Ultrasound in Lumbar Neuraxial Anesthesia

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August Bier 1898

- First spinal anesthetic

- Also –
  First nausea, vomiting and headache

US Lumbar Spine

- RA is currently the gold standard for OB and this won’t soon change
- Therefore the search for improvement in quality and safety deserves our closest attention
- Failure is multi-factorial – one of the biggest is the **blind nature** of the block

Labor Epidural Failure Rate

- Reported labor epidural failure rates 1.5-20%
- ADP 1-5% with ~50% incidence of PDPH
Pre Block Assessment

- Palpation – (most of the time)
  - Interspace
  - Midline

Can’t palpate –
- depth (distance from skin-epi space)
- angle of insertion

? Obesity, scoliosis, previous spinal surgery?

Palpation – Intercristal Line

Interspace Identification:
Accuracy of palpation

<table>
<thead>
<tr>
<th>Interspace Selection</th>
<th># pt’s</th>
<th>% correct</th>
<th>Incorrect caudad</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whitty</td>
<td>121</td>
<td>55%</td>
<td>13%</td>
</tr>
<tr>
<td>Schlotterbeck</td>
<td>99</td>
<td>36%</td>
<td>15%</td>
</tr>
</tbody>
</table>
Accuracy of Palpation – Intercristal Line

n=45, term OB
Palpated IC line – verified by US

Lee – n=51 – clinical estimate - 14% in agreement with US
23% one IS higher
25% > one IS higher

Anatomical variation

<table>
<thead>
<tr>
<th>INVESTIGATOR</th>
<th>LANDMARK</th>
<th>MEAN</th>
<th>RANGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kim - 690 MRI’s</td>
<td>Tuffier’s line</td>
<td>L4-5</td>
<td>L3-4 to L5-S1</td>
</tr>
<tr>
<td>Conus Medularis</td>
<td>L1 (lower 1/3rd)</td>
<td>T12 to L3</td>
<td></td>
</tr>
<tr>
<td>Soleiman – 635 MRI’s</td>
<td>Conus Medularis</td>
<td>L1 (middle 1/3rd)</td>
<td>T11 to L3</td>
</tr>
</tbody>
</table>

Interspace selection – Accuracy of palpation

Conus medullaris
30% T12
60% L1
10% L3
L 3-4

32% one IS ↑
55% correct
13% one IS ↓

Traumatic Spinal Cord Injury

- Report 2001 – 7 cases of cord injury
  - Pencil point needle
  - Thought to be inserted at L 2-3
  - 6/7 were OB
- Damage to more than one root
- Unilateral
- If pain – *stop, don’t inject*
Morbid obesity

- BMI $\geq 40 = $ morbid obesity in pregnancy
- MO = ASA 3 (healthy pregnancy is a 2)

↓ FRC

Obesity – Risks and Complications

<table>
<thead>
<tr>
<th></th>
<th>Morbidly Obese (%)</th>
<th>Control (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vaginal delivery</td>
<td>38</td>
<td>76</td>
</tr>
<tr>
<td>Cesarean section</td>
<td>62</td>
<td>24</td>
</tr>
<tr>
<td>Labor requiring C/S</td>
<td>48</td>
<td>9</td>
</tr>
<tr>
<td>Emergency C/S</td>
<td>32</td>
<td>9</td>
</tr>
<tr>
<td>Operative time &gt; 60 min</td>
<td>48</td>
<td>9</td>
</tr>
<tr>
<td>Prolonged delivery interval</td>
<td>25</td>
<td>4</td>
</tr>
</tbody>
</table>

Anesth Analg 1993;79:1210-8

Morbid Obesity Predicts Difficulty?

- 427 patients
  - BMI
  - Ability to palpate
  - Ability to flex
  - Experience of practitioner

# of passes and total time required

AA 2009;109:1225-31

Obesity – Risk for C/S

<table>
<thead>
<tr>
<th>BMI</th>
<th>Rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;20</td>
<td>0</td>
</tr>
<tr>
<td>21-30</td>
<td>0.3</td>
</tr>
<tr>
<td>31-40</td>
<td>31.6</td>
</tr>
<tr>
<td>41-50</td>
<td>77.6</td>
</tr>
<tr>
<td>51-60</td>
<td>94.0</td>
</tr>
<tr>
<td>&gt;60</td>
<td>97.5</td>
</tr>
</tbody>
</table>

Anesth Analg 1999;91:A1064
US (Ultrasound) **Advantages**

- Determine best insertion point
- Ability to estimate needle insertion angle
- Calculate distance from skin to epidural space
- Improvement of successful block

US (Ultrasound) **Advantages**

- Noninvasive technique
- Same machine used for OB patients
- Screening tool to predict difficulty
- Excellent non-invasive training tool

US **Disadvantages**

- New skill to learn
  - requires training and practice to master
- Expensive equipment
- Longer preparation time
- Pre-puncture scan, not real time guidance
- Much more difficult in the thoracic spine –
  - Angulated spinous processes
  - Lamina overlap

**Evidence for Utility and Application**

Limited evidence suggests US improves **success and quality**

- RCT n=300 OB
  - Incomplete analgesia 2% vs 8%
  - Lower post block pain scores
  - Assessment was not blinded

- RCT n=370 OB Vallejo *et al.*
  - Epi failure rate 1.6% vs 5.5%
Evidence for Utility and Application

Increases **ease of performance**
(time and needle manipulations)

- RCT n=120 Chin *et al.*
  - Pt’s with difficult surface landmarks (obesity, spinal deformity, previous difficulty)
  - US pt’s
    - First attempt success rate – 62% v 32%
    - Needle passes for success – 6 v 13


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Why has the technology been slow to catch on?

Anatomy - Spinal

- Cervical 7
- Thoracic 12
- Lumbar 5
- Sacral fused

Anesth 1980;52:513-6
Anatomy - Vertebral

- **Vertebral Column**
  - Spinous processes
  - Transverse processes
  - Articular processes (facet joints)
  - Lamina

Anatomy

- **Spinous Processes**
- **Transverse Processes**
- **Lamina**
- **Articular Surfaces**

Position

- Scan in position used for block placement
- Not sterile
- Pre procedure mapping of anatomy
**Flexion**

**Transducer Selection**

**High Frequency**
- 7 - 15 m Hz
- Linear transducer
- High resolution picture
  - Relatively clear picture
  - Undistorted image
- Poor tissue penetration
- Useful for superficial nerves
  - Peripheral nerve & TAP blocks

**Low Frequency**
- 2-5 m Hz
- Curved array transducer
- Lower resolution
  - Poor picture quality
- Better tissue penetration
- Useful for deeper blocks such as spinal and epidural

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**Useful Tips for a Good Image**

- GEL, GEL, GEL
- CONTACT, CONTACT, CONTACT
- APPLY fair amount of PRESSURE
- Adjust probe depth to 7-10 cm

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**Useful Tips for a Good Image**

- Constant small probe adjustments
  - Slide, rotate, tilt
Anatomical Planes –
2 basic ultrasonographic views

**Longitudinal Paramedian:**
Probe lateral to median plane
Image through paraspinous muscle
Lamina, lig flavum and sacrum

**Transverse Midline:**
Probe horizontal
Image spinous processes and interspaces

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**Longitudinal Paramedian (oblique)**

**Paramedian**
Passes through paraspinous muscle
Visualize lamina and Ligamentum flavum
Used to count interspaces

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**Transverse Midline**

- Transverse
  - Determines midline
  - Depth to ligamentum flavum
**Imaging Echogenicities**

- **Hyperchoic** (white & bright)
  - Bone
  - Ligament
  - Dura

- **Isoechoic** (grey)
  - Muscles

- **Hypoechoic** (dark & black)
  - Intrathecal space
  - CSF
  - Blood
  - Fluids

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**Pattern Recognition**

**Step One:** Longitudinal Paramedian Image of Sacrum and L5-S1 Interspace

- Start left paramedian (top of crease)
- Slightly angled toward center, 2-3 cm off midline
- Sacrum is solid white line – ID L5-S1 interspace

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**Step Two:** Slide Probe Cephalad

- Move cephalad
- Look for “saw” image
- Count and mark interspaces – from center of probe
The lig flavum-epi space-post dura appear as a single linear hyperechoic structure "posterior complex"

Step Three: Rotate Probe to Transverse and ID interspace

- When at the desired interspace –
- Rotate probe to transverse
- Position in midline
- “Cone” image indicates probe is over spinous process
**Step Four:** Slide Probe into Interspace

- Slide probe cephalad or caudad into selected interspace
- Looking for “bat head” image
- “Ears” are articular processes – top of “head” is flavum/dura (posterior complex)
- Mark skin

**Place Marks – Insertion Point is Intersection of Lines**

*Images of the process*

**Step Five:** Measure Distance from Skin to Dura/flavum

*Image of measurement process*

**Sonoanatomy in Scoliosis**

- L2-L3 – essentially normal
- L3-L4 - assymetrical

*Images of sonoanatomy in scoliosis*
Avoid significant compression of subcutaneous tissue during measurement of skin to flavum distance