Estimation of the depth to the thoracic epidural space in children using magnetic resonance imaging

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Introduction

- Prediction of actual skin-to-epidural distance (SED) may increase success rate and improve safety of epidural procedures in children.
- SED varies depending on vertebral level, patient characteristics including age and weight, and angle of needle entry for puncture.
- SED in children has been derived mainly from direct needle measurements, CT and MRI imaging, and ultrasonography.
- MRI is the most comprehensive imaging modality of paraspinal tissues and ligaments, the measurements derived are more accurate and thereby provide a useful tool to derive SED.
- Primary objective - derive a formula from MRI-based data for predicting SED in children.
- Secondary objective - evaluate potential differences in the SED at various thoracic levels and determine how changes in needle approach may affect measurements.

Methods

- Sagittal T2-weighted imaging of thoracic spine was used to measure SED (distance from skin edge to dural side of ligamentum flavum) at T6-7 and T9-10 levels. Two measurements were taken at each level. The first measurement was taken perpendicular to long axis of the vertebral body. The second measurement (inclined) was taken between spinous processes with measurement parallel to spinous processes (Figures 1 and 2).
- Exclusion criteria included any condition that would cause abnormal spinal anatomy (scoliosis, tethered cord, spina bifida, myelomeningocele, tumors of spinal cord or vertebral bodies), and patients outside 10th-90th percentile of weight-for-age based on World Health Organization growth standards.

Results

- 109 MRI scans of spine in children aged 1 month to 8 years.
- 62% were boys (mean age 46.1 ± 16.1 months) and 37% were girls with a mean age of 63 ± 21.6 months.
- Using univariate analysis all variables (age, height and weight), showed a significant positive relationship with inclined SEDs.
- Using multivariate regression analysis, weight showed strongest association with inclined SED (T6-7 and T9-10) (Figure 3).
- Incline to straight ratios at T6-7 and T9-10 were 1.1 ± 0.1 and 1.1 ± 0.09 respectively.
- Based on these data, the following formulas were developed:
  - T6-7 Inclined (mm) = 7 + 0.9 x kilograms
  - T9-10 Inclined (mm) = 7 + 0.8 x kilograms

Conclusion

- The depth to the pediatric thoracic epidural space shows a stronger correlation with weight than with age or height.
- Predictive weight-based formulas, based on MRI data, can serve as a guide to clinicians for placement of thoracic epidural catheters by providing an estimation of the SED, facilitate accurate needle placement and decrease the risk of complications.
- Data derived needs subsequent clinical validation with a clinical study comparing the calculated versus the actual SED.

Tables

<table>
<thead>
<tr>
<th>Level of measurement</th>
<th>Gender</th>
<th>Mean ± SD (mm)</th>
<th>95% Confidence interval (mm)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>T6-7 Inclined</td>
<td>Boys</td>
<td>28.0 ± 5.3</td>
<td>28.0 ± 5.3</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td>Girls</td>
<td>28.0 ± 5.3</td>
<td>28.0 ± 5.3</td>
<td>0.00</td>
</tr>
<tr>
<td>T9-10 Inclined</td>
<td>Boys</td>
<td>28.0 ± 5.3</td>
<td>28.0 ± 5.3</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td>Girls</td>
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Conclusion