Ultrasound for Regional Anesthesia

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Currently used techniques for blocks
- Anatomical
- Fascial clicks
- Paresthesia technique
- Peripheral Nerve stimulators
- “Fluoroscopy”
- Ultrasonography
- Combined US and PNS

Problem with anatomy

Tremendous variations between individuals
Nerves move like noodles around vessels
Obesity is increasing
Scary Data

- 30 patients for ISB
- 100% paresthesia = contact with nerve
- PNS activated, increased to 1 mA
- Only 30% had MR

*We often fine-tune motor response, multiple passes = potential for neurotrauma*

Neurostimulation reliability?

**RAPM 2003;28:384-8**

Relationship Between Evoked Motor Response and Sensory Paresthesia in Interscalene Brachial Plexus Block

Carlos A. Bollini, M.D., William F. Urrey, M.D., Luis Vascello, M.D., and Fernando Cachero, M.D.

Disturbing Data

- 22 patients ISB
- Twitches @ 0.5 mA
- PNS turned off and needle advanced to paresthesia (21/22)
- PNS turned on again
- MR only in 13 of them
- Withdrawal resulted in MR in all

*Where are we when we do not get the motor response? Inside or outside the nerve?*
USRA: The Beauty

- Can see the nerves even in morbidly obese
- Can see the surrounding structures
  - Avoid pneumothorax, vascular puncture
- Can see the needle and nerve interaction
- Can see the spread of the local anesthetic
- Can rescue after LA injection
- Can aid epidural catheterization in children*
- Can help assess the depth of TP for PVB, Psoas block
  - Avoid multiple blind passes, pneumo, bowel/kidney perforation, hematome
- *Willschke H et al BJA 2006;97:200

The Beauty: Continued

- Can see/estimate the catheter tip location
- Fewer passes less painful : need not use PNS with fractures@
- Higher primary success*
- Lower secondary catheter failure#
- Lower doses**
- Can even see small nerves (Facet, saphenous,GON)
- Identify anatomical abnormalities
  
  
  **Triado VD et al A&A 2007;104:1270
  
  **Casati Et al BJA 2007;98:823
  
  # Dhir S and Ganapathy ASRA abstract 2006
  
  # Dhir S and Ganapathy ASRA abstract 2006

Basics of Ultrasound

- Human hearing 20 Hz to 20,000 Hz
- Ultrasound is > 20,000 Hz or 20 KHz
- Diagnostic ultrasound is 2 MHz to 15 MHz
Neurostimulation Unreliability
Anesthesiology 2002;96:552-4

Inability to Consistently Elicit a Motor Response following Sensory Paresthesia during Interscalene Block Administration
William F. Uhl, M.D., Jennifer Santos, B.S.T.

What is Ultrasound
- Sound waves outside hearing range of humans
- Physical characteristics akin to normal sound waves

Characterized by

<table>
<thead>
<tr>
<th>Physical Characteristic</th>
<th>Interaction with Tissue</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pressure</td>
<td>Reflection</td>
</tr>
<tr>
<td>Frequency</td>
<td>Refraction</td>
</tr>
<tr>
<td>Wavelength</td>
<td>Scattering</td>
</tr>
<tr>
<td>Speed of sound</td>
<td>Attenuation</td>
</tr>
</tbody>
</table>

Doppler effect to identify flow

What do the transducers do?
- Generate pulses of US and receive US waves
- Piezoelectric crystals that vibrate with electricity
- Can also receive vibrations and convert to electrical signals
- Can Span and Focus at a point: show activities at this point
- Doppler effect to identify flow
How do tissues look?

- Artery: Hypoechoic, pulsatile, noncompressible
- Vein: Hypoechoic, Compressible “nonpulsatile”
- Bone: Hyperechoic rim, anechoic under
- Tendon: Hyperechoic or hypoechoic
- Muscles: Hypoechoic with striations
- Nerves: Hypoechoic with rim
  - Bunch of grapes
  - Hyperechoic

Transverse or SHORT AXIS orientation: Most commonly used

Longitudinal or LONG AXIS orientation
What probe to select

- Higher the frequency lower the penetration, better resolution
  - For superficial structures
  - Axillary, Supraclavicular, ISB.IJ
- Lower the frequency, greater the penetration
  - For deep structures
  - Sciatic Lumbar plexus, spinals, PVB

Selection of Probes

- Linear
- Curved array
- Low Frequency
- High Frequency
- Phased Array
- 3 and 4D
Linear Vs Curved array

Advantage of curved array
- Can see adjacent landmarks such as greater trochanter and ischial tuberosity for sciatic

Physical Principles
Acoustic Couplants

Ultrasound will not travel through air at this frequency. A transmission gel is required to eliminate surface air.
Acoustic Coupling: Probe covers

Machine setting to optimize

- Gain: General and Time Gain Compensation
  - Autogain
  - capacity to hear, can be adjusted with buttons
- Depth: depth of vision
- Gray map
- Focus position
- Tissue Harmonics
- Cross beam, Multibeam, compound imaging
Non perpendicular incidence of sound beam

Angle of incidence of US beam
- Perfectly perpendicular
- 70 degrees
- 45 Degrees

Toggling the probe 90 degrees to 45 degrees
Needle probe orientation
Parallel and perpendicular

Needle orientation
1. SAX OOP
2. SAX IP

In plane short axis
- See the entire needle
Handling the Probe: Probe needle alignment

What impedes sound transmission?

- Acoustic Impedance
- \( Z = \rho c \) (Density X speed of sound in that medium (Kg/m²/s Rayl))
- Air = 0.0004X10⁶
- Skull = 7.8 X 10⁶
- Muscle Kidney etc = 1.6-1.7 X 10⁶
- Lung = 0.18X10⁶
- Factors that distort waves: air bubbles, metal objects, bone etc
Imperative

- Do not scan over a bone
- Do not inject too much air/bubbles
- Aim at perpendicular orientation to Nerve
- Rotate probe to get this orientation

Color Doppler

- Use it to identify vessels
  - Often nerves run in association with vessels
- Use to identify catheter tips and needle tips (tissue movement with injection)
- Learn to adjust color gain
- Angle of probe in relation to flow

Echogenic needles
Hakko™ Medical Co Japan
Havel's™ USA

Patented Corner Cube Reflectors (CCR™)
Provide multi-angled surfaces for maximum reflection even at steep angles.
The notch

- Probes have a notch to guide you with orientation of the image
- Notch is represented by a marker on the screen
- The position of the marker can be changed by the operator in the machine
- The images can be inverted too!!!
- Have a standard setting to get going

Where is the Evidence the USRA is better?

Ultrasound Guidance With Nerve Stimulation Reduces the Time Necessary for Resident Peripheral Nerve Blockade

- RAPM 2007;32:448-454
- Retrospective analysis of residents' blocks
- Time to perform block
- Number of needle insertion
- Number of vessel punctures
- Block efficacy
### US guided PNS

<table>
<thead>
<tr>
<th>Block</th>
<th>N</th>
<th>Time</th>
<th>Passes</th>
<th>N</th>
<th>Time</th>
<th>Passes</th>
</tr>
</thead>
<tbody>
<tr>
<td>SB</td>
<td>31</td>
<td>1</td>
<td>2</td>
<td>37</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>AX</td>
<td>31</td>
<td>1.5</td>
<td>6</td>
<td>37</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>FEM</td>
<td>32</td>
<td>1</td>
<td>2</td>
<td>37</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>PFB</td>
<td>30</td>
<td>1</td>
<td>1.5</td>
<td>31</td>
<td>2.5</td>
<td>3</td>
</tr>
</tbody>
</table>

No difference in failures

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### Is it the same with experts?

“The Trojan War will not take place?” Borgeat

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### Study

- 60 adults
- Multiple injection US or with PNS
- 20mls of 0.75% ropivacaine
- Onset, offset of block, number of passes, pt acceptance and failure
- Only the experienced did both blocks
Results

<table>
<thead>
<tr>
<th>Variable</th>
<th>US</th>
<th>PNS</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>passes</td>
<td>4</td>
<td>6</td>
<td>0.002</td>
</tr>
<tr>
<td>Sen onset</td>
<td>14</td>
<td>18</td>
<td>0.01</td>
</tr>
<tr>
<td>Motor on</td>
<td>24</td>
<td>25min</td>
<td>NS</td>
</tr>
<tr>
<td>Failure</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Pain procedure</td>
<td>20%</td>
<td>48%</td>
<td>0.028</td>
</tr>
<tr>
<td>sat</td>
<td>100%</td>
<td>93%</td>
<td>NS</td>
</tr>
</tbody>
</table>

Should we use PNS at all?

Reports of Original Investigations

Ultrason guidance improves success rate of axillary brachial plexus block

Chan VW Can J of Anesthesia 2007;54:176
Ultrasound Guidance for Lateral Midfemoral Sciatic Nerve Block: A Prospective, Comparative, Randomized Study

61 adults for ankle/forefoot surgery
Randomized to US+PNS or PNS alone

Data

- Time to locate nerve
- Number of attempts
- Depth and Diameter of Sciatic nerve (US)
- Distribution of LA (US)
- Type of twitch
- Onset and offset of motor/sensory block
- Tourniquet tolerance
Table 2. Number of Attempts, Time Required to Perform the Block, Time to Complete Block, Patient Discomfort During Block

<table>
<thead>
<tr>
<th>US Group (n = 30)</th>
<th>ES Group (n = 31)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of attempts</td>
<td>1</td>
<td>13 (11.9%)</td>
</tr>
<tr>
<td>2</td>
<td>7 (23.3%)</td>
<td>6 (19.4%)</td>
</tr>
<tr>
<td>3</td>
<td>0 (0%)</td>
<td>12 (38.8%)</td>
</tr>
<tr>
<td>Median number of attempts</td>
<td></td>
<td>1 (1-2)</td>
</tr>
<tr>
<td>Time (min)</td>
<td>5 (5-15)</td>
<td>5 (5-15)</td>
</tr>
<tr>
<td>Sensory latency (min)</td>
<td>45 (5-60)</td>
<td>45 (5-60)</td>
</tr>
<tr>
<td>Deep peroneal</td>
<td>45 (5-60)</td>
<td>40 (5-60)</td>
</tr>
<tr>
<td>Tibial</td>
<td>35 (5-60)</td>
<td>35 (5-60)</td>
</tr>
<tr>
<td>Motor latency (min)</td>
<td>40 (5-60)</td>
<td>50 (5-60)</td>
</tr>
<tr>
<td>Tibial</td>
<td>35 (5-60)</td>
<td>50 (5-60)</td>
</tr>
<tr>
<td>Duration (h)</td>
<td>17.5 (6.25)</td>
<td>17 (6.2)</td>
</tr>
<tr>
<td>Sensory</td>
<td>20 (7-24)</td>
<td>17 (11-24)</td>
</tr>
<tr>
<td>Motor</td>
<td>17 (7-24)</td>
<td>17 (11-24)</td>
</tr>
<tr>
<td>VAS</td>
<td>23 (7.7%)</td>
<td>27 (7.7%)</td>
</tr>
<tr>
<td>≥4</td>
<td>7 (23.3%)</td>
<td>4 (12.9%)</td>
</tr>
</tbody>
</table>

Table 3. Quality of Nerve Block, Tolerance to the Pneumatic Tourniquet and Stimulated Nerve

<table>
<thead>
<tr>
<th>US Group (N = 30)</th>
<th>ES Group (n = 31)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensory block quality</td>
<td>0</td>
<td>29 (96.7%)</td>
</tr>
<tr>
<td>1</td>
<td>0 (0%)</td>
<td>7 (22.6%)</td>
</tr>
<tr>
<td>2</td>
<td>1 (3.3%)</td>
<td>2 (6.5%)</td>
</tr>
<tr>
<td>Tolerance to tourniquet</td>
<td>0</td>
<td>28 (93.3%)</td>
</tr>
<tr>
<td>1</td>
<td>2 (6.7%)</td>
<td>14 (45.2%)</td>
</tr>
<tr>
<td>2</td>
<td>0 (0%)</td>
<td>2 (6.5%)</td>
</tr>
<tr>
<td>Stimulated nerve</td>
<td>Peroneal</td>
<td>21 (70%)</td>
</tr>
<tr>
<td>Tibial</td>
<td>9 (30%)</td>
<td>18 (58.1%)</td>
</tr>
</tbody>
</table>

Sensory block quality: 0 = complete sensory block; 1 = partial sensory block; 2 = normal sensory perception. Tolerance to tourniquet: 0 = good tolerance; 1 = sensation necessary; 2 = no tolerance. US group = ultrasound guided group; ES group = nerve stimulator group.

Neurostimulation in Ultrasound-Guided Infraclavicular Block: A Prospective Randomized Trial

Emmanuel D’Amico, MD, FACP
Stephen J. Williams, MD, FACP
Concettina Arcuri, MD, FACP
Philippe Droguett, MD, FACP
Patrick Harris, MD, FACP
Monique Rod, RN
Francisco Girard, MD, FACP

Ultrasound-guided US infraclavicular blocks provides real-time visualization of the advancing needle and local anesthetic distribution. Whether visualization of local anesthetic spread can augment neurostimulation at the end point for local anesthetic injection during US block has never been formally evaluated. Therefore, for this prospective randomized study, we recruited 71 patients scheduled for hand or forearm surgery and compared the speed of injection and quality of US infraclavicular blocks with either US alone (Group 1) or US combined with neurostimulation (Group 2). In Group 2, local anesthetic was deposited in a U-shaped distribution posterior and to each side of the subclavian artery using two injections as close to the mid clavicle (2) and 2 cm above the clavicle (3). The study was designed as a single-blind study. Patients in Group 1 received 1.2 mL of 0.5% lidocaine plus 1:100,000 epinephrine at the time of injection, while patients in Group 2 received 1.2 mL of 0.5% lidocaine plus 1:200,000 epinephrine at the time of injection. The number of patients in each group that required additional injections was significantly lower in Group 2 compared to Group 1 (P < 0.05).

A&A 2007;104:1275

Do you need a PNS with US
Study

- 72 patients randomized
- Purely US guided ICB to generate a U around artery or
- With PNS eliciting distal twitch (0.3-0.5mA)
- 0.5mL/Kg of a mixture of 1.5% lido and 0.125% bupi with epi
- Persevered for upto 20mins
- Procedure time, motor sensory block