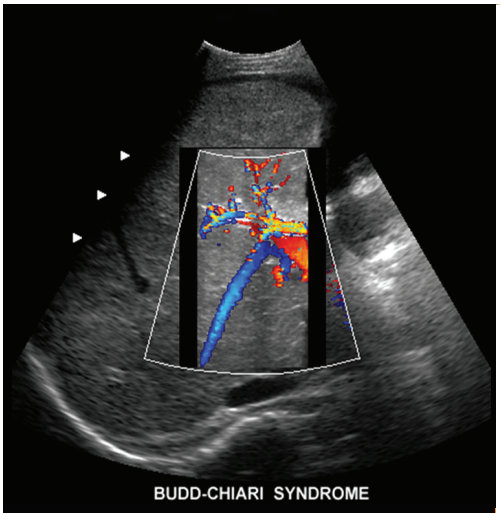

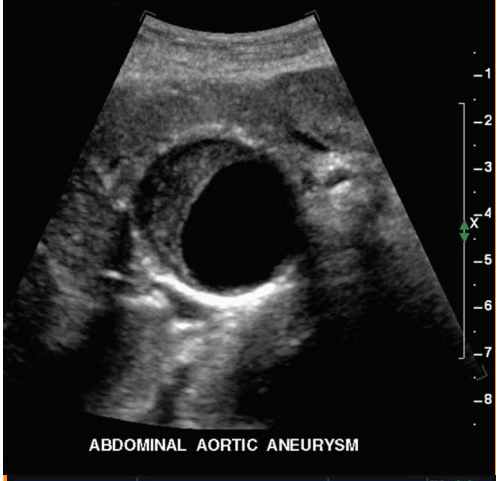

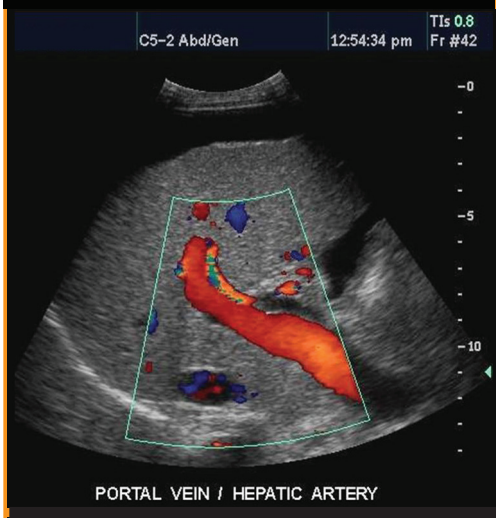

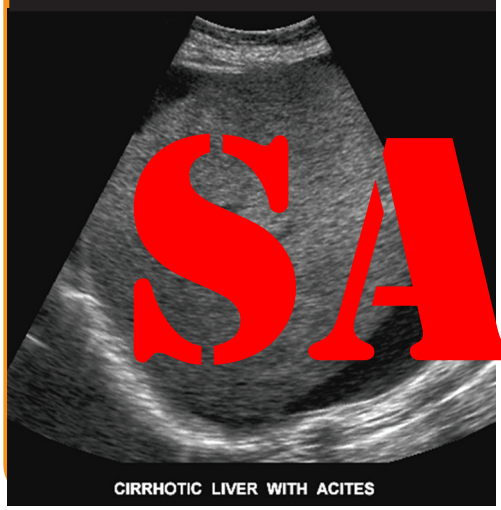

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RELEASE INFORMATION: See Back Cover

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Table of Contents

Section 1: Liver Sonography

Objectives

Upon completion of this module, you should be able to:

- State liver anatomy and physiology.
- Identify normal imaging characteristics of the liver.
- Outline routine scanning protocols for the ultrasound evaluation of the liver.
- State patient presentation and common indications for the ultrasound examination of the liver.
- Recognize characteristics of commonly seen liver pathology.

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ANATOMY

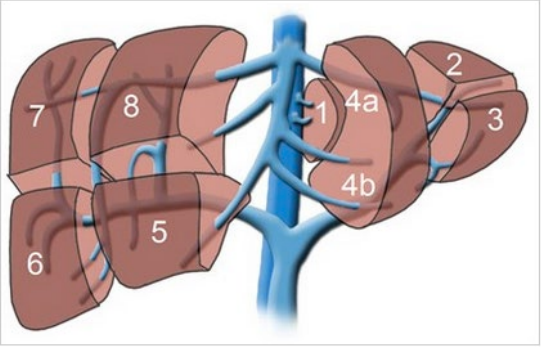
The liver is the largest internal organ in the abdomen and is located in the RUQ. The upper border of the liver is found at the approximate level of the nipples with the lower border extending to the level of the 8th or 9th rib.

There are a range of normal measurements published, but as a rule, the greatest cranio-caudal length of the right lobe is from 15-17cm in the adult patient measured at the mid clavicular line. The greatest transverse portion ranges from 20 to 22.5 cm and the greatest anteroposterior measurement from 10 to 12.5 cm (Kawamura 102). Liver length and anteroposterior measurements are obtained from the sagittal and parasagittal sections at the mid clavicular line. Hepatomegaly is present when right lobe extends below inferior pole of right kidney without the presence of Reidel's lobe.

A thin connective tissue surrounds the entire liver and is referred to as **Glisson's Capsule.**

Historically, the liver was divided by surface anatomy into 4 lobes: right, left, quadrate, and caudate lobes. The bare area (posterosuperior region) is not covered by peritoneum. This is the area of the coronary ligament, IVC, and porta hepatis and is an area for infection to spread from abdominal to thoracic cavity.

Couinaud's anatomy divides the liver into 8 segments based on using the main lobar fissure and vascular landmarks including branches of the hepatic vein, portal vein, and biliary tree. Couinaud's anatomy has become more widely used since it provides more specific descriptions of abnormalities based on portal segments allowing the surgeon to make more appropriate decisions for hepatic lobe resection (Rumack 79).



The liver is divided into eight (8) segments reflecting the eight (8) major divisions of the portal vein and the bile duct. *Image provided courtesty of Royal College of Surgeons of Ireland (RCSI) under Creative Common License.http://www.healcentral.org/*

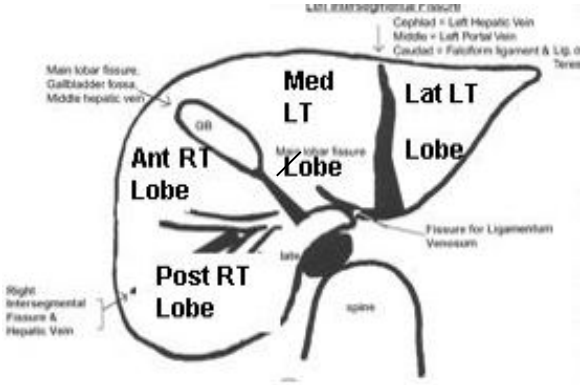
Couinaud's Anatomy

The **right lobe** is the largest, occupying almost the entire right hypochondrium. A common anatomical variation called **Riedel's lobe** is seen more often in women. This is a tongue–like projection of the right lobe that may extend down to the iliac crest. Most cephalic portion is called the "dome". Based on Couinaud's anatomy sections, the **main lobar fissure** divides the right and left lobes of the liver. Other identifying landmarks to divide the right and left lobes include the gallbladder fossa inferiorly, the IVC posteriorly, and the middle hepatic vein superiorly. The right lobe is also divided into anterior and posterior segments by the RHV.

The **left lobe** is located in the epigastric region and is smaller than the right lobe. The left lobe is divided into medial and lateral segments. The medial segment is referred to as the Quadrate lobe. The inferior and undersurface lies adjacent to the body of the pancreas and stomach.

The **falciform ligament** and the fissure for the **ligamentum teres (round ligament)** is a remnant of fetal umbilical vein and divides

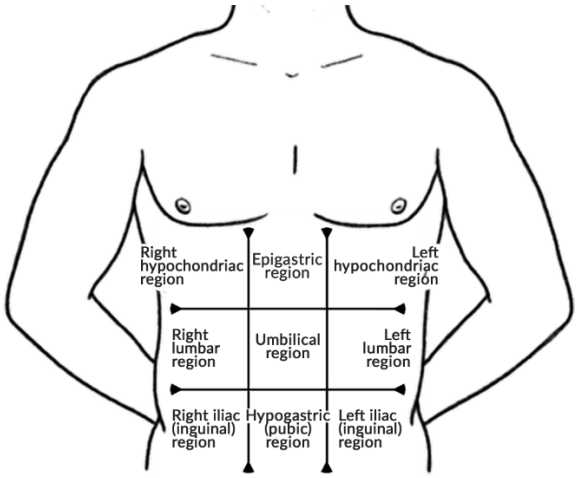
the caudal aspect of the left lobe into medial and lateral segments. Another identifying landmark for dividing the medial and lateral segments of the left lobe is the LHV. The fissure for the **ligamentum venosum** (remnant of fetal ductus venosus) separates the left lobe from the caudate lobe. During fetal development, the ductus venosum is responsible for shunting blood from the umbilical vein to the IVC.



Liver Anatomy Diagram

The l**eft portal vein** (LPV) courses anterior to the caudate lobe and can also be utilized as a dividing landmark of the left lobe and caudate lobe.

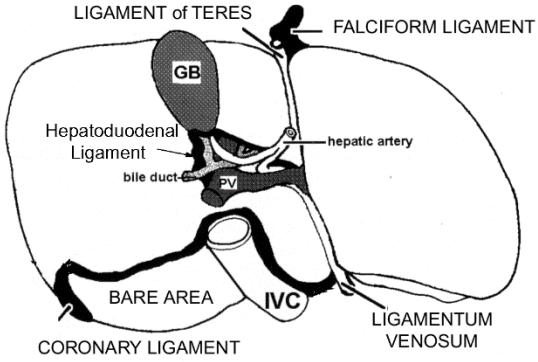
The **caudate lobe** is located on the posterior-superior surface of the right lobe. It is located posterior to the porta hepatis, between the fissure for the ligamentum venosum, and the IVC. The right margin of the caudate lobe appears as a tongue-like projection situated between the IVC and the main portal vein. This lobe has an independent blood supply.



Regions of Abdominal Area

The caudate lobe can be prominent in some patients with a more hypoechoic echogenicity. Care should be taken not to mistake this normal variant for a mass of the pancreatic head.

The liver may also be subdivided into the quadrate lobe. It is located on the posterior-inferior surface of the left lobe.



View from beneath liver

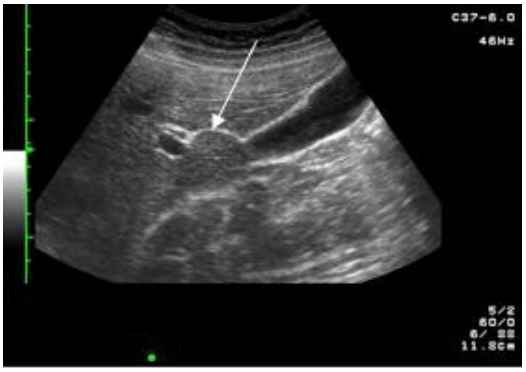
VASCULAR ANATOMY

The liver receives its nutrients from the portal vein and hepatic artery. The portal vein provides 70-75% of the total volume of incoming blood to the liver. It is 80% saturated with oxygen, allowing for 50-60% of the oxygen requirements of the hepatocytes (Rumack 81).

LIVER SECTION QUIZ

1. A thin connective tissue which surrounds the entire liver is referred to as:
    a. Gerota's fascia
    b. Glisson's capsule
    c. Bowman's capsule
    d. None of the above

2. A common anatomical variation resembling a tongue-like projection of the right lobe of the liver is called:
    a. Uncinate process
    b. Dromedary hump
    c. Riedel's lobe
    d. Caput Medusa



3. The structure indicated by the arrow in the above image represents:
    a. Falciform ligament
    b. Ligamentum Teres
    c. Main lobar fissure
    d. Fissure of ligamentum venosum

4. The dividing landmark(s) for the left lobe and the caudate lobe are:
    a. Falciform ligament
    b. Ligamentum venosum
    c. Left portal vein
    d. a and c
    e. b and c

5. All of the following structures are utilized as dividing landmarks of the right and left lobes except:
    a. Main lobar fissure
    b. GB fossa
    c. IVC
    d. Middle hepatic vein
    e. Falciform ligament

6. What structures are located within the portal triad?
    a. Proper hepatic artery
    b. Main portal vein
    c. Common Bile Duct
    d. Gastroduodenal artery
    e. a, b, and c
    f. b, c, and d

7. The CBD is formed by the confluence of the: *(mark all that apply)*
    a. Duct of Wirsung
    b. Hepatoduodenal duct
    c. Cystic duct
    d. Common hepatic duct
    e. All of the above

8. Hepatic veins increase in caliber as they course towards the:
    a. IVC and diaphragm
    b. Porta hepatis
    c. Hepatic veins do not increase in caliber

9. The right lobe of the liver is divided into anterior and posterior segments by the:
    a. Left hepatic vein
    b. Middle hepatic vein
    c. Right hepatic vein
    d. All of the above

10. Why is the Doppler signal detected from hepatic veins more pulsatile than the portal veins?
    a. Multiple veins merging towards IVC
    b. Increased size of hepatic veins towards IVC
    c. Close proximity to the heart
    d. Hepatic veins do not have any pulsatile characteristics.

11. Phagocytosis is the removal of bile pigment and old RBC from the blood by specialized hepatic cells called:
    a. Kupffer cells
    b. AST cells
    c. Kwashiorkor cells
    d. All of the above

Section 2: BILIARY TREE SONOGRAPHY

Objectives

Upon completion of this module, you should be able to:

- State gallbladder and biliary anatomy and physiology.
- Identify normal imaging characteristics of the gallbladder and biliary tree.
- Outline routine scanning protocols for the ultrasound evaluation of the gallbladder and biliary tree.
- State patient presentation and common indications for ultrasound examination of gallbladder and biliary tree.
- Recognize characteristics of commonly seen gallbladder and biliary tree pathology.

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ANATOMY

The gallbladder is a musculomembranous sac, which is variable in shape and size. The average gallbladder diameter is 3.0 cm and 7 to 10cm in length. It is located in the main lobar fissure between the right and left lobes and is divided into three segments: the fundus, body, and neck. The main lobar fissure and RPV serve as anatomic landmarks to locate the gallbladder neck.

The gallbladder stores bile. When fatty food enters the duodenum, a hormone called cholecystokinin, or CCK, is released from the duodenum causing gallbladder contraction.

Sonography of the normal gallbladder will demonstrate an anechoic fluid-filled structure (with posterior enhancement) along the junction of the medial segment of the left and right lobes of the liver. The **main lobar fissure** is utilized as an anatomic landmark for the gallbladder location. It is seen as a linear echo connecting the gallbladder to the main portal vein (PV).

The normal distended gallbladder will have smooth walls, which do not exceed 3 mm. No internal echoes or echogenic foci should be seen.

Normal GB

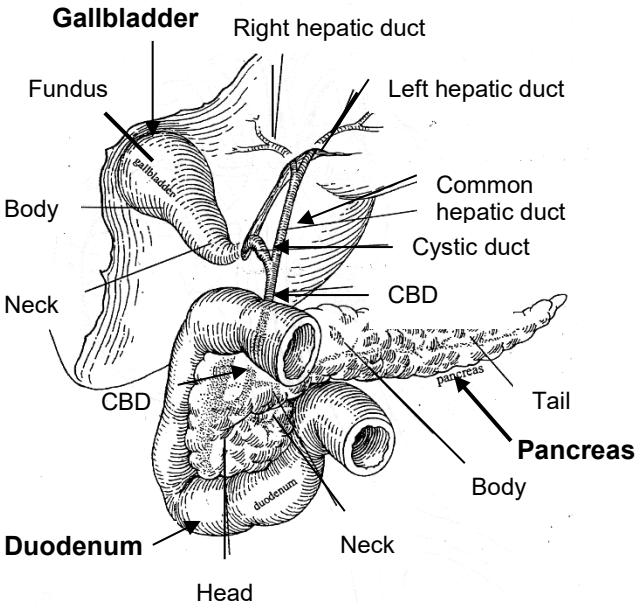
A variety of folds or kinks may be seen with the most common being **Hartmann's Pouch** near neck. A fold towards the fundus is referred to as a **Phrygian cap** and it occurs in about 4% of healthy people.

Multiple developmental anomalies may occur and include:

- Hypoplasia
- Hyperplasia
- Sub-total division
- Agenesis: rare
- Total reduplication: rare
- Floating gallbladder
- Hourglass shape

The cystic duct drains the gallbladder and joins with the **common hepatic duct (CHD)** to form the **common bile duct (CBD).** The cystic duct is difficult to evaluate by ultrasound, but has an average diameter of 1.8 mm. The cystic duct contains **spiral valves of Heister**, which can produce a shadowing affect that should not be mistaken for stones.

The right and left hepatic ducts join to form the common hepatic duct (CHD). The CHD joins with the cystic duct to form the CBD. The CBD enters the second portion of the duodenum through the **ampulla of Vater**.



The CBD is located lateral to the hepatic artery and anterior to the PV. As the CBD courses posterior to the duodenal bulb, it enters the pancreas. It then courses more posteriorly and close to the anterior margin of the IVC.

VIDEO 2A: Common Bile Duct

The **portal triad** is the region where the PV, hepatic artery, and bile duct enter and exit the liver.

The hepatic artery lies anterior to the portal vein however; the left hepatic artery is often seen coursing posterior to the PV.

Portal Triad: PV, HA, CBD (arrow)

The ducts should be measured from the internal (intraluminal) borders. CHD/CBD should measure ≤ 6mm in pts with no history of biliary disease. There is controversy regarding the normal CBD size post-cholecystectomy. Current literature indicates 8-11mm is considered normal post-cholecystectomy (Kawamura 194).

CBD Diameter:
Normal ≤ 6 mm
Dilated > 7 mm

In the event the sonographer has difficulty in determining a duct from a vessel, several characteristics can be evaluated.

1. Arteries pulsate, ducts don't
2. Veins collapse and distend with respiration. Doppler signals are obtained from vessels, but no flow is detected in ducts.

Intrahepatic ducts should measure ≤ 2mm.

Dilated CBD

TECHNIQUE

When performing a gallbladder exam the patient should ideally be NPO after midnight to allow maximum distention of the gallbladder and minimize bowel gas.

The gallbladder exam is initially performed with the patient supine in longitudinal and transverse scan planes. Multiple images are obtained from each view taking care to scan through the entire gallbladder.

Images of the CHD are taken as it courses anterior to the PV. If the gallbladder is in a high location, it may be necessary to scan from a coronal approach. When the supine views are complete, place the patient in an LPO position or LLD and scan the gallbladder in longitudinal and transverse scan planes. If stones were detected in the supine position, movement of the stones should be demonstrated in the oblique views. The region of the CHD and CBD are again visualized. The patient can also be examined in an upright position. Thorough evaluation of the intrahepatic ducts, liver

parenchyma, and other hepatic vasculature and pancreas should be included.

LABORATORY VALUES

The following laboratory values should be compared with ultrasound findings.

1. **Serum Bilirubin:** Increases of direct (conjugated) bilirubin may indicate sub-acute cholecystitis, choledocolithiasis, CA of the gallbladder, bile duct injury, internal biliary fistula or retained bile duct stones.
2. **Leukocyte count (WBC):** WBC count will increase in the presence of infection.
3. **Serum Alkaline phosphatase: (ALP)** is manufactured in the liver, bones, intestines, kidneys, and placenta. Elevated ALP may indicate obstruction or injury to ducts.
4. **Liver function test: SGOT (AST), SGPT (ALT)** Increases indicates active primary liver disease, particularly in an acute onset.
5. **Prothrombin Time or clotting time:** Abnormal values indicate sub-acute or acute cholecystitis, CA of the gall bladder, prolonged extrahepatic bile duct obstruction, internal biliary fistula, or bile duct injury.

INDICATIONS

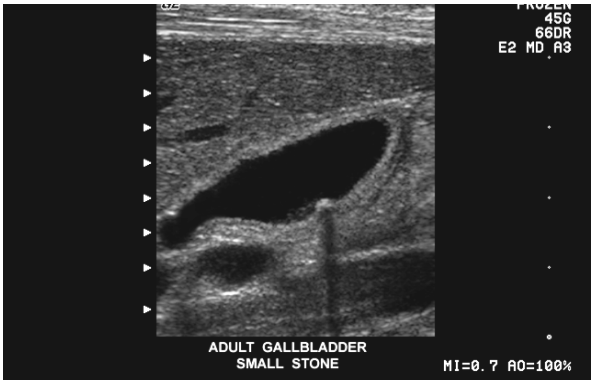
A GB examination is indicated when a patient presents with any of the following clinical conditions: RUQ pain that may extend to the right shoulder, fatty food intolerance, nausea, vomiting or jaundice. Patients may also have a family history of GB disease, elevated liver function tests or non-visualization via oral cholecystography (OCG) or nuclear hepatobiliary (HIDA) study. Ultrasound is highly recommended to R/O intrahepatic versus extrahepatic obstruction.

PATHOLOGY

Cholelithiasis (Gallstones)
The three most significant factors affecting formation of gallstones include bile composition, stasis, and infection.

Gallstones are common abnormalities that affect females more than males. The perfect gallstone candidate has been described as *"fair (complexion), fat, fertile, female, and forty"*. Gallstone composition varies but most stones include a mixture of cholesterol, calcium, and bilirubin. Ninety percent of all gallstones are mixed, containing contents of all three types of stones.

The patient may be asymptomatic or present with RUQ pain, possibly radiating to the back and/or shoulder. The pain may be more severe after eating a fatty meal. Nausea and vomiting may also occur.



Small Gallstones

Sonographically, gallstones are echogenic and usually produce a shadow when > 3mm in size. The degree of shadowing is dependent upon transducer position, gain settings, and focusing.

The gallstones should be thoroughly evaluated in at least two scan planes. The gallbladder neck should also be evaluated for stones. Impacted stones are seen as curved highly reflective echoes producing an acoustic shadow. The impacted stones will not move with changing patient

positions. Normally, the cystic duct is not visualized and the presence of a cystic duct stone is extremely difficult to assess.

Gallstone with acoustic shadow

Large Gallstone

Multiple Gallstones

Many non-biliary structures can mimic a stone such as echogenic fat in the porta hepatis, shadowing from the spiral valves of Heister, and duodenal gas. Hepatobiliary nuclear studies are recommended for patients suspected of cystic duct stones.

Level of Obstruction:

Distal CBD: most common, entire system distends including the GB.

CHD: only the CHD and intrahepatic ducts dilate, GB will be contracted.

Junction of hepatic ducts: only intrahepatic ducts dilate, GB will be contracted.

The diagnosis of an obstructed cystic duct can be suggested when two parallel structures are seen separate from the portal veins in a patient with obstructive jaundice. The appearance has been described as the “triple-channel sign” (Mittelstaedt 279).

VIDEO 2B: Rolling Stones

Mirizzi Syndrome

Mirizzi syndrome is a potential source of extrahepatic obstruction. The distinguishing features include an impacted stone in the cystic duct, or cystic duct remnant of the gallbladder neck.

A partial mechanical obstruction of the CHD may occur by compression or by an inflammatory reaction around the impacted stones. Courvoisier sign: patient with painless jaundice and enlarged GB (or right upper quadrant mass). The cause is unlikely to be gallstones and an obstructing pancreatic or biliary neoplasm should be considered until proven otherwise.

Sonographic Findings

Sonographic findings will reveal biliary obstruction and the gallbladder may have characteristics of acute or chronic cholecystitis.

Section 3: PANCREAS SONOGRAPHY

Objectives

Upon completion of this module, you should be able to:

- State pancreas anatomy and physiology.
- Identify normal imaging characteristics of the pancreas.
- Outline routine scanning protocols for the ultrasound evaluation of the pancreas.
- State patient presentation and common indications for ultrasound examination of the pancreas.
- Recognize characteristics of commonly seen pancreatic pathology

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ANATOMY

The normal pancreas can be visualized in most patients by knowing the pancreatic anatomy, adjacent structural anatomy, and the ability to identify vascular landmarks. The pancreas drapes across the mid aspect of the abdomen, just under the xyphoid process. It consists of five segments: the head, uncinate process, neck, body, and tail.

The majority of the gland lies in the retroperitoneal cavity with the exception of a small portion of the head which is surrounded by peritoneum. The **head** of the pancreas lies caudal to body and tail and anterior to the IVC.

The **uncinate process**, or lingula, is a "tongue-like" projection of the pancreatic head, which is located anterior to the IVC and posterior to the superior mesenteric vein (SMV).

The **neck of the pancreas** is the segment located directly anterior to the superior mesenteric vein (SMV). The SMV and splenic veins join at this point to form the portal vein (PV), which serves as the posterior border.

The **body** represents the longest segment of the pancreas although its AP measurement is the smallest. The splenic vein serves as the posterior-medial border to the body of the pancreas. The antrum of the stomach lies anterior to the neck/body region of the pancreas.

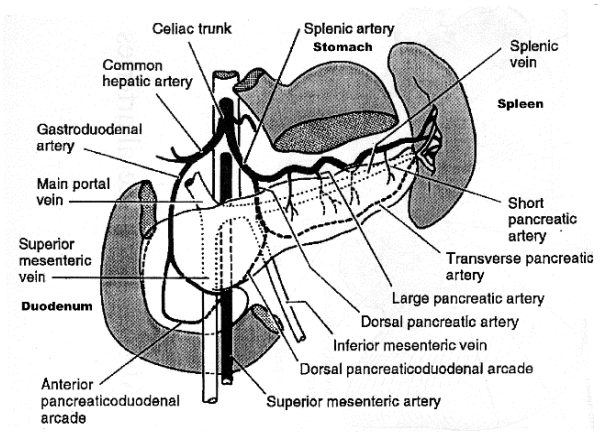
The **pancreatic tail** courses to the left lateral aspect of the body, extending to the hilum of the spleen. It is the most difficult of all the segments to visualize.

The splenic vein serves as the posterior border to the tail and the spleen forms the left lateral border of the pancreatic tail. The left kidney is located posterior to the tail, the stomach is found anterior to the tail.

The **main pancreatic duct, or Duct of Wirsung,** courses along the entire length of the pancreas. It enters into the duodenum via the ampulla of Vater.

The **accessory duct, or Duct of Santorini**, drains the anterior segment of the head. The pancreatic ducts are visualized as lucencies bordered by two echogenic lines. It looks like a vessel but will not demonstrate flow with Doppler.

The anteroposterior (AP) diameter of a normal pancreatic duct should not exceed 2 mm (Kawamura 211). The splenic vein, splenic artery, retroperitoneal fat, and the posterior wall of the stomach are all structures, which could mimic a pancreatic duct. Color Doppler is helpful in distinguishing the pancreatic duct from vessels.



Pancreas Anatomy Diagram

Measurements

The size of the pancreas will vary from patient to patient. The average size by AP dimension of the head is 2.0 – 3.0 cm, the neck is 1.5 – 2.5 cm, the body is 2.0 – 2.5 cm and the tail is 1.0 – 2.0 cm. The length of the adult pancreas ranges from 12 – 15 cm.

Section 4: KIDNEYS/URINARY TRACT SONOGRAPHY

Objectives

Upon completion of this module, you should be able to:

- Recognize normal renal anatomy and physiology.
- Identify normal imaging characteristics of the kidneys.
- Outline routine scanning protocols for the ultrasound evaluation of the kidneys.
- State common indications for renal sonography examinations.
- Recognize characteristics of commonly seen pathology of the kidneys and bladder.

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ANATOMY

The kidneys are bean shaped structures, which develop in the pelvis and ascend to their normal retroperitoneal location between the 1st and 3rd lumbar vertebrae.

The right kidney is usually lower (1-2 cm) than the left due to the inferior displacement by the right lobe of the liver.

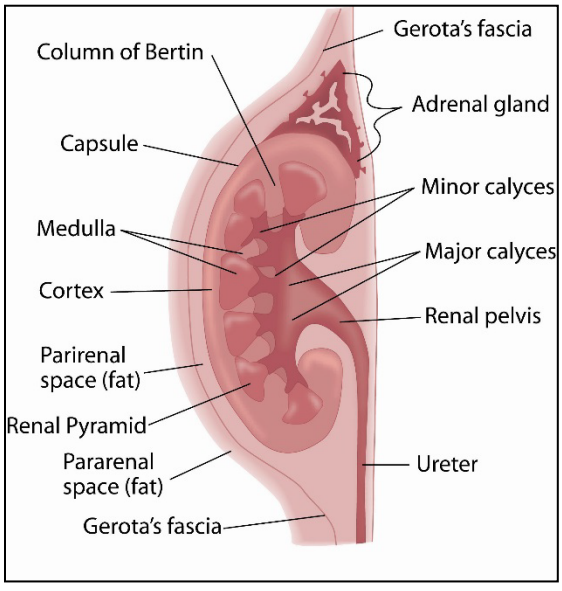
The normal adult kidney measures approximately 9-12 cm in length, 2.5 cm in AP diameter, and 5 cm in width.

A difference > 1.5 - 2 cm between right and left kidneys is considered significant.

A fibrous capsule surrounds the kidney and is referred to as the **true capsule.** The capsule is covered by perinephric fat.

Gerota's fascia surrounds the true capsule and perinephric fat.

The outer portion of the kidney is referred to as the **renal cortex,** which measures approximately 1 cm in AP diameter. The renal arcuate and interlobular arteries, Bowman's capsule, and convoluted tubules are located in this area.



Kidney Diagram

The inner portion of the kidney is called the **medulla.** The renal pyramids (8-18 per kidney), calyces and loop of Henle are located in this region.

The apices of the renal pyramids converge toward the renal sinus and project into the lumen of the minor calyces.

The pyramids empty urine into minor calyces which empty urine into the major calyces. The major calyces empty urine into renal pelvis which then becomes the ureter. Renal sinus is the space within kidney containing major and minor calyces, blood vessels, lymphatics, fat and fibrous tissue, and the renal pelvis. The above structures make the renal sinus appear echogenic by ultrasound. The medial portion of the kidney where vessels and ureters enter and exit is called the renal hilum.

Extrarenal pelvis is when a portion of collecting system is located just outside of renal hilum.

Extrarenal Pelvis

The **Columns of Bertin** consist of cortical tissue extending into the space between adjacent pyramids.

The **nephron** is the structural and functional unit of the kidney. (See illustration below)

Section 5: SCROTUM AND TESTES SONOGRAPHY

Objectives

Upon completion of this module, you should be able to:

- Recognize scrotum and testicular anatomy and physiology.
- Identify normal imaging characteristics of the scrotum and testes.
- Outline routine scanning protocols for the ultrasound evaluation of the scrotum and testes.
- State common indications for scrotal and testicular sonography examinations.
- Recognize characteristics of commonly seen pathology of the scrotum and testes.

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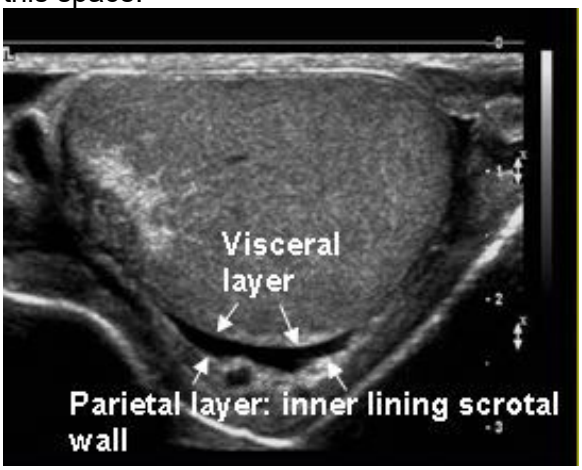
ANATOMY

The scrotum is a fibromuscular sac composed of several layers of muscle and fascia. The scrotal wall is composed of (superficial to deep): rugated skin, superficial fascia, dartos muscle, external spermatic fascia, cremasteric muscle, and internal spermatic fascia. The normal scrotal wall is homogeneous and slightly echogenic compared to the normal testis. The scrotal wall measures approximately 2-8 mm depending on the level of contraction of the cremasteric muscle. The scrotum is divided into two compartments by a midline fibrous band of tissue called the median raphe which runs ventral to the underside of the penis and dorsal from the middle peritoneum to the anus.

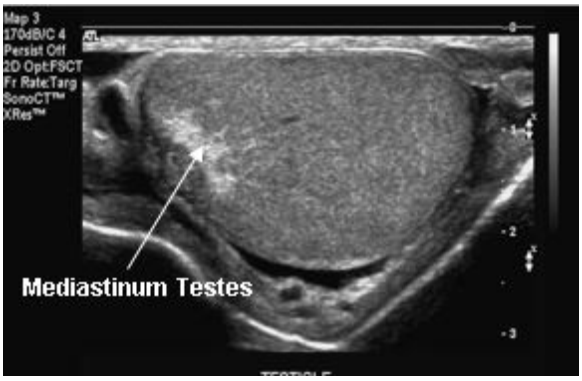
The testis are bilateral ovoid glands located within the scrotum. The function of the testis is the production of sperm and testosterone, the primary sex hormone that is responsible for the development of male secondary sex characteristics and the development of male reproductive tissues. The **seminal vesicles** are two sac-like structures, which store the sperm and are located posterior to the bladder. The testis develops between the posterior abdominal wall and the peritoneum and normally pass through the inguinal region during the 7th month of gestation. The normal adult testis measures 3 to 5 cm in length and 2 to 3 cm in AP and transverse diameter, with the size of the testicle decreasing with age.

The **tunica vaginalis** is a peritoneal sac that surrounds the testis and epididymis except for a small posterior area. The tunica vaginalis is composed of two layers**, the visceral and parietal layers**. The visceral layer is a serous membrane that covers the testis and epididymis and produces secretions. The parietal layer is the inner lining of the scrotal wall. These two layers are separated by a potential space that usually contains a few millimeters of fluid. Large amounts of fluid (hydrocele), scrotal hernias (bowel), or blood can accumulate in this space.



Tunica Vaginalis

A dense fibrous capsule referred to as the **tunica albuginea** surrounds the testicles. The **mediastinum testis** is visualized as a linear echogenic band extending across the testis in a craniocaudal direction. In a transverse plane the mediastinum testis is seen as an echogenic structure at approximately the 3 or 9 o'clock position. The mediastinum testis is continuous externally with the tunica albuginea and functions as a supporting system for the arteries, veins, tubules, and lymphatics. The **rete testis** is an anastomosing network of tubules located in the hilum (mediastinum testis) which drain into the epididymis through 10 to 15 efferent ducts.



Mediastinum testes

The **epididymis** is divided into the head, body, and tail. The head of the epididymis is

Section 6: PROSTATE SONOGRAPHY

Objectives

Upon completion of this module you should be able to:

- Recognize the prostate anatomy and physiology.
- Identify normal imaging characteristics of the prostate.
- Outline routine scanning protocols for the ultrasound evaluation of the prostate.
- State common indications for prostate examinations.
- Recognize characteristics of commonly seen pathology of the prostate.

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ANATOMY

The prostate is a conical shaped structure located anterior to the rectum, inferior to the bladder and behind the inferior border of the symphysis pubis.

The prostate is composed of glandular and fibromuscular tissue and surrounded by a two layer capsule composed of smooth and collagenous tissue.

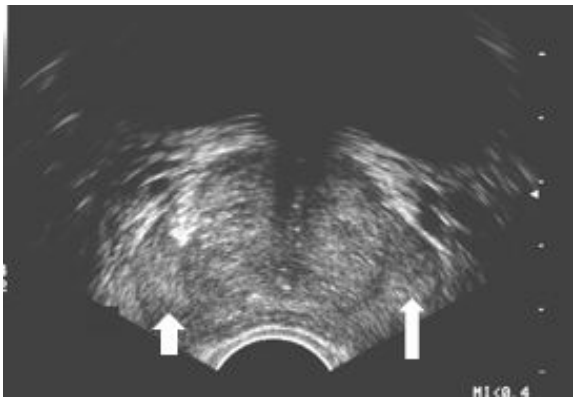
In the young adult, the normal prostate gland weighs approximately 20 plus or minus 6 g and measures approximately 4x3x2 cm (Kawamura 368). There are two methods of describing prostate anatomy. Historically, the prostate has been divided into five lobes, which include anterior, middle, posterior and lateral lobes. The method is useful for the digital exam and staging of disease but is not useful for identifying prostate cancer.

Zonal anatomy is the current method of choice where the prostate is divided into four primary zones. These include peripheral, transitional, central and periurethral zones. Due to the difficulties of differentiating each zone by sonography, an abbreviated method has proven more successful where the prostate is separated into a peripheral zone and inner gland.

The **peripheral zone,** or outer gland, contains about 70% of the prostate tissue. This region is the most common location for carcinomas with approximately 70% arising from this area. The peripheral zone is separated from the inner gland by a hyperechoic region, which represents the surgical capsule. This zone is thickest at apex (inferior) and thinnest at base (superior) and extends to both lateral margins.

The **transition zone** surrounds the urethra, and although this region accounts for only10% of prostate glandular tissue in young men, it exhibits significant growth with age. This area is difficult to visualize and is where benign prostatic hypertrophy originates.

The **central zone** consists of the glandular tissue adjacent to the proximal urethral segment or transitional zone and is primarily in the base (superiorly) of the prostate where the vas deferens, seminal vesicles and ejaculatory ducts are located. Only about 5% of prostate cancers occur in the region. The central zone is immediately deep to peripheral zone. The seminal vesicles are paired structures that lie obliquely and caudally to the prostate. The seminal vesicles act as a reservoir for seminal fluid.



Zonal Anatomy (Arrows: Peripheral Zone)

BLOOD SUPPLY

The **prostatic vesical arteries** arise from the internal iliac arteries bilaterally to provide blood supply to the prostate. The prostatic and inferior vesicle arteries arise from the prostatic vesical arteries. The **inferior vesicle artery** provides blood supply to the base of the bladder, seminal vesicles, and ureter. The **urethral and capsular arteries** arise from the prostatic artery to provide blood supply to the prostate gland.

INDICATIONS

Transrectal prostate ultrasound is indicated in patients with palpable mass on digital exam, elevated PSA levels, frequency or dysuria, F/U post radiation treatment, and

Section 7: SPLEEN SONOGRAPHY

Objectives

Upon completion of this module, you should be able to:

- Recognize spleen anatomy and physiology.
- Identify normal imaging characteristics of the spleen.
- Outline routine scanning protocols for the ultrasound evaluation of the spleen.
- State patient presentation and common indications for ultrasound examination of spleen.
- Recognize characteristics of commonly seen splenic pathology.

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ANATOMY

The spleen represents the largest unit of the reticuloendothelial system. It is an intraperitoneal structure, which is located between the left hemidiaphragm and the stomach.

The superior border is formed by the left hemidiaphragm and the stomach. The tail of the pancreas, left kidney, and splenic flexure border its medial surface. The spleen is covered by the peritoneum, except for the area of the hilum.

The normal adult spleen should measure < 12 cm in length. The size of the spleen decreases with increasing age. Sonographically, the spleen should appear homogeneous and slightly hyperechoic or isoechoic to liver.

The blood supply to the spleen is via the splenic artery, which arises from the celiac trunk. The splenic vein exits at the hilum and merges with the inferior mesenteric and superior mesenteric veins to form the portal vein.

The spleen has an important role in the defense mechanism of the body. It acts as a filter and source of blood storage. In the adult, it produces lymphocytes and monocytes.

SCAN TECHNIQUE

The spleen is imaged through the intercostal spaces with the patient supine or in the right lateral decubitus (RLD) position. Longitudinal and transverse images are obtained utilizing a 3.5 – 5.0 MHz transducer.

The normal spleen will exhibit a homogeneous, low to medium level gray echogenicity similar to the liver. The diaphragm is seen as a bright echogenic border to the superior, lateral and posterior aspects of the spleen. The left kidney is generally seen inferior and medial.

INDICATIONS

An ultrasound examination of the spleen is indicated when a patient has a systemic infection (lymphatics) or hematopoietic disorder. It is also indicated in cases of trauma to rule-out splenic fracture or hematoma and should be evaluated whenever portal venous hypertension (PVH) is suspected.

LABORATORY VALUES

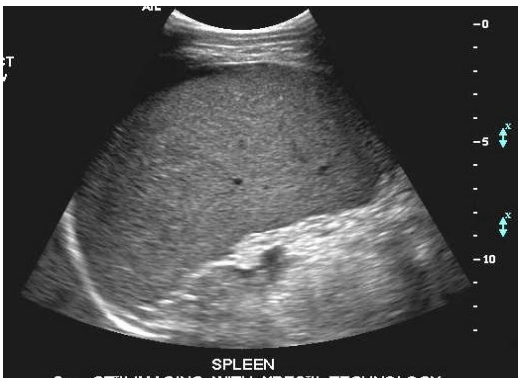
Some corresponding laboratory values that may indicate evaluation is warranted include elevated WBC count and a decreased hematocrit or hemoglobin.

NORMAL VARIANTS

Accessory spleens (supernumerary spleens) are a common incidental finding. They are usually detected near the hilum of the spleen exhibiting the same echogenicity as the normal primary spleen. Accessory spleens can mimic an enlarged lymph node, a splenic mass, or a mass in the tail of the pancreas.

PATHOLOGY

Splenomegaly
Splenomegaly represents spleen enlargement. Normal spleen measurements of < 12 cm in length, 7 cm in width and 3-4 cm in thickness can be utilized as guidelines for enlargement.



Splenomegaly

Section 8: RETROPERITONEUM SONOGRAPHY

Objectives

Upon completion of this module, you should be able to:

- List compartments and structures of the retroperitoneum.
- Identify normal imaging characteristics of the retroperitoneum.
- Outline scanning protocols for the ultrasound evaluation of the retroperitoneum.
- Recognize characteristics of commonly seen pathology of the retroperitoneum

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ANATOMY

Peritoneum

The serous membrane that forms the lining of the abdominal cavity is the peritoneum. It consists of two layers:

Parietal (outer layer)-lines abdominal wall
Visceral (inner layer) - covers the abdominal organs.

The space between the two layers is the peritoneal cavity. The peritoneal cavity contains two compartments:
Lesser sac - space between liver, pancreas, and stomach
Greater sac - remaining peritoneal cavity

Retroperitoneum

The retroperitoneum lies between the transversalis fascia and the parietal peritoneum. It can be divided into three segments or compartments:

- Perirenal (perinephric) space
- Posterior pararenal space
- Anterior pararenal space

Perirenal Space

The **perirenal compartment** is separated by two fascia layers (Gerota's Fascia) and encloses the kidneys, adrenal glands, perinephric fat, prevertebral aorta and IVC, and proximal ureter.

The **left pararenal space** includes the splenic vein and tail of the pancreas.

Posterior Pararenal Space

The **posterior pararenal space** mainly consists of fat. Retroperitoneal muscles such as the quadratus lumborum and psoas muscles are separated from the space by its own fascia. This space contains no organs, only fat.

The **psoas muscle** is located in the paraspinal region, coursing posterior and medial to the kidneys. When evaluating the segments where muscles course, symmetry is the important characteristic to document. Normal muscles are relatively hypoechoic with vertically oriented echogenic lines. Enlargement or atrophy of one side is indicative of pathology.

Anterior Pararenal Space

The **anterior pararenal space** is bordered anteriorly by the posterior parietal peritoneum and posteriorly by the anterior perirenal fascia.

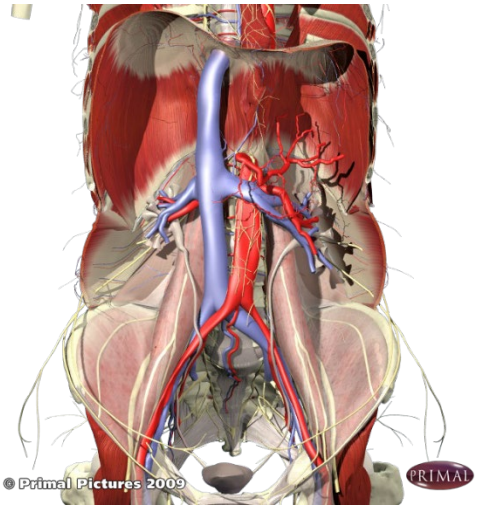
The IVC, pancreas and segments of the duodenum are located within the right anterior pararenal space.

The anterior pararenal space extends into the pelvis and contains other structures such as the ascending and descending colon, duodenum, and pancreas (Hagen-Ansert 66).

Aorta/IVC

The **abdominal aorta** is located just to the left of midline, originating after it pierces the diaphragm at the level of the first lumbar vertebra. It continues coursing along the spine until the approximate level of the fourth lumbar vertebrae, where it bifurcates into the common iliac arteries.

The **IVC** originates at about the level of the fifth lumbar vertebrae coursing along the right side of the spine and terminating at the right atrium of the heart.



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