Presentation title: Diagnostic Medical Sonography: *A Dynamic Healthcare Profession*

This presentation was developed and is copyrighted by Daniel A. Merton, BS, RDMS, FAIUM, FSDMS with funding support provided by the **American Institute of Ultrasound in Medicine's** Endowment for Education and Research (Grant title: *"Enhancing Awareness of the Diagnostic Medical Sonography Professions: A High School Outreach Program").* It is intended as a presentation for sonography professionals to provide information about Diagnostic Medical Sonography in general and DMS careers in particular to high school students (ideally those in anatomy / physiology or advanced biology classes). The program can also be presented to middle-school students, guidance councilors, teachers and others with an interest in this topic.

The presentation includes 40 slides and requires 35 to 45 minutes to complete. It is strongly suggested that presenters include a live scanning demonstration at the conclusion of the slide show. Manufacturers of hand-carried ultrasound systems are often willing to loan their systems to interested professionals for this purpose. Alternatively, the presenter can invite a company applications specialist to assist in the program or the program can be provided in a healthcare setting where there is access to an ultrasound system.

Format and Content

The presentation is provided in PowerPoint Show (PPS; Microsoft Office 2003) format. It includes still images, photographs, audio (on slide #six) and video clips. The PPS file and all video clips must be kept within a single folder to function properly. The sequence of slides and individual components of the presentation (text boxes, images, photographs and video clips) are locked in place but are displayed automatically and sequentially as the presenter manually advances the show using the right or down arrow keys or left mouse click. Video clips can be identified on each slide as having a red line around them. In some cases the video clips will play automatically when the slide is initially shown while in other cases the video begins to play on the next mouse click (which provides time for the presenter to describe other items shown on that slide).

Complementary items included with this presentation include a Handout with additional information pertaining to DMS professions and a presentation Questionnaire. Theses items can be distributed to students after the presentation. The Questionnaire is used to obtain feedback from the students and their instructors.

Presenter Notes and Suggestions

Each slide includes notes that can be viewed by selecting "Notes Page" under the "View" tab. It is recommended that presenters view the notes prior to using the presentation to become familiar with the content and sequence. The Notes include a brief description of what is shown on each slide as well as "presenter notes" that are suggestions that the presenter can employ to enhance speaker/audience interactions. The inclusion of interactive opportunities during the presentation tends to increase the attention level of students and makes the experience more interesting and educationally rewarding.

Acknowledgements and Restrictions

Users of this presentation are requested to recognize the AIUM's EER as the funding source and Daniel Merton as the developer (slides recognizing each are included at the end of the presentation). Contact Dan by email: Daniel.A.Merton@jeffersonhospital.org or realtime911@yahoo.com.

About the developer:

Daniel A. Merton is a Clinical Instructor and the Technical Coordinator of Ultrasound Research at the Jefferson Ultrasound Research and Education Institute of Thomas Jefferson University Hospital in Philadelphia, PA and an Adjunct Associate Professor at Drexel University's School of Biomedical Engineering Science and Health Systems. He has been a sonographer for more than 25 years and is active in professional organizations including the American Institute of Ultrasound in Medicine, the Society of Diagnostic Medical Sonography and the American Registry for Diagnostic Medical Sonography. Dan has provided presentations like this to more than 400 students ranging from 5th to 12th graders. He is always willing to discuss the topic with other DMS professionals who would like to provide this presentation.

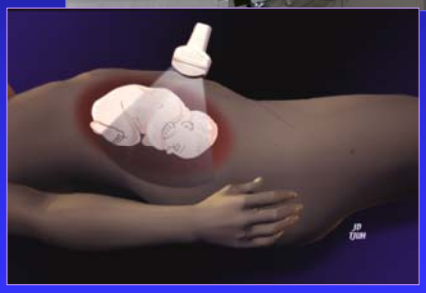
Reference: Merton DA, Enhancing Awareness of the Diagnostic Medical Sonography Professions: A High School Outreach Program. Presented at the American Institute of Ultrasound in Medicine Annual Convention, San Diego, CA. *J Ultrasound Med* 27(S):S16, March, 2008.

1. Presenters should introduce themselves and describe their institutional affiliation.
2. The presenter can verbalize their education and / or experience in the field of sonography as well as any other information that can enhance their credibility.

1. This slide introduces the topics that will be covered.
2. The top photo shows an early real-time linear array being used (c. early 1980s).
3. It is assumed that the scanning demonstration will be performed after the presentation (If a scanning demo is not going to be included the presenter should indicate that).

What is medical sonography?

- Sonography is a diagnostic medical imaging modality
  - X-ray
  - Computed Tomography (CT)
  - Magnetic Resonance Imaging (MRI)
  - Nuclear Medicine
- Diagnostic exams provide information that is used for patient management
  - Medication
  - Surgery
  - Conservative



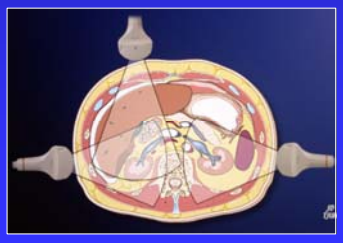
Also referred to as "Ultrasound" or "Ultrasonography"

1. Describe the various types of diagnostic imaging modalities and how diagnostic imaging is utilized in medicine (i.e., to determine if therapy is indicated and the most appropriate management approach).

PRESENTER NOTE: Emphasize that although "ultrasound" is commonly used to describe the modality, the preferred word to describe the medical application of ultrasound energy is sonography which is specific to diagnostic medical applications. ["ultrasound" is a form of energy that has many uses including to clean jewelry, focus cameras and detect fish (fish finders used by fishermen)].

What is medical sonography?

- Sonography uses sound waves above the frequency of the human audible range (>20,000 Hertz)
- A hand-held transducer transmits sound waves into the body and receives returning echoes
- The echoes are processed to form real-time images that are displayed on a video monitor



1. Describe the upper limit of the human audible range (20kHz) and the typical frequencies used for sonography (approximately 1.5 million (mega) hertz to 12 megahertz and higher).
2. Describe the user-dependant nature of sonography (i.e., using hand-held transducers) and how the image acquisition process compares to performing x-ray or CT (i.e., other modalities use more automated image acquisition).
3. Describe the basis of real-time image formation (i.e., echoes are processed to form individual images and images are updated rapidly to provide real time data).

Origins of medical sonography (1890's - 1940's)

- Invention of SONAR
  - Industrial applications (testing I-beams, etc)
  - Medical applications
    - Therapeutic (treatment of disease)
    - Diagnostic (detection of abnormalities)
- SONAR- *n* [***so***und ***na***vigation ***r***anging] an apparatus that detects the presence and location of a submerged object (such as a submarine) by means of sonic and supersonic waves reflected back to it from the object

Webster's New Collegiate Dictionary

1. This slide provides information regarding the origins of sonography.
2. All diagnostic applications utilize the basic principles of SONAR which was identified in the late 19th century. A definition of SONAR is provided from Webster's New Collegiate Dictionary.
3. Ultrasound energy is used to assess building materials such as I-beams (i.e., detect defects in the material).
4. The medical use of ultrasound energy was initially investigated for therapeutic applications. By the 1940s the clinical utility of diagnostic applications were recognized.
5. The photo, c. 1967, shows a patient having their brain scanned with an early A-mode water-bath scanner. From: Medical diagnostic ultrasound: A retrospective on its 40th anniversary, © Eastman Kodak Co. 1988, used with permission.
6. Therapeutic applications (high intensity focused ultrasound; HIFU) are currently gaining in popularity as an alternative to conventional surgery.

Military sonar

- Detect submarines and other underwater objects

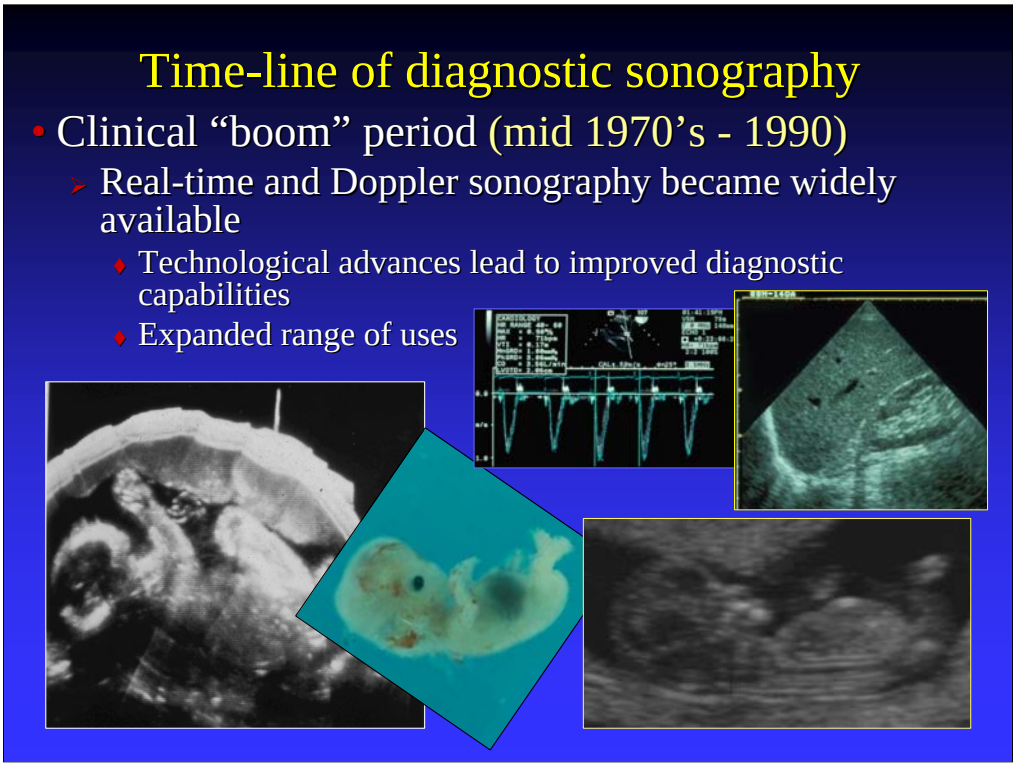
- The ping produced on the surface ship travels through the water and strikes the submarine
- An echo from the submarine returns to the ship
- The time from the ping to the return of the echo determines the distance to the submarine

$$D = \tfrac{1}{2}\, tc$$

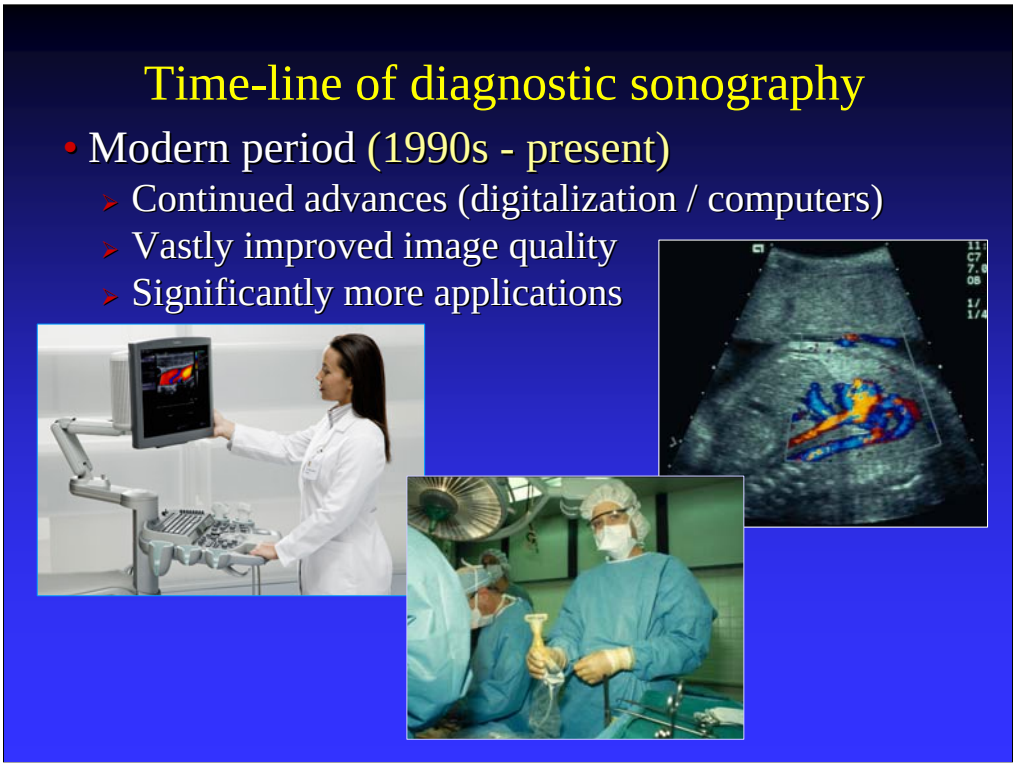
D: distance to reflector
t: time elapsed
c: speed of sound through medium

1. Most people are familiar with the use of sonar for detection of submarines. This cartoon demonstrates how the sound (ping) is generated by the surface ship and an echo is returned from the submarine.
2. The simple range equation is provided.

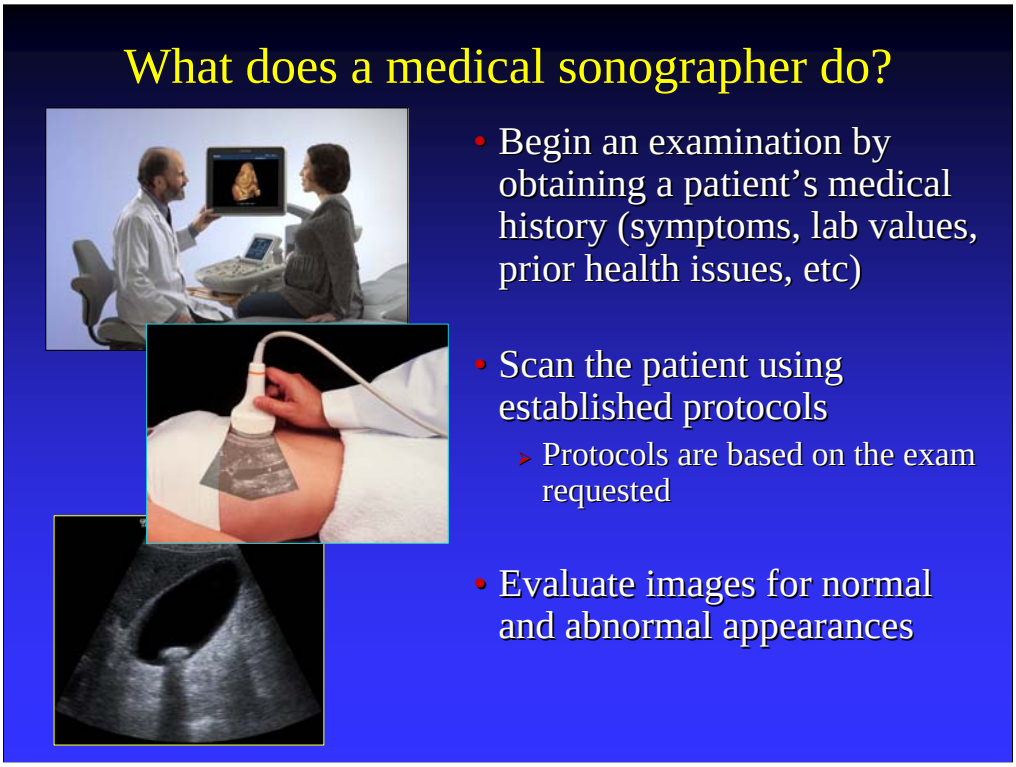
PRESENTER NOTE: To make the presentation interactive ask the audience why "½" is used in the equation (because the sound travels to and from the target but only one direction is required) before you show the equation key. Describe that in this case the "medium" through which the sound travels is water, whereas in medical applications the medium is body tissues or organs.



1. The clinical utilization of sonography grew rapidly in the mid-1970s and 1980s. The addition of real time capabilities was a primary reason for the rapid growth as well as the introduction and refinement of Doppler blood flow detection techniques.
2. The late second trimester fetal scan on the left was obtained with an articulated arm scanner (not in real time) in the 1970s. The relatively crude depiction of the fetal head and arm as well as the placenta can be seen. Compare these features to what is described below.
3. The 11 week fetal scan (bottom right) obtained in 1990 clearly demonstrates the fetal aorta as two distinct lines. The diameter of the aorta is less than 1mm. The specimen (in center) closely approximates the sonogram of the fetus.



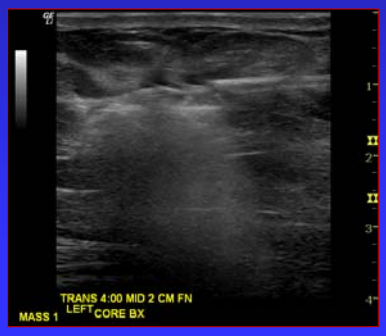
1. The use of digital components and other computer technology was migrated into medical ultrasound instruments resulting in significantly improved image quality, as well as smaller and less expensive portable scanners
2. These advances and others contributed to the use of sonography in a wide range of applications (top right image demonstrates grayscale contrast resolution between the fetal liver and lung with simultaneous depiction of blood flow through the fetal heart and great vessels with color flow imaging).
3. Bottom photo shows a specially designed small intraoperative transducer with sterile cover.



1. This slide describes the role of the sonographer including:
   - the importance of bed-side manners and obtaining a relevant patient history;
   - systematic scanning approach (exam protocol) and;
   - assessment of images obtained during the examination.

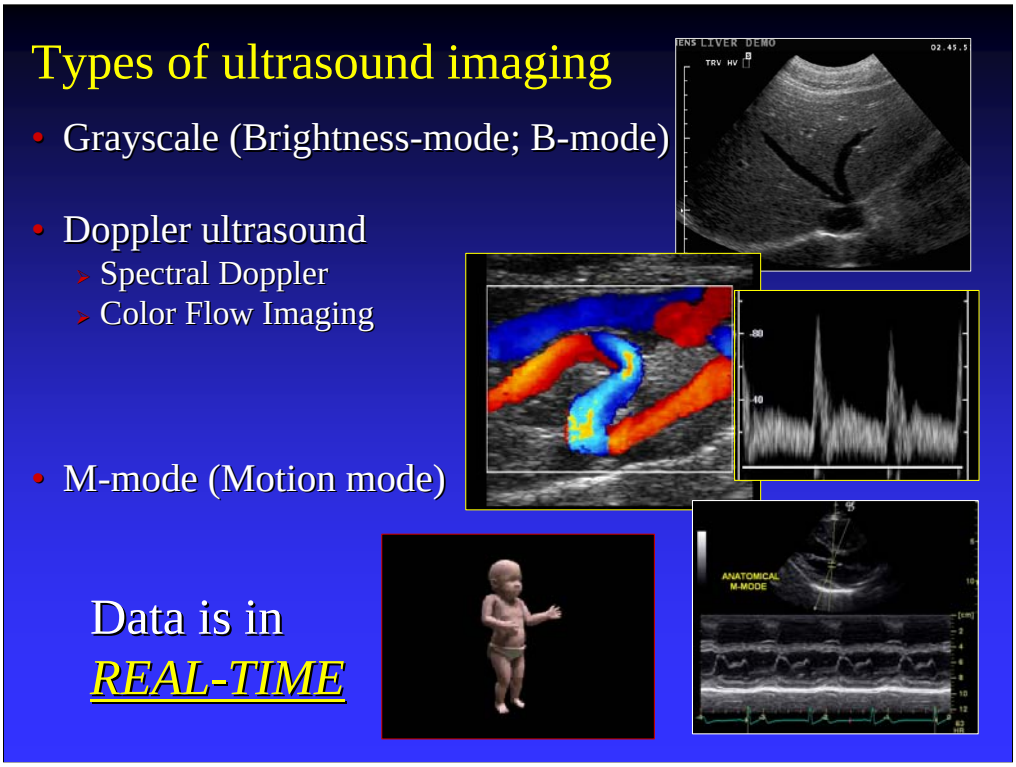
What does medical sonographer do?

- Based on their knowledge of anatomy and pathology they obtain specific images to be shown to a physician for a formal diagnosis



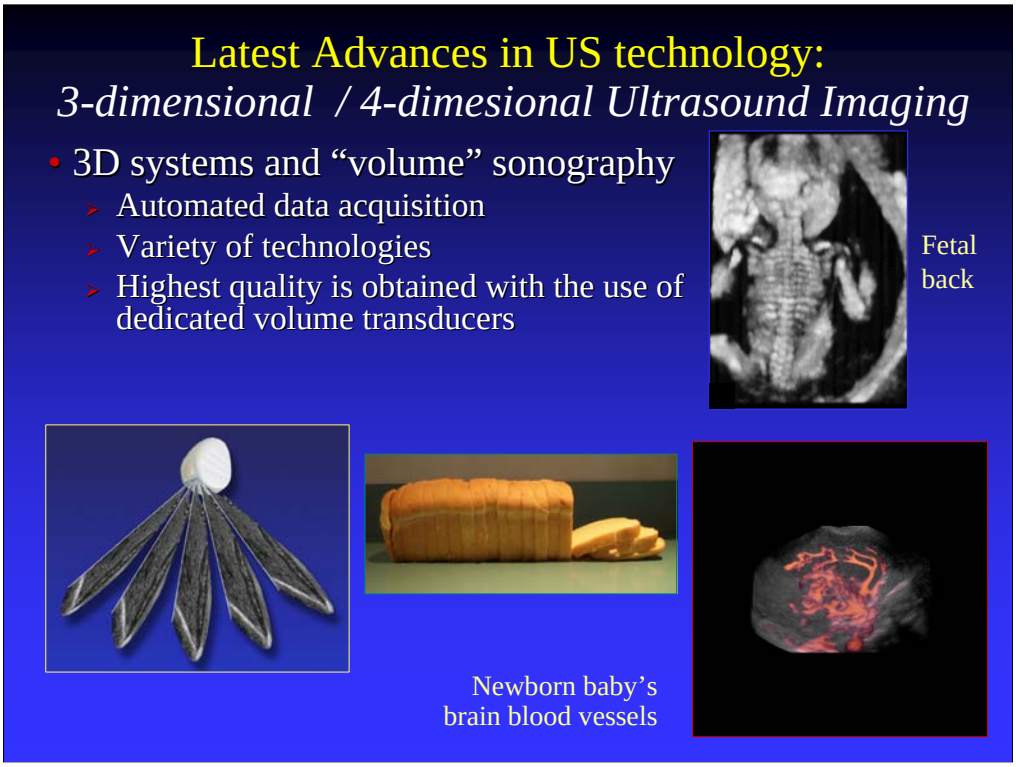
- Provide guidance for biopsies, drainages and other US-guided invasive procedures

1. This slide describes the role of the sonographer within the diagnostic team (i.e., sonographer acquires images that are interpreted by a specially trained physician who then establishes a formal diagnosis).
2. The importance of recognizing normal anatomical variations is demonstrated by the color flow imaging scan showing three renal arteries posterior to the inferior vena cava (normal anatomical variation).
3. The real-time video clip demonstrates an ultrasound-guided needle biopsy of a breast mass.



1. The most common modes of imaging are listed. Grayscale imaging (also known as “brightness mode” or “B-mode”) is the most frequently used mode which shows patient anatomy.
2. Several versions of Doppler sonography are used including qualitative color flow imaging and spectral Doppler which provides quantitative data (e.g., velocity estimations and various flow ratios).
3. M-mode (motion mode) is used to accurately measure the motion of structures such as the opening and closing of heart valves and the dynamics of heart walls.
4. The importance of the real time capabilities of sonography should be emphasized.

PRESENTER NOTE: To make the presentation interactive ask the audience what is so important about “real-time” then show the dancing baby video “*everything is better in real-time!*”



1. Recent advances in ultrasound technology include three- and four dimensional imaging (i.e., volume sonography). There is a variety of methods used to obtain 3D scans. The best quality 3D scans are obtained by the use of dedicated 3D transducers and systems.
2. Three-dimensional scans are created by obtaining multiple two-dimensional scans in sequence then reconstruction of the images into a volume of data that can be displayed in many ways.
3. A 3D color flow display of a neonatal brain is shown as a video clip. Volume imaging allows the viewer to visualize the spatial relationships of the various vessels from multiple perspectives.

PRESENTER NOTE: To demonstrate this concept, explain that 2D images are like slices of bread which can be assembled to form a complete loaf or 3D volume data set.

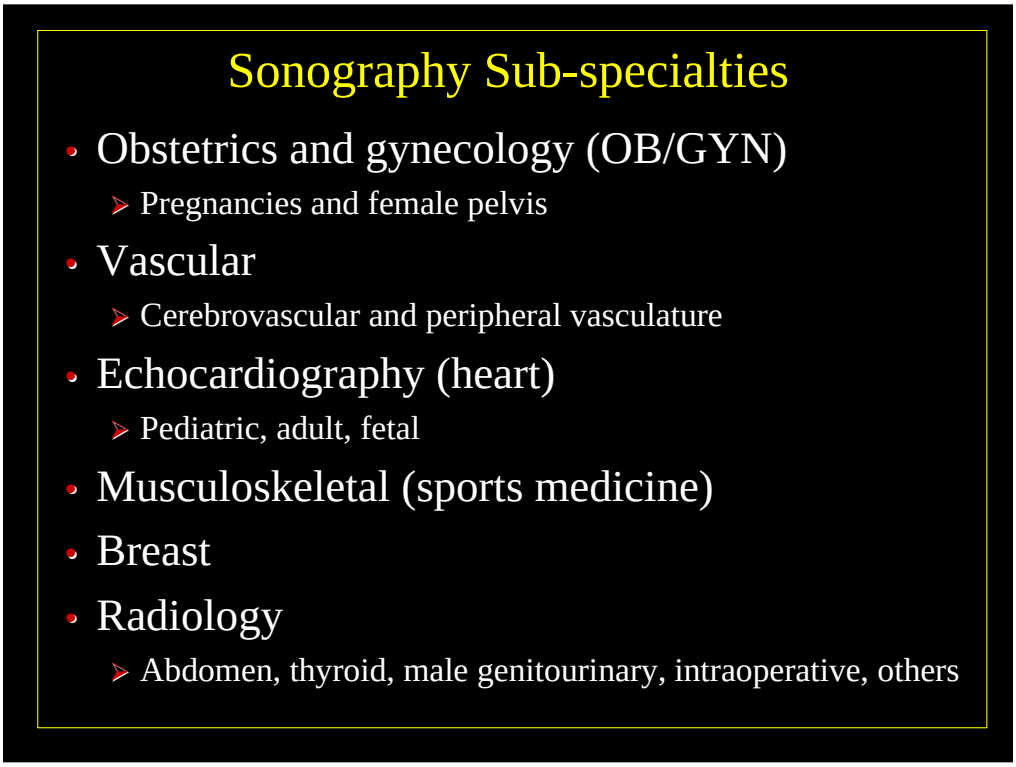
Latest Advances in US technology: *Hand-Carried Ultrasound Systems*

- Dedicated US system or modified laptop computers
  - Very portable
  - Battery operated

- Low-cost
  - Cost-effective for non-imaging professionals
- Easy to use
  - Permits use by non-traditional users who may have limited expertise

1. Another recent advance in ultrasound technology is the introduction of highly-portable compact scanners. These systems can be battery operated and are no larger than a laptop computer.
2. There are some instruments that use a transducer and specialized software to convert a standard personal computer into a very low-cost (<$4000) ultrasound scanner.
3. The combination of low cost and ease of use makes the technology attractive to many medical professionals besides imaging specialists (i.e., “non-traditional” users) including sports medicine physicians, anesthesiologists, emergency medical technologists, etc.

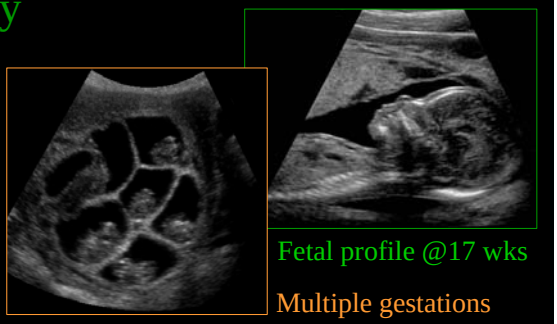
1. The easy to use compact ultrasound scanner has been referred to as the *"stethoscope of the future"* because it can be utilized virtually anywhere in a hospital or doctor's office for a wide range of indications.
2. The most recent advance in compact scanners are those that are as small as an iPod and can be carried in a lab coat pocket. These palm-sized scanners can be used for rapid and improved patient assessments.



1. This slide lists the sub-specialties of the modality. The presenter should describe the meaning of words that may be unfamiliar to the audience (e.g., “cerebrovascular”, “echocardiography”, “genitourinary”, etc.)

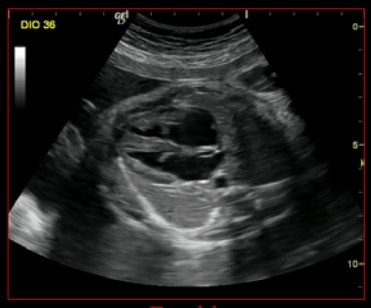
Obstetrical Sonography

- Assess fetal number
- Estimate gestational age
- Assess fetal growth and normal anatomy
- Detect abnormalities
- Monitor fetal heart rate, body movement and other indications of fetal well-being
- Evaluate the uterus and placenta
- Determine fetal position



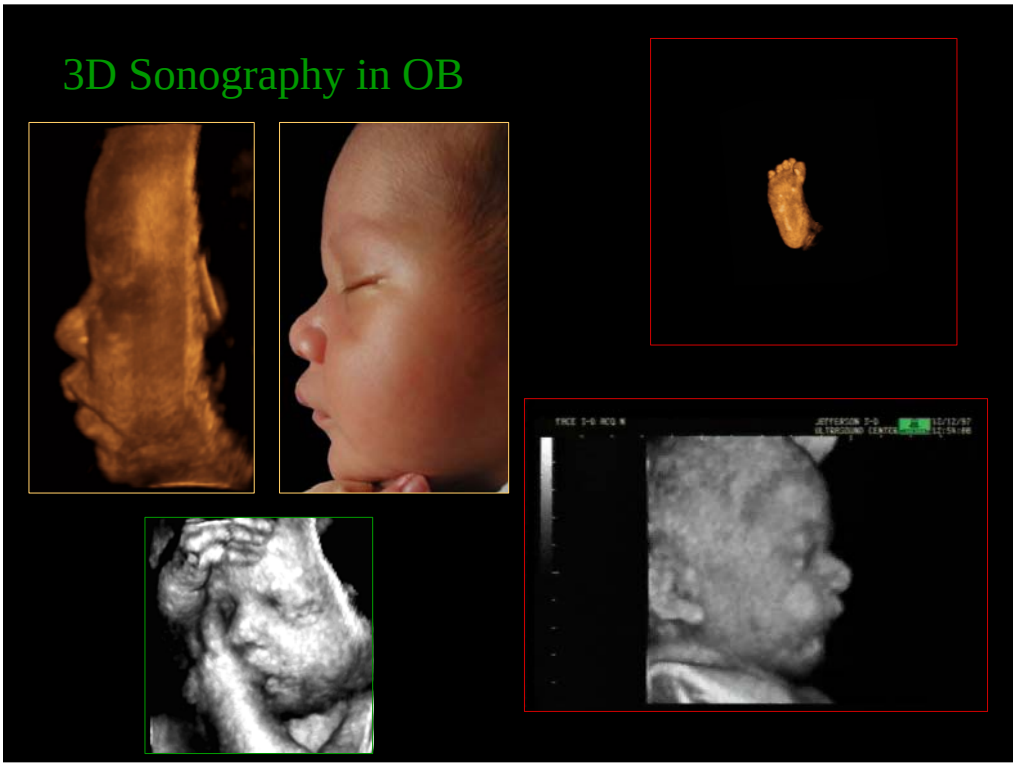
Fetal profile @17 wks

Multiple gestations

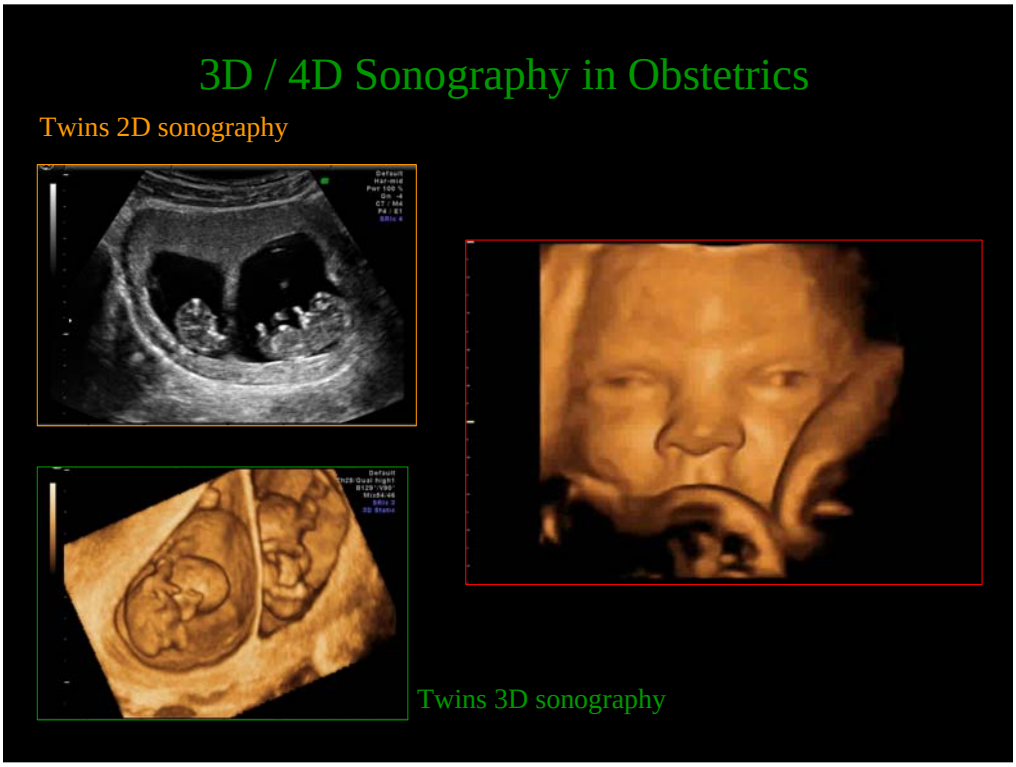


Fetal heart

1. This slide lists most common applications of obstetrical sonography. A real time video is used to demonstrate fetal heart dynamics.



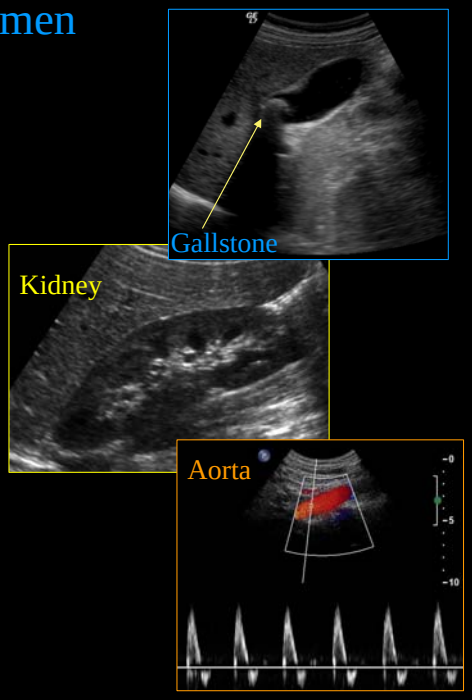
1. Examples of 3D obstetrical images.
2. The image pair in the top left shows a 3D sonogram and a photo of the same baby after it was born.
3. Two video clips are used to demonstrate how the fetal anatomy (foot at top right, and face at bottom right) can be viewed from multiple perspectives.



1. Examples of 3D and 4D obstetrical images.
2. The image pair on left shows examples of twin pregnancies in 2D and 3D sonography.
3. The video clip on the right demonstrates how the combination of 3D imaging and real-time data acquisition results in a dramatic 4D display of the fetal face.

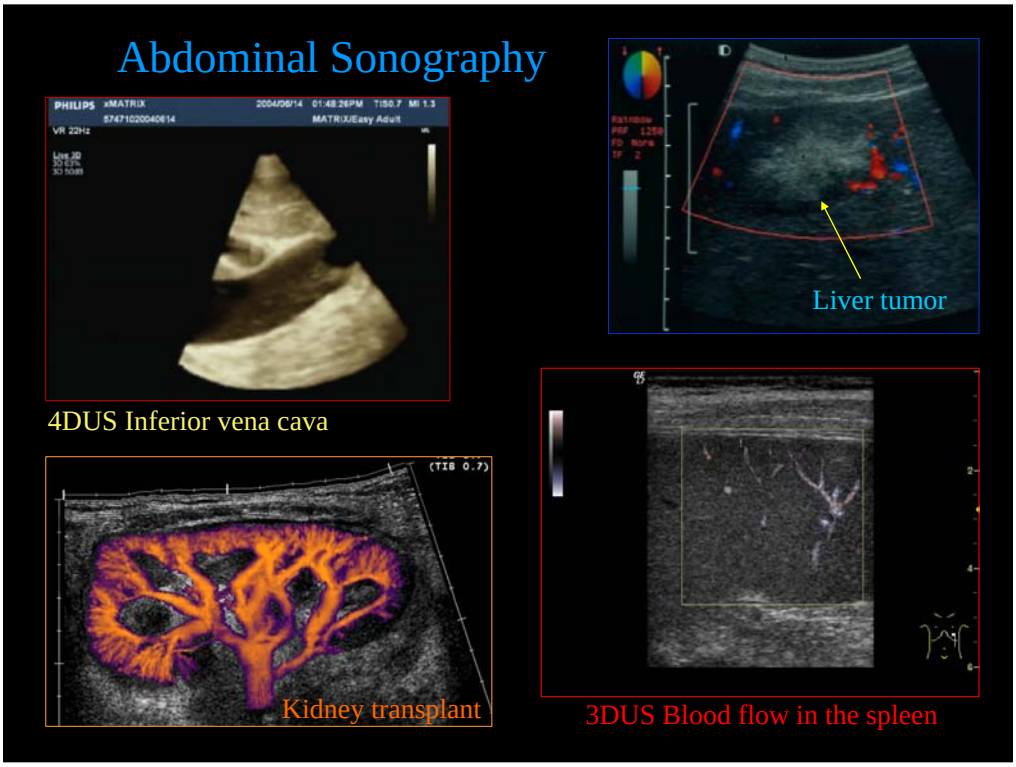
Sonography of the Abdomen

- Identify causes of pain
  - Gallstones, kidney stones, tumors, obstructions
- Assess organs for diffuse abnormalities
  - Hepatitis, AIDS
- Evaluate blood vessels and blood flow
  - Aorta, renal arteries
- Evaluate organ transplants



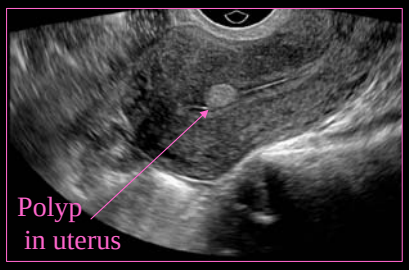
1. This slide lists the most common applications of abdominal sonography.

PRESENTER NOTE: Describe what the Doppler waveform obtained from the aorta represents (time on the X-axis and velocity on the Y-axis). Forward flow is depicted above the baseline followed by a brief period of flow reversal. Explain how the waveform corresponds to the cardiac cycle (i.e., systole and diastole). The presenter may also choose to explain the cause of the flow reversal in early diastole (i.e., vascular compliance and rebound of the arterial wall).

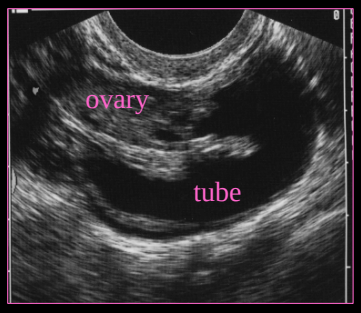


1. Examples of abdominal sonography images.
2. The video at the top left is an example of a 4D scan of the inferior vena cava.
3. The video at the bottom right depicts blood flow as obtained by a sweep of the ultrasound beam through the spleen.

Gynecologic Applications



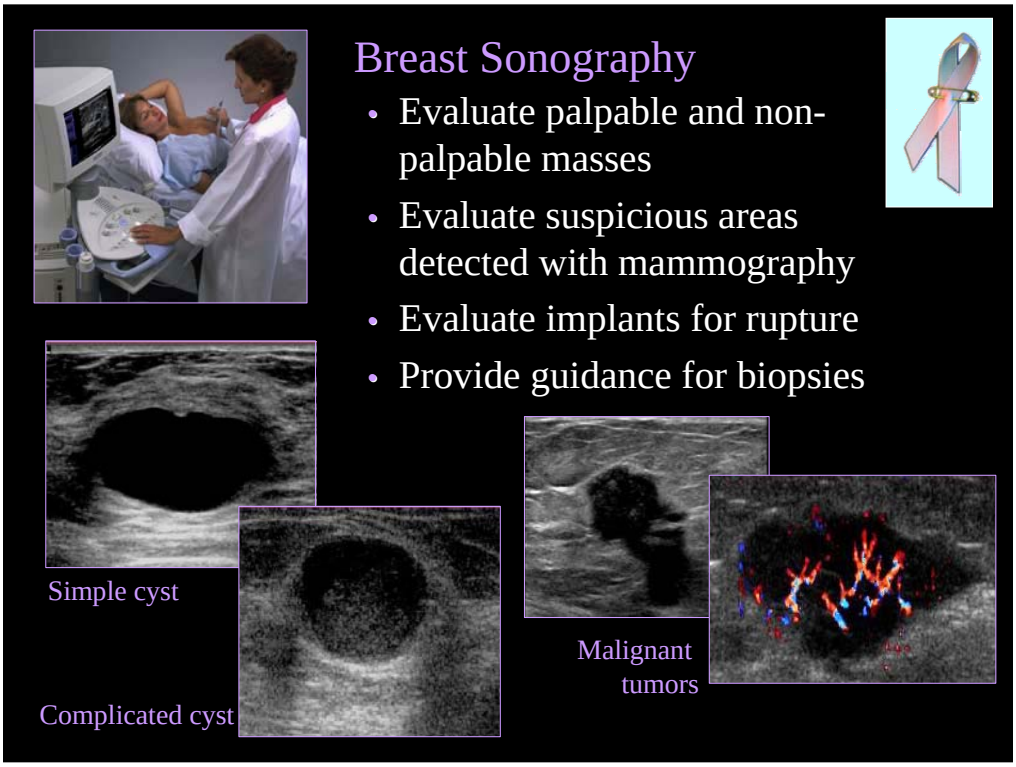
- Identify cause of pelvic pain
- Evaluate palpable masses
- Determine causes of abnormal bleeding
- Monitor response to fertility therapy (medications)
- Guide needles for biopsy, aspiration & ovum retrieval



Ovary and fluid-filled fallopian tube

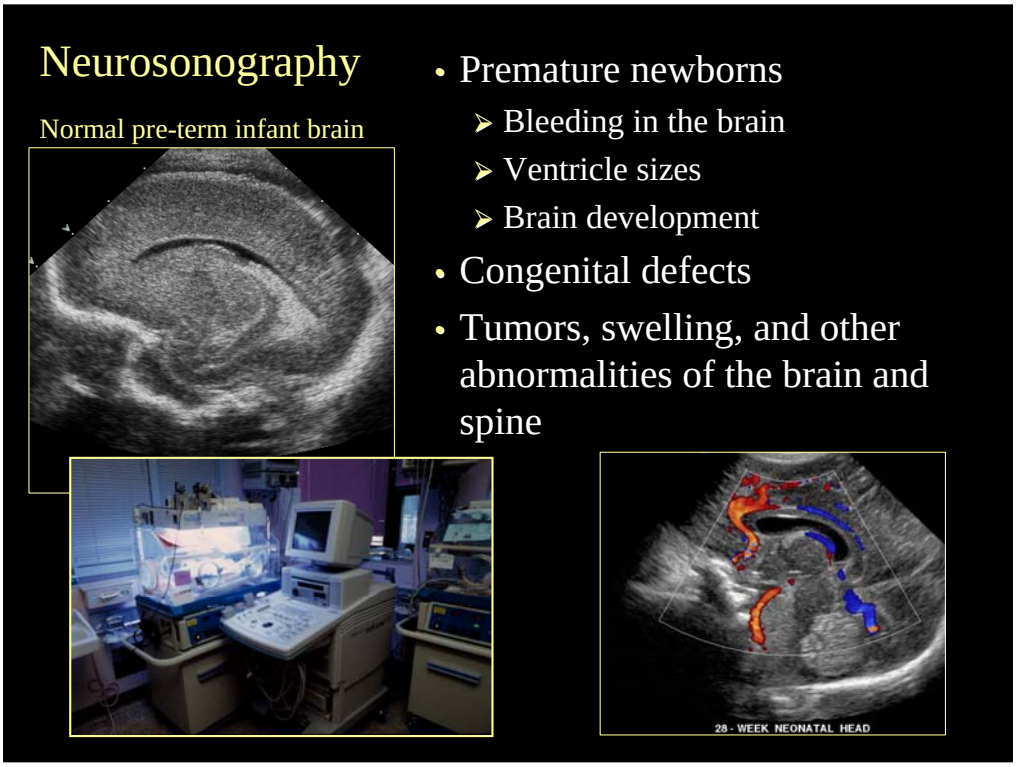
1. This slide lists the most common gynecologic applications of sonography.

PRESENTER NOTE: Describe how sonography plays an important complementary role to the routine physical examination and is an important tool for monitoring infertility therapy.



1. This slide lists the most common applications of breast sonography.
2. Sonography plays a complementary, but important role to mammography.
3. Malignant tumors typically are taller than they are wide whereas benign tumors are wider than tall.

PRESENTER NOTE: Explain the difference between a simple cyst and a complicated cyst. Describe how sonography is no longer used only to differentiate cysts from solid masses(as in the past).



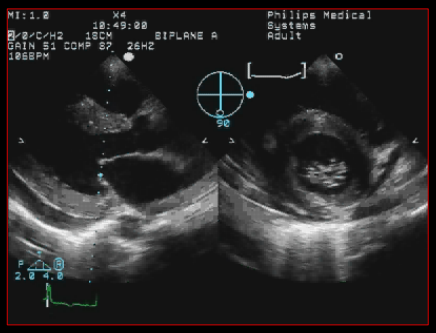
1. This slide lists the most common applications of neurosonography.

PRESENTER NOTES: Explain the meaning of “neurosonography”. Describe the benefit of using sonography to evaluate neonatal brains (i.e., portability, safety, assist management of infants in intensive care settings).

Echocardiography

- Evaluate cardiac structures
  - Heart valves and walls
- Evaluate cardiac function
  - Wall contractility, valve motion and blood flow
- Identify cardiac masses
- Evaluate for congenital abnormalities

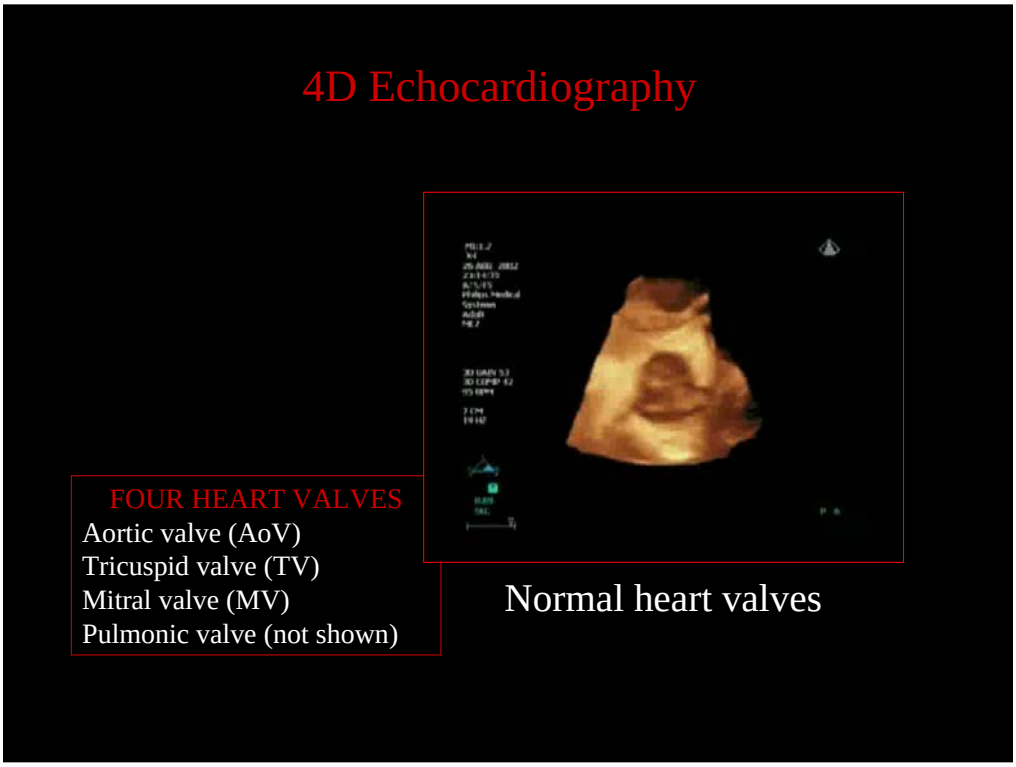
Four-chamber view



Bi-plane Echocardiography:
Evaluation of valve motion

1. This slide lists the most common applications of echocardiography.
2. A “four-chamber view” is shown top right.
3. The video at bottom right shows a bi-plane scan that simultaneously demonstrates two real time images in perpendicular planes.

PRESENTER NOTES: Explain the meaning of “echocardiography”. Ask students to name the four chambers and some or all of the cardiac valves and their locations. (Valve names are listed on next slide)

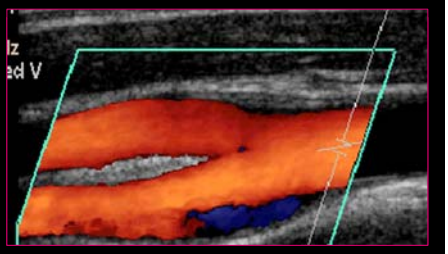


1. A four-dimensional scan demonstrating the normal cardiac valves.

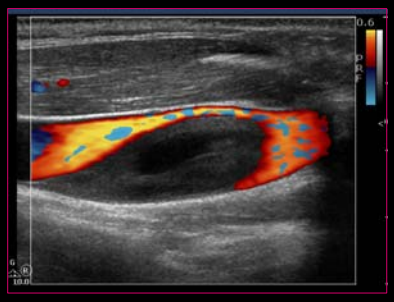
PRESENTER NOTES: Ask students to name the chamber where blood flow comes from before going through each of the cardiac valves (e.g., aortic valve: left ventricle, mitral valve; left atrium, etc.)

Vascular Sonography

- Evaluate the carotid and vertebral arteries
  - Assess blood flow to the brain
- Evaluate peripheral arteries and veins
  - Assess blood flow in the extremities
- Detect stenoses, occlusions, blood clots and other abnormalities



Carotid bifurcation



Clot in the jugular vein

1. This slide lists the most common applications of vascular sonography.

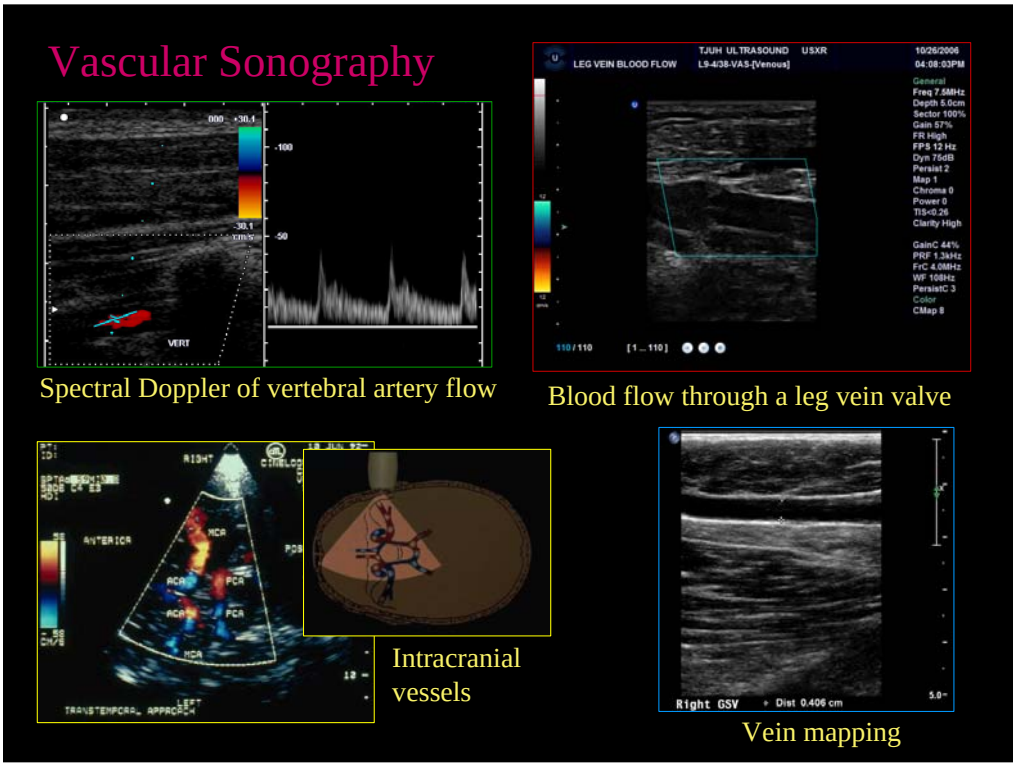
PRESENTER NOTES: Explain the importance of Doppler sonography for vascular examinations (i.e., provides physiologic data) while gray scale sonography provides anatomical data. Explain that sonography is primarily used to evaluate arteries for stenoses and occlusions whereas evaluations of veins are typically done to detect or rule-out blood clots.

Vascular Sonography

Color Doppler imaging of a carotid artery stenosis (narrowing)

1. This video demonstrates a carotid artery stenosis.

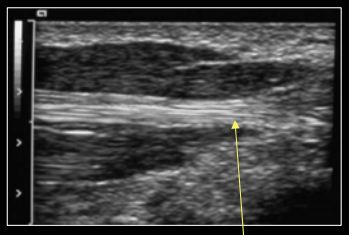
PRESENTR NOTES: Explain what is shown in the color flow image (e.g., aliasing due to increased velocity through the “jet”, flow reversal “eddy current”, etc.)



1. Examples of vascular sonography applications.
2. The image at top left demonstrates flow in the vertebral artery with a high diastolic flow component.
3. The video at top right demonstrates flow through a normal popliteal vein. The dynamics of blood flow and valve motion is clearly seen with real time imaging. The popliteal artery is also seen.
4. The image of the intracranial vessels correlates well with the schematic which demonstrates how the transducer is positioned so that the ultrasound beam enters through a thinner portion of the skull (temporal window).
5. The example of vein mapping demonstrates the high resolution of sonography (vein diameter is just 4mm).

PRESENTER NOTES: Explain why the vertebral artery has a high diastolic flow component (low down-stream resistance in the brain). Ask students to describe the purpose of venous valves (to prevent back-flow due to gravity and other factors). Describe how venous flow is phasic with respiration. Briefly describe the purpose of vein mapping and the importance of vein measurements.

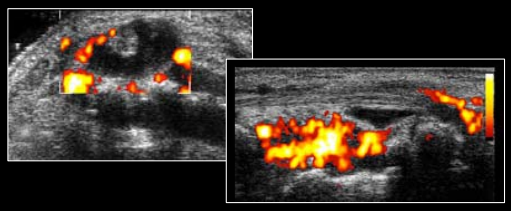
Musculoskeletal Sonography



Normal tendon

- Identify inflammation, tears and other abnormalities of muscles, joints, tendons and ligaments
- Evaluate soft tissue masses
- Guide biopsies and therapies
- Increasing diagnostic and therapeutic applications in Sports Medicine

Abnormal Achilles tendon



Color flow imaging of tenosynovitis (inflammation) of wrist

1. This slide lists the most common applications of musculoskeletal sonography. Power Doppler imaging is useful to evaluate blood flow (as shown in the case of tenosynovitis).

PRESENTER NOTES: Describe the recent increase in the use of sonography for musculoskeletal (MSK) and sports injury applications. Describe how the use of high-resolution real time sonography can be used to evaluate the anatomy and motion (dynamics) of muscles, tendons and other joint structures which cannot be accomplished with other imaging modalities (e.g., MRI). Compact scanners have been used on playing fields, in the Olympics and in other settings to evaluate athletes who are inured during games or while training. Explain how the use of MSK sonography has lead to the need for specialist sonographers who's sole responsibility is to assess athletes and others who may have MSK injuries (remember, sports are important to many students). Sonography represents an opportunity to be employed in sports-related occupation working directly with trainers, coaches and athletes.

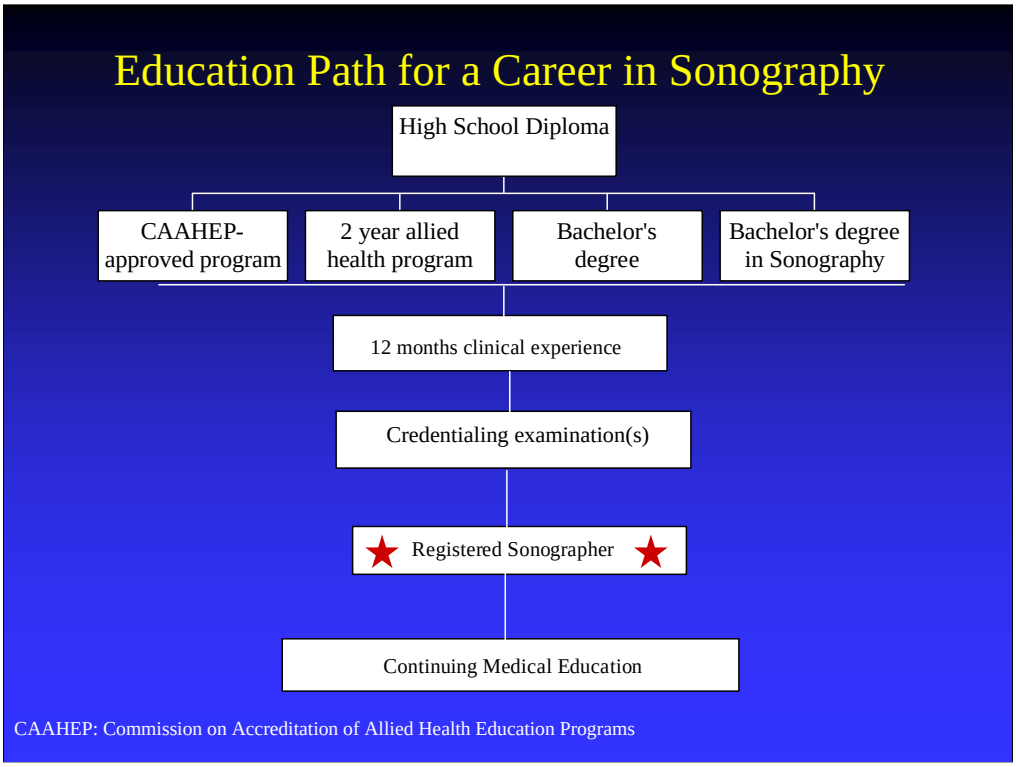
Knowledge Required to be a Sonographer

- Anatomy / physiology
- Physics
- Pathology/ disease processes
- General medical practices and patient care skills

- Beneficial attributes
  - Compassion
  - A willingness and desire to help others

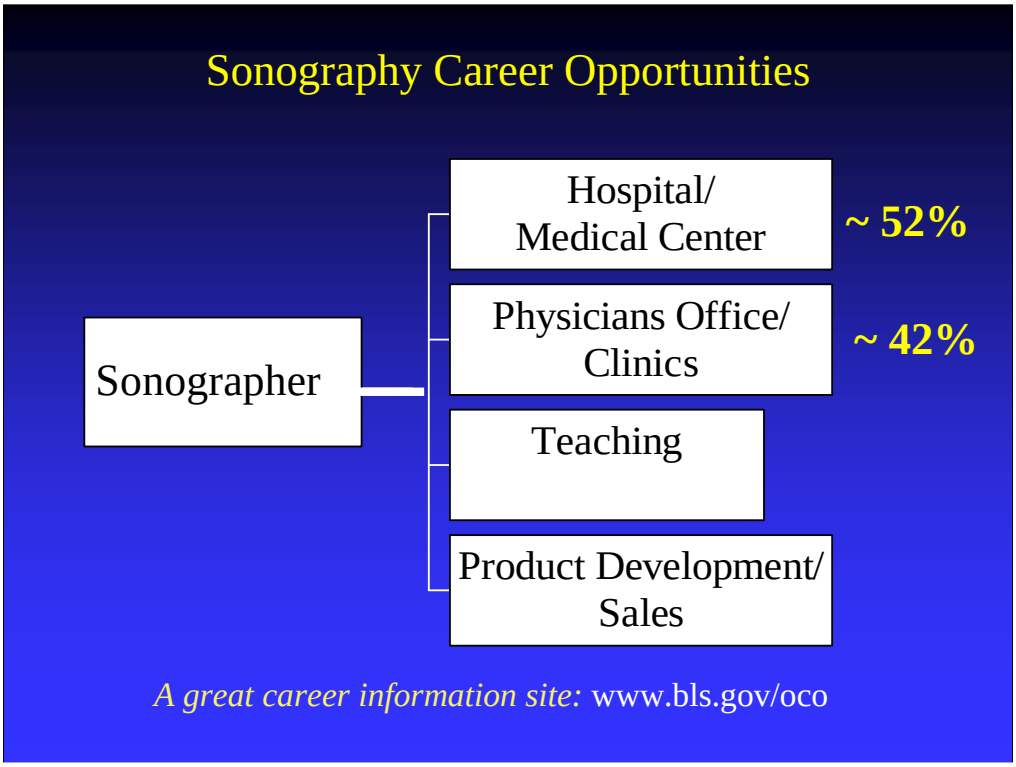
1. The sonographer needs to have a thorough understanding of the subjects listed.
2. Sonography professionals (like all medical professionals) should be compassionate and have a willingness and desire to help others.

PRESENTER NOTES: Describe how sonographers utilize high technology (which is often what is most attractive to students) but equally important is that they must also be willing to provide patient care (i.e., be willing to work around sick or injured patients) and have a genuine desire to help others.



1. A typical sonography career path is presented.

PRESENTER NOTES: Explain that other career paths exist including educational programs that award college degrees (AS and BS) and certificates. On-the-job training, while common in the past, is currently not a viable option for sonography professionals. Describe the benefits of obtaining a college-based degree specifically in sonography (i.e., greater employment opportunities). If time permits, emphasize the importance of attending a CAAHEP-accredited program and the potential problems that can be encountered by attending a non-accredited program (unable to take credentialing examinations and, therefore, limitations in employment).



1. The most common career opportunities are listed.
2. The majority of sonographers work in hospitals (approx. 52%) followed by physician's offices and free-standing clinics (approx. 42%). The remaining 6% work as educators or for companies (sales, research and development).
3. Additional employment opportunities exist in academic research, veterinary medicine and other areas.

$onographer Earning$

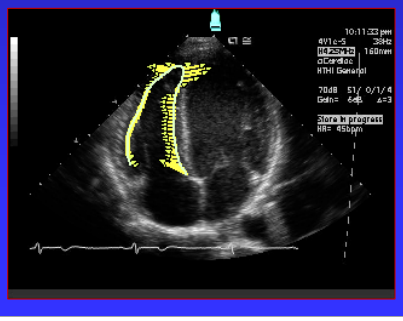
- High income potential
  - Starting salaries: $46,000 / yr
  - Median annual earnings: $66,768 / yr*
  - Experienced Sonographer salary $60,000 to >$100K
- Employment is expected to increase 19% through 2016
  - High degree of job security
  - Numerous opportunities

* Data from the Society of Diagnostic Medical Sonography *2008 Salary and Benefit Survey Report*

1. Sonographers earnings are near the top of the range of comparably educated healthcare professionals.
2. Starting, median and salary ranges are listed.
3. Based on U.S., government forecasts, the demand for sonographers is expected to remain strong through at least 2016 which means that sonographers will enjoy good job security and many options if they wish to relocate.

The future of diagnostic medical sonography

- Increased use
  - More patients (aging population)
  - Greater utilization throughout medicine
  - Safer than radiation-based imaging modalities
- Advances in technology
  - More powerful computer technology
  - Improved capabilities
  - More cost-effective
  - Portability

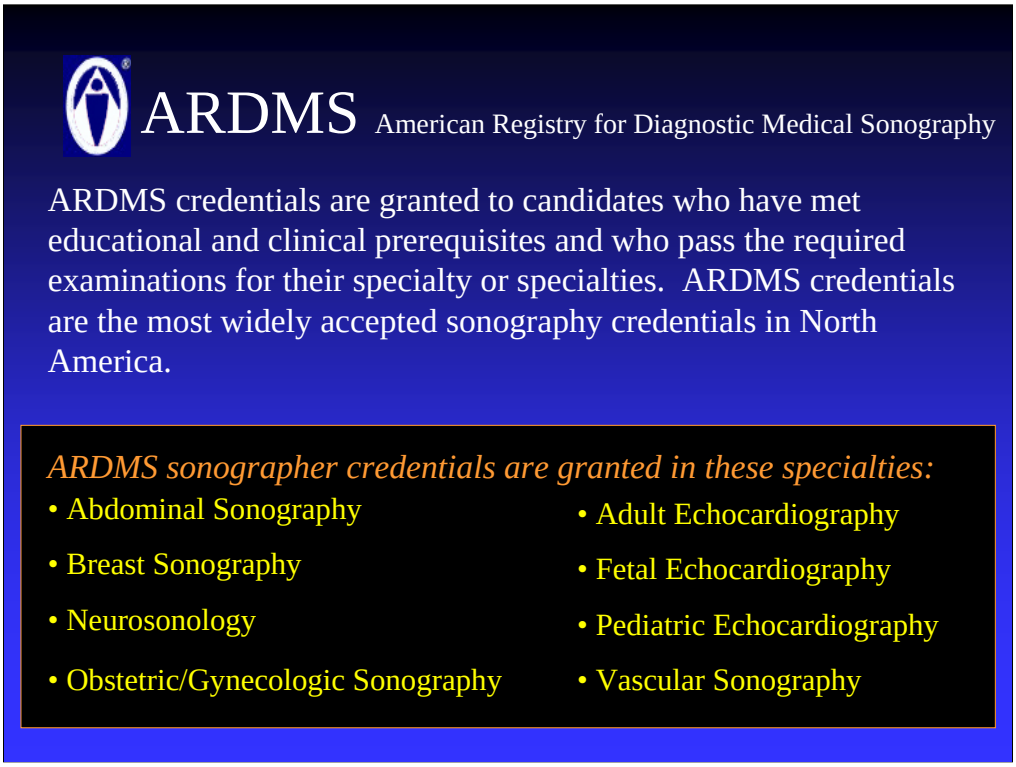


1. The future is bright for diagnostic medical sonography as a result of:

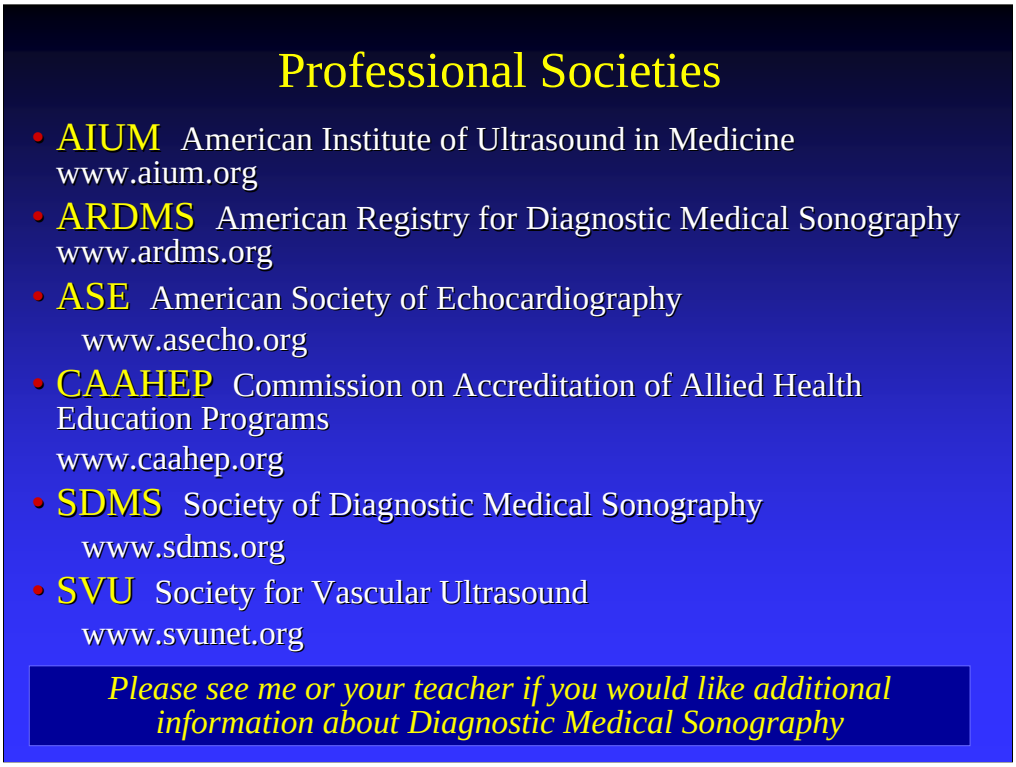
   A. Increased demand (aging population and increased use of the modality).

   B. Advances in technology (which continues to improve the diagnostic capabilities and ease of use).

2. The profession could be a perfect choice for students who have an interest in technology (computers) and life-sciences.

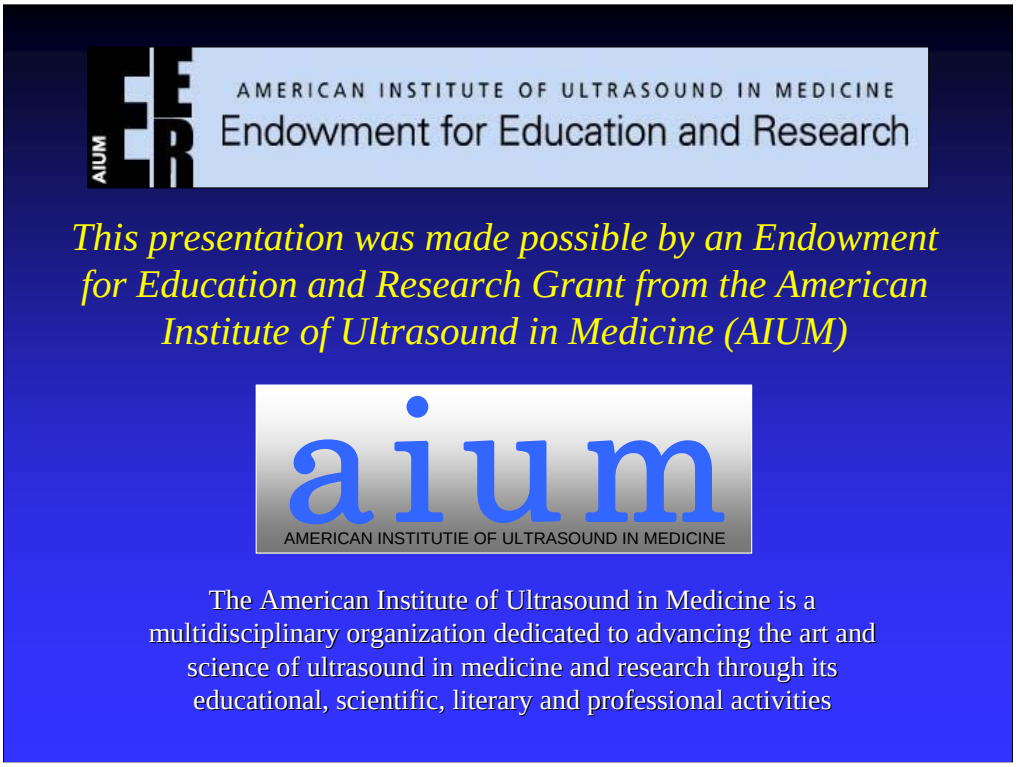


1. Sonographers earn credentials by passing specific examinations in one or several specialty areas (depending on their preferences in employment).
2. The ARDMS is the most widely recognized credentialing organization. It grants credentials in the specialty areas listed. Once credentialed, sonographers must maintain their level of competency through obtaining continuing medical education credits.
3. Beginning in 2010 some states (including New Mexico and Oregon) are going to require sonographers to be licensed (which requires sonographers to be credentialed). This trend will likely expand to additional states in the future.
4. Other credentialing organizations exist including the Cardiovascular Credentialing Institute (CCI).



1. Sonography professional societies are listed. Each of these has a web site where additional information can be obtained.

PRESENTER NOTE: Provide the teacher with your contact information so that they can share it with any interested students.



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Please acknowledge Dan Merton as the creator of this presentation.

Fetus appears to be waving good-bye.