



8

The Blood Vessels of the Abdomen, Pelvis, and Perineum



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THE ABDOMINAL AORTA

Traumatic Injury to the Abdominal Aorta

Because of the deep position of the aorta on the posterior abdominal wall behind the peritoneum (see text Figs. 8-1 and 8-2), **blunt injuries** to the aorta are relatively rare. In children the elasticity of the aortic wall and the usual absence of atherosclerosis make the condition even more rare.

In blunt trauma from an automobile accident, the abdominal aorta can be injured by the crossing band of a seat belt. The tunical intima is commonly damaged just distal to the origin of the inferior mesenteric artery at the level of the third lumbar vertebra. The diagnosis is difficult since occlusion due to thrombosis may occur at the time of the trauma or be delayed for several months. In the presence of complete occlusion, the femoral pulses are absent, and motor and sensory deficits may be present in the lower limbs due to ischemia of the peripheral nerves.

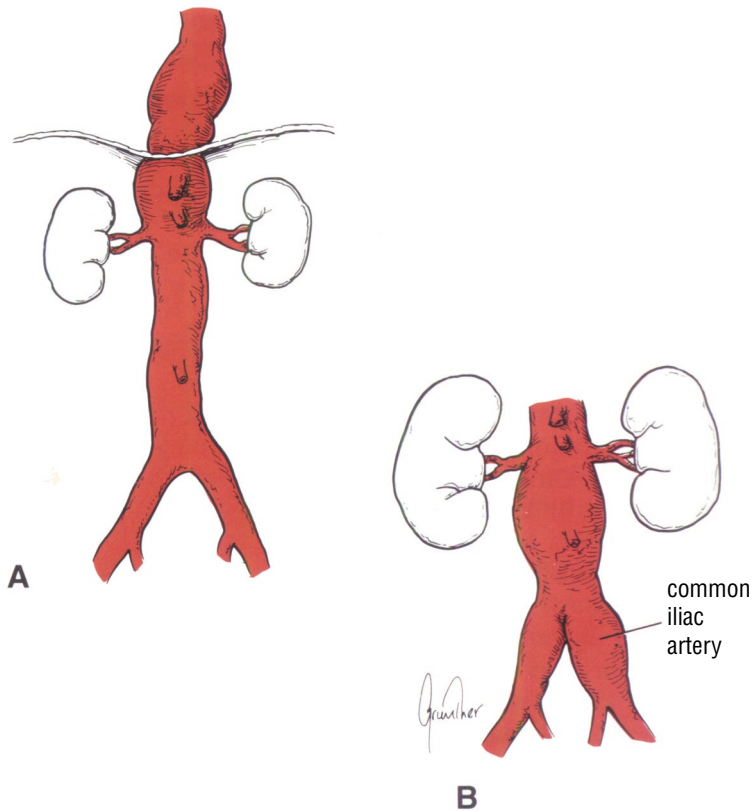
Deceleration injuries to the renal vessels may occur as the body stops its forward motion. The abdominal aorta, like the descending thoracic aorta, is tightly attached to the vertebral column by connective tissue. The kidney,

however, is relatively mobile and continues to move forward after body impact, being finally restrained by the attachment of the renal artery to the aorta. Excessive stretching of the renal artery may cause intimal damage with clot formation. The renal vessels may be avulsed from the hilum of the kidney, or the renal artery may be torn free from the aorta. The hemorrhage may be contained in the retroperitoneal space, and hypovolemic shock may not immediately occur.

Penetrating injuries to the abdominal aorta are common and are usually associated with multiple intraabdominal injuries. The peritoneum has been violated, and hemorrhage occurs directly into the peritoneal cavity. The signs of a distended abdomen associated with those of hypovolemic shock make the diagnosis relatively simple. However, when the arterial leak is small, peritoneal lavage may be necessary to confirm the diagnosis. Penetrating injuries through the back or flank (especially when directed from the left) may cause a retroperitoneal injury to the aorta; the blood may be contained within the retroperitoneal space and delay the onset of hypovolemic shock.

Aortic Aneurysms

Localized or diffuse dilatations of the abdominal part of the aorta (aneurysms) usually occur below the origin of the renal arteries (CD Fig. 8-1). Most result from atherosclerosis, which causes weakening of the arterial wall, and occur most commonly in elderly men. Large aneurysms should be surgically excised and replaced with a prosthetic graft.



CD Figure 8-1 Aneurysms of the abdominal aorta. **A.** Above the origin of the renal arteries. **B.** Below the level of the renal arteries. The latter aneurysms, which are the most common, may extend inferiorly to involve the common iliac arteries.

Gradual Occlusion of the Abdominal Aorta

Gradual occlusion of the aorta may occur due to atherosclerosis. Intermittent claudication in both legs may be present due to insufficient arterial blood reaching the muscles of the lower limbs. If the progress of the atherosclerosis is slow, an adequate collateral circulation may become established (CD Fig. 8-2).

Embolus Blockage of the Abdominal Aorta

The bifurcation of the abdominal aorta where the lumen suddenly narrows may be a lodging site for an embolus discharged from the heart. Severe ischemia of the lower limbs results.

Mesenteric Artery Occlusion

Occlusion of the superior or inferior mesenteric arteries with intestinal ischemia is discussed in CD Chapter 19. The occlusive process commonly occurs at the origin of the artery or in the proximal 1 to 2 cm of the artery and may be caused by an embolus, a thrombus, or trauma. Oc-

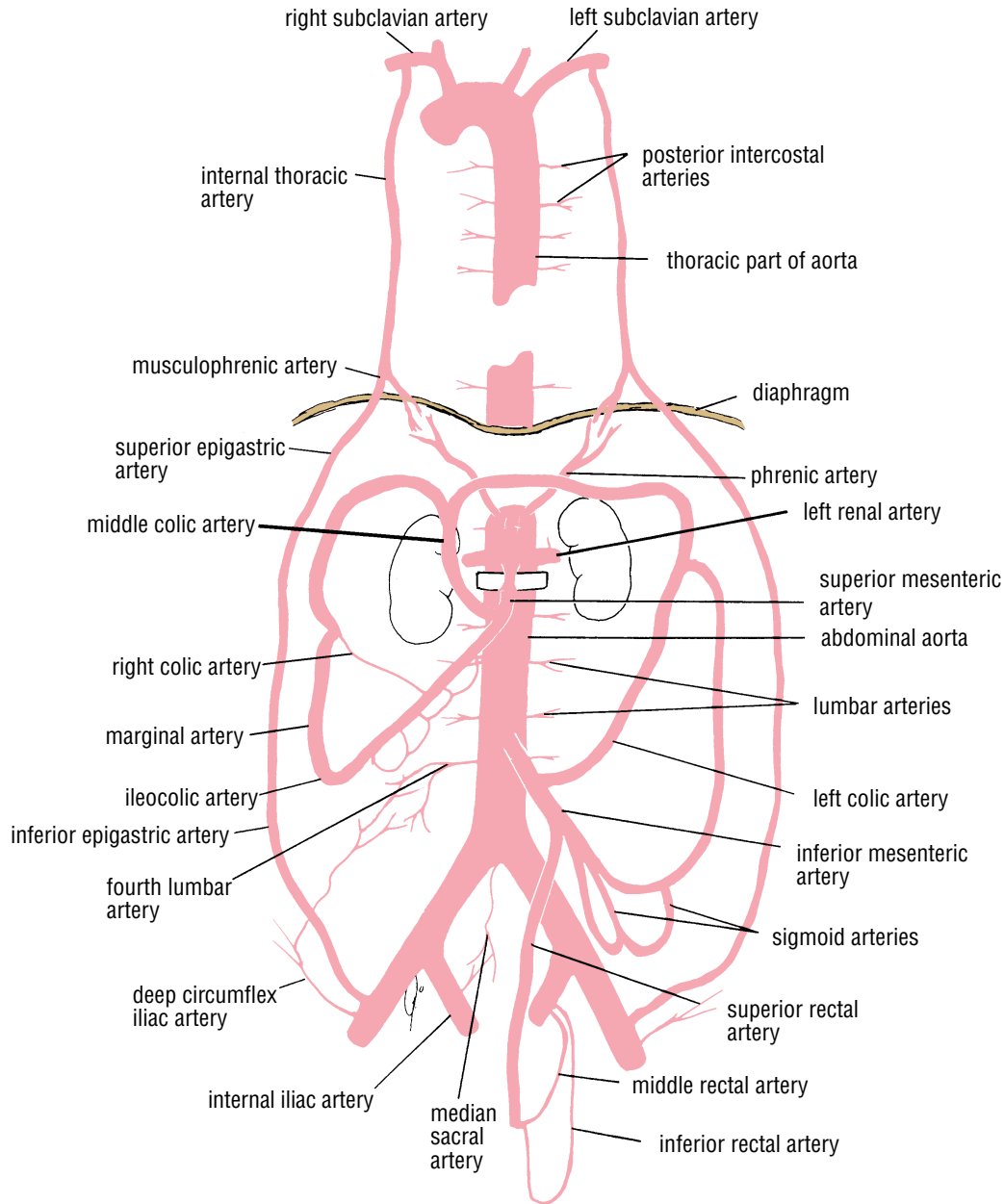
clusive disease of the superior mesenteric artery is much more common than that of the inferior mesenteric artery, which may be explained by the angle of takeoff of the superior artery from the aorta. In cases of embolus of the superior mesenteric artery, the embolus usually lodges in the region of the middle colic artery so that the jejunum may be spared.



THE INFERIOR VENA CAVA

Caval-Caval Anastomosis

A caval-caval shunt is the opening up of an alternative venous pathway should the superior or inferior vena cava become blocked by disease. The anastomoses of the vena cava are as follows (CD Fig. 8-3): The lumbar veins, which are tributaries of the inferior vena cava, anastomose behind the diaphragm with the azygos and hemiazygos veins, which are tributaries of the superior vena cava. The lumbar veins also anastomose with the superficial veins of the trunk, which eventually drain into the superior vena cava via the lateral thoracic veins, tributaries of the axillary veins.



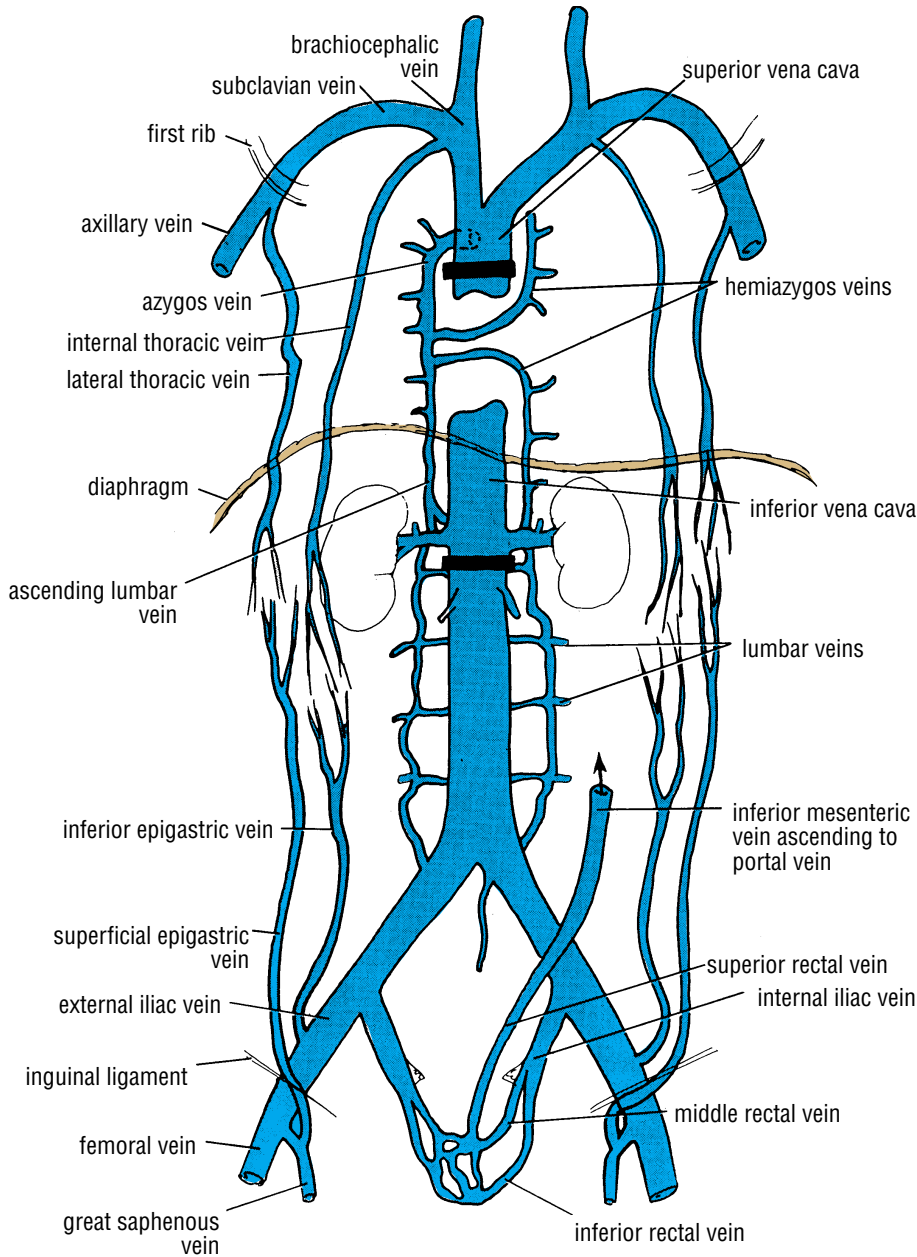
CD Figure 8-2 The possible collateral circulations of the abdominal aorta. Note the great dilatation of the mesenteric arteries and their branches, which occurs if the aorta is slowly blocked just below the level of the renal arteries (*white bar*).

Compression of the Inferior Vena Cava

The inferior vena cava is commonly compressed by the enlarged uterus during the later stages of pregnancy. This produces edema of the ankles and feet and temporary varicose veins.

Malignant retroperitoneal tumors can cause severe compression and eventual blockage of the inferior vena cava. This results in the dilatation of the extensive anastomoses of the tributaries (see CD Fig. 8-3).

This alternative pathway for the blood to return to the right atrium of the heart is commonly referred to as the **caval-caval shunt**. The same pathway comes into effect in patients with a superior mediastinal tumor compressing the superior vena cava. Clinically, the enlarged subcutaneous anastomosis between the lateral thoracic vein, a tributary of the axillary vein, and the superficial epigastric vein, a tributary of the femoral vein, may be seen on the thoracoabdominal wall (see CD Fig. 8-3).



CD Figure 8-3 The possible collateral circulations of the superior and inferior venae cavae. Note the alternative pathways that exist for blood to return to the right atrium of the heart if the superior vena cava becomes blocked below the entrance of the azygos vein (*upper black bar*). Similar pathways exist if the inferior vena cava becomes blocked below the renal veins (*lower black bar*). Note also the connections that exist between the portal circulation and the systemic veins in the anal canal.

Trauma to the Inferior Vena Cava

Injuries to the inferior vena cava are commonly lethal, despite the fact that the contained blood is under low pressure. The anatomic inaccessibility of the vessel behind the liver, duodenum, and mesentery of the small intestine and the blocking presence of the right costal margin make a surgical approach difficult. Moreover, the thin wall of the vena cava makes it prone to extensive tears.

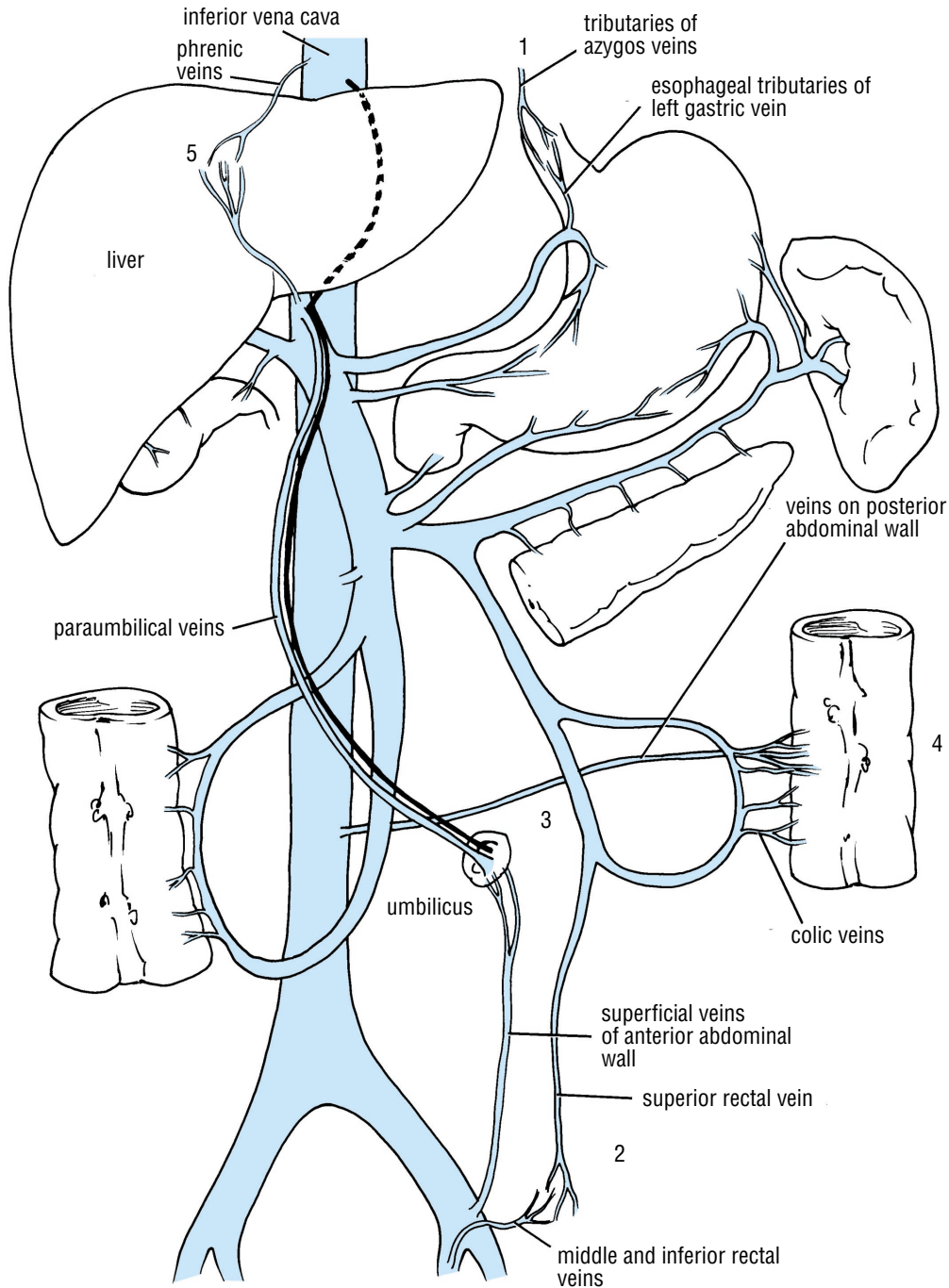
Because of the multiple anastomoses of the tributaries of the inferior vena cava (see CD Fig. 8-3), it is possible in an emergency to ligate the vessel. Most patients have venous congestion of the lower limbs.



THE PORTAL VEIN

Portal-Systemic Anastomoses

Under normal conditions, the portal venous blood traverses the liver and drains into the inferior vena cava of the systemic venous circulation by way of the hepatic veins. This is the direct route (see text Fig. 8-19). However, other, smaller communications exist between the portal and systemic systems, and they become important when the direct route becomes blocked (CD Fig. 8-4).



CD Figure 8-4 Important portal–systemic anastomoses.

These communications are as follows:

- **At the lower third of the esophagus**, the esophageal branches of the left gastric vein (portal tributary) anastomose with the esophageal veins draining the middle third of the esophagus into the azygos veins (systemic tributary).
- **Halfway down the anal canal**, the superior rectal veins (portal tributary) draining the upper half of the anal canal anastomose with the middle and inferior rectal veins (systemic tributaries), which are tributaries of the internal iliac and internal pudendal veins, respectively.
- The **paraumbilical veins** connect the left branch of the portal vein with the superficial veins of the anterior abdominal wall (systemic tributaries). The paraumbilical veins travel in the falciform ligament and accompany the ligamentum teres.
- The **veins of the ascending colon, descending colon, duodenum, pancreas, and liver** (portal tributary) anastomose with the renal, lumbar, and phrenic veins (systemic tributaries).

Portal Hypertension

Portal hypertension is a common clinical condition; thus, the list of portal–systemic anastomoses should be remembered. Enlargement of the portal–systemic connections is frequently accompanied by congestive enlargement of the spleen. Portacaval shunts for the treatment of portal hypertension may involve the anastomosis of the portal vein, because it lies within the lesser omentum, to the anterior wall of the inferior vena cava behind the entrance into the lesser sac. The splenic vein may be anastomosed to the left renal vein after removing the spleen.

Blood Flow in the Portal Vein and Malignant Disease

The portal vein conveys about 70% of the blood to the liver. The remaining 30% is oxygenated blood, which passes to

the liver via the hepatic artery. The wide angle of union of the splenic vein with the superior mesenteric vein to form the portal vein leads to streaming of the blood flow in the portal vein. The right lobe of the liver receives blood mainly from the intestine, whereas the left lobe plus the quadrate and caudate lobes receive blood from the stomach and the spleen. This distribution of blood may explain the distribution of secondary malignant deposits in the liver.

Penetrating Injuries to the Portal Vein

Penetrating injuries to the portal vein are life threatening and are usually associated with multiple abdominal injuries. A deep penetrating abdominal wound on the transpyloric plane, about two fingerbreadths to the right of the midline, could easily penetrate the liver and perforate the first part of the duodenum, the portal vein, and the inferior vena cava.

Clinical Problem Solving Questions

Read the following case histories/questions and give the best answer for each.

1. A 59-year-old man was involved in a head-on automobile accident. When seen in the emergency department, he was in hypovolemic shock and showed signs of extensive bruising on the lower part of the anterior abdominal wall. He was wearing a seat belt at the time of the accident. On examination, his abdomen was distended and tense; he had hypotension and tachycardia. A diagnosis of ruptured abdominal aorta was made during an emergency laparotomy. In cases of blunt traumatic injury to the abdominal aorta, do all patients become hypotensive immediately? Explain the possible role that the kidneys may play in causing damage to the aorta in deceleration injuries.
2. A 74-year-old man was seen in the emergency department complaining of the sudden onset of severe lumbar back pain. Three years previously he had had a myocardial infarction. On questioning, the patient admitted that he often experienced mild back and hip pains on getting up in the morning, but never had he experienced such a severe back pain. On examination, a somewhat tender pulsatile swelling could be felt in the abdomen at the level of the umbilicus. Both femoral pulses were present. A diagnosis of abdominal aortic aneurysm was made. What is the surface marking of the abdominal aorta? Explain why the back pain had started so suddenly and its significance. When an abdominal aneurysm ruptures, does an immediate fatal outcome always occur?

Into which hollow viscera or blood vessels may an aortic aneurysm rarely rupture into?

3. Explain in anatomic terms why penetrating injuries to the inferior vena cava are commonly fatal. Explain how it is possible to ligate the inferior vena cava below the level of the renal veins without adverse effects.

A 63-year-old man with a long history of a duodenal ulcer was seen in the emergency department after vomiting blood-stained fluid and exhibiting all the signs and symptoms of severe hypovolemic shock.

4. The following statements concerning duodenal ulcers could apply to the patient's condition **except** which?
 - A. Hemorrhage from a duodenal ulcer often reveals itself by the passage of black stools on defecation.
 - B. The pyloric sphincter prevents most of the blood from the duodenal lumen from passing up into the stomach.
 - C. The gastroduodenal artery lies behind the first part of the duodenum and was probably eroded by the ulcer.
 - D. The gastroduodenal artery is a small branch of the hepatic artery.
 - E. The duodenal ulcer was most likely to be situated on the posterior wall of the first part of the duodenum.

A 58-year-old man was in a restaurant when he suddenly started to vomit blood. He was taken unconscious to the emergency department of a local hospital. On examination, he had all the signs of severe hypovolemic shock. On palpation of the anterior abdominal wall, the right

lobe of the liver was felt three fingerbreadths below the costal margin. Several enlarged superficial veins could be seen around the umbilicus. His wife said that he had vomited blood 3 months previously and had nearly died. She admitted that he was a chronic alcoholic. The diagnosis was cirrhosis of the liver secondary to chronic alcoholism.

5. The symptoms and signs displayed by this patient can be explained by the following statements **except** which?
 - A. The normal flow of portal blood through the liver is impaired by cirrhosis of the liver.
 - B. The portal–systemic anastomoses become enlarged in this condition.
 - C. At the lower end of the esophagus, a branch from the right gastric vein anastomoses with an esophageal tributary of the azygos vein.
 - D. Rupture of a varicose esophageal vein could produce a severe hemorrhage so that the patient would vomit up blood.
 - E. With portal hypertension the paraumbilical veins linking the superficial veins of the skin (systemic veins) to the portal vein become congested and visible.

A 56-year-old man visited his physician complaining that he experiences severe pain in both legs when taking long walks. He noticed recently that the cramp-like pain occurs after walking only a hundred yards. On questioning, he said that the pain quickly disappears on rest only to return after he walks the same distance. When the physician asked about his sex life the patient admitted that he was experiencing difficulty with erection.

6. The symptoms and signs displayed by this patient can be explained by the following statements **except** which?
 - A. Arteriography of the abdominal aorta revealed blockage in the region of the bifurcation.
 - B. Only the right common iliac artery was involved by disease.
 - C. The gradual blockage of the aorta was caused by advanced arteriosclerosis.
 - D. An insufficient amount of blood was reaching both legs, causing pain (claudication) on walking.
 - E. The lack of blood entering both internal iliac arteries was responsible for the difficulty with erection.

A 23-year-old woman, who was 8 months pregnant, told her obstetrician that she had recently noticed that her feet and ankles were swollen at the end of the day. She said that the swelling was worse if she had been standing for long periods. She also noticed that the veins around her ankles were becoming prominent.

7. The symptoms and signs displayed by this patient can be explained by the following statements **except** which?
 - A. The enlarged uterus is an abdominal organ and often compresses the inferior vena cava.
 - B. Venous back pressure causes the tissue fluid to accumulate in the subcutaneous tissues of the feet and ankles.
 - C. Venous back pressure impairs the venous return in the superficial veins in both the legs, leading to varicose veins.
 - D. High levels of progesterone in the blood during pregnancy cause the smooth muscle in the wall of the veins to relax, thus permitting the veins to dilate.
 - E. The pregnant uterus presses on the sympathetic trunks, causing vasodilatation of the blood vessels of the legs.
8. After complete occlusion of the origin of the inferior mesenteric artery with a blood clot, the blood supply of the left portion of the colon is maintained by the following arteries **except** which?
 - A. The marginal artery
 - B. The middle colic artery
 - C. The left lumbar arteries
 - D. Anastomoses between the superior, middle, and inferior hemorrhoidal arteries
 - E. Sigmoid arteries
9. In patients with an obstruction of the superior vena cava, blood may return to the right atrium through the following anastomotic channels **except** which?
 - A. The lateral thoracic, lumbar, and superficial epigastric veins
 - B. The superior and inferior epigastric veins
 - C. The lateral thoracic, paraumbilical, and portal veins
 - D. The posterior intercostal and lumbar veins
 - E. The lateral thoracic veins alone
10. If the common hepatic artery is unavoidably ligated during surgery, the arterial supply to the liver is maintained by the following anastomotic connections **except** which?
 - A. The superior pancreaticoduodenal artery anastomosing with the inferior pancreaticoduodenal artery
 - B. The right gastric artery anastomosing with the left gastric artery
 - C. The gastroduodenal artery anastomosing with the splenic artery
 - D. The esophageal arteries anastomosing with the inferior phrenic arteries
 - E. The right gastroepiploic artery anastomosing with the left gastroepiploic artery

Answers and Explanations

1. Frequently, patients with blunt rupture to the abdominal aorta may not immediately show signs of hypovolemic shock because the aorta is situated behind the peritoneum in the retroperitoneal space and the blood may not escape immediately into the peritoneal cavity (see text Fig. 5-62).

On impact, the patient may be held stationary by the seat belt, but the kidneys may continue forward until restrained by the vascular pedicles. Avulsion of the renal artery from the side of the aorta may take place under these circumstances.

2. The abdominal aorta is a midline structure that enters the abdomen at the level of the twelfth thoracic vertebra, and its entrance may be projected onto the anterior abdominal wall just above the transpyloric plane (see text Fig. 8-3). The vessel extends downward to its bifurcation into the common iliac arteries at the level of the summit of the iliac crests.

The sudden onset of severe back pain can be explained by the aneurysm suddenly expanding or rupturing and pressing on the vertebral column, which lies immediately posterior to the aorta.

Death does not always immediately follow an abdominal aneurysm rupture. This can be explained by the fact that the hemorrhage may be initially confined to the retroperitoneal space, and a tamponade effect may temporarily prevent further bleeding.

The abdominal aorta is crossed by the third part of the duodenum, and cases have been reported of an aneurysm rupturing into the duodenal lumen. The inferior vena cava lies along the right side of the aorta, and an aneurysm has been known to rupture into it, producing a massive arteriovenous fistula.

3. Penetrating injuries of the upper part of the inferior vena cava are commonly fatal because (a) the

site of the injury is inaccessible behind the liver, duodenum, and the mesentery of the small intestine; (b) the presence of the right costal margin makes surgical access difficult; (c) the thin walls of the vena cava are likely to tear extensively and make repair difficult; and (d) the almost certain possibility that the liver is also damaged.

The extensive anastomosis of the lumbar veins with other retroperitoneal veins ensures that the blood is able to bypass the obstruction should the inferior vena cava be ligated below the level of the renal veins (see CD Fig. 8-3).

4. **D** is the correct answer. The gastroduodenal artery is a large branch of the hepatic artery.
5. **C** is the correct answer. At the lower end of the esophagus, a branch from the left gastric vein anastomoses with an esophageal tributary of the azygos vein.
6. **B** is the correct answer. The blockage of the aorta in the region of the bifurcation had effectively blocked the entrances into both common iliac arteries.
7. **E** is the correct answer. The sympathetic trunks are not pressed on by the pregnant uterus.
8. **C** is the correct answer. The left lumbar arteries do not significantly contribute to the left portion of the colon. The middle colic artery from the superior mesenteric artery, the sigmoid arteries, and the marginal artery, as well as the hemorrhoidal arteries, will maintain the blood supply to the left portion of the colon.
9. **E** is the correct answer. The lateral thoracic and the superior epigastric veins are directly or indirectly connected with the superior vena cava only.
10. **C** is the correct answer. The gastroduodenal artery does not directly anastomose with the splenic artery.

