Prospective Examination of Epidural Catheter Insertion

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Background: Although it is generally accepted that inserting epidural catheters 3–4 cm into the epidural space minimizes complications, no prospective randomized examination of epidural catheter insertion length has been published.

Methods: Eight hundred healthy parturients requesting epidural analgesia were randomized to have open-tip epidural catheters inserted 2, 4, 6, or 8 cm within the epidural space. The incidences of intravenous cannulation, unilateral sensory analgesia, and subsequent catheter dislodgement were recorded. Catheter insertions that resulted in intravenous cannulation or unilateral analgesia were incrementally withdrawn and retested with additional local anesthetic to determine the effectiveness of epidural catheter manipulation.

Results: Epidural catheters inserted 8 cm within the epidural space were more likely to result in intravenous cannulation. Epidural catheters inserted 2 cm within the epidural space were less likely to result in unilateral sensory analgesia but were more likely to become dislodged. Twenty-three percent of epidural catheters inserted >2 cm within the epidural space required manipulation. Epidural catheters inserted 2 or 4 cm required replacement more often than epidural catheters inserted 6 or 8 cm. Ninety-one percent and 50% of epidural catheters that resulted in unilateral sensory analgesia and intravenous cannulation, respectively, provided analgesia for labor and delivery after incremental withdrawal.

Conclusions: Epidural catheters should be inserted either 2 cm when rapid labor is anticipated or 6 cm when prolonged labor or cesarean delivery is likely. Additionally, epidural catheters that result in intravenous cannulation or unilateral sensory analgesia can be manipulated effectively to provide analgesia for labor and delivery. (Key words: Anesthesia: obstetric. Anesthetic techniques: epidural.)

BROMAGE has suggested that inserting epidural catheters 3–4 cm into the epidural space minimizes complications because a greater length of catheter insertion increases the likelihood of unilateral sensory analgesia or intravenous cannulation and shorter lengths may risk unintentional dislodgment. Kumar et al. further suggest that inserting lumbar epidural catheters more than 3 cm risks transforaminal escape. Despite these suggestions, no prospective randomized examination of epidural catheter insertion length has been published.

The few existing studies addressing management of poorly functioning epidural catheters did not randomize patients with respect to epidural catheter insertion length.

At our institution, epidural catheters routinely are inserted more than 4 cm in obese patients with no apparent increase in complications. We therefore speculated that epidural catheters can be inserted farther than 4 cm in all patients without increased risk.

Also controversial is whether to manipulate epidural catheters (by partial withdrawal and administration of additional local anesthetic) or to remove and replace those that result in unilateral sensory analgesia or intravenous cannulation. Epidural catheter replacement is time-consuming and risks additional complications. Alternatively, if effective, epidural catheter manipulation may save time and avoid placement complications.

In this analysis, we ask two questions: Which epidural catheter insertion length minimizes insertion-related complications? When a complication occurs, is epidural catheter manipulation effective?

Materials and Methods

After institutional review board approval and informed consent, 800 women in active labor requesting epidural analgesia were randomized to have epidural catheters inserted 2, 4, 6, or 8 cm (200 patients per group) within the epidural space. Before epidural catheter placement, the physician was given an index card with a randomly assigned insertion length (by table of random numbers). Patients with a contraindication...
to regional anesthesia, at high risk for urgent cesarean delivery, or weighing more than 250 pounds were excluded from study. The increased risk of cesarean section in high-risk patients and the concern for epidural catheter dislodgment of epidural catheters inserted 2 cm within the epidural space precluded enrollment of these patients.

Intravenous access was obtained in all patients before epidural placement. Automated maternal blood pressure, tocodynamometry, and continuous fetal heart rate tracing were monitored throughout labor. The epidural space was identified via loss-of-resistance technique with either saline or air through a 17-G, 3.5-inch Tuohy-Schiff epidural needle and an 18-G, open-tip, lumbar epidural catheter (B Braun Medical, Bethlehem, PA) inserted. Epidural catheters were inserted the randomized length unless significant resistance or paraesthesia was encountered. Epidural catheters that could not be inserted the designated length were examined as a separate subset. The academic training level of the physician inserting the epidural catheter, approximate interspace, patient position during placement, and depth to the epidural space were recorded. Only experienced physicians who had performed at least 50 epidural anesthetics enrolled patients in the study.

Intravenous catheters were defined as any catheter from which blood could be aspirated or that was associated with neurologic symptoms after the administration of local anesthetic. Unilateral sensory analgesia was defined as any epidural catheter associated with >2 dermatomal sensory disparity to pinprick associated with patient discomfort, patchy sensory analgesia, or missed dermatomal segments or when inadequate sacral root analgesia occurred. Epidural catheter dislodgment was defined as any catheter that functioned well and subsequently ceased to function after the administration of additional local anesthetic.

After insertion and negative aspiration of cerebrospinal fluid or blood, catheters were tested with a 2-ml 2% plain lidocaine intrathecal test dose followed in 5 min by a 5-ml 2% plain lidocaine intravenous test dose. If both test doses were negative, an additional 3 ml 2% plain lidocaine was administered for a total of 10 ml 2% plain lidocaine per patient.

Intravenous catheters were withdrawn in 1-cm increments until blood could no longer be aspirated. At this point, catheters still lying within the epidural space (as assessed by markings on the epidural catheters) were retested with 5 ml 2% plain lidocaine and were removed if positive neurologic symptoms recurred. Catheters no longer lying within the epidural space were replaced. Additionally, epidural catheters were removed and replaced if neurologic symptoms occurred after the lidocaine test doses and no blood could be aspirated during incremental withdrawal.

Sensory levels to pinprick were assessed 20 min after the administration of lidocaine from patients not exhibiting signs and symptoms of intrathecal or intravenous cannulation. Comfortable patients received epidural infusions of 0.125% bupivacaine. Epidural catheters inserted 2 cm within the epidural space associated with unilateral sensory analgesia were automatically replaced. Epidural catheters inserted more than 2 cm within the epidural space associated with unilateral sensory analgesia were withdrawn 2 cm, and an additional 5-ml 2% plain lidocaine bolus was administered. This procedure was repeated every 15 min until patient comfort was achieved or the catheter was replaced. Theoretically, an epidural catheter inserted 8 cm into the epidural space resulting in inadequate analgesia would be manipulated three times with the patient receiving 25 ml 2% plain lidocaine (500 mg) over 65 min before replacement.

Any patient requiring catheter replacement was excluded from further study. One exception was patients with negative intrathecal and intravascular symptoms after the lidocaine test doses and no analgesia within 20 min of local anesthetic administration. These epidural catheters were aspirated during incremental withdrawal and were assumed to lie outside the epidural space if aspersion was negative for blood or cerebrospinal fluid. These patients then were reentered for study with the same insertion length.

Unless indicated, continuous data are presented as mean ± SD. Because epidural catheter insertion length is not an independent variable (i.e., 2 vs. 4 cm, 2 vs. 6 cm, and 2 vs. 8 cm all include the same 2 cm value when comparing various insertion lengths), multiple comparison adjustments were not initially made. Instead, a "protected chi-square test" analogous to Fisher's protected least significant difference overall F test was used. 11-17 That is, an overall chi-square test was performed for each complication studied, and, only if the overall difference was significant, six 2-by-2 chi-square analyses were performed, one for each possible pair of depths, to determine whether catheter insertion lengths differed from each other. If the overall test was not significant, correction for multiple comparisons was performed for individual pairwise comparisons. Data unrelated to epidural catheter insertion length were

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analyzed by chi-square or Fisher’s exact test with adjustments for multiple comparisons made as appropriate. \( P < 0.05 \) was considered significant.

### Results

Eight hundred patients were enrolled in the study. Of these, 784 patients had epidural catheters inserted one of four lengths (2, 4, 6, or 8 cm) within the epidural space. The epidural catheter could not be inserted to the randomized insertion length in 16 patients.

Treatment groups did not differ in demographic variables, parity, interspace of insertion, depth to the epidural space, initial sensory level to pinprick, duration of epidural analgesia, or mode of delivery (table 1).

Intravenous cannulation occurred with 62 of 784 (8%) epidural catheter insertions (table 2). In these cases, blood was aspirated from 60 catheters (97%) and could not be aspirated from 2 catheters during incremental withdrawal when positive neurologic symptoms occurred after the lidocaine test dose. Of the 60 catheters with a positive aspiration of blood, 32 (53%) remained within the epidural space and 28 (47%) lay outside the epidural space when blood could no longer be aspirated during incremental withdrawal. Thirty-one of the 32 catheters remaining within the epidural space provided analgesia for labor and delivery after additional lidocaine administration, and recurrent neurologic symptoms occurred in the remaining patient (fig. 1).

Unilateral sensory analgesia occurred with 77 of 784 (10%) epidural catheter insertions (table 2). Seven of these catheters were initially inserted 2 cm and were automatically replaced. Of epidural catheters inserted

### Table 1. Patient Characteristics

<table>
<thead>
<tr>
<th></th>
<th>2 cm</th>
<th>4 cm</th>
<th>6 cm</th>
<th>8 cm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample size (n)</td>
<td>200</td>
<td>198</td>
<td>196</td>
<td>190</td>
</tr>
<tr>
<td>Age (yr)*</td>
<td>27 ± 5.9</td>
<td>27 ± 5.8</td>
<td>27 ± 5.5</td>
<td>26 ± 5.6</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>163 ± 2.6</td>
<td>164 ± 2.8</td>
<td>164 ± 2.7</td>
<td>164 ± 2.5</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>76 ± 12.2</td>
<td>77 ± 13.1</td>
<td>79 ± 13.2</td>
<td>79 ± 13.5</td>
</tr>
<tr>
<td>Nulliparous (%)</td>
<td>56</td>
<td>48</td>
<td>55</td>
<td>52</td>
</tr>
<tr>
<td>Placement interspace†</td>
<td>(L_{3,2,3} )</td>
<td>(L_{3,2,3} )</td>
<td>(L_{3,2,3} )</td>
<td>(L_{3,2,3} )</td>
</tr>
<tr>
<td>Depth to space (cm)</td>
<td>5.0 ± 1.01</td>
<td>5.0 ± 1.02</td>
<td>5.0 ± 1.2</td>
<td>5.0 ± 1.1</td>
</tr>
<tr>
<td>Initial sensory level†</td>
<td>(T_{10,8,10} )</td>
<td>(T_{10,8,10} )</td>
<td>(T_{10,8,10} )</td>
<td>(T_{10,8,10} )</td>
</tr>
<tr>
<td>Duration (min)‡</td>
<td>300 ± 215</td>
<td>280 ± 226</td>
<td>330 ± 209</td>
<td>290 ± 229</td>
</tr>
<tr>
<td>Spontaneous delivery (%)</td>
<td>66</td>
<td>68</td>
<td>66</td>
<td>66</td>
</tr>
<tr>
<td>Instrumental delivery (%)</td>
<td>19</td>
<td>21</td>
<td>19</td>
<td>19</td>
</tr>
<tr>
<td>Cesarean delivery (%)</td>
<td>15</td>
<td>11</td>
<td>15</td>
<td>15</td>
</tr>
</tbody>
</table>

No significant difference exists between groups; \( P < 0.05 \) considered significant.

*Unless indicated, data are presented as mean ± SD.
†Median ± 25th percentile, 75th percentile.
‡Duration in minutes from epidural placement until delivery.

### Table 2. Associated Complications (%)

<table>
<thead>
<tr>
<th>Complications</th>
<th>Overall ( P^* )</th>
<th>2 cm (n = 200)</th>
<th>4 cm (n = 198)</th>
<th>6 cm (n = 196)</th>
<th>8 cm (n = 190)</th>
<th>All Catheters (n = 784)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intraoperative cannulation</td>
<td>&lt;0.001</td>
<td>5</td>
<td>6.5</td>
<td>5.5</td>
<td>14†</td>
<td>8</td>
</tr>
<tr>
<td>Unilateral analgesia</td>
<td>0.003</td>
<td>3.5†</td>
<td>13.5</td>
<td>13.5</td>
<td>9</td>
<td>10</td>
</tr>
<tr>
<td>Catheter dislodgement</td>
<td>&lt;0.001</td>
<td>0.6†</td>
<td>15</td>
<td>1</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Manipulated‡</td>
<td>0.626</td>
<td>12.5†</td>
<td>24</td>
<td>19.5</td>
<td>23.5</td>
<td>23</td>
</tr>
<tr>
<td>Replaced‡</td>
<td>0.029</td>
<td>10.5†</td>
<td>6</td>
<td>5</td>
<td>9</td>
<td></td>
</tr>
</tbody>
</table>

*Overall \( P \) value of the four epidural catheter insertion lengths with respect to each complication using a "protected chi-square analysis" analogous to Fisher’s protected LSD test. If the overall \( P < 0.05 \), then six \( 2 \times 2 \) chi-square analyses were performed, one for each possible pair of lengths.
†\( P < 0.05 \) versus all other lengths without a dagger.
‡Epidural catheters inserted 2 cm within the epidural space were automatically replaced and not manipulated when associated with a complication.

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>2 cm, 64 of 70 (91%) provided analgesia for labor and delivery after withdrawal in 2-cm increments and additional local anesthetic administration (fig. 1). The remaining six epidural catheters were removed and replaced secondary to inadequate analgesia.

Catheter dislodgment occurred with 21 of 784 (3%) epidural catheters (table 2). These patients experienced significantly longer labors than patients with no catheter dislodgment (table 3).

Sixteen epidural catheters (0, 2, 4, and 10 catheters inserted 2, 4, 6, and 8 cm, respectively) could not be inserted the randomized length. Of these, ten (63%) provided adequate analgesia after placement. Five catheters (35%) were associated with unilateral sensory analgesia (1, 2, and 2 catheters inserted 4, 6, and 8 cm, respectively), four of which functioned well after manipulation. One catheter inserted 4 cm dislodged, and one catheter inserted 6 cm was replaced. None of the 16 catheters was inserted intravenously.

Although not randomized, patient position (31.5% sitting, 51.3% left lateral decubitus, and 15.4% right lateral decubitus), loss of resistance with saline (30%) or air (70%), and the level of training of the physician inserting the epidural catheter (58%, 24%, 10%, and 8% by junior resident, senior resident, fellow, and staff, respectively) had no significant effect on intravenous cannulation, unilateral sensory analgesia, subsequent catheter dislodgment, catheter manipulation, or the number of epidural catheters requiring replacement.

### Discussion

This study was designed to answer two questions: Which epidural catheter insertion length minimizes insertion related complications? How effective is epidural catheter manipulation when an insertion-related complication occurs? Although Bromage suggests that inserting epidural catheters 4 cm within the epidural space minimizes the risk of intravenous cannulation, unilateral sensory analgesia, and unintentional catheter dislodgment, we found no optimal insertion length. Either 2- or 6-cm insertions may minimize insertion-related complications depending on the expected labor outcome of the patient requesting epidural analgesia.

Epidural catheters inserted 2 cm within the epidural space minimize the risk of intravenous cannulation and unilateral sensory analgesia. However, these catheters dislodge significantly more often than catheters inserted more than 2 cm, and 12.5% require replacement (table 2). More specifically, epidural catheters dislodge significantly more often during prolonged labor (table 3).

Consequently, inserting epidural catheters 2 cm within the epidural space may best be used in patients likely to experience rapid labor, i.e., the multiparous patient with prior uncomplicated vaginal deliveries. On the other hand, 6-cm insertions may be preferred when prolonged labor is expected or when the patient is at increased risk for cesarean section. This insertion length minimizes the risk of intravenous cannulation and catheter dislodgment, although unilateral sensory analgesia occurs with 13.5% of these catheters, 19.5% require manipulation, and 6% require replacement (table 2). Six-centimeter insertions may be preferred over 4 cm because the latter require more frequent replacement (table 2).

Fifty percent of intravenous catheters provided adequate analgesia for labor and delivery after incremental withdrawal (fig. 1). Intravenous catheters are identified either by a positive aspiration of blood through the catheter or with positive neurologic symptoms asso-

### Table 3. Catheter Dislodgement

<table>
<thead>
<tr>
<th></th>
<th>Dislodged Catheters</th>
<th>All Other Catheters</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>No.</td>
<td>21</td>
<td>779</td>
<td></td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>86.1 ± 17.7</td>
<td>77.4 ± 12.7</td>
<td>0.07</td>
</tr>
<tr>
<td>Duration (min)</td>
<td>385 ± 228</td>
<td>297 ± 222</td>
<td>0.002</td>
</tr>
</tbody>
</table>

Data are presented as mean ± SD.

* Duration in minutes from epidural placement until delivery.
ciated with the local anesthetic test dose after an initial negative aspiration. Aspirating intravenous catheters during incremental withdrawal eventually will result in a negative aspiration. Catheters still lying within the epidural space (assessed by markings on the epidural catheter) can be retested with local anesthetic, whereas catheters no longer lying within the epidural space are removed and replaced. If positive neurologic symptoms recur after administration of local anesthetic, the catheter should be removed and replaced, because it still lies within an epidural vein and the patient is at risk for local anesthetic toxicity with the administration of additional local anesthetic. However, recurrent neurologic symptoms after catheter manipulation occurred in only 1 of 32 (3%) such catheters in this study. Conversely, 97% (31 of 32) of these catheters provided adequate epidural analgesia for labor and delivery. On the other hand, intravenous catheters no longer lying within the epidural space after incremental withdrawal take only seconds to assess and are removed with no additional administration of local anesthetic. Therefore, although the manipulation of an intravenous catheter is only 50% effective, the anesthesiologist can quickly determine which catheter to retest with local anesthetic or which to replace.

Ninety-one percent of epidural catheters inserted more than 2 cm resulting in unilateral sensory analgesia functioned well after manipulation and additional local anesthetic was administered. According to protocol design, analgesia was assessed 20 min after the administration of the local anesthetic, and epidural catheters were automatically manipulated if associated with unilateral sensory analgesia. We argue in favor of this maneuver because it is 91% effective and appears to be time-efficient.

At our institution, local anesthetic test doses do not include epinephrine, necessitating the need to test epidural catheters with relatively large volumes of concentrated local anesthetic solutions. This practice initially may provide satisfactory analgesia when more dilute solutions of bupivacaine with epinephrine would provide inadequate analgesia. How can our conclusions apply to other obstetric practices? In this study, analgesia was maintained using continuous infusions of 0.125% bupivacaine without opioid to detect inadequate analgesia once the lidocaine-induced analgesia had resolved. The average time from epidural placement to delivery was 300 ± 220 min for all patients (354 ± 222 min and 264 ± 210 min for nulliparous and multiparous patients, respectively), allowing ample time to detect inadequate analgesia. Furthermore, all epidural catheters associated with unilateral sensory analgesia, whether detected initially or throughout labor, were included in our results.

Epidural catheters inserted 2 cm dislodge more often than catheters inserted >2 cm within the epidural space (table 2). Despite adequate securing of the epidural catheter to the patient's back, movement of the skin may cause the epidural tip to be withdrawn >2 cm, resulting in catheter failure. The risk of this occurring is theoretically greater in obese patients or during prolonged labor. In fact, patients who experienced catheter dislodgment had significantly longer labors than patients who did not experience catheter dislodgment (table 3). On the other hand, there was no significant difference in weight between groups (table 3); however, patients weighing >114 kg were excluded from the study.

The importance of patient position and the use of saline or air for loss of resistance during epidural catheter placement is controversial. However, these variables had no effect on the incidence of intravenous cannulation, unilateral sensory analgesia, catheter dislodgment, catheter manipulation, or catheter replacement in this study. Although we did not control for these variables, total enrollment in this study was sufficient to conclude that these variables make no significant clinical difference during epidural catheter placement. Likewise, the level of training of physicians placing epidural catheters had no significant effect on insertion-related complications. One explanation is that no inexperienced physicians participated in this study. Junior residents had performed at least 50 epidural anesthetics before enrolling patients. Alternatively, patients with histories of difficult epidural placement may have requested more senior physicians to place their epidural catheters.

In summary, epidural catheter insertion length makes a difference, although no particular length is optimal. Epidural catheter insertion should vary with the anticipated duration of labor or mode of delivery. Inserting epidural catheters 2 cm within the epidural space is recommended in patients likely to experience rapid labor. On the other hand, inserting catheters 6 cm

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within the epidural space may be most appropriate when prolonged labor is expected or cesarean section is likely. Additionally, when an epidural catheter results in intravenous cannulation or unilateral sensory analgesia, incremental withdrawal and administration of additional local anesthetic can be effective and may be more time-efficient than automatic epidural catheter replacement.

References


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