Maximizing Safety of Cervical Epidural Injections

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“Cervical transforaminal epidural steroid injections: more dangerous than we think?”

- Scanlon - *Spine* 2007
  - 78 complications (with 13 deaths) including:
    - 16 vertebrobasilar brain infarcts
    - 12 cervical spinal cord infarcts
    - 2 combined brain/spinal cord infarcts
Introduction

• CERVICAL TF EPIDURAL COMPLICATIONS
  • Overall = 16-18% ¹
  • Minor = 14.5%
    • neck pain, headache, insomnia, and facial flushing
  • Moderate = 0.9% - 2.0% ²
    • dural puncture, vasovagal reaction, and allergic reaction
  • Serious = NONE reported in any large case series
    • 1579 injections - (Derby 2004)
    • 1036 injections - (Ma 2005)

¹ (Botwin 2003, Ma 2005, Huston 2005)
² (Slipman 1995, Botwin 2003)
Cervical Epidural Injections

- Serious complications reported
  - Transforaminal
    - Radiculopathy - (Windsor 2003)
    - Anterior spinal artery syndrome - (Brouwers 2001, Rosenkranz 2004)
    - Quadriplegia - (Bose 2005, Rathmel 2004)
    - Ischemic stroke - (Scanlon 2003, Windsor 2003, Beckman 2006)
    - Death - (Tiso 2004, Rozin 2003)
Cervical Epidural Injections

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    - Death - (Tiso 2004, Rozin 2003)
  - Interlaminar
    - Epidural hematoma - (Williams 1990)
    - Epidural abscess - (Huang 2004)
    - Cervical myelopathy - (Bose 2005)
    - Death - (Reitman 2002)
Introduction

• EPIDURAL INJECTIONS
  • The good news
    • Complications are uncommon
    • Most complications are minor
  • The bad news
    • Injections are common
    • Patients are abundant
    • Some complications are SEVERE !!
Sources of Complications

- Physician
  - Procedure/Patient Selection
    - Poor outcome
    - Angry, litigious patient
    - Unnecessary exposure to RISK
  - Needle placement
    - Vascular insult
    - Dural puncture
    - Spinal cord injection
    - Hematoma
    - Pneumothorax
    - Infection
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PREVENTING HEMATOMA

• ASRA anticoagulation guidelines
PREVENTING SPINAL CORD INJECTION
Sources of Complications

- Physician
- Procedure/Patient Selection
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Mechanisms

- Vascular insult
  - Spasm
  - Dissection
    (Rozin 2003, Brouwers 2001)
- Arterial embolization
  - Vertebral Artery
    (Rathmell 2004)
  - Radiculomedullary artery
    (Rosenkranz 2004)
Mechanisms

- **Basic science**
  - Support embolization
    - (Tiso2004, Derby 2008)

- **Animal studies**
  - Support embolization
    - (Okubadejo 2008, Dawley 2009)

- **Anatomic studies**
  - Support embolization
    - Many vulnerable arteries
      - (Huntoon 2005)
  - Discount spasm
    - Abundant collateral circulation
      - (Huntoon 2005)
PREVENTING VASCULAR INJECTIONS

• Why does it matter?
  – Let me count the ways...
Prevention

- Reason 1 = Inadvertent vascular injections happen
  - Lumbar incidence
    - 11% - (Sullivan 2000)
    - 11% - (Furman 2003)
    - 13% - (Smuck 2007)
      - 9% simultaneous to epidural flow
  - Cervical incidence
    - 19% (Furman 2003)
    - 30% (McLean 2009)
    - 30% (Smuck 2009)
      - 19% simultaneous to epidural flow
Prevention

- Reason 2 = Vascular injections are *BAD*
  - Venous
    - IV corticosteroids = placebo - (Finckh 2006)
  - Arterial
    - Seizure - (Smuck 2010, Chung 2011)
    - Myelopathy
    - CVA - (Scanlon 2003, Windsor 2003, Beckman 2006)
  - Death - (Tiso 2004, Rozin 2003)
Prevention

- Incidence of Arterial Injection
  - Radicular Artery = 0.56%
    - 2 in 354 injections (Derby 2004)
  - Vertebral Artery = ?????????????
Vertebral Injection Estimate

Informal analysis of 1 small community

- Locally 1 serious complication
  (Washtenaw County during a 5 year period)
- 18 physicians in the county
- 70 Cervical TF ESI/year
  - Average by University PM&R Interventionalists

\[
18 \text{ MD's} \times 70/\text{yr} \times 5\text{yrs} = 6300 \text{ injections} \\
1/6300 = 0.016\%
\]

Prevention

- **Reason 3**
  - There are methods known to reduce the incidence of vascular injections.
HOW TO PREVENT?
PREVENTION  Method #1

•  Don’t do them
PREVENTION  Method #1

• Don’t do them
  • Alternative Injection Techniques
    • Interlaminar ESI
      • Same minor complications as transforaminals (Derby 2004, Maus 2013)
      • Less effective (lumbar)
      • Reports of similar serious complication
        • Quadriplegia (Bose 2005)
        • Death (Reitman 2002)
        • Malpractice claims (Lofsky 2005)
    • Epidural catheter (Larkin 2003)
Prevention Method #2

- **Needle Type**

  % Vascular injections

  (Smuck 2010)

  - Trucath
    - 4.9%*
  - Whitacre
    - 16.6%
  - Blunt-tip
    - 15.6%

  (Smuck 2012)

  - Quinke
    - 12.8%
  - Chiba
    - 15.6%

  *p<0.05
PREVENTION Method #3

• **Needle Position**
  
  • Posterior foramen
    • Avoid vertebral artery
    • Be aware of abnormal anatomy!!
  
  • Midsection of the lateral pillar (in AP view)
    • Too deep risks subdural injection
    • Too shallow increases vascular risk
      • Deep and Ascending Cervical arteries
      • Radicular arteries are larger at the outer foramen and thus more prone to cannulation (Huntoon 2005)
PREVENTION Method #4

- Syringe Aspiration
  - Aspiration negative in 74% of intravascular injections (Sullivan 2000)
  - Blood flashback (Furman 2003)
    - 97% specific
    - 45.9% sensitive
PREVENTION Method #5

- Fluoroscopy
  - Improves needle placement
  - Confirms medication delivery
Accuracy of Intermittent Fluoroscopy to Detect Intravascular Injection during Transforaminal Epidural Injections
Smuck et al. Spine 2008

• Hypothesis:
  – Intermittent fluoroscopy is less accurate than live fluoroscopy in detecting accidental intravascular injection during transforaminal epidurals
Accuracy of Intermittent Fluoroscopy to Detect Intravascular Injection

• **Methods**
  
  – Observation under live fluoroscopy
    • 25 cervical injections
    • 25 lumbar injection
  
  – Save 2 images = 100 static images
    (mimics intermittent fluoro)
    • 50 “contrast” (C)
    • 50 “post-contrast” (PC)

  – Five interventional physiatrists
    • independently interpreted all images
      – epidural, non-epidural, vascular
Accuracy of Intermittent Fluoroscopy to Detect Intravascular Injection

Epidural contrast pattern     Vascular contrast pattern

C                                                    PC
Accuracy of Intermittent Fluoroscopy to Detect Intravascular Injection

• Results – 57% missed overall
Accuracy of Intermittent Fluoroscopy to Detect Intravascular Injection

- Results
Accuracy of Intermittent Fluoroscopy to Detect Intravascular Injection

- **Results**

![Pie charts showing accuracy of intermittent fluoroscopy for different regions.](chart.png)
Accuracy of Intermittent Fluoroscopy to Detect Intravascular Injection

• Summary
  – Overall, **57%** of vascular injections missed
  – Worse if:
    • Image taken after contrast injection (p=0.075)
      – 68% of “post-contrast” images
    • Lumbar injections (p=0.012)
    • Simultaneous vascular and epidural injection (p=0.041)
      – 74% of “post-contrast” images
PREVENTION  Method #6

• Digital Subtraction
  
  • Software that adjusts the fluoro image so that a vascular contrast pattern is less likely to be obscured (Baker 2003, Rathmell 2004, Ludwig 2005)

  • Increased detection of vascular uptake compared to live fluoro (McLean 2009, Lee 2010)
PREVENTION Method #7

- Avoid Needle Movement
  - Use extension tube (Tiso 2004)
    - After final needle placement
    - To inject contrast
    - Then to inject anesthetic and steroids
PREVENTION  Method #8

• Anesthetic Test Dose
  • Despite adherence to all previous methods, serious complications have occurred (Ludwig 2005)

• Test Dose Proposed (Baker 2003, Tiso 2004, Karasek 2004)
  • Positive if prior methods fail to reveal a potentially dangerous intra-arterial injection

• Positive in 4/678 = 0.59% incidence (Smuck 2010)
  • May have prevented serious morbidity
  • Needs to be validated prospectively
PREVENTION  Method #9

• Small-particulate Corticosteroids

• Clinical Comparison
  • Equivalent to triamcinolone/methylprednisolone
    • Cervical (Dreyfuss 2006) (Lee 2009)
    • Lumbar (Kim 2011) (Kennedy 2014)
  • Less effective
    • Lumbar (Park 2010)
PREVENTION Method #10

• Experience
  • Lower complication rates for more experienced surgeons.
  • How about for spine injection procedures?
    • Fellows (6mo experience)
      less accurate interpretation relative to experienced physicians
        (Smuck 2008)
**Conclusion**

**Table 1. Methods to reduce the risk of inadvertent vascular injection during transformaminal injections are shown in this table along with supporting citations; methods with known accuracy to detect vascular injections are listed first, followed by methods without defined accuracy but with evidence of some benefit in formal research; finally, methods not yet formally tested are listed.**

<table>
<thead>
<tr>
<th>Methods with known vascular detection accuracy in the cervical spine</th>
<th>Sensitivity (%)</th>
<th>Specificity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aspiration for blood [43]</td>
<td>46</td>
<td>97</td>
</tr>
<tr>
<td>Intermittent fluoroscopy [44]</td>
<td>54</td>
<td>90</td>
</tr>
<tr>
<td>Live fluoroscopy [40*]</td>
<td>99</td>
<td>100</td>
</tr>
</tbody>
</table>

**Methods with other impacts defined by research**

<table>
<thead>
<tr>
<th>Test</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anesthetic test dose</td>
<td>Positive in 0.75 % of cervical injections following live fluoroscopy to confirm contrast spread [41*]</td>
</tr>
<tr>
<td>Digital subtraction (DSA)</td>
<td>Increases rate of detection of vascular uptake [39*]</td>
</tr>
<tr>
<td></td>
<td>Anesthetic test dose negative in 146 consecutive cervical injections confirmed using DSA [41*]</td>
</tr>
<tr>
<td>Needle size</td>
<td>22-Gauge needles may cannulate cervical radicular arteries [51]</td>
</tr>
<tr>
<td></td>
<td>No difference in cervical injection vascular rates between various quinke needle gauges [48*]</td>
</tr>
<tr>
<td>Needle type</td>
<td>In animals, advantages of blunt-tip needles are isolated to large [18, 20] gauges [46, 47]</td>
</tr>
<tr>
<td></td>
<td>No difference in vascular injection rates during lumbar transformaminals using quinke, chiba, whitacre and blunt-tip needles [48*, 50]</td>
</tr>
<tr>
<td>Needle location</td>
<td>Posterior foramen to avoid vertebral artery, however intraforaminal vertebral artery anomalies are present in 7.6 % of patients [52*]</td>
</tr>
<tr>
<td></td>
<td>Mid foramen depth to avoid larger radicular arteries and deep cervical arteries in and near the outer foramen [36]</td>
</tr>
<tr>
<td>Corticosteroid</td>
<td>Corticosteroids with particles consistently smaller than red blood cells do not cause the ischemic injuries observed from larger-particle steroids when intentionally injected into the vertebral arteries of animals [37, 38**]</td>
</tr>
</tbody>
</table>

**Methods suggested but not formally tested**

<table>
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<tr>
<th>Test</th>
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</tr>
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<tbody>
<tr>
<td>Dissection risk screen</td>
<td>High risk suggests alternate methods be considered</td>
</tr>
<tr>
<td>Minimizing sedation</td>
<td>Patients are more able to provide feedback about potential complications</td>
</tr>
<tr>
<td>Extension tubing</td>
<td>Used to avoid manipulation and movement of the needle between contrast and corticosteroids</td>
</tr>
</tbody>
</table>
Conclusion

- Complications happen
- To maximize safety
  - Select patients carefully
  - Be aware of risks and
  - Be aware of all methods available to prevent injury
Thank You!

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Partial List of References


Williams KN, Jackowski A, Evans PJ. Epidural haematoma requiring surgical decompression following repeated cervical epidural steroid injections for chronic pain. Pain. 1990;4