Function and Anatomy of the Spleen and Splenomegaly

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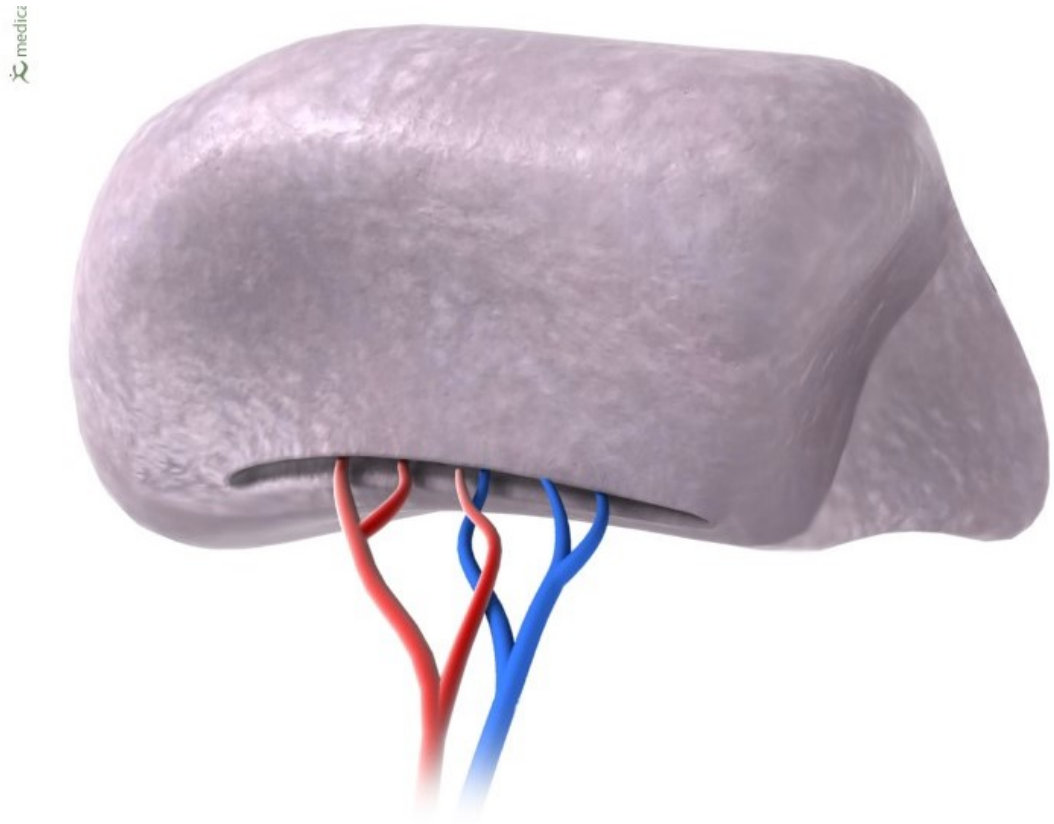
The spleen (from Greek: *splen*; Latin: *lien)* has the shape of a coffee bean, weighs about 150 grams, and is located in the left posterior upper abdomen (epigastric region). Next to such large topics as heart, liver, or lung, the spleen is sometimes a bit neglected in the curriculum; therefore, many students struggle in exams when it comes to questions about the ligaments or blood circulation of the spleen. This article provides a compact overview of the anatomy, functions, and diseases of the spleen.



Location of the Spleen

The spleen, with a size of about 4 x 7 x 11 cm (“4711-rule”) and a weight of 150—200 grams, is an organ shaped like a shoe that lies relative to the 9th and 11th ribs and is **located**

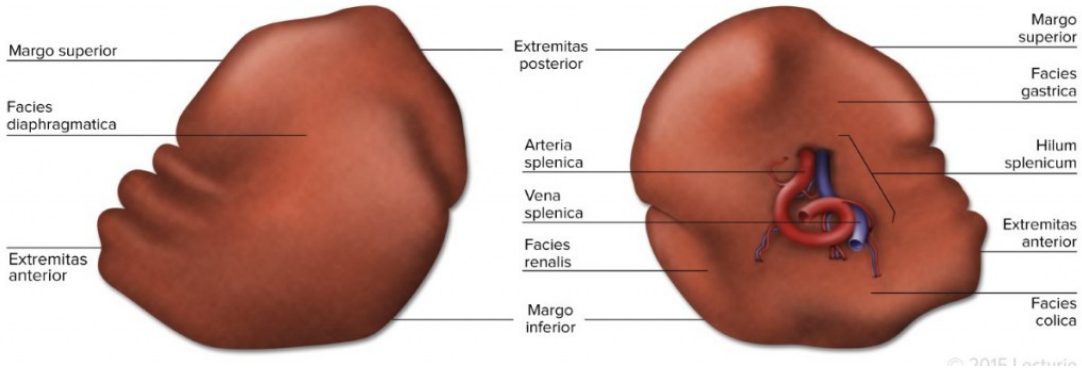
Image: “Laparoscopic view of a human spleen.” by Hic et nunc. License: CC BY-SA 3.0

in the left hypochondrium and partly in the epigastrium. Thus, the spleen is situated between the fundus of the stomach and the diaphragm. The spleen is very vascular and reddish-purple in color; its size and weight vary. A healthy spleen is not palpable. It can be palpated when it is enlarged (splenomegaly) Causes include infections (mononucleosis), metabolic disorders (Gaucher’s disease), or tumors (see below).

External Shape of the Spleen

The splenic tissue itself is very soft and filled with blood that trickles through the parenchyma and clears of its old and deformed red and white cells. However, the spleen is surrounded by a fibrous capsule (tunica fibrosa) made out of tough connective tissue, resulting in its relatively constant ‘coffee bean shape’. From the capsule, so-called trabeculae run through the inside of the spleen; they form a supporting framework and divide the spleen into segments.

The spleen’s three borders are the superior, inferior, and intermediate. The superior border of the spleen is notched by the anterior end. The inferior border is rounded. The intermediate border directs toward the right. The two surfaces of the spleen are the convex diaphragmatic surface, which abuts the diaphragm and rests on the upper pole of the left kidney and the concave visceral surface, which overlays the bowel and contains the splenic hilum where vessels enter and leave the spleen.



Peritoneal Relationships of the Spleen

The spleen is an intraperitoneal organ. **Various ligament structures run to and from it:**

- The gastrosplenic ligament extends from the hilum of the spleen to the greater curvature of the stomach; it contains short gastric vessels and associated lymphatics and sympathetic nerves.
- The splenorenal ligament extends from the hilum of the spleen to the anterior surface of the left kidney; it contains the tail of the pancreas and splenic vessels.
- The phrenicocolic ligament is a horizontal fold of peritoneum that extends from the splenic flexure of the colon to the diaphragm along the midaxillary line; it forms the upper end of the left paracolic gutter.

Relation of the Spleen to Adjacent Organs

With its visceral surface, the spleen borders on various other visceral organs.

- **Stomach (gastric surface):** when the stomach is very full, the spleen moves into a more vertical position. An important radiological feature in a plain film of the abdomen is the moving of the gastric bubble away from the spleen and toward the midline. This may signify a subcapsular hematoma of the speed or perisplenic hemorrhage such as mononucleosis-induced splenic rupture.
- **Colon with left colic flexure (colic surface):** when experiencing strong flatulence, the spleen moves into a more horizontal position. Because of its close relationship with the spleen, the left colic flexure is also called splenic flexure.
- **Pancreas:** the tail of the pancreas joins the splenic artery and vein and they abut on the splenic hilum.
- **Diaphragm (diaphragmatic surface):** the spleen sits very close to the diaphragm and therefore follows the respiratory movements.
- **Anterior Surface of the Left kidney (renal surface):** between the left kidney and the spleen lays the splenorenal recess. This is an anatomical space where sonography can quickly detect any free fluid or blood accumulated in the recess from trauma or other pathological events.

Blood Circulation of the Spleen

The spleen is made up of the following 4 components:

- Supporting tissue
- White pulp
- Red pulp
- Vascular system

Supporting tissue is fibroelastic and forms the capsule, coarse trabeculae, and a fine reticulum.

The white pulp consists of lymphatic nodules, which are arranged around an eccentric arteriole called the Malpighian (or splenic) corpuscle.

The red pulp is formed by a collection of cells in the interstices of its reticulum, in between the red pulp sinusoids. The cell population includes all types of lymphocytes, blood cells, and fixed and free macrophages. The lymphocytes are freely transformed into plasma cells, which can produce large amounts of antibodies and immunoglobulins.

The terminal vessels of the spleen’s arterial tree are the sheathed capillaries, which

either enter directly into splenic sinusoids or empty openly into the spleen's connective tissue. This open circulation is unique in the human circulatory system which is normally a closed circuit. The sinusoids form the beginning of the venous system. From the sinuses, blood is collected in short pulpar veins is emptied into the trabecular veins which finally join together as the splenic vein. The splenic vein then collects the inferior mesenteric vein and other branches from the pancreas and the stomach and joins the superior mesenteric vein to ultimately form the hepatic portal vein.

Accessory Spleen as an Anatomical Variation

Image: "Nebenmilz" by Drahreg01. License: CC BY-SA 3.0

In around 20 % of people, incidental findings reveal a solitary or multiple accessory spleens. Usually, it is found near the hilum of the main spleen, but also further in the abdomen, or even in the pelvic or scrotal area.

The histological structure corresponds to that of the main spleen. In principle, the presence of an accessory spleen does not represent any health risks. If, however, the main spleen has to be removed in a splenectomy, the accessory spleen is too small and too remote from the splenic artery to take over its functions—which would mean that the desired treatment effect (e.g., trapping of old red and white cells) cannot be achieved.

Functions of the Spleen

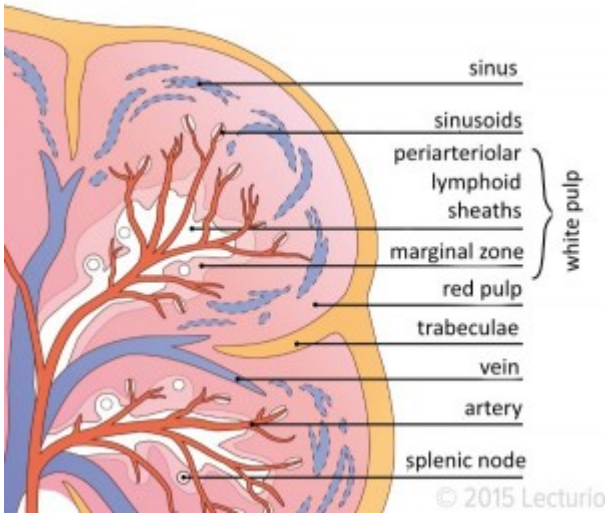
The spleen is one of the secondary lymphatic organs and can be described as the central organ of the immune system. Furthermore, it filters the blood and removes old or damaged red blood cells.

Already in the macroscopic view of a transected spleen, a division of the parenchyma into white and red areas, the white and red pulp, becomes apparent. The different coloring is due to their different tissue composition: in the white pulp, there are mainly splenic corpuscles and lymphoid sheaths, while the red pulp consists of numerous erythrocytes located in the splenic sinusoids.

White Pulp and the Immune System

The white pulp contains lymphocytes, which is why it belongs to the lymphatic tissue. T-

cells surround the central arteries like a cuff, forming the periarteriolar lymphoid sheath (PALS). PALS is an important histological characteristic of the spleen that distinguishes it from other lymphatic organs— and which makes it a frequently tested exam topic. B-cells are mostly found in the splenic (Malpighian) corpuscles.



In the marginal zone, the junction between white and red pulp, there are mostly B- but also T-cells, macrophages, and dendritic cells.

After leaving the bloodstream, the lymphocytes move to their ‘place of destination’: the T-cells to PALS and the B-cells to the splenic (Malpighian) corpuscles.

Red Pulp and Blood Filtration

Cellular elements of the blood are destroyed when they become obsolete. This occurs in the red pulp of the spleen. Here, the erythrocytes have to ‘wedge’ through a close-meshed network of splenic cords. They can only achieve this when they are still young and flexible. Obsolete or deformed erythrocytes are not flexible enough and get caught in the meshes, where they eventually become phagocytized by macrophages.

If the spleen is depleting too much blood, it can cause hemolytic jaundice: because of the increased breakdown of hemoglobin (red pigment of the erythrocytes), more bilirubin is being produced from the heme, which gives the skin a yellowish color.

Extramedullary Hematopoiesis

During prenatal development, the spleen contributes to the development of red blood cells (erythropoiesis). Since the liver also participates in this process of hematopoiesis, which takes place between the second and seventh month, this is called the hepatolienal phase.

Diseases of the Spleen

Splenomegaly

Splenomegaly is a massive enlargement of the spleen, which makes the spleen palpable under the left costal arch. Ultrasounds show a bulging shape and rounding of the normally pointy poles. Any ectopic tissue such as accessory spleens would also be hypertrophied.

Diseases associated with splenomegaly include:

- **Infectious mononucleosis (glandular fever):** triggered by the Epstein-Barr virus. Mild splenomegaly without clinical significance can persist throughout

the entire life.

- **Congestion in the portal vein:** caused by portal hypertension, right heart insufficiency, or splenic vein thrombosis.
- **Hematological systemic diseases:** acute or chronic lymphatic leukemia, hemolytic anemia, polycythemia vera.
- **Malaria:** extreme enlargement of the spleen can occur in chronic forms of malaria tropica.
- **Echinococcosis:** Splenic cysts caused by *Echinococcus granulosus* (dog tapeworm).

Asplenia: Life without a Spleen

Asplenia describes the absence of a spleen. The most common anatomical reason for this is surgical removal; only rarely is asplenia congenital. If this is the case, it is often associated with a malformation of the big thoracic vessels. In functional asplenia, the spleen is existent but not functioning. Causes can include autoimmune diseases like systemic lupus erythematosus or sickle-cell anemia.

The absence of a spleen implies the lack of a filtration function for bacteria, especially for encapsulated bacteria (*pneumococci*, *meningococci*, and *Hemophilus influenzae* type B). The result is a lifelong increased risk of sepsis. Physicians dread the OPSI syndrome (overwhelming post-splenectomy infection) which can lead within a few hours to a septicemia, caused by pathogenic bacteria getting into the bloodstream, with severe general symptoms and eventually leads to death.

A prophylactic vaccination against the mentioned bacteria is therefore advisable for asplenic patients and should be repeated every five years. In addition, an annual vaccination against influenza is important for prophylaxis. If fever or chills should suddenly set in, an early use of antibiotics is indicated. It is crucial that asplenic patients receive an emergency card from their doctor so that first responders or other doctors may be informed about the immune disorder.

Rupture of the Spleen

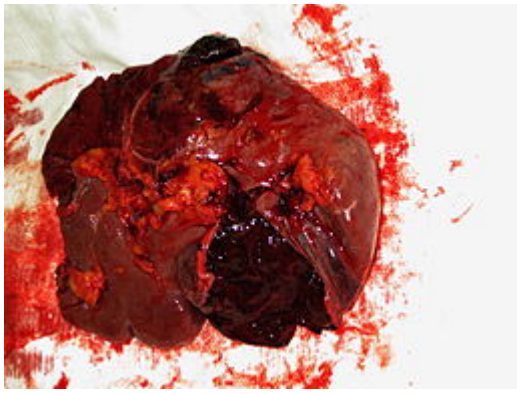


Image: “Zweizeitige traumatische Milzruptur; Operationspräparat nach Splenektomie” by Thomas Zimmermann. License: CC BY-SA 3.0

The most common reason for a rupture of the spleen is a blunt abdominal trauma; for individuals with splenomegaly, a minimal trauma is already enough to cause a rupture of the capsule. A distinction is made between an early or delayed rupture. In an early rupture, the splenic capsule and parenchyma are both ruptured at the same time, which

leads to immediate bleeding into the abdominal cavity.

In a delayed rupture, the parenchyma is injured first, but it may take hours or even weeks until the capsule ruptures, causing bleeding into the abdominal cavity.

Please note: In case of a blunt abdominal trauma, the possibility of a splenic rupture should always be considered and ruled out, as covert bleeding can be life-threatening!

Sonography or CT scans are the appropriate tools since they can show, among other things, any accumulations of fluid in the splenorenal recess. Furthermore, patients may feel referred pain in their left shoulder.

Because of the possible severe consequences, a splenectomy can have, the goal of surgery should be the preservation of the spleen (esp. in children) or at least the (difficult) partial resection.

Removal of the Spleen (Splenectomy)

It is difficult to only partially resect the spleen since it is not as distinctly divided into lobes as, for instance, the lungs or the liver. Also suturing the thin capsule is a challenging procedure.

A total splenectomy, in turn, is relatively easy because it only requires the dissection of the splenic artery and vein at the hilum of the spleen. Accesses to the spleen are: laparoscopic, left subcostal incision, or laparotomy with the upper midline incision.

The spleen is an important but not a vital organ as its functions can be compensated by other organs; for instance, immune responses by other lymphatic organs or red blood cell breakdown by the liver.

Removal of the spleen (e.g., after a spleen rupture) could lead to severe sepsis. Splenectomized patients should receive a prophylactic vaccination against pathogens that frequently cause sepsis, such as Streptococcus pneumoniae, Hemophilus influenza, and Meningococci.

Examination of the Spleen

Please note: In healthy individuals, the spleen is not palpable!

Palpation	Healthy spleen: not palpable. Splenomegaly: palpable below left costal arch. Cave: if the pressure is too hard, the capsule can burst. Start: always in the lower abdomen in order not to overlook a splenic tumor.
Percussion	Spleen: dull percussion note. Cranial: resonant percussion note of the lung. Ventral: tympanitic percussion note of stomach and colon. Caudal: no distinction to the dull note of the kidney. BUT: difficult because the location of the spleen does not admit definite distinctions.
Sonography	Right lateral decubitus or supine position (preferably supine position). Expiration (no attenuation through acoustic shadowing of the lung). ‘Kissing phenomenon’: displacement of the stomach caused by splenomegaly so that the spleen touches the left hepatic lobe. Ultrasonographic visualization of a clear splenorenal space is helpful to exclude splenic rupture. Incidental finding: accessory spleen. BUT: parts of the spleen that are directly caudal of the diaphragm are often difficult to visualize.
Scintigraphy	Evaluation of the exact dimensions of the spleen can be achieved by using radioactively marked and thermally damaged erythrocytes.

Review Questions

Solutions can be found below the references.

1. What statement regarding the spleen is correct?

A. The spleen’s location is retroperitoneal.
B. Asplenic patients may develop the OPSI syndrome.
C. The space between the left kidney and the spleen is called Morrison pouch.
D. In percussion, the spleen can be easily distinguished from the surrounding organs.
E. The spleen should always be removed completely when operating.

2. Which of the following ligamentous structures does not exist?

A. Gastrosplenic ligament
B. Phrenicocolic ligament
C. Splenorenal ligament
D. Splenocolic ligament
E. Splenohepatic ligament

3. Which association does not apply?

A. Splenorenal ligament: contains splenic vein and artery
B. Phrenicocolic ligament: builds the caudal limit of the spleen’s location
C. Omental bursa: forms the splenic recess
D. Splenocolic ligament: part of the lesser omentum
E. Gastrosplenic ligament: contains the short gastric arteries

References

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Correct Answers: 1B, 2E, 3D

Notes