A randomised trial comparing the spread of retrolaminar block with the combination of erector spinae block and retrolaminar block in soft embalmed Thiel cadavers

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Running Head:
Spread of Injectate in cadavers after ESP and ESP+RL blocks

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ESP: erector spinae
RL: retrolaminar
CAHID: Centre for Anatomy and Human Identification

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Erector spinae; cadaver; regional anaesthesia; CT; MRI
Introduction

Spread after erector spinae plane (ESP) block and retrolaminar (RL) block is unreliable. Combined ESP and RL injection is associated with greater paravertebral spread compared to ESP injection in the Thiel cadaver. We now hypothesize that combined injection is more extensive than RL injection. Our primary objective was to compare the spread of dye to the paravertebral and epidural spaces, dorsal and ventral rami, intercostal nerves and sympathetic chain. The primary endpoint was the number of ipsilateral stained structures.

Methods

Approval was given by the University of Dundee Thiel advisory group. We randomized RL and ESP + RL injections to both sides of 8 prone Thiel cadavers. Injections were administered by an anesthesiologist using a 3-8 MHz linear transducer (Zonare, Palo Alto, CA) and a 21g needle (Stimuplex, B.Braun, Melsungen, Germany) inserted in-plane and directed cephalad to caudal. For the combination, 10 ml of red dye was injected at the tip of the T3 transverse process, then 10ml on the corresponding lamina. RL injection used 20 ml green dye. CT scanning of 3 cadavers used dye mixed with iodinated contrast (Iohexol). Cadavers were dissected by an anatomist 24 hours later. Our secondary objectives were to: measure accuracy (complete spread from T2 to T4) and reliability (range of maximal spread per injection); identify lateral fascial plane spread, including contralateral spread; and spread on CT scans.

Power Analysis

Assuming a reduction from 24 vs 12 anatomical structures, effect size 1.67, $\alpha = 0.05$, $\beta = 0.80$, we required 16 injections (G*Power, Dusseldorf, Germany).

Statistical analysis

Median values were compared using the Mann-Whitney-U test and Hodges-Lehmann estimate (95%) (GraphPad Prism 9, San Diego, CA). Categorical data used Fisher’s test.
Results

The median (IQR [range]) number (n) of stained ipsilateral structures was greater, 28 (22 - 29 [21 - 31]) vs 14 (10 - 25 [8 - 34]), difference 11 (1, 17), P = 0.03 after ESP + RL injection (Table 1). With combined injection, the proportion (%) of stained T2 to T4 levels was greater, 100% VS 25%, RR (5.0 - 17.6), P = 0.007 (Figure 1); and maximal cranio-caudal spread was less 3.5 (1.0 – 5.25) [1.0 -6.0]) vs 6.5 (5.8 – 7.0 [5.0 -7.0]), difference 3 (1, 6). P = 0.015. the proportion of stained angles was greater, 100% vs 38%, RR 3.7 (1.5-10.2), P = 0.026 using the combination. CT scans validated craniocaudal dye spread (Figure 2).

Table 1: Overall and individual spread to anatomical structures. Overall spread was greater using the combination of ESP + RL injection. Spread was greater at dorsal rami using the combination. Maximal craniocaudal spread was less using ESP + RL injection, thus showing greater reliability of the combination injection.

<table>
<thead>
<tr>
<th>Overall spread</th>
<th>RL</th>
<th>ESP + RL</th>
<th>Difference (95%CI)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paravertebral space</td>
<td>14.0 (9.8 - 25.3 [8.0 - 34.0])</td>
<td>27.5 (22.3 - 29.8 [21.0 - 31.0])</td>
<td>11.0 (1.0 - 17.0)</td>
<td>0.030</td>
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<tr>
<td>Epidural</td>
<td>3.0 (1.3 - 5.8 [1.0 - 7.0])</td>
<td>5.5 (4.3 - 6.8 [4 - 8])</td>
<td>2.0 (0.0 - 4.0)</td>
<td>0.094</td>
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<tr>
<td>Dorsal rami</td>
<td>2.5 (1.3 - 6.0 [0.0 - 6.0])</td>
<td>5.0 (4.0 - 5.0 [4 -5])</td>
<td>2.0 (-1.0 to 3.0)</td>
<td>0.018</td>
</tr>
<tr>
<td>Ventral rami</td>
<td>2.5 (1.0 - 6.8 [0.0 - 8.0])</td>
<td>5.5 (4.0 - 8.0 [3 - 8])</td>
<td>2.0 (-1.0 to 5.0)</td>
<td>0.107</td>
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<tr>
<td>Intercostal nerves</td>
<td>1.5 (1.0 - 3.0 [0.0 - 4.0])</td>
<td>3.0 (2.3 - 4.0 [0 - 5])</td>
<td>1.0 (0.0 to 3.0)</td>
<td>0.157</td>
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<tr>
<td>Sympathetic chain</td>
<td>2.0 (0.3 - 4.0 [0.0 - 8.0])</td>
<td>2.5 (2.0 - 5.5 [0.0 - 6.0])</td>
<td>1.0 (-2.0 to 3.0)</td>
<td>0.543</td>
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<tr>
<td>Maximal craniocaudal spread</td>
<td>6.5 (5.8 - 7.0 [5.0 - 7.0])</td>
<td>3.5 (1.0 - 5.3 [1.0 - 6.0])</td>
<td>-3.0 (-6.0 - 1.0)</td>
<td>0.015</td>
</tr>
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</table>

Values are presented as median (IQR [Range]) and median of the differences (95% CI). Statistical test used The Mann-Whitney-U test and Hodges-Lehmann estimate (95%) in order to compare the median of the differences.

RL, retrolaminar injection; ESP+RL, combination of erector spinae and retrolaminar injection.
Discussion

Our results provide further evidence to support a dual approach to thoracic wall fascial plane blocks. Spread to predefined anatomical structures was more extensive using the combination of ESP and RL injections compared to RL injection alone. Although only spread to dorsal rami showed significance, our primary outcome was achieved by the cumulative spread of dye to all locations using the combination (Table 1).

By using two injections with different patterns of spread\(^1\), the inherent variability of the ESP injection was reduced, and accounts for the greater accuracy and reliability of ESP + RL injection. Moreover, intercostal spread to the angles of the ribs was achieved after all ESP injections despite using only a 10ml volume. Our results validate our previous work that the combination injection was more reliable than ESP injection alone. We hypothesise that RL injection is directed medially along paths of least resistance towards the superior cost-transverse ligament and paravertebral space because ESP injectate provides resistance to lateral flow.

In conclusion, the combination of ESP and RL block showed more extensive spread, and greater accuracy and reliability compared to RL block alone. We intend to conduct a clinical study in order to inform practice.
Figure 1: Spread of injectate. Boxes represent vertebral level per cadaver (1 to 8) per injection: RL – retrolaminar; ESP erector spinae plane. C – Cervical vertebral level; T – Thoracic vertebral level. Dye spread consistently in all cadavers from T2 to T4 vertebral levels using the combination of ESP + RL injections. Dye was not visualized in the retrolaminar plane in cadavers 2 and 6 after RL injection.

Figure 2: CT imaging of cadaver 7 after retrolaminar (RL) and combined Erector spinae plane (ESP) and RL injection. Image (a) shows spread of contrast (highlighted by arrows) following RL injection over 4 vertebral levels. Image (b) shows spread of contrast (highlighted by arrows) following combined ESP and RL injection spread 7 vertebral levels.
References


<table>
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<tr>
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(b)

(c)