

PATIENT CARE AND NEW TECHNOLOGIES

CHAPTER 6



PATIENT IDENTIFICATION, DOCUMENTATION, AND VERIFICATION OF EXAMS

- Correct identification of patients is a fundamental part of patient care
- Identification of a patient should not be limited to asking the patient their first and last name
 - Verification of wristband information for identifying markers to include patient's full name, date of birth, and medical record number
- In 2003, the **Health Insurance Portability and Accountability Act** (HIPAA) became effective in the United States
- The HIPAA privacy rules influence many aspects of patient care and ensure that patient records are kept private by establishing certain standards or safeguards

PATIENT IDENTIFICATION, DOCUMENTATION, AND VERIFICATION OF EXAMS

- HIPAA attempts to:
 - Establish new standards for the release of health records
 - Protect health records by establishing new standards for health care professionals to follow
 - Apply strict penalties for those who violate patient confidentiality and patient rights
 - Provide more patient education

PATIENT IDENTIFICATION, DOCUMENTATION, AND VERIFICATION OF EXAMS

- Proper documentation, both on images obtained and of the procedure performed, is critical to patient care
 - Patient's name and other identifying information
 - Facility information
 - Date of the exam
 - Image orientation (annotations)

PATIENT INTERACTION, COMMUNICATION, AND OBTAINING HISTORY

- Sonographers should not only be capable of performing a thorough and diagnostic exam, but also proficient in effectively communicating with their patients
- Awareness of cultural diversity is essential, and accommodations should be provided for those who require assistance
 - Religious backgrounds
 - Non-English speaking

PATIENT INTERACTION, COMMUNICATION, AND OBTAINING HISTORY

- Communication is the transfer of information from one person to another
 - Verbal or nonverbal
 - Nonverbal communication can be helpful in cases of non-English speaking patients (i.e. signs, hand gestures, facial expressions, body motions)
- Always make sure the patient is completely informed about the procedure prior to the procedure taking place
 - High risk of litigation if patient is not thoroughly informed of the procedure prior to its initiation

PATIENT INTERACTION, COMMUNICATION, AND OBTAINING HISTORY

- Obtaining a thorough patient history is also a significant step toward proper patient care
 - Clinical history should be discussed with the patient before the sonographic examination begins
- One goal of the sonographer should be to perform clinical correlation with the sonographic images acquired throughout the examination
- There are several general questions that can be asked to start a conversation with the patient who presents with pain and for those without noticeable pain

PATIENT INTERACTION, COMMUNICATION, AND OBTAINING HISTORY

- Questions for patients complaining of pain:
 - Where is the problem or area of pain?
 - When did the pain start?
 - How severe is the pain?
 - What makes the pain go away or get worse?
 - What else happens when the pain begins?

PATIENT INTERACTION, COMMUNICATION, AND OBTAINING HISTORY

- Questions for patients not complaining of pain:
 - Are you a diabetic?
 - Do you have high blood pressure?
 - Do you smoke?
 - Do you take any medications?
 - Have you had any surgeries (related to the examination area)?

EMERGENCY SITUATIONS

- It is a requirement that cardiopulmonary resuscitation (CPR) certification and automatic external defibrillator (AED) training is maintained
- CPR is most often used to counteract suspected cardiac arrest, or heart attack
 - Patients may present with loss of consciousness, drop in blood pressure, dilation of pupils, and possible seizures

EMERGENCY SITUATIONS

- Sonographers must also be prepared to deal with patients who experience shock
 - Shock is the body's pathologic response to illness, trauma, or severe physiologic or emotional stress
- Patient may become cold and clammy, have decreased urine output, increased respiration, increased anxiety
 - May lead to tachycardia, chest pain, and loss of mental alertness
 - If not addressed, vital organs will begin to shut down and death may occur

EMERGENCY SITUATIONS

- Some exams require patients to fast, and diabetics can be affected if they have not had anything to eat for an extended period
- Patients with diabetes mellitus may suffer from three complications:
 1. Hypoglycemia
 2. Diabetic ketoacidosis
 3. Hyperglycemic hyperosmolar nonketotic syndrome
- Complications of diabetes include tachycardia, headache, blurred vision, extreme thirst, polyuria, or sweet odor to the breath

INFECTION CONTROL AND UNIVERSAL PRECAUTIONS

- Hepatitis B and C viruses, human immunodeficiency virus (HIV), tuberculosis (TB), and methicillin-resistant staphylococcus aureus (MRSA) are among the list of communicable disease that may be transmitted in the hospital from the patient to the sonographer
- Toxins, certain drugs, diseases, heavy alcohol use, and infections can all cause hepatitis
- Hepatitis B and C are transmitted through contaminated bodily fluids and blood
 - Hepatitis B vaccine provided to all healthcare workers
 - No vaccine for Hepatitis C but treatment is available

INFECTION CONTROL AND UNIVERSAL PRECAUTIONS

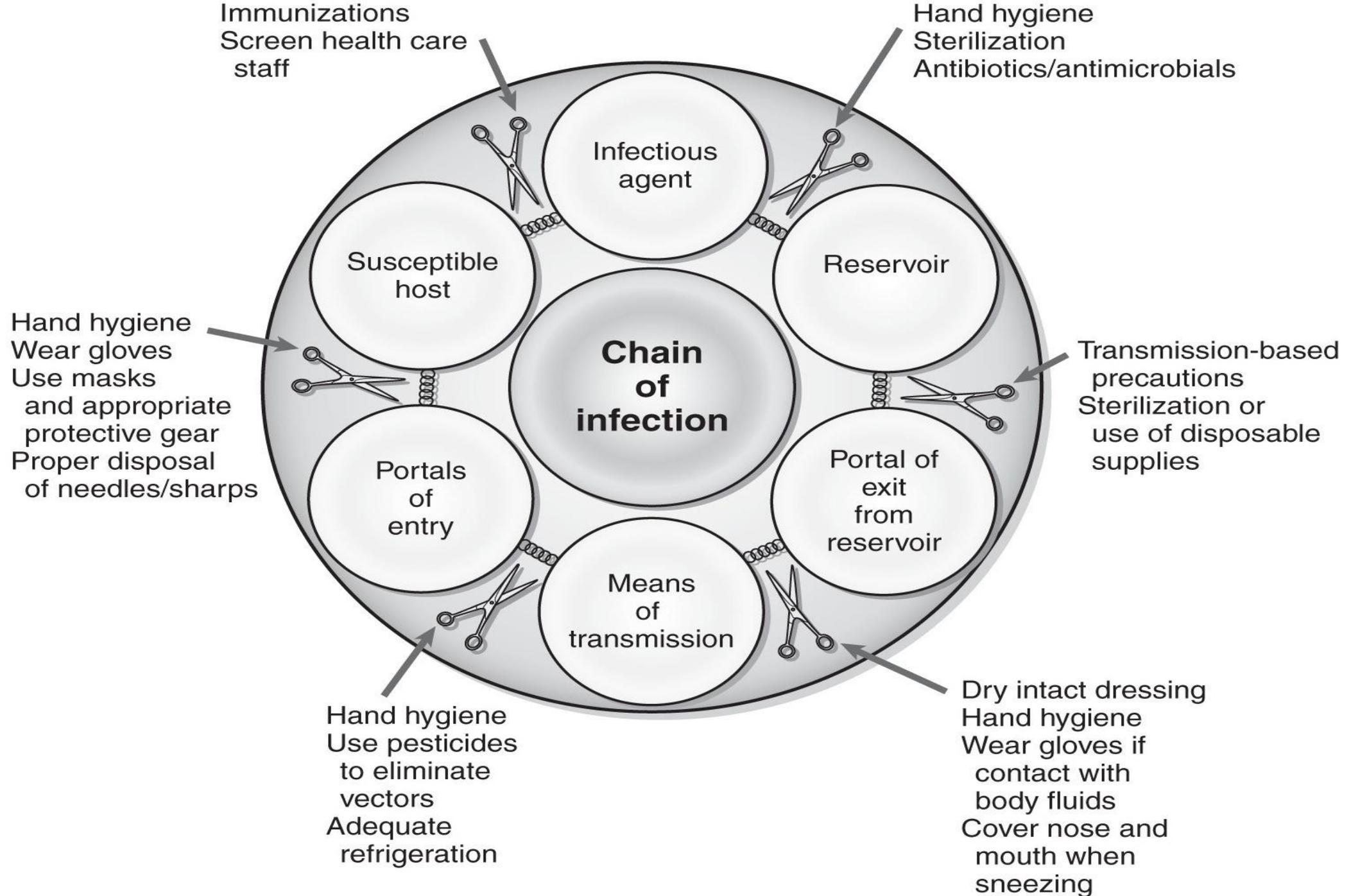
- HIV is the virus that leads to acquired immune deficiency syndrome (AIDS)
- It is spread by sexual contact or sharing needles with an infected person, through transfusions of infected blood or blood clotting factors, or through childbirth or breast milk
- In the health care setting, workers have been infected with HIV after being stuck with needles containing HIV-infected blood, although the risk is minimal

INFECTION CONTROL AND UNIVERSAL PRECAUTIONS

- TB is an airborne disease found in the lungs, and possibly other organs, of an infected person
- The TB skin test, the Mantoux tuberculin skin test, is performed to detect whether the individual is infected with TB
- MRSA is a type of staphylococcus or “staph” bacteria that is resistant to many antibiotics
- Most staph infections manifest as an infected area on the skin

INFECTION CONTROL AND UNIVERSAL PRECAUTIONS

- The chain of infection begins with a pathogenic organism
 - Pathogens include viruses, fungi, and parasites
- Pathogens need a reservoir to stay alive
 - The reservoir provides an environment in which the pathogen can grow or multiply
 - A reservoir could be found anywhere in the clinical setting, including on our hands, the ultrasound machine, and the examination table
- Pathogens are also found in body fluids such as blood and urine, in the mucosa



INFECTION CONTROL AND UNIVERSAL PRECAUTIONS

- Most pathogens are transferred to another individual through touch
 - Alcohol based sanitizers are easily accessible but if hands are visibly soiled, hand-washing is a must
 - Hand-washing should take place before and after patient contact
- Use of personal protective equipment (PPE) is also an effective means of reducing the spread of infection
 - Prevents the transportation of pathogens from the infected person to the general environment

INFECTION CONTROL AND UNIVERSAL PRECAUTIONS

- Nosocomial infections are hospital-acquired infections
- Most common is the urinary tract infection (UTI) from the incorrect use/placement of a Foley catheter
- To minimize the risk of a UTI, the patient's catheter bag should be placed below the level of the bladder



INFECTION CONTROL AND UNIVERSAL PRECAUTIONS

- Disinfection of the ultrasound equipment should be performed daily between patients
- The transducer, the transducer cord, and keyboard should all be cleaned with a disinfectant
- Endocavity transducers are soaked in a glutaraldehyde-based solution or some type of hydrogen peroxide-based solution (Tropon)
- Disinfectant of endocavity transducers should be well documented
- PPE should be always worn during use of these chemicals

STERILE TECHNIQUE

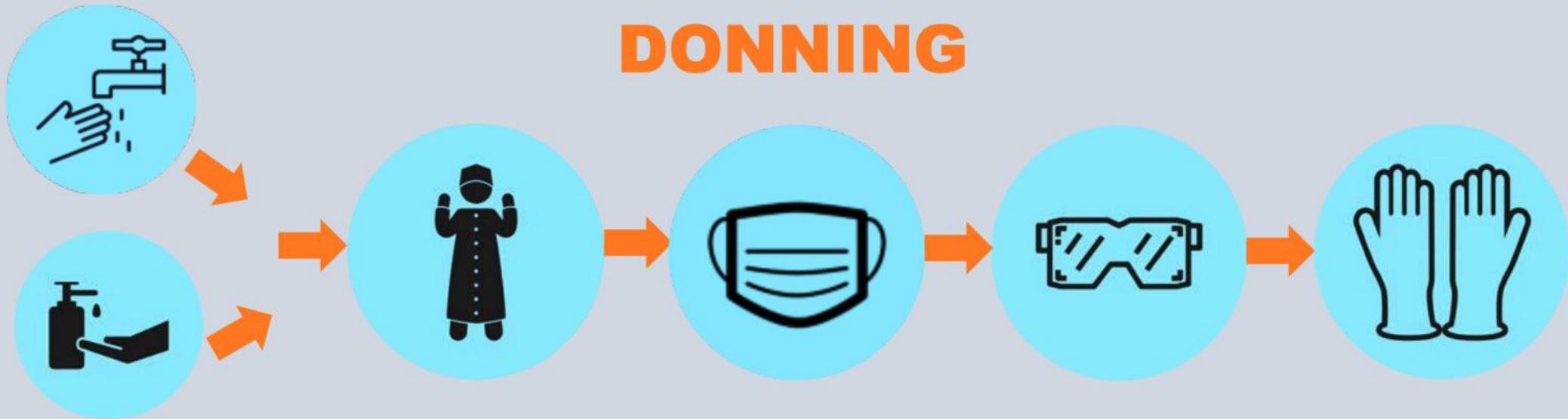
- Surgical asepsis
 - Complete removal of microorganisms and their spores from an object or surface
- Invasive procedures, such as organ biopsies and fluid drainage, require the practice of sterile technique



STERILE TECHNIQUE

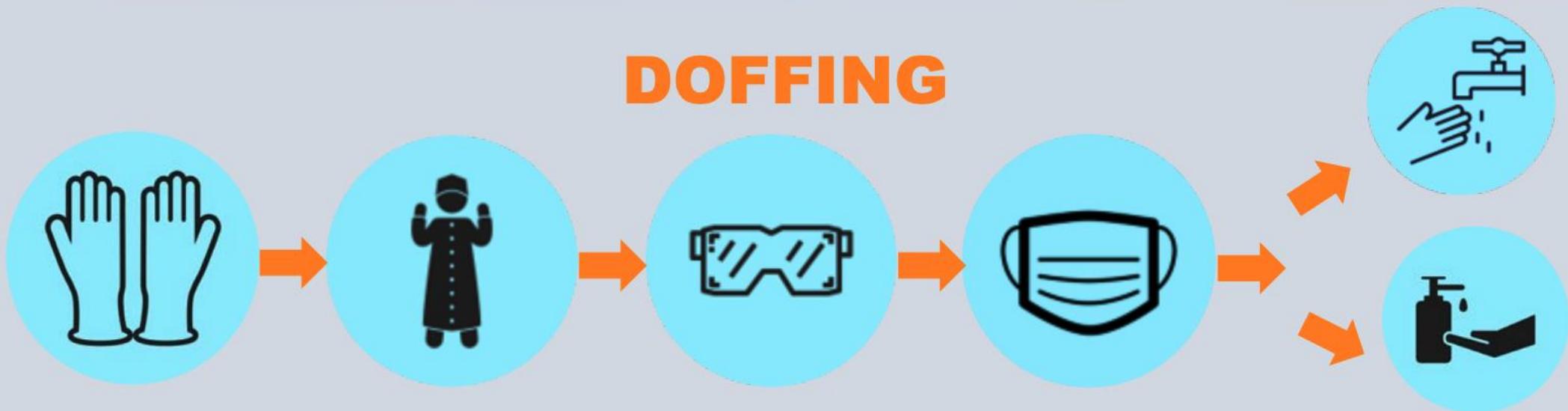
- 1. Always be aware of what is considered sterile
- 2. If an object's sterility is questionable, one must assume that the object is nonsterile
- 3. Never reach or lean across a sterile field
- 4. To be considered sterile, a person must don sterile gloves and a sterile gown
- 5. The cuffs of a sterile gown are not considered sterile
- 6. The edges of a sterile wrapper are not sterile
- 7. Never leave a sterile tray unattended
- 8. If you recognize that a sterile item has become contaminated, remedy the issue immediately

DONNING



For respiratory protection use a surgical mask or above
For eye protection use goggles or a face shield

DOFFING



BIOEFFECTS

- According to the AIUM's *Prudent Use and Clinical Safety* statement, "No independently confirmed adverse effects caused by exposure from present diagnostic ultrasound instruments have been reported in human patients in the absence of contrast agents. Biological effects (such as localized pulmonary bleeding) have been reported in mammalian systems at diagnostically relevant exposures but the clinical significance of such effects is not yet known. Ultrasound should be used by qualified health professionals to provide medical benefit to the patient. Ultrasound exposures during examinations should be as low as reasonably achievable (ALARA)" – AIUM 2012

BIOEFFECTS

- ALARA – As Low As Reasonably Achievable
- The official AIUM statement reads as follows:
"The potential benefits and risks of each examination should be considered. The ALARA (As Low As Reasonably Achievable) principle should be observed when adjusting controls that affect the acoustical output and by considering transducer dwell times." – AIUM, 2014

BIOEFFECTS

- Thermal Mechanism and Thermal Index
 - As sound travels through the body, it is attenuated
 - The primary reason why tissue heats as sound is attenuated in the human body is absorption
 - Sound energy is converted to heat typically as a result of an increase in intensity and frequency
 - Elevation in the temperature of certain tissues can cause significant damage

BIOEFFECTS

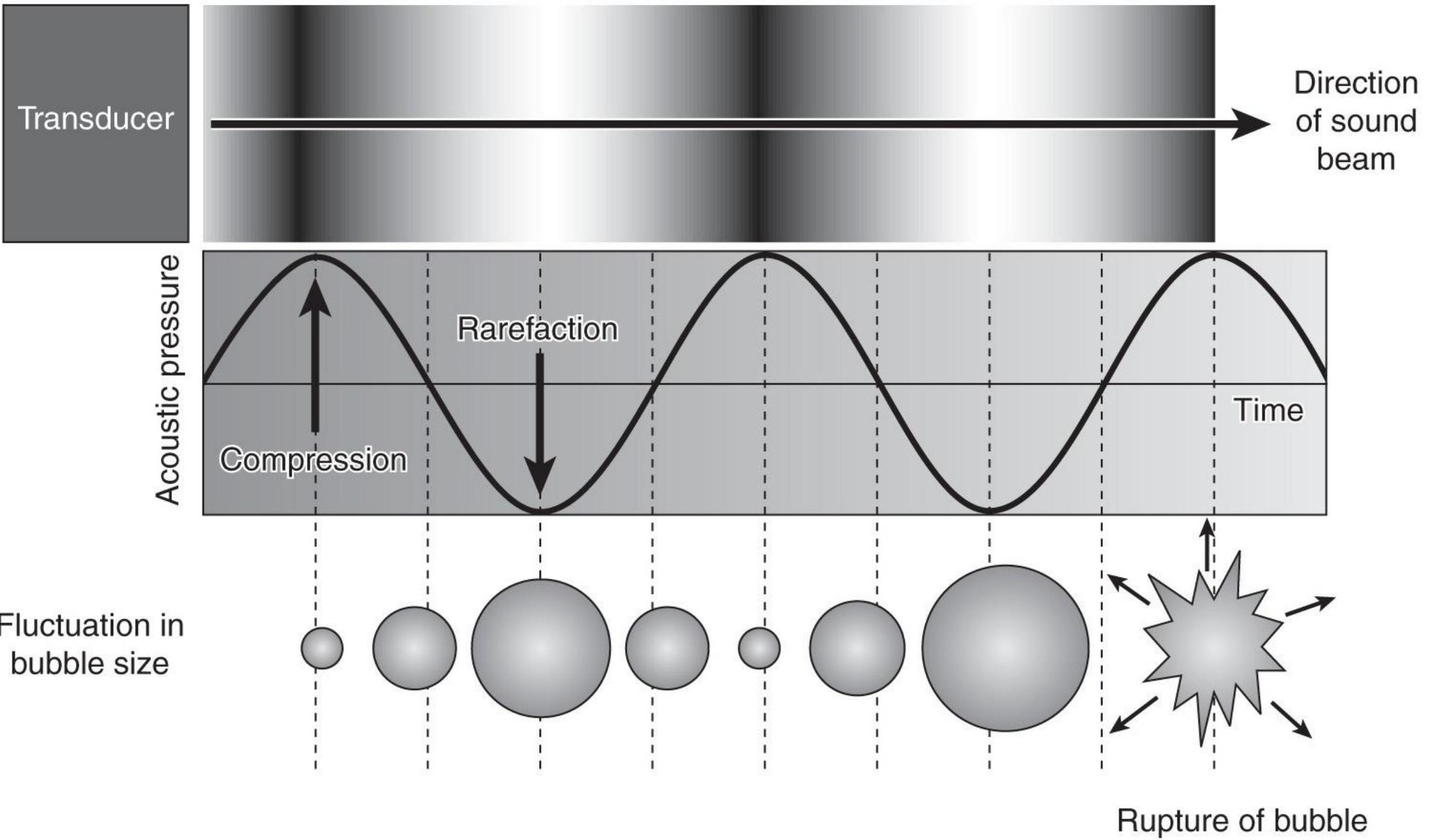
- The **thermal index** is a calculation used to predict the maximum temperature elevation in tissues as a result of the attenuation of sound
- The maximum heating of tissue is related to the sound beams spatial peak temporal average (SPTA)
 - “No effects have been observed for an unfocused beam having free-field SPTA intensities below 100 mW/cm², or a focused beam having intensities below 1 W/cm², or temperature increases of less than 1.5 C° (AIUM, 2015).”
- It is important to remember that absorption is greater in bone than in soft tissue

BIOEFFECTS

- Nonthermal Mechanism and Mechanical Index
 - Nonthermal mechanisms include **radiation forces, streaming, and acoustic cavitation**, with the latter being the most worrisome
 - Nonthermal mechanisms may also be referred to as “mechanical mechanisms”
 - Cavitation is the action of an acoustic field within a fluid to generate bubbles

BIOEFFECTS

- There are two types of cavitation: stable and transient
 - Stable cavitation produces bubbles that oscillate, or fluctuate, in size, but do not rupture
 - Transient cavitation, also referred to as “collapse,” has the potential of causing the most biologic damage
- With transient cavitation, larger bubbles are produced and subsequently rupture (This produces a shock wave and an increase in tissue temperature in that area)
 - This increase in temperature has been associated with biologic effects



BIOEFFECTS

- The **mechanical index (MI)** was developed to assist in evaluating the likelihood of cavitation to occur

$$\text{Mechanical Index} = \frac{\text{peak rarefaction pressure}}{\sqrt{\text{frequency}}}$$

- Lower MI numbers are seen with higher frequencies and small pressure variations
- Higher MI numbers are seen with lower frequencies and large pressure variations

BIOEFFECTS

Low MI: Less than 0.1	Higher MI: 0.1 to 1.0	Highest MI: Greater than 1
No harmonics	Some harmonics	Strongest harmonics
Backscatter	Resonance	Bubble disruption
Linear behavior	Nonlinear behavior	Extreme nonlinear behavior
Higher frequency sound	Lower frequency sound	Lowest frequency sound
Low beam strength	Higher beam strength	Highest beam strength
Bubble expands very little	Bubble expands moderately	Bubble expands greatly

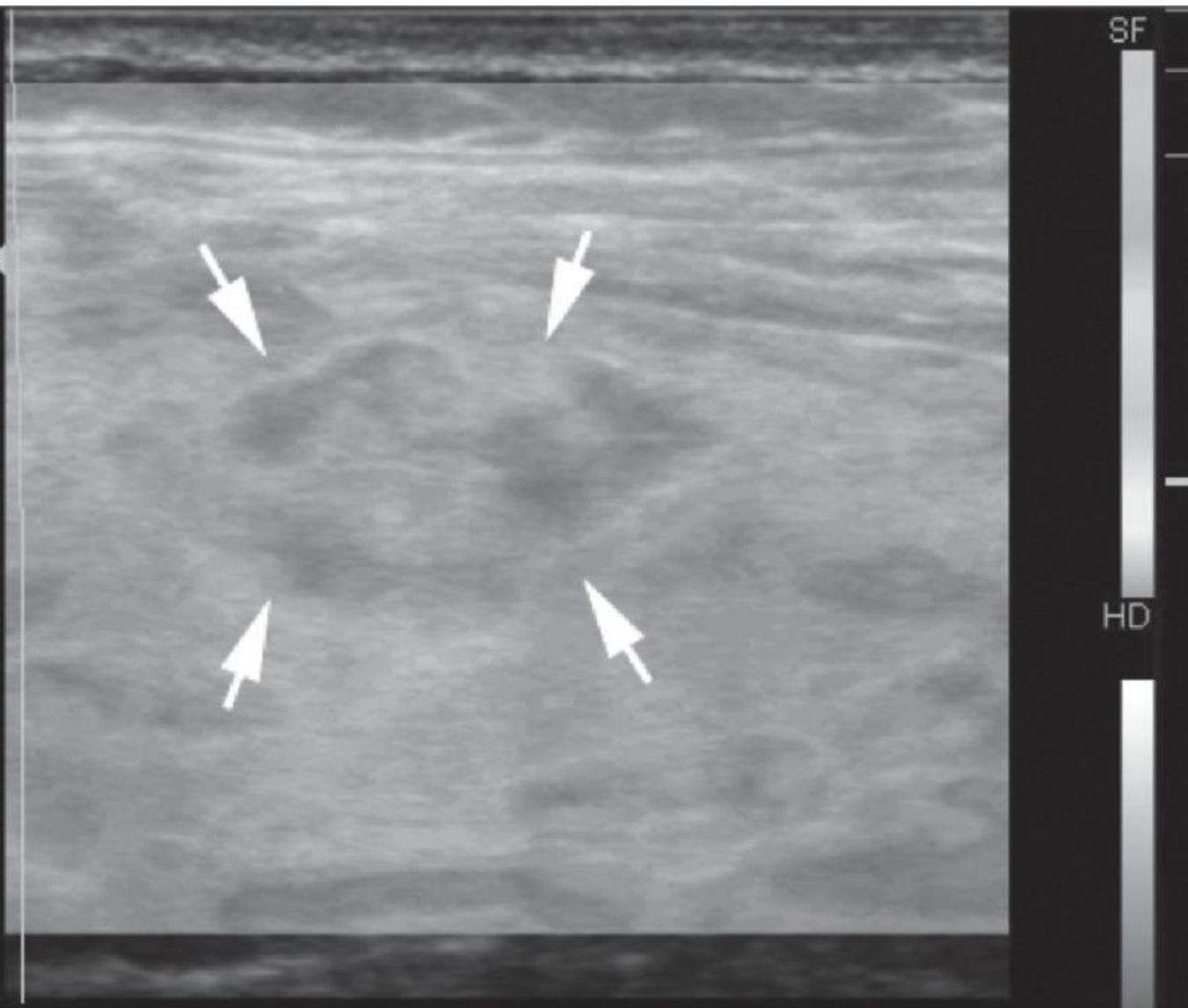
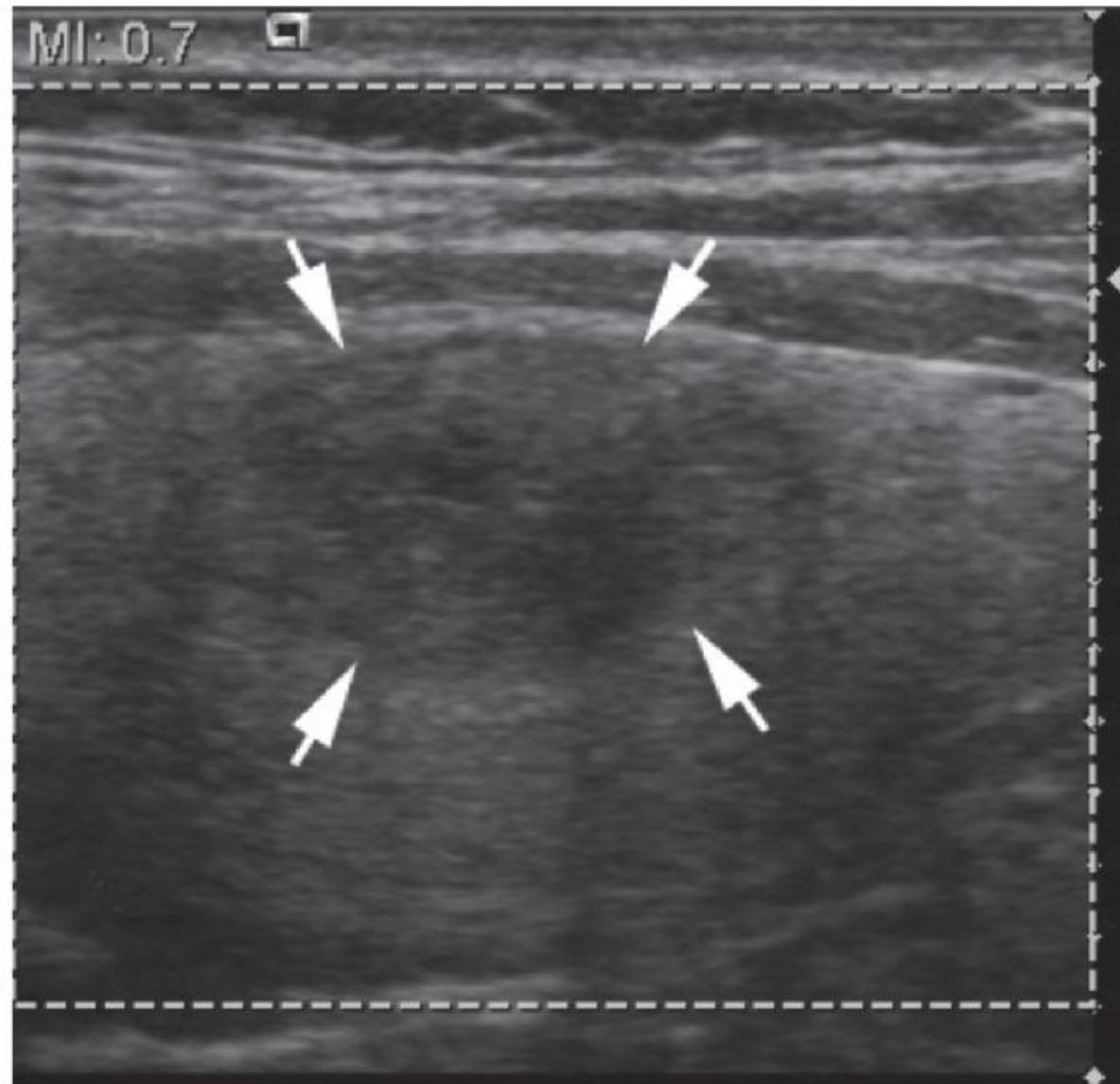
BIOEFFECTS

- However, the AIUM states, "For diagnostic ultrasound exposure by actual medical devices or laboratory equipment, no adverse effects have been observed in tissues containing naturally occurring gas bodies for in situ peak rarefactional pressures below approximately 0.4 MPa (estimated mechanical index [MI] values less than ≈ 0.4)." - AIUM, 2015
- Therefore, diagnostic ultrasound is not associated with an increase in biologic tissue damage

NEW TECHNOLOGIES

ELASTOGRAPHY

- **Elastography** uses sound waves to virtually palpate lesions in the body to evaluate stiffness
 - On most machines, elastograms are presented in dual-screen mode, with the B-mode image on one side of the screen and the elastogram on the other side
 - The elastogram presents as a change in shades of gray or colors indicating variations of stiffness
 - Elastography is also being used most recently in determining the presence of liver fibrosis in patient with known liver disease

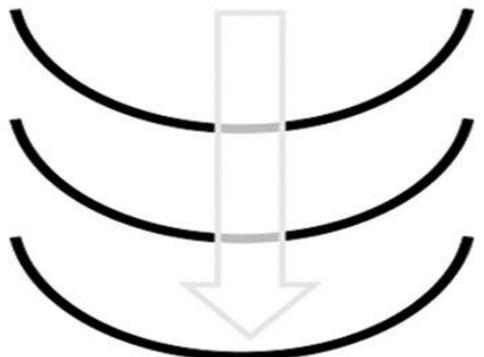
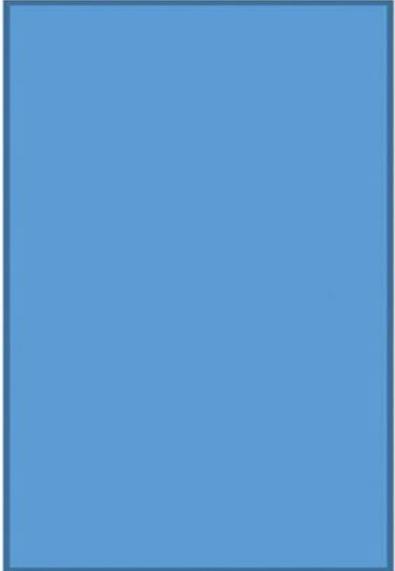


A

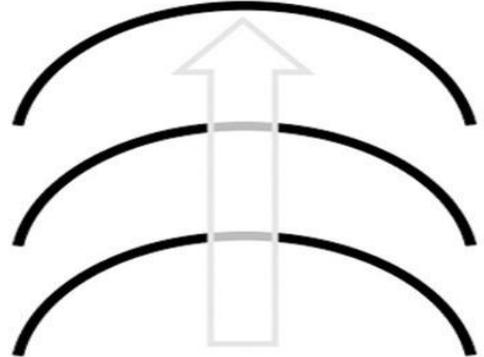
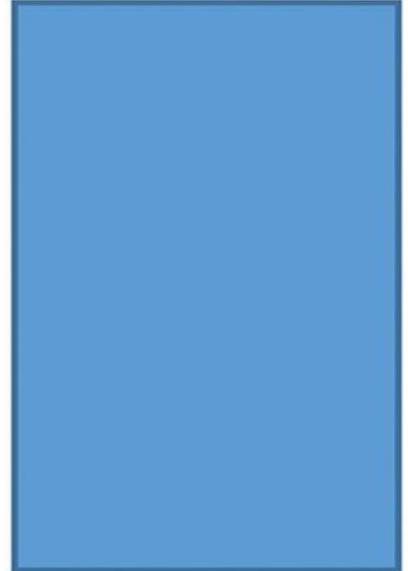
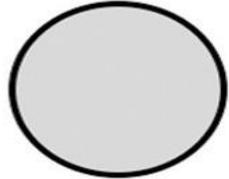
B

ELASTOGRAPHY

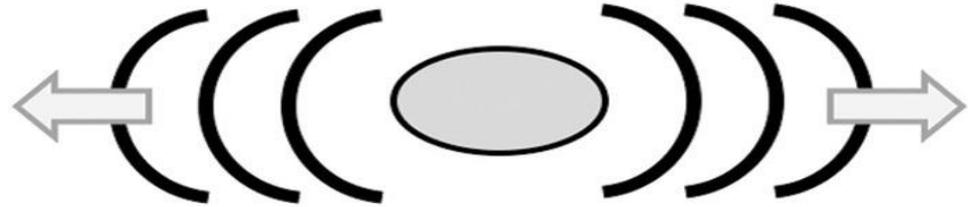
- Two types of elastography:
 - Strain elastography (SE)
 - Measures the tissue strain, or change in tissue length, as a result of *compression*
 - Requires operator to apply steady, repeated compressions (high variability among sonographers)
 - Shear wave elastography (SWE) “transient elastography”
 - Measures the stiffness of the tissue as a result of *shear waves*
 - Produces a quantitative result in the form of pressure, kPa
 - Uses concept similar to Acoustic Radiation Force Impulse (ARFI) elastography



Transmitted pulse



Reflected pulse

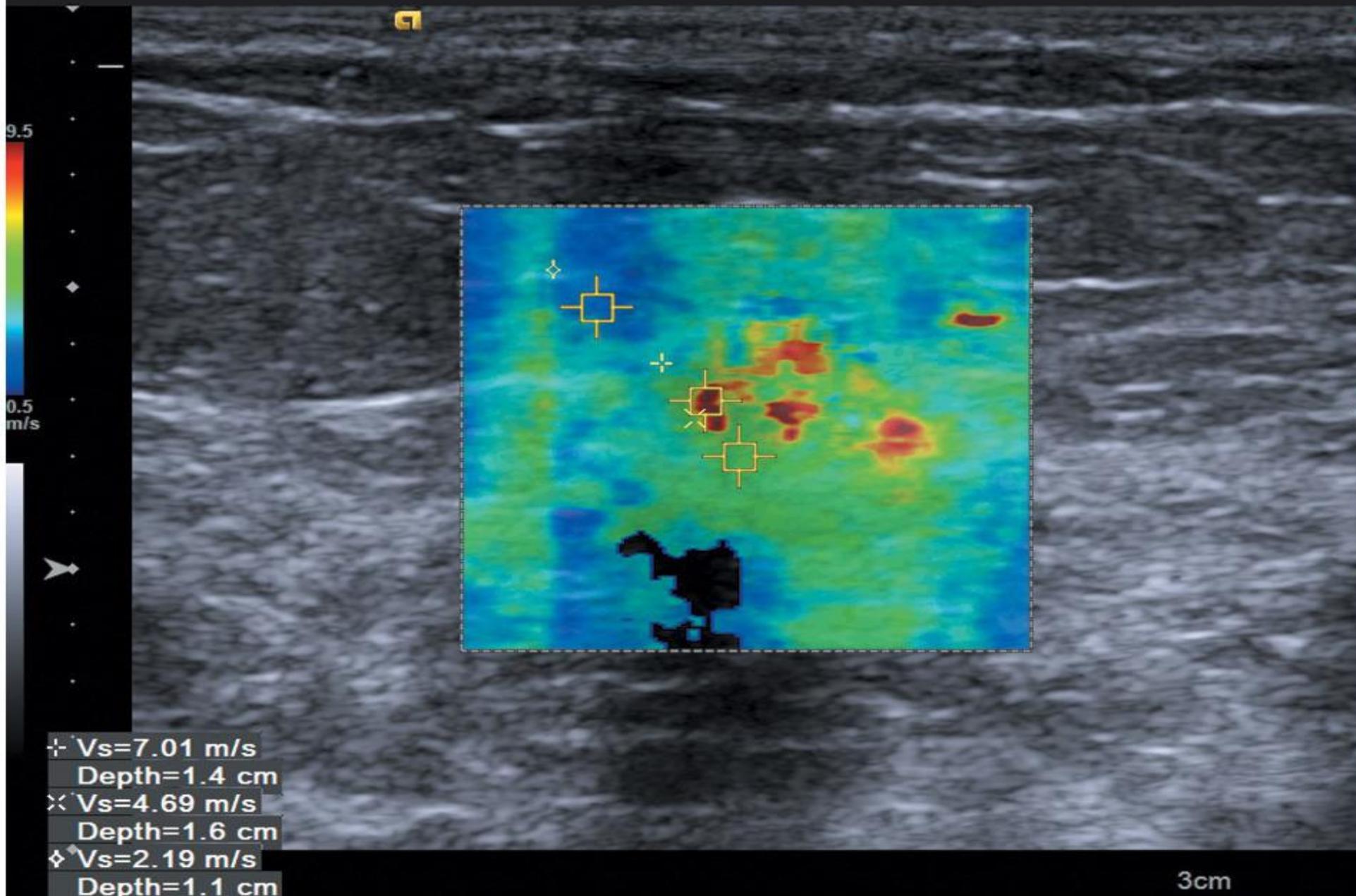


Shear waves

Shear waves

A

B



SIEMENS
9L4
Breast
General
TIS: 1.0
TIB: 1.0
MI: 1.5
13fps
2D-- 100%
THI
H8.00 MHz
0dB DR65
CTI1
SC Off
DTCE M
MapE/ST3
SW Velocity

+ Vs=7.01 m/s
Depth=1.4 cm
x Vs=4.69 m/s
Depth=1.6 cm
◇ Vs=2.19 m/s
Depth=1.1 cm

3cm

CONTRAST ENHANCED ULTRASOUND

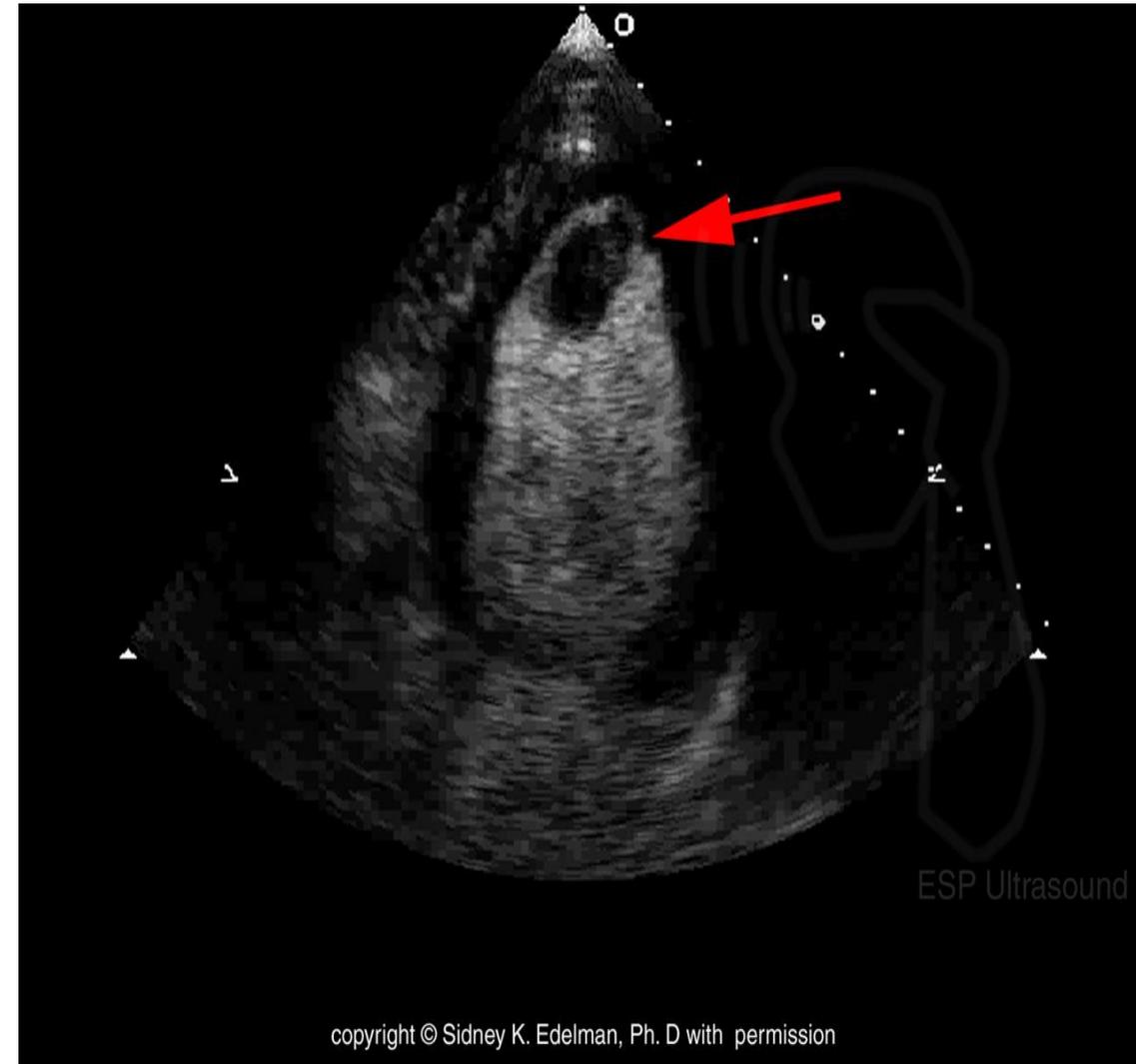
- Contrast-enhanced ultrasound (CEUS) has been utilized for many years.
 - Ultrasound contrast agents help with the visualization of blood vessels and may be used to identify neoplasms
- Although widely used in cardiac sonography, CEUS was once only used as part of a research protocol for general and vascular applications
- In 2016, the U.S. Food and Drug Administration approved the use of certain CEUS agents for liver sonography

CONTRAST ENHANCED ULTRASOUND

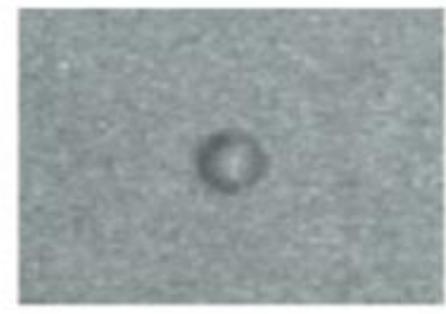
- Ultrasound contrast agents are different from those used in MRI and CT
 - The typical CEUS agent is a microbubble, usually smaller than 10 μM
- The bubble shell may be albumin, a phospholipid, a surfactant, a cyanoacrylate, or possibly another type of substance
- The gas inside of the bubble can be a type of perfluorocarbon or air
- When ultrasound strikes the microbubble it causes the bubble to resonate, creating a harmonic signal that is detected by the transducer

CONTRAST ENHANCED ULTRASOUND

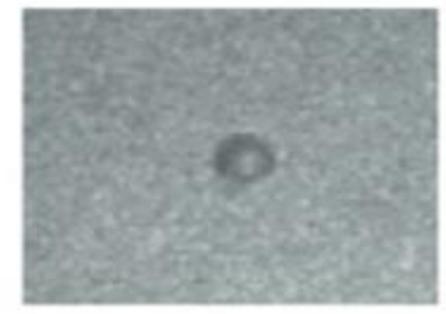
- Contrast agents are simply microbubbles that contain gas bubbles trapped in a shell that are:
 - Ingested
 - Injected
- Create strong reflections that “light up” when struck by a sound beam



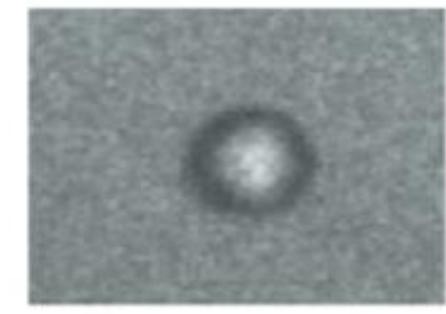
Micro-photos



Equilibrium

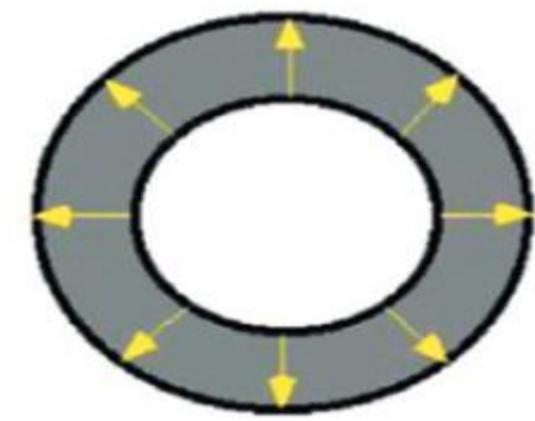
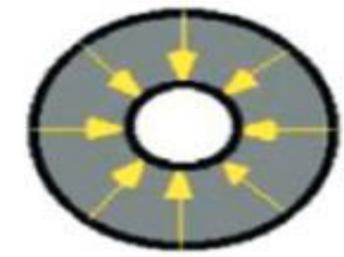
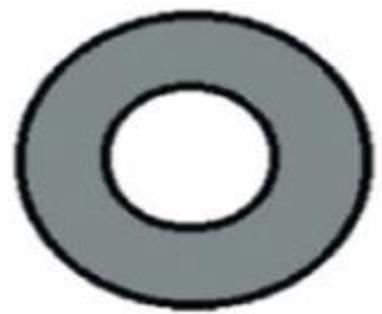


Contraction

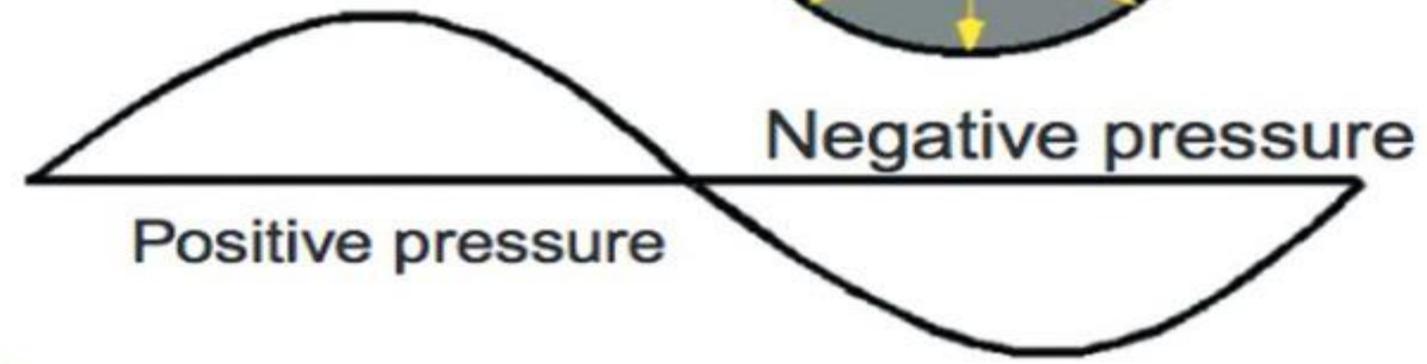


Expansion

Bubble size changes with acoustic field

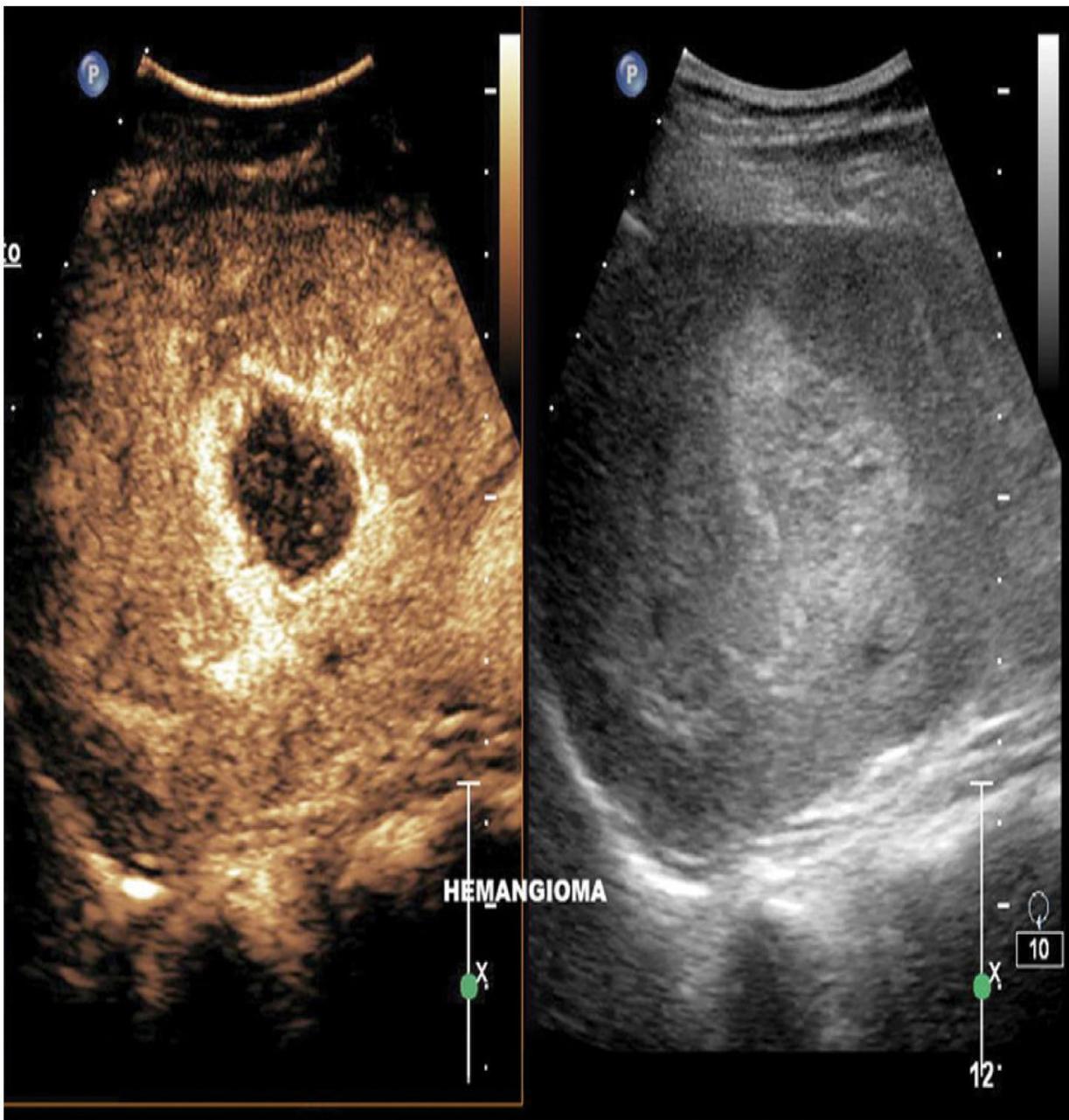


Incident RF acoustic field

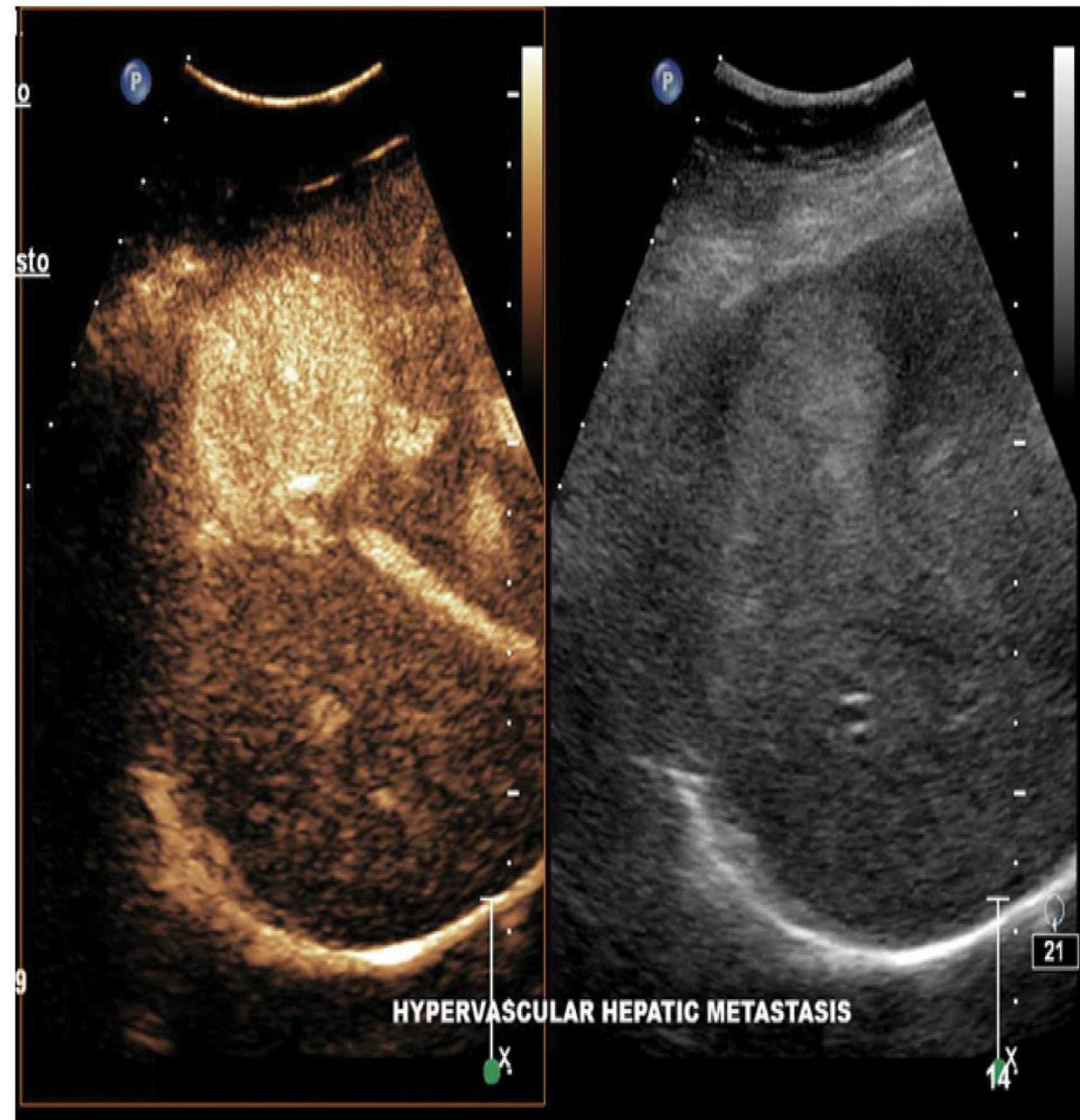


Linear Range

0.1-1 μs



A



B

CONTRAST ENHANCED ULTRASOUND

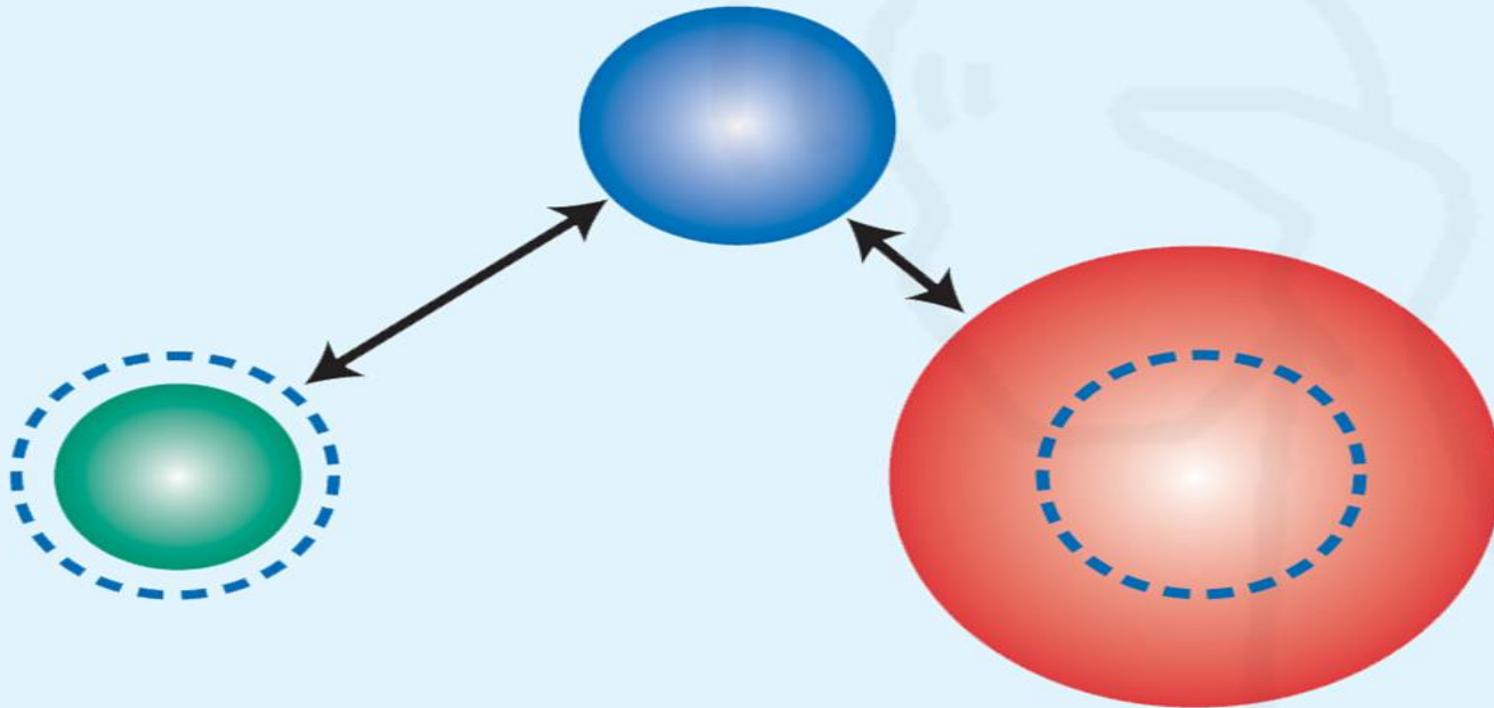
- Contrast agents must be:
 - Safe
 - Metabolically inert
 - Long lasting
 - Strong reflector of ultrasound
 - Small enough to pass through capillaries
- Create harmonics during reflection when the pulse interacts with the microbubble (non-linear behavior)

CONTRAST ENHANCED ULTRASOUND

- Microbubbles within a sound beam expands and contracts due to oscillation of pressure
 - High pressure causes the microbubble to shrink and increases the inside pressure
 - Low pressure causes the microbubble to expand and decreases the inside pressure
- Contrast harmonics is created due to the uneven changes in size
 - Uneven behavior is called RESONANCE

CONTRAST ENHANCED ULTRASOUND

Non-linear behavior



CONTRAST ENHANCED ULTRASOUND

- Mechanical Index (MI) estimates the amount of contrast harmonics produced
 - Dependent on the frequency of the transmitted wave and the pressure of the sound wave
- Two important characteristics that determine the contrast's stability and longevity
 - Nature of the outer shell
 - Gas that fills the microbubble

CONTRAST VS. TISSUE HARMONICS

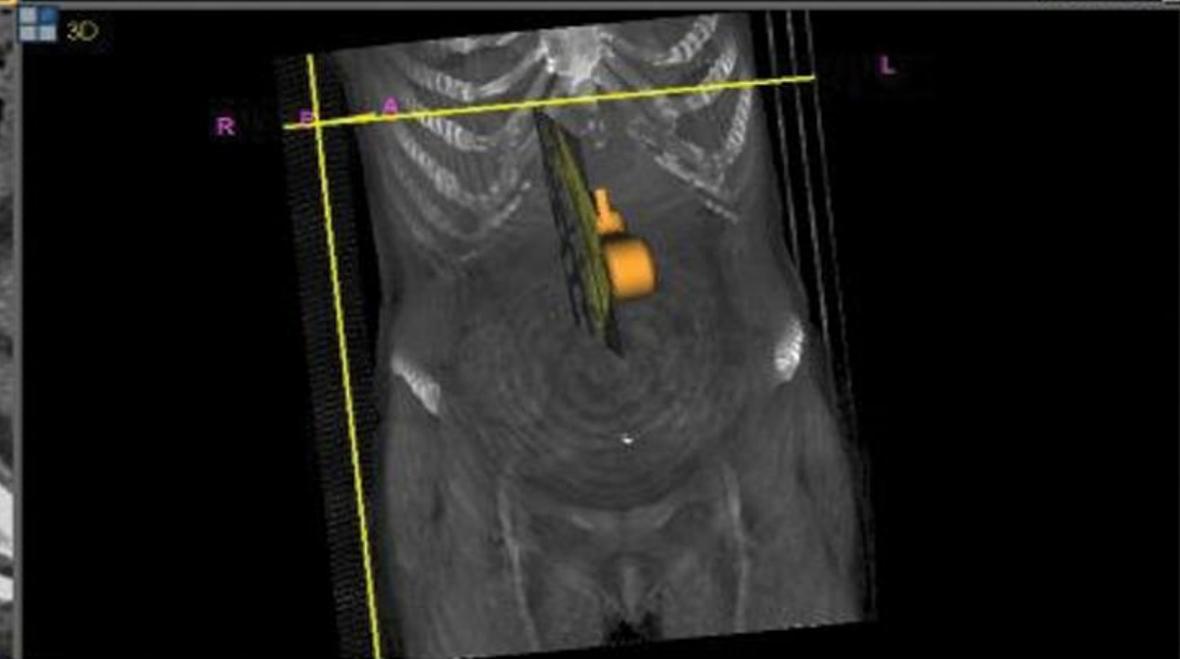
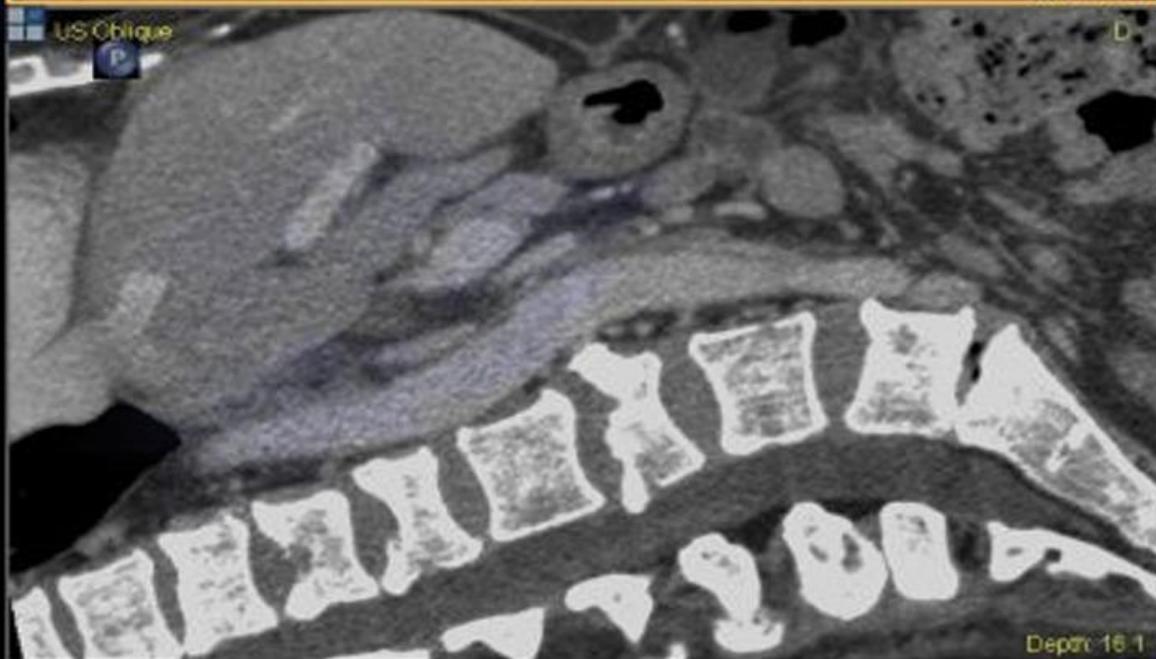
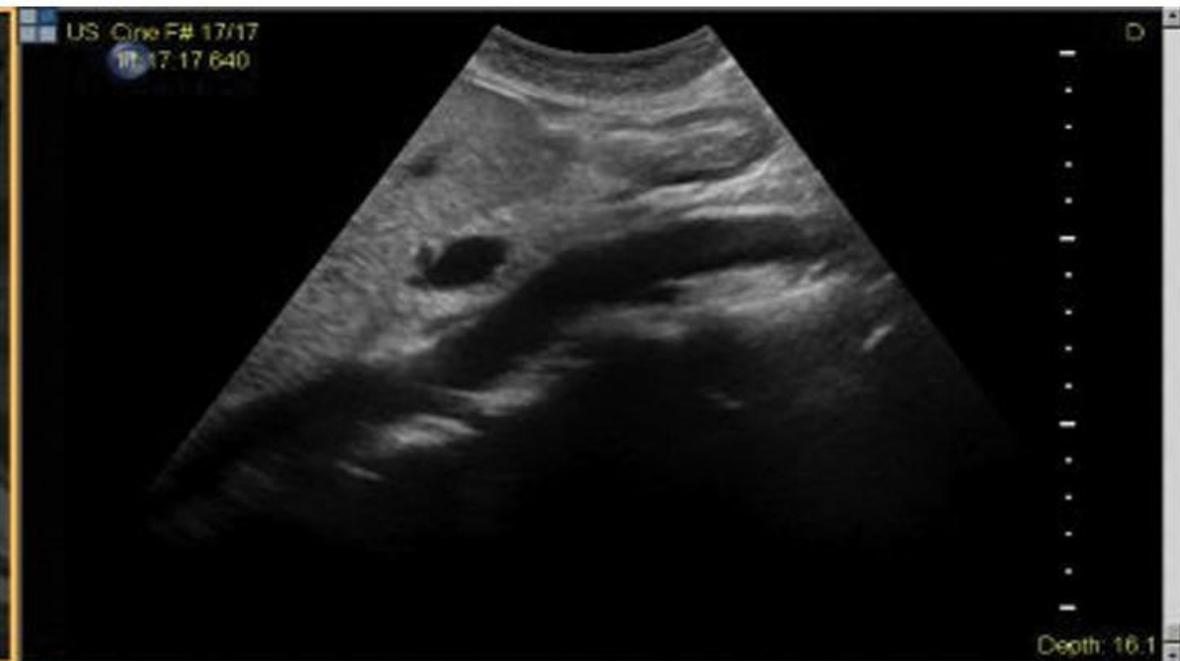
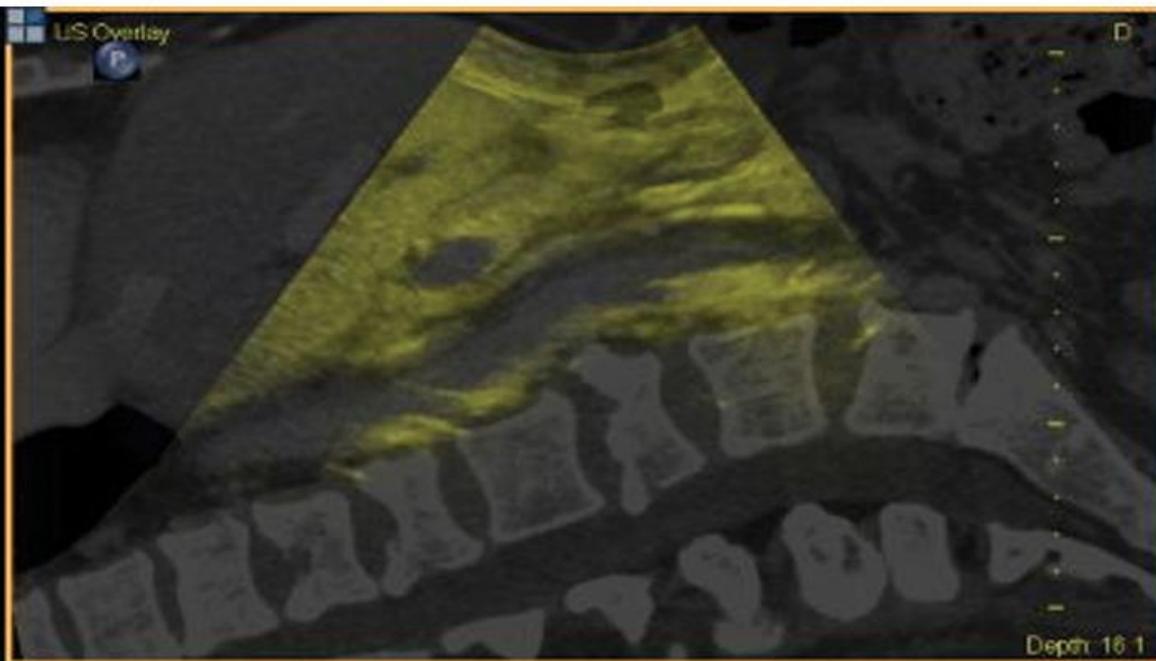
Contrast	Tissue
Created during reflections off of microbubbles	Created during transmission
Occurs only when contrast agents are present with MI's greater than 0.1	Occurs as sound propagates in tissue
Results from non-linear behavior of microbubbles	Results from non-linear behavior of transmitted sound beam
Stronger harmonic signal	Weaker harmonic signal

CONTRAST ENHANCED ULTRASOUND

- Other uses of CEUS include targeted delivery of drugs through a specialized outer shell and medication inside the bubble
 - After the microbubbles reach the area of interest, high-intensity sound waves can be used to pop the bubbles, releasing the medication contained within
- CEUS is also used in subharmonic imaging (SHI), which is a technique that images at one-half the fundamental frequency in order to suppress the tissue information and better display microvessels

FUSION IMAGING

- Fusion imaging or hybrid imaging, enables the simultaneous display of real-time sonography and a stored CT or MRI
- Using a tracking system, the machine knows where the transducer is placed on the patient, and automatically moves the CT or MRI image to correspond with the plane of the sonographic image
- This technology improved biopsy guidance and the ability to assess relevant anatomy during tissue ablation



B

CT AND ULTRASOUND FUSION OF AORTA

INTRAVASCULAR ULTRASOUND

- Intravascular ultrasound (IVUS) is a procedure that pairs a miniature ultrasound transducer and a vascular catheter
 - Utilizes frequencies much higher than standard ultrasound ranges
- The IVUS probe is placed in the circulatory system and the transducer is used to analyze the vessel wall
- The combination of IVUS and 3D sonography are currently being united in hopes of providing improved diagnosis and enhanced treatment of otherwise difficult to evaluate vascular conditions

Mechanical:

Transducer
Rotating acoustic beam

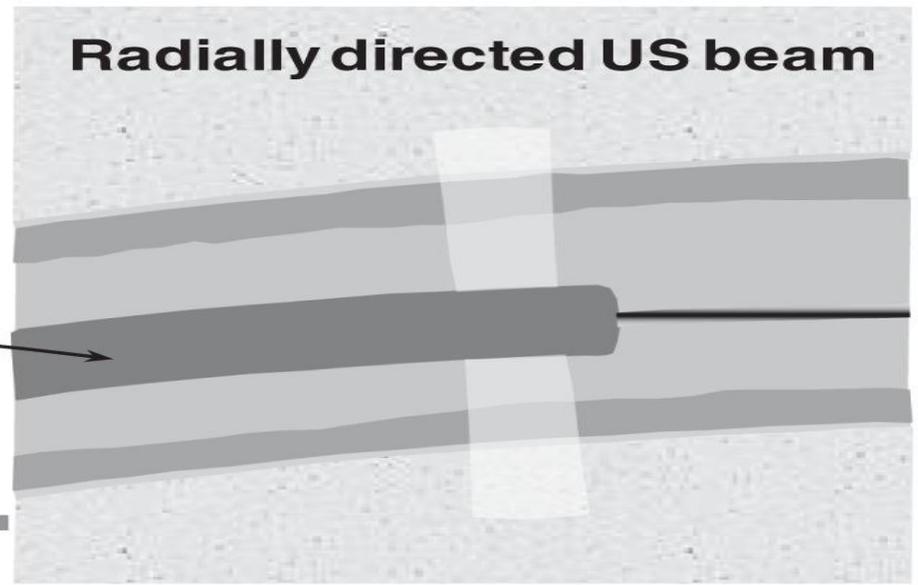


Electronic:

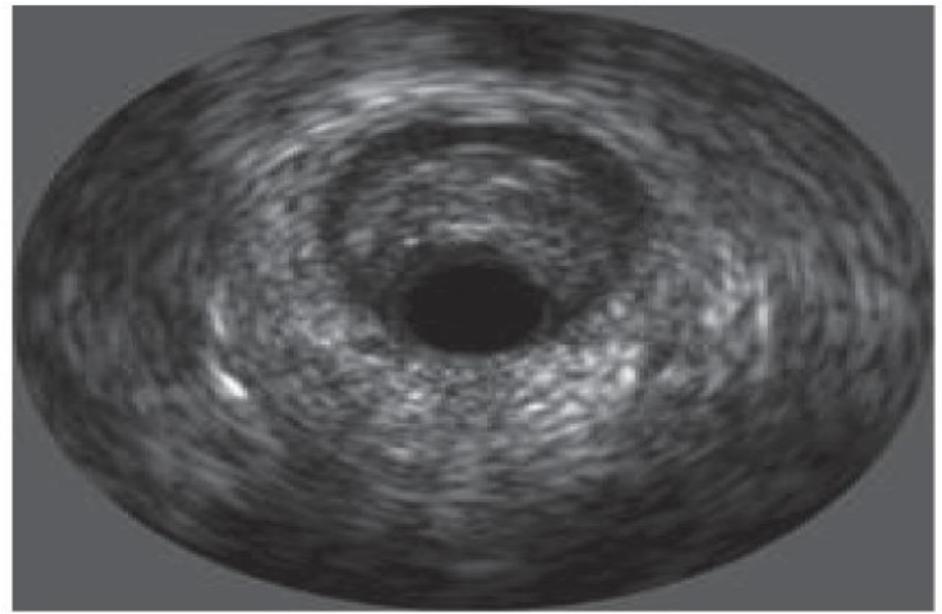
Multi-element transducer



Catheter



Normal vasculature



Elliptical stenosis

ERGONOMICS

ERGONOMICS

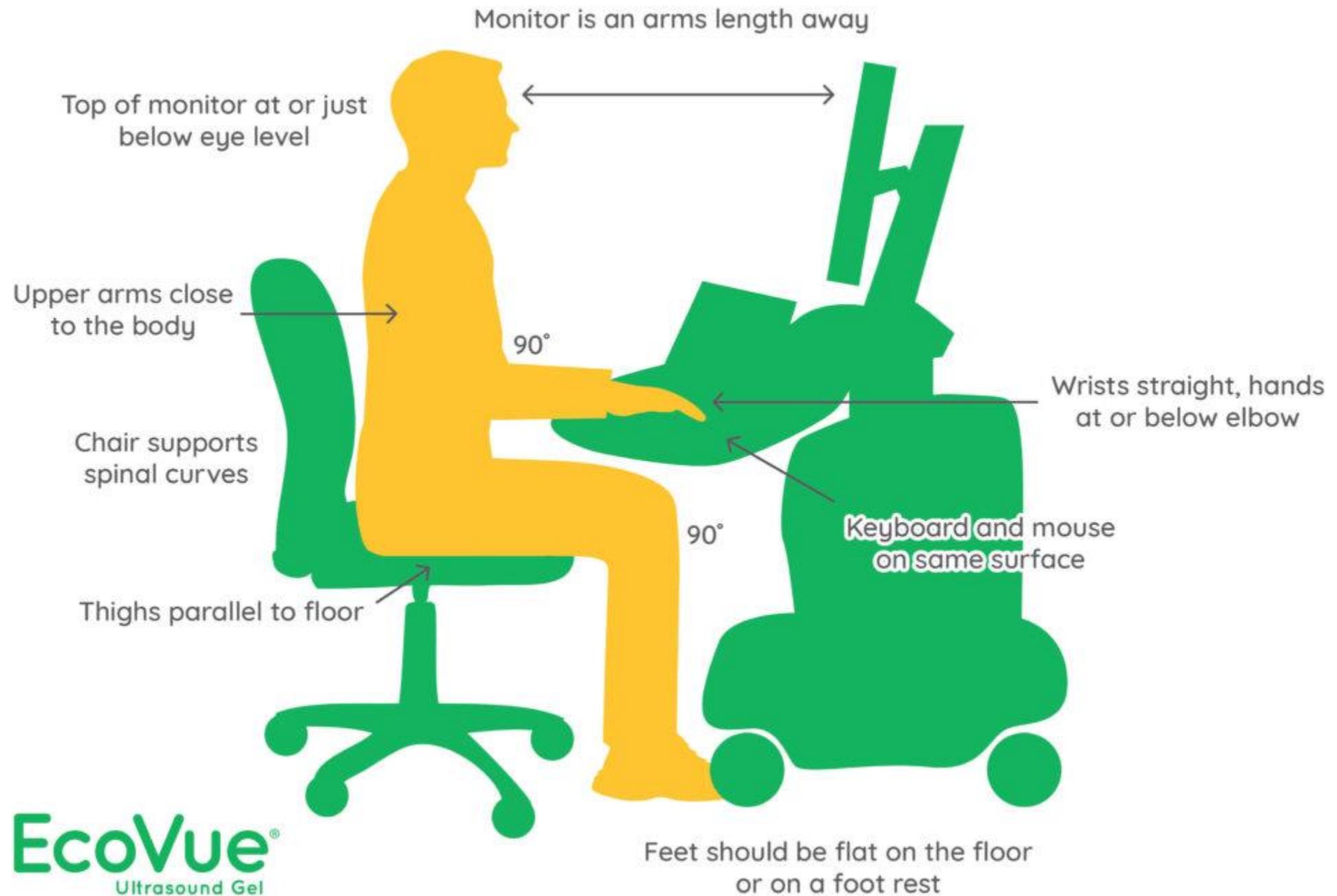
- Ergonomics is the scientific study of creating tools and using equipment effectively in order to help the human body adjust to the work environment
 - For the sonographer, ergonomics is geared toward recognizing the potential for, and thus preventing, work-related musculoskeletal disorders (WRMSDs)
 - Preventing WRMSDs can be accomplished by combining the use of proper body mechanics, creating a practical work environment with room design, and by using equipment that is functionally supportive for the occupation of the sonographer

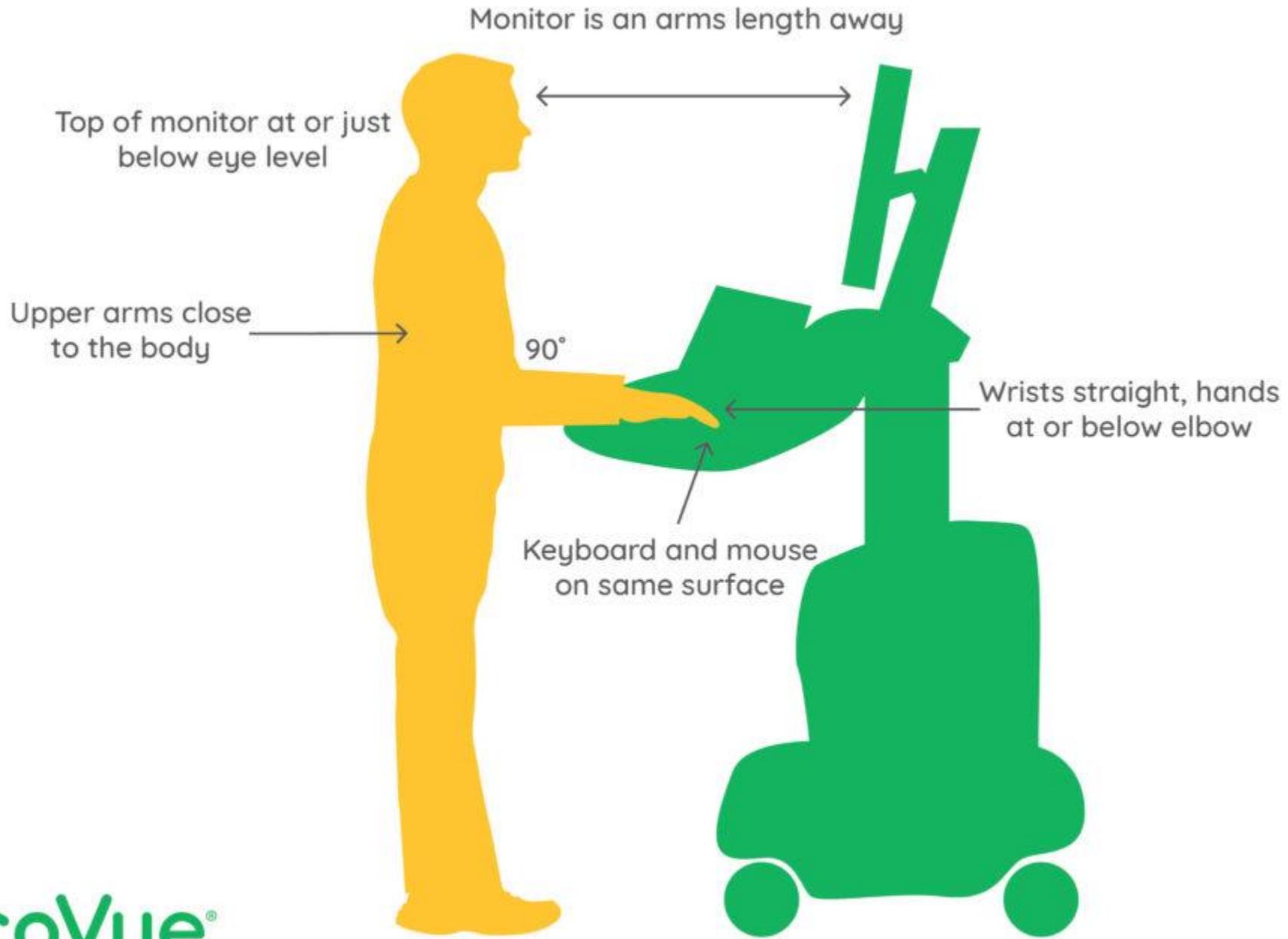
ERGONOMICS

- The symptoms of WRMSDs include those associated with inflammation, such as swelling, numbness, burning, muscle spasm, stabbing pains, tingling, loss of sensation, and perhaps a “pins and needles” feeling in the affected region
- The damage from WRMSDs is cumulative, and thus devastation of the affected area occurs over time
- For the sonographer, these types of injuries result from repetitive strain, and are thus referred to as repetitive strain disorders or injuries

ERGONOMICS

- Tendinitis, tenosynovitis, epicondylitis, bursitis, and pinched nerves are all examples of repetitive strain disorders
 - The neck, back, feet, elbows, wrists, and hands are common locations of pain for the sonographer
- The shoulder is the most common source of pain for the sonographer
 - To prevent shoulder discomfort and repetitive damage, the sonographer should decrease shoulder abduction while scanning (no more than a 30° angle of abduction)
- The sonographer should also place the patient as near to him or her as practical, because this situation will also reduce the amount of reach needed to perform most examinations





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