EXTRADURAL ANALGESIA REVISITED

A statistical study

E. M. GRUNDY, S. RAMAMURTHY, K. P. PATEL, M. MANI AND A. P. WINNIE

SUMMARY

The results of 334 lumbar extradural analgesics, administered in a standard manner, allowed reassessment of some factors influencing the spread of local anaesthetic solution in the extradural space. There was no evidence of increased spread in patients with degenerative vascular disease when compared with a control group free from such disease. The patient's height and age had a small effect on spread. The results contradict the earlier assumption of a direct relationship between the volume of anaesthetic solution injected and the number of segments blocked.

The widely accepted volume–analgesia relationships for extradural analgesia were originally reported by Bromage (1962a). He reported all his data in terms of volume (and later mass) per spinal segment blocked. Our experience with low volume extradural injections for pain control and high volume injections for upper abdominal surgery was that Bromage's data became inaccurate at extremes of volume. We have studied prospectively data from a standardized extradural analgesic technique in an attempt to confirm or reject this clinical impression.

MATERIALS AND METHODS

Our technique of extradural analgesia has been standardized; with the patient in the lateral position on a horizontal operating table an extradural needle was introduced in the third lumbar interspace and advanced. The extradural space was identified by the "loss of resistance" technique using air in a glass syringe. After attempted aspiration, injection of air from the glass syringe was performed in all four quadrants to ensure complete entry of the needle tip into the extradural space. With the bevel pointing towards the head, multiples of 5 ml of bupivacaine 0.75% solution, were injected at a rate of 1 ml s⁻¹. An extradural catheter was inserted, if indicated, and the patient was turned to the supine position with the operating table horizontal. The onset of analgesia was followed by noting the level of dulling pinprick, which later developed to full analgesia.

For each patient the highest level of block achieved on each side was recorded. On the rare occasion of asymmetric spread of analgesia, the level on the side dependent at the time of injection was taken as the maximum spread. Whenever possible the presence of sacral analgesia was established, or assumed if analgesia was adequate for perineal surgery.

DATA ANALYSIS AND RESULTS

We collected data from 334 extradural analgesics, divided into three groups (10 ml, 15 ml and 20 ml volumes of 0.75% bupivacaine (not yet available in U.K.) without adrenaline). Table I gives the patient data for the three groups. Height and weight were not significantly different between the groups but age decreased and upper level of analgesia increased with larger volumes. Each group will be considered separately.

Regression lines were calculated for the upper level of analgesia against age for injections of 10 ml, 15 ml and 20 ml (figs 1–3). The slope of each line was statistically significant at the 5% level. Regression lines were calculated similarly for upper level against height for 10 ml, 15 ml, and 20 ml (figs 4–6). The slopes for the 15-ml and 20-ml groups were both statistically significant at the 5% level, whereas the slope for the 10-ml group did not achieve significance.

Multiple linear regression analysis of the upper level of analgesia against age, height and weight was performed for each of the three groups. At the 5% level, Fisher's ratio test (F test) revealed that the influence of the patient's weight was not significant in any of the three groups and, in addition, the influence...
### Table I. Data (mean ± SD) for patient age, height, weight and upper level of analgesia

<table>
<thead>
<tr>
<th>Volume of bupivacaine injected (ml)</th>
<th>10</th>
<th>15</th>
<th>20</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. patients</td>
<td>53</td>
<td>177</td>
<td>104</td>
</tr>
<tr>
<td>Age (yr)</td>
<td>53.7 ± 19.1</td>
<td>49.7 ± 17.6</td>
<td>41.6 ± 14.2</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>171.7 ± 9.2</td>
<td>170.4 ± 10.0</td>
<td>168.5 ± 10.6</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>71.2 ± 15.7</td>
<td>71.8 ± 14.2</td>
<td>71.5 ± 14.2</td>
</tr>
<tr>
<td>Upper level analgesia</td>
<td>7.4 ± 2.3</td>
<td>5.8 ± 1.8</td>
<td>4.8 ± 2.0</td>
</tr>
</tbody>
</table>

### Table II. Mathematical models for thoracic upper level of analgesia after injection of 0.75% bupivacaine in third lumbar interspace

| Level with 10 ml | 10.9452 - 0.0655 yr |
| Level with 15 ml | -1.5687 - 0.0212 yr + 0.0493 cm |
| Level with 20 ml | -0.8045 - 0.0300 yr + 0.0408 cm |

**FIG. 1.** Regression line for upper level of analgesia against age for injection of 0.75% bupivacaine 10 ml at L3-4.

**FIG. 2.** Regression line for upper level of analgesia against age for injection of 0.75% bupivacaine 15 ml at L3-4.

of height in the 10-ml group was not significant. Recalculation of these lines for upper level against the significant variables allowed us to produce a mathematical model for the upper level of analgesia for each volume. Products of these mathematical models are shown in figure 7 for a 170-cm tall patient and in figure 8 for a 50-yr-old patient.

Logarithmic transformation of the data was performed, but did not improve the fit of the regression lines in any of the three cases, thus the linear models of table II best represent our data.

**FIG. 3.** Regression line for upper level of analgesia against age for injection of 0.75% bupivacaine 20 ml at L3-4.

**FIG. 4.** Regression line for upper level of analgesia against height for injection of 0.75% bupivacaine 10 ml at L3-4.
EXTRADURAL ANALGESIA

Upper Level of Analgesia
T2 - T3 - T4 - T5 - T6 - T7 - T8 - T9 - T10 - T11

n = 177
r = 0.24

FIG. 5. Regression line for upper level of analgesia against height for injection of 0.75% bupivacaine 15 ml at L3-4.

10 ml of 0.75% bupivacaine. This was the smallest group, consisting of 53 patients. To our surprise, we obtained full sacral analgesia consistently in these patients. We failed to document perineal analgesia on three occasions, including two patients undergoing hip operations in whom the placing of surgical drapes precluded further testing of perineal analgesia. About 60% of the operative procedures were upon the perineum (such as trans-urethral resection of the prostate and haemorrhoidectomy), which attests to the quality of the sacral analgesia obtained. The regression line for the upper level of analgesia and age was significant (fig. 1) whereas that between upper level and height was not (fig. 4).

15 ml of 0.75% bupivacaine. This was the largest group, consisting of 177 extradural analgesics. Within this group a subgroup of 18 patients with established arteriosclerosis was identified. This subgroup was compared with another subgroup of 70 patients, all over the age of 45 yr with no evidence of cardiac or vascular disease. Regression lines were calculated, but the slopes were not significant at the 5% level; therefore the data were treated as a normal distribution. Student’s t test for unpaired data showed that the two subgroups were not significantly different at the 5% level. This allowed the data to be pooled, and the regression lines for the combined data to be calculated. Both of these lines were significant at the 5% level; the upper level against age is shown in figure 2 and the upper level against height in figure 5.

20 ml of 0.75% bupivacaine. This group comprised 104 extradural analgesics. Regression lines for upper level against age and height (fig. 3 and fig. 7) were significant at the 5% level in both cases.

DISCUSSION

Many factors may influence the spread of local analgesic solutions in the extradural space. In this study some of these were standardized and others were varied in a controlled manner.

Site of injection. The third lumbar interspace was identified only by surface markings and there is a
possibility that on some occasions the second or fourth interspace may have been used in error.

**Bevel direction.** Although often mentioned, we know of no documentation of its effect. However, in this study the bevel direction was standardized.

**Rate of injection.** The magnitude of this effect is not great: Erdemir, Soper and Sweet (1965) showed that by tripling the rate of injection of 20 ml into the extradural space they achieved only a 0.68 higher segmental level on average. Our injections were made manually at as near to 1 ml s\(^{-1}\) as could be managed, and we do not feel that variations in the rate of injection influenced the upper level to any significant extent.

**Gravity.** All our patients were anaesthetized on a horizontal operating table which remained horizontal for at least 15 min after the injection, by which time fixation of the local anaesthetic would have occurred. The transition from the lateral to the supine position occurred at a variable time after the injection. In the 46 patients in whom asymmetrical analgesia developed, the level on the side dependent at the time of injection was taken as the level of maximum spread. It has been shown that, even when the patient remains on his side for 15 min after the injection, the average difference in segmental spread between the two sides is only two segments (Grundy, Rao and Winnie, 1978).

**Arteriosclerosis.** Following the original case report (Bromage, 1962b) the phenomenon of dramatically increased spread in the arteriosclerotic patient has been questioned. Our comparison of the two subgroups within the 15-ml group showed no difference between patients with and without arteriosclerosis. This is in agreement with recent comparison of arteriosclerotic and normal patients who had received 10 ml of 0.75% bupivacaine (Sharrock, 1977).

**Height.** Although no significant influence of height on the level of analgesia could be shown for the 10-ml group, we feel that this may be the result of a small sample size. Both the 15-ml and 20-ml groups show a weak correlation between spread and height, which agrees with Bromage (1962a). The impact of this effect can be gauged from the model, from which it can be seen that a difference of 30 cm in height makes only one segment of difference in the level of analgesia.

**Age.** Our results show that, with increasing age, a given volume will block more segments, but the magnitude of this effect is small; with 15 ml or 20 ml a difference of 40 yr results in only one additional segment being blocked. This is at variance with the results of Bromage (1962a, 1969), who reported large reductions in dose requirements with advancing age. Unfortunately, Bromage's results and ours are not directly comparable, as his relate to the volume of lignocaine required in order to achieve a given segmental level (an upper level of about T6 for most surgical procedures) while our figures are for the upper level achieved after a fixed volume of bupivacaine.

**Volume-analgesia relationship.** Bromage (1962a) assumed a direct volume-analgesia relationship (double the volume injected = double the number of segments blocked). Our results refute this assumption. Figure 7 shows that, for a 170-cm tall, 60-yr-old man, 10 ml of solution will block to T7.1 (16.9 segments), 15 ml to T5.6 (18.4 segments) and 20 ml to T4.3 (19.7 segments). This suggests that as we double the volume to be injected from 10 ml to 20 ml we can expect a 3-4 segment higher level of analgesia, whereas an increase from 15 ml to 20 ml, will result in only a 1-1.5 segment higher level.

We believe that when fluid is injected into the extradural space it takes the path of "least resistance". With a small volume, such as 10 ml, this is along the central axis of the extradural space with minimal spillage out of the lateral intervertebral foramina, even in the young patient.

The cervical extradural space is very shallow, and indeed the dura is adherent to the periostium in parts, to produce a potential space (Cheng, 1963); thus cephalad spread beyond the high thoracic extradural space meets considerable resistance. Moore and others (1957) injected radio-opaque dye into the lumbar extradural spaces of cadavers and showed that while 20 ml reached the body of T4, doubling the volume to 40 ml increased the spread to only T1, with increased spillage into the paravertebral spaces. All this is consistent with our results in that large increases in volume resulted in only a small amount of additional spread.

It is also interesting to note that, in this series, the highest level of analgesia achieved was to T2. This suggests that the cervical extradural space is merely a potential space which is difficult to open.

Usobiaga, Wikinski and Usobiaga (1967) showed that after the injection of 10 ml of 2% lignocaine into the extradural space, there was a strong correlation between residual extradural pressure, age and level of analgesia. We would suggest that the occasional cases of high extradural analgesia occur in patients with extremely low extradural space compliance.

Despite our standardization of interspace, bevel direction during injection, volume injected, rate of...
injection, concentration of the local analgesic and appreciation of the weak influence of patient age and height, our results for the upper level of analgesia after a given volume of local analgesic show a considerable range. Most probably this is a result of anatomical differences in the capacity of the extradural space for a given vertebral level associated with such factors as body habitus. This and perhaps other unmeasured factors, may have a much larger influence on the spread of analgesia than the known factors.

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REFERENCES