The ALARA principle in CT guided Epidural Steroid Injections

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Purpose

Epidural steroid injections with CT guidance have become a widely used intervention in the treatment of spinal radiculopathy.

CT guided epidural injections may be required at multiple levels and on multiple occasions for maximal therapeutic effect.

The lowest radiation dose in accordance with the ALARA principle should be a primary treatment goal, taking into account the requirement for accurate needle placement and verification of epidural position, before injection of therapeutic substances.

Reported radiation doses vary greatly between different institutions for CT guided epidural interventions.

The purpose of this study is to present a retrospective audit of a private practice patient cohort presenting for a single level CT guided epidural steroid injection utilising an ultra-low dose CT scanning technique permitting rapid and accurate needle placement for steroid delivery.
Methods and Materials

Study Design: Retrospective case note and image audit of 200 consecutive patients presenting over 2 months with intention to treat by epidural or perineural steroid injection, irrespective of spinal level, pathology involved and first time or repeat intervention. There was one exclusion where the treatment DLP was not recorded. Radiation dose was collected prospectively. Technical factors and clinical notes were recorded prospectively. Technical success was based on review of images demonstrating epidural contrast opacification after CT guided needle placement.

In all cases CT guidance was by several acquisitions of a stack of 4 axial slices using a partial scan low mAs technique. For lumbar epidural injection, the needle orientation was adjusted after each slice acquisition in order to place the needle tip immediately superficial to the epidural space under CT guidance. A 22g 9 or 12cm spinal anaesthesia needle and a 1 or 2.5cc syringe was employed with injection of 0.1 to 0.5cc of contrast to confirm epidural positioning followed by 1-2cc of dexamethasone (4mg/ml) infused into the epidural space at the selected spinal level.

For cervical injection, CT guided 25g 38mm needle placement within the right or left target facet joint was followed by contrast injection to confirm perineural and epidural spread of contrast in each case at the target level.

Scanners were either 16 slice or 160 slice with scan protocols varied as follows. For 16 slice machines, a sectored half scan was acquired in 0.3s, as a 2, 4 or 8mm scan thickness, reconstructed into 4 by 0.5, 1 or 2mm axial slices. For 160 slice machines, a sectored half scan was acquired in 0.23s, as a 2, 4 or 8mm scan thickness, reconstructed into 4 by 0.5, 1 or 2mm axial slices for cervical and 4 by 2mm slices for lumbar needle placement.

The radiation dose differences between 16-slice and 160-slice scanners was compared. A minimum of 2 and a median of 4 image acquisitions was used to confirm needle position in the target space. Radiation doses recorded were compared with published data in the literature. Shepherd et al [1] reported a mean procedural dose length product (DLP) of 199 +/- 101 mGy.cm. Chang et al [2] reported a mean DLP of 89.6 +/- 3.33 mGy.cm representing an average effective dose of 1.34 +/- 0.05mSv per interlaminar epidural
steroid injection in the lumbar spine. Amrhein et al [3] reported a radiation exposure DLP of 94.2 +/- 52 mGy.cm.
Results

<table>
<thead>
<tr>
<th>Region</th>
<th>Lowest DLP</th>
<th>Median DLP</th>
<th>Highest DLP</th>
<th>Mean DLP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cervical (n=41)</td>
<td>0.8</td>
<td>3</td>
<td>14.9</td>
<td>3.79</td>
</tr>
<tr>
<td><strong>Lumbar</strong></td>
<td>0.9</td>
<td>4.8</td>
<td>102.4</td>
<td>11.42</td>
</tr>
<tr>
<td>(n=141)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SIJ (n=13)</td>
<td>1.2</td>
<td>3.2</td>
<td>26.4</td>
<td>6.06</td>
</tr>
<tr>
<td>Thoracic (n=5)</td>
<td>5.4</td>
<td>7</td>
<td>87.9</td>
<td>22.82</td>
</tr>
<tr>
<td><strong>Total: Consecutive 200 patients 9.700</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

** excludes one case where needle placement DLP was combined with a diagnostic scan.

<table>
<thead>
<tr>
<th>Scanner</th>
<th>Lowest DLP</th>
<th>Median DLP</th>
<th>Highest DLP</th>
<th>Mean DLP</th>
</tr>
</thead>
<tbody>
<tr>
<td>160 slice</td>
<td>0.8</td>
<td>2.6</td>
<td>29.4</td>
<td>3.92</td>
</tr>
<tr>
<td>(n=77)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>16 slice</strong></td>
<td>1.6</td>
<td>5.9</td>
<td>102.4</td>
<td>10.82</td>
</tr>
<tr>
<td>(n=123)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

** excludes one case where needle placement DLP was combined with a diagnostic scan.

There was a non-significant difference of DLP means between the two 160 slice scanners of 3.21 and 5.15 mGy.cm (p<0.078). There was a significant difference between the two 16 slice scanners with DLP means of 12.47 and 6.22 mGy.cm (p<.01).

In this study there was a highly significant difference between the mean DLP delivered by the 16 (DLP=10.82) and 160 slice scanners (DLP=3.92; p<0.001). The radiation dose delivered for both types of scanner is substantially smaller than the published data from other series (DLP 89, 94, 199).

The principle methods used to reduce radiation dose were;

- elimination of CT fluoroscopy and replacement with single sequential acquisitions to adjust needle position
• use of a sub 1cm axial acquisition slice reconstructed as 4 contiguous 0.5-2mm slices to assess needle position
• use of the shortest possible slice acquisition time by sectored scanning and maximum rotation speed to reduce respiratory motion artefact
• use of the thinnest possible slice thickness
• use of lowest possible mA while maintaining needle identification
• acceptance of substantial image quantum mottle, while needle angle and tip position could still be discerned

Factors resulting in an increased DLP included:

• larger patient size necessitating higher mA and a larger number of acquisitions to achieve needle placement in the target space
• lack of patient cooperation resulting in a larger number of acquisitions to achieve needle placement in the target space
• higher rotation time for 16 slice scanners resulted in a higher average DLP although this was still very low compared to published data
• operator variability
• technical difficulty of needle placement in the target space due to hostile anatomy
**Fig. 1:** 0.23s/1.0mm/2mAs (DLP=0.50 mGy.cm) used for needle tip identification for a C5/6 epidural steroid injection.

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Fig. 2: 0.23s/2.0mm/2mAs (DLP=2.70 mGy.cm) used for needle tip identification for a L5/S1 epidural steroid injection.

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**Fig. 3:** 0.23s/2.0mm/2mAs (DLP=1.50 mGy.cm) used for needle tip identification for a L3/4 epidural steroid injection.

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**Conclusion**

Thin slice multi-level axial scanning with high rotation speed and partial sector reconstruction has a reduced radiation dose compared to published data using pulsed or continuous CT fluoroscopy.

Needle conspicuity is inversely related to slice thickness and scan acquisition time; image noise ultimately increases to obscure needle tip identification as patient size increases, and for scan factors less than 10 mA or 2mAs.

Modest increases in mA (20-50 mA) can be used to assist final needle tip positioning where body habitus increases quantum mottle and dose related artefact to the point where needle location is obscured.
Personal information

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References

