How to Make Your Spinal Work

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Failed Spinal

• How common is failure?
• Wake Forest experience 2000-2002
  – Spinal failure occurred in 2.7% overall
• Basel, Switzerland 2009
  – Failure rate 2.7%
  – Authors reference a range of 0.46%-17%

Pan et al. IJOA 2004
Steiner et al. BJA 2009
Case Reports

- Series of four cases\(^1\)
- 2 consecutive cases\(^2\)
- 5 cases, same batch\(^3\)
- WFU – 2 in one day\(^4\)
- Several others in literature; many anecdotal reports

2. Harris IJOA 2004; 13:130-1
“Bupivacaine Gone Bad”

- Perhaps the single most popular explanation for failed spinal
“Bupivacaine Gone Bad”

- Perhaps the single most popular explanation for failed spinal
Atomic Decay

$\frac{^{14}\text{C}}{^{13/12}\text{C}}$ Ratio

Time
Bupivacaine decay

Bupivacaine Activity

Time
Road Kill
Road Kill
Road Kill

- The carcass is not fresh for a set period of time, then suddenly dust in the cracks
Road Kill

Time

Ratio Fresh/Rotten flesh

\[ \text{Road Kill} \]
Bupivacaine
Bupivacaine

- With “bad bupivacaine” a *spectrum* of failure would occur.
- In contrast, reports are of rare complete failure, with success of surrounding blocks in same lot.
For the Sake of Argument

- Bupivacaine violates universal laws to decay on this curve:
For the Sake of Argument

- Spinal Fentanyl 20mcg reliably causes mid-thoracic pin prick levels\(^1\)
- Case reports refer to complete absence of levels to cold and/or pinprick
- This implies that whatever happened to the bupivacaine also happened to the fentanyl

1. Anesthesiology 2002;96:1070-1073
In vitro testing

- Dr Klaus Lipfert (Astra Zeneca)
- Bupivacaine (and other amides) are very heat stable
  - 120°C for at least 15 minutes – no degradation
  - Long term storage at >38°C causes only insignificant degradation

Personal communication Jan 2007
Bupivacaine stability

• Indeed, Astra Zeneca is quite confident in its stability.
Bupivacaine stability

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Figure 1: Mass Spectrophotometry Results

Absorbance (Relative Concentration)

<table>
<thead>
<tr>
<th>Case #1 (Lot 51-218-DK)</th>
<th>Case #2 (Lot 46-407-DK)</th>
<th>Control (Lot 51-218-DK)</th>
<th>Control (Lot 50015DD)</th>
</tr>
</thead>
</table>

Bupivacaine Vial

SOAP 2008, A189
so, what's causing the failures?
Cause of Failures

• Local Anesthetic Resistance
  • Rachiresistance
  • Sodium channel mutation
  • Tachyphylaxis

• Anatomical Abnormalities
  • Cysts
  • Physical barriers to CSF communication
  • Extremes of CSF volume
Anatomic abnormalities
Physical Barriers

- *Human Spinal Arachnoid Septa, Trabeculae, and “rogue strands”*
- Sixty two human cadaver spinal cords dissected
- Investigation not designed to predict spinal failure
- Findings suggest that no barriers to CSF flow exist (very detailed descriptions and many photos)
- Anatomic barriers have been suggested, but never implicated in a case of spinal failure

Anatomic abnormalities

CSF Volume

- **Lumbosacral CSF Volume is the Primary Determinant of Sensory Block Extent and Duration During Spinal Anesthesia**
- 10 healthy volunteers - 50mg lidocaine SAB
- Pin prick levels
- Motor block
- Time to regression
- Axial MRI measurements of lumbar CSF volume were compared to clinical parameters

Carpenter, Hogan, Liu, et. al. Anesthesiology 1998; 89: 24-9
Anatomic abnormalities

CSF Volume

Figure 1. Examples of magnetic resonance images used to determine cerebrospinal fluid (CSF) volume. (A) Axial image at the L4-L5 intervertebral foramen showing bright CSF containing nerve roots seen as gray defects. The area enclosed by the perimeter of the CSF (arrows) is measured to determine the dural sack volume. Cord volume (not seen at this level) is subtracted to determine the volume of CSF and roots. (Orientation is anterior up; scale bar = 1 cm; g = posterior root ganglion; vb = vertebral body.) (B) Sagittal scout image showing levels of axial images.

Anesthesiology 1998; 89: 24-9
Anatomic abnormalities

CSF Volume

Anesthesiology 1998; 89: 24-9
Anatomic abnormalities

CSF Volume

Anesthesiology 1998; 89: 24-9
Anatomic abnormalities
CSF Volume

- Case Report
- 37 yo G2P2 for PPBTL; spinal planned
- Hyperbaric 2% mepivacaine 44mg
- Hyperbaric 2% mepivacaine 40mg
- Hyperbaric 5% lidocaine 62.5mg
- One sided S1 level; no motor block
- Uneventful GA and recovery
- Post-op MRI – very large CSF volume

J Anesth 2007 21:399-402
Anatomic Abnormalities
Dural Ectasia – case report

• 28 yo with Marfan’s Syndrome
• Elective C/S (indicated by aortic dissection)
  – Continuous spinal catheter
  – 21mg bupivacaine incrementally dosed
  – Eventual T10 level
  – Converted to GA

Lacassie et al. Br J Anaesth. 2005 Apr;94(4)
Dural Ectasia

Lacassie et al. Br J Anaesth. 2005 Apr;94(4)
Dural Ectasia

Lacassie et al. Br J Anaesth. 2005 Apr;94(4)
Maldistribution
Maldistribution

• What is Maldistribution?
  – Injected drug is restricted to a small volume of CSF
  – The term was popularized by reports of nerve injury with spinal microcatheters

Maldistribution

- Safe care of the patient is most important, anyway
- Maldistribution must be assumed when a spinal block fails.
- Assuming that the local anesthetic has “gone bad” can be hazardous:
  - Cauda equina with high dose single shot, and repeat spinals
  - Cauda equina with microcatheter use – FDA’s conclusion was maldistribution
Maldistribution

- “Microcatheter era”: Drasner et al, UCSF
- Spinal cord model – fluid filled glass tube

Maldistribution

- BJA June 2009
  - 2 scientific articles
  - 1 review article
  - 1 editorial
Maldistribution

• Article 1
  – CSF Bupivacaine concentrations during spinal failure
    • CSF sample drawn at time of repeat injection
    • Concentrations were highly variable
    • More than half of the failures had “adequate” levels
    • Many had “high” levels

Steiner et al. BJA 102(6): 2009
Maldistribution

• Article 2
  – CSF Bupivacaine concentrations during *successful* spinal anesthesia
    • Patients consented to have a sample drawn from second puncture at same site
    • Concentrations were highly variable
    • Many were below the concentrations previously defined as “adequate” by the authors

Ruppen et al. BJA 102(6): 2009
Maldistribution

CSF Bupivacaine Concentration Ranges - Successes vs. Failures

Failures = 3.36 to 1020 ug/ml

Successes = 25.9 to 781 ug/ml

CSF Bupivacaine Concentration (ug/ml)

Steiner et al BJA 102(6): 2009
Ruppen et al BJA 102(6): 2009
Conclusion – How to Make Your Spinal Work

- It’s not “bad bupivacaine”.
- **Anomalous resistance** to local anesthetics is exceedingly rare.
  - Rachiresistance
  - Tachypylaxis
  - Sodium channel mutation
- **Anomalous anatomy** is also uncommon, but a possible cause in some cases.
  - CSF Cysts
  - Barriers
  - *Extreme CSF volume*
- **Maldistribution** is most likely in most cases.
Conclusion – Recommendations

- Patient safety can be jeopardized by incorrectly assuming that an amide local anesthetic has “gone bad”
- Assume that each and every spinal injection has delivered drug to the subarachnoid space.
- Make sure block has had adequate time to set up
- Check sacral dermatomes for restricted block
Maldistribution

- Complete failure might be indistinguishable from a restricted sacral block
Conclusion – Recommendations

• When reinjecting:
  • Choose a different interspace
  • Keep the *total* dose within a safe maximum
  • Omit morphine; use other adjuncts with caution
  • Be prepared for high block
  • Be prepared for prolonged block

• Consider postponing elective cases
• Consider plan B
The End