The Spleen

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Embryology

- Develops from the mesoderm during the 5th week of gestation
- Rotation of the gut during subsequent development places the spleen in its typical position in the LUQ
- Relates to the diaphragm both superiorly and laterally, and it generally spans the 9th, 10th, and 11th ribs
Embryology

- Ventral surface abuts the greater curvature of the stomach and the tail of the pancreas.
- The tail of the pancreas touches the splenic capsule in 30% of cases and is 1 cm away in 73% of cases.
- The inferior pole relates to the left kidney posteriorly and the splenic flexure of the colon anteriorly.
The vascular anatomy is rather straightforward. The splenic artery is one of the three major trunks of the celiac axis. There are several small pancreatic branches that supply blood to the body and tail of the pancreas along its length. The first major splenic branch occurs approximately 2 to 3 cm from the hilum, and it is called the superior polar artery.
Anatomy

- The main artery then divides into three to five segmental branches.
- Additional blood supply to the spleen comes from the left gastroepiploic artery via the short gastric vessels.
- The splenic vein is formed by segmental venous branches that leave the trabecula and coalesce into the main splenic vein in the hilum of the spleen.
Anatomy

• The splenic vein is intimately associated with the posterior surface of the tail and body of the pancreas from the hilum of the spleen to its junction with the SMV, where they form the portal vein.

• The IMV may join the splenic vein directly at several areas along its course or may come together right at the junction of the SMV.
Anatomy

- There are several pancreatic branches that directly enter the splenic vein.

- The blood flow to the spleen in the typical adult is estimated to be 200 to 300 mL/minute, or approximately 5% of the cardiac output.
There are several ligaments that maintain the spleen in its fixed position in the LUQ.

The first ligament that is constant is the splenogastric ligament:
- a left-sided superior extension of the greater omentum along the proximal greater
- supplied by the left gastroepiploic vessels are short gastric vessels that branch to the upper pole and often provide the upper 2/3 of the spleen with alternative blood supply.
Ligaments

- The splenorenal ligament runs parallel to the posterolateral border of the spleen and attaches this to the superior pole of the Gerota fascia.
- The splenocolic ligament is short and may be avascular or have small blood vessels that go from the inferior tip of the spleen to the splenic flexure of the colon.
- The splenooomental and the splenophrenic are variably present.
Accessory

- Small nodules of splenic tissue that are completely separate from the main body of the spleen

- Range in size from 0.5 cm up to 3 to 4 cm

- Incidence = 10% and 20%
Most common location = the splenic hilum, the omentum (most commonly between the stomach and transverse colon but also within the greater omentum), and the small bowel mesentery

Can occur virtually anywhere in the abdomen including the RP behind the spleen and in the pelvis
Physiology
Functions

• Hematologic

• Immunologic
Hematologic

- The primary hematologic function is removal of senescent erythrocytes or remodeling of abnormal red blood cells, and the recycling of iron by splenic macrophages.

- The process of removal or phagocytosis of erythrocytes or other blood cells is called culling.
The second physiologic process involving circulating erythrocytes is remodeling or pitting, which is partial removal of the cell membrane, typically associated with cytoplasmic inclusions.

The destruction of the other circulating cellular elements of the blood (platelets and leukocytes) is typically more pathophysiologic of the spleen than normal physiologic function.
The final hematologic function is as a reservoir of circulating cellular elements – 30% of all platelets may reside in the spleen. This may be more important in those mammals with significant smooth muscle lining the capsule of the spleen that allows contracture with expulsion of large numbers of stored cells as a physiologic response to injury.
Immunologic

- Generate an immune response to antigens that are identified and cleared from the blood system
- Also involved in nonspecific immune responses
- It is the site of synthesis of both properdin and tuftsin, which are opsonins
Pathophysiology
Hypersplenism

• Physical enlargement of the spleen
  - neoplastic disorders, hematopoietic disorders of the bone marrow, and metabolic or storage disorders

• Secondary hypersplenism can also occur due to deposition of lipid within the spleen

• Associated with pancytopenia and mass effect of the spleen causing early satiety and weight loss
Neoplasms
Hemangioma

- The most common benign primary neoplasm of the spleen
- Often an incidental finding
- May be solitary or multiple
- It can be identified as a more intensely bluish-purple colored lesion when seen from the surface compared to the reddish-purple color of the splenic parenchyma
Hemangioma

- Can be identified with excellent sensitivity and specificity by MRI
- Rarely cause Sx, but massive hemangiomas can either rupture spontaneously or make the spleen more susceptible to a traumatic rupture
- In cases of massive hemangioma with capsular distention and pain, either a splenectomy or partial splenectomy may be helpful
Hemangioendothelioma

- A slightly more aggressive neoplasm than the typical benign hemangioma
- Pathologically it is an intermediate benign hemangioma and malignant angiosarcoma
- Does not seem to have met potential and generally is an incidental finding
- Larger lesions can cause symptoms or be noted for their size and rupture either spontaneously or with minor trauma
Lymphangiomas

- Also occur in the spleen and are much less common than hemangiomas
- Can be multiple or solitary
- Can be identified by a lighter color and compressibility when seen in surgery
Hamartomas

- Focal developmental abnormalities that occur in spleen and other solid organs
- Contain normal cellular elements and are non-neoplastic but have a random fibrotic organization
- The major significance is that they are identified either at laparotomy as incidental findings or they are seen as incidental lesions on CT scans
Pseudotumors

- Inflammatory pseudotumors are described throughout most organs
- These sometimes are quite large with a wide variety of reactive cells
- A subcategory are related to mycobacterial infection, particularly in HIV-positive patients
Cysts

- Almost uniformly unrelated to parasitic infection
- They are also relatively common lesions seen across all age groups and may be multifocal
- Dx can be made by ultrasound or CT
- These benign lesions have no clinical significance unless they reach a large size
Abscess

- An uncommon but important disease
- Associated with a significant mortality rate and may be cured by splenectomy
- In most series, the mortality rate ranges between 40% and 100%
- The typical patient has hematogenous seeding of the spleen by bacteria from a remote source
Abscess

- There may be in some cases direct spread of infection from adjacent intra-abdominal sources.
- Splenic trauma treated conservatively may eventually result in an infected splenic hematoma.
Abscess

- In 80% of cases, there is an additional source of infection in locations other than the spleen, and in only 20% of cases is the splenic abscess the sole source of sepsis identified.

- Enteric organisms account for 2/3 of the splenic abscesses and staph and strep cause the remainder of the cases.
ITP

• Dx of exclusion

• Characterized by autoimmune destruction of platelets with clinical manifestations of thrombocytopenia such as easy or excess bleeding

• Occurs as an acute form and a chronic form
ITP

- Acute ITP generally appears in children younger than 8 years of age following a viral URI
- 80 to 90% of children with acute ITP have spontaneous remissions
- Only to 10% of adults who develop ITP have remission, and most develop chronic ITP
Chronic ITP accounts for the vast majority of cases considered for splenectomy

IgG antibody to a platelet antigen

An inappropriately decreased level of production of thrombopoietin for the level of thrombocytopenia
First-line medical therapy options include platelet transfusion, corticosteroid therapy, gamma-immunoglobulin, and the Rho(d) immunoglobulin.

Platelet transfusions should be limited unless patients are actively bleeding as platelets become rapidly coated with IgG and then sequestered and destroyed in the spleen.
High-dose corticosteroid therapy produces an initial response in most patients, but this is usually not sustained.

75% of patients have an increase in platelet count that is significant within 24 hours of starting high-dose steroids.

Only 15 to 25% of patients with chronic ITP have a sustained remission following steroid therapy.
• Intravenous IgG immunoglobulin takes between 3 and 5 days to show an effect and generally does not put patients into complete remission

• In patients who have not achieved a sustained remission with medical therapy, which is most patients with chronic ITP, an elective splenectomy is recommended
Operative Approach
Options

- Open splenectomy
- Laparoscopic splenectomy
- Partial splenectomy
Splenectomy

• All patients should receive appropriate pre-operative vaccination with Pneumovax and possibly also vaccination against *Haemophilus influenzae* and *Neisseria meningococcus* 10-14 days prior to the procedure if possible

• Patients must have appropriate blood products ready
Splenectomy

• For patients with ITP, platelets should not be given until the spleen is either removed or at least until the arterial inflow is controlled
  - clearance of transfused platelets by the spleen in this disease

• Similarly, for diseases in which the spleen is the site of platelet or blood cell destruction, it is important to identify and remove accessory spleens
• Initially recognized as an important epidemiologic phenomenon in the early 1950s

• The risk is inversely related to age
  - the younger the child is, the greater is the impact and risk of developing overwhelming postsplenectomy sepsis
For adults, there is a 40 to 60% increased risk of sepsis compared to people with normal splenic function.

Septic episodes typically occur within the first 2 years in 80% of the cases.

In adults, the reason for the splenectomy also relates to the incidence of sepsis:
- For trauma, the instance of sepsis in a large series was 1.4%.
Typically, encapsulated organisms cause the postsplenectomy sepsis-related infection. These bacteria have special features that allow them to be opsonized and cleared from circulation by the spleen, making them more dangerous in hyposplenic or splenectomized patients.
OPS

• The most common organism causing postsplenectomy sepsis is *Streptococcus pneumoniae*
  - accounts for 50% of septic episodes

• Other bacteria include *Haemophilus influenzae, Neisseria meningitides, β-hemolytic streptococcus, Staphylococcus aureus, Escherichia coli, and Pseudomonas*
The current recommendations for patients who are having elective splenectomy are to vaccinate susceptible individuals to pneumocococcus strains.

This is ideally done 2 weeks before the operation if possible, but should be done at any time preoperatively or even postoperatively if the patient was not vaccinated.
Recent studies have shown that administration of vaccine with the first postoperative visit does not lead to beneficial immune stimulation.

Waiting for 14 days postoperatively is equivalent to waiting 1 month or longer.

Therefore, vaccination at 2 weeks after an unplanned splenectomy is ideal timing.
Trauma
History

- Most common intra-abdominal organ injured by blunt trauma in the US
- The history of splenic surgery mirrors the history of surgery for trauma
- In the ancient medical literature, the spleen often herniated through a flank wound and there are reports of either partial splenectomy or total splenectomy of the herniated portions
History

• The first documented splenectomy was performed in San Francisco by a British naval surgeon (O'Brien) in 1816 when a spleen protruded out the side of a KSW.

• In the late 19th century, Billroth observed during an autopsy that there was minimal blood in the peritoneum from the fracture of the splenic capsule and predicted that these injuries may be managed operatively.
History

• Although in the earlier part of the 20th century splenic trauma was uniformly managed by a complete splenectomy, Dr. Campos Christo of Brazil reported partial splenectomy and splenic salvage for both penetrating and blunt trauma in 1962.
Current

• This initial report, combined with the ability to obtain repeated cross-sectional imaging, with the understanding of splenic function and with the appreciation for OPSI, has led to the current guidelines for nonoperative management of lower-grade splenic injuries and operative management centered around splenic preservation when possible.
What You Need to Know

- Non-operative management of blunt splenic injuries mandates hemodynamic stability.
- Little role for non-op management of penetrating splenic injury.
- Delayed splenic rupture does occur.
- When in doubt – operate.