Demystifying Epidural Spread

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Introduction

+ “X” mL of local anesthetic gives “Y” dermatome(s) of spread (e.g. 1-2 ml of local anesthetic per dermatome) is oversimplified and inaccurate

+ The various factors that affect the distribution of blockade can be divided into patient characteristics, technical factors and agents used

+ We will discuss effects of individual factors but multi-variable analysis suggests that cross-dependency of multiple characteristics more accurately represents anesthetic requirements
Patient Characteristics
Patient Characteristic: Age

- Lumbar Epidurals:
  - Linearity b/w age & spread of local anesthetic (LA) originally described by Bromage but then proven false
  - Some reports show sensory block 3-8 segments higher in cephalad direction in patients > 60 yr vs. < 40 yr
  - Others show linearity b/w age and spread is stronger for low volumes (≤ 10 mL) compared to high volumes (10-20 mL)
  - Still others show linearity b/w age and spread is stronger for patients < 40 yr compared to > 40 yr
Patient Characteristic: Age

- Thoracic Epidurals:
  - Correlation b/w age and spread stronger: LA dose in patients 60-79 yr is 40% less than 20-39 yr
  - Low thoracic epidural test doses of 2% lidocaine, 5 and 8 mL, resulted in greater extent of blockade and an increased incidence of hemodynamic instability in patients aged 56–80 yr compared to patients aged 18–51 yr
  - Compliance of the epidural space has been shown to increase with age, and it is positively correlated with spread of sensory blockade
  - With age, the dura becomes more permeable and there is a decrease in the number of myelinated nerve fibers allowing LA to more easily penetrate nerve roots in older patients
Patient Characteristics

+ **Height:**
  + Lumbar epidurals: conflicting results; weak correlation b/w height and spread at best
  + Thoracic epidurals: weak correlation b/w height and spread of contrast medium

+ **Weight/BMI:**
  + Lumbar epidurals: no correlation b/w spread and weight; weak correlation b/w spread and BMI
  + Thoracic epidurals: no correlation b/w weight or BMI and spread of contrast medium
Patient Characteristic: Pregnant

- No thoracic epidural studies
- Lumbar epidurals: less LA required to produce a given level – implied mechanism is engorgement of epidural vessels by increased intra-abdominal pressure
- Appearance of increased spread in early pregnancy (when intra-abdominal pressure is normal) may be from known faster onset and more intense block in pregnant patients
- Strong correlation b/w spread and BMI: LA requirements reduced in BMI > 30 compared with BMI ≤ 30
Technical Factors
Technical Factor: Insertion Site

- After injection of 15 mL of 2% mepivacaine in the thoracic and lumbar epidural space the spread of blockade was 14.3 ± 0.4 and 13.3 ± 0.7 segments, respectively.

- No difference in number of segments blocked between different locations of injection of contrast medium (from high thoracic to lumbar).
Mean spread of 5 mL of contrast medium
Technical Factor: Insertion Site

- Different pattern of sensory blockade is seen at different sites of injection in thoracic spine (may be due to different epidural pressure and relative volume of the cord and sac in cervical and lumbar regions)
  - Spread primarily caudal after high-thoracic injection
  - Spread primarily cephalad after low-thoracic injection
  - Spread equally caudal and cephalad after mid-thoracic
Extension of sensory blockade by pinprick after administration of 3 mL 2% lidocaine
Technical Factor: Insertion Site

- It has been suggested that epidural catheters should be placed at an intervertebral space that represents the middle of the area of surgical incision.

- Probably better to aim a little high for high thoracic incisions to make sure you get the most cephalad portion.

- And aim a little low for lower abdominal incisions to make sure you get the most caudal portion – though not too low so as to effect the lower extremities.
Technical Factor: Patient Position

- Lumbar Epidurals:
  - Lateral position produces sensory block 0-3 segments greater on dependent side compared to supine
  - No difference in maximum cranial level comparing sitting vs. supine
  - Slightly faster onset of block in lateral or sitting position compared to supine
  - Trendelenberg results in faster onset and higher sensory block in pregnant women – may occur with continuous infusions in other patients over time

- Thoracic Epidurals: no studies done
Technical Factor: Needle & Catheter Direction

- Injection through a Touhy needle with bevel to one side or caudal, compared to cephalad, has no effect on spread of sensory blockade.

- Threading a lumbar epidural catheter through a Tuohy with bevel to the side produces preferential sensory and motor block to that side.

- However, in pregnant patients, insertion of an epidural with the bevel of a Touhy turned to the side results in no higher incidence of asymmetric block; but it is more difficult to thread the catheter and more paresthesias occur.
Technical Factors

- Injection Through Needle vs. Through Catheter:
  - Lumbar epidurals: most studies show no difference in spread
  - Thoracic epidurals: no studies done

- Catheter Design:
  - Differential flow occurs with multi-orifice catheters (first at proximal hole and last at distal) – at low injection pressure flow is only via the proximal
  - Has been suggested that unilateral analgesia and unblocked segments occurs more frequently with single orifice catheters, but some studies refute this
  - Contrast injection results in similar number of blocked segments with both single and multi-orifice catheters
Technical Factors

• Fractional vs. Single Bolus Injection:
  • Low-thoracic epidurals: two 5 mL doses of LA at a 5 minute interval produces a block similar to a single 10 mL dose, but increasing the interval to 10 minutes results in fewer segments blocked – residual epidural pressures may explain this
  • Prior injection of 5-10 mL of saline may result in greater spread of LA (exaggerated when short interval between injections)

• Speed of Injection:
  • Lumbar epidurals: possible quicker onset and increased spread of sensory block with more rapid injection of LA (studies on both sides of the argument)
Technical Factor: Cavity Pressure

- Use of a continuous positive airway pressure device (CPAP) causes the distal border of sensory blockade to extend further away from the thorax.
  - Lidocaine injection in a low-thoracic epidural results in an increased number of segments blocked by 57% primarily through more caudal spread.
  - Lidocaine injection in a C6-7 or C7-T1 epidural results in a more cranial extension of sensory block.
- Similar effect may occur with positive pressure ventilation.
- Pneumoperitoneum (laparoscopic procedures) and PEEP increase epidural pressure but no studies exist looking at spread of blockade.
Agents Used
Agents Used: Additives

- Bicarbonate:
  - Increases nonionized fraction and improves penetration
  - Increases the pain threshold and depth of motor block; reduces onset time of block; no effect on spread of sensory blockade

- $\alpha_2$ Agonists (*i.e.* epinephrine and clonidine):
  - Faster onset and longer duration of sensory and motor block; improved anesthetic quality; no change in spread of sensory block

- Opioids:
  - Faster onset of sensory and motor block; enhanced pain relief; does not affect the spread of the block
Agents Used: Local Anesthetics

+ Total mass (in mg) of LA in different concentrations and volumes produces similar spread of sensory, motor and sympathetic block – seen for bolus injection in lumbar epidurals and for bolus and continuous infusions in thoracic

+ Although administering same mass of LA in different volumes results in similar spread of blockade, the intensity of blockade may vary with the concentration

+ However, many studies exist using bupivacaine concentrations between 0.1 and 0.5% and they all report satisfactory analgesia, therefore intensity of blockade may not be clinically relevant (at least for a population)
Epidural Adjustments:
Rate vs. Concentration

- Dense band with good analgesia not covering surgical area usually increase rate (it’s easier and faster) but concentration increase with same rate will work as well

- Adequate size band covering surgical area with poor analgesia increase concentration and decrease rate (example: 0.125% bupivacaine at 6 mL/hr = 7.5 mg LA; would change to 0.2% bupivacaine at 4 mL/hr = 8 mg LA – hopefully to get a denser block but not change the spread too much)

- Inadequate size and density of band (example: 0.125% bupivacaine at 6 mL/hr; change to 0.2% bupiv at 5 mL/hr = 10 mg LA – to get a denser block and increase the spread)
Misunderstandings Explained

- Misconception exists that higher concentrations of bupivacaine cause more hypotension – unlike degrees of sensory and motor block, sympathetic block is basically all or none regardless of the concentration.

- What has caused this misconception?: patient with adequate size band but with pain, epidural running 0.0625% bupiv at 6 mL/hr = 3.75 mg LA; change to 0.125% but keep rate at 6 mL/hr = 7.5 mg LA – the band is now unnecessarily big and the larger sympathetic block causes the BP to drop; should have changed to 0.125% bupivacaine at 3 mL/hr = 3.75 mg LA – to densen the band but keep the spread the same and not effect the BP.
People wonder why they have a nice large band pre-operatively after the 3 mL 2% lidocaine test dose (e.g. have a T6-7 epidural and a band from T2-T12) and then they run a 0.125% bupivacaine epidural at 6 mL/hr through the case (i.e. twice the volume!) and find they only have a T5-T8 band in the recovery room.

What’s the cause?: 3 mL of 2% lidocaine = 60 mg LA, whereas 0.125% bupivacaine at 6 mL/hr = 7.5 mg LA – the spreads aren’t exactly equal between bupivacaine and lidocaine and one is a bolus while the other is an infusion over time, but the significantly larger amount in the test dose causes the large spread.
Conclusions

- Age may be a factor in spread of sensory block (i.e. older patients need less LA) – stronger evidence for thoracic vs. lumbar epidurals; stronger evidence for motor and sympathetic blocks.

- Pregnancy: less LA required to produce a given level, strong correlation b/w spread and BMI (i.e. less LA is needed if BMI > 30), and Trendelenberg position results in a higher sensory block.

- In thoracic epidurals: two boluses of LA given 10 minutes apart results in fewer blocked segments than if a single bolus is given due to residual epidural pressure.
Conclusions

+ The site of epidural insertion in the thoracic spine governs the pattern of distribution of sensory blockade relative to the injection site (i.e. high thoracic goes down and low thoracic goes up)

+ CPAP, and possibly positive pressure ventilation, alters this pattern (i.e. spread goes away from the thorax)

+ The total mass (in mg) of local anesthetic is the most important factor in determining the extent of spread of sensory, motor and sympathetic blockade
Thank you so much
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(Khawp khun maak maak)