

Ultrasound Guidance in Anesthesia Practice

Maria Hirsch, CRNA, DNAP



Objectives

- Describe the basic principles of ultrasound
- Explore the various applications of ultrasound in anesthesia practice
- Discuss the benefits of using ultrasound to improve patient safety and satisfaction

- A 1998 WHO report addresses the urgent need for improving the training and clinical performance of physicians and allied health professionals who utilize ultrasound

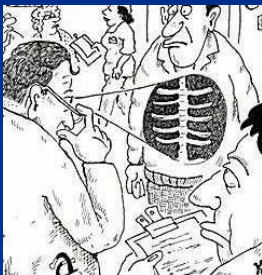


Why Use Ultrasound???

- Increased success of performing procedures
- Decreased risk of inadvertent arterial or nerve puncture
- Reduction of number of attempts to be successful for procedures
- Decreased length of procedure time
- Ability to assess anatomy



And because we don't have....



Safety of Ultrasound

- Ultrasound produces *some* heat with use which can transfer into tissues.
- In over three decades of medical ultrasound use, there has never been a report of injury to patients or operators from medical ultrasound equipment. (American Institute of Ultrasound in Medicine, 1994)

History of Ultrasound

- Ultrasound= Sound that cannot be heard (cyclic sound with a frequency greater than the upper limit of human hearing)
- Discovered by an Italian priest in the 1700s-Lazzaro Spallanzani
- Experimented with bats

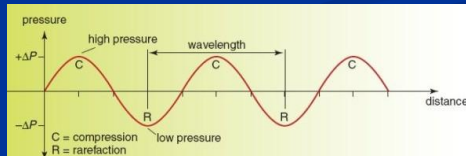


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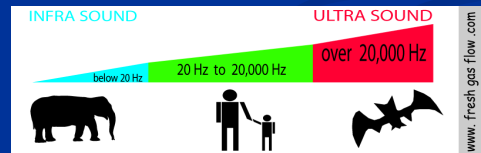


Physics of Ultrasound

- Sound travels in waves
- Speed of sound = frequency X wavelength



- Ultrasound is high frequency sound
 - Over 20,000 cycles/second (20kHz)
 - Typical ultrasound frequency is 2 – 15 MHz



Creating ultrasound

- In 1880 Jacques & Pierre Curie, French physicists, described the transformation of electrical energy into mechanical energy and vice versa
- "Piezoelectric effect"



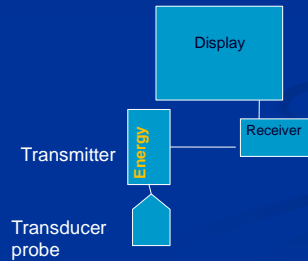
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Piezoelectric Effect

- Piezoelectric crystals (PZT) are located in the transducer probe head.
 - When electric energy is applied to the crystals, they vibrate, emitting ultrasound waves
 - The sound goes out and is reflected back to the transducer and to the PZT crystals
 - The energy is then measured by the machine, and the difference from out/in waves calculated

Ultrasound Equipment

Four basic components of an ultrasound unit:



Anatomy of a transducer probe

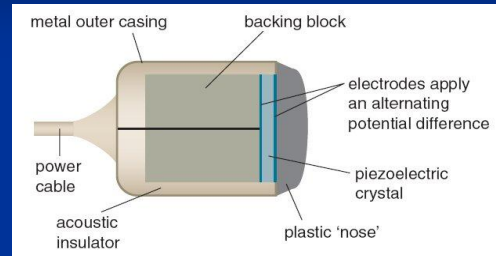
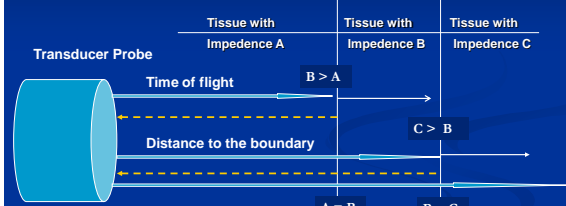


Image from www.genesis.net

Speed of sound in different tissues

Tissue	Speed of sound (m/sec)
Lung	300-1,200
Fat	1,450
"Soft" tissue	1,540
Bone	2,000-4,000
Blood	1,570

Transmission and reflection of US (echogenicity)



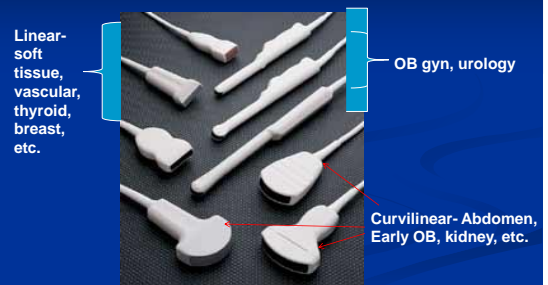
The greater the difference between tissues, the more reflection will occur back. (larger contrast)

Image Generation



A math equation converts the signals to a picture

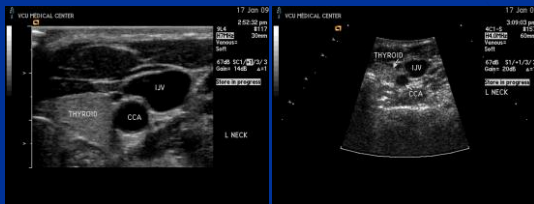
Examples of transducers



High vs. Low Frequency

High Frequency

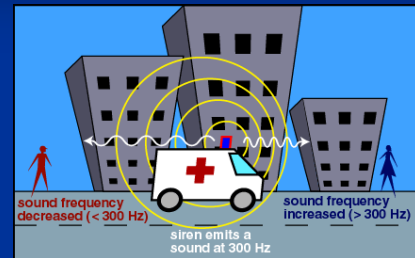
Low Frequency



Images by C. Faylar, CRNA

The Doppler Effect

As siren approaches, you hear one pitch (frequency), as it passes, it sounds lower.



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Doppler Effect

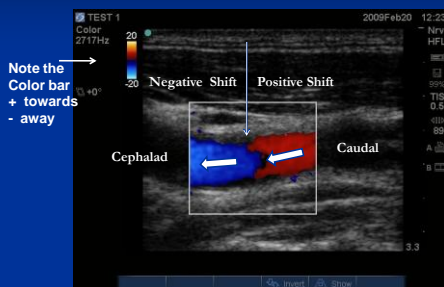


Image by C. Faylar, CRNA

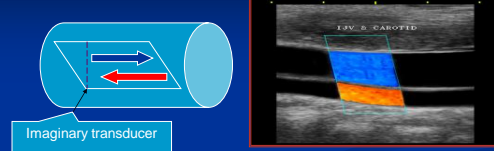
Effect of Gain Adjustment



Effect of Probe Angle

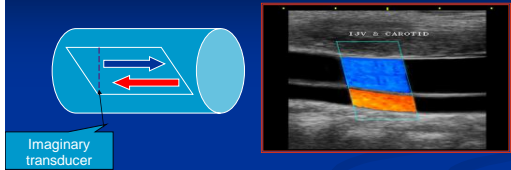


Longitudinal orientation



- Orient yourself longitudinally using doppler and the "imaginary transducer"
- When you apply the doppler "box" to the image on the screen, the top of the box leans toward the imaginary transducer

Longitudinal orientation, con't.



- In the example above, the top of the box leans towards the *left*, which means that the imaginary transducer is also on the *left* but looking *right*, so the blood in the top vessel is going AWAY from the probe and blood in the bottom vessel is going TOWARDS the probe.
- This technique allows you to always know artery from vein.

Ultrasound Guidance: Dynamic vs. Static

Dynamic

- Consists of ultrasonic localization, and image-guided cannulation
- More precise and "real time"
- Difficult to keep sterility of transducer site
- More hard to screen coordination

Static

- Consists of ultrasonic localization and marking of landmarks only
- Cannulation is not image guided, but is separate
- Time delay between marking and cannulation
- Easy to keep sterility of transducer and site
- Less technically demanding

Getting Started:

- The two most important elements of using ultrasound:



Establish a Routine



- Gather equipment and supplies
- Prepare patient- position comfortably
- Prepare provider- position comfortably and place machine in your line of vision
- Know what the anatomy should be
- Know what probe you need
- Practice, practice, practice!!

Tips: Proper positioning



Proper positioning of equipment for right IJ

Put the US machine in your line of sight (the needle should point toward it during cannulation)

For subclavian lines, the machine should be on the opposite side of the patient, directly within your line of sight.

Preparing the probe

Probe must be placed in sterile sleeve

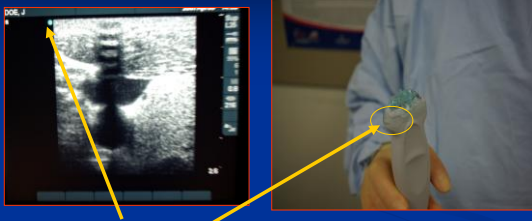


Note large amount of ultrasound gel on probe surface



Now ready to use

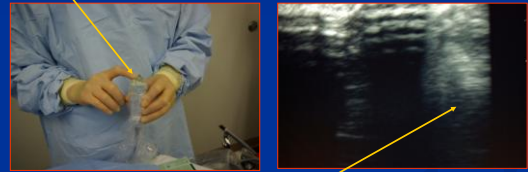
Transverse orientation- first rule



When applied to the patient, the notch on the probe must be on the same side as the dot on the screen, otherwise you will be looking at a mirror image

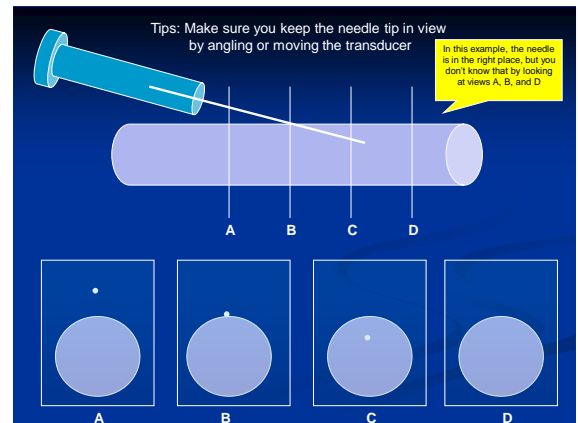
Transverse orientation- “finger wiggle”

Finger on one side of the probe



Acoustic shadow of finger on same side of image

Orientation- “mock poke”



US Guidance for Central Vascular Access

- The 2001 Agency for Healthcare Research and Quality (AHRQ) Evidence Report listed ultrasound assistance of central cannula placement as one of the “Top 11 highly proven” patient safety practices that are not routinely used in patient care.

■ NICE (Britain) Guidelines:

- US is the *preferred* method of IJ insertion in non-emergent situations
- US should be considered in emergent situations
- Proper training is required

Bishop L, Dougherty L, Bodenham A, et al. Guidelines on the insertion and management of central venous access devices in adults. Int Jnl Lab Hem. 2007;29:261-278.

■ Meta-analysis in BMJ 2003:

- 2-D US associated with:
 - 86% risk reduction: failure
 - 57% RR: complications (arterial stick, PTX, etc)
 - 41% RR: repeated sticks

Hind D, Calvert N, McWilliams A, et al. Ultrasonic locating devices for central venous cannulation: meta-analysis. BMJ 2003; 327

Keenan (J Crit Care. 2002; Jun 17(2): 126-37)

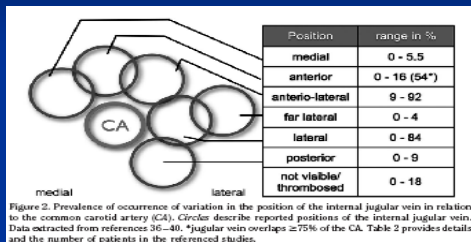
- Systematic review of 18 RCT of ultrasound-guided CVP placement vs. using landmarks alone
- Significant reduction in procedure failure rate, number of attempts and arterial puncture rate
- Increased rate of successful placement with ultrasound
- Inexperienced clinicians placing IJV catheters may benefit the most

ASA Task Force on Central Venous Access- March 2012

- Practice guidelines recommends use of both static- and real-time ultrasound imaging for internal jugular placement and subclavian/femoral when possible
 - Vein identification (static)
 - Vessel localization and venipuncture (real time)
 - Confirming venous access (needle, catheter in vessel)

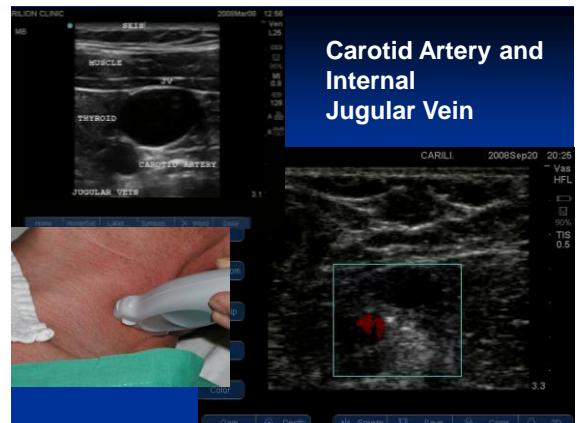
Anesthesiology 2012; 116:539-73.

Anatomical Variations



Maecken, T Crit Care Med. 2007; Vol. 35 No.5 (Supp)

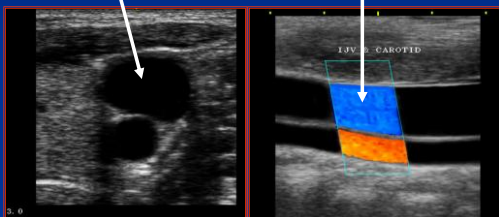
Carotid Artery and Internal Jugular Vein



Insertion Method

Transverse orientation- IJ

Longitudinal orientation- IJ



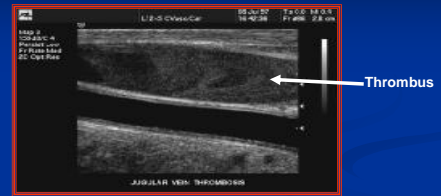
Longitudinal IJ



Check compressibility



Check vein for patency



Vein should be free of clot and freely compressible when pressure is applied with the probe

Basic Insertion Method

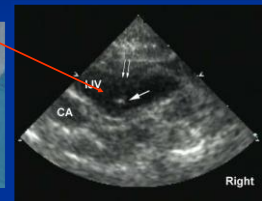
Vein cannulation under dynamic guidance

For insertion of the needle, using transverse view is preferred



Can see acoustic shadow of needle

Ultrasound confirms vein cannulation



Subclavian Lines

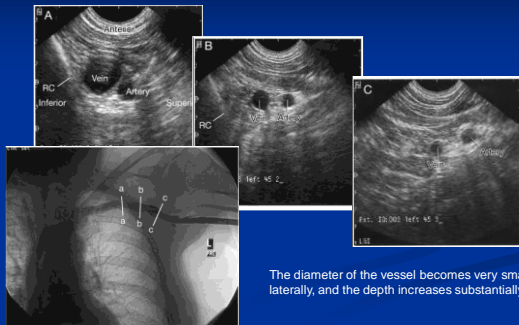
- Subclavian is more difficult to visualize with ultrasound; static guidance is possible
- Must manipulate/angle the probe to "see" under the clavicle
- Cumbersome and technically difficult to cannulate vessel under dynamic guidance
- Why struggle? go for the IJ or axillary, unless subclavian line is essential

Axillary Vein



- The mid portion of the subclavian vein lies under the clavicle
- The lateral SCV and axillary vein travel inferiorly and, thus, become "exposed"
- This exposure facilitates insonation and cannulation under direct guidance

Axillary Vein



Keyes, et al (Ann Emerg Med 1999; 34: 711-4)

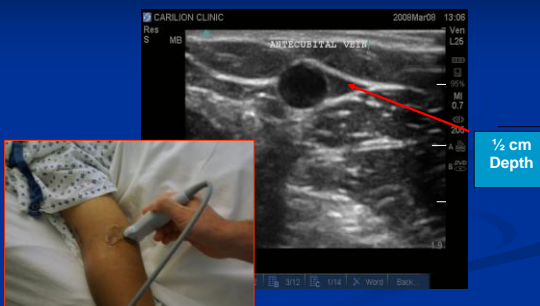
Study of 101 emergency department patients with history of difficult intravenous access.

Patients had two unsuccessful attempts at establishing a peripheral intravenous line

Ultrasound guidance was used to cannulate the deep brachial or basilic vein with a 2 inch 18-20 gu catheter

91% had successful catheter placement with US, 73% on first attempt

Antecubital vein



Deep brachial vein

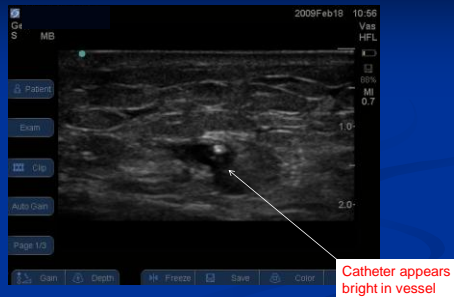


Longitudinal view basilic vein



Basilic Vein

Catheter in Vein



Arterial Cannulation

- Arteries will appear pulsatile
- US allows the artery to be checked for stenosis
- Normally are non-compressible
 - Patients who are in a low-flow state can have compressible arteries
 - Appear thicker-walled than veins

Radial artery



Translaryngeal Ultrasound



Image by C. Butcher MD

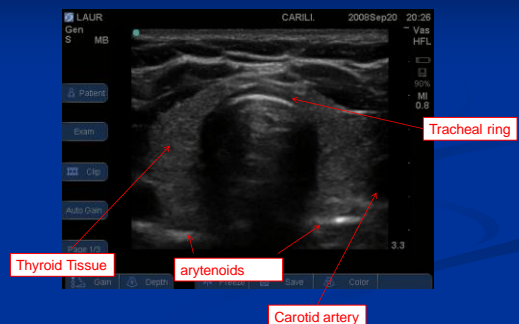
Airway Assessment

- Vascular structures can be marked
- Tracheal rings numbered
- Location and size of thyroid gland confirmed
- All vascular and soft tissue anatomical abnormalities identified prior to attempted intubation

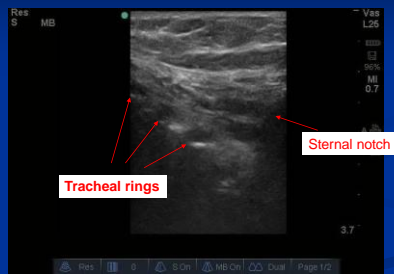


Image from C. Butcher, MD

Airway Assessment



Mapping: “diving trachea”



Vocal Cords



Mapping the Neck: Depth

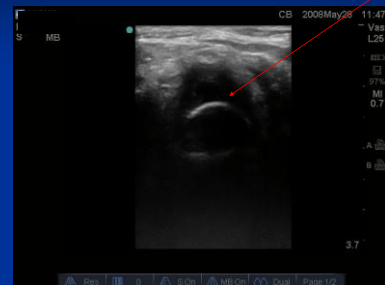


Depth is indicated here

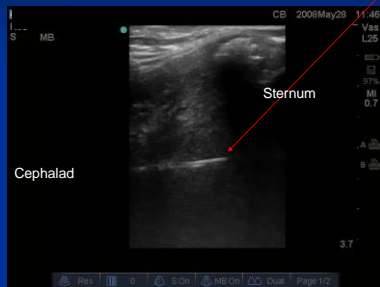
Ascertaining endotracheal tube position

- Can do translaryngeal U/S to look for proximal ETT malposition
 - Esophageal
 - Too shallow/deep
 - Unilateral pleural sliding may indicate mainstem intubation; b/l pleural sliding normal
- Combination of both may eliminate need for x-ray

Transverse view showing ETT



Longitudinal view showing ETT



Lung Assessment-Pleura

- Easily accessible to U/S study
- Can rule out pneumothorax/effusions

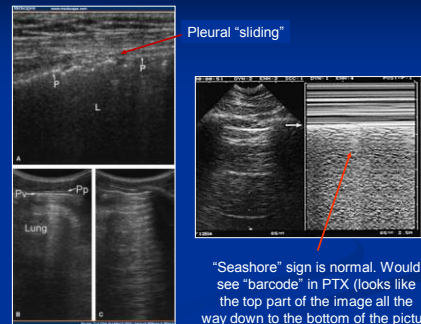


Note tissue appears to "shimmer"

Normal Lung



Pneumothorax



"Seashore" sign is normal. Would see "barcode" in PTX (looks like the top part of the image all the way down to the bottom of the picture)

US Guidance for Regional Anesthesia

- Cochrane Review (2009) found that US guidance for regional anesthesia resulted in:
 - Decreased time to perform blocks
 - Faster onset of effective block
 - Reduced amounts of local required
 - Reduction in tissue trauma

US Guided Regional Anesthesia

- Study by Mariano (2009) showed ultrasound guidance for infraclavicular brachial plexus perineural catheters is quicker and more successful than electrical stimulation

Mariano E, Loland VJ, Bellars R, et al. Ultrasound guidance versus electrical stimulation for infraclavicular brachial plexus perineural catheter insertion. J of Ultrasound in Med. 2009; 28(9):1211
- Recent case report by Schober (9/2009) described successful use of ultrasound-guided regional anesthesia in a patient with progressive fibrodysplasia ossificans (stone-man's disease) for an ankle block

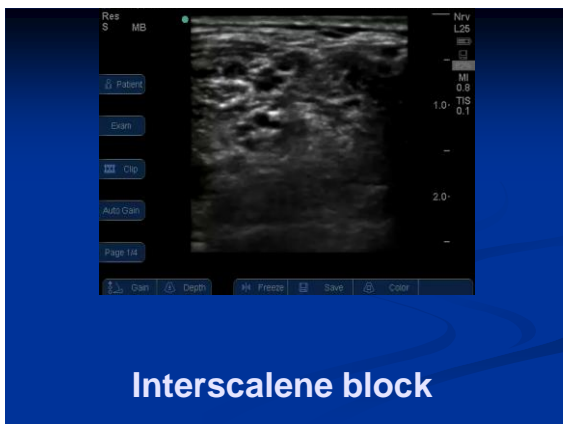
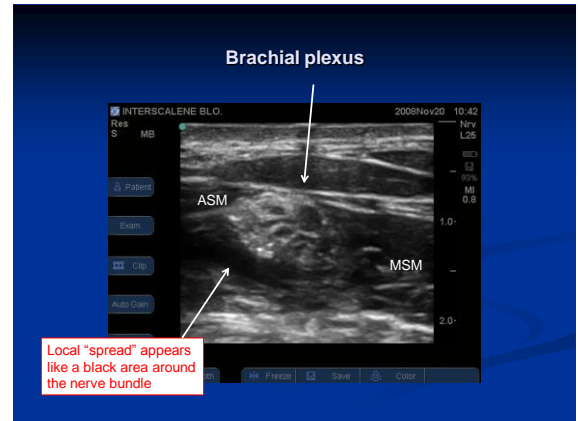
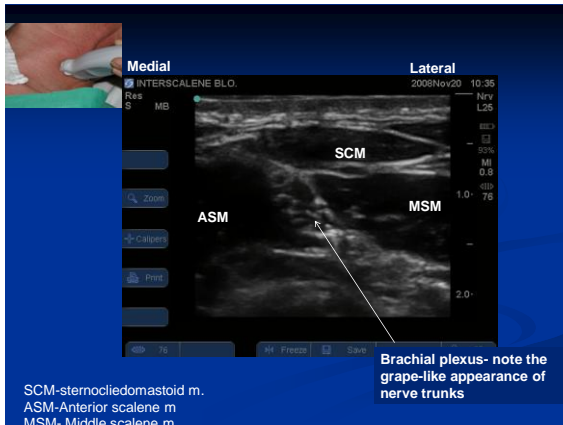
Schober P, Krage R, Thone, D. Ultrasound-guided ankle block in stone man disease, fibrodysplasia ossificans progressive. Anes Analg. 2009; (109/3):988.

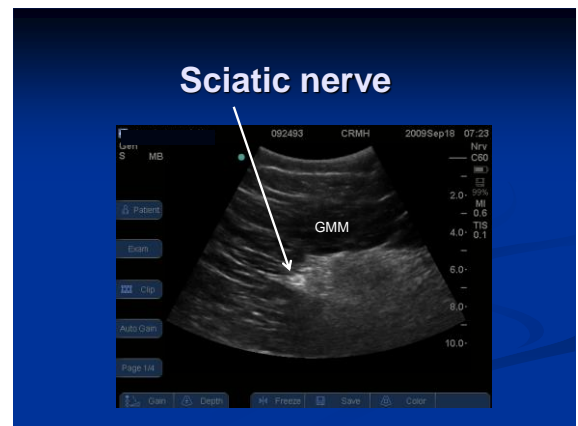
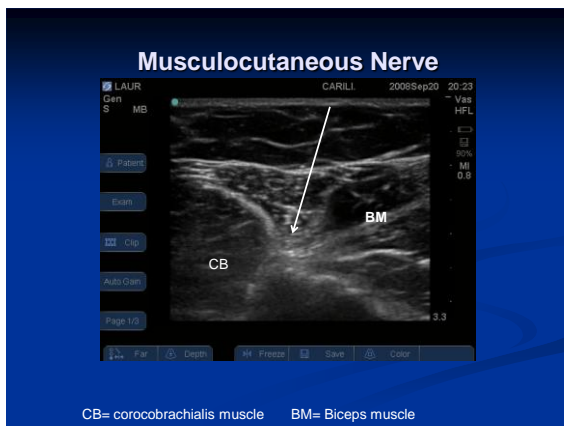
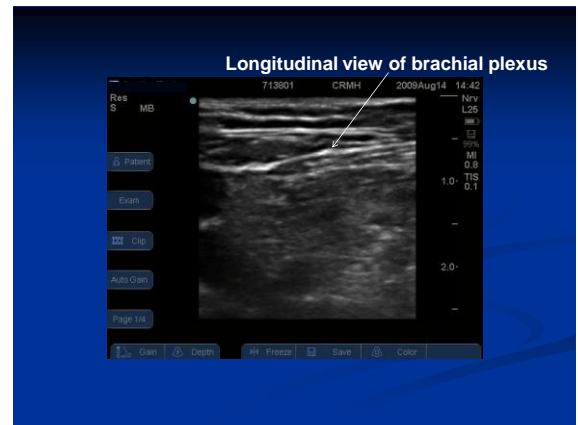
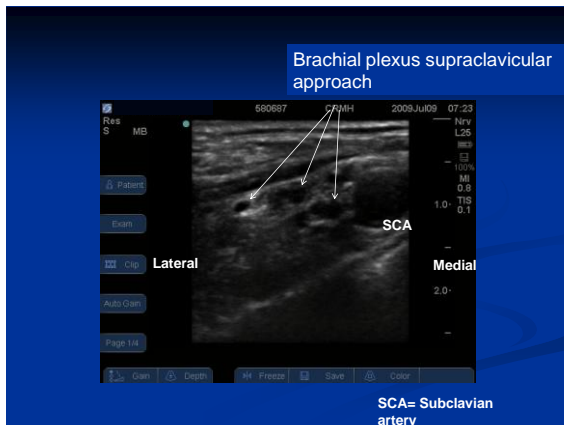
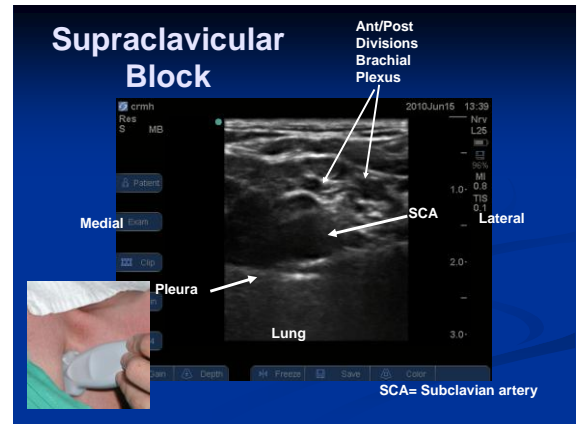
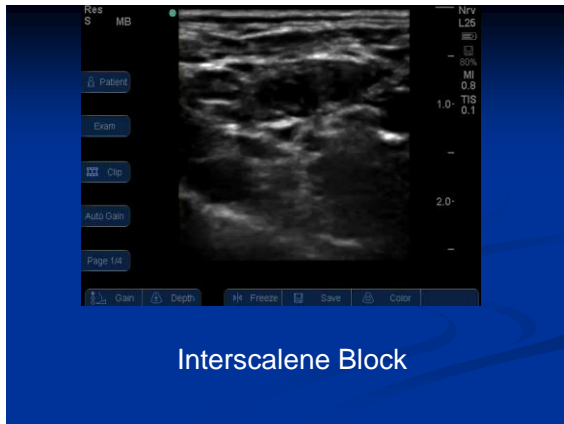
Identifying Nerves with U/S

- Knowledge of relevant anatomy is most important
- Nerves are not always easy to identify
- Identify associated anatomical structures such as arteries, bony landmarks
- “Traceback” method- obtain an obvious anatomical landmark not too far removed from one point along the target nerve’s path

U/S Appearance of Nerves

- Nerve tissue is denser than muscle and appears brighter (hyperechoic)
- Nerves can appear hollow on ultrasound (like vessels without flow)
- Neurovascular bundles in transverse orientation can appear grape-like
- Doppler imaging can help to differentiate nerves from vessels





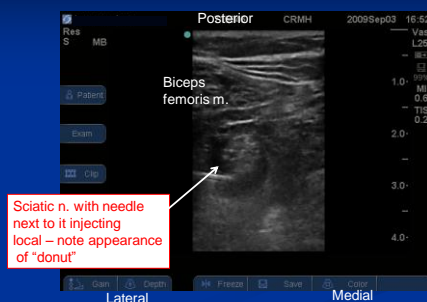
Sciatic n.



Sciatic n. bifurcating to Common Peroneal and Tibial n.



Popliteal block



Femoral nerve



Other applications of U/S in anesthesia

- Cardiac assessment
 - Anomalies
 - Function
 - Volume status
- Facilitation of spinal and epidural placement
- Gastric volume/contents assessment

What the future holds....



Vscan- Cell-phone sized ultrasound device made by GE™

Cost of equipment

- Portable ultrasound machines average between \$40K-\$80K
- The transducer probe is the most expensive part of the machine, one transducer can cost up to \$25K alone
- Can buy or lease a machine, or some vendors "loan" equipment based on use of disposables

Reimbursement for US

- If you or your employer owns the equipment, you can submit for a facility charge for US use for procedures.
- The provider can submit a professional charge for US guidance in some circumstances.
- You must retain a permanent record (picture or digital image) of the ultrasound utilization
- Some insurers require proof of training for some types of US exams

Recommended Textbooks

Harmon D, et al. Perioperative Diagnostic and Interventional Ultrasound. Philadelphia, Saunders, 2008.

Tsui B. Atlas of Ultrasound and Nerve Stimulation-Guided Regional Anesthesia. New York, Springer, 2007.

Acknowledgements

Thank you to my colleagues for use of their images, assistance, and/or wisdom:

Dr. Christian Butcher

Dr. Alexander Levitov

Mark Mizuba, MS CRNA

Christian Faylar, MSNA CRNA

Dr. Suzanne Wright, PhD CRNA