis is the surface that normally lies upon the scrotum. There are three cylinders of epithelium-lined erectile tissue within the penis – a ventral corpus spongiosum and two dorsal corpus cavernosa. The three corpora generally give a high T2 signal on MRI.

There is a fibrous capsule surrounding each of the corpora, known as the tunica albuginea. A second fibrous layer, called Buck's fascia, surrounds the corpora cavernosa and separates them from the corpus spongiosum. As these two layers are both formed of dense fibrous tissue, they appear as a low-signal band on both T1- and T2-weighted MRI, and as such cannot be distinguished from each other. There is a layer of connective tissue superficial to Buck's fascia that has a relatively high T2 signal. Enveloping this is a further fascial layer called the tunica dartos, which is again T1 and T2 hypointense. The tunica dartos is a continuation of Scarpa's fascia, and is responsible for the wrinkled appearance of the scrotum.

Question 6.15

Name the structures labelled **A** to **E**.

6.15 Sagittal T2 MRI of the female pelvis

A Fundus of uterus.
B Junctional zone.
C Endometrium.
D Myometrium.
E Cervix.

The uterus is an extra-peritoneal structure, lying between the bladder and the rectum. It can be divided into the fundus (the apex of the uterus), body and cervix. The endometrium is the lining of the uterine cavity and is seen as a hyperechoic stripe on ultrasound. The uterus is mostly smooth muscle that is known as myometrium, of which the innermost layer is the junctional zone. The junctional zone is an important structure to assess on imaging for endometrial carcinoma. It is best evaluated on T2-weighted MRI where it has a low signal compared than the myometrium. Tumours are considered to be confined to the endometrium when the junctional zone is preserved, although the junctional zone can be difficult to visualize in post-menopausal women.

Question 4.14

Name the structures labelled **A** to **E**.

4.14 Coronal T2 spin-echo MRI of the male pelvis

A Right iliacus.
B Sigmoid colon.
C Right seminal vesicle.
D Rectum.
E Right levator ani.

The seminal vesicles are paired structures that lie superiorly to the prostate and between the bladder and the rectum. Their function is to produce fluid that contributes to the ejaculate as it travels through the vas deferens. This fluid exits the seminal vesicles via the excretory ducts into the vas deferens as it enters the prostate gland. The seminal vesicles have a characteristic lobulated shape and their fluid content makes them readily identifiable on T2 weighted imaging.

Question 3.3

Name the structures labelled A to E.

3.3 Axial T1 MRI of the male pelvis

A Right sartorius muscle.
B Right femoral vein.

C Left obturator externus muscle.
D Right pectineus muscle.
E Right iliopsoas muscle.

The femoral triangle is an anatomical area of the upper thigh. Its boundaries can be remembered by using the mnemonic **SAIL** – the **S**artorius, the **A**dductor longus and the **I**nguinal **L**igament.

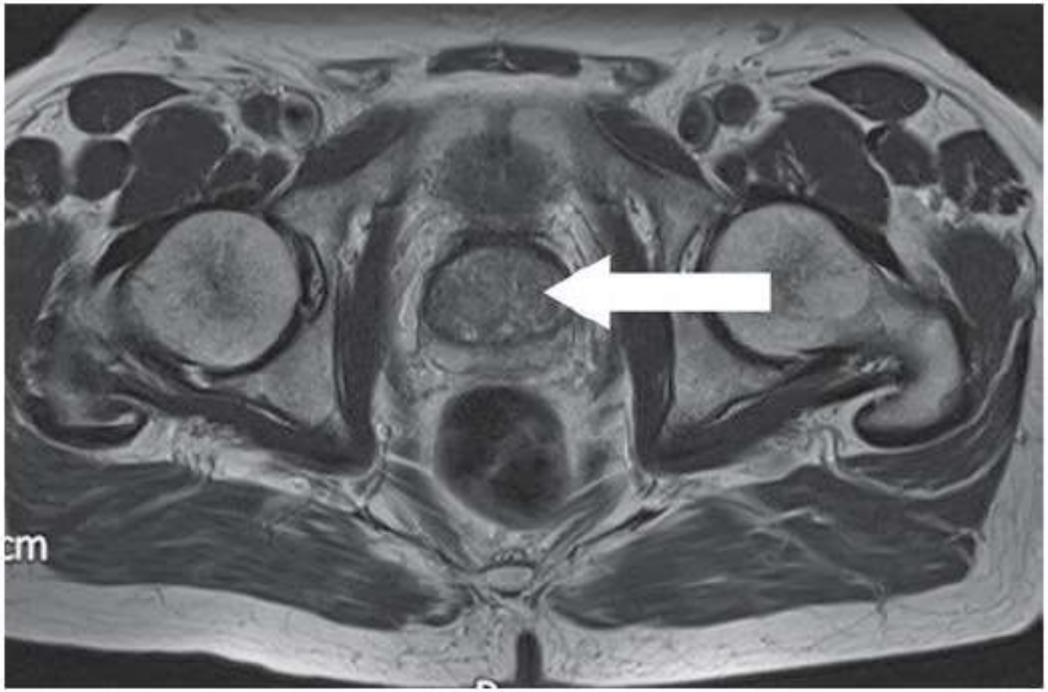
- Medial border – medial border of sartorius.
- Lateral border – medial border of adductor longus.
- Roof – inguinal ligament.

The floor is formed (from lateral to medial) by iliopsoas, pectineus and adductor longus.

A useful mnemonic for remembering the relative position of the femoral artery, vein and nerve in the groin is **NAVY** (Lateral to medial: **N**erve, **A**rtery, **V**ein, **Y**-fronts).

The femoral canal lies medial to the femoral vein, contains the deep inguinal lymph nodes and provides the short narrow passage for femoral herniae.

- Question 34:



Question 34: Axial T2-weighted MRI of the male pelvis

Answer: Prostate gland

- The prostate gland is a walnut-sized gland in the male pelvis, lying at the apex of the urinary bladder.
- The urethra passes in the superoinferior direction.
- The normal prostate gland has a characteristic zonal anatomy on T2-weighted MR imaging, consisting of a transitional, central, and peripheral zone as well as the anterior fibromuscular stroma.

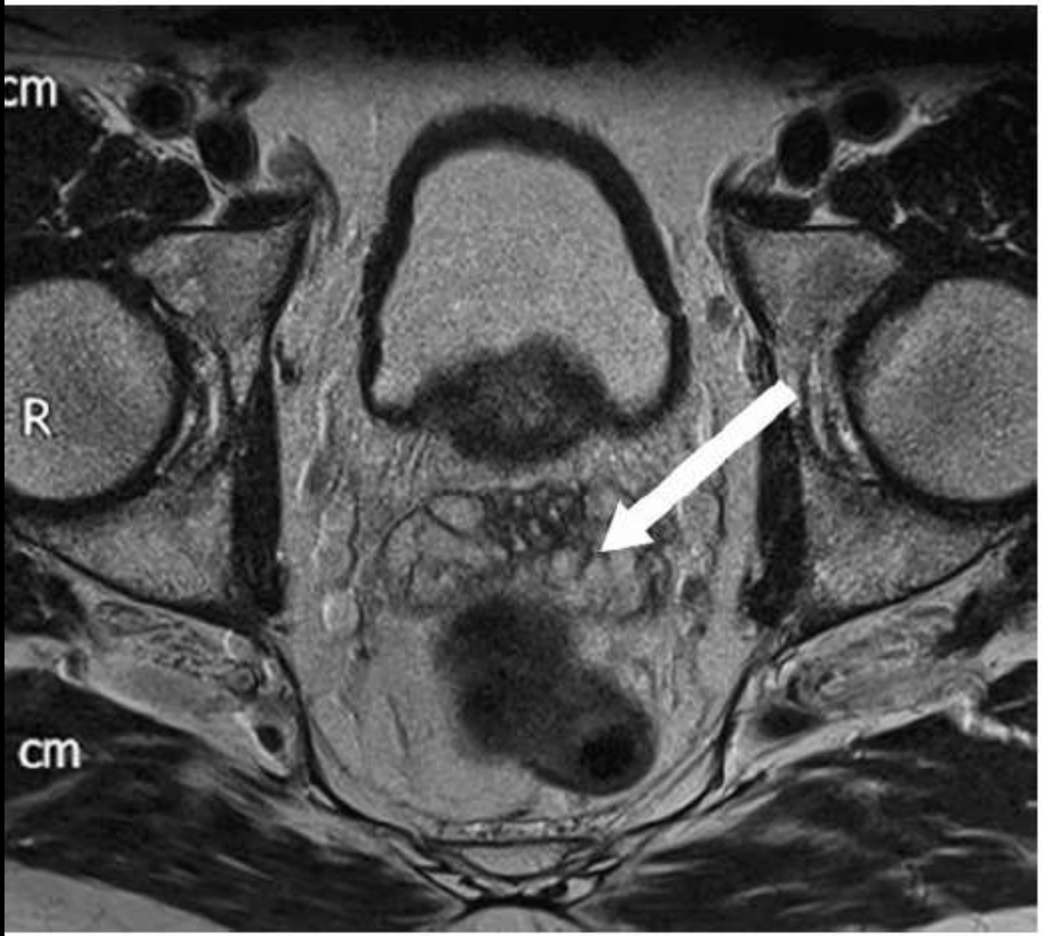
■ **Question 35:**

Question 35: Axial T1-weighted MRI of the sacrum

Answer: Left sacroiliac joint

- The sacroiliac joint is a large, partly fibrous, partly synovial joint between the sacral ala and the iliac bone.
- It is stabilised by very strong ligaments.

Question 9:



Question 9: Axial T2-weighted MRI of the male pelvis

Answer: Left seminal vesicle

- The seminal vesicles are paired structures posterior to the male bladder.
- Due to the high water content of the vesicles, they are of high signal intensity on T2-weighted MRIs.
- It is possible to confuse the seminal vesicles with ovaries when looking at just one slice. The way to determine whether this is a male or female pelvis is to look for the presence of the uterus—not here in this example—and to look for the presence of the prostate gland, situated behind the bladder as in this image.

Question 5.11

Name the structures labelled **A** to **E**.

5.11 Coronal T1 MRI of the pelvis

A Right gluteus minimus muscle.
B Right gluteus medius muscle.
C Right iliacus muscle.
D Left ovary.
E Uterus.

The buttocks are made up of three gluteal muscles – gluteus maximus, gluteus medius and gluteus minimus. These muscles act as extensors and abductors of the hip joint. The gluteus maximus is the largest and most powerful of these, and its distal attachments are to the iliotibial band and gluteal tuberosity of the femur. It is innervated by the inferior gluteal nerve (L5, S1 and S2). The gluteus medius and minimus are innervated by the superior gluteal nerve (L5 and S1).

Question 1.15

Name the structures labelled **A** to **E**.

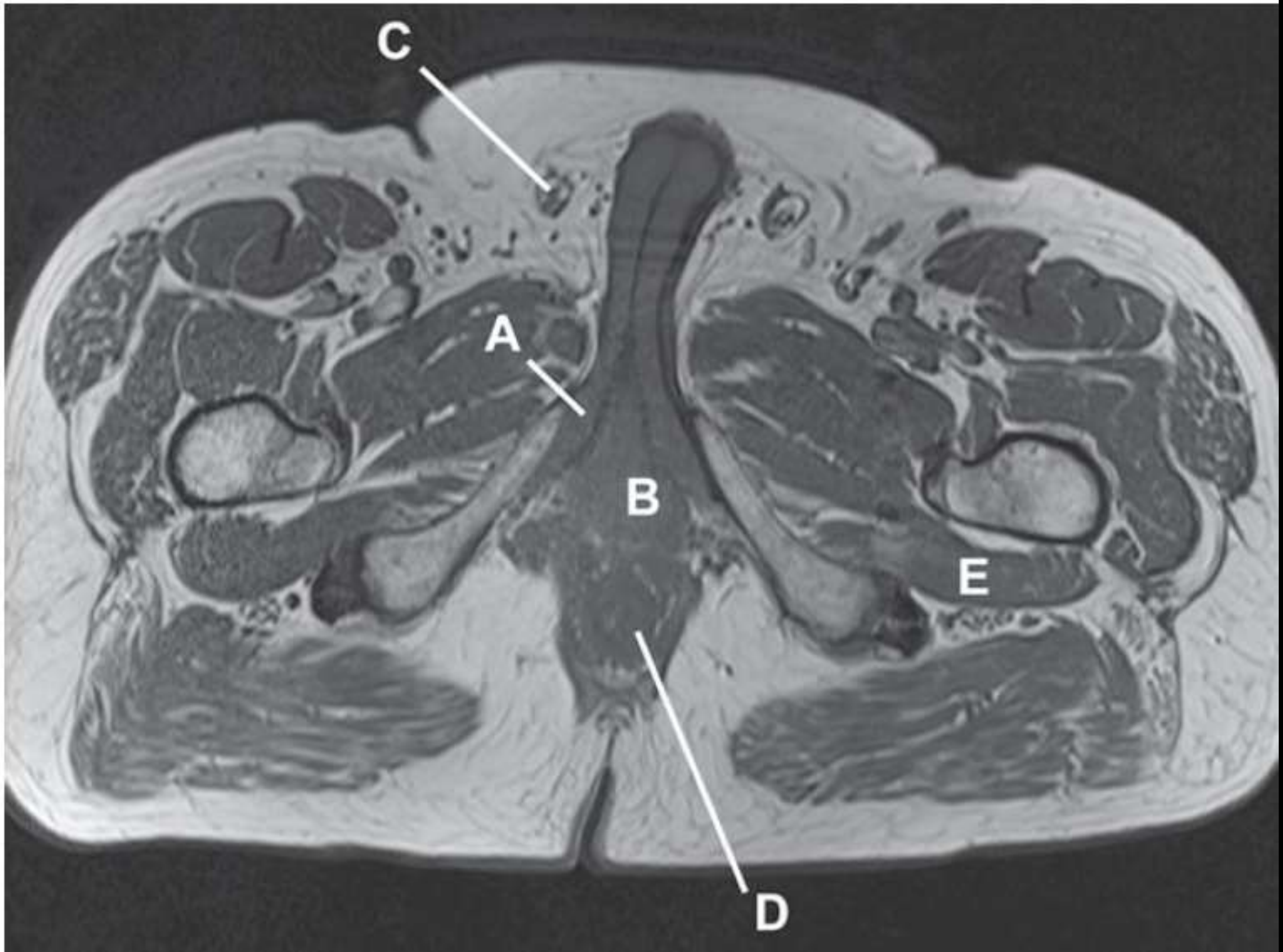
1.15 Sagittal T2 MRI of the female pelvis

A Bladder.
B Vesicouterine pouch.
C Pouch of Douglas (rectouterine pouch).
D Rectum.
E Uterine fundus.

The uterus is pear-shaped and composed of four parts: the fundus, body, cervix and internal os. It lies between the rectum and the bladder. The rectouterine pouch (pouch of Douglas) is an extension of the peritoneal cavity between the posterior uterus and the anterior rectum and is a common site for the spread of pathology and collection of fluid. The rectum is the final portion of the large intestine and is about 12 cm long. The lower third of the rectum is extraperitoneal. The levator ani supports the viscera and together with the coccygeus forms the pelvic floor. It is composed of three muscles: the puborectalis, pubococcygeus and iliococcygeus.

Q12

a Name the structure labelled A
b Name the structure labelled B
c Name the structure labelled C
d Name the structure labelled D
e Name the functional muscle group to which E belongs



Q12 Answers

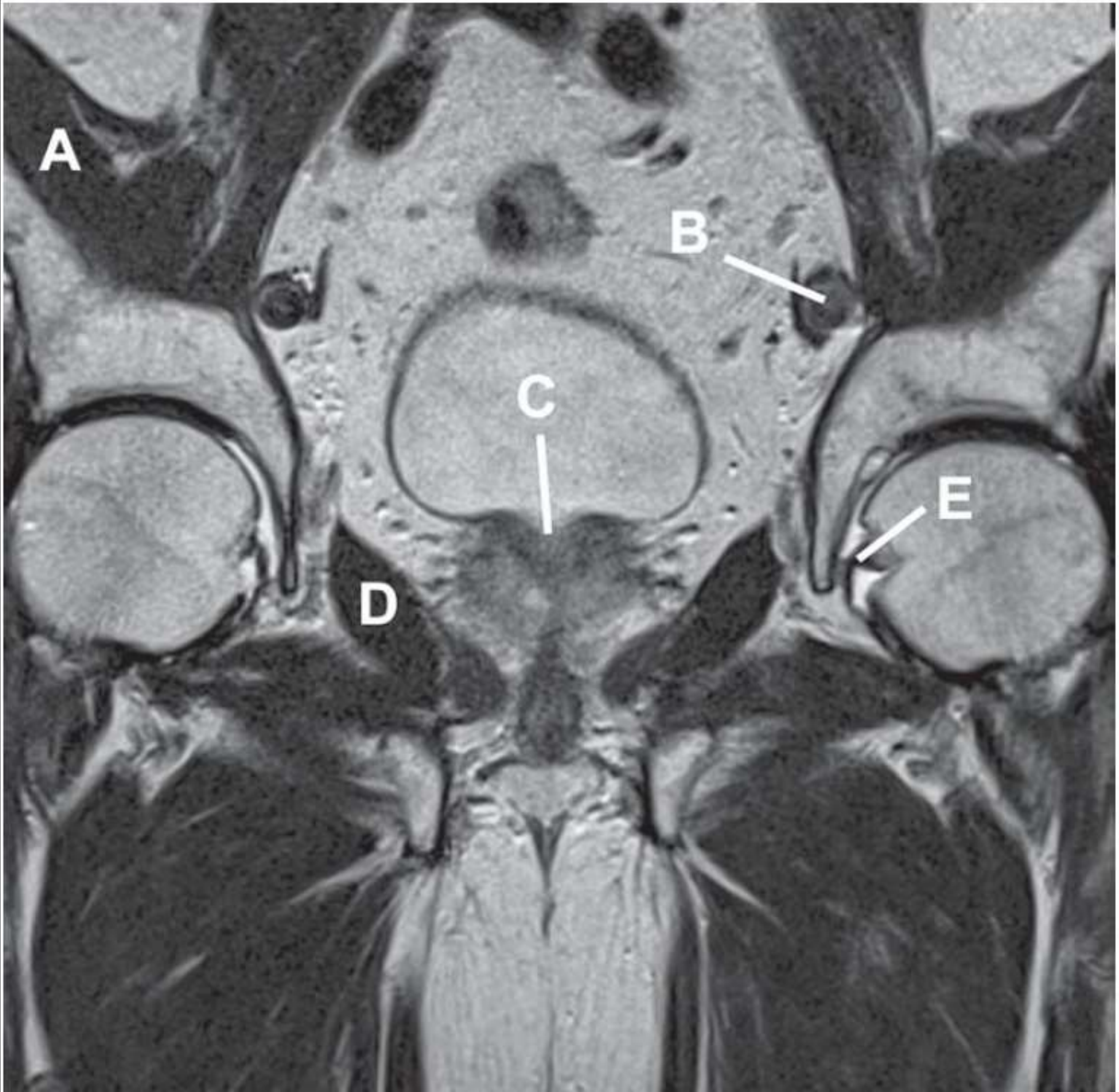
a Ischiocavernosus muscle
b Bulbospongiosus muscle
c Spermatic cord
d External anal sphincter
e The obturator externus is one of the external rotators of the hip

T1W MRI of male pelvic floor, axial slice

The penis is composed of three cylindrical bodies of erectile tissue, namely the corpus spongiosum (contains the urethra) and two paired corpora cavernosa (lie dorsally in the penis). In the pelvic floor the cavernosa divide to form the penile crura which lie along the ischiopubic rami, while the spongiosum forms the penile bulb in the midline. Muscular compression of these tissues by the ischiocavernosus and bulbospongiosus muscles at the root of the penis leads to erection.

The spermatic cord contains the structures running to and from the testis; the major structures include the vas deferens, testicular artery, pampiniform venous plexus and nerves.

The external anal sphincter is a ring of voluntary muscle surrounding the anal canal and is part of the levator ani muscle group.


A
B
C
D
E

Q13 Answers

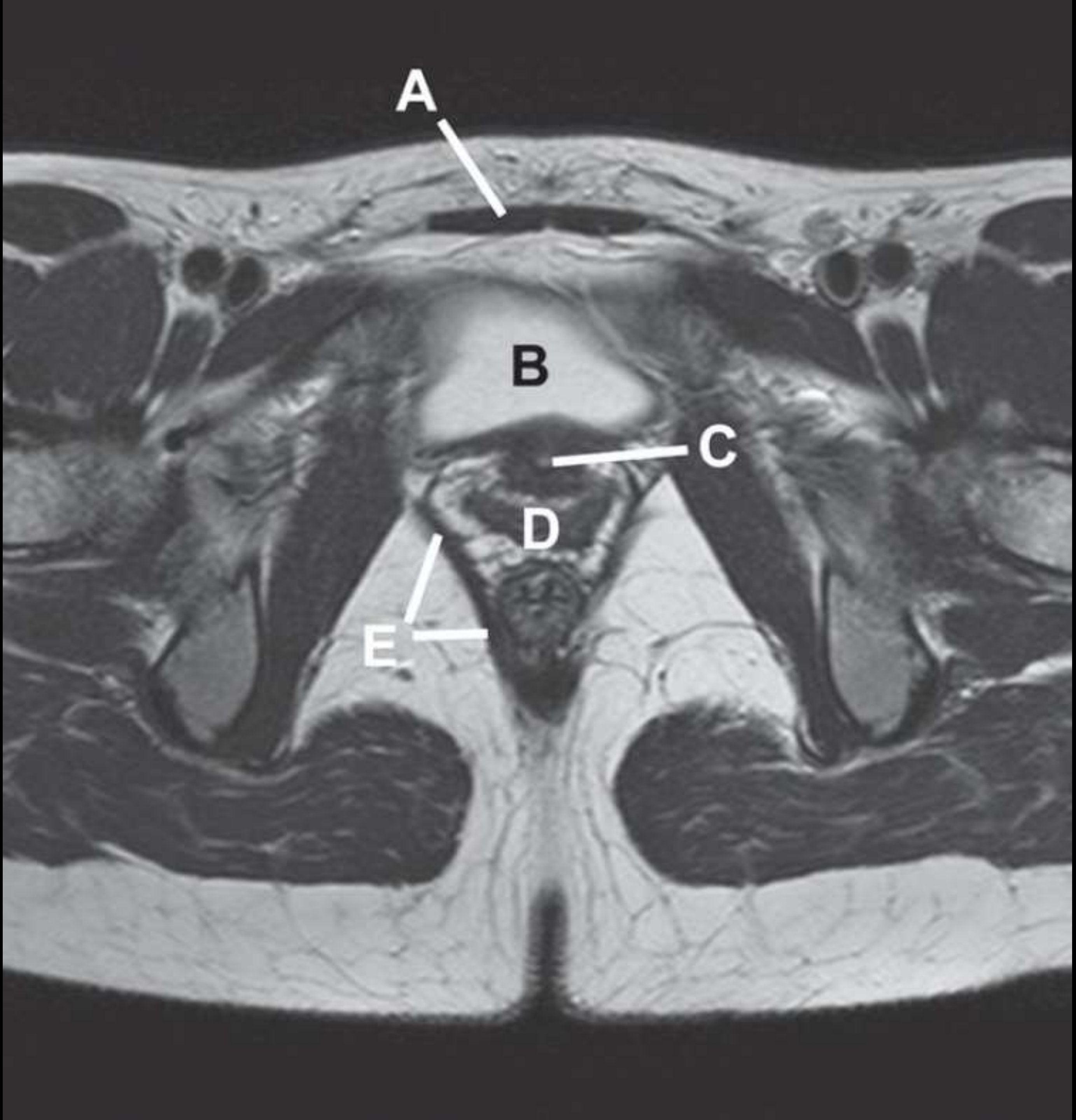
a Iliacus muscle
b External iliac artery
c Opening of the prostatic urethra (internal urethral orifice)
d Obturator internus muscle
e Ligamentum teres of the hip

T2W MRI of male pelvis, coronal section through prostate

The prostate sits on the urogenital diaphragm in the lower pelvis immediately beneath the urinary bladder. The prostatic urethra can be visualised with MRI.

Iliacus is a hip flexor which arises from the iliac fossa (hence the name) and joins with the psoas major muscle in its attachment to the lesser trochanter of the femur. The obturator internus muscle is attached to the lateral wall of the pelvic cavity and leaves the pelvis posteriorly by passing through the lesser sciatic foramen to attach to the greater trochanter of the femur.

The external iliac artery runs along the medial border of psoas major before exiting the pelvis.


A
B
C
D
E

Q14 Answers

a Rectus abdominis muscle
b Urinary bladder
c Urethra surrounded by external urethral sphincter
d Vagina
e Levator ani muscle

T2W MRI of female pelvic floor, axial section

The female pelvic floor has many of the same constituents as the male equivalent. The urogenital diaphragm stretches between the two sides of the pubic arch and provides support for the vagina. In both sexes, the urethra passes through the urogenital diaphragm which forms the external urethral sphincter at this level.

The ischiocavernosus and bulbospongiosus muscles have a very similar location in both sexes (not shown here) but in females the bulbospongiosus surrounds the vagina and these muscles provide erectile function to the clitoris.

The levator ani are a group of muscles which close the pelvic outlet (pelvic diaphragm) and form a loop around the anus providing support at the level of the pelvic floor. Lateral to the levator ani muscles lie the ischioanal fossae. These are fat filled triangular spaces which normally accommodate rectal expansion when required. Occasionally the ischioanal fossae can become infected leading to an ischioanal abscess. An ischioanal abscess can spontaneously open into both the anal canal and perineal skin leading to the formation of a perianal fistula.


A
B
C
D
E

Q15 Answers

a Endometrium
b Junctional zone of myometrium
c Trace of fluid in the recto-uterine pouch (of Douglas)
d Endocervical canal
e Myometrium of uterus

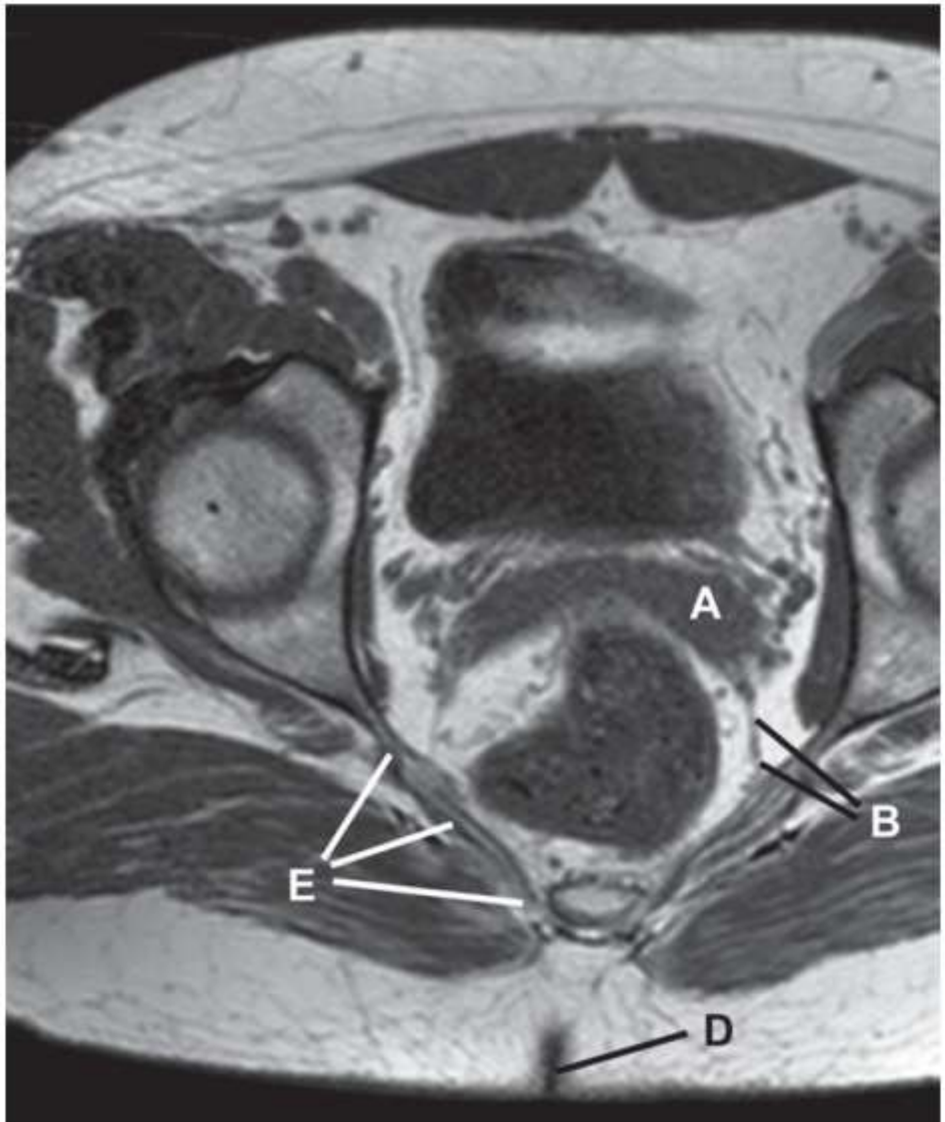
T2W MRI of female pelvis, midline sagittal section

T2W MRI is often used to evaluate the uterus as its zonal anatomy can be appreciated. The endometrium, endocervical canal and vaginal canal all appear with high signal intensity. The myometrium is divided into the low signal, inner junctional zone and the intermediate signal of uterine bulk. Both the internal and external cervical os can usually be seen at either end of the endocervical canal. The cervix normally protrudes into the upper vagina creating anterior and posterior recesses, known as the fornices. The position of the uterus is readily appreciated relative to the bladder; the normal position is anteverted (angle between vagina an uterus) and anteflexed (angle between cervix and uterus) meaning it lies anterior t the cervix and curves anteriorly over the bladder (as shown).

The deepest intraperitoneal part of the female pelvis is the space between the posterior uterus and anterior rectum. This is known as the recto-uterine pouch (of Douglas) and will often be seen to contain a trace of free peritoneal fluid (as a consequence of ovulation). In pathological states, this area is also where free fluid may collect first.

Q16

a Name the structure labelled A
b Name the structure labelled B
c Name the fatty spaces either side of structure B
d Name the structure labelled D
e Name the structure labelled E



Q16 Answers

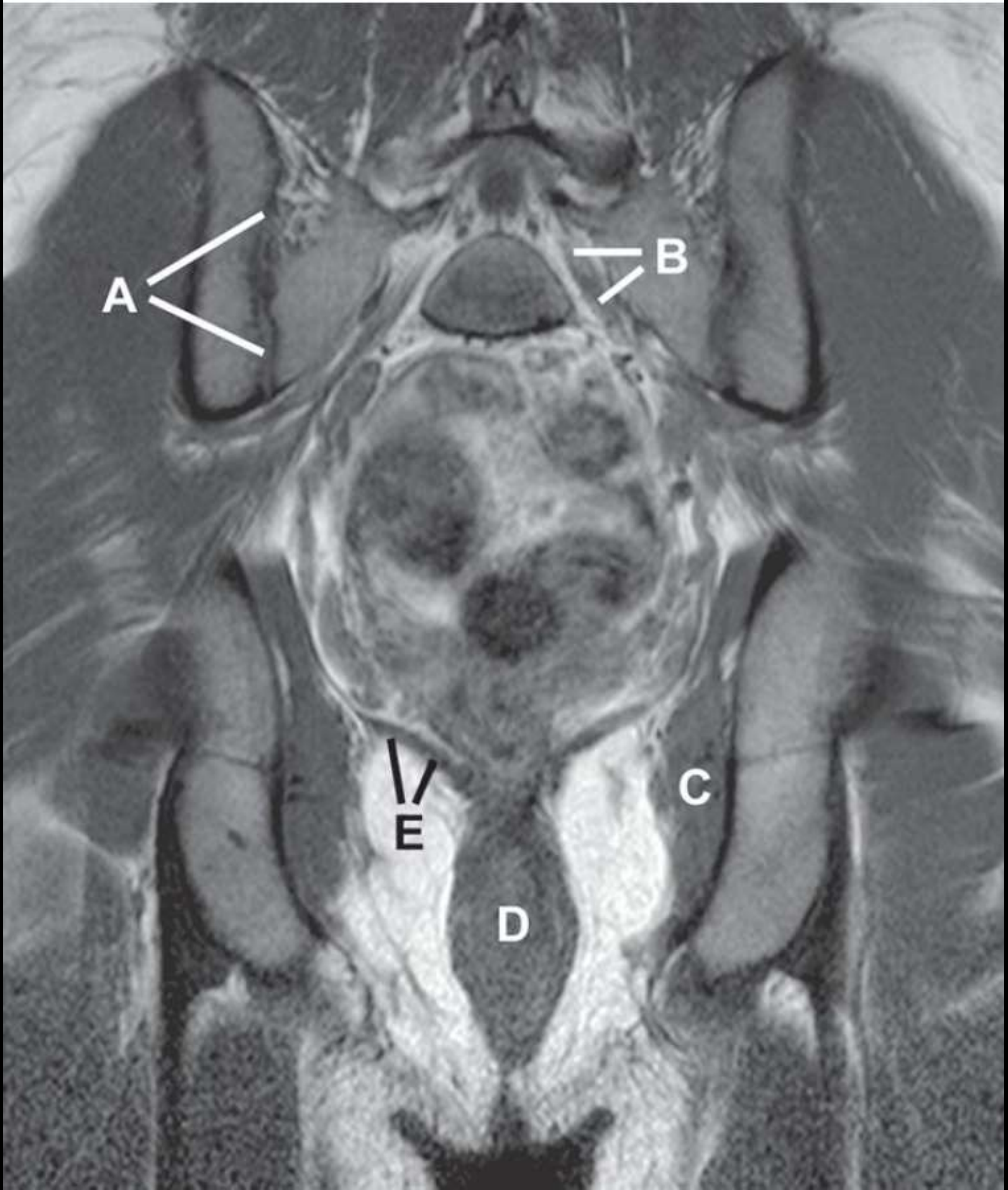
a Seminal vesicle
b Perirectal/mesorectal fascia
c Perirectal and pararectal fat
d Natal cleft
e Coccygeus muscle

T1W MRI of male pelvis at level of seminal vesicles, axial section

The seminal vesicles produce the medium in which sperms are transmitted from the body. The seminal vesicles lie on either side of the midline posterior to the prostate and bladder and anterior to the rectum in males. T2W MRI shows the seminal vesicles to be fluid filled.

The rectum is surrounded by fat within which is a layer known as the perirectal (or mesorectal) fascia. The perirectal fascia is an important plane to identify when staging rectal cancer using MRI.

The coccygeus muscle extends from the inferior sacrum and coccyx to the ischial spine and is one of the muscles of the pelvic diaphragm along with the levator ani group. The pelvic diaphragm separates the pelvic cavity from the perineum.


A
B
C
D
E

Q17 Answers

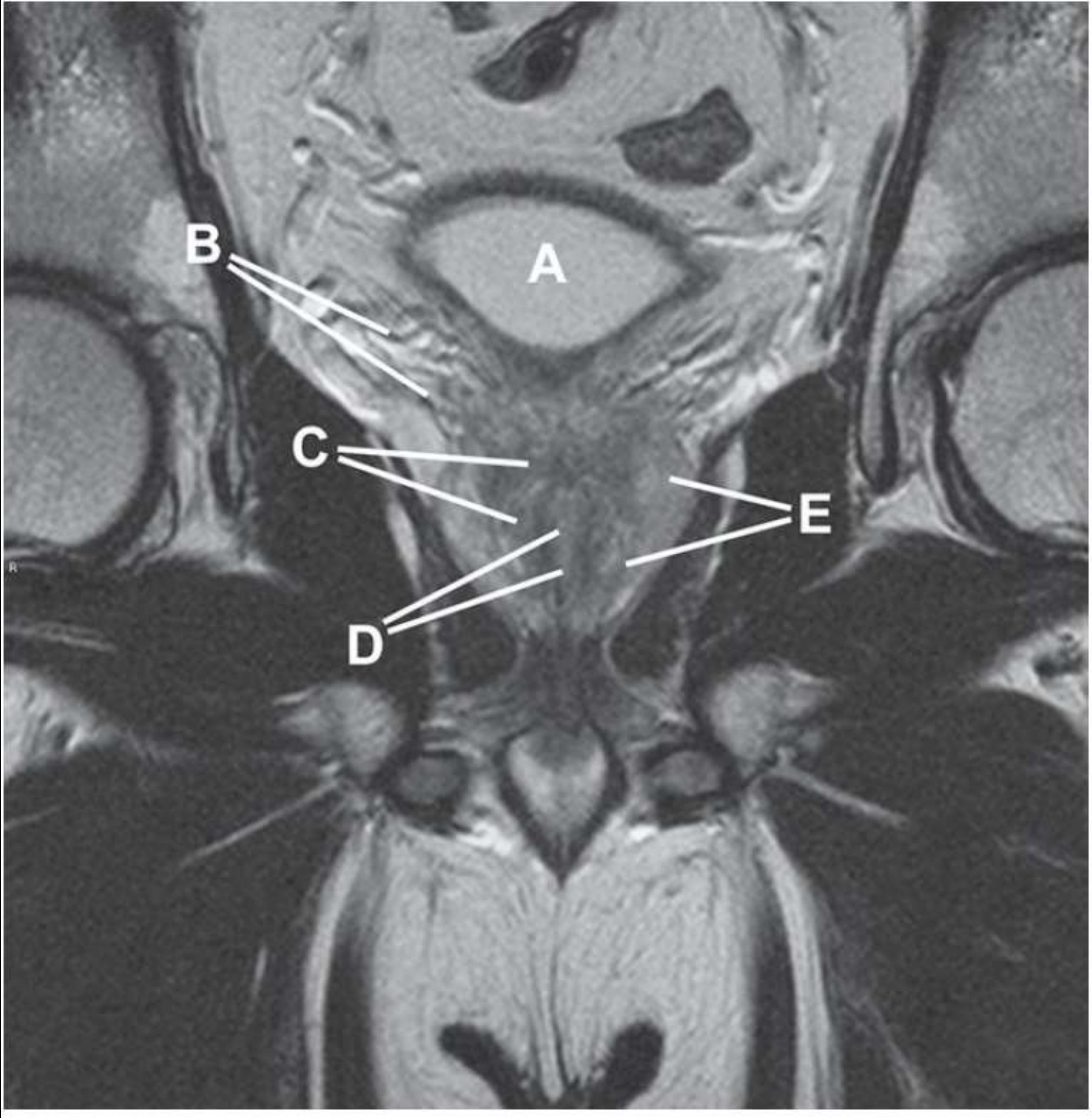
a Sacroiliac joint
b Sacral nerve root in sacral foramina
c Obturator internus muscle
d Rectum
e Levator ani muscle

T1W MRI showing rectum and posterior pelvis, coronal section

The sacroiliac joints are synovial joints but have very little mobility. They are strong weight bearing joints which link the spine to the pelvis. On MRI, the sacroiliac joints should show the interlocking corticated edges of both the sacrum and ileum.

The sacral nerves enter the pelvic cavity through the anterior sacral foramina as is demonstrated on this image. Sacral nerves supply the pelvis and lower limb.

The obturator internus muscle is an external rotator of the hip and covers most of the lateral wall of the pelvic cavity.



A
B
C
D
E
R

Q18 Answers

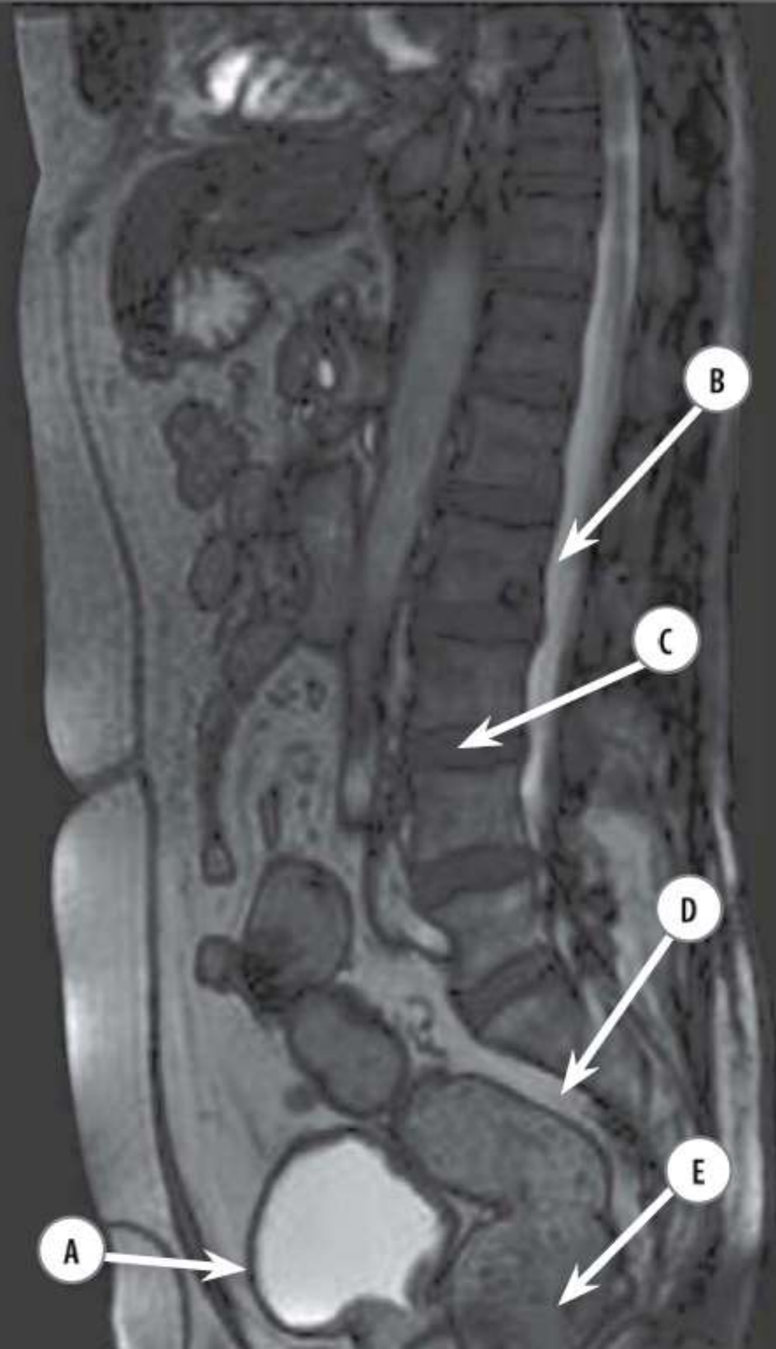
a Urinary bladder
b Right seminal vesicle
c Central zone of the prostate
d Prostatic urethra
e Peripheral zone of prostate

T2W MRI of prostate, coronal section

The prostate usually measures 3–5cm in length and sits inferior to the urinary bladder. The first part of the urethra passes through the prostate and is therefore named the prostatic urethra. Both transrectal ultrasound and T2W MRI can demonstrate the peripheral, central and transitional zones of the prostate. Most of the glandular tissue of the prostate can be found in the peripheral zone. On coronal T2W MRI the peripheral zone is seen as a high signal 'U' shaped area surrounding the lower signal superiorly placed central zone. The transitional zone surrounds the midportion of the urethra (not well seen here) and is not always differentiated from the central zone. The 'central gland' is a term used to describe the central and transitional zones collectively. With increasing age the transitional zone tends to hypertrophy; this can lead to an increase in size of the central gland which may reduce the diameter of the prostatic urethra leading to urinary outflow problems.

The seminal vesicles sit on either side of the midline postero-superiorly to the prostate and are fluid filled.

Case 3.30



Case 3.30

A Anterior bladder wall

B CSF within spinal canal

C L3/4 intervertebral disc

D Fat within the presacral space

E Rectum

Sagittal T2-weighted abdominal MRI.

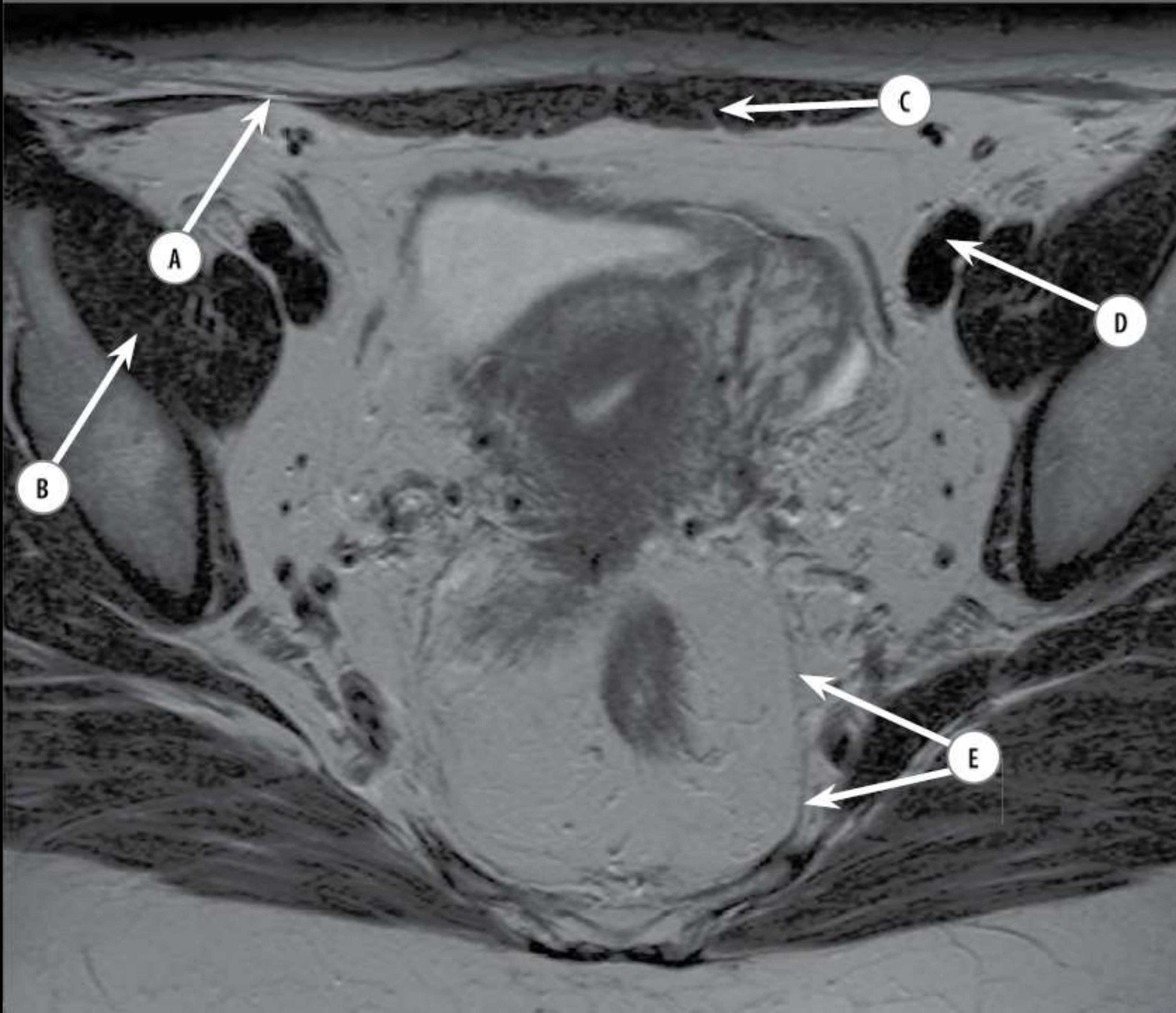
T2-weighting can help identify structures, e.g. the urine within the bladder returns a high signal but the adjacent muscular bladder wall appears dark and the CSF within the spinal canal appears bright.

The presacral space is located between the rectum and sacrum/coccyx. It typically measures up to 15 mm in the anteroposterior dimension, although this figure may be higher in older or obese patients. Superiorly, this space is bounded by reflections of the peritoneum. Its inferior border is made up of the levator ani and coccygeus muscles, and the ureter and iliac vessels are found laterally.

The rectum begins at the level of S3, and is approximately 13 cm long. The rectum does not have haustrations, but it does have three lateral folds, which are known as the valves of Houston. These are formed by the curved shape that the rectum adopts, due to the convexity of the rectal ampulla (a focal dilation) as it sits on the pelvic diaphragm. There are two left sided valves and one on the right. The rectum is extraperitoneal, with the pelvic peritoneum draped over the superior and lateral aspects of the upper and middle thirds, leaving the lower third uncovered.

Butler P, Mitchell AM, Ellis H. Applied Radiological Anatomy. Cambridge: Cambridge University Press, 1999: 219.
Kocaoglu M, Frush DP. Paediatric pre-sacral masses. Radiographics 2006; 26: 833–57.

Case 3.32



Case 3.32

A Spigelian fascia/linea semilunaris

B Right iliopsoas

C Left rectus abdominis

D Left external iliac artery

E Mesorectal fascia

Axial T2-weighted pelvic MRI.

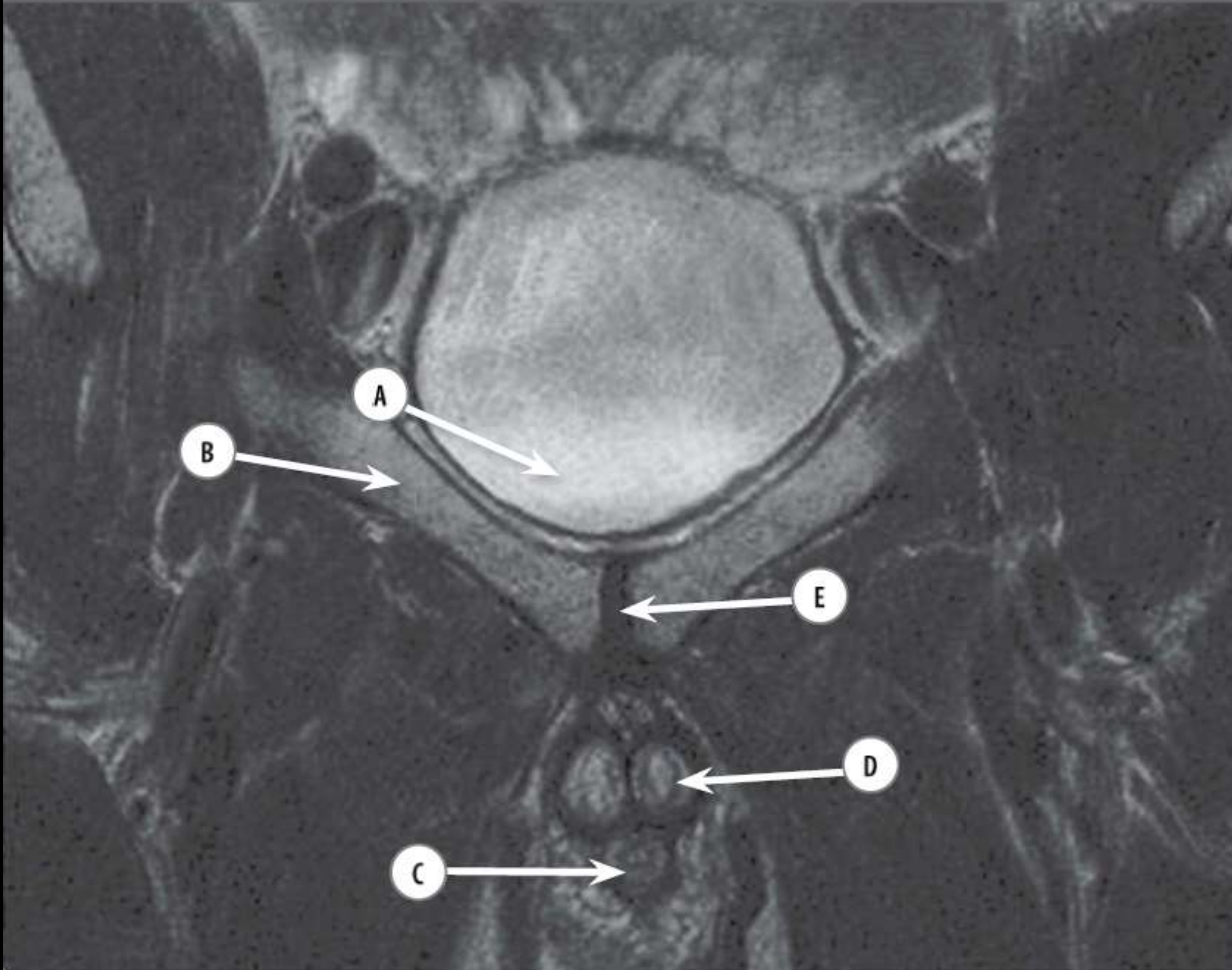
The spigelian fascia is formed from the aponeuroses of the internal and external obliques and transversus abdominis. It extends from the medial edge of these muscles to the lateral edge of the rectus muscles. These fibres then surround the rectus abdominis muscles, forming the rectus sheath and attaching them to the linea alba in the midline.

The mesorectal fascia is an important structure in the evaluation of rectal cancer as total mesorectal excision – removal of the rectum and mesorectum en-bloc within their enveloping fascia – has been shown to reduce local recurrence rates. The mesorectal fascia is seen as a thin, low signal intensity line surrounding the mesorectal tissue. It is best visualised on axial section. The mesorectal tissue is seen as high signal intensity, similar to fat, and contains blood vessels and lymphatics.

Brown G. High Resolution MRI of the Anatomy Important in Total Mesorectal Excision of the Rectum. Am J Roentgenol 2004; 182: 431–9.

Skandalakis LJ, Skandalakis JE, Skandalakis PN. Surgical Anatomy and Technique: a Pocket Manual, 3rd edn. New York: Springer, 2009: 174.

Case 3.38



Case 3.38

A Urinary bladder

B Right superior pubic ramus

C Corpus spongiosum

D Left corpus cavernosum

E Symphysis pubis

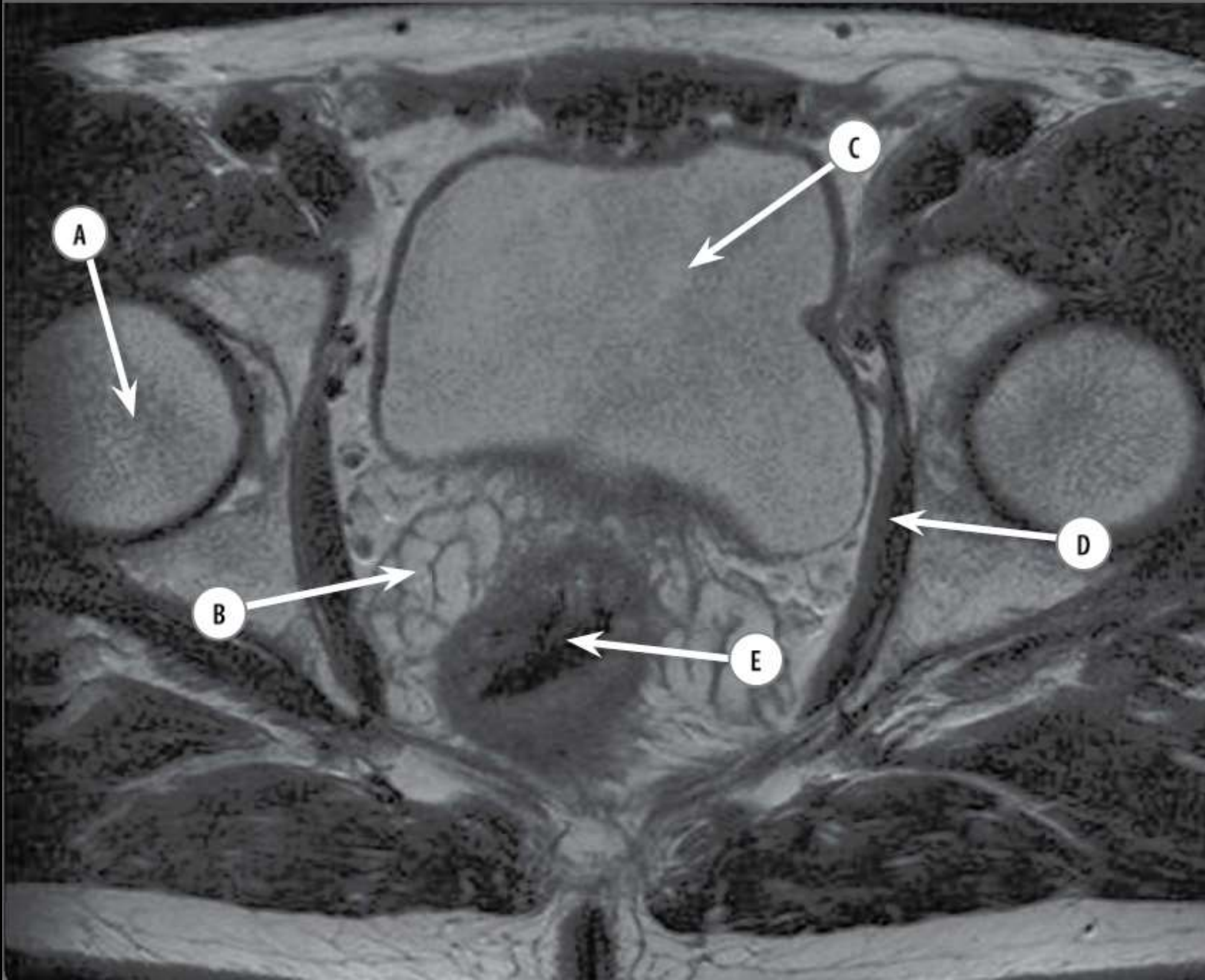
Coronal T2-weighted pelvic MRI.

The penis is comprised of three corpora which are bound together by Buck's fascia, an extension of the deep perineal fascia. The corpora are cylindrical in shape and are made up of the corpus spongiosum on the ventral surface, and the corpora cavernosum on the dorsal surface. Within the corpus spongiosum is the penile urethra, and within the corpora cavernosum are the cavernosal arteries. The corpora appear as high signal on T2-weighted images, and intermediate signal on T1-weighted images. On contrast-enhanced imaging, they appear very vascular.

The symphysis pubis is a fibrous joint, and therefore appears dark on MRI. In this image it is seen in the midline joining the two superior pubic rami. The bladder is seen superiorly and with a high signal intensity, due to its fluid content.

Ryan S, McNicholas M, Eustace SJ. Anatomy for Diagnostic Imaging, 3rd edn. Edinburgh: Saunders, 2011: 239.

Case 3.39



Case 3.39

A Right femoral head

B Right seminal vesical

C Urine within bladder

D Left obturator internus

E Rectum

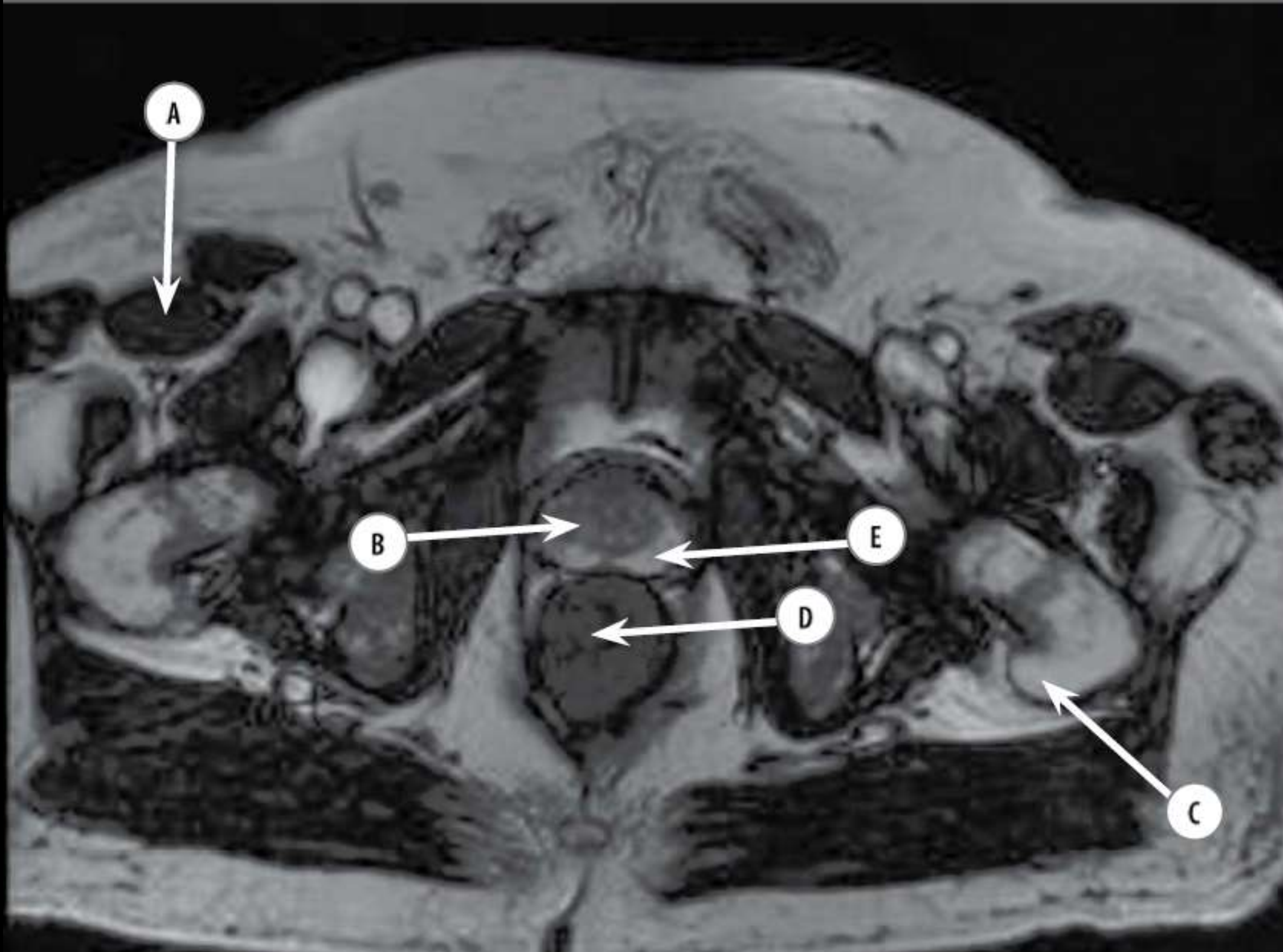
Axial T2-weighted pelvic MRI.

The seminal vesicles are found posterior, and superior to the prostate gland. They are paired, sacculated structures, which run transversely behind the bladder, and store semen. They are approximately 5 cm in length, and are continuous with the ampulla of the vas deferens inferomedially, where they form the ejaculatory ducts. These pass obliquely through the prostate gland to enter the prostatic utricle.

On T2-weighted MRI, the seminal vesicles return a high signal due to their fluid contents. On T1-weighted MRI, they appear dark and will stand out from the surrounding fat, which returns a high signal. On CT, they appear as soft tissue density structures, and have a 'bow tie' shape in between the bladder and prostate. Transrectal ultrasound imaging can be used as part of the assessment of prostatic carcinoma, and can demonstrate the seminal vesicles very clearly. With ultrasound, they appear as serpiginous tubular structures, which contain anechoic fluid.

Butler P, Mitchell AM, Ellis H. Applied Radiological Anatomy. Cambridge: Cambridge University Press, 1999: 289.

Case 3.40



Case 3.40

- **A** Right rectus femoris
- **B** Central prostate gland
- **C** Lesser trochanter of left femur
- **D** Rectum
- **E** Peripheral zone of prostate gland

Axial T2-weighted pelvic MRI.

The prostate can be described as having a pyramidal shape, with its base situated superiorly against the bladder and its apex inferiorly against the urogenital diaphragm. It has an anterior wall behind the pubic symphysis, a posterior wall adjacent to the rectum and two inferolateral walls.

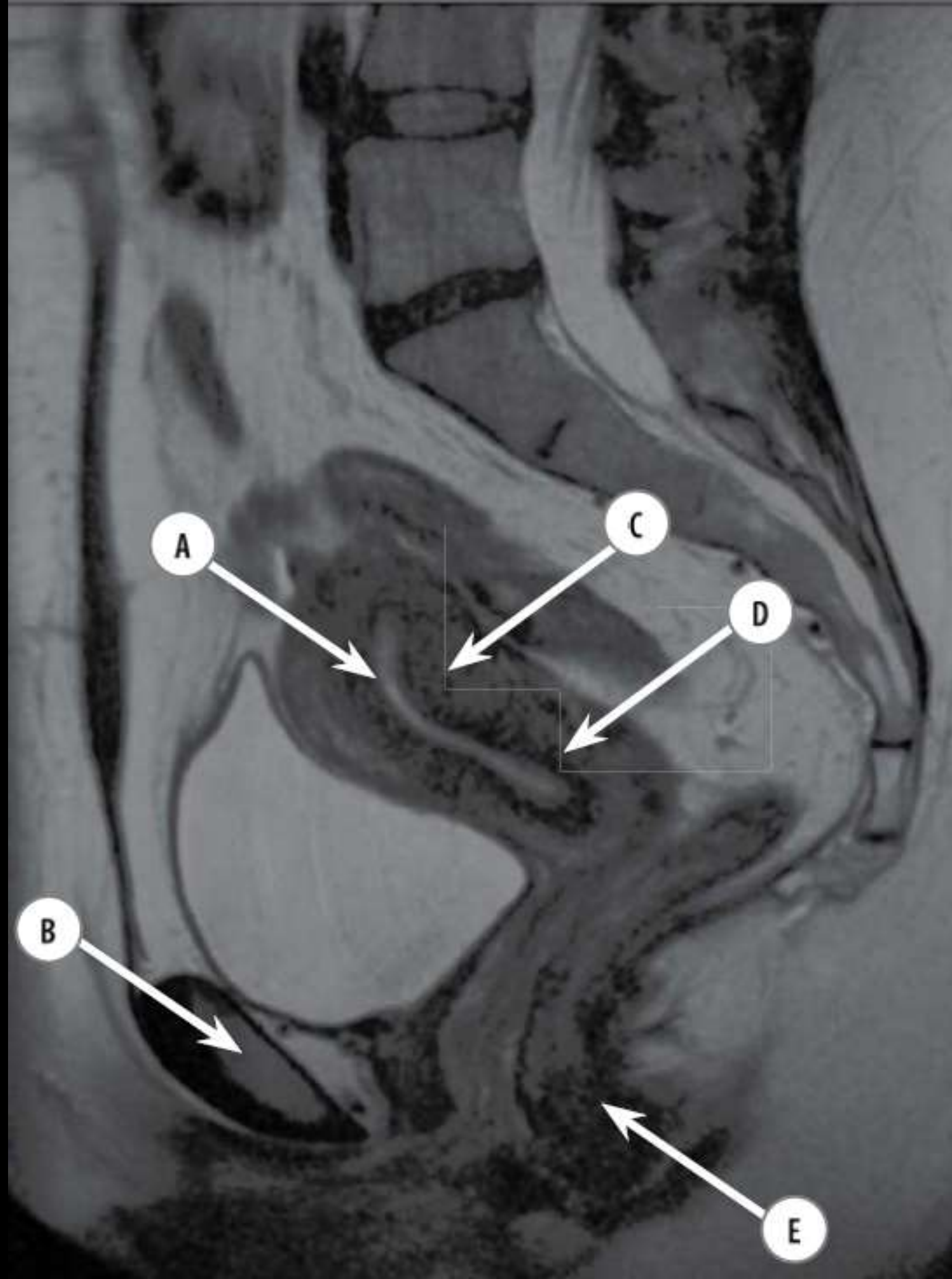
The prostate gland has three different glandular zones, which are nicely demonstrated on T2-weighted MRI images. There is also a fibromuscular isthmus located anterior to the urethra, containing little glandular tissue.

The peripheral zone returns a high signal on T2-weighted images, and is located posterolaterally extending towards the apex. The central and transitional zones return an intermediate signal and cannot be distinguished radiologically; both zones together are usually referred to as the central gland. They are located more superiorly within the gland and surround the urethra. The transitional zone is located within the central zone; it is a small area of tissue around the urethra at the level of the verumontanum. The ejaculatory ducts pass through the central zone to join the urethra at the verumontanum.

As part of the ageing process, the transitional zone hypertrophies and the central zone atrophies. The transitional zone is the area of the prostate affected by benign prostatic hypertrophy. Most prostate cancers, however, occur in the peripheral zone.

Ryan S, McNicholas M, Eustace SJ. Anatomy for Diagnostic Imaging, 3rd edn. Edinburgh: Saunders, 2011: 233–234.

Case 3.44



Case 3.44

A Endometrium

B Pubis

C Myometrium

D Junctional zone

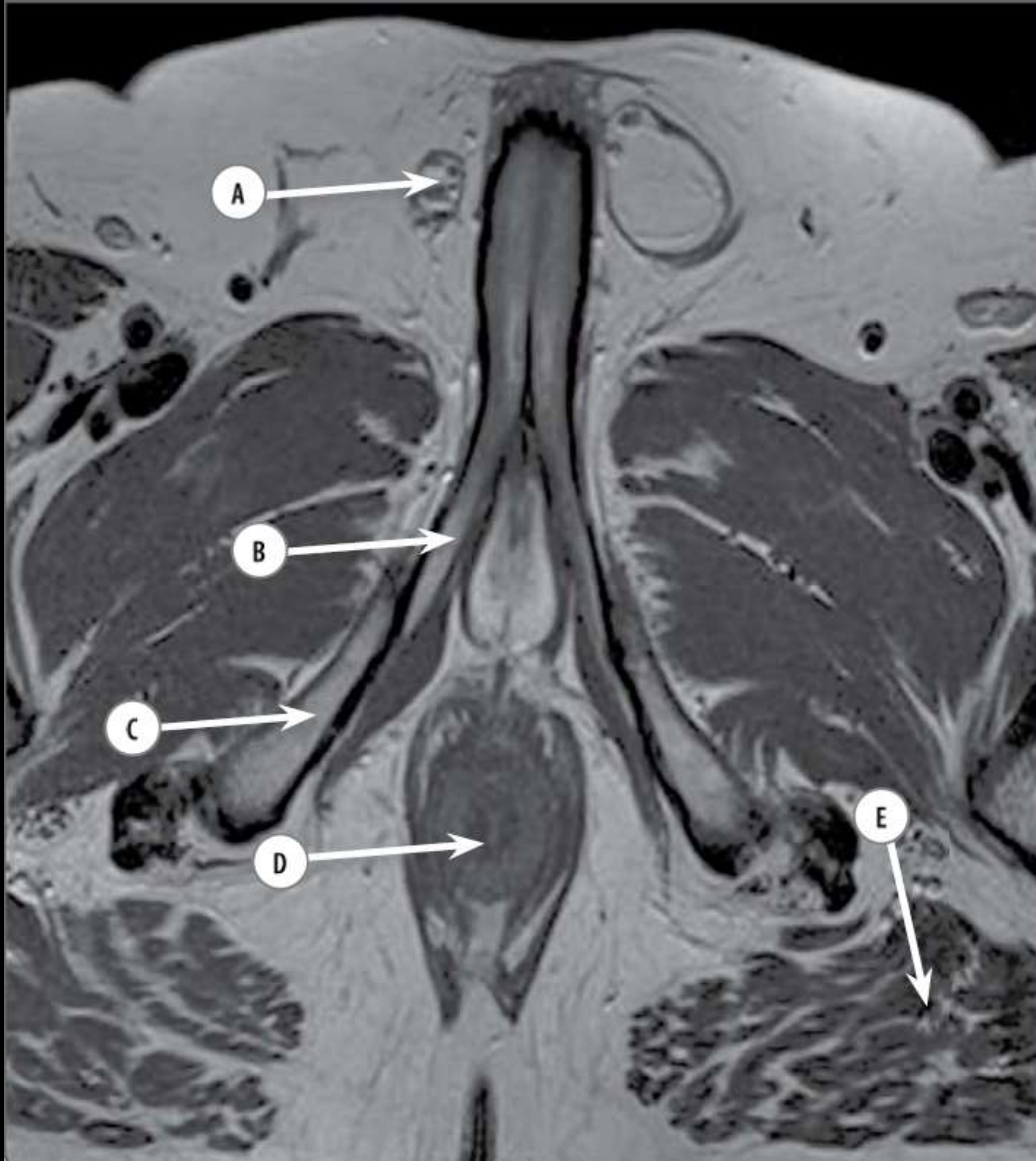
E Anal canal

Sagittal T2-weighted MRI of a female pelvis.

Uterine anatomy is well demonstrated on MRI. On T2-weighted sequences the endometrium, endocervical canal and vaginal canal all return a high signal. The serosal layer which surrounds the uterus gives a thin hypointense line around the periphery. Below this is the myometrial tissue which returns an intermediate signal. However, the deeper myometrium, found just below the endometrial layer, returns a low signal and is known as the junctional zone. This tissue is histologically similar to the remainder of the myometrium, but it is thought that its increased nuclear:cellular ratio is responsible for this low signal. The low signal junctional zone is continuous with the fibrous stroma of the cervix, which can be nicely demonstrated on sagittal images.

Ryan S, McNicholas M, Eustace SJ. Anatomy for Diagnostic Imaging, 3rd edn. Edinburgh: Saunders, 2011: 240–247.

Case 3.57



Case 3.57

A Spermatic cord within right inguinal canal

B Crus of right corpus cavernosum

C Right inferior pubic ramus

D Anal canal

E Left gluteus maximus

Axial T2-weighted pelvic MRI.

The spermatic cord is made up of the arterial and venous supply to the testis and the lymphatics, nervous supply and vas deferens. The cord travels from the abdominal cavity to the scrotum via the inguinal canal and is covered by a tough fibrous sheath which originates from the fasciae of the anterior abdominal wall muscles. As they descend, these fascial layers become the internal and external spermatic, as well as the cremasteric, fascial layers.

The corpora cavernosa, located on the dorsal aspect of the penis, are paired cylindrical structures comprised of erectile tissue. They are fused in the sagittal plane, separated by a septum. However, at their most posterior extent they separate to form the crura. These crura are each attached to the ischiopubic rami on the inferomedial surface. On T2-weighted MRIs the corpora return a high signal, with the surrounding fascial layers appearing dark. On T1-weighted scans they are of an intermediate signal.

The anal canal begins at the level of the pelvic floor, and is angled posteriorly, at 90° to the rectum. At this level it is encircled by the puborectal sling, which causes its angulation. It passes downwards and backwards, and is about 3cm in length. The upper two thirds of the canal is formed by the internal sphincter. The external sphincter forms the lower two thirds, and the two muscles therefore overlap in the middle. The inferior rectal artery supplies the lower half of the anal canal, below the level of the mucocutaneous junction, which marks the termination of the hind gut. The proximal portion is supplied by the superior rectal artery. The lymphatic drainage is similarly split, with the inferior half of the anal canal draining to the medial group of the superficial inguinal nodes, and the upper canal draining via the inferior mesenteric nodes.

The lymphatic drainage in the abdomen tends to follow the arterial supply. Lymph drains first to local nodes, and then on to regional nodal groups (lumbar, celiac, superior and inferior mesenteric groups). These lymphatic groups drain via the intestinal and lumbar lymphatic trunks to the cisterna chyli, which in turn drains into the thoracic duct.

Ryan S, McNicholas M, Eustace SJ. Anatomy for Diagnostic Imaging, 3rd edn. Edinburgh: Saunders, 2011: 207–208, 225–226, 239.
Butler P, Mitchell AM, Ellis H. Applied Radiological Anatomy. Cambridge: Cambridge University Press, 1999: 221–222, 274–275.