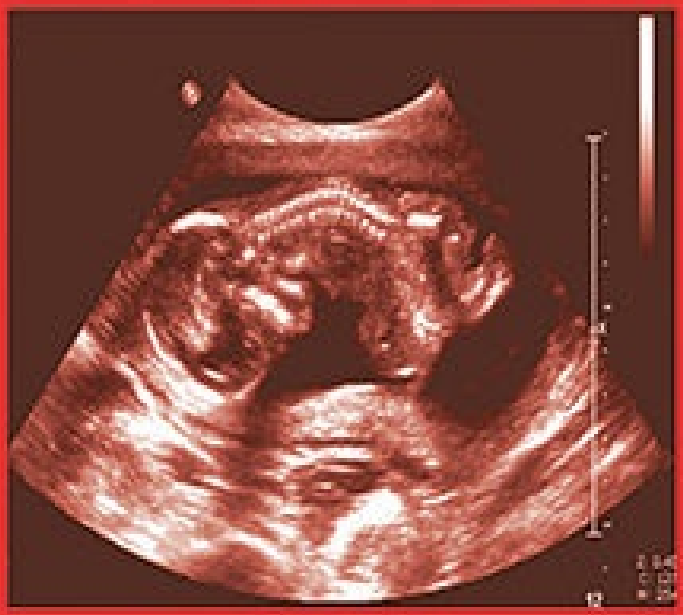
EXAMINATION REVIEW FOR ULTRASOUND

SECOND EDITION



Abdomen & Obstetrics and Gynecology

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Steven M. Penny

Examination Review for Ultrasound

Abdomen & Obstetrics and Gynecology

Second Edition

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Dedication

To Him, my Teacher and Counselor—Thank you for allowing me the opportunity to serve others by granting me the wisdom and fortitude required to complete this undertaking. Thank you for everything that you have supplied, and will supply, for me and my family. I know that you are my shepherd and will never fail me. You will always be my pilot, my protector, and my provider.

To Lisa, my wife—Thank you for your abiding love and faith in my potential. I know that without you I would not be the man I am today. You have been my encourager and supporter. Thank you so much for all that you do for me and our children. Your daily sacrifices for me and my career do not go unrecognized. I neither say it, nor show it enough, but I love you, and I will always love you.

To Devin and Reagan—There are times that I wish I could temporarily place life's distractions on pause in order to enjoy the time that I spend with both of you more. You are a blessing to me and you are the motivation behind much of what I try to achieve in life. I pray that I am providing you with an adequate fatherly example, but more importantly, I pray that you both continually seek the will of our Heavenly Father in your lives.

Preface

The overwhelming success of the first edition of *Examination Review for Ultrasound: Abdomen & Obstetrics and Gynecology* confirmed the demand among aspiring sonographers for a narrative-style review for the national certification examinations offered by the American Registry for Diagnostic Medical Sonography (ARDMS) and American Registry of Radiologic Technologists (ARRT). We watched the book at it ascended the best-selling charts—where it still remains—to become one of the preeminent sourcebooks for registry review and clinical practice, quantifying its popularity, and solidifying the need for this much anticipated second edition.

Objective

Our profession demands the best of us because the best of us is what our patients both expect and deserve. Standardized tests, such as those offered by the ARDMS and ARRT, have remained, for many years, a hallmark of our profession. We can be assured that maintaining high-quality patient care rests at the heart of these certification examinations. It is through their successful completion that the sonographer earns recognition as a proficient medical professional. Consequently, the contents of this book are founded upon the components of these examinations.

Like the first edition, the primary objective of *Examination Review for Ultrasound: Abdomen & Obstetrics and Gynecology, Second Edition* is to provide the user with a comprehensive review in sonography of the abdomen, gynecology, and obstetrics in preparation for national certification. Secondarily, because of its straightforward narrative style, like the first edition, this book can further provide a quick reference guide in the clinical setting.

Organization

In general, the book is again divided into three sections: Section 1, Abdominal Sonography Review; Section 2, Gynecologic Sonography Review; and Section 3, Obstetric Sonography Review. Each chapter follows a similar path that was established in the first edition, with the addition of a few noteworthy improvements. Key terms—with plainly written, uncomplicated definitions—are provided in each chapter and highlighted in the chapters as well. The key terms allow for a rapid assessment of one's familiarity with the subject and also provide a quick reference for the reader. Each chapter begins with a review of basic anatomy, function, and sonographically relevant information. The narrative piece of this book is once more written in a clear-cut manner, offering the most essential facts about the topic, many times providing tables or boxes that include both clinical and sonographic findings. Throughout each chapter, a new feature referred to as "Sound Off" boxes can be found. "Sound Off" boxes are used to highlight imperative facts the reader must recognize about many of the topics. These boxes may also provide a specific way to recall this vital information. Tables and many new, high-quality sonographic images and anatomic drawings further enhance the straightforward narrative. Most chapters conclude with a review of the pertinent pathology for the subject matter. Also, at the end of each chapter, 40 review questions are provided for a basic appraisal of the reader's knowledge. With a total of 1,280 review questions in this edition, the assessment has undoubtedly been improved. The answers to these questions can be found in the back of the book.

Section 1—Abdominal Sonography Review—has many notable changes in this edition. In Chapter 1, a brief overview of infection control has been added, as well as several rules for surgical asepsis. Also, a table on Doppler artifacts can be found in Chapter 1. In Chapter 2, an enhanced section on liver Doppler, TIPS evaluation, and liver transplant assessment can be found. Chapter 5 includes a section on pancreatic transplant, whereas Chapter 7 includes more information about renal transplant assessment. In Chapter 12—Face and Neck—the reader will find information about the facial glands and associated pathology. Last, Chapter 14, which is the chapter on musculoskeletal and superficial structures, offers a brief review in breast imaging and developmental dysplasia of the infant hip.

In Section 2—Gynecologic Sonography Review—there are some vital additions as well. In Chapter 15, information on instrumentation, basic patient care, pediatric gynecologic sonography, and two-dimensional and Doppler artifacts in pelvic imaging is provided. In Chapter 19, the user will find a way to recall the relationship of the menstrual cycle phases of the ovary and endometrium. Also, distributed throughout the other gynecologic chapters, the user will find superior sonographic images, helpful drawings, and essential diagrams. In Section 3—Obstetric Sonography Review—

several revisions include an overview of gravidity and parity (Chapter 22), an improved review of the fetal heart (Chapter 27), and information concerning fetal alcohol syndrome (Chapter 32). Once more, these are only highlights, as there are countless improvements to this edition.

Additional Resources

As with the first edition, the review associated with this book does not need to end with its conclusion. There are several online resources for this book, including a mock registry examination that can be attempted by using the code at the beginning of this book and going to **thepoint.lww.com/penny_abobgyn2e**. This exam simulator will provide the user with more intense "registry-like" questions, with topics that can be selected and answers that provide rationale. Instructors can use the faculty resources as well, which include an image bank and PowerPoint presentations.

Final Note

The material contained in this book is deliberately not exhaustive. With candid prayer for discernment, much care has been taken to explore each topic, and I have tried to select the most vital information for you as you study for these complicated examinations. Thus, this book, if used for its primary purpose of registry review, should emerge to the user as focused and purposeful. The exclusion of numerical statistics and extraneous facts from the text—in most regards—is intentional. However, in the pursuit of exhaustive comprehension, where data or information is critical to more complete patient care, the list of bibliographical references at the end of each chapter should provide you with essential aid.

In the classroom setting, many instructors have discovered that the use of the first edition of this book can certainly be beneficial. This edition will also provide the instructor with a topic-based review that can identify subject matter weaknesses. And instructors that offer registry review courses will find that this book and its resources will offer them a focused tool for preparing their students for the national certification exams.

For those who have moved beyond national certification, the manner in which this book has been constructed—with clinical and sonographic findings highlighted—certainly allows for its application during sonographic practice. Nevertheless, it is my greater hope that you exploit all relevant resources in your mission and obligation to provide each patient with the most favorable care you can afford.

I anticipate that this book will serve you, your students, and your patients well. I may never meet you face-to-face, but I would like to express gratitude for the choice that you have made to select this book. I wish you well as you care for *our* patients, and my hope is that you have a long-lasting and prosperous career as a registered diagnostic medical sonographer.

Steven M. Penny

Acknowledgments

I would first like to thank my acquisitions editor, Jay Campbell, for giving me the opportunity to pursue this second edition and for his confidence in me as an author. Thanks to all of the workers behind the scenes at Wolters Kluwer, including my editorial coordinator Lexi Pozonsky and marketing manager Leah Thompson, and the other members of the staff who make a project like this come together.

To my parents, Ted and Linda Penny, thank you for all that you have done for me and my family over the years. I hope that you know that I love you and that I am grateful for the love you have shown me throughout my life.

To my brother, Jeff Penny, and his family, Tammy, Nick, and Mackenzie—thanks for your encouragement and for being in my life.

To my coworkers and the leadership at Johnston Community College, thank you for your companionship and direction over the years. To my past, current, and future students, thank you for demanding that I continue to learn, and thank you for allowing me to be your instructor.

To all of my former teachers and professors, thank you for your unwavering patience.

Test-Taking Tips

"By failing to prepare, you are preparing to fail."

– Ben Franklin

The national certification examinations offered by the American Registry for Diagnostic Medical Sonography (ARDMS) and American Registry of Radiologic Technologist (ARRT) are not easy. These exams should be difficult because they have been created to test your knowledge of a vital imaging modality that can save people's lives. Consequently, preparing for and challenging these exams should not be approached dispassionately. There are many resources on test taking that you can access at your local library and online. Below are three basic steps, which include tips for getting organized, studying, and preparing for these significant certification exams.

Step 1—Get Organized and Schedule the Exam

Both the ARDMS (ardms.org) and ARRT (arrt.org) provide content outlines for each of their certification examination. In fact, the content of this book is based on these content outlines, and accordingly this book includes pertinent information on each topic. However, you can use these content outlines as a guide for focused study as well. Keep your study materials—which should include all of the resources you obtained throughout your sonography education—organized by these content outlines. School lecture notes, note cards, quizzes, and tests should be organized well before you begin to study.

Once you have organized your study materials, you should apply for the exam and then try to consider the best time to attempt it. When scheduling the examination, consider all of your other obligations (e.g., family responsibilities, vacations, job requirements) and allow for an ample amount of time to study so that you are thoroughly prepared on examination day. Do not postpone scheduling the exam. Scheduling the examination will provide you with a firm date, and it will hopefully help those of you who suffer from procrastination to focus on test preparation.

Step 2—Establish a Study Routine and Study Schedule

Next, since you have your deadline, find a quiet place to study and develop a study routine and schedule. Your study space should be quiet and free from distractions, like television and your cell phone (stay off of social media). The study schedule that you create for yourself should be realistic. That is to say, do not schedule two hours each night to study if you know that you will not be dedicated to that schedule. Instead, it may be best to schedule one solid hour each night. Also, studying in 45-minute increments with 15-minute breaks may work best for some. You can create your own deadlines on your schedule and strive to meet them. Be sure to study at least for a few minutes every day to maintain momentum going into the exam.

The amount of time one requires to study will vary per individual. Only *you* know how much time *you* need to study, so if you struggle with certain topics, then allow for extra time to focus more attention on those topics. It may be best to review those topics you are most familiar with first, and as the exam approaches, review the topics that you struggle with just before your attempt, with the hopes of making the challenging information more readily accessible.

Most people know what manner they prepare for an exam best. Some test takers find flashcard useful, some create their own notes from reading, whereas others may simply read and choose to gradually answer registry review questions. A study group may be helpful for some as well. Nonetheless, the main concern of your studies should be *learning* the material and not just *memorizing* it to pass the exam. By learning the information, you will most likely be successful on the exam, with the added benefit of being able to apply your knowledge in your daily clinical practice as a registered sonographer.

Step 3—Confidently Attempt the Exam

Test anxiety is a challenge for many people. Some tips for reducing anxiety include eating well, getting plenty of rest and exercise, keeping a positive attitude, and taking practice tests. The ARDMS offers some tips for exam-day success, which include getting a good night’s sleep before exam day, knowing how long it takes to get to the testing center (traffic included), being early to the testing center, and being familiar with all of the test center requirements, like testing day registrant identification specifications. Currently, the ARDMS Sonographic Principles & Instrumentation (SPI) exam consists of 110 questions, whereas the specialty exams consist of 170 questions. Nearly all of the questions are in multiple choice format. The SPI exam may also include advanced item type question in the form of a semi-

interactive console, which requires the test taker to make adjustments to a simulated ultrasound machine console. The specialty exams may also include an advanced item type question referred to as hotspot questions. These questions require that the test taker use the cursor to mark the correct answer directly on the image.

Multiple choice questions consist of the stem—which is the question—and four possible answers to choose from. The correct answer must be included along with three other options referred to as distractors. You should read the question cautiously first, and try to answer the question before looking at the provided choices. If your given answer is provided, it will most likely be the correct choice to make. If you do not know the answer immediately, then try to eliminate the choices you know are incorrect. For these exams, you are allowed to mark questions and return to answer them later. You can also make changes before final submission. But be careful, it may be best to not change any of your answers. You should only make changes to questions that you feel confident you have answered incorrectly because for many of us our first impulse or guess is correct.

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Contents

Section I: Abdominal Sonography Review

1

Abdominal Sonography Overview

Introduction

A synopsis of abdominal sonography practice is provided in this chapter. Accordingly, the subsequent abdominal chapters will build on the foundation established in this chapter. It is important for the sonographer to obtain and recognize vital clinical information from patients, including laboratory results and other data that are obtained through patient inquiry. This chapter offers relevant laboratory findings, imaging artifacts, a brief overview of physics and instrumentation, infection control, and serves as a general abdominal imaging guide. Lastly, cross-referencing of potential information that may be encountered on the abdominal certification examination offered by the American Registry for Diagnostic Medical Sonography (www.ardms.org) and the abdominal portion of the examination offered by the American Registry of Radiologic Technologists (www.arrt.org) has been performed to establish this chapter.

Key Terms

anemia—a condition in which the red blood cell count or the hemoglobin is decreased

anticoagulation therapy—drug therapy in which anticoagulant medications are given to a patient to slow the rate at which the patient's blood clots

ascites—a collection of abdominal fluid within the peritoneal cavity

chromaffin cells—the cells in the adrenal medulla that secrete epinephrine

and norepinephrine

clinical findings—the information gathered by obtaining a clinical history

clinical history—a patient's signs and symptoms, pertinent illnesses, past surgeries, laboratory findings, and the results of other diagnostic testing

coagulopathies—disorders that result from the body's inability to coagulate or form blood clots also referred to as bleeding disorders

computed tomography—an imaging modality that uses X-ray to obtain cross-sectional images of the body in multiple planes; also referred to as CT or CAT scan

elastography—a sonographic technique employed to evaluate a mass based on its stiffness, ultimately providing a prediction as to whether a mass is more likely malignant or benign

endoscopy—a means of looking inside of the human body using an endoscope

exudate ascites—a collection of abdominal fluid within the peritoneal cavity that may be associated with cancer

fluid-fluid level—a distinctive line seen within a cyst representing the layering of two different fluid densities

gastrin—hormone produced by the stomach lining that is used to regulate the release of digestive acid

hematocrit—a laboratory value that indicates the amount of red blood cells in the blood

homeostasis—the body's ability or tendency to maintain internal equilibrium by adjusting its physiologic processes

hyperthyroidism—a condition that results from the overproduction of thyroid hormones

hypothyroidism—a condition that results from the underproduction of thyroid hormones

intraluminal—something located within the lumen or opening of an organ or structure

intraperitoneal—located within the parietal peritoneum

Kaposi sarcoma—cancer that causes lesions to develop on the skin and other places; often associated with AIDS

leukocytosis—an elevated white blood cell count

lymphadenopathy—disease or enlargement of the lymph nodes

lymphedema—build-up of lymph that is most likely caused by the obstruction of lymph drainage

mass effect—the displacement or alteration of normal anatomy that is

located adjacent to a tumor

Morrison pouch—the space between the liver and the right kidney; also referred to as the posterior right subhepatic space

multiloculated—having many cavities

mural nodules—small solid internal projections of tissue originating from the wall of cyst

nosocomial infections—hospital-acquired infections

nuclear medicine—a diagnostic imaging modality that utilizes the administration of radionuclides into the human body for an analysis of the function of organs or for the treatment of various abnormalities

oncocytes—large cells of glandular origin

paracentesis—a procedure that uses a needle to drain fluid from the abdominal cavity for diagnostic and/or therapeutic reasons

parietal peritoneum—the portion of the peritoneum that lines the abdominal and pelvic cavities

pineal gland—endocrine gland located in the brain that secretes melatonin

radiography—a diagnostic imaging modality that uses ionizing radiation for imaging bones, joints, organs, and some other soft tissue structures

retroperitoneal—posterior to the peritoneum

serosal fluid—fluid that is secreted by the serous membranes to reduce friction in the peritoneal and other cavities of the body

signs—an objective evidence of a disease such as abnormal laboratory findings and fever

sonographic findings—information gathered by performing a sonographic examination

space of Retzius—the space between the urinary bladder and the pubic bone; also referred to as the retropubic space

standoff pad—a gel pad that is used to provide some distance between the transducer face and the skin surface, allowing superficial structures to be imaged more clearly

symptoms—any subjective evidence of a disease such as nausea, weakness, or numbness

thoracentesis—a procedure that uses a needle to drain fluid from the pleural cavity for either diagnostic or therapeutic reasons

thymus gland—gland of the immune and lymphatic system located in the chest

transudate ascites—a collection of abdominal fluid within the peritoneal cavity often associated with cirrhosis

tumor markers—substances produced by cancer cells or organs in response to cancer

unilocular—having a single cavity

visceral peritoneum—the portion of the peritoneum that is closely applied to each organ

voiding cystourethrogram—a radiographic examination used to evaluate the lower urinary tract, where a contrast agent is instilled into the urinary bladder by means of urethral catheterization

Wilson disease—a congenital disorder that causes a person to retain excess copper

SONOGRAPHIC TERMINOLOGY AND PRACTICE GUIDELINES

Before beginning your studies, you must have a fundamental appreciation of sonographic terminology and commonly used sonographic descriptive terms (Table 1-1). Abdominal sonograms may be requested for various reasons. The American Institute of Ultrasound in Medicine (AIUM) publishes the practice guidelines for an abdominal sonogram on their website at www.aium.org (Table 1-2).

SONOGRAPHIC DESCRIPTION OF ABNORMAL FINDINGS

The appreciation and recognition of sonographic pathology is vital for the sonographer. Not only should one be able to recognize the normal echogenicity of organs and structures, but one must also be capable of identifying abnormalities. The normal echogenicity of the abdominal organs from greatest (brightest) to least (darkest) is as follows: renal sinus → pancreas → spleen → liver → renal cortex → renal pyramids → gallbladder. Therefore, if the right kidney appears more echogenic than the liver, both the liver and the right kidney must be closely examined for a cause of this deviant sonographic finding.

SOUND OFF

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TABLE 1-1 Sonographic descriptive terms

Sonographic Descriptive Term	Definition	Examples
Anechoic	Without echoes	Gallbladder Simple renal cyst
Complex	Having both cystic and solid components	Hemorrhagic cyst Hepatic abscess
Echogenic	Structure that produces echoes	Fatty liver Chronic renal disease
Heterogeneous	Of differing composition	Graves disease Diffuse liver metastasis
Homogeneous	Of uniform composition	Normal liver Normal testicle
Hyperechoic	Having many echoes	Cavernous hemangioma Angiomyolipoma
Hypoechoic	Having few echoes	Hepatic adenoma Thyroid adenoma
Isoechoic	Having the same echogenicity	Focal nodular hyperplasia

TABLE 1-2 AIUM indications for abdomen and/or retroperitoneum sonogram

AIUM Indications for an Ultrasound Examination of the Abdomen and/or Retroperitoneum[a]
• Abdominal, flank, and/or back pain. • Signs or symptoms that may be referred from the abdominal and/or retroperitoneal regions such as jaundice or hematuria. • Palpable abnormalities such as an abdominal mass or organomegaly. • Abnormal laboratory values or abnormal findings on other imaging examinations. • Suggestive of abdominal and/or retroperitoneal pathology. • Follow-up of known or suspected abnormalities in the abdomen and/or retroperitoneum. • Search for metastatic disease or an occult primary neoplasm. • Evaluation of suspected congenital abnormalities. • Abdominal trauma. • Pretransplantation and posttransplantation evaluation. • Planning for and guiding an invasive procedure.

- Searching for the presence of free or loculated peritoneal and/or retroperitoneal fluid.
- Suspicion of hypertrophic pyloric stenosis or intussusceptions.
- Evaluation of a urinary tract infection.

An abdominal and/or retroperitoneal ultrasound examination should be performed when there is a valid medical reason. There are no absolute contraindications.

[a] This is a limited list of indications. Other indications exist.
AIUM, American Institute of Ultrasound in Medicine.

Pathology is often described sonographically, relative to surrounding or adjacent tissue. For example, a hepatic mass may be described as hyperechoic compared to the surrounding echotexture of the normal liver. Solid tumors may be hyperechoic (occasionally described as echogenic), hypoechoic, homogeneous, heterogeneous, complex, isoechoic, cystic, or a combination of terms. For example, a renal mass may be described as a hypoechoic mass with a central area of increased echogenicity.

Lastly, a cyst must fit certain criteria to be referred to as a simple cyst. Simple cysts have smooth walls or borders, demonstrate through transmission, are anechoic, and are round in shape (STAR criteria). Occasionally, with higher frequency transducers with superior resolution, a diminutive amount of internal debris may be noted within a simple cyst. However, cysts that have a large amount of internal debris, septations, mural nodules, have a fluid–fluid level, or other components may be described as complex cysts. Cysts may also be referred to as multiloculated or unilocular. Although simple cysts may not be worrisome, complex cysts may be followed closely or further analyzed with another imaging modality.

SOUND OFF

A simple cyst should have *s*mooth walls, demonstrate *t*hrough transmission, be completely *a*nechoic, and be *r*ound in shape (STAR criteria).

PATIENT PREPARATION FOR AN ABDOMINAL SONOGRAM

Patients who are required to undergo an abdominal sonogram, and particularly patients who still have a gallbladder, need to fast for 8 hours, although some authors suggest that only a 6-hour fast may be warranted. However, diagnostic studies can be obtained in the nonfasting patient,

especially those requiring an emergency sonogram. The purpose of fasting is to ensure that the gallbladder is distended and to potentially reduce the amount of upper abdominal gas that may inhibit diagnostic accuracy. For renal sonograms, the patient is not typically required to fast, although some facilities may recommend that the patient be well hydrated. This is true especially if the urinary bladder needs to be assessed sonographically for intraluminal masses, irregularities, or urinary stones. Diabetic patients need to be scheduled early in the morning for studies that require them to fast to prevent hypoglycemic episodes. Abdominal sonography should also be performed prior to radiographic examinations that utilize barium contrast agents. For pediatric patients who must undergo renal sonography and urologic radiographic examinations, such as a voiding cystourethrogram, the renal sonogram is typically performed first. Small part sonography, such as scrotal and thyroid imaging, does not require patient preparation. The sonographic imaging process should be clearly explained to the patient, and a thorough clinical history obtained prior to performing each examination.

GATHERING A CLINICAL HISTORY AND LABORATORY FINDINGS

Although the patient–sonographer interaction is exceedingly important, a review of prior examinations and relevant documents should be performed by the sonographer before any contact with the patient. Gathering a thorough clinical history includes a review of reports from previous sonograms, computed tomography (CT) scans, magnetic resonance imaging studies, nuclear medicine examinations, radiography procedures, endoscopy examinations, and any additional related laboratory and diagnostic reports available. Moreover, sonographers must be capable of analyzing the clinical complaints of their patients. This practice will aid not only in clinical practice but also in answering complex certification examination questions. By correlating clinical findings with sonographic findings, the sonographer can directly impact the patient's outcome by providing the most targeted examination possible. Furthermore, when faced with a complicated, in-depth registry question, the test taker should be capable of eliminating information that is not applicable, to answer the question appropriately. Helpful information can be gathered from patient inquiry and from analyzing the registry review question at hand.

Although not all patients visit the sonography department with laboratory results (labs) in hand, sonographers must be capable of analyzing labs when they are available. For most inpatients and emergency room patients, labs from blood work and/or a urinalysis will be available. Although an increase

in most labs reveals evidence of an abnormality, some lab levels decrease with certain abnormalities. For example, leukocytosis, or an elevation in white blood cell (WBC) count, in general, indicates the presence of an inflammatory response due to infection. Patients who have some form of "itis" (such as cholecystitis or pancreatitis), or possibly even an abscess, will most likely have an abnormal WBC count with existing infection. Conversely, a decrease in hematocrit indicates bleeding. Patients who have suffered recent trauma or have an active hemorrhage will most likely have a decreased hematocrit level. Keep these two labs in mind as you study. Other labs and specific associated pathologies will be included in organ-specific chapters. A summary of labs can be found in Table 1-3 for quick broad reference (Table 1-3).

SOUND OFF

Patients who have some form of "itis" (such as cholecystitis or pancreatitis), or possibly even an abscess, will most likely have an abnormal WBC count with existing infection.

BASIC PATIENT CARE AND EMERGENCY SITUATIONS IN ABDOMINAL IMAGING

Sonographers must be capable of providing basic patient care for every patient equitably and in a timely manner. Although we may spend a limited amount of time with each patient, we must also be prepared for emergency situations and know how to respond. Basic patient care includes the assessment of body temperature, pulse, respiration, and blood pressure if needed (Table 1-4). Sonographers should be competent at transferring patients safely from wheelchairs and stretchers to the examination stretcher, being mindful of intravenous therapy, postsurgical, and urinary catheter needs. For patients with intravenous therapy, the intravenous fluid bag should be continually elevated to prevent retrograde flow. For urinary catheter care, the urinary bag should be placed below the level of the urinary bladder to prevent retrograde urine flow that could result in a urinary tract infection. One of the most common causes of nosocomial infections, or hospital-acquired infections, is the urinary tract infection.

TABLE 1-3 Basic overview of commonly encountered and relevant laboratory findings for abdominal imaging

Lab	Results

Alanine aminotransferase	↑ Biliary tree disease
	↑ Pancreatic disease
	↑ Hepatic disease
Albumin	↓ Liver damage
Alkaline phosphatase	↑ Biliary obstruction
	↑ Liver cancer
	↑ Pancreatic disease
	↑ Gallstones
	↓ **Wilson disease**
Aspartate aminotransferase	↑ Liver damage
	↑ Pancreatic disease
Bilirubin	↑ Liver disease
	↑ Biliary obstruction
	↑ Other systemic disorders and syndromes
λ-glutamyl transferase	↑ Liver disease
	↑ Biliary obstruction
PTT	↑ Liver disease
	↑ Hereditary **coagulopathies**
	↓ Vitamin K (deficiency)
	↑ **Anticoagulation therapy**
PT	↑ Liver disease
	↑ Bleeding abnormalities
	↑ Anticoagulation therapy
Urobilirubin (urine test)	↑ Liver disease
	↑ Biliary obstruction
Calcitonin	↑ Thyroid cancer
	↑ Lung cancer
	↑ **Anemia**
Thyroid-stimulating hormone	↑ **Hypothyroidism**
	↓ **Hyperthyroidism**
Thyroxine (T_4) or free thyroxine	↑ Hyperthyroidism
	↓ Hypothyroidism
Triiodothyronine (T_3)	↑ Hyperthyroidism
	↓ Hypothyroidism
BUN	↑ Renal disease
	↑ Renal obstruction
	↑ Dehydration
	↑ Gastrointestinal bleeding
	↑ Congestive heart failure
Creatinine	↑ Renal damage
	↑ Renal infection
	↑ Renal obstruction
Amylase	↑ Pancreatic disorders
	↑ Gallbladder disease

Lipase	↑ Biliary or pancreatic obstruction ↑ Pancreatic disorders ↑ Gallbladder disease ↑ Biliary or pancreatic obstruction
Serum calcium	↑ Parathyroid abnormalities
Prostatic-specific antigen	↑ Prostate abnormalities
Hematocrit	↓ Hemorrhage
WBC	↑ Inflammatory disease/infection

BUN, blood urea nitrogen; PT, prothrombin time; PTT, partial thromboplastin time; WBC, white blood cell.

TABLE 1-4 Normal numbers or ranges for basic patient care assessment

Basic Patient Assessment	
Body temperature	98.6° (oral)
Adult pulse	60–100 beats/minute
Adult blood pressure	<120/80
Adult respiration	12–20 breaths/minute

INFECTION CONTROL AND TRANSDUCER CARE

The cycle of infection may be depicted as a succession of steps (Fig. 1-1). Sonographers should continually employ standard precautions and good hygiene to prevent the spread of infection. Standard precautions are put into place to reduce the risk of microorganism transmission in the clinical setting. Standard precautions, formerly referred to as universal precautions, include (1) hand hygiene, (2) the use of personal protective equipment, (3) safe injection practices, (4) safe handling of potentially contaminated equipment and surfaces, and (5) respiratory hygiene and coughing etiquette. These precautions apply to blood, nonintact skin, mucous membranes, contaminated equipment, and all other body fluids, except for sweat.

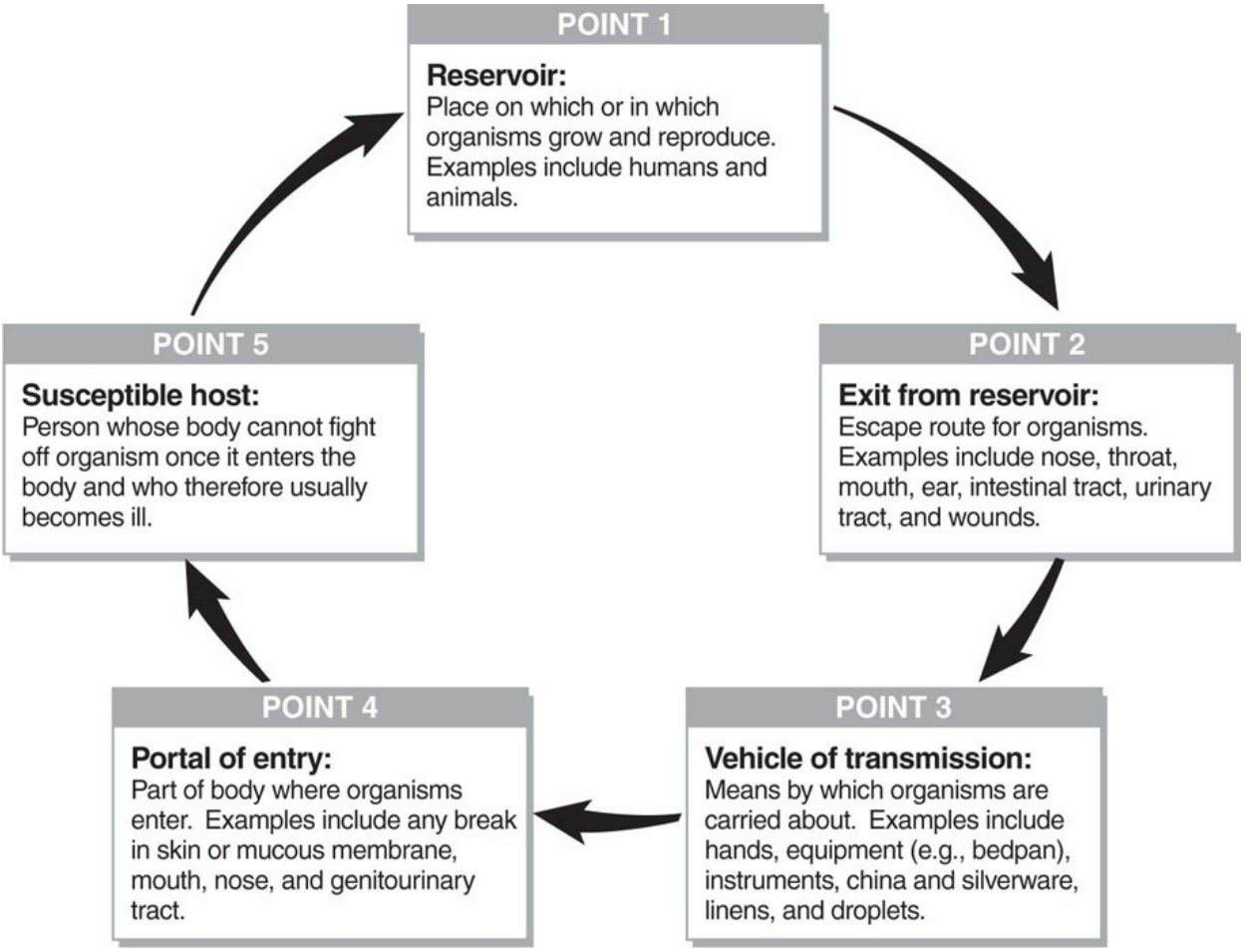


Figure 1-1 The cycle of infection.

The use of proper hand-washing and hand-cleaning techniques is one of the most effective means of preventing the spread of infection. The Center for Disease Control now recommends that health care workers employ an alcohol-based hand rub as the primary mode of hand hygiene in the clinical setting. Traditional hand-washing should be used as well when time permits, especially in situations when the hands are visibly soiled. Sonographers should also utilize personal protective equipment, such as gloves, gowns, face shields, and masks, when clinically applicable. Gloves, which are made of latex, nonlatex, or other synthetic material, should be worn during the sonographic examination and should be changed between patients. Be mindful of the potential for patient latex allergies and adapt accordingly by using another form of synthetic gloves.

Medical asepsis refers to the practices used to render an object or area free of pathogenic microorganisms. Although medical asepsis includes hand-washing, it also includes the use of disinfectants in the clinical setting, as well as the use of transducer or probe covers. Probe covers should be used for endocavity examinations, such as endovaginal and endorectal imaging. The use of sterile or nonsterile probe covers for these examinations is recommended by the institution. Transducers used during invasive

procedures should be covered with a sterile probe cover, and sterile ultrasound gel should be utilized.

Following each examination, the transducer, ultrasound machine, stretcher, and any other equipment used during the examination should be thoroughly disinfected. The transducer should be cleaned with a disinfectant spray or wipe as recommended by the institution and manufacturer. Endocavity transducers should be sterilized in some manner after each examination. Lastly, to prevent the spread of infection, sonographers should maintain good personal hygiene and health.

INVASIVE AND STERILE PROCEDURES

Patient preparation for invasive procedures varies among clinical facilities. However, informed consent from the patient and laboratory results are universally obtained. Laboratory findings, including an analysis of prothrombin time (PT), partial thromboplastin time (PTT), international normalizing ratio, fibrinogen, and platelets, are used to evaluate the patient for coagulopathies. Sterile field preparation is performed prior to the procedure as well, and sterile asepsis, also referred to as surgical asepsis, must be maintained (Table 1-5). Of course, sterile asepsis is always practiced in the surgical suite. Some invasive procedures that are commonly performed in the sonography department include thoracentesis, paracentesis, organ biopsies, mass biopsies, and abscess drainages. Biopsies can be performed using a freehand technique or under ultrasound guidance using a needle guide that attaches to the transducer. They may also be described as fine needle aspiration (FNA), which uses a thin needle and a syringe, or a core biopsy, which uses a much larger diameter needle to obtain a substantial tissue sample. An example of an FNA would be that of a thyroid biopsy, whereas an example of a core biopsy would be a liver biopsy.

TABLE 1-5 Ten vital rules of surgical asepsis to remember

1. Always know which area and items are sterile and which are not.
2. If the sterility of an object is questionable, it is considered nonsterile.
3. If you recognize that an item has become nonsterile, act immediately.
4. A sterile field must never be left unmonitored. If a sterile field is left unattended, it is considered nonsterile.
5. A sterile person does not lean across a sterile field.
6. A sterile field ends at the level of the tabletop.
7. Cuffs of a sterile gown are not considered sterile.
8. The edges of a sterile wrapper are not considered sterile.

9. If one sterile person must pass another, they must pass back-to-back.
10. Coughing, sneezing, or excessive talking over a sterile field leads to contamination.

INSTRUMENTATION

Although a thorough physics review is beyond the scope of this book, there are several topics that must be addressed in preparation for the abdominal examination. Sonographic images are typically recorded and stored in a picture-archiving and communication system (PACS). PACS allows for both easy storage and comparison between sonographic findings and straightforward correlation between other imaging modality findings.

General abdominal imaging requires the use of a transducer that balances penetration with high-quality resolution. In general, the higher the frequency employed, the poorer the penetration abilities, but the better the resolution. Conversely, the lower frequencies provide better penetration with a sacrifice in resolution. Transducers that may be used for abdominal and small part sonographic imaging include linear array, matrix array, curved or convex array, phased array, or vector or sector array. Higher frequency linear array transducers (7.5 to 18 MHz or higher when appropriate) should be used for superficial structures, such as thyroid, scrotum, breast, musculoskeletal (MSK) imaging, and some gastrointestinal examinations (e.g., appendix and pylorus). A standoff pad or a mound of gel may be used for imaging some superficial structures, such as splinters or foreign objects just below the skin surface. Lower frequency curved array transducers (2.0 to 5.0 MHz) are employed for general abdominal imaging for the assessment of deeper or larger structures such as the liver, abdominal aorta, or pancreas. When applicable, sonographers should utilize technology such as power Doppler, color Doppler, pulsed Doppler, harmonics imaging, compound imaging, extended-field of view, elastography, and three-dimensional (3D) sonography to promote diagnostic accuracy.

SOUND OFF

↑Frequency = ↑Resolution = ↓Penetration
↓Frequency = ↓Resolution = ↑Penetration

IMAGING AND DOPPLER ARTIFACTS

Gray-scale, or brightness mode (B-mode), provides a two-dimensional (2D)

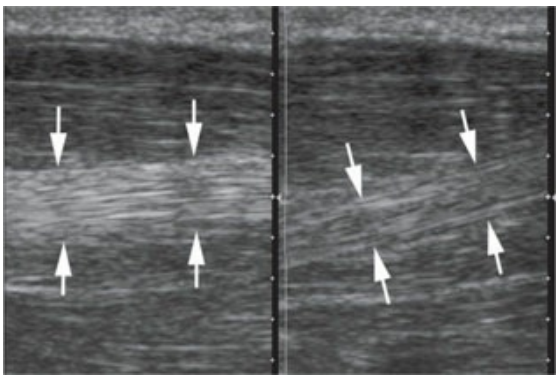
image of the human body in real time. Real-time imaging provides anatomy and motion, much like watching a live video of the internal structure being analyzed. Abdominal sonography involves careful analysis of vital structures. Often, artifacts will be observed during real-time imaging (Table 1-6). Also, there are several Doppler imaging artifacts (Table 1-7).

BODY SYSTEMS AND ABDOMINAL CAVITY

Overview of Body Systems

Throughout the following chapters, specific vital details will be provided for both normal and abnormal conditions that can be demonstrated with sonography. However, a fundamental understanding of several of the body systems is an important commission for the sonographer. The body consists of many mutually supporting body systems. These systems work together to preserve homeostasis, the body's tendency to maintain internal equilibrium by adjusting internal processes. These systems include the cardiovascular system, endocrine system, lymphatic system, MSK system, nervous system, and reproductive system. The excretory system includes the digestive system, urinary system, and respiratory system. Table 1-8 provides some insight into the basic functions of these systems and relevant topics to keep in mind as you study the various components that are applicable to abdominal imaging (Table 1-8).

TABLE 1-6 2D real-time imaging artifacts

Artifact	Explanation	Example
Anisotropy	Occurs when the sound beam strikes a structure in a nonperpendicular manner, resulting in a loss of the true echogenicity of the structure.	Seen when imaging tendons (Fig. 1-2).  **Figure 1-2** Anisotropy. Left image is obtained perpendicular to the tendon (arrows), while the right image is obliqued.
Comet tail	A type of	Seen with adenomyomatosis of the gallbladder

	reverberation artifact caused by several small, highly reflective interfaces.	(Fig. 1-3).

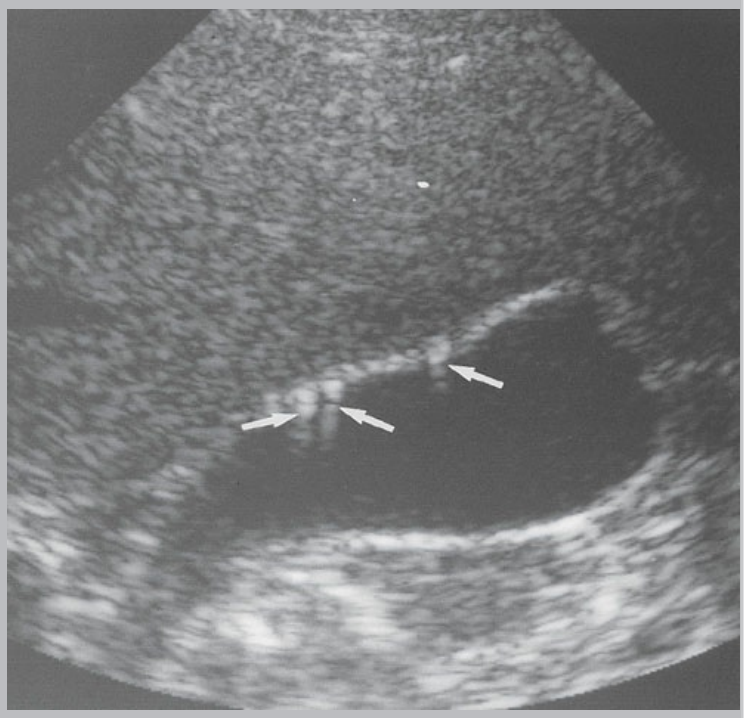


Figure 1-3 Comet tail artifact (arrows).

Dirty shadowing	Caused by air or bowel gas.	Most often seen emanating from bowel. May be seen posterior to gas within an abscess (Fig. 1-4).

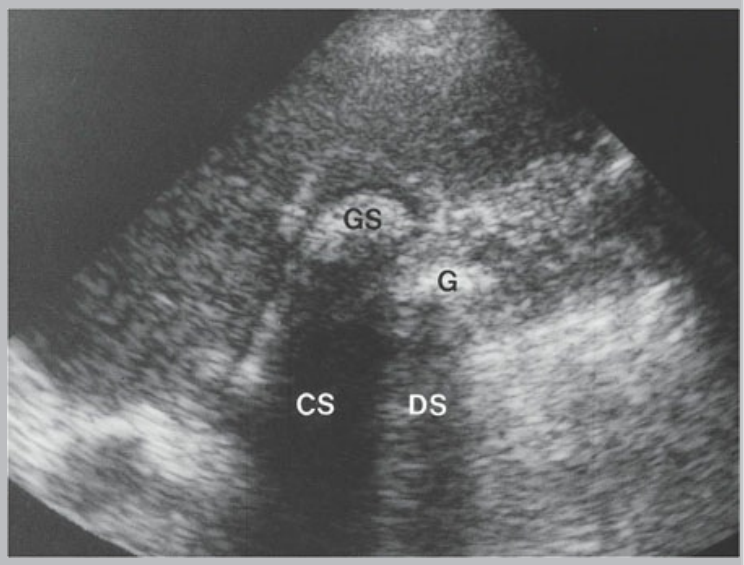
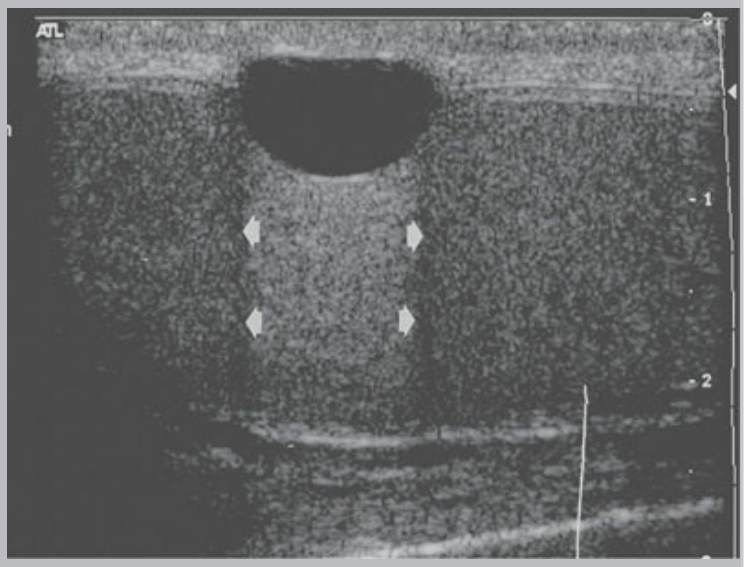
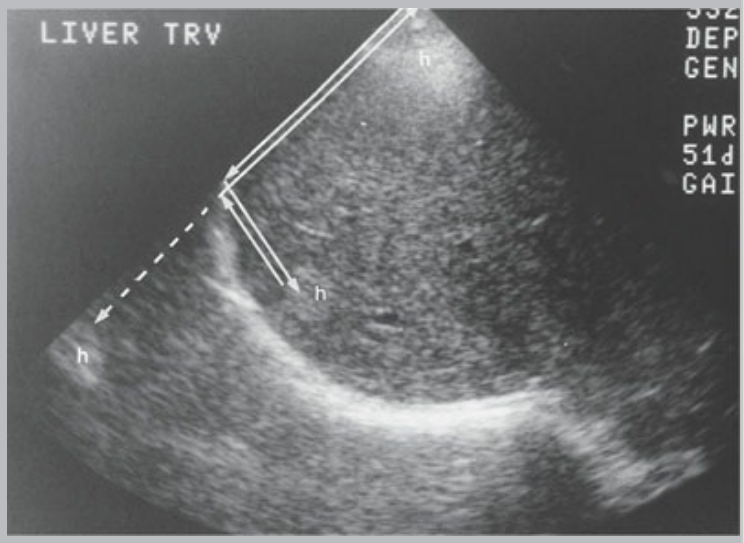


Figure 1-4 Dirty shadowing (DS) produced by gas (G). Clean shadow (CS) produced by gallstone (GS).

Edge shadowing	Reflective or refractive effect seen deep to the margins of a round structure that have a	Often seen arising from cystic structures and appears as narrow shadow lines originating at the edge of these structures (Fig. 1-5).

	significantly different speed of sound compared to surrounding tissue. May be termed refractive shadowing.	 **Figure 1-5** Edge artifact (arrowheads).
Mirror image	Produced by a strong specular reflector and results in a copy of the anatomy being placed deeper than the correct location.	Seen posterior to the liver and diaphragm (Fig. 1-6).  **Figure 1-6** Mirror image artifact of a hemangioma (h) of the liver. The artifact is identified by the broken arrow outside of the liver.
Posterior (acoustic) enhancement or through transmission	Produced when the sound beam is barely attenuated through a fluid or a fluid-filled structure.	Seen posterior to fluid-filled structures such as the gallbladder and renal cysts, and with ascites (Fig. 1-7).

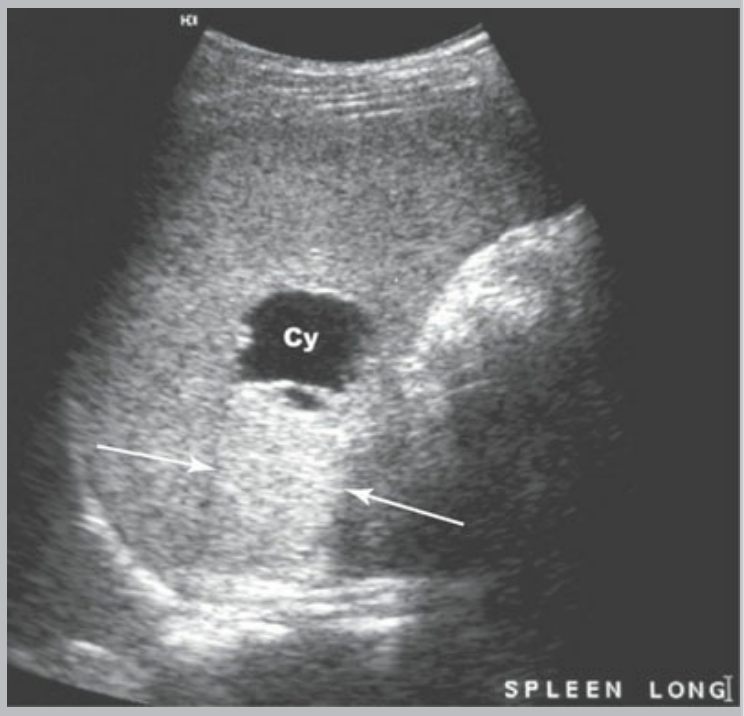


Figure 1-7 Through transmission (arrows) seen posterior to a liver cyst (Cy).

Refraction	Caused by the bending of the ultrasound beam when it passes through an interface between two tissues with vastly dissimilar speeds of sound and the angle of the approach is not perpendicular.	Seen when imaging through the rectus muscles of the abdominal wall (Fig. 1-8).

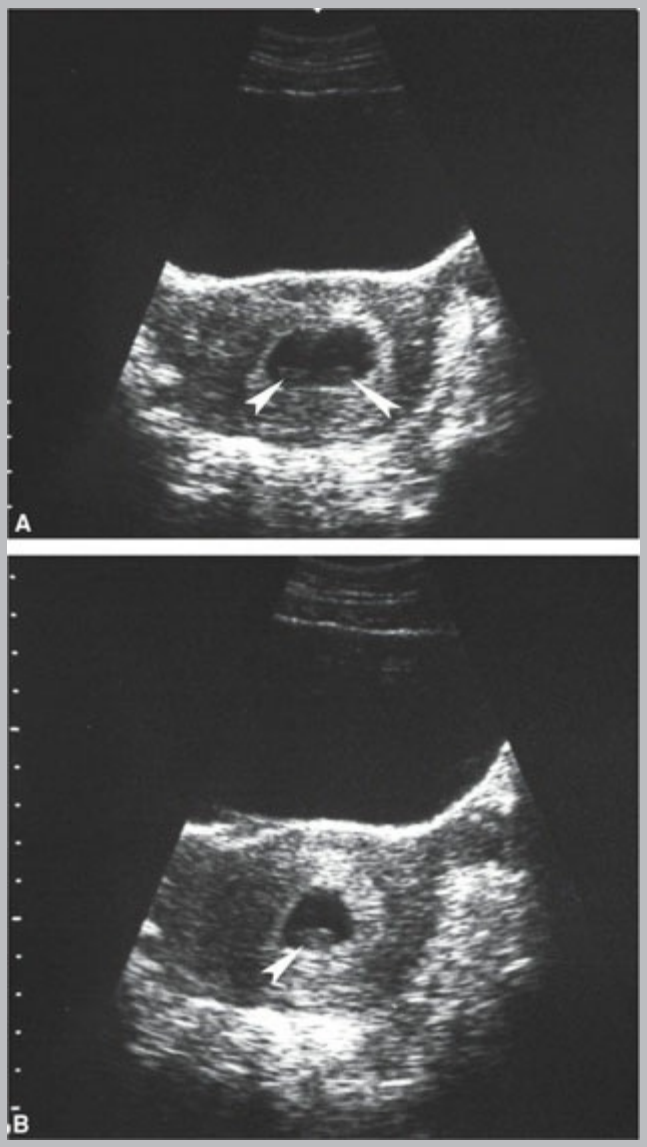


Figure 1-8 Refraction caused the appearance of two gestational sacs (image A arrowheads) when there was truly only one (image B arrowhead).

Reverberation artifact	Caused by a large acoustic interface and subsequent production of false echoes.	Seen as an echogenic region in the anterior aspect of the gallbladder or other fluid-filled structures (Fig. 1-9).

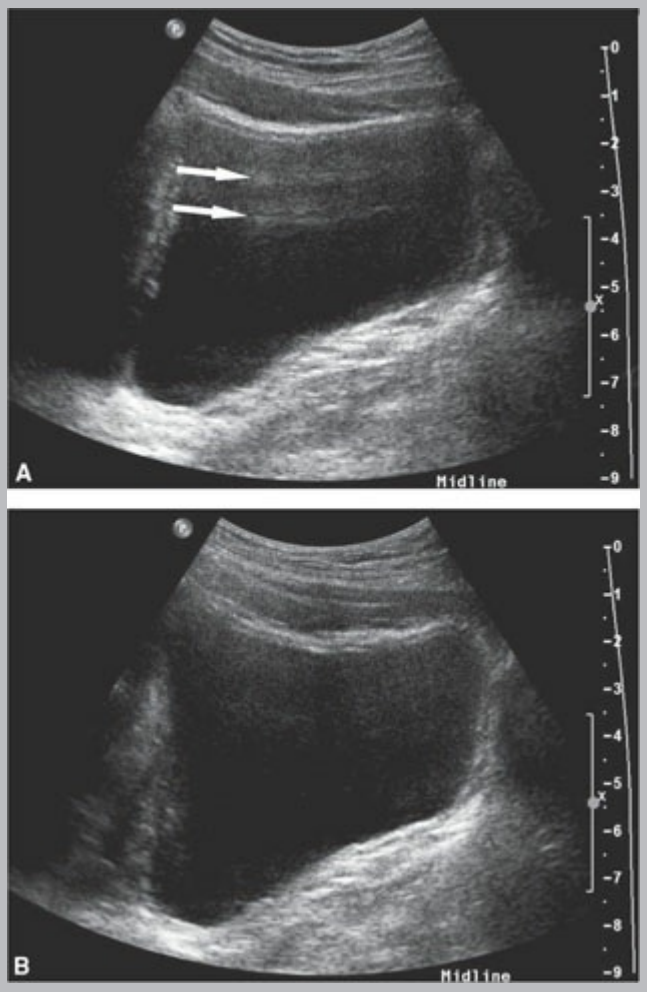


Figure 1-9 Reverberation. A. Reverberation in the anterior aspect of the urinary bladder (arrows). B. Changing the scanning angle minimizes the artifact.

Ring-down artifact	Artifact that appears as a solid streak or a chain of parallel bands radiating away from a structure.	Seen emanating from gas bubbles within the abdomen. Can help to identify the presence of air in a structure, such as in the case of pneumobilia (Fig. 1-10).

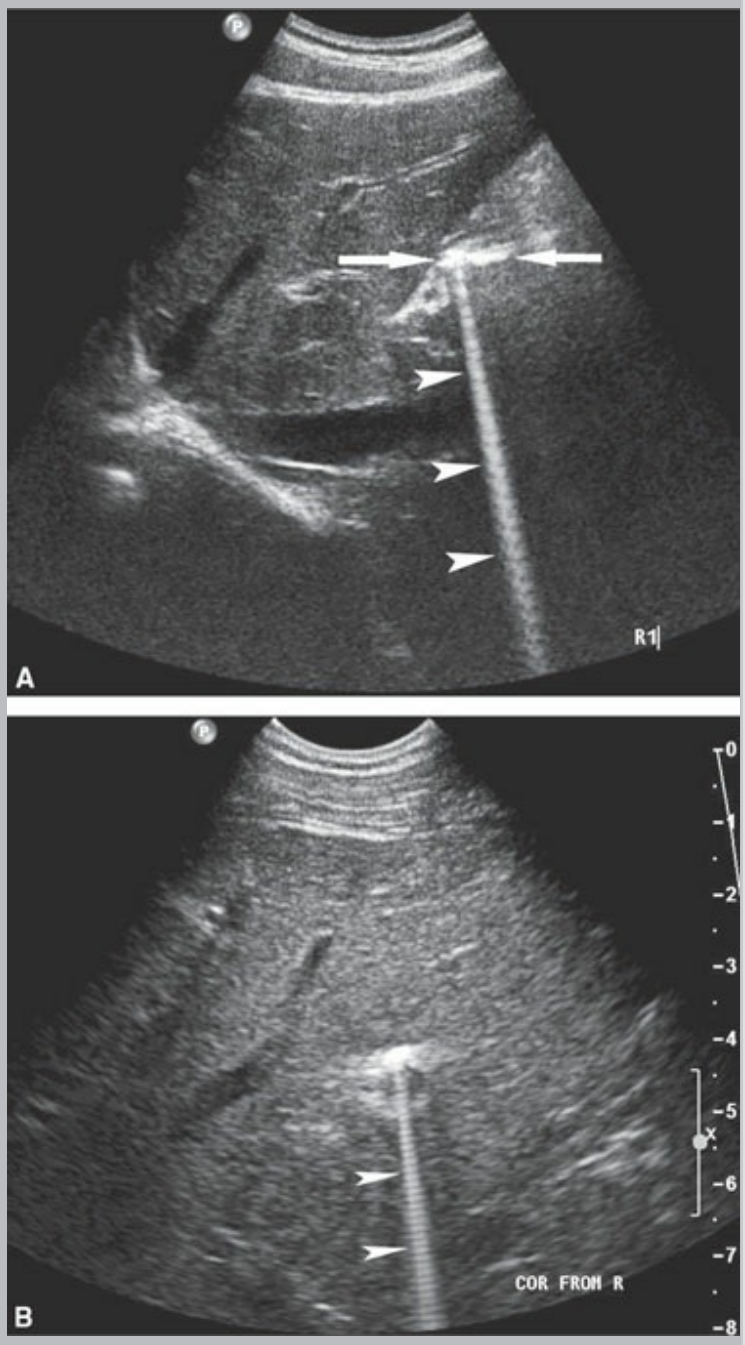


Figure 1-10 Ring down artifact. A and B. Air (between arrows in A) producing ring down artifact (arrowheads in A and B).

Shadowing	Caused by attenuation of the sound beam.	Seen posterior to bone, and calculi like gallstones and renal stones (see label CS in Fig. 1-4).
Side lobes	Caused by sound beams that are peripheral to the main sound beam.	Seen as low-level echoes within fluid, mimicking sludge, debris, or pus within a fluid-filled structure like the gallbladder (Fig. 1-11).

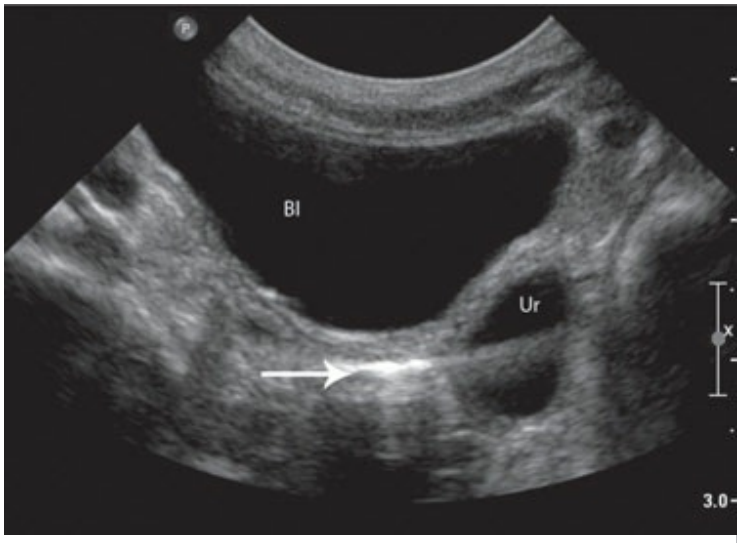


Figure 1-11 Side lobe artifact from air (arrow) within the rectum extending into the fluid-filled dilated ureter (Ur) that lies adjacent to the urinary bladder (Bl).

Slice thickness	Caused by compression from 3D to 2D images.	Simulates false echoes that could resemble sludge or debris in the urinary bladder or gallbladder (Fig. 1-12).

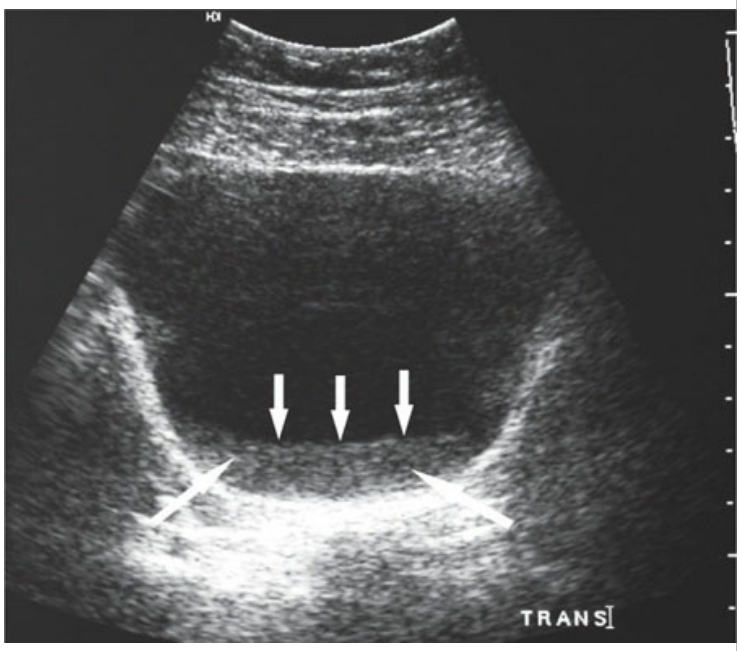


Figure 1-12 Slice thickness artifact produces false layering debris (arrows) within the urinary bladder.

Although a detailed comprehension of cardiac system function and circuitry may not be compulsory for the abdominal sonographer, you should have a fundamental understanding of blood circulation to enhance your grasp

of some abdominal anatomy and pathologic processes. The cardiovascular system has both a pulmonary and systemic function. The pulmonary circulation provides blood to the lungs and drains the lungs as well, while the systemic circulation provides this same function for the rest of the body's organs and structures.

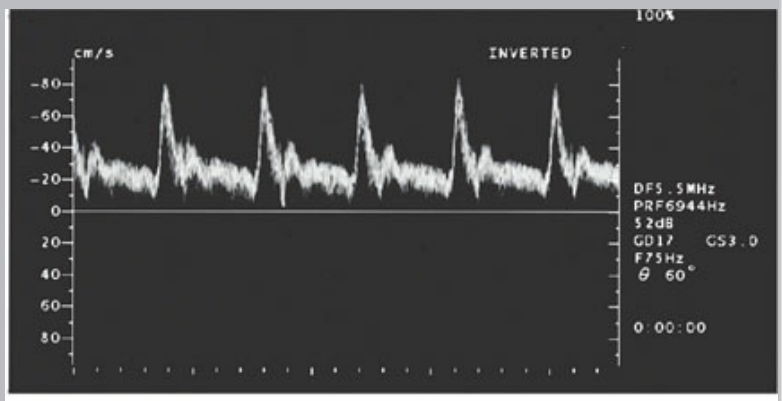
The heart consists of four chambers: two atria and two ventricles. Blood returning from the heart from the system circulation is via the superior vena cava and the inferior vena cava (IVC). The superior vena cava and the IVC empty into the right atrium of the heart. Thus, recognizing an enlargement of IVC during an abdominal sonogram can be indicative of right-sided heart failure. Although the heart is not specifically imaged by the abdominal sonographer, the fluid around the heart, or a pericardial effusion, may be noted during an abdominal sonogram. Also, fluid within the chest cavity, or a pleural effusion, may be noted. Vascularity of the abdomen can be evaluated with sonography with real-time, pulsed Doppler, and color or power Doppler. Although there are a few exclusions, the typical pattern of blood flow is as follows: arterioles–capillary–venule–vein.

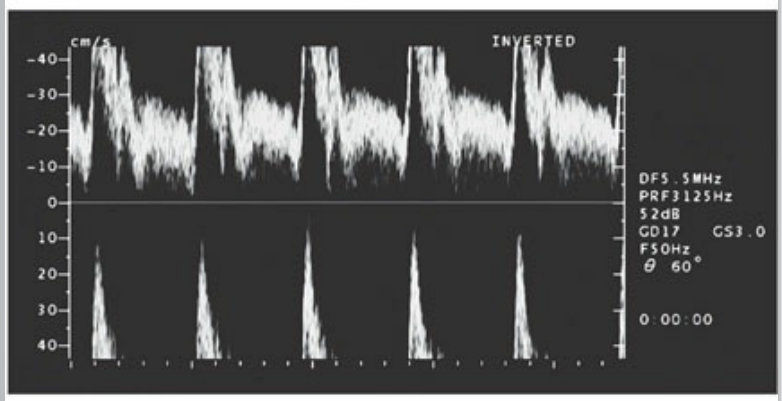
The digestive system can be evaluated with sonography for various indications. The esophagus may be seen while imaging the liver, especially in the sagittal plane when analyzing the left lobe of the liver. Although gastritis may be demonstrated, the adult stomach is not often analyzed specifically with sonography. However, the distal portion of the pediatric stomach can be evaluated for pyloric stenosis. The intestines may be examined for disorders such as intussusception, volvulus, diverticulitis, and appendicitis. Tumors of the gastrointestinal tract may be seen with sonography as well. Of course, the accessory organs of the digestive system, the liver, gallbladder, and pancreas are readily imaged with sonography.

The glands of the endocrine system, specifically the thyroid gland, parathyroid glands, adrenal glands, and testicles, are imaged by abdominal sonographers (Fig. 1-17). Endocrine glands release their hormones directly into the bloodstream. Exocrine glands, such as the salivary glands, release their enzymes through ducts. Some organs, such as the pancreas and testicles, have both exocrine and endocrine functions. Whereas the pancreatic endocrine function is to produce the hormones insulin, glucogan, and somatostatin, the exocrine function is to produce the digestive enzymes amylase, lipase, sodium bicarbonate, and others. The testicular endocrine function is to produce testosterone, whereas the testicular exocrine function is to produce and transport sperm.

TABLE 1-7 Doppler artifacts

Doppler Artifact	Explanation	Adjustment
Absent Doppler signal	Could be caused by low gain, low frequency, high wall filter, or too high velocity scale.	• Decrease PRF • Turn up spectral gain • Decrease the wall filter • Open the sample gate
Aliasing	Occurs when the Doppler sampling rate (pulse-repetition frequency) is not high enough to accurately display the Doppler frequency shift.	• Increase the pulse-repetition frequency. • Adjust the baseline. • Switch to a lower transmitted frequency. • Increase the angle of insonation to decrease Doppler shift (Figs. 1-13 and 1.14).





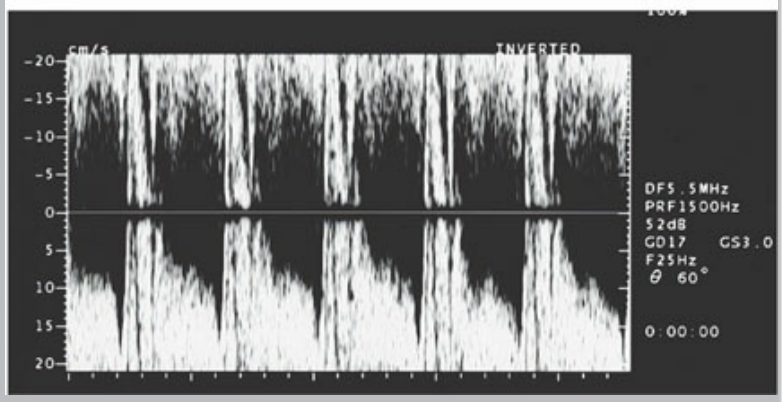


Figure 1-13 Pulsed Doppler Aliasing. A. Pulsed waveform of internal carotid shows normal systolic peaks. B. Sampling rate set too low demonstrating aliasing. C. Further decrease in sampling rate produces more aliasing.

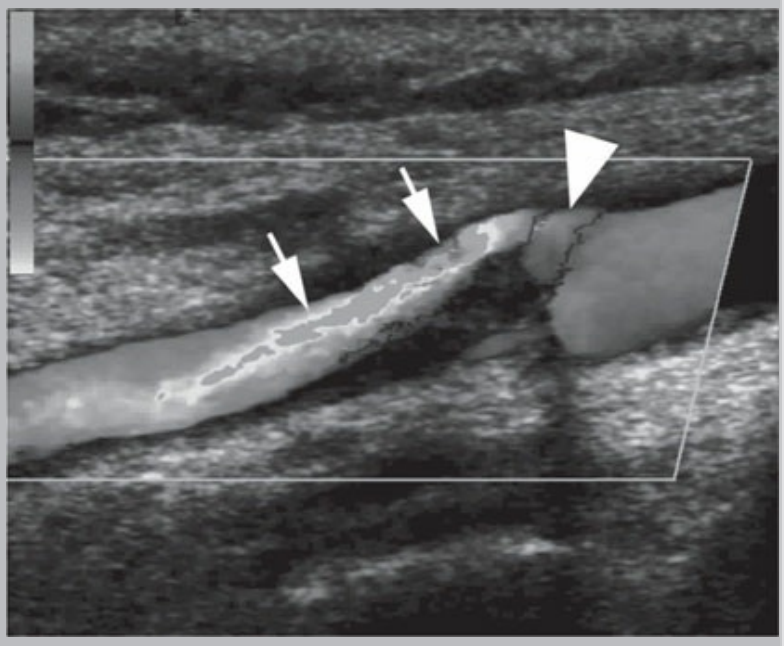


Figure 1-14 Color Doppler aliasing. The arrows demonstrate localized aliasing within a stenotic internal carotid artery. The arrowhead demonstrates a true reversal of flow. Color image provided online.

Doppler noise	Caused by inappropriately high Doppler settings.	Reduce color gain setting or adjust wall filter. (Fig. 1-15).

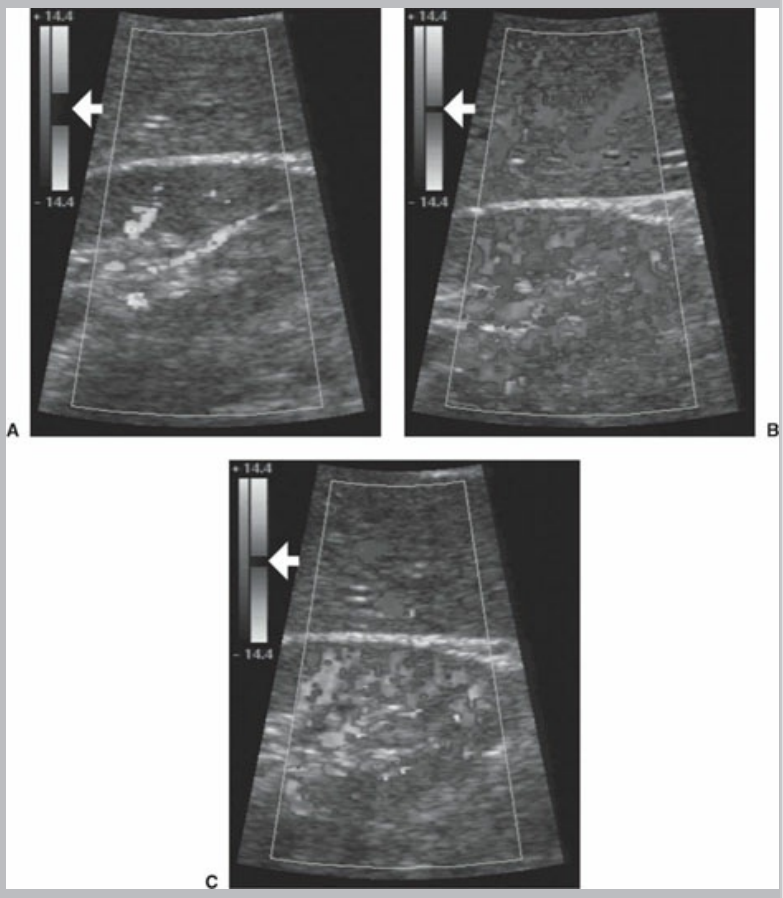


Figure 1-15 Doppler noise and the wall filter (arrow). A. High filter setting produces minimal flow detection. B. Low filter setting produces excessive noise. C. Medium filter setting eliminates noise and correctly depicts flow. Color image provided online.

Flow directional abnormalities	Caused by the sound beam striking a vessel at a 90-degree angle, producing an area void of color.	Change the angle of insonation.
Twinkle artifact	Occurs behind strong, granular, and irregular surfaces like crystals, calculi, or calcifications.	Artifact that is actually useful at identifying small kidney or biliary stones (Fig. 1-16).

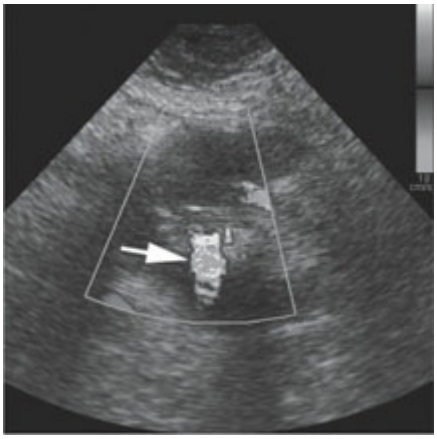


Figure 1-16 Twinkle artifact (arrow) seen posterior to a small kidney stone.

TABLE 1-8 Functions and structures of body systems

Body System	Primary Function	Organs or Structures
Cardiovascular	Supplies the body with oxygen, nutrients, hormones, and WBCs and removes waste and toxins by pumping and transferring blood.	Arteries and arterioles Capillaries Heart Veins and venules
Digestive	Provides metabolism, nutrient uptake, energy storage, and the excretion of waste.	Accessory digestive organs: Liver Gallbladder Pancreas Esophagus Mouth Small and large bowel Stomach
Endocrine	Secretion of hormones into the blood to control many different body functions. The hypothalamus in the brain controls the pituitary gland's secretion of various hormones, which in turn controls the secretion of hormones by endocrine organs or glands.	Adrenal glands Liver Ovaries Pancreas Parathyroid glands **Pineal gland** Pituitary gland (anterior and posterior) Testicles Thyroid gland
Exocrine	Secretes hormones or juices through ducts.	Breast Pancreas

		Salivary glands (parotid glands, submandibular glands, and sublingual glands) Liver
Lymphatic	Collection and transportation of excess fluid, absorption of fats (which are eventually sent to the liver), and immune response.	Adenoids Bone marrow Lymph nodes Spleen **Thymus gland** Tonsils
MSK	Provides the structural support system for the body.	Cartilage Connective tissue Joints Ligaments Muscles Tendons
Nervous	Controls almost every organ system and structure in the body.	Brain Spinal cord Nerves
Respiratory	Supplies the body with oxygen and removes carbon dioxide from the blood.	Bronchus Larynx Lungs Nasal cavity Pharynx Trachea
Reproductive	Produce new life.	Male: Epididymis Prostate gland Scrotum Testes Vas deferens Female: Fallopian tubes Ovaries Uterus Vagina
Urinary	Maintain chemical and water balance, regulate blood pressure, and filter waste products from the blood.	Kidneys Ureters Urethra Urinary bladder

MSK, musculoskeletal; WBC, white blood cells.

SOUND OFF
Endocrine organs release hormones into the bloodstream, whereas exocrine organs use ducts. Remember, *ex*ocrine *ex*it through ducts.

The lymphatic system plays a vital role in the immune response. Small structures known as lymph nodes are scattered throughout the body and serve the purpose of filtering lymphatic fluid from foreign material (Fig. 1-18). The lymphatic system also plays an important role in the transportation of lymphatic fluid or lymph, and thus fluid balance. This fluid makes its way through lymphatic channels to the thoracic duct, ultimately to be returned to the systemic circulation. A build-up of lymphatic fluid, most likely caused by obstruction of this drainage process with subsequent swelling, is referred to as lymphedema. Lymph nodes, which contain lymphocytes and macrophages, are commonly imaged by the sonographer in the neck, the groin, the armpit, and perhaps, when enlarged, they may be seen within the abdomen. Enlargement of a lymph node may be referred to as lymphadenopathy. The largest mass of lymphatic tissue is the spleen. Other lymphatic system components include the thymus gland in the chest, and the tonsils and adenoids in the neck.

The MSK system provides the framework for the human body. It comprises bones, muscles, tendons, ligaments, and joints. Although there is an additional certification covering MSK sonography offered by the ARDMS, the abdominal sonographer may be called upon to analyze some MSK structures, including the pediatric hip and the Achilles tendon. Sonography can be useful at detecting many pathologic complications of the MSK system, including joint effusions and tendon tears or ruptures.

The reproductive system of both the male and the female can be readily imaged with sonography. For abdominal sonography, one must have an understanding of the function and anatomy of male reproductive organs and structures, including the penis, scrotum, testes, and prostate gland. Testicular torsion and infection of the testicles and epididymis are among the common indications for scrotal sonography.

The urinary tract consists of an upper and a lower part. The upper urinary tract includes the kidney and ureters, whereas the lower part includes the bladder and urethra. The kidneys function to regulate blood volume, filter the blood, and regulate blood pressure. The kidneys produce urine, which comprises waste such as urea. Urine flows from the paired kidneys down the paired ureters and is temporarily stored in the urinary bladder before exiting the body. Sonography can be used to evaluate the urinary tract for obstruction, tumors, and renal calculi, as well as to perform an overall assessment of other disorders that can inhibit the system’s functions.

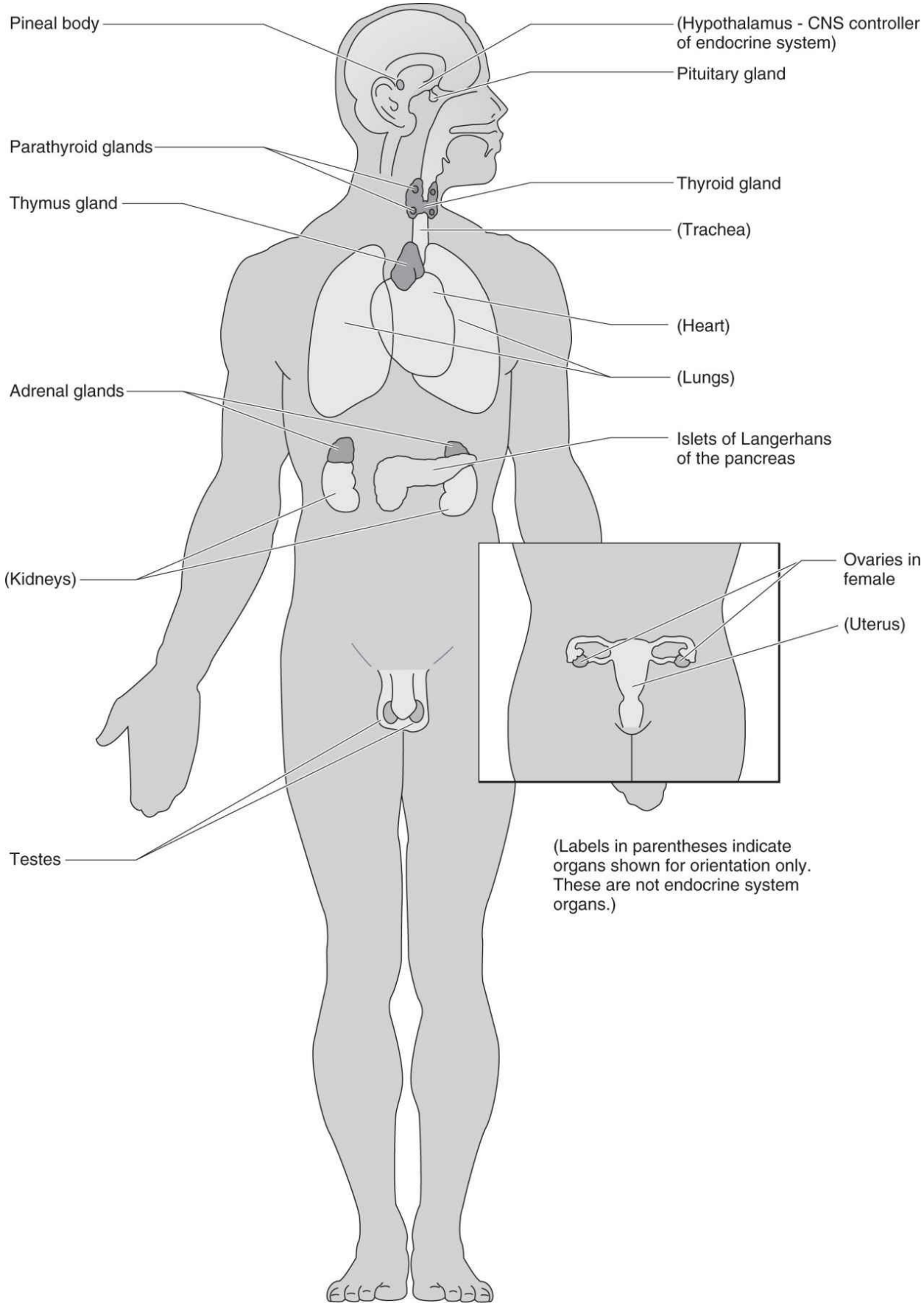


Figure 1-17 Endocrine system.

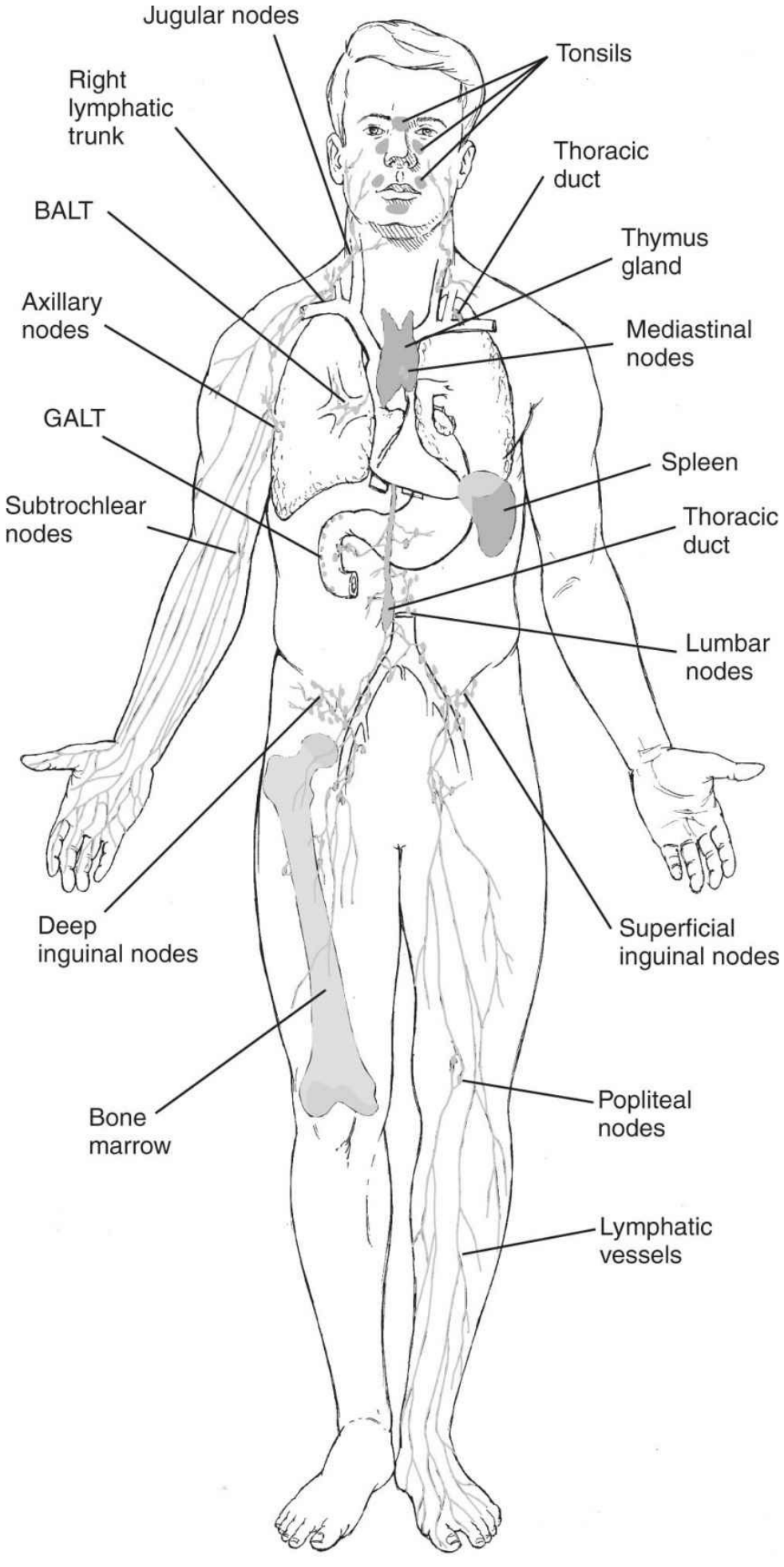

Jugular nodes
Tonsils
Right lymphatic trunk
Thoracic duct
BALT
Thymus gland
Axillary nodes
Mediastinal nodes
GALT
Spleen
Subtrochlear nodes
Thoracic duct
Lumbar nodes
Deep inguinal nodes
Superficial inguinal nodes
Bone marrow
Popliteal nodes
Lymphatic vessels

Figure 1-18 Lymphatic system. GALT is gut-associated lymphoid tissue and BALT is bronchus-associated lymphoid tissue.

Abdominal Cavity

The double lining of the abdominal cavity is the peritoneum. The peritoneum consists of a parietal and visceral layer. The parietal peritoneum forms a closed sac, except for two openings in the female pelvis, which permits passage of the fallopian tubes from the uterus to the ovaries. Furthermore, each organ is covered by a layer of visceral peritoneum, which is essentially the organ's serosal layer.

Some abdominal organs are considered intraperitoneal and others retroperitoneal (Tables 1-9 and 1-9). The retroperitoneal structures are only covered anteriorly with peritoneum. The abdominal parietal peritoneum can be divided into two sections: the greater sac and the lesser sac. The greater sac extends from the diaphragm to the pelvis, while the lesser sac is located posterior to the stomach. Potential spaces, which are essentially outpouching in the peritoneum, exist between the organs (Table 1-11).

These spaces provide an area for fluid to collect in the abdomen and pelvis. Ascites is an abnormal collection of abdominal fluid in these spaces. It can be found in association with several pathologies (Table 1-12). Ascites can be a single fluid, such as serosal fluid, pus, blood, or urine, or it may be a combination of fluids. Exudate ascites can be a malignant form of ascites. It may appear as complex fluid with loculations and produce matting of the bowel. Benign ascites, or transudate ascites, consists of serosal fluid, and typically appears simple and anechoic.

SONOGRAPHIC ABDOMINAL PATHOLOGY OVERVIEW

A mass, also referred to as a neoplasm or tumor, may be benign, potentially malignant (precancerous), or malignant. Whereas malignant, or cancerous, tumors both invade adjacent tissue and have the potential to metastasize to other parts of the body, a benign tumor, although certainly not normal, typically does not invade neighboring tissue and does not metastasize. However, some benign tumors have the potential for progressing to cancer. Tumors, whether benign or malignant, may also displace adjacent anatomy, termed mass effect, causing secondary clinical complaints such as pain.

A synopsis of the most common benign and malignant adult abdominal solid masses encountered with sonography is provided in Tables 1-13 and 1-13, respectively. Though a description of each mass and the most common abdominal location is provided, each of these masses will be further

discussed in the following chapters. A synopsis of the most common pediatric malignant abdominal masses encountered with sonography is provided in Table 1-15. A common theme that one can recognize is the presence of the word part "blast" in these childhood malignant tumors.

SOUND OFF

The word part "blast," as in hepato*blast*oma, often refers to a childhood malignancy.

TABLE 1-9 The list of intraperitoneal organs

Gallbladder
Liver (except for the bare area)
Ovaries
Spleen (except for splenic hilum)
Stomach

TABLE 1-10 The list of retroperitoneal organs

Abdominal lymph nodes
Adrenal glands
Aorta
Ascending and Descending Colon
Duodenum
IVC
Kidneys
Pancreas
Prostate gland
Ureters
Urinary bladder
Uterus

TABLE 1-11 The location and significance of the peritoneal cavity spaces

Peritoneal Cavity Spaces	Location and Significant Points
Subphrenic spaces	• Inferior to the diaphragm • Divided into right and left

Subhepatic spaces	• Divided into right (anterior and posterior) and left • Right is located between the right lobe of the liver and right kidney • Posterior right subhepatic space is also referred to as **Morrison pouch** • Left is located between the left lobe of liver and stomach
Retropubic space	• Between the pubic bone and urinary bladder • Also referred to as the **Space of Retzius**
Lesser sac	• Between the stomach and pancreas • Common location for pancreatic pseudocysts
Paracolic gutters	• Extend alongside the ascending and descending colon on both sides of the abdomen
Posterior cul-de-sac	• Male: between the urinary bladder and rectum; also referred to as the rectovesical pouch • Female: between the uterus and rectum; also referred to as pouch of Douglas and rectouterine pouch
Anterior cul-de-sac	• Between the urinary bladder and uterus • Also called the vesicouterine pouch in females

TABLE 1-12 Pathologies associated with ascites

Acute cholecystitis
Cirrhosis
Congestive heart failure
Ectopic pregnancy
Malignancy
Portal hypertension
Ruptured abdominal aortic aneurysm

As a screening modality, sonography has some challenges in regard to predicting whether a mass is benign or malignant. However, there are several clinical findings that can be indicators for the presence of malignancy. These indicators may present as signs or symptoms. A sign is something that can be observed by others and is therefore objective. An example of a sign is fever, vomiting, and elevated laboratory tests. A symptom is something felt by the person themselves, such as nausea, a headache, or abdominal pain, and is therefore subjective. In general, patients with cancer may present with vague

signs and symptoms, such as unexplained weight loss, fever, fatigue, pain, and possible skin changes. Throughout this text, you will see signs and symptoms placed together in tables and referred to as clinical findings. Clinical findings also include laboratory results. Some labs can be used as tumor markers. Tumor markers are substances produced by cancer cells or organs in response to cancer (Table 1-16).

TABLE 1-13 Common locations of benign abdominal/small part tumors

Benign Abdominal Tumor	Description	Common (Abdominal) Location
Adenoma	Tumor of glandular origin	Most organs
Adrenal rest tumor	Tumor containing adrenal tissue	Testicle
Angiomyolipoma	Tumor of blood vessels, muscle, and fat	Kidney
Focal nodular hyperplasia	Abnormal accumulation of cells within a focal region of an organ	Liver
Granuloma	Tumor consisting of a group of inflammatory cells	Liver and spleen
Gastrinoma	Tumor that secretes **gastrin**	Pancreas
Hamartoma	Tumor consisting of an overgrowth of normal cells of an organ	Kidney
Hemangioma	Tumor consisting of blood vessels	Liver, spleen, and kidney
Hematoma	Localized collection of blood	Anywhere an organ/tissue is affected by trauma
Insulinoma	Tumor that secretes insulin	Pancreas
Lipoma	Tumor that consists of fat	Liver, spleen, kidney, and superficial
Oncocytoma	Tumor consisting of **oncocytes**	Kidney
Pheochromocytoma	Tumor that consists of **chromaffin cells** of the adrenal gland	Adrenal gland
Teratoma	Tumor that consists of	Testicle/ovary

	tissue from all three germ cell layers	
Urinoma	Localized collection of urine	Adjacent to a kidney transplant

TABLE 1-14 Common locations of malignant abdominal/small part tumors

Malignant Abdominal Tumor	Description	Common (Abdominal) Location
Adenocarcinoma	Cancer of glandular origin	Pancreas and gastrointestinal tract
Angiosarcoma	Cancer in the lining of vessels (lymphatic or vascular)	Spleen
Choriocarcinoma	Cancer that consists of trophoblastic cells	Testicle
Cholangiocarcinoma	Cancer of the bile ducts	Biliary tree
Cystadenocarcinoma	Cancer that is fundamentally adenocarcinoma with cystic components	Pancreas
Embryonal cell carcinoma	Cancer that is of germ cell origin	Testicle
Follicular carcinoma	Cancer of aggressive abnormal epithelial cells	Thyroid
Hepatocellular carcinoma (Hepatoma)	Cancer that originates in the hepatocytes	Liver
Hypernephroma (Renal cell carcinoma)	Cancer that originates in the tubules of the kidney	Kidney
Leukemia (focal)	Cancer of the blood cells	Spleen, liver, and testicle
Lymphoma	Cancer of the lymphatic system	Spleen, kidney, and testicle
Medullary carcinoma	Cancer originating from the parafollicular cells of the thyroid	Thyroid
Papillary carcinoma	Cancer that has formation of many irregular, fingerlike projections	Thyroid
Seminoma	Cancer that originates in the seminiferous tubules	Testicle
Transitional cell carcinoma	Cancer that originates in the transitional epithelium of an	Bladder, ureter, and kidney

	organ or structure	
Yolk sac tumor	Cancer that is of germ cell origin	Testicle

TABLE 1-15 Common locations of malignant pediatric abdominal masses

Solid Pediatric Malignant Abdominal Mass	Common Location
Hepatoblastoma	Liver
Nephroblastoma (Wilms tumor)	Kidney
Neuroblastoma	Liver

There are many syndromes, multisystem disorders, and diseases that you will encounter as you study abdominal pathology. A summary of these is provided in Table 1-17. Keep in mind that a syndrome is a group of clinically observable findings that exist together and allow for classification, whereas a disease is the result of the incorrect functioning of an organ or body system that can result from many different issues, including genetic predisposition, infection, and environmental factors. Some diseases have associated syndromes.

TABLE 1-16 Basic overview of tumor markers relevant to abdominal imaging that may be elevated with some cancers

Abdominal/Small Part Tumor Marker	Possible Cancer Present[a]
alpha-Fetoprotein	Liver, ovarian, and testicular cancers
CA 15-3	Breast
CA 19-9	Pancreatic, biliary tract, stomach, and colon
CA-125	Ovarian
Calcitonin	Medullary thyroid cancer
beta-hCG	Testicular cancers and germ cell tumors
LDH	Testicular, ovarian, and other germ cell tumors

[a] Some benign conditions may cause an increase in these labs.
beta-hCG, human chorionic gonadotropin; LDH, Lactate dehydrogenase.

TABLE 1-17 Summary of multisystem disorders, diseases, or syndromes

Multisystem Disorder, Disease, or Syndrome	Synopsis	Affected Structures or Organs
Autosomal dominant polycystic kidney disease	Inherited condition that causes cysts in multiple organs; usually seen in adults later in life	Kidneys, liver, spleen, and pancreas
Autosomal recessive polycystic kidney disease	Inherited condition that causes cysts in the kidneys, renal failure, and hepatic fibrosis; usually discovered in utero or in newborns	Kidneys and liver
AIDS and HIV	Virus that attacks the immune system	Liver, spleen, lymph nodes, and skin tumors (**Kaposi sarcoma**)
Beckwith–Weidemann syndrome	Growth disorder that causes enlargement of many organs and structures; increased risk for kidney and liver cancer in children	Skull, abdominal visceromegaly, and tongue (macroglossia)
Budd–Chiari syndrome	Narrowing or occlusion of the hepatic veins and possibly IVC	Liver and IVC
Conn syndrome	Results from high levels of aldosterone; can be caused by adrenal adenoma	Adrenal glands
Crohn disease	Autoimmune disease that causes chronic inflammation of the gastrointestinal tract	Gastrointestinal tract
Cushing syndrome	Results from high levels of cortisol; can be caused by adrenal adenoma	Adrenal glands
Diabetes	Caused by hyposecretion or hypoactivity of insulin Type 1—Early onset (juvenile or young adult) Type 2—Adult onset	Multiple organs including eyes, extremities, kidneys, nerves, and vasculature
Fitz-Hugh–Curtis syndrome	Rare complication of pelvic inflammatory disease causing inflammation of the tissue around the liver	Liver
Graves disease	Associated with hyperthyroidism	Thyroid
Hashimoto disease	Associated with hypothyroidism	Thyroid

Klinefelter syndrome	Genetic condition in which a male has an extra X chromosome	Testicles and male breast
Marfan syndrome	Disorder of the connective tissue	Heart, vascular structures, and skeleton
Mirizzi syndrome	Jaundice, pain, and fever associated with a stone lodged in the cystic duct	Liver, gallbladder, and biliary tract
Nephrotic syndrome	Damaged filtration of kidneys causes excessive protein in the urine (proteinuria)	Kidneys, swelling of feet and ankles
Sarcoidosis	Inflammatory disease that results in scar tissue development in multiple organs	Liver, spleen, kidneys, testicles, lymphatics, and lungs
Tuberculosis	Infectious disease spread through the air	Lungs, lymphatics, and testicles
Tuberous sclerosis	Rare genetic disorder that leads to the development of tumors within various organs	Brain, heart, and kidneys (angiomyolipoma)
von Hippel–Lindau disease	Rare genetic disorder characterized by cysts and tumors in various organs	Pancreas, kidneys, and adrenal glands
Zollinger–Ellison syndrome	Tumor (gastrinoma) in the pancreas or intestine that causes an increase in the production of gastrin	Pancreas and stomach (produces excessive stomach acid)

Many of these diseases, syndromes, or conditions affect other organs. This is a condensed list for the purpose of focused study.
IVC, inferior vena cava.

REVIEW QUESTIONS

1. Transitional cell carcinoma is commonly found in all of the following locations except:
   a. Liver
   b. Renal pelvis
   c. Urinary bladder
   d. Ureter

2. A patient with cholecystitis most likely has an elevation in which of the following labs?

a. alpha-Fetoprotein
b. WBC count
c. Lactate dehydrogenase (LDH)
d. Chromaffin

3. The neuroblastoma is a malignant pediatric mass commonly found in the:
a. Kidney
b. Liver
c. Testicle
d. Adrenal gland

4. What is a substance produced by a cancerous tumor or an organ or structure in response to cancer?
a. Oncocyte
b. Tumor marker
c. Lymphadenopathy
d. Homeostatin

5. The pheochromocytoma is a benign mass commonly located in the:
a. Testicle
b. Thyroid gland
c. Adrenal gland
d. Liver

6. A tumor that is of similar echotexture to normal liver tissue is discovered in the liver of an asymptomatic patient. What is the echogenicity of the tumor?
a. Echogenic
b. Hypoechoic
c. Isoechoic
d. Hypodense

7. Which of the following is not considered to be an intraperitoneal organ?
a. Liver
b. Pancreas
c. Gallbladder
d. Spleen

8. Which of the following are not considered retroperitoneal organs?
a. Abdominal lymph nodes
b. Adrenal glands
c. Kidneys
d. Ovaries

9. What is another name for Morrison pouch?
    a. Posterior right subhepatic space
    b. Anterior subhepatic space
    c. Posterior cul-de-sac
    d. Anterior cul-de-sac

10. The hypernephroma may also be referred to as the:
    a. Nephroblastoma
    b. Neuroblastoma
    c. Hepatocellular carcinoma
    d. Renal cell carcinoma

11. A type of reverberation artifact caused by several small, highly reflective interfaces, such as gas bubbles, describes:
    a. Mirror image artifact
    b. Posterior shadowing
    c. Comet tail artifact
    d. Ring-down artifact

12. The term cholangiocarcinoma denotes:
    a. Bile duct carcinoma
    b. Hepatic carcinoma
    c. Pancreatic carcinoma
    d. Splenic carcinoma

13. Which of the following occurs when the Doppler sampling rate (pulse-repetition frequency) is not high enough to display the Doppler frequency shift?
    a. Doppler noise
    b. Aliasing
    c. Mirror image
    d. Twinkle artifact

14. The hepatoma is a:
    a. Benign tumor of the spleen
    b. Benign tumor of the liver
    c. Malignant tumor of the pancreas
    d. Malignant tumor of the liver

15. The hepatoblastoma is a:
    a. Benign tumor of the pediatric liver
    b. Malignant tumor of the adult liver

c. Malignant tumor of the pediatric liver
d. Malignant tumor of the pediatric adrenal gland

16. Which of the following is the space located between the pancreas and the stomach?
a. Morrison pouch
b. Lesser sac
c. Space of Retzius
d. Pouch of Douglas

17. Which of the following is another name for the Wilms tumor?
a. Nephroblastoma
b. Hepatoblastoma
c. Neuroblastoma
d. Hepatoma

18. An angiosarcoma would most likely be discovered in the:
a. Rectum
b. Gallbladder
c. Spleen
d. Pancreas

19. Which of the following is not an endocrine organ or structure?
a. Thymus
b. Pancreas
c. Thyroid
d. Spleen

20. Which of the following is an artifact that alters the echogenicity of a tendon?
a. Acoustic enhancement
b. Anisotropy
c. Ring-down artifact
d. Mirror image artifact

21. The gastrinoma would most likely be discovered in the:
a. Pancreas
b. Adrenal gland
c. Stomach
d. Spleen

22. Of the list below, which is considered to be an intraperitoneal organ?
a. Left kidney

b. Aorta
c. IVC
d. Liver

23. Which of the following is considered to be a malignant testicular neoplasm?
    a. Neuroblastoma
    b. Hepatoma
    c. Yolk sac tumor
    d. Hamartoma

24. Which of the following is caused by the bending of the ultrasound beam when it passes through an interface between two tissues with vastly dissimilar speeds of sound and the angle of the approach is not perpendicular?
    a. Comet tail
    b. Refraction
    c. Reverberation
    d. Acoustic enhancement

25. These potential spaces extend alongside the ascending and descending colon on both sides of the abdomen.
    a. Paracolic gutters
    b. Periumbilical gutters
    c. Greater gutters
    d. Pericentric gutters

26. This common tumor of the kidney consists of blood vessels, muscle, and fat.
    a. Hemangioma
    b. Angiomyolipoma
    c. Oncocytoma
    d. Lipoma

27. Which of the following is not a salivary gland?
    a. Thyroid gland
    b. Parotid gland
    c. Submandibular gland
    d. Sublingual gland

28. Which of the following is not a pediatric malignant tumor?
    a. Hepatoblastoma
    b. Neuroblastoma

c. Pheochromocytoma
d. Nephroblastoma

29. A tumor that consists of tissue from all three germ cell layers is the:
    a. Pheochromocytoma
    b. Hamartoma
    c. Adrenal rest tumor
    d. Teratoma

30. Which of the following laboratory values would be most helpful in evaluating a patient who has suffered from recent trauma?
    a. WBC count
    b. alpha-Fetoprotein
    c. Blood urea nitrogen (BUN)
    d. Hematocrit

31. The insulinoma is a:
    a. Malignant pediatric adrenal tumor
    b. Benign pancreatic tumor
    c. Malignant pediatric tumor
    d. Benign liver tumor

32. A tumor that consists of a group of inflammatory cells best describes the:
    a. Hematoma
    b. Hepatoma
    c. Lymphoma
    d. Granuloma

33. A tumor that consists of a focal collection of blood best describes the:
    a. Hematoma
    b. Hamartoma
    c. Lipoma
    d. Angiomyolipoma

34. Which of the following is a tumor marker that may be used in cases of suspected testicular malignancy?
    a. BUN
    b. Creatinine
    c. Human chorionic gonadotropin (beta-hCG)
    d. Calcitonin

35. The malignant testicular tumor that consists of trophoblastic cells is the:
    a. Cholangiocarcinoma

b. Yolk sac tumor
c. Teratoma
d. Insulinoma

36. What is the artifact most likely encountered posterior to a gallstone?
a. Acoustic enhancement
b. Shadowing
c. Ring-down
d. Reverberation

37. A collection of abdominal fluid within the peritoneal cavity often associated with cancer is termed:
a. Transudate ascites
b. Chromaffin ascites
c. Peritoneal ascites
d. Exudate ascites

38. Which of the following is not a rule of surgical asepsis?
a. If you recognize that an item has become nonsterile, act immediately.
b. If one sterile person must pass another, they must pass face-to-face.
c. A sterile field must never be left unmonitored. If a sterile field is left unattended, it is considered nonsterile.
d. A sterile person does not lean across a sterile field.

39. Which of the following occurs behind strong, granular, and irregular surfaces like crystals, calculi, or calcifications such as a kidney stone?
a. Twinkle artifact
b. Refraction
c. Anisotropy
d. Side lobes

40. Which of the following has both an endocrine and an exocrine function?
a. Adrenal glands
b. Spleen
c. Pancreas
d. Duodenum

SUGGESTED READINGS

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2

The Liver

Introduction

The liver is a vital organ. Therefore, much attention should be paid to the significance of comprehending its function and the various pathologic changes that can distort its sonographic appearance. This chapter provides an overview of the normal sonographic anatomy, as well as many pathologic processes of the liver. Because there are numerous conditions that can involve the liver, pathology has been categorized as either focal or diffuse disease. Clinical findings and sonographic features of these pathologies are also provided.

Key Terms

amebic hepatic abscess—an abscess that develops from a parasite that grows in the colon and invades the liver via the portal vein

anastomosis—the surgical connection between two structures

arteriovenous fistula—an abnormal passageway between an artery and a vein

autoimmune disorders—disorders in which the body's immune system attacks and destroys health tissues and/or organs

autosomal dominant polycystic kidney disease—an inherited disease that results in the development of renal, liver, and pancreatic cysts late in life; also referred to as adult polycystic kidney disease

bare area—the region of the liver not covered by peritoneum

Beckwith–Wiedemann syndrome—a growth disorder syndrome

synonymous with enlargement of several organs, including the skull, tongue, and liver

Budd–Chiari syndrome—a syndrome described as the occlusion of the hepatic veins, with possible coexisting occlusion of the inferior vena cava

caput medusa—recognizable dilation of the superficial veins of the abdomen

cavernous hemangioma—the most common benign liver tumor

cholangitis—inflammation of the bile ducts

cirrhosis—condition defined as hepatocyte death, fibrosis and necrosis of the liver, and the subsequent development of regenerating nodules

cystic fibrosis—genetic disorder linked with the development of scar tissue accumulation within the lungs, liver, pancreas, kidneys, and/or intestines

diaphragmatic slip—a pseudomass of the liver seen on sonography resulting from hypertrophied diaphragmatic muscle bundles

dysentery—infection of the bowel which leads to diarrhea that may contain mucus and/or blood

echinococcal cyst—see key term hydatid liver cyst

***Echinococcus granulosus*—**a parasite responsible for the development of hydatid liver cysts

Epstein–Barr virus—the virus responsible for mononucleosis and other potential complications

fatty liver—a reversible disease characterized by deposits of fat within the hepatocytes; also referred to as hepatic steatosis

fibrosis—the formation of excessive fibrous tissue; the development of scar tissue within an organ

focal fatty infiltration—manifestation of fatty liver disease in which fat deposits are localized

focal fatty sparing—manifestation of fatty liver disease in which an area of the liver is spared from fatty infiltration

focal nodular hyperplasia—a benign liver mass composed of a combination of hepatocytes and fibrous tissue that typically contains a central scar

gastroesophageal junction—the junction between the stomach and the esophagus

Glisson capsule—the thin fibrous casing of the liver

hematemesis—vomiting blood

hematoma—a localized collection of blood

hemochromatosis—an inherited disease characterized by disproportionate absorption of dietary iron

hemopoiesis—the formation and development of blood cells

hepatic candidiasis—a hepatic mass that results from the spread of fungus in the blood to the liver

hepatic encephalopathy—a condition in which a patient becomes confused or suffers from intermittent loss of consciousness secondary to the overexposure of the brain to toxic chemicals that the liver would normally remove from the body

hepatic steatosis—see fatty liver

hepatitis—inflammation of the liver

hepatocellular adenoma—a benign liver mass often associated with the use of oral contraceptives

hepatocellular carcinoma—the primary form of liver cancer

hepatofugal—blood flow away from the liver

hepatoma—the malignant tumor associated with hepatocellular carcinoma

hepatomegaly—enlargement of the liver

hepatopetal—blood flow toward the liver

hepatosplenomegaly—enlargement of the spleen and liver

hydatid liver cyst—a liver cyst that develops from a tapeworm that lives in dog feces; also referred to as an echinococcal cyst because it originates from the parasite *Echinococcus granulosus*

hyperlipidemia—abnormally high levels of fats within the blood (i.e., high cholesterol and high triglycerides)

hypovolemia—decreased blood volume

idiopathic—no recognizable cause; from an unknown origin

immunocompromised—a patient who has a weakened immune system

jaundice—the yellowish discoloration of the skin, mucous membranes, and sclerae; found with liver disease and/or biliary obstruction

kernicterus—brain damage from bilirubin exposure in a newborn with jaundice

Kupffer cells—specialized macrophages within the liver that engulf pathogens and damaged cells

leukocytosis—an elevated white blood cell count

lipoma—a benign fatty tumor

liver hilum—the area of the liver where the common bile duct exits the liver and portal vein and hepatic artery enter the liver; also referred to as the porta hepatis

low-resistance flow—a flow pattern that characteristically has antegrade flow throughout the cardiac cycle

malaise—feeling of uneasiness

malignant degeneration—the deterioration of a benign mass into a malignancy

mass effect—the displacement or alteration of normal anatomy that is located adjacent to a tumor

monophasic—vascular flow yielding a single phase

necrosis—death of tissue

periportal cuffing—an increase in the echogenicity of the portal triads as seen in hepatitis and other conditions

porta hepatis—the area of the liver where the portal vein and hepatic artery enter and the hepatic duct exit; also referred to as the liver hilum

portal hypertension—the elevation of blood pressure within the portal venous system

portal triads—an assembly of a small branch of the portal vein, bile duct, and hepatic artery that surround each liver lobule

portal vein thrombosis—the development of clot within the portal vein

pseudocirrhosis—nodular appearance of the liver caused by multiple metastatic tumors

pseudomass—false mass

pyogenic liver abscess—a liver abscess that can result from the spread of infection from inflammatory conditions such as appendicitis, diverticulitis, cholecystitis, cholangitis, and endocarditis

quadrate lobe—the medial segment of the left lobe

recanalization—the reopening of canals or pathways

Riedel lobe—a tonguelike extension of the right hepatic lobe

sequela—an illness resulting from another disease, trauma, or injury

serpiginous—twisted or snakelike pattern

situs inversus—condition in which the organs of the abdomen and chest are on the opposite sides of the body (e.g., the liver is within the left upper quadrant instead of the right upper quadrant)

splenomegaly—enlargement of the spleen

starry sky sign—the sonographic sign associated with the appearance of periportal cuffing in which there is an increased echogenicity of the walls of the portal triads

steatohepatitis—a type of fatty liver disease that causes inflammation of the liver

total parental hyperalimentation—procedure in which an individual receives vitamin and nutrients through a vein, often the subclavian vein

transjugular intrahepatic portosystemic shunt (TIPS)—the therapy for portal hypertension that involves the placement of a stent between the portal veins and hepatic veins to reduce portal systemic pressure

triphasic—vascular flow yielding three phases

von Gierke disease—condition in which the body does not have the ability to break down glycogen; also referred to as glycogen storage disease type 1

von Hippel–Lindau disease—a inherited disease that includes the development of cysts within the liver, pancreas, and other organs

Wilson disease—a congenital disorder that causes the body to accumulate excess copper

ANATOMY AND PHYSIOLOGY OF THE LIVER

The liver is an essential organ (Table 2-1). In early embryonic life, the liver is responsible for hemopoiesis. The function of the liver can be analyzed with certain laboratory tests (Table 2-2). It is the largest parenchymal organ in the body, with the majority of its bulk—the right lobe—located in the right upper quadrant, whereas the left lobe is positioned within the epigastrium and may traverse the midline and extend into the left hypochondrium (Fig. 2-1). In some persons, the liver may actually come in contact with the spleen.

The liver is considered an intraperitoneal organ, with only a small portion left uncovered, including the bare area, the area of the falciform ligament, the gallbladder fossa, the porta hepatis, and an area adjacent to the inferior vena cava (IVC). The liver is also covered by Glisson capsule, a thin fibrous casing. It is composed of three main hepatic lobes—right, left, and caudate. Each hepatic lobe can be further divided into thousands of liver lobules. Lobules contain hepatocytes, biliary epithelial cells, and Kupffer cells. Each lobule is also surrounded by portal triads, which are composed of small branches of the portal vein, bile duct, and hepatic artery.

TABLE 2-1 Vital functions of the liver

1. Carbohydrate metabolism
2. Fat (lipid) metabolism
3. Amino acid metabolism
4. Removal of waste products
5. Vitamin and mineral storage
6. Drug inactivation
7. Synthesis and secretion of bile
8. Blood reservoir

9. Lymph production
10. Detoxification

LOBES OF THE LIVER

The Couinaud system is used to separate the liver into eight surgical segments. However, fundamentally, the liver can be divided into three primary hepatic lobes: right, left, and caudate (Table 2-3). An additional anatomic lobe, the quadrate lobe, is located between the gallbladder fossa and the round ligament. However, sonographically this lobe is referred to as the medial segment of the left lobe, and thus it is usually not considered one of the main hepatic lobes.

SOUND OFF
The liver is composed of a right lobe, left lobe, and caudate lobe.

The right hepatic lobe is the largest lobe. It takes up most of the right upper quadrant. The right lobe can be divided into an anterior and posterior segment by the right hepatic vein, which lies within the right intersegmental fissure. The right lobe can be separated from the left lobe by the middle hepatic vein, which lies within the main lobar fissure. The right and left lobes are also separated by the gallbladder fossa.

The left lobe is much smaller than the right lobe. It is located within the epigastrium and may extend to the left hypochondrium. The left lobe may be divided into a medial and lateral segment by the left hepatic vein, which lies within the left intersegmental fissure. These segments can also be separated by the ligamentum teres and falciform ligament.

The caudate lobe, which has its own separate blood supply and venous drainage, is the smallest hepatic lobe. It is also located within the epigastrium, and is bounded anteriorly by the ligamentum venosum and posteriorly by the IVC. Thus, the caudate lobe can be separated from the left lobe by the ligamentum venosum.

SOUND OFF
The medial segment of the left lobe may also be referred to as the quadrate lobe.

PORTAL VEINS

The main portal vein enters the liver at the porta hepatis, also referred to as the liver hilum. The main portal vein is created by the union of the superior mesenteric vein and splenic vein (Fig. 2-2). The merger of these two vessels and the inferior mesenteric vein, which typically takes place posterior to the neck of the pancreas and anterior to the IVC, is an area referred to as the portal confluence or portal splenic confluence. The portal vein provides the liver with approximately 75% of its total blood supply. The blood within the portal vein is partially oxygenated because it is derived from the intestines. The remainder of hepatic perfusion is via the hepatic artery.

TABLE 2-2 Specific liver function test, results, and associated abnormalities

Liver Function Test	Result	Associated Abnormality
Albumin	Decrease	Chronic liver disease[a] **Cirrhosis**
ALP	Increase	Cirrhosis Extrahepatic biliary obstruction Gallstones **Hepatitis** Metastatic liver disease Pancreatic carcinoma
ALT	Increase	Biliary tract obstruction Hepatitis Hepatocellular disease Obstructive **jaundice**
AST	Increase	Cirrhosis **Fatty liver** Hepatitis Metastatic liver disease
gamma-Glutamyl transferase	Increase	Diffuse liver disease Posthepatic obstruction
LDH	Increase	Cirrhosis Hepatitis Obstructive jaundice
Serum bilirubin	Increase	Unconjugated (direct) bilirubin: acute hepatocellular disease Conjugated (indirect) bilirubin: biliary tract obstruction Total bilirubin: cirrhosis, hepatitis, and other liver cell diseases

PT		Prolonged PT: metastasis of the liver and hepatitis Shortened PT: extrahepatic duct obstruction
AFP	Increase	**Hepatocellular carcinoma** (**hepatoma**) Hepatoblastoma

[a]This is an abbreviated list of complications for review purposes, as other complications may exist.
AFP, α-Fetoprotein; ALP, alkaline phosphatase; ALT, alanine aminotransferase; AST, aspartate aminotransferase; LDH, lactate dehydrogenase; PT, prothrombin.

As the main portal vein enters the liver, it splits into the right and left portal veins. The right portal vein, like the right hepatic lobe, is separated into an anterior and posterior division. The left portal vein, like the left hepatic lobe, is separated into a medial and lateral division. These vessels supply blood to their related segments. The diameter of the main portal vein can vary with respiration, although typically it measures less than 13 mm in the anteroposterior dimension. Enlargement of the portal vein is often indicative of portal hypertension. Normal portal veins decrease in size as they approach the diaphragm. They are also considered intrasegmental because they course within the segments of the liver. On a sonogram, their walls appear much brighter than those of the hepatic veins (Fig. 2-3). This may be because of an increase in the amount of collagen within their walls. Normal flow within the portal veins should be hepatopetal and monophasic, with some variation noted with respiratory changes (Fig. 2-4). In addition, scanning after a meal will often demonstrate an increase in portal vein flow.

SOUND OFF
The portal veins branch into corresponding branches that match the segments of the liver (right portal = anterior and posterior branches; left portal = medial and lateral branches). The portal veins also typically have brighter walls compared to the hepatic veins.

HEPATIC VEINS

Most persons have three hepatic veins: right, middle, and left. These veins drain into the IVC. They are considered both intersegmental and interlobar because they are located between the segments and the lobes (Fig. 2-5). As mentioned earlier, they are readily used to distinguish the hepatic segments. Unlike the portal veins, the hepatic veins increase in size as they approach

the diaphragm. Hepatic veins have a triphasic blood flow pattern secondary to their association with the right atrium and atrial contraction (Fig. 2-6). Enlargement of the hepatic veins and IVC is seen with right-sided heart failure, and occlusion or narrowing of the hepatic veins is seen with Budd–Chiari syndrome.

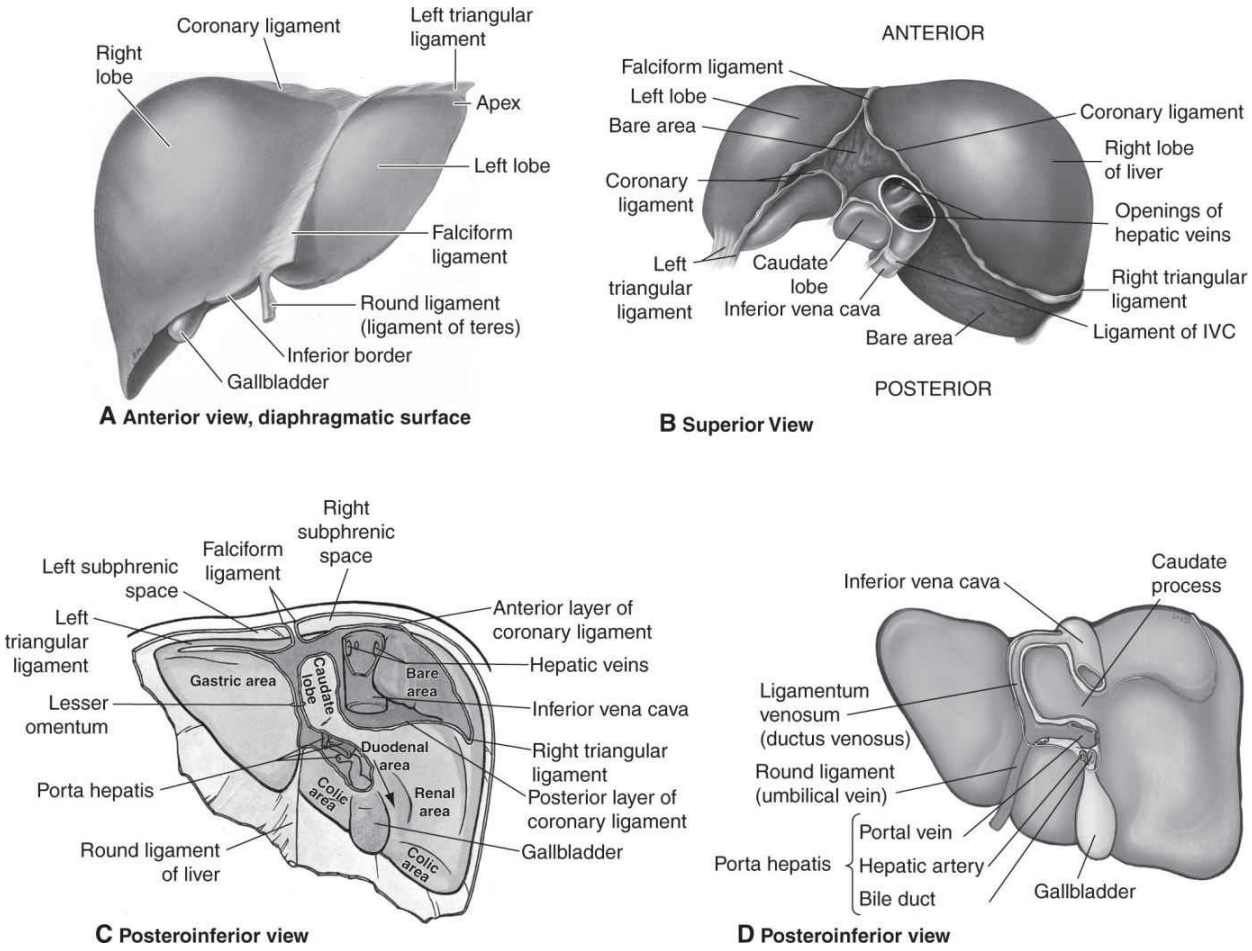

Figure 2-1 The surfaces of the liver.

TABLE 2-3 Useful landmarks for separating the hepatic segments and lobes	
Right hepatic vein Right intersegmental fissure	Separates the anterior segment of the right lobe from the posterior segment of the right lobe
Middle hepatic vein Main lobar fissure Gallbladder fossa	Separates the right lobe from the left lobe (these are located between the anterior segment of the right lobe and the medial segment of the left lobe)
Left hepatic vein Left intersegmental fissure Ligamentum teres Falciform ligament	Separates the left lateral segment of the left lobe from the left medial segment of the left lobe

THE PORTA HEPATIS

The porta hepatis may also be referred to as the liver hilum. The three

structures located within the porta hepatis are the main portal vein, common bile duct, and hepatic artery. The common hepatic artery carries oxygenated blood to the liver from the abdominal aorta. It is a branch of the celiac trunk, the first main branch of the abdominal aorta as it passes below the diaphragm. The normal low-resistance flow pattern of the hepatic artery can be noted with Doppler imaging (Fig. 2-7). Typically, the hepatic artery takes a course anterior to the main portal vein in the porta hepatis. When a longitudinal-oriented image is obtained of this area, the artery can be noted anterior to the main portal vein and posterior to the common bile duct (Fig. 2-8). The “Mickey” sign describes the transverse image taken of the porta hepatis (Fig. 2-9). In some persons, the relationship of the artery and common bile duct is reversed.

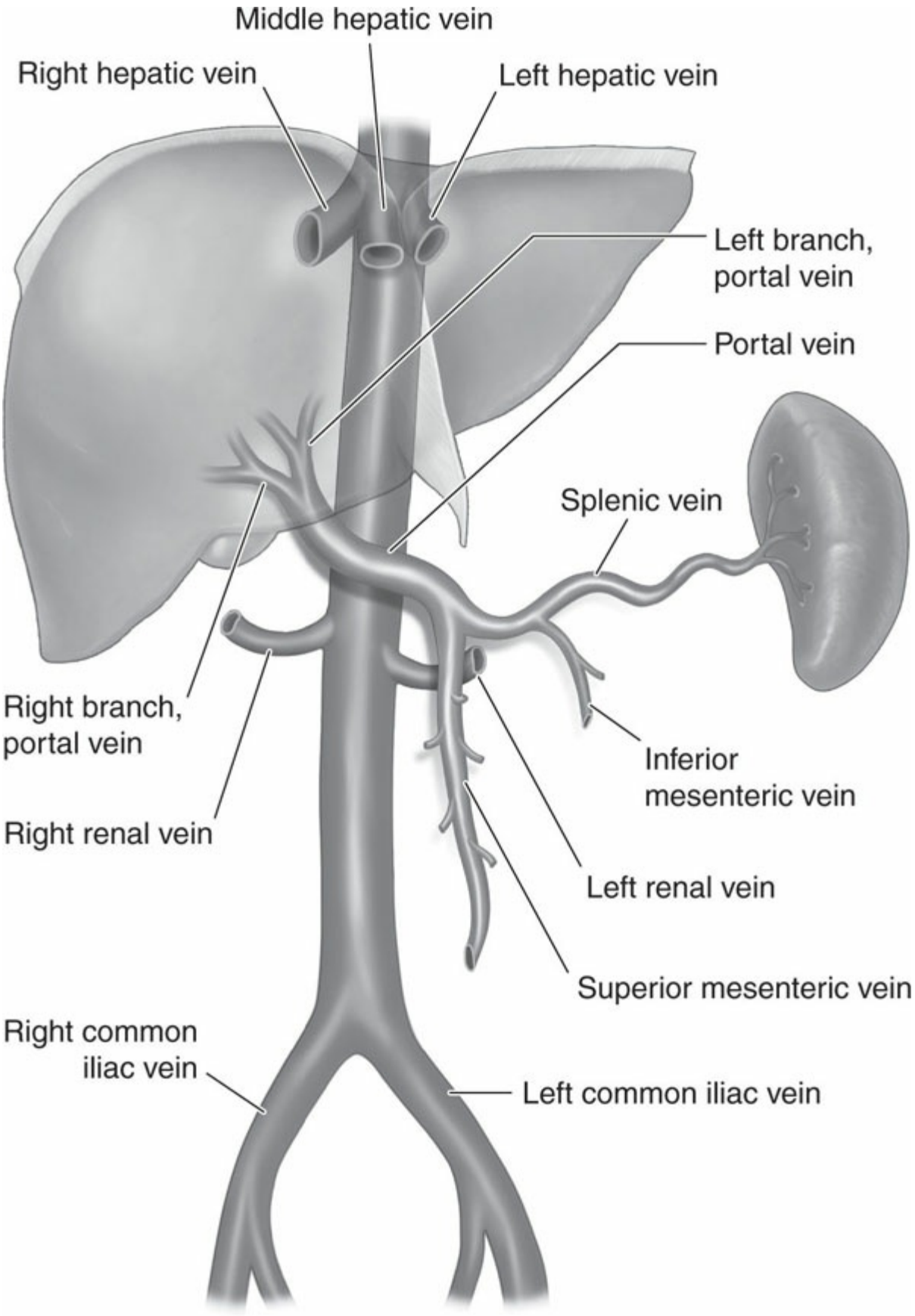

Figure 2-2 The construction of the portal venous system.

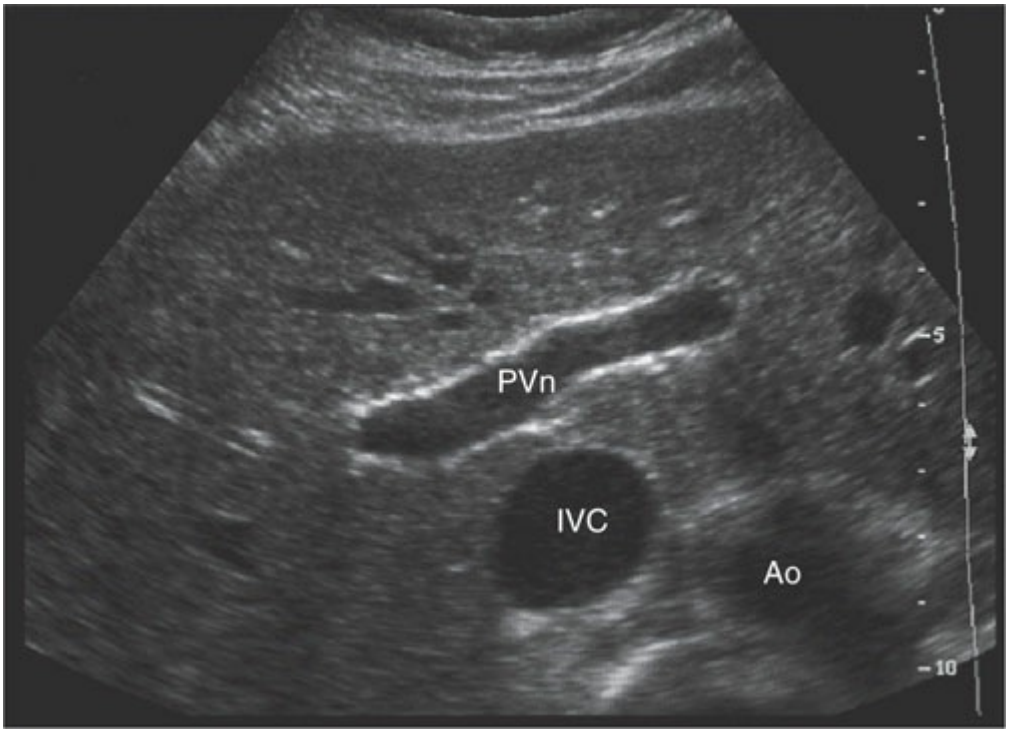

Figure 2-3 Portal veins. The portal veins (Pvn) are easily identified by their echogenic wall.

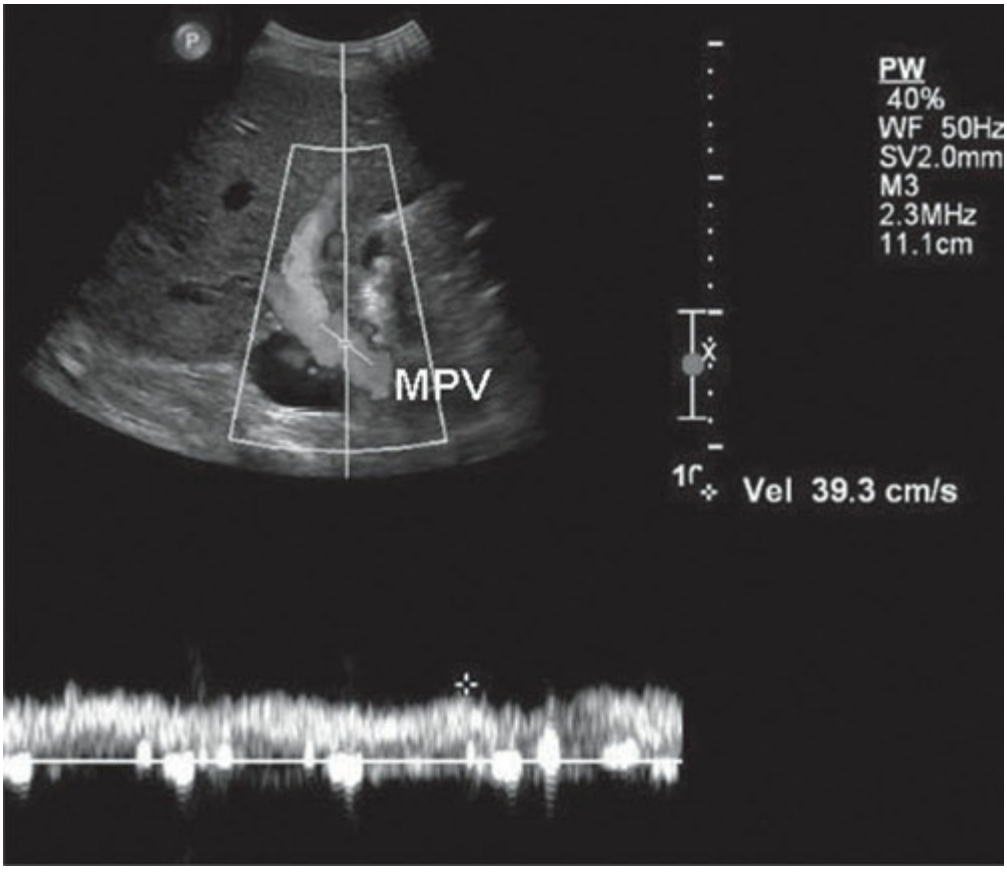

Figure 2-4 Normal hepatopetal flow within the main portal vein (MPV) with some respiratory variation. (Color image provided online.)

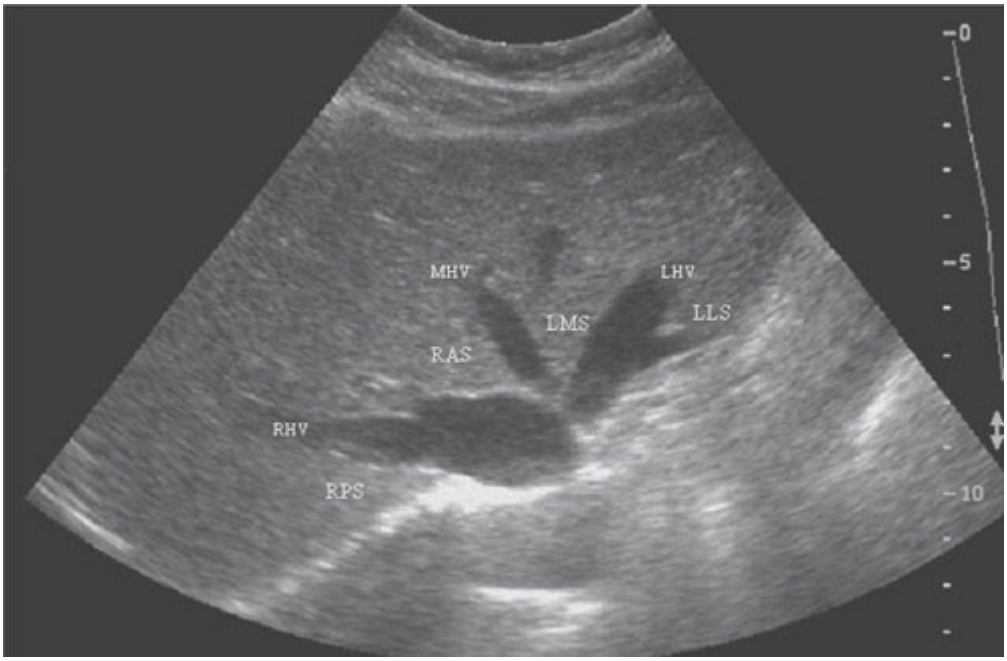

Figure 2-5 Hepatic veins. The left hepatic vein (*LHV*), middle hepatic vein (*MHV*), and right hepatic vein (*RHV*) are noted in this image. The LHV can be used to separate the left lateral segment (*LLS*) from the left medial segment (*LMS*). The RHV can be used to separate the right anterior segment (*RAS*) from the right posterior segment (*RPS*). The MHV can be used to separate the left lobe from the right lobe.

LIGAMENTS AND FISSURES OF THE LIVER

Two readily identifiable ligaments may be noted within the normal liver during a sonogram: the ligamentum venosum and the falciform ligament. In utero, the umbilical vein supplies the fetus with oxygenated blood. The umbilical vein travels to the liver and bifurcates into a left and a right branch. The right branch, also referred to as the ductus venosus, shunts blood directly into the fetal IVC. Shortly after birth, the ductus venosus collapses and becomes the ligamentum venosum. The left umbilical vein connects directly to the left portal vein. After birth, it becomes a fibrous cord referred to as the ligamentum teres or round ligament. The ligamentum teres ascends along the falciform ligament. Recanalization of the paraumbilical vein in the ligamentum teres can occur in the presence of portal hypertension.

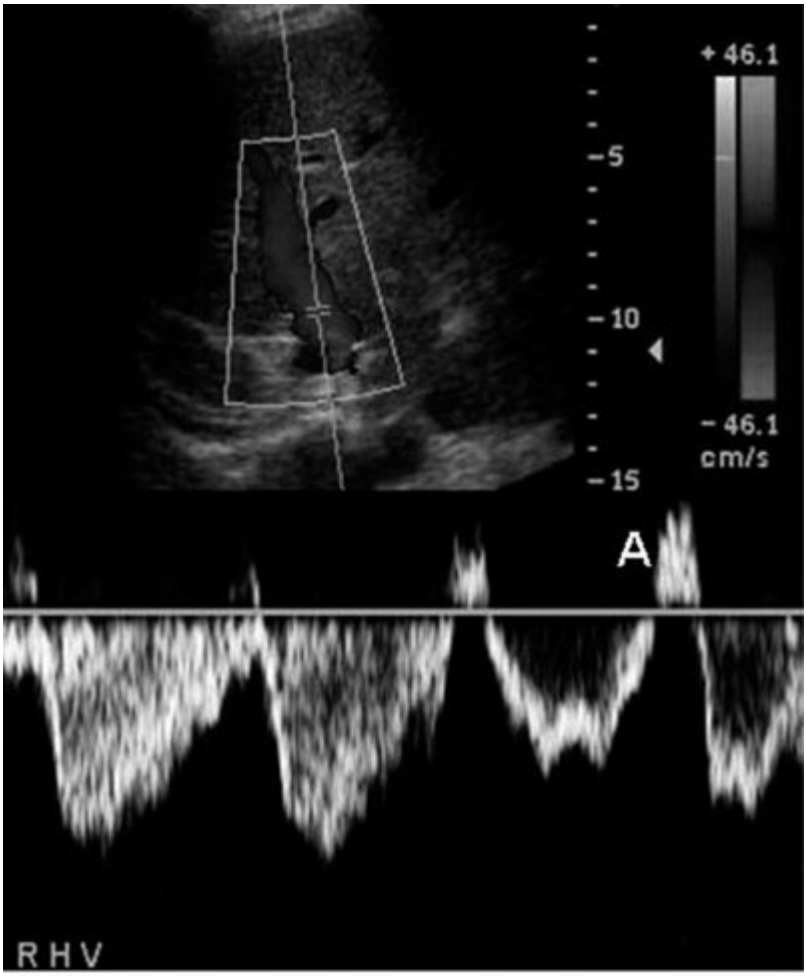

Figure 2-6 Doppler signal of the normal right hepatic vein. (Color image provided online.)

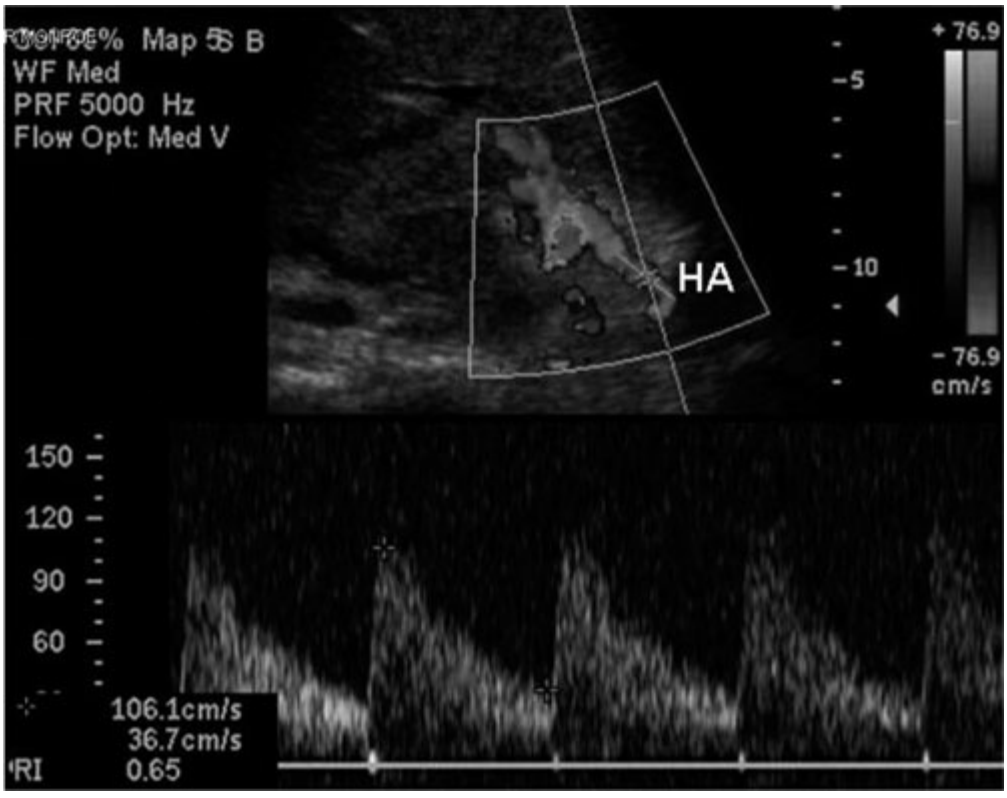

Figure 2-7 Doppler signal of the hepatic artery (HA). (Color image provided online.)

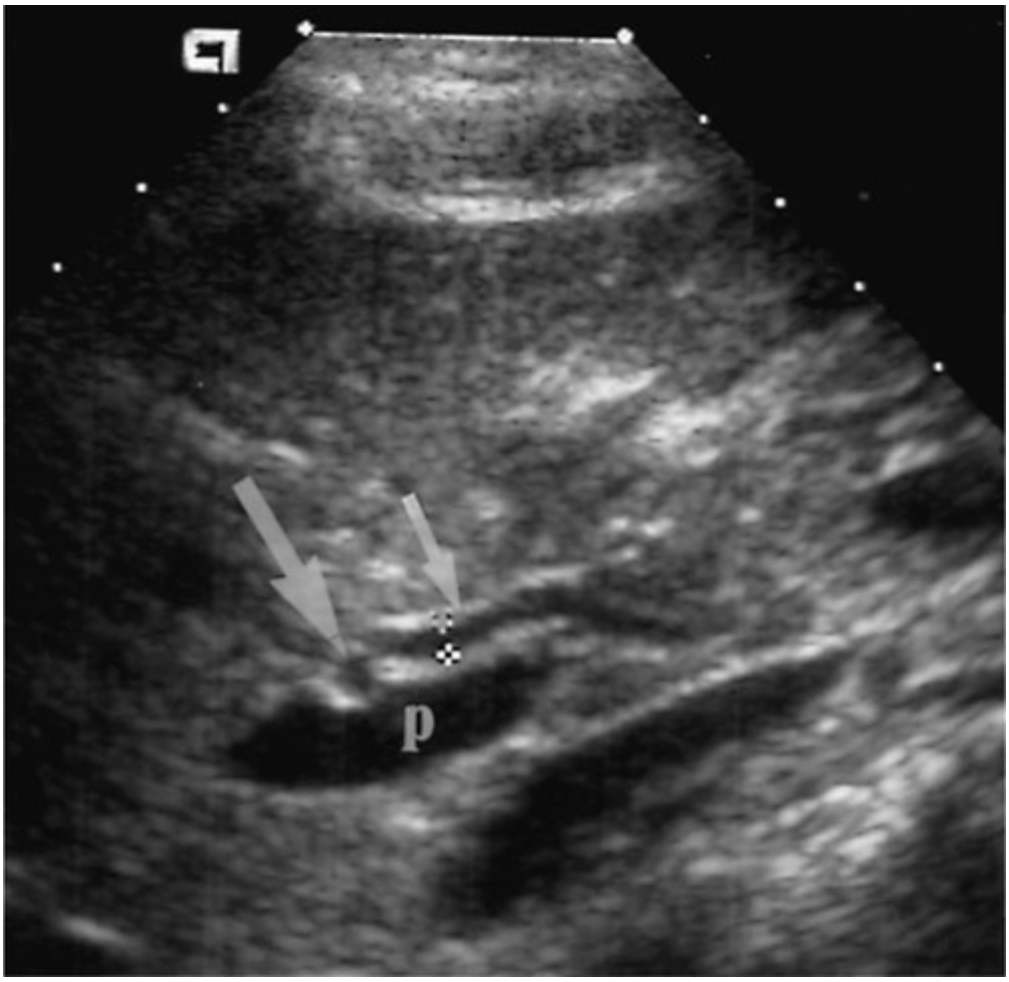

Figure 2-8 The portal vein (*p*), common bile duct (*short arrow*), and hepatic artery (*large arrow*) comprise the porta hepatis.

Sonographically, ligaments appear hyperechoic because of the fat located within and around them. The ligamentum venosum, which appears as a hyperechoic linear structure, can be noted anterior to the caudate lobe, between the caudate lobe and left hepatic lobe (Fig. 2-10). The falciform ligament can be appreciated near the left portal vein in most persons. In the transverse scan plane, it often appears as a hyperechoic, triangular-shaped structure between the left and right hepatic lobes (Fig. 2-11). It is important to note that some texts may refer to the area of the falciform ligament as the ligamentum teres. And thus it is vital to understand that the ligementum teres is potentially identifiable with sonography within the lower margins of the falciform ligament. The main lobar fissure, which houses the middle hepatic vein, may also be identifiable in many persons. It is seen in the sagittal oblique plane as a hyperechoic line, which seems to connect the neck of the gallbladder to the right portal vein (Fig. 2-12). The main lobar fissure may be used to separate the right and left hepatic lobes. Finally, although not a true

fissure, occasionally, a diaphragmatic slip or diaphragmatic muscular bundles may present as a pseudomass on sonography. Diaphragmatic slip, which typically occurs in older patients, is caused by hypertrophied diaphragmatic muscle bundles. It appears as hyperechoic strands extending from the diaphragm in the sagittal plane, and may be confused for a hyperechoic mass in the transverse plane.

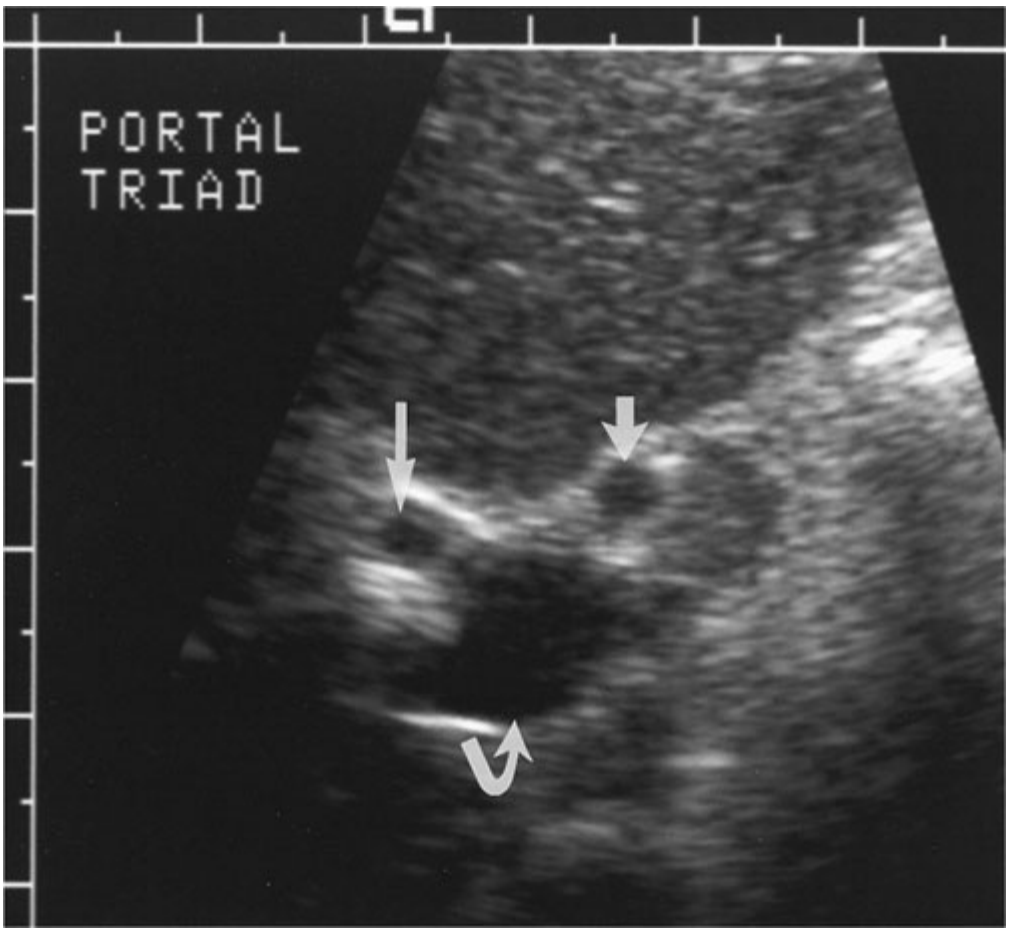

Figure 2-9 Mickey mouse sign. Transverse image of the porta hepatis. The face of Mickey is the portal vein (*curved arrow*), the hepatic artery is the left ear (*short arrow*), and the common bile duct is the right ear (*long arrow*).

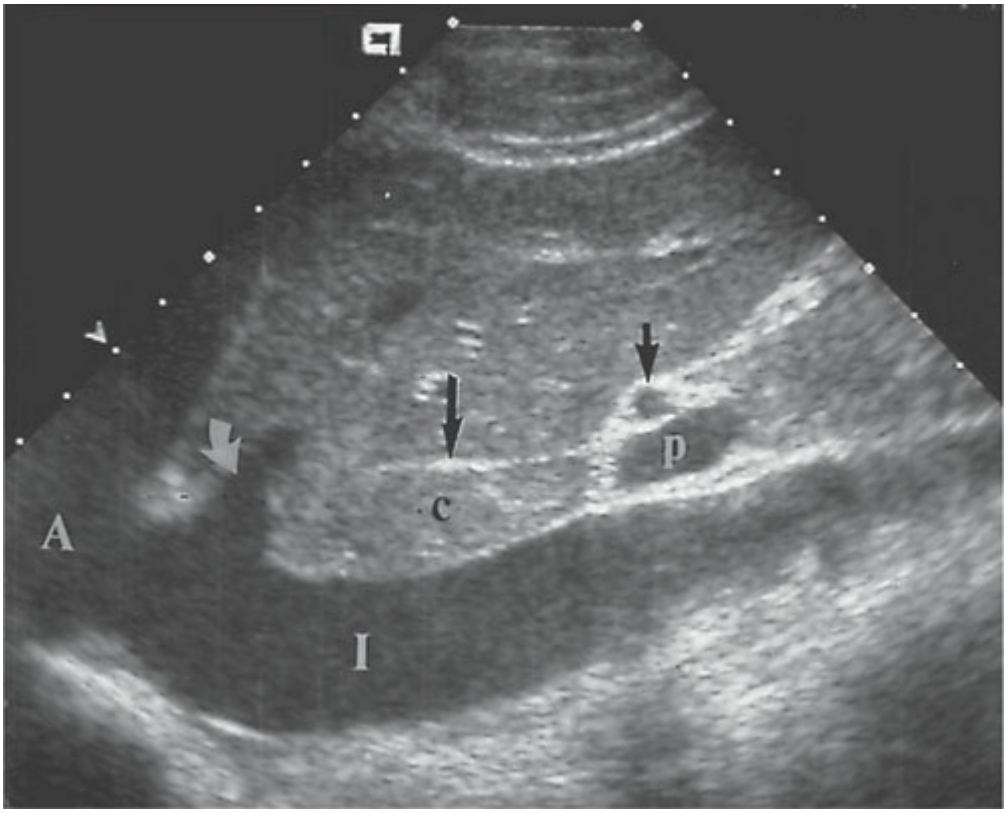

Figure 2-10 Caudate lobe. The caudate lobe (*c*) is located between the ligamentum venosum (*long arrow*) and the inferior vena cava (*I*). The inferior vena cava terminates at the heart's right atrium (*A*). The *curved arrow* indicates the right hepatic vein. Also seen are the portal vein (*p*) and hepatic artery (*short arrow*).

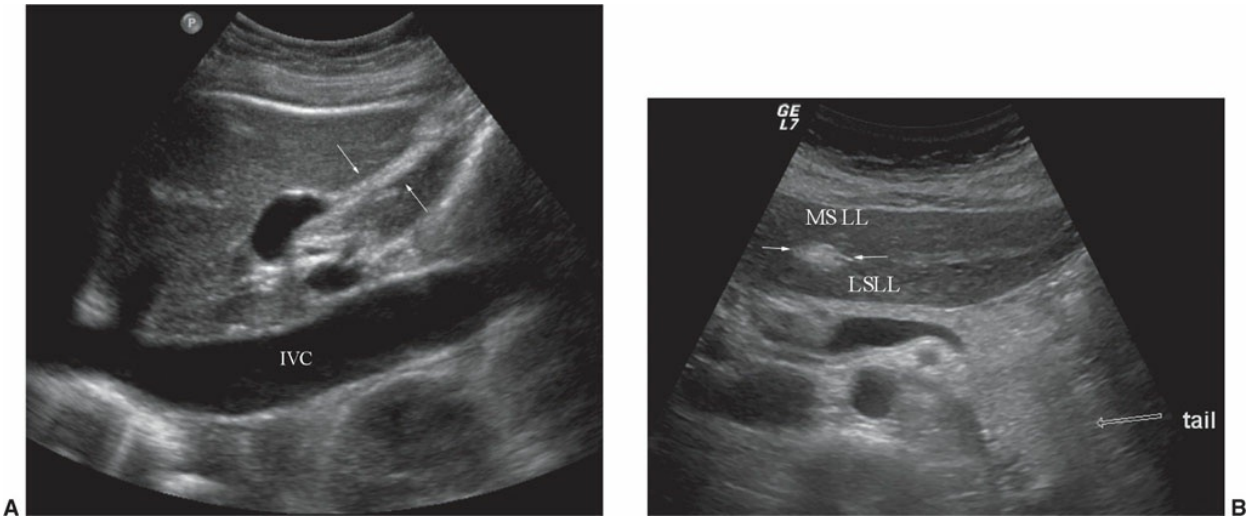

Figure 2-11 The falciform ligament is seen in sagittal (*A*) *between the arrows* and transverse (*B*) *between the arrows*. MSLL, medial segment left lobe and LSLL, lateral segment left lobe.

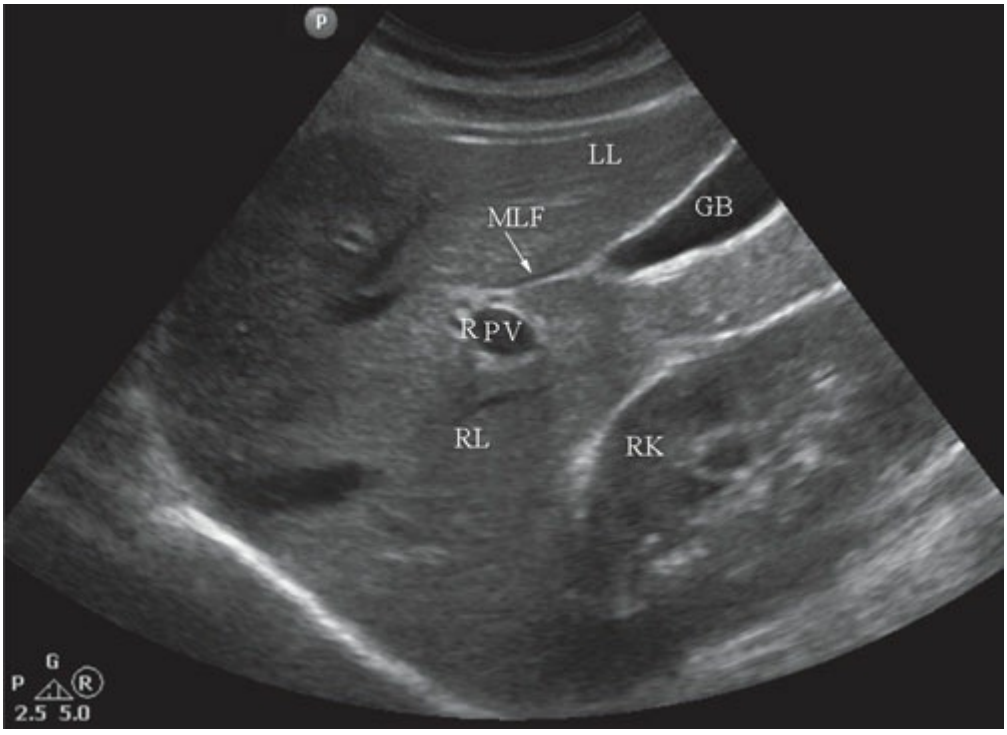

Figure 2-12 Sagittal oblique image of the liver demonstrating the right lobe (*RL*), left lobe (*LL*), and right kidney (*RK*). The main lobar fissure (*MLF*), the right portal vein (*RPV*), and gallbladder (GB) can be visualized well.

ANATOMIC VARIANTS OF THE LIVER

A Riedel lobe can be described as a tonguelike extension of the right hepatic lobe. This anatomic variant is more often seen in women. Riedel lobe may extend inferiorly as far as the iliac crest. To differentiate Riedel lobe from hepatomegaly, one could examine the left lobe for coexisting enlargement. An additional variant of the liver is the papillary process of the caudate lobe. This inferior extension of the caudate lobe can resemble a mass. If a papillary process is suspected, care to evaluate the caudate lobe in both transverse and sagittal scan planes is warranted. Other anomalies of the liver include situs inversus, agenesis of a lobe, and there are many vascular variations.

SONOGRAPHY OF THE LIVER

A sonogram of the liver can be ordered for several reasons. The patient should fast for a period of 8 hours if the entire right upper quadrant is to be evaluated. While some facilities may only require 4 hours of fasting, some may not require any special patient preparation if only the liver is being examined with sonography, as in the situation where a brief follow-up for findings identified with other imaging modalities such as computed tomography (CT) or magnetic resonance imaging (MRI).

The normal liver is homogeneous. Its echogenicity is either equal to or slightly greater than the parenchyma of the normal right kidney, and slightly less echogenic than the normal spleen. In addition, when compared with the pancreas, the liver is slightly less echogenic in an adult. The liver measures approximately 13 to 15 cm in length in an adult. Although many authors differ, hepatomegaly is often suspected if the liver measures greater than 15.5 cm in the midhepatic line. One recent study suggested that the most accurate measurement of the right lobe can be obtained from the uppermost right hemidiaphragm to the inferior tip of the right lobe using a horizontal plane parallel to the anterior liver wall through the midaxillary line. Conversely, there are indirect sonographic signs that have been suggested (Table 2-4). And as mentioned earlier, in some individuals, particularly females, Riedel lobe can mistakenly suggest hepatomegaly, so careful correlation with clinical history is strongly warranted when hepatomegaly is suspected sonographically.

SOUND OFF

Careful correlation with clinical history—especially an analysis of current laboratory findings—is strongly warranted when hepatomegaly is suspected sonographically.

TABLE 2-4 Indirect signs of hepatomegaly

- Extension of right lobe beyond the lower pole of the right kidney (without evidence of Riedel lobe).
- Rounding of the inferior tip of the right lobe.
- Extension of left lobe well into the left upper quadrant.

LIVER PATHOLOGY

Diffuse Liver Disease

Fatty Liver Disease

Fatty liver disease, also referred to as hepatic steatosis, is a disorder characterized by fatty deposits (triglycerides) within the hepatocytes. It can be classified as nonalcoholic fatty liver disease and alcoholic fatty liver disease. Nonalcoholic fatty liver disease has been cited as the most common liver disorder in the Western World, and subsequently the most common cause of chronic liver disease. In general, nonalcoholic fatty liver disease is both acquired and reversible. The causes of nonalcoholic fatty liver include

starvation, obesity, chemotherapy, diabetes mellitus, hyperlipidemia, pregnancy, glycogen storage disease or von Gierke disease (glycogen storage disease type 1), total parental hyperalimentation, severe hepatitis, cystic fibrosis, intestinal bypass surgery for obesity, and the use of some drugs such as corticosteroids. Fatty liver disease is also the hepatic manifestation of a disorder known as metabolic syndrome and can lead to steatohepatitis. Steatohepatitis, whether caused by alcoholic or nonalcoholic conditions-termed nonalcoholic steatohepatitis, is inflammation of the liver that has been shown to be a precursor for chronic liver disease, leading to fibrosis, cirrhosis, and hepatocellular carcinoma (HCC) in some individuals.

Although fatty liver is typically asymptomatic, patients may present clinically with elevated liver function tests. Fatty liver can be described as mild, moderate, or severe based on the sonographic visualization of both the hepatic vasculature and diaphragm. Fatty changes within the liver can also be diffuse or focal. Diffuse infiltration will cause the liver to appear diffusely echogenic, and it will be more difficult to penetrate. Frequently, in the presence of diffuse fatty infiltration, the walls of the hepatic vasculature and diaphragm will not be easily imaged, secondary to the attenuation of the sound beam (Fig. 2-13).

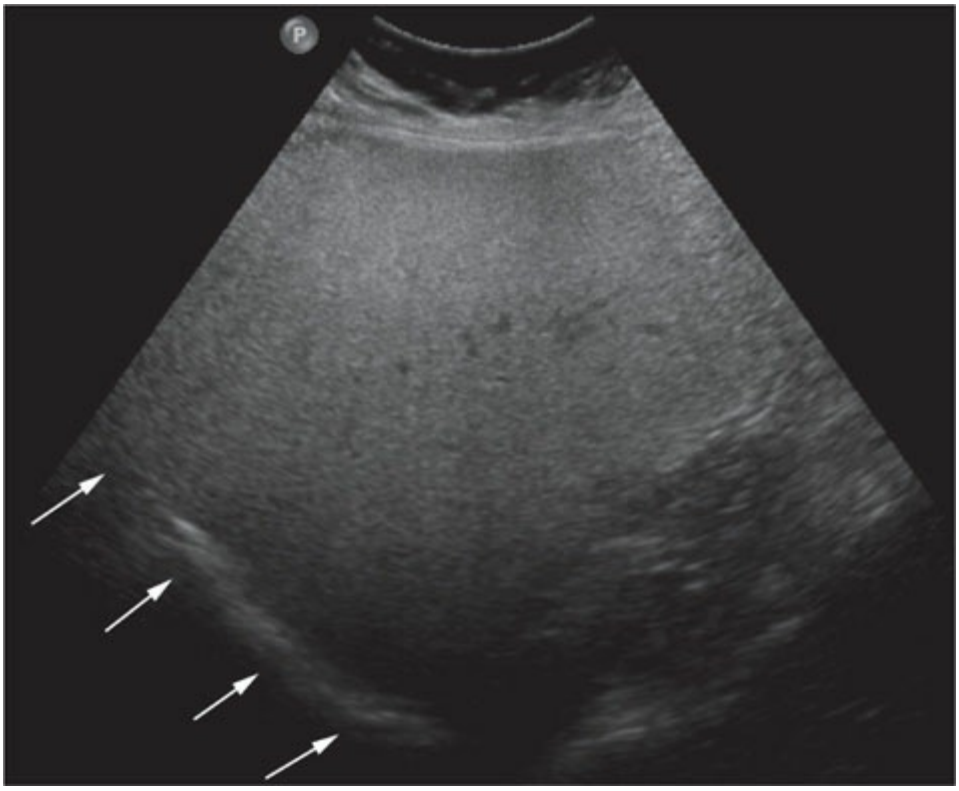

Figure 2-13 Sagittal image of a diffusely fatty liver that demonstrates the inability to clearly visualize the diaphragm (*arrows*).

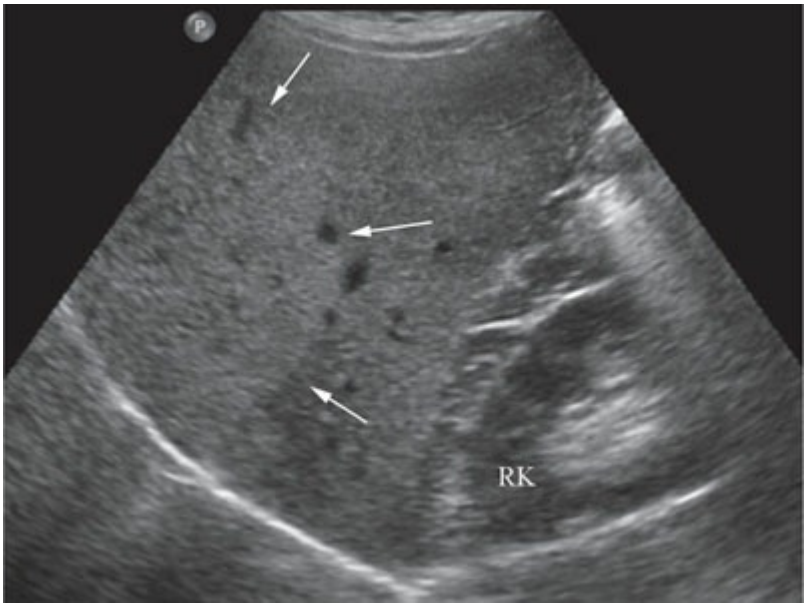

Figure 2-14 Sagittal image of the liver demonstrating an area of focal fatty infiltration (*arrows*).

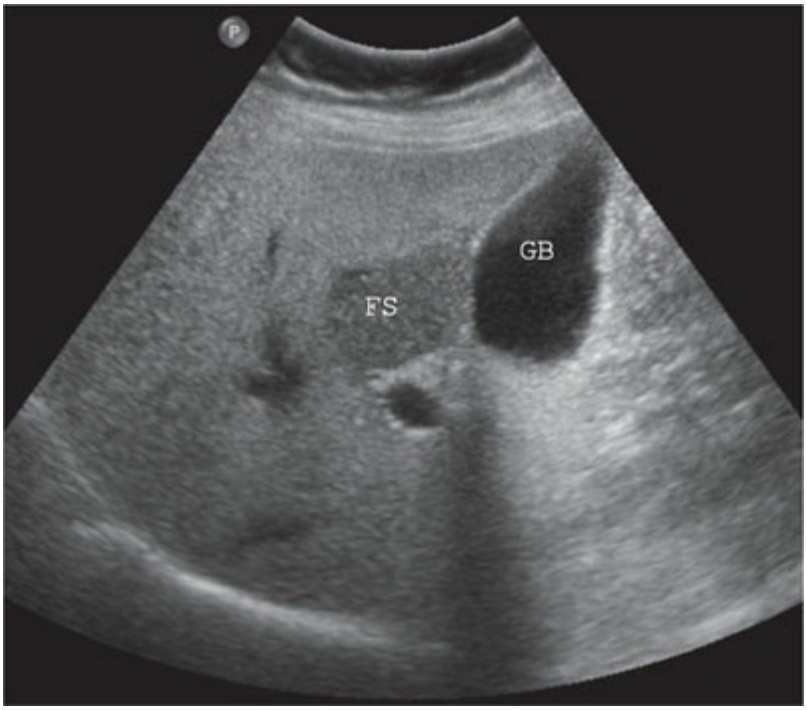

Figure 2-15 Focal fatty sparing (*FS*) is noted in this sagittal image of the liver adjacent to the gallbladder (*GB*).

Sonographically, the liver segment affected by focal fatty infiltration will appear as an area of increased echogenicity and can thus appear much like a solid, hyperechoic mass (Fig. 2-14). Alternatively, focal fatty sparing of the liver can occur. In this circumstance, the liver is involved with diffuse fatty infiltration, with certain areas spared. This area of sparing can appear much like a solid, hypoechoic mass or possibly even fluid (Fig. 2-15).

Both focal fatty infiltration and focal fatty sparing occur in essentially the

same places. It is much more likely that the signs of sparing and infiltration are seen adjacent to the gallbladder, near the porta hepatis, and the left medial segment. Although both of these abnormalities may mimic solid masses, they will not produce mass effect and therefore will not distort adjacent anatomy.

Clinical Findings of Fatty Liver Disease

1. Asymptomatic
2. Alcohol abuse
3. Chemotherapy
4. Diabetes mellitus
5. Elevated liver function test (specifically AST and ALT)
6. Hyperlipidemia
7. Obesity
8. Pregnancy

Sonographic Findings of Diffuse Fatty Liver Disease

1. Diffusely echogenic liver
2. Increased attenuation of the sound beam
3. Wall of the hepatic vasculature and diaphragm will not be easily imaged

Sonographic Findings of Focal Fatty Infiltration

1. Hyperechoic area adjacent to the gallbladder, near the porta hepatis, or part of a lobe may appear echogenic

Sonographic Findings of Focal Fatty Sparing

1. Hypoechoic area adjacent to the gallbladder, near the porta hepatis, or part of a lobe or an entire lobe may be spared
2. Can appear much like pericholecystic fluid when identified adjacent to the gallbladder

Hepatitis

Hepatitis is inflammation of the liver, which can ultimately lead to cirrhosis, portal hypertension, and HCC. Hepatitis can be acute or chronic. Acute hepatitis is said to resolve in within 4 months, whereas chronic hepatitis persists beyond 6 months. Hepatitis comes in many forms, including hepatitis A, B, C, D, E, and G. The two most common forms are hepatitis A and B.

Hepatitis A is spread by fecal–oral route in contaminated water or food. Hepatitis B is spread by contact with contaminated body fluids, mother-to-infant transmission, or inadvertent blood contact, as seen in the case of

intravenous drug abuse or occupational exposure. An additional concern for health care workers is work-related exposure to hepatitis C. This form of hepatitis is also spread by means of contact with blood and body fluids. Currently, hepatitis C is the leading indication for liver transplantation in the United States. Fortunately, new drug regimens exist that are having a high success rate for removing hepatitis C from the body.

Hepatitis may also be triggered by reactions to systemic viruses such as herpes simplex virus and Epstein–Barr virus. Chronic hepatitis can be caused by Wilson disease, hemochromatosis, autoimmune disorders, or be drug induced. Both Wilson disease and hemochromatosis are inherited conditions. Wilson disease causes the body to accumulate excess copper, whereas hemochromatosis is characterized by disproportionate absorption of dietary iron.

SOUND OFF

Wilson disease results from excessive copper accumulation, whereas hemochromatosis results from excessive iron. If a patient has either of these diseases, sonographers should evaluate the liver for signs of chronic hepatitis.

Hepatitis is often a clinical diagnosis. Patients with any form of hepatitis can experience a wide range of clinical troubles, including fever, chills, nausea, vomiting, fatigue, hepatosplenomegaly, dark urine, and jaundice. However, the jaundice related to hepatitis is on a cellular level and is not associated with biliary obstruction. This is referred to as nonobstructive jaundice. Elevation in the liver function tests—specifically prothrombin, alkaline phosphatase (ALP), aspartate aminotransferase (AST), alanine aminotransferase (ALT), lactate dehydrogenase (LDH), and serum bilirubin levels—is often apparent as well. Impaired liver function, as a result of hepatitis and other hepatic diseases, may lead to hepatic encephalopathy, a condition in which a patient becomes confused or suffers from intermittent loss of consciousness secondary to the overexposure of the brain to toxic chemicals that the liver would normally remove from the body. In newborns, brain damage can occur with severe jaundice as a result of bilirubin exposure, a condition referred to as kernicterus.

Sonographically, a patient with hepatitis may initially have a completely normal-appearing liver. With time, hepatomegaly and splenomegaly, termed hepatosplenomegaly, can be observed with sonography. As the liver enlarges, it tends to become more hypoechoic. Periportal cuffing may be seen in some patients with hepatitis, although this is not always a specific finding. Periportal cuffing is described as an increase in the echogenicity of

the walls of the portal triads. The sonographic manifestation of this phenomenon is referred to as the "starry sky" sign (Fig. 2-16). The gallbladder wall may also be thickened in the presence of hepatitis.

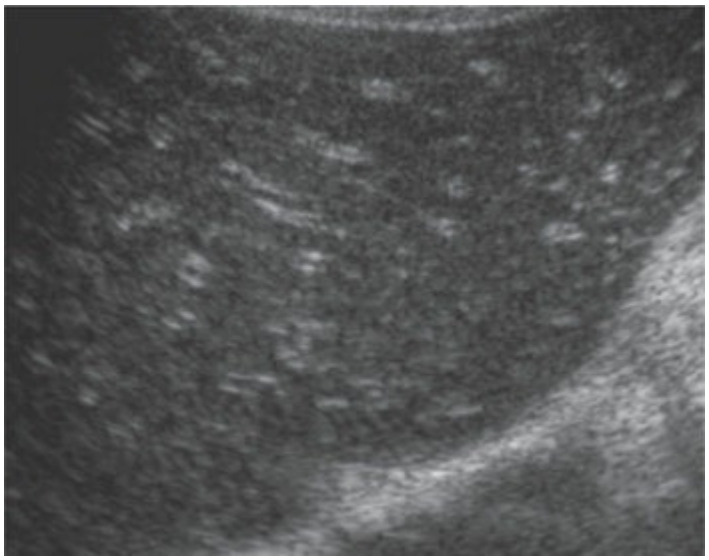

Figure 2-16 Transverse image of the liver demonstrates the "starry sky" appearance frequently associated with hepatitis.

CLINICAL FINDINGS OF HEPATITIS

1. Chills
2. Dark urine
3. Elevated liver function tests (specifically ALP, ALT, AST, LDH, total bilirubin, prothrombin [PT])
4. Fatigue
5. Fever
6. Hepatosplenomegaly
7. Jaundice
8. Nausea
9. Vomiting

SONOGRAPHIC FINDINGS OF HEPATITIS

1. Normal liver
2. Enlarged, hypoechoic liver
3. Periportal cuffing with "starry sky"
4. Gallbladder wall thickening

Cirrhosis

Cirrhosis is a devastating liver disorder that is defined as hepatocyte death, fibrosis and necrosis of the liver, and the subsequent development of regenerating nodules. Common sequela of cirrhosis includes portal

hypertension, the development of varicosities within the abdomen, portal vein thrombosis, splenomegaly, and HCC. The most common cause of cirrhosis is alcoholism. However, cirrhosis can also be caused by Wilson disease, primary biliary cirrhosis, hepatitis, cholangitis, and hemochromatosis.

Patients may have normal laboratory findings until cirrhosis advances into end-stage liver disease. However, when laboratory abnormalities are evident, they include elevation in AST, LDH, ALT, and bilirubin. Patients may also present with jaundice, fatigue, weight loss, diarrhea, initial hepatomegaly, and ascites.

SOUND OFF

Remember this possibly pathway of disease:

Alcoholism → hepatic steatosis (fatty liver) → steatohepatitis → cirrhosis → portal hypertension → portal vein thrombosis → hepatocellular carcinoma

Sonographic findings of cirrhosis include an echogenic, small right lobe, an enlarged caudate and left lobe, nodular surface irregularity, coarse echotexture ascites, and splenomegaly (Figs. 2-17 and 2-18). Cirrhosis caused by alcoholism will lead to the development of nodules that typically measure less than 1 cm (termed micronodular), whereas cirrhosis caused by hepatitis will lead to the development of larger nodules that measure between 1 and 5 cm (termed macronodular). Larger nodules may be readily seen when ascites surrounds the liver. If ascites is not present, a high-frequency linear transducer can be used to analyze the liver surface for evidence of surface nodularity or lumps. In recent years, transient elastography, which is used to evaluate the stiffness of the liver, has been used to stage liver fibrosis. It has been demonstrated that liver stiffness (i.e., the stiffer the liver tissue the more fibrosis present) correlates with cirrhosis complication, including variceal hemorrhage, ascites, and HCC, all of which are signs of advanced cirrhosis and portal hypertension.

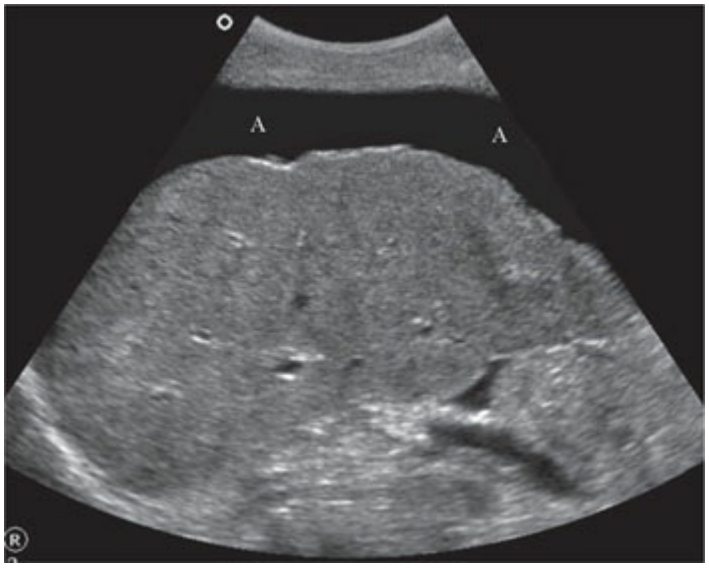

Figure 2-17 Ascites (*A*) is noted surrounding this liver that is affected by cirrhosis. Note the irregular, nodular contour of the liver.

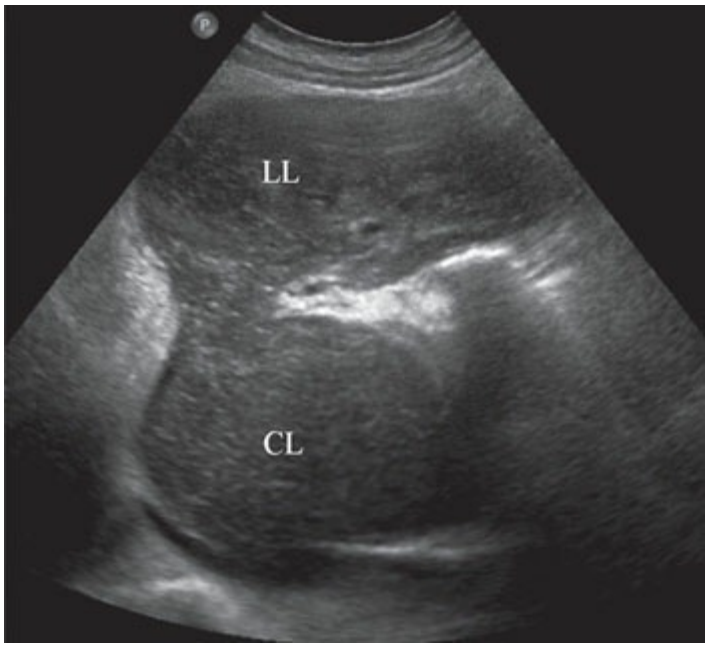

Figure 2-18 Enlargement of the caudate lobe (*CL*) compared to the left lobe (*LL*) is noted in this patient with cirrhosis.

Possible Doppler findings in patients with cirrhosis include monophasic flow within the hepatic veins and hepatofugal flow within the portal veins. These are both findings consistent with advanced cirrhosis and portal hypertension. With these findings, the sonographer is encouraged to further investigate the liver and abdomen for further signs of portal hypertension, portal vein thrombosis, and HCC.

CLINICAL FINDINGS OF CIRRHOSIS

1. Ascites

2. Diarrhea
3. Abnormal liver function tests (specifically elevated ALP, ALT, AST, bilirubin, PT, partial prothrombin time [PTT], total protein, and decreased albumin)
4. Fatigue
5. Hepatomegaly (initial)
6. Jaundice
7. Splenomegaly
8. Weight loss

SONOGRAPHIC FINDINGS OF CIRRHOSIS

1. Hepatosplenomegaly (initial)
2. Shrunken, echogenic right lobe of the liver
3. Enlarged caudate and left lobes
4. Nodular surface irregularity
5. Coarse echotexture
6. Splenomegaly
7. Ascites
8. Monophasic flow within the hepatic veins
9. Hepatofugal flow within the portal veins

SOUND OFF

When you suspect cirrhosis, always look for signs of portal hypertension, portal vein thrombosis, and hepatocellular carcinoma.

Portal Hypertension

Portal hypertension is the elevation of blood pressure within the portal venous system. The pressure within the portal vein can be altered by several abnormalities. The most common cause of portal hypertension is cirrhosis. However, portal hypertension can also result from portal vein thrombosis, hepatic vein thrombosis, IVC thrombosis, or compression of the portal veins by a tumor in an adjacent organ.

Recall that normal flow toward the liver within the portal vein is termed hepatopetal. With cirrhosis, the liver becomes fibrotic or scarred and more difficult to perfuse. Consequently, the blood traveling into the liver via the main portal vein meets greater vascular resistance. Therefore, the pressure within the portal veins increases, resulting in portal hypertension. The hepatic artery, which also brings blood into the liver, has to increase its supply as well, and will consequently enlarge. The flow within the portal vein can eventually become reversed—termed hepatofugal. Portosystemic collaterals and varicosities can consequently develop within the abdomen as a result of the body's attempt to repair itself by channeling blood away from

the damaged liver (Table 2-5).

SOUND OFF
Because the liver becomes so scarred with cirrhosis, the blood flowing to the liver meets greater vascular resistance, resulting in portal hypertension or high blood pressure within the portal veins.

TABLE 2-5 Examples of portosystemic collaterals that may result from portal hypertension

1. Coronary vein
2. Short gastric vein
3. Gastrorenal pathway
4. Splenorenal pathway
5. Umbilical vein
6. Anterior abdominal wall vein
7. Superior mesenteric vein

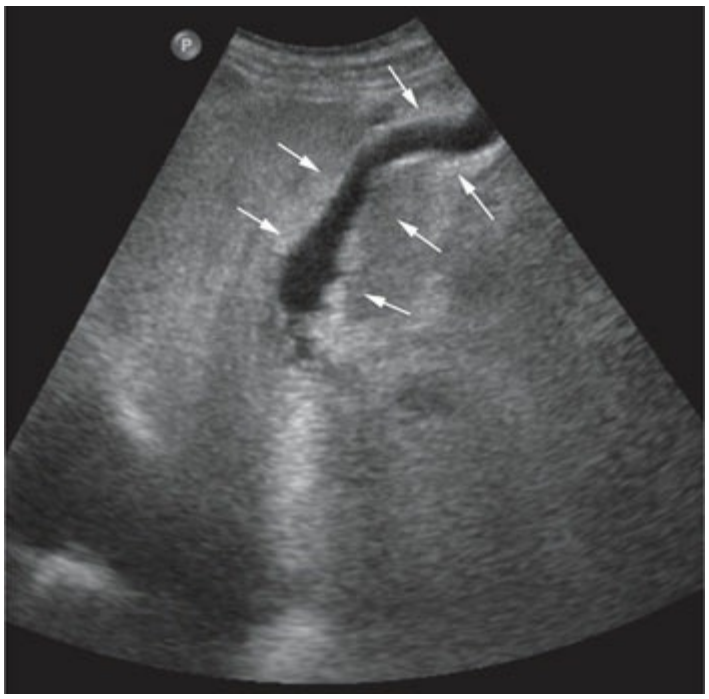

Figure 2-19 A patent or recanalized paraumbilical vein (*arrows*) is noted extended from the left lobe of this patient who is suffering from cirrhosis and portal hypertension.

One of the most common sonographically identifiable collaterals in portal hypertension is the recanalization of the paraumbilical vein, also termed a

patent paraumbilical vein (Figs. 2-19 and 2-20). The umbilical vein, which is associated with the left portal vein, ligamentum teres, and falciform ligament, becomes open again (as it once was in utero) and shunts blood away from the liver and into the inferior epigastric veins or superior epigastric vein—termed Cruveilhier–Baumgarten syndrome.

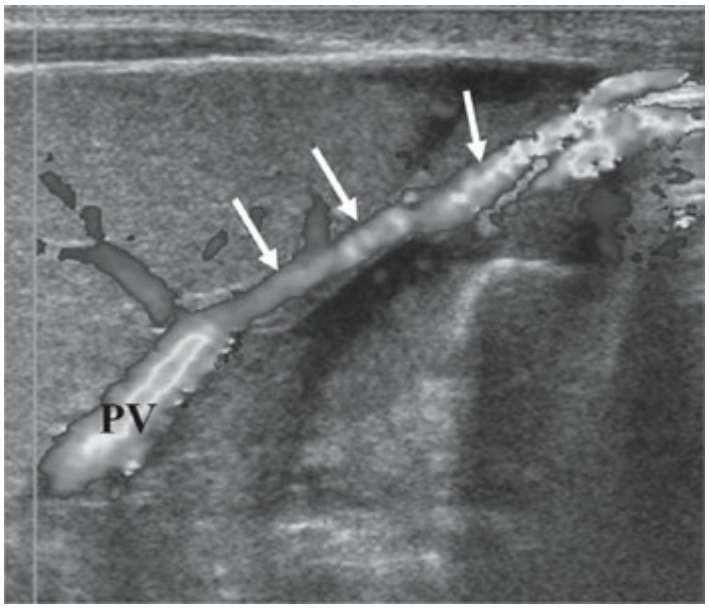

Figure 2-20 Recanalized paraumbilical vein (*arrows*) is demonstrated extended from the left portal vein (*PV*) toward the anterior abdominal wall in a patient with portal hypertension. (Color image provided online.)

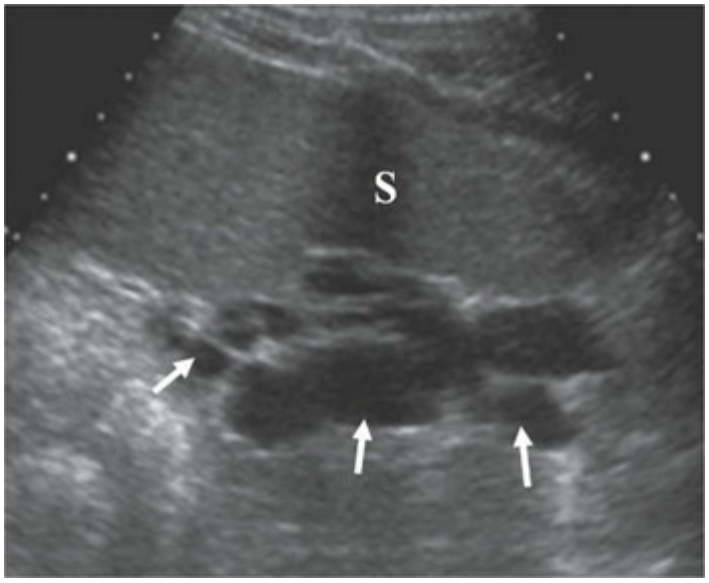

Figure 2-21 In a patient with portal hypertension, splenic varices (*arrows*) are noted adjacent to the spleen (*S*) in the area of the splenic hilum.

Abdominal varicosities may be noted near the splenic hilum, renal hilum, and gastroesophageal junction (Fig. 2-21). Furthermore, sonographic evidence of enlargement and reversed flow within the coronary vein, also

referred to as the left gastric vein, may be seen with portal hypertension (Fig. 2-22). In some individuals, the normal coronary vein can be seen arising from the splenic vein and extending superiorly toward the left. With portal hypertension, the coronary vein will demonstrate abnormal flow toward the esophagus and will measure greater than 6 mm. Unfortunately, shunting of blood toward the esophagus increases the risk for esophageal hemorrhage and death.

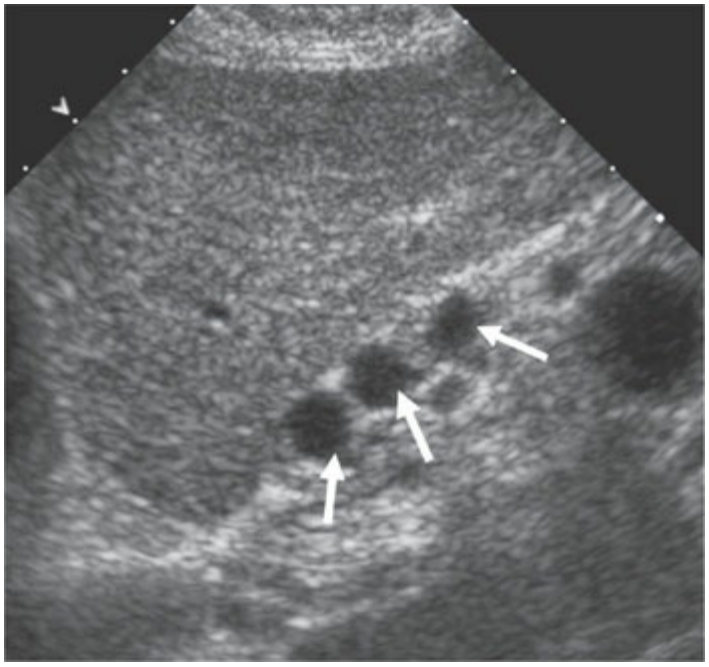

Figure 2-22 Enlarged coronary vein (*arrows*) can be seen posterior to the left lobe in a patient with portal hypertension.

Enlargement of the portal vein with portal hypertension is often apparent, especially prior to collateral development. Along with hepatofugal flow, the portal vein diameter will exceed 13 mm in the anteroposterior dimension, and the superior mesenteric vein will exceed 10 mm. This irregular, and often stagnant flow, increases the patient's likelihood of developing portal vein thrombosis. Essentially, patients with portal hypertension will have many of the same sonographic findings of cirrhosis, including ascites and splenomegaly, with the addition of portal vascular and shunting abnormalities and the development of collaterals channels.

Clinical features of portal hypertension often mimic cirrhosis. Hematemesis, if present, is an ominous sign of ruptured esophageal varices because it markedly increases mortality and morbidity. Other clinical findings of portal hypertension include hepatic encephalopathy, recognizable dilation of the superficial veins of the abdomen (termed caput medusa), and tremors.

Surgical shunts may be placed to reduce the likelihood of complications

resulting from portal hypertension. Surgically placed shunts include the portocaval shunt, splenorenal shunt, and mesocaval shunt. A common, minimally invasive interventional treatment for portal hypertension is by means of a transjugular intrahepatic portosystemic shunt (TIPS). Although it is only a temporary treatment for portal hypertension, this therapy involves the placement of a stent between the portal veins and hepatic veins to shunt blood and reduce portal systemic pressure. The TIPS is often evaluated for patency with Doppler sonography (see "Liver Doppler, TIPS Evaluation, and Liver Transplant Assessment" section in this chapter).

SOUND OFF

If you suspect cirrhosis, be sure to closely analyze the *left portal vein* for evidence of recanalization of the paraumbilical vein. The recanalized paraumbilical vein will extend from the left portal vein, continue through the left lobe, and may travel inferiorly toward the umbilicus.

CLINICAL FINDINGS OF PORTAL HYPERTENSION

1. Abnormal liver function tests
2. Ascites
3. Diarrhea
4. Fatigue
5. Hepatomegaly (initially)
6. Hepatic encephalopathy
7. Caput medusa
8. Tremors
9. Gastrointestinal bleeding

SONOGRAPHIC FINDINGS OF PORTAL HYPERTENSION

1. Hepatomegaly (initially)
2. Shrunken right lobe of the liver
3. Enlarged caudate lobe of the liver
4. Nodular surface irregularity
5. Coarse echotexture
6. Splenomegaly
7. Ascites
8. Monophasic flow within the hepatic veins
9. Hepatofugal flow within the portal veins
10. Enlargement of the portal vein (diameter will exceed 13 mm in the anteroposterior dimension)
11. Enlargement of the superior mesenteric vein
12. Enlargement and reversed flow within the coronary vein

13. Enlarged hepatic arteries
14. Abdominal varicosities at the splenic hilum, renal hilum, and gastroesophageal junction
15. Patent paraumbilical vein (also called a recanalized paraumbilical vein)

Portal Vein Compression and Portal Vein Thrombosis

Portal vein compression, which subsequently leads to portal vein obstruction, is most commonly caused by tumors from adjacent organs or lymphadenopathy. Portal vein thrombosis is the development of clot within the portal vein. Portal vein thrombosis is seen in conditions such as HCC, portal hypertension, pancreatitis, cholecystitis, pregnancy, oral contraceptive use, and surgery. Thrombus can completely occlude the portal vein. In this case, the development of collaterals within the portal vein region will occur. These small vessels try to shunt blood around the clot. This results in a mesh of tiny blood vessels in the area of the portal vein, termed cavernous transformation of the portal vein. In addition, as the disease progresses, larger collaterals can develop.

Patients may complain of abdominal pain, low-grade fever, leukocytosis, hypovolemia, elevated liver function tests, and nausea and vomiting. Initial sonographic evaluation of portal vein thrombus may be difficult because clot can be isoechoic to the surrounding circulating blood. With time, thrombus will become more echogenic and may be more noticeable within the portal vein (Fig. 2-23). The cavernous transformation of the portal veins will appear as wormlike or serpiginous vessels within the region of the portal vein (Fig. 2-24). Portal occlusion can also be the result of tumor invasion within the portal vein. Because of the compromise to hepatic blood flow, color Doppler should be used to evaluate the vascularity of liver.

SOUND OFF

Cavernous transformation of the portal vein is a sequela of portal vein thrombosis. With cavernous transformation of the portal vein, you will find multiple serpiginous or tortuous vessels in the porta hepatis.

CLINICAL FINDINGS OF PORTAL VEIN THROMBOSIS

1. Abdominal pain
2. Elevated liver function tests
3. Hypovolemia
4. Leukocytosis
5. Low-grade fever
6. Nausea
7. Vomiting

SONOGRAPHIC FINDINGS OF PORTAL VEIN THROMBOSIS

1. Echogenic thrombus within the portal vein
2. Cavernous transformation of the portal veins will appear as wormlike or serpiginous vessels within the region of the portal vein

Portal Venous Gas

Gas within the portal veins or mesenteric veins that results from ischemic bowel disease is typically fatal. However, portal venous gas may also be associated with diverticulitis, appendicitis, inflammatory bowel disease, bowel obstructions, ulcers within the bowel, gastrointestinal cancer, and invasive procedures that involve stent placement or endoscopic analysis of the bowel. The sonographic findings of portal venous gas are consistent with evidence of small, bright reflectors noted within the circulating blood inside the portal vein. Larger air collections may produce ring-down artifact. Care should be taken to not confuse portal venous gas with pneumobilia, which is air located within the biliary ducts.

CLINICAL FINDINGS OF PORTAL VENOUS GAS

1. Recent bout of diverticulitis, appendicitis, inflammatory bowel disease, bowel obstruction, ulcers within the bowel, gastrointestinal cancer, and invasive procedures that involve stent placement (TIPS) or endoscopic analysis of the bowel

SONOGRAPHIC FINDINGS OF PORTAL VENOUS GAS

1. Small, bright reflectors noted within the circulating blood inside the portal vein.
2. Larger air collections may produce ring-down artifact.

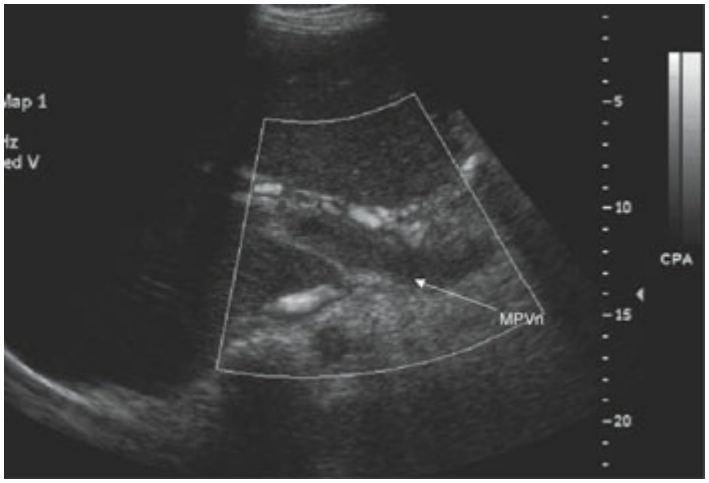

Figure 2-23 Sagittal, color Doppler image of the main portal vein (*MPVn*) reveals portal vein thrombosis and the development of collateral vessels diverting blood

around the clot. (Color image provided online.)

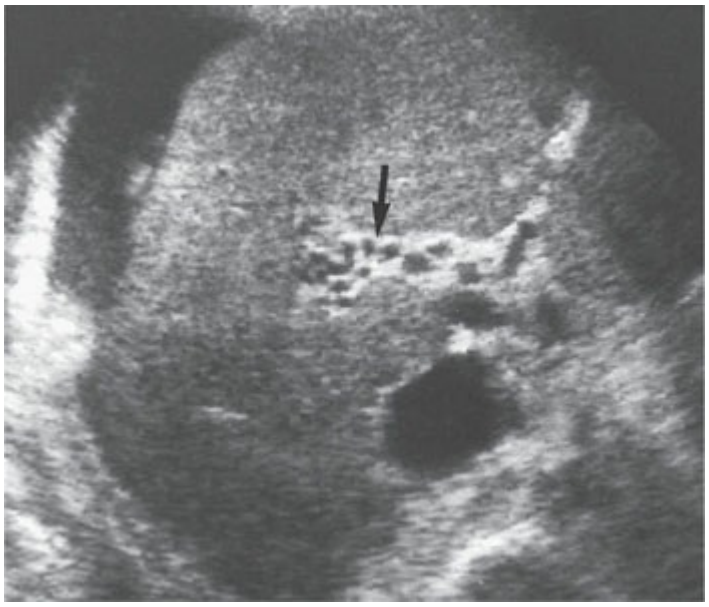

Figure 2-24 Cavernous transformation of the portal vein. Transverse image through the porta hepatis demonstrates multiple, small collateral vessels (*arrow*) in the area of the portal vein.

Budd–Chiari Syndrome

Budd–Chiari syndrome is described as the occlusion of the hepatic veins, with possible coexisting occlusion of the IVC. Budd–Chiari syndrome can be seen secondary to a congenital webbing disorder, coagulation abnormalities, tumor invasion from HCC, thrombosis, oral contraceptive use, pregnancy, and trauma. Clinical symptoms of this abnormality, when found in female patients on oral contraception, include ascites, right upper quadrant pain, hepatomegaly, and possibly splenomegaly. Other patients may suffer from extensive upper abdominal pain and elevated liver function test. Sonographic findings include the nonvisualization or reduced visualization of the hepatic veins. Thrombus may be noted within the hepatic veins, the caudate lobe may be enlarged, and color Doppler will often yield evidence of absent flow within the hepatic veins. The IVC may also be narrowed.

CLINICAL FINDINGS OF BUDD–CHIARI SYNDROME

1. Ascites
2. Elevated liver function test
3. Hepatomegaly
4. Splenomegaly
5. Upper abdominal pain

SONOGRAPHIC FINDINGS OF BUDD–CHIARI SYNDROME

1. Nonvisualization or reduced visualization of the hepatic veins
2. Thrombus within the hepatic veins
3. Enlarged caudate lobe
4. Lack of flow within the hepatic veins with color Doppler
5. Narrowing of the IVC

SOUND OFF
Budd–Chiari syndrome is characterized by occlusion of the hepatic veins and possibly the IVC.

Focal Liver Disease

Hepatic Cysts

True hepatic cysts are usually not encountered until middle age (Fig. 2-25). They are often associated with autosomal dominant polycystic kidney disease (ADPKD). Clinically, hepatic cysts associated with ADPKD are often asymptomatic and they do not alter liver function tests. They may be multiple, and they may not always conform to the sonographic appearance of a simple cyst because their shape can be somewhat irregular. Clusters of cysts with jagged walls may be noted, which may produce a complex appearance (Fig. 2-26). However, all other simple cyst criteria should be present, including a smooth wall and the presence of posterior acoustic enhancement, and they should be entirely anechoic. Complex hepatic cysts are often due to hemorrhage and may have internal echoes, thick walls, calcification, or solid components. When pain occurs because of hepatic cysts, it may be due to hemorrhage, infection, or secondary to mass effect. Hepatic cysts may also be noted in patients with von Hippel–Lindau disease, or be solitary and idiopathic.

CLINICAL FINDINGS OF HEPATIC CYSTS

1. Asymptomatic
2. Possible normal liver function tests
3. ADPKD
4. Hemorrhagic or large cysts may cause right upper quadrant pain

SONOGRAPHIC FINDINGS OF HEPATIC CYSTS

1. Anechoic mass or masses with posterior enhancement
2. May have irregular shapes
3. Clusters of cysts may be noted

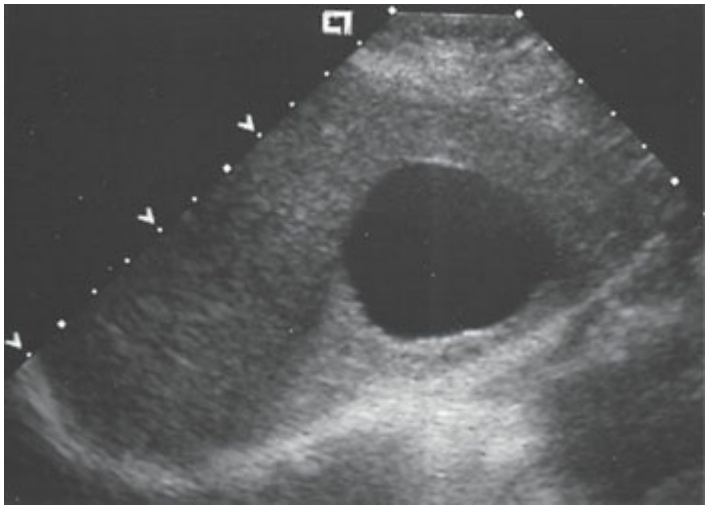

Figure 2-25 Benign hepatic cyst. This liver mass has well-defined borders, is completely anechoic, has thin walls, and demonstrates posterior enhancement.

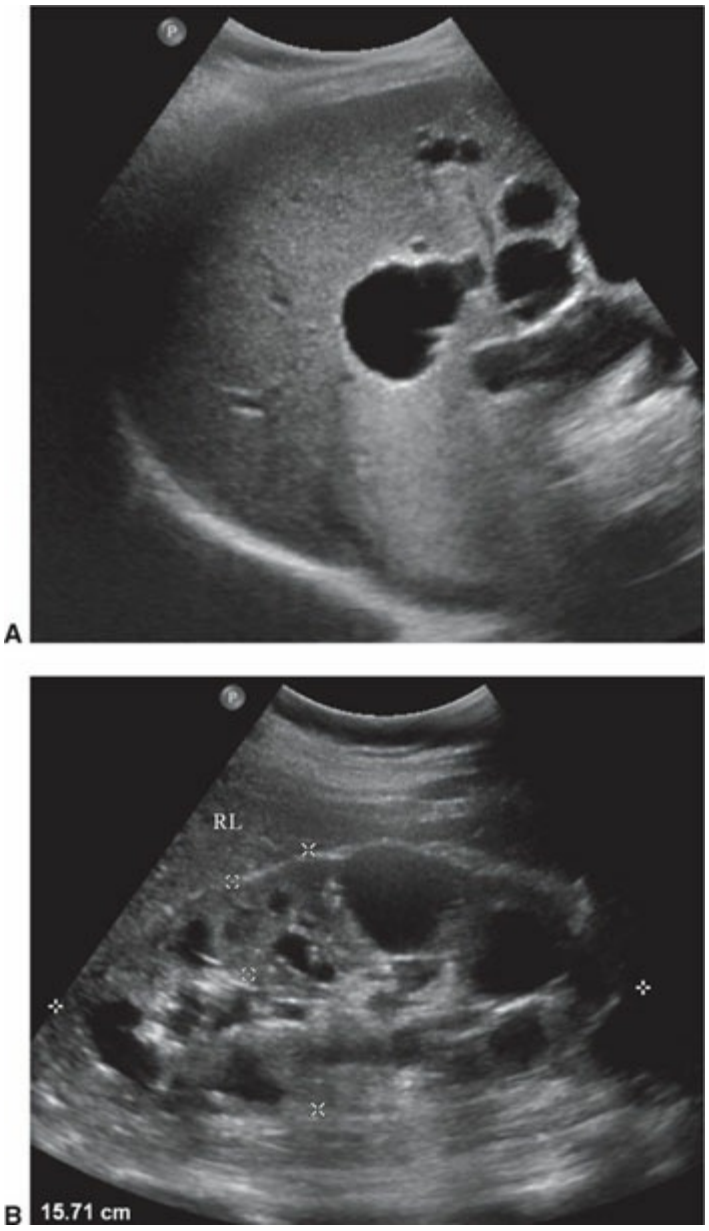

Figure 2-26 ADPKD cysts. This appearance of hepatic cysts (image A) is commonly

associated with cysts of the kidney affected by ADPKD (image B). ADPKD, autosomal dominant polycystic kidney disease. RL, right lobe.

Hydatid Liver Cyst

A hydatid liver cyst may also be referred to as an echinococcal cyst. These cysts develop most commonly from a parasite referred to as Echinococcus granulosus. This parasite is a tapeworm that lives in dog feces. Food, such as vegetables, contaminated by the infected feces is consumed indirectly by sheep, cattle, goat, and possibly humans. Therefore, there is a higher prevalence of hydatid disease in sheep- and cattle-raising countries such as the Middle East, Australia, and the Mediterranean. The parasite moves from the bowel through the portal vein to enter the liver.

Clinically, patients present with a low-grade fever and right upper quadrant tenderness. Other signs and symptoms include nausea, obstructive jaundice, leukocytosis, and a slight raise in alkaline phosphatase. The sonographic appearance is variable. Hydatid cysts may appear as an anechoic mass containing some debris. This debris is referred to as hydatid sand. The cyst is composed of an endocyst, and a pericyst or ectocyst. The endocyst, contained within the pericyst, may disconnect from the pericyst, and its wall may be clearly identified floating within the larger cyst. This has been referred to as the “water lily” sign.

Hydatid cysts may also appear as cysts within a cyst. This has been described as a “mother” cyst containing “daughter” cysts. This sonographic description is highly specific for hydatid disease (Fig. 2-27). The mass may also contain some elements of dense calcification. Surgical resection, catheter drainage, or medical treatment may be used to manage a hydatid liver cyst. Unfortunately, cyst ruptures could lead to anaphylactic shock.

Clinical Findings of a Hydatid Liver Cyst

1. Leukocytosis
2. Low-grade fever
3. Nausea
4. Obstructive jaundice
5. Right upper quadrant tenderness
6. Possible recent travel abroad

Sonographic Findings of A Hydatid Liver Cyst

1. Anechoic mass containing some debris (hydatid sand)
2. “Water lily“ sign appears as an endocyst floating within the pericyst
3. “Mother” cyst containing one or more smaller “daughter” cyst
4. Mass may contain some elements of dense calcification

Amebic Hepatic Abscess

An amebic hepatic abscess comes from the parasite Entamoeba histolytica that grows in the colon and invades the liver via the portal vein. It is typically transmitted through contaminated water found in places such as Mexico, Central America, South America, Asia, India, and Africa. Therefore, patients who present with amebic abscesses may have traveled out of the country recently. Clinical features may be hepatomegaly, right upper quadrant pain, general malaise, or signs of dysentery, which include bloody diarrhea, abdominal pain, and fever.

Laboratory findings may include leukocytosis, elevated liver function tests, and mild anemia. Like other abscesses, amebic abscesses have variable sonographic appearances. They are typically round, hypoechoic or anechoic, contain debris, and have some acoustic enhancement. Amebic abscesses are most often noted within the right lobe of the liver near the capsule. They may also be multiple and appear hypoechoic or contain a fluid-debris level (Fig. 2-28). Often, they are indistinguishable sonographically from a pyogenic liver abscess and therefore require a serologic confirmation. These masses are typically treated medically, although aspiration may be performed. Complications include rupture or extension into the chest or peritoneal cavity, resulting in a high mortality rate if not treated efficiently.

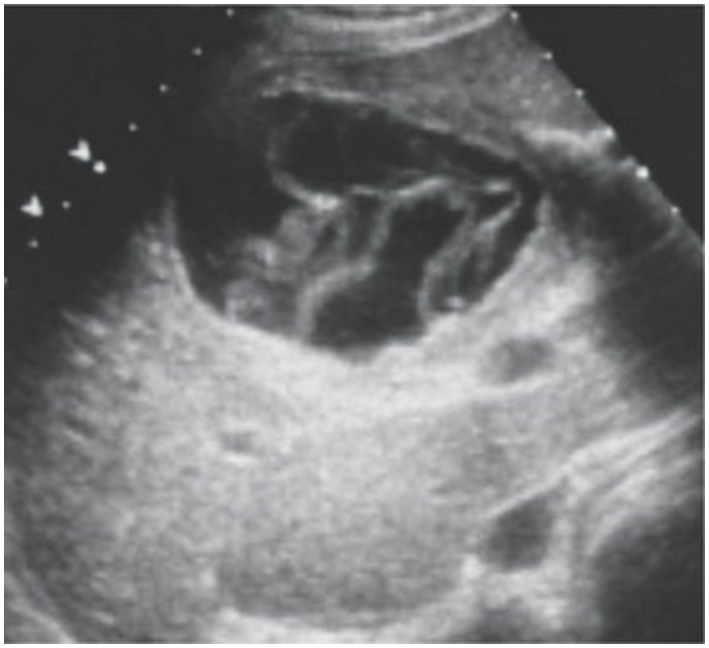

Figure 2-27 Hydatid disease. Transverse image of the liver demonstrates a complex mass containing a detached membrane, which is the typical appearance of a hydatid cyst.

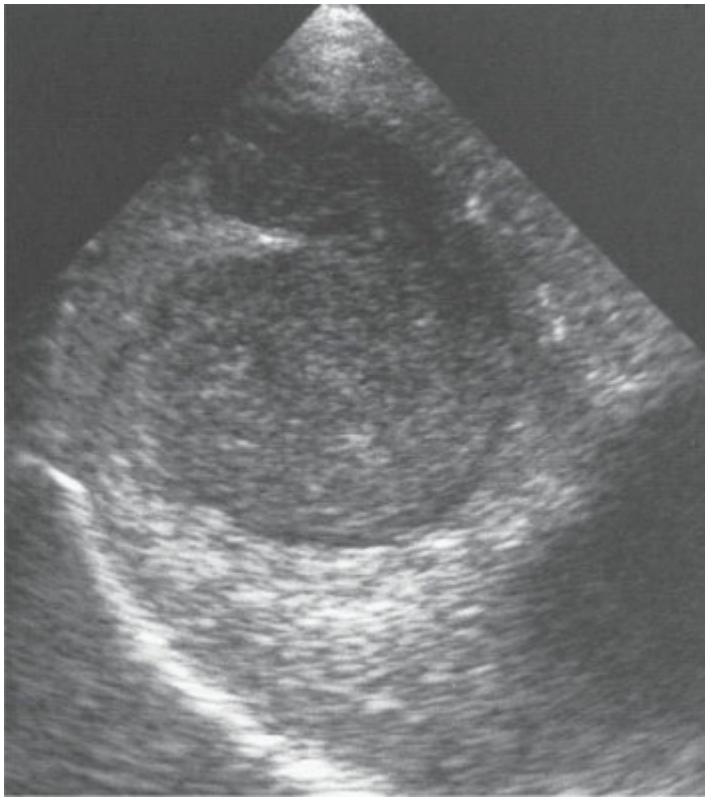

Figure 2-28 Amebic abscess. This amebic abscess appears as a hypoechoic mass surrounded by a hypoechoic wall.

CLINICAL FINDINGS OF AN AMEBIC HEPATIC ABSCESS

1. Hepatomegaly
2. Right upper quadrant or general abdominal pain
3. General malaise
4. Diarrhea (possibly bloody)
5. Fever
6. Leukocytosis
7. Elevated liver function tests
8. Mild anemia
9. Possible recent travel abroad

SONOGRAPHIC FINDINGS OF AN AMEBIC HEPATIC ABSCESS

1. Round, hypoechoic or anechoic mass or masses
2. May contain debris (with fluid-debris layering)
3. Acoustic enhancement

Pyogenic Hepatic Abscess

A pyogenic hepatic abscess can result from the spread of infection from inflammatory conditions such as appendicitis, diverticulitis, cholecystitis, cholangitis, or endocarditis. The bacteria enter the liver through the portal vein, hepatic artery, biliary tree, or from an operative procedure. Clinical

symptoms of a pyogenic abscess include fever, leukocytosis, possible abnormal liver function tests, right upper quadrant pain, and hepatomegaly. The sonographic findings of a hepatic abscess are variable (Fig. 2-29). It may appear as a complex cyst with thick walls. It may also contain debris, septations, and/or gas. The air within the abscess may produce dirty shadowing or ring-down artifact.

CLINICAL FINDINGS OF A PYOGENIC HEPATIC ABSCESS

1. Fever
2. Hepatomegaly
3. Leukocytosis
4. Possible abnormal liver function tests
5. Right upper quadrant pain

SONOGRAPHIC FINDINGS OF A PYOGENIC HEPATIC ABSCESS

1. Complex cyst with thick walls
2. Mass may contain debris, septations, and/or gas
3. The air within the abscess may produce dirty shadowing or ring-down artifact

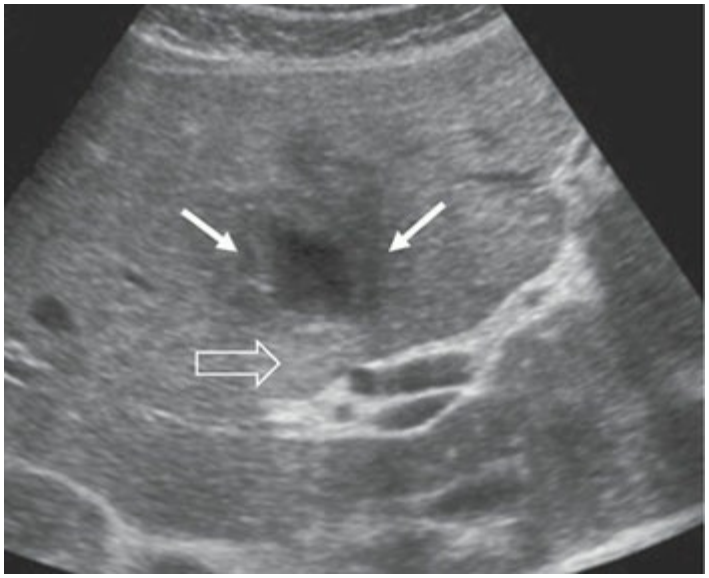

Figure 2-29 Pyogenic abscess. Longitudinal image of the liver containing a hypoechoic mass with indistinct borders (*solid arrows*) and posterior enhancement (*open arrow*).

Hepatic Candidiasis

Hepatic candidiasis results from the spread of fungus, namely Candida albicans, in the blood to the liver. Those who are prone to develop hepatic candidiasis are typically immunocompromised in some way. For example, cancer patients, recent organ transplant patients, and those with human

immunodeficiency virus are more prone to develop this type of fungal abscess within their liver. Besides being immunocompromised, patients may have right upper quadrant pain, fever, and hepatomegaly. Sonographic findings include multiple hyperechoic (central portion) masses with hypoechoic borders. These masses may be described as "target," "halo," or "bull's-eye" lesions and are typically 1 cm or smaller in size (Fig. 2-30). Older lesions may calcify.

CLINICAL FINDINGS OF HEPATIC CANDIDIASIS

1. Immunocompromised patients including cancer patients, recent organ transplant patients, and patients with human immunodeficiency virus
2. Right upper quadrant pain
3. Fever
4. Hepatomegaly

SONOGRAPHIC FINDINGS OF HEPATIC CANDIDIASIS

1. Multiple masses with hyperechoic central portions and hypoechoic borders (may be described as "target," "halo," or "bull's-eye" lesions)
2. These masses are typically 1 cm or smaller in size
3. Older lesions may calcify

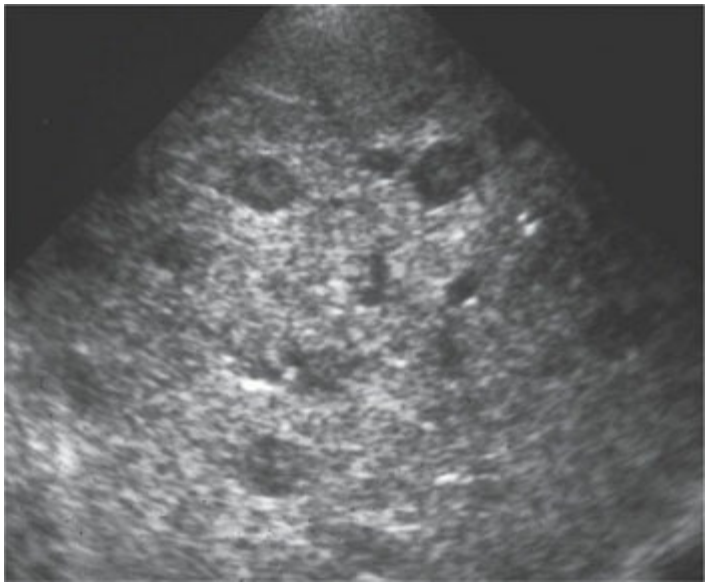

Figure 2-30 Candidiasis. This transverse image of the liver demonstrates multiple hypoechoic lesions that appear as small bull's-eyes scattered throughout the organ.

Cavernous Hemangioma

The most common benign liver tumor is the cavernous hemangioma. Although they can be found in men, they are more commonly discovered in women. Hepatic hemangiomas are usually incidentally detected and

asymptomatic. The most common location of the cavernous hemangioma is within the right lobe of the liver. They characteristically appear as a small, hyperechoic mass measuring less than 3 cm, although some may be quite large and referred to as giant hemangiomas (Fig. 2-31). Occasionally, posterior enhancement may be seen. Although hemangiomas are comprised of blood vessels, detectable flow may not be seen with color Doppler because the flow within the vessels tends to be exceedingly slow. Unfortunately, hemangiomas may also appear hypoechoic or complex, and therefore they can be sonographically indistinguishable from metastatic liver disease. There may also be multiple hemangiomas present, further complicating the sonographic diagnosis and consequently leading to other imaging or biopsy.

SOUND OFF
The cavernous hemangioma is the most common benign liver mass. It is most often found in the right hepatic lobe.

CLINICAL FINDINGS OF A CAVERNOUS HEMANGIOMA

1. Asymptomatic

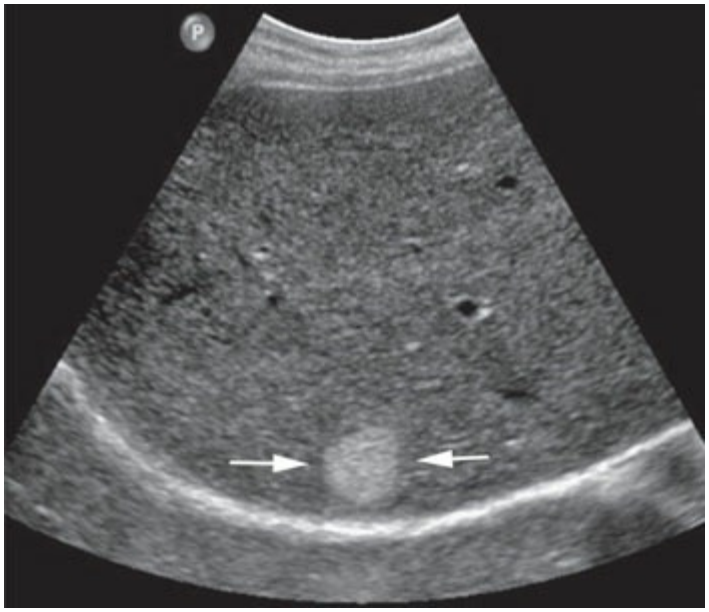

Figure 2-31 Cavernous hemangioma. A hyperechoic mass (*arrows*) is noted within the right lobe of the liver.

SONOGRAPHIC FINDINGS OF A CAVERNOUS HEMANGIOMA

1. Small, hyperechoic mass
2. Typically in the right lobe

Focal Nodular Hyperplasia

Focal nodular hyperplasia (FNH) has been cited as the second most common benign liver tumor and more commonly incidentally discovered in women. The mass is composed of a combination of hepatocytes and fibrous tissue. Patients who have FNH are most often asymptomatic, but if the mass impinges upon surrounding anatomy or hemorrhage occur, pain will most likely ensue. Although the mass is not caused by oral contraceptive use, it may enlarge because of oral contraceptive use as a result of estrogen exposure.

Sonographically, FNH may have varying sonographic appearances, including isoechoic, echogenic, and hypoechoic (Fig. 2-32). It typically contains a central stellate (star-like) scar that is not always detected with sonography but is readily identified with CT and MRI. The central scar, when seen, will appear as a hypoechoic or hyperechoic, linear structure within the mass. Hypervascularity within the scar can be identified by using color Doppler. FNH has been referred to as a "stealth lesion" because it may be difficult to identify secondary to its slight sonographic disparity from normal liver parenchyma.

CLINICAL FINDINGS OF FOCAL NODULAR HYPERPLASIA

1. Asymptomatic

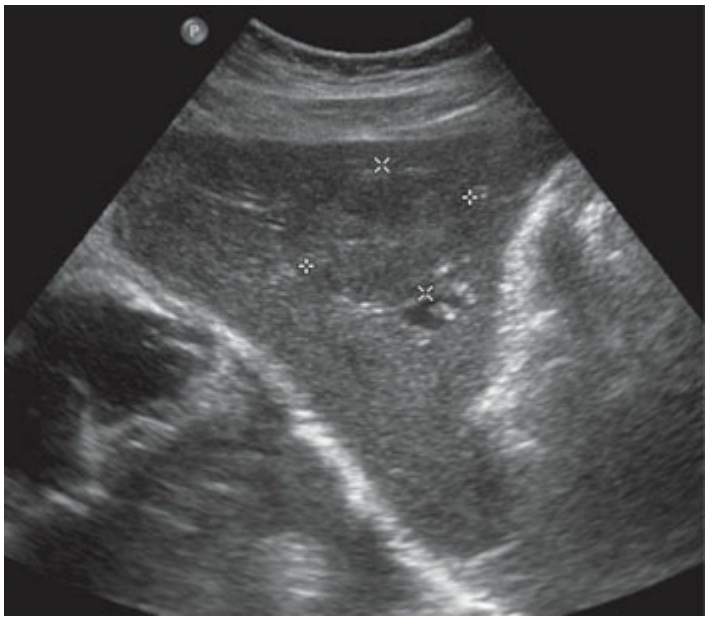

Figure 2-32 Focal nodular hyperplasia. An isoechoic mass (*between calipers*) is noted within the left lobe of the liver.

SONOGRAPHIC FINDINGS OF FOCAL NODULAR HYPERPLASIA

1. Isoechoic, hyperechoic, or hypoechoic mass

2. Central scar may appear as hyperechoic or hypoechoic linear structure within the mass and will often reveal hypervascularity with color Doppler

SOUND OFF
Although FNH is not caused by oral contraceptive use, the mass tends to be estrogen dependent, and thus can grow as the result of oral contraceptive use.

Hepatocellular Adenoma

The hepatocellular adenoma, which may also be referred to as a hepatic adenoma or liver cell adenoma, is a rare benign liver tumor. It is often associated with the use of oral contraceptives. Patients are typically asymptomatic with an adenoma, but hemorrhage of the tumor leads to abdominal pain. Because of hemorrhage, and a small propensity to become malignant (termed malignant degeneration), hepatic adenomas are often surgically removed. There may be multiple adenomas present at the time of discovery. The sonographic appearance of a hepatic adenoma is variable, and although a solid, hypoechoic echogenicity is common, they may be hyperechoic, isoechoic, or have mixed echogenicities (Fig. 2-33).

SOUND OFF
Hepatic adenomas can be caused by oral contraceptive use.

CLINICAL FINDINGS OF A HEPATOCELLULAR ADENOMA

1. Asymptomatic
2. Oral contraceptive use
3. Pain occurs with hemorrhage

SONOGRAPHIC FINDINGS OF A HEPATOCELLULAR ADENOMA

1. Mostly hypoechoic
2. May be hyperechoic, isoechoic, or be comprised of mixed echogenicities

Hepatic Lipoma

The hepatic lipoma is rarely encountered. Patients are asymptomatic, and its sonographic appearance is that of a hyperechoic mass.

CLINICAL FINDINGS OF HEPATIC LIPOMA

1. Asymptomatic

SONOGRAPHIC FINDINGS OF HEPATIC LIPOMA

1. Hyperechoic mass

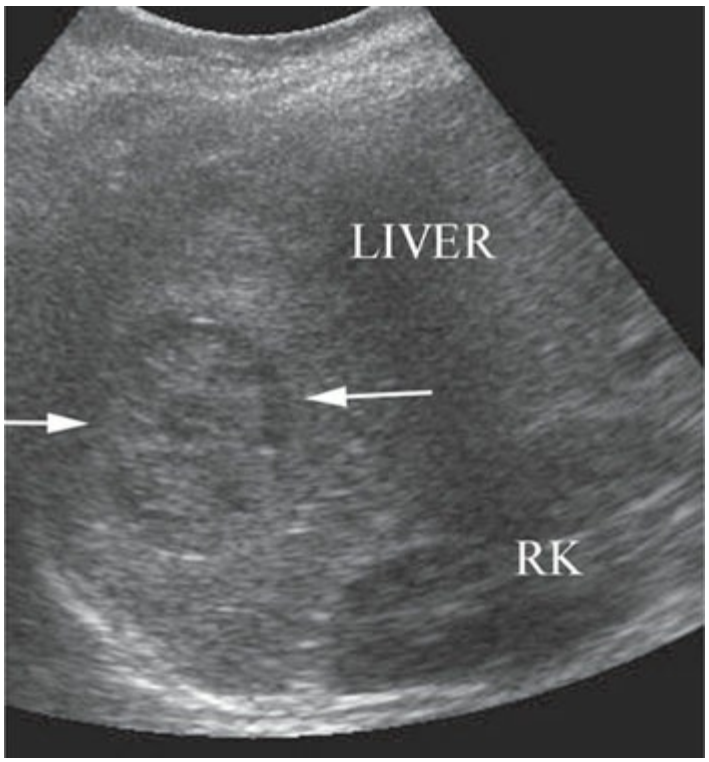

Figure 2-33 Hepatic adenoma. This well-circumscribed mass (*between arrows*) is a hepatic adenoma located within the right lobe of the liver, superior to the right kidney (*RK*).

Hepatic Hematoma

A hepatic hematoma can be a consequence of trauma or surgery. Patients will have pain and a decreased hematocrit. Hematomas can be located within the liver parenchyma, termed intrahepatic, or around the liver, which is termed subcapsular (under Glisson capsule). Hematomas can appear solid or complex depending on their age. Initial hemorrhage appears echogenic with the development of clot, and over time as it resolves, it may appear more cystic or complex. Focal hematomas have been known to calcify as well. Therefore, in the acute stage, an intrahepatic hematoma adjacent to the liver may be difficult to visualize with sonography because it may be isoechoic to the normal hepatic tissue. When the subcapsular hematoma is anechoic, it may appear similar to ascites surrounding the liver (Fig. 2-34). Following trauma to the liver, an abnormal passageway between an artery and vein—termed arteriovenous fistula—can result. Arteriovenous fistulas may also be discovered following a liver biopsy, cholangiography, or hepatic surgery. Multiple anechoic spaces will be noted in the area of the fistula, and color Doppler can be used to prove that the mass is vascular in origin.

Clinical Findings of Hepatic Hematoma

1. Trauma
2. Recent surgery
3. Pain
4. Decreased hematocrit

Sonographic Findings of Hepatic Hematoma

1. Fresh clot may appear hyperechoic
2. Older hemorrhage can appear anechoic or complex
3. May be intrahepatic or subcapsular

Liver Cancer

Hepatocellular Carcinoma

HCC is the most common primary form of liver cancer, although it is not encountered as often as metastatic liver disease. HCC is most often seen in men, and frequently accompanied by cirrhosis or chronic hepatitis. The malignant mass associated with HCC is referred to as a hepatoma. Other causes include hemochromatosis, von Gierke disease, and Wilson disease. Hepatomas can invade the portal veins or hepatic veins. Occlusion of the hepatic veins, with possible tumor invasion into the IVC, is termed Budd–Chiari syndrome, and thus the sonographic evaluation of pertinent vasculature is warranted for evidence of tumor thrombus. Color Doppler may yield evidence of hypervascularity within the mass, although this is not a specific indicator for malignancy.

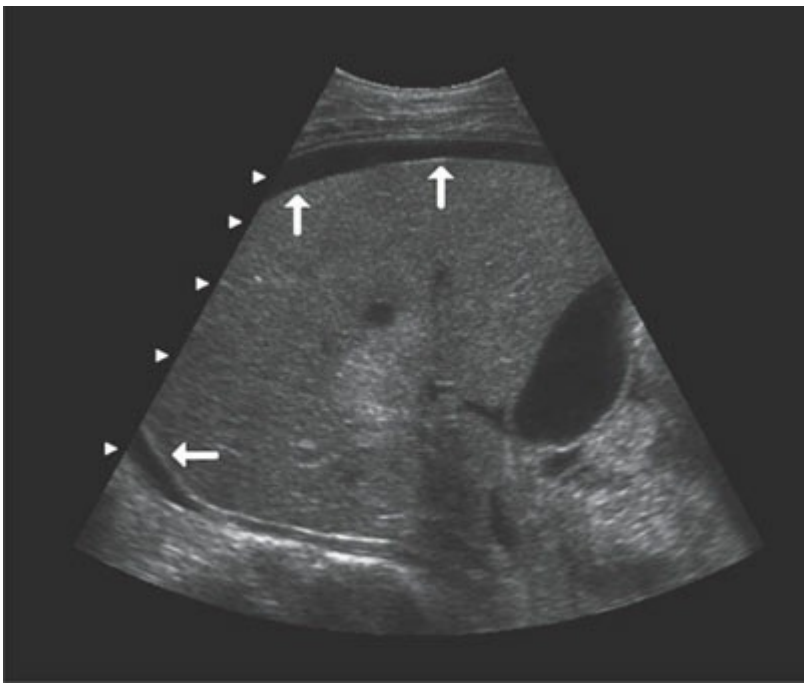

Figure 2-34 This older hematoma (anechoic fluid, *arrows*) has become sonolucent. Fresh hematomas may appear isoechoic to normal liver tissue.

Clinically, patients with HCC will have possible abnormal liver function tests, signs of cirrhosis, history of chronic hepatitis, unexplained weight loss, hepatomegaly, fever, abdominal swelling with ascites, and perhaps a palpable mass. A tumor marker for HCC is serum alpha-fetoprotein (AFP). In the fetus, AFP is produced in large amounts by the liver, whereas in the adult, low levels of AFP exist. Most patients with HCC will have an elevated AFP. This occurs because AFP is produced in excess by the malignant hepatocytes that make up the tumor.

The sonographic findings of HCC are unpredictable. There may be an individual mass or multiple masses present at the time of diagnosis. HCC may appear as a solitary, small, hypoechoic mass, or as heterogeneous masses scattered throughout the liver (Fig. 2-35). A hypoechoic halo may be noted around the hepatoma as well, yielding the "target" or "bull's-eye" pattern. The target lesion will yield a hypoechoic rim, with the center of the mass often isoechoic to normal liver tissue.

SOUND OFF
The tumor marker for hepatocellular carcinoma is AFP.

CLINICAL FINDINGS OF HEPATOCELLULAR CARCINOMA

1. Elevated AFP
2. Abnormal liver function tests (possibly)
3. Cirrhosis
4. Chronic hepatitis
5. Unexplained weight loss
6. Hepatomegaly
7. Fever
8. Palpable mass
9. Abdominal swelling with ascites

SONOGRAPHIC FINDINGS OF HEPATOCELLULAR CARCINOMA

1. Solitary, hypoechoic mass
2. Heterogeneous masses scattered throughout the liver
3. Mass with a hypoechoic halo and central echogenic portion ("target" or "bull's-eye" lesion)
4. Possible ascites

Hepatic Metastasis

The liver is a common location for metastatic disease to manifest in the abdomen. Metastatic liver disease is the most common form of liver cancer. Because it is much more common than primary liver cancer (cancer that starts in the liver). The malignant cells from other sites enter the liver through the portal veins or lymphatic channels. Primary cancers that metastasize to the liver include the gallbladder, colon, stomach, pancreas, breast, and lung, with the latter being the most common primary source. Patients with hepatic metastasis may present with weight loss, jaundice, right upper quadrant pain, hepatomegaly, and ascites. However, in about half of patients there are no clinical signs or symptoms, including the possibility of normal liver function tests.

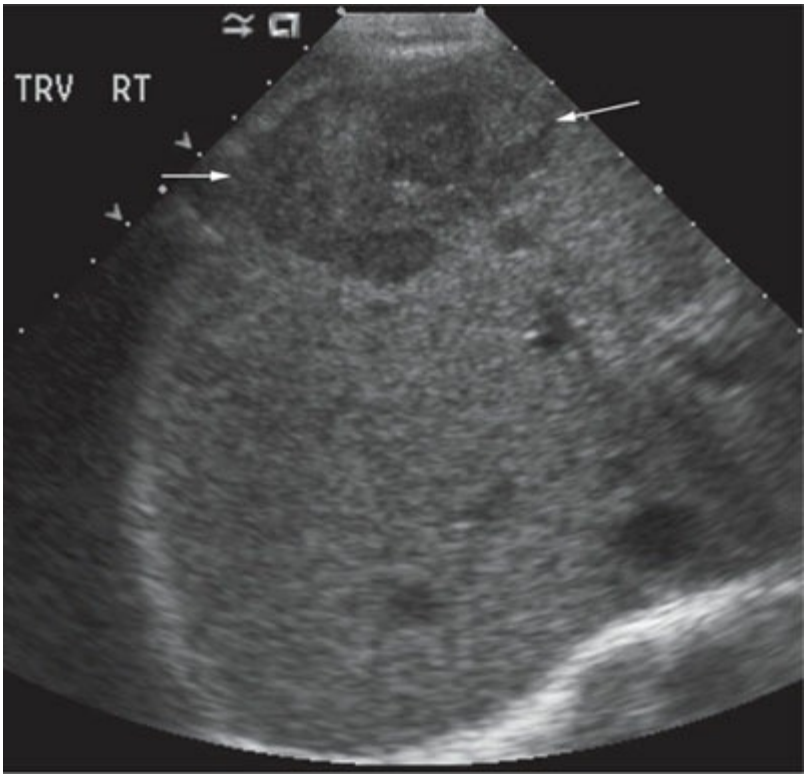

Figure 2-35 Hepatoma. This solid, hypoechoic mass (*between arrows*) was found to be hepatocellular carcinoma.

The sonographic findings of metastatic liver disease are variable, often depending on the location of the primary cancer. Metastatic cancer from the gastrointestinal tract and pancreas tends to be calcified tumors. Hyperechoic masses tend to arise from the gastrointestinal tract as well, most commonly the colon, but they may also be from the kidney, pancreas, or biliary tree. Hypoechoic masses may be from the breast, lung, or lymphoma. Cystic metastatic masses within the liver have also been seen with ovarian cancers. Metastatic disease in the liver can appear as an individual mass, several large masses, or diffuse involvement (Figs. 2-36 and 2-37). Target lesions are also common with metastasis and may be the expression of lung or colon