WHY ULTRASOUND?
Visual Acuity
Why is that important?
Variant Anatomy

- University of Texas, Galveston 1997
- 51 cadavers (102 sides) examined
- Normal route of BP occurred in only 60%
- C5 & C6 roots fused together through AS 15%
- C5 root through AS 13%
- C5 & C6 separately through AS 6%
Variant Anatomy

- Brazilian study 2003 (Acta Cirurgica Brasiliera)
- 27 cadavers (54 sides) examined
- Phrenic had complete origin from BP in 20%
- Accessory phrenic nerve in 12 of the cadavers
- Long thoracic nerve through the MS in 63%
- Dorsal scapular nerve through the MS in 73%
Variant Anatomy

- The American Surgeon 2006
- 98 cadavers (186 sides) examined
- C5 root anterior to the AS in 12 sides
- AS doubled in 1 cadaver with upper trunk of BP passing through it
- Upper trunk of BP passed anterior to AS in 4 cadavers, and through the AS in 12 cases
- C5 passed anterior and C6 passed through the AS in 1 case
Conclusions:
- May account for inexplicable block failures
- Potentially defines the “circles” seen with ultrasound while viewing the scalene muscles
- Intramuscular passage of a root or trunk is usually fairly easy to see with ultrasound
ULTRASOUND IN ANESTHESIOLOGY
INTRODUCTION

- HOW IT BEGAN
- HOW IT ALL WORKS
- HOW IT CAN BE USEFUL FOR YOU
HOW IT BEGAN

- 1790 - Lazzaro Spallazani
- Experimented with bats noting how they maneuvered through the air with hearing rather than sight.
- 1826 – Jean-Daniel Colladon
- Discovered sonography with an underwater bell.
- Accurately determined speed of sound through water.
HOW IT BEGAN

10 miles apart
HOW IT BEGAN

- 1881 - Pierre Curie
  - Found a connection between electrical voltage and pressure on crystalline material, the breakthrough needed for modern transducers.
- 1912 – Paul Langevin
  - Invents the “hydrophone” after the titanic sinks, which sends and receives low frequency sound waves, later used to detect submarines in WWI.
1930s - Dr. Karl Dussik
- Introduced “hyperphonography” to diagnose brain tumors with the use of heat sensitive paper to record echoes.

1940s – Dr. George Luwig, Univ. of Penn.
- Studied and recorded sound wave differences passing through tissues and organs.
HOW IT BEGAN

Dussik and his ultrasonic apparatus in 1946
HOW IT BEGAN
HOW IT BEGAN

- 1950s – Ian Donold, Univ. of Glasgow
- Became the “Father of Obstetric Ultrasound.”
- Studied a woman diagnosed with inoperable stomach cancer and found that she really had an ovarian cyst which was removed safely.
- Developed the B-Mode scanner which involved
  - submerging the patient in water.
HOW IT BEGAN
HOW IT BEGAN
HOW IT BEGAN

- 1960 - Douglas Howry and Joseph Holmes
- Invented a transducer that was placed in contact with the patient.
- 1973 - Martin Wilcox
- Introduction of a real time scanner.
- 1990s - SonoSite
- Introduces low cost and portable units.
- 2000s - Second most widely-used diagnostic imaging modality today.
The definition of ultrasound is energy generated by sound waves of 20,000 or more vibrations per second.

Medical ultrasound is sound waves in the 2-12 million cycles per second (MHz) range which are produced and detected by transducers contained in a hand-held probe.
HOW IT ALL WORKS

- The transducers are piezoelectric crystals which change electrical voltage into sound waves and reflected sound waves back into voltage.
- The image seen on the screen is made up of many individual scan-lines. Each scan-line is made from the transmitted and received ultrasound pulse from one set of crystals.
Tissue penetration or the depth to which sound waves produced by the transducer will travel and reflect, largely depends upon the frequency range of the transducer.

- Superficial Structures (0-3cms) require High Frequencies (6-12MHz). i.e.: interscalene
- Deeper Structures (4-8cms) require Lower Frequencies (2-4MHz). i.e.: sciatic
The denser or more rigid the layer encountered, the greater the amount of wave that will be reflected (bone).

- The reflected wave imprints a white dot on the ultrasound screen.
- Hyperechoic.
The less dense or less rigid the layer encountered, the less wave will be reflected (vessels).

- The lack of a reflected wave leaves a blackened area on the ultrasound screen.
- Hypoechoic
HOW IT ALL WORKS

- Orientation of the probe:
  - One side of the probe has a dot.
  - The other side will have 2 raised lines usually perpendicular to each other.
  - The side with the perpendicular lines should be oriented to the patient’s right.
HOW IT ALL WORKS
Planes:
- The Short Axis View
  - The most common way to view a target nerve is to hold the probe at a right angle to the long axis of the nerve. (transverse view)
  - If the needle is directed perpendicular to the long axis of the probe, the approach is said to be out-of-plane.
HOW IT ALL WORKS

Transverse Scan Aligns Probe across Short Axis of the Target Nerve

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Illustration 2: Probe Orientation Transverse to Target
"Out of Plane" Needle Approach Crosses the Plane of the Probe Transversely
HOW IT ALL WORKS

Illustration 6: Best Needle Trajectory for Out-of-Plane
HOW IT ALL WORKS
The Long Axis View

The longitudinal edge of the probe is held facing the long axis of the nerve. (longitudinal view)

Most difficult view for needle placement since it is difficult to hold the probe centered.

If the needle is introduced parallel to the long axis of the probe, the approach is said to be in-plane.

This is a good view to appreciate anatomy
HOW IT ALL WORKS

Longitudinal Scan Aligns Probe Face along Long Axis of the Target Nerve

Illustration 3: Probe Orientation Longitudinal to Target
HOW IT ALL WORKS

"In Plane" Needle Approach Crosses the Plane of the Probe Longitudinally

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JACK VANDER BEEK
HOW IT ALL WORKS
HOW IT ALL WORKS

- Making changes to the angle at which the transducing probe is held to the body surface can result in very different images being produced (toggle).
- Use plenty of gel.
- Press firmly.
- Turn down the gain.
HOW IT ALL WORKS

1 = on/off button
2 = function control buttons
3 = depth buttons
4 = zoom (2x)
5 = track pad/ball
6 = gain button
7 = review stored images
8 = patient information
9 = save video clips
10 = save image
11 = color doppler
12 = freeze image
HOW IT CAN BE USEFUL FOR YOU

- Arterial and Central Line Placement (IJs)
- Peripheral Nerve Blocks
- Reimbursement
HOW IT CAN BE USEFUL FOR YOU
HOW IT CAN BE USEFUL FOR YOU

- Central Line Placement
  - differentiate between IJ and carotid artery.
  - the IJ can be compressed with the probe and will usually distend when placed in trendelenburg.
  - the carotid artery pulsates and will not compress with pressure.
  - view IJ overlap of carotid artery.
HOW IT CAN BE USEFUL FOR YOU
HOW IT CAN BE USEFUL FOR YOU
HOW IT CAN BE USEFUL FOR YOU
Peripheral Nerve Blocks

The factors which favor US over PNS are a combination of the advantages of US and the disadvantages of PNS.

The advantage of US guidance over nerve stimulation is simply based on visually guiding the needle through recognizable anatomical structures in a completely reproducible way.
Disadvantages of PNS:
- not all nerves stimulated produce a motor response (neuropathies, hyperglycemia).
- not every place you touch a nerve will produce a twitch.
- there is no absolute relationship between the current strength that produces a twitch and the distance to the needle tip.
(disadvantages of PNS cont.)
- nerve tissue does not have a characteristic “feel” to it as you pass a needle through it.
- passing a needle into or through a nerve does not always produce a paresthesia.
- use of a PNS ultimately leads to positioning a needle and maintaining that needle position throughout the entire volume of injection, since there is a loss of twitch.
Advantages of ultrasound
- procedures are done under direct vision.
- allows for the repositioning of the needle after injection.
- local anesthetic placement in relation to nerve location is seen immediately.
- lower volumes of local anesthetic can be used due to more accurate placement around the nerve.
HOW IT CAN BE USEFUL FOR YOU

- Reimbursement
  - Medicare will cover an anesthesia provider performing a nerve block, but proper coding and payment will depend on the particular circumstance.
  - nerve block as the anesthetic
  - nerve block for postoperative pain control
  - documented request from surgeon
- Documentation
  - a separate written record of the US visualization procedure should be maintained in the patient record.
  - many US codes require the production and retention of image documentation, either electronic or hardcopy.
HOW IT CAN BE USEFUL FOR YOU
US Guided Peripheral Nerve Blocks

- Interscalene
- Supraclavicular
- Axillary
- Femoral
- Popliteal Sciatic
- Fascia Iliaca
Supraclavicular

- Produces a dense and rapid block.
- May be used as the sole anesthetic or for post-operative pain relief.
- Suitable for procedures involving the humerus, elbow and forearm.
- May also be used for procedures of the shoulder and hand with slight modification of technique.
Needed Materials

- US Machine and probe (high frequency)
- Sterile gel with sterile sleeve
- Skin prepping solution
- Local anesthetic 20 – 30 ml and syringe
- 22 ga short bevel needle or stimulating needle
- Portless extension tubing
Position:
- Supine or head slightly elevated
- Both arms at side
- Head turned away from side being blocked
- US screen should be opposite from the blocker for best visualization.
- Scan with the non-dominant hand
- Use the dominant hand to control the needle
SUPRACLAVICULAR

- Scanning
  - Place the probe over the supraclavicular fossa, just behind the clavicle.
  - Aim the probe downward into the chest.
  - Look for a bright horizontal line, this is 1st rib.
  - Look for a hollow circle, this is the subclavian artery.
  - Look for a group of small circles bunched together like grapes or bubbles, this is the brachial plexus.
  - Adjust the probe to optimize the visualization of...
SUPRACLAVICULAR

ANTERIOR

BRACHIAL PLEXUS BUNDLE

SUBCLAVIAN ARTERY

1ST RIB

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Needle Approach

- The brachial plexus can be approached either in-plane or out-of-plane with the needle.
- Approach from the postero-lateral edge of the probe if using the in-plane technique.
- A small angle formed by the subclavian artery and the first rib will frequently house the ulnar nerve.
- Injection is made into the sheath of the brachial plexus and the angle area formed by the subclavian artery and the first rib.
SUPRACLAVICULAR

Illustration 13: Supraclavicular Injection Points
SUPRACLAVICULAR

Illustration 17: Supraclavicular Survey Labels
Suggestions:

- Aim directly for one of the identifiable nerves within the nerve sheath.
- Inject local anesthetic directly into the nerve sheath.
- Inject slowly.
- Watch for cephalad spread of the local.
SUPRACLAVICULAR
SUPRACLAVICULAR
SUPRACLAVICULAR
SUPRACLAVICULAR
SUPRACLAVICULAR
SUPRACLAVICULAR
SUPRACLAVICULAR
INTERSCALENE

- Produces a dense brachial plexus block.
- Best suited for procedures of the shoulder and upper arm.
- May be used for procedures of the elbow and forearm but requires a longer time to set up.
- Relatively easy to locate within the brachial plexus sheath between the middle and anterior scalene muscles.
INTERSCALENE

- **Needed Materials:**
  - US Machine and probe (high frequency)
  - Sterile gel with sterile sleeve
  - Skin prepping solution
  - Local anesthetic 20 – 30 ml and syringe
  - 22 ga short bevel needle or stimulating needle
  - Portless extension tubing
INTERSCALENE

- Position:
  - Supine or head slightly elevated
  - Both arms at side
  - Head turned away from side being blocked
  - US screen should be opposite from the blocker for best visualization.
  - Scan with the non-dominant hand
  - Use the dominant hand to control the needle
Scanning

- Start out by locating the brachial plexus in the supraclavicular space and follow it back to the interscalene space.
- Place the probe over the supraclavicular fossa just behind the clavicle.
- Identify the subclavian artery.
- On the postero-lateral side of the artery is a group of smaller “circles” bunched together, this is the brachial plexus.
INTERSCALENE

ANTERIOR

BRACHIAL PLEXUS BUNDLE

SUBCLAVIAN ARTERY

1ST RIB
INTERSCALENE

- Move the probe slowly cephalad keeping the group of circles in view.
- If you lose the group of nerves, move the probe back to the supraclavicular space and start over.
- While tracing the nerves back to the neck, you will notice that they line up in a vertical column. This indicates the nerves are passing between the anterior and middle scalene muscles.
- This is the interscalene region of the brachial plexus and may be blocked anywhere within this section.
Ultrasound anatomy

INTERSCALENE

Skin

SCM

Lateral

C5

C6

C7

MS

AS

IJ

CA
Needle Approach:
- Less discomfort with in-plane technique, avoids the Jugular veins and Carotid.
- The out of plane technique works well, this way you may visualize the axis of the needle approach.
- Keep the needle between the scalene muscles and within the brachial plexus sheath.
- If the injection goes into the scalene muscle, just stop injecting and redirect the needle between the muscles again.
Suggestions:
- Stabilize the hand used for holding the probe.
- Aspirate frequently.
- Stop injecting if the local anesthetic solution is not seen accumulating around the nerve.
- Withdraw the needle or advance it if there is excessive resistance to injection depending on the image seen.
Avoiding Phrenic Nerve Block:

- Approach the brachial plexus at a lower point.
- Use less local anesthetic volume (6 mls).
- Use a lower concentration of anesthetic. May not be sufficient for surgical motor block but may work well for post-op pain control.
INTERSCALENE
INTERSCALENE

Single injection interscalene
INTERSCALENE

SternoCleido-Mastoid m.
Anterior Scalene

Middle Scalene

Brachial Plexus Trunks

neuraxiom.com
INTERSCALENE
INTERSCALENE
INTERSCALENE
INTERSCALENE
INTERSCALENE
INTERSCALENE
INTERSCALENE
INTERSCALENE
INTERSCALENE
INTERSCALENE
INTERSCALENE
INTERSCALENE
AXILLARY

- Produces a dense block with a rapid onset.
- Works as the primary anesthetic or for post-operative analgesia.
- Suitable block for procedures of the forearm and hand.
- Requires the re-positioning of the needle minimally 3 times to provide coverage to the nerve targets.
**AXILLARY**

- Needed Materials:
  - US Machine and probe (high frequency)
  - Sterile gel with sterile sleeve
  - Skin prepping solution
  - Local anesthetic 20 – 30 ml and syringe
  - 22 ga short bevel needle or stimulating needle
  - Portless extension tubing
Position:
- Supine
- Arm should be abducted with the elbow flexed and the hand near the head.
- Position yourself facing the axilla.
- Your non-dominant hand should hold the probe while your dominant hand holds the needle.
Illustration 19: Axillary External Probe Position
Scanning:

- Hold the probe transverse to the long axis of the brachial plexus.
- Place the probe over the axillary artery high on the upper arm close to the junction with the shoulder.
- Maintain the axillary artery in the center of the scanning picture.
- The nerves of the brachial plexus will appear much brighter in the axilla (hyper-echoic).
- Color Flow Doppler to identify vascular structures.
- Needle Approach:
  - May use in-plane or out-of-plane.
  - In-plane should be directed from the top side.
  - Out-of-plane approach uses a 1 cm long skin wheal parallel to the probe to change entry points.
  - Direct the needle towards each individual nerve.
AXILLARY

LATERAL

MEDIAL

Jack VanderBeek
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AXILLARY BRACHIAL PLEXUS BLOCK

1. NEEDLE POSITION 1: ULNAR-RADIAL
2. NEEDLE POSITION 2: MEDIAN n.

CIRCUMFLEX BLOOD VESSEL
LATERAL
MEDIAL
ULNAR n.
RADIAL n.
MEDIAN n.
AXILLARY n.
MUSOLOCUTANEOUS n.
CORACOBRACHIALIS m.

(c) 2005 Jack Vande Beer
Neuraxiom.com
AXILLARY
AXILLARY

WITHOUT COMPRESSION FROM ULTRASOUND PROBE

LATERAL

NEURAXION LLC © 2008

JACK VANDER BEEK
AXILLARY
Suggestions:

- Aspirate frequently.
- Be sure to see the local anesthetic spreading around the nerves.
- If there is excessive resistance to injection, withdraw or advance the needle.
AXILLARY
AXILLARY
AXILLARY
AXILLARY
AXILLARY
FEMORAL

- Simple and reliable block for postoperative pain relief for procedures of the anterior thigh, knee and medial portion of the lower leg.
- For pain relief involving the posterior portion of the upper leg, knee and lower leg, the femoral block is commonly combined with a sciatic block.
FEMORAL

- Needed Materials:
  - US Machine and high frequency probe
  - Sterile gel with sterile sleeve
  - Skin prepping solution
  - Local Anesthetic and 20 – 30 ml syringe
  - 22 ga short bevel or a stimulating needle or a 20 ga Tuohy 3.5 inches,
  - Portless extension tubing
FEMORAL

- Position:
  - Supine
  - Stand alongside upper thigh
  - US Machine should be opposite your position for easy viewing.
  - Hold probe in non-dominant hand
FEMORAL

- Scanning:
  - Set scanning depth to about 4 – 5 cms.
  - Locate the femoral artery. Stay above the bifurcation of the femoral artery.
  - Focus on the area lateral to the femoral artery, the space containing the femoral nerves will resemble a triangular shape.
Needle Approach:
- In-plane or out-of-plane approach.
- The out-of-plane approach should maintain a narrow angle between needle and probe.
- View the needle progress by watching the tissue layers move as the needle passes through them.
Injection:

Three separate injections:
  - Just lateral to the femoral artery
  - At the angle below the artery
  - At the lateral tip of the triangle
FEMORAL

Illustration 30: Femoral Injection Points
Probe Position for Femoral Block
LEFT FEMORAL NERVE TARGET AREA

FASCIA LATA

FEMORAL NERVE

FEMORAL ARTERY

FEMORAL VEIN

ILIOPSOAS MUSCLE

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JACK VANDER BOEK

Illustration 34: Femoral Nerve Labels
FEMORAL

LEFT FEMORAL NERVE TARGET AREA

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JACK VANDER BOEK

Illustration: 2008 E. Neurax Imaging LLC
FEMORAL
Suggestions:

- Aspirate frequently.
- Stop injecting if you can not see the local anesthetic accumulating in the space.
- When excessive resistance is encountered, either withdraw the needle or advance it slightly.
The sciatic nerve blocked in the popliteal area will provide post-operative pain control for surgeries of the lower leg and foot.

The exception to this is the medial area of the lower leg which is innervated by the femoral nerve.

In order to completely block the lower leg and foot, the addition of a femoral or saphenous block is required.
The tibial nerve is generally easy to find in the popliteal space because it lies closest to the skin at this point.

The tibial nerve lies next to the popliteal artery.

The sciatic nerve bifurcates into the tibial and common peroneal nerves at approximately 8 to 10 cm cephalad of the popliteal crease.

Injection should be at or above the bifurcation.
Popliteal Sciatic

Right Leg Slice 8cm above Knee

Jack Vander Beer

(c)NeuroX.com
PoPliteal Scientific

- Needed Materials:
  - US Machine and high frequency probe
  - Sterile gel with sterile sleeve
  - Skin prepping solution
  - Local Anesthetic and 20 – 30 ml syringe
  - 22 ga short bevel or a stimulating needle or a 20 ga Tuohy 3.5 inches,
  - Portless extension tubing
Position:

- The patient may be prone or lateral.
- You should position yourself to have access to the popliteal space and thigh.
- The ultrasound machine should be opposite you for easy viewing.
- Hold the probe in your non-dominant hand and the needle in your dominant hand.
Popliteal Sciatic
Popliteal Sciatic
Popliteal Sciatic
Poopleal Sciatic

Illustration 56: Poopleal External Probe Position
Scanning:
- Place the probe transversely over the popliteal crease.
- The scanning depth is set to 4-5 cm.
- Identify the popliteal artery. Be careful to not mistake this for the vein that is frequently seen here.
- Once the artery is identified, look cephalad and lateral for the tibial nerve.
- Typically it will appear brighter (hyperechoic) and about the same size as the nerve.
Follow the nerve up the thigh to visualize where the common peroneal nerve joins the tibial nerve.

In most cases the nerves are joined together, sometimes however they remain separate but run alongside each other.

The common peroneal nerve should appear from the lateral side.

Place the block in the area where the two nerves lie side by side.

If at any time you feel you may be mistaking tendon for nerve, flex the knee, tendons will
Needle Approach

- In-plane or out-of-plane technique.
- Keep the angle between the needle and probe very small if using the out-of-plane technique.
- Place the needle tip next to the nerve.
- If resistance is felt with injection, withdraw the needle slightly or advance it.
- Aspirate frequently during the injection.
Illustration 55: Popliteal Injection Points
Popliteal Sciatic

Illustration 57: Popliteal Ultrasound Survey
POPLITEAL SCIATIC
Popliteal Sciatic
Popliteal Sciatic
Popliteal Sciatic
Popliteal Sciatic
Poaliteal Sciatic
FASCIA ILIACA

- Simple block for post-operative pain relief for procedures involving the hip, anterior thigh, and knee.
- This block is well suited for either pre-operative or post-operative administration.
- Especially useful in fractured hips, proximal to mid-femur fractures, and total hip arthroplasty.
FASCIA ILIACA

- Originally described by Alon Winnie as 3 in 1 block (femoral, lateral cutaneous femoral and obturator).
- Frequently performed by a 2 “pop” technique and landmarks.
  - 1st pop is through the fascia lata
  - 2nd pop is through iliacus fascia
US simplifies the needle positioning.

US allows the clinician to view the formation of the pocket from the local anesthetic injected beneath the fascia.
FASCIA ILIACA

- Needed Materials:
  - US machine and high frequency probe
  - Sterile gel and sterile sleeve
  - Skin prepping solution
  - Local Anesthetic and 2 - 30 ml syringes (50 ml)
  - 22 ga short bevel or a 20 ga Tuohy 3.5 inches
  - Portless extension tubing
FASCIA ILIACCA

- Position:
  - Supine
  - Stand alongside upper thigh
  - Non-dominant hand holds the probe
  - US machine should be opposite your position for easy viewing
FASCIA ILIACA

- **Scanning:**
  - Place the probe in a perpendicular orientation over the inguinal ligament between the anterior superior iliac spine and the femoral artery.
  - Locate the femoral artery with the probe.
  - Locate the edge of the ilium.
  - The muscle overlying the bone is iliopsoas.
  - The bright band covering the muscle is the iliacus fascia.
  - Make note of the sartorius muscle position.
FASCIA ILIACA

PROBE POSITION FOR
FASCIA ILIACA COMPARTMENT BLOCK
FASCIA ILIACUS
FASCIA ILIACA

- Needle Approach:
  - Best approach is with an in-plane technique.
  - Insert the needle with the bevel up near the inferior edge of the probe.
  - While advancing the needle you should feel the resistance of the fascial layer.
  - After puncturing the iliacus fascia, stop advancement so that the needle tip lies close to the most superficial level of the iliopsoas muscle.
Aspirate and slowly inject 1 - 2 mls of local anesthetic to see how the volume accumulates beneath the fascia.

Make repeated test injections until the volume accumulated in the desired plane,

Once you are satisfied with the needle placement, inject 5 – 10 mls of local and observe.

Advance the needle into the accumulated pocket an additional 1 – 3 cm while watching on the US and inject the remainder of the local anesthetic.

Be sure the local volume is spreading in a superior
FASCIA ILIACA

SKIN

FASCIA Iliaca
LOCAL

SARTORIUS

ILIOPSCAS
MUSCLE

EDGE OF
ILIUM

SUPERIOR

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Jack Vander Beek

Illustration 34: Fasica Iliaca Injection Points
FASCIA ILIACUS
FASCIA ILIACUS
FASCIA ILIACUS
FASCIA ILIACUS
Suggestions:

- Aspirate frequently.
- Stop injecting if you do not view the local anesthetic accumulating in the space.
- If you experience excessive resistance to injection, either advance or withdraw the needle slightly.
- It is not always possible to get the needle tip exactly between fascia and iliopsoas, however injecting beneath fascia into the superficial layers of the muscle will still create a compartment block.