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ORIGINAL ARTICLE
Appropriate length of epidural catheter in the epidural space for postoperative analgesia: evaluation by epidurography

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Summary
In current practice, the length of epidural catheter that should be left in the epidural space is not standardised for effective postoperative analgesia. This prospective, randomised, double-blinded study aimed to determine the most appropriate length of epidural catheter that should be inserted into the epidural space for postoperative analgesia. We recruited 102 women and assigned them into three study groups (3, 5 and 7 cm insertion). An epidural catheter was inserted and epidurography was performed. Postoperatively, mean pain scores, motor and sensory levels, and any complications associated with the epidural catheter were recorded. No statistically significant difference for mean postoperative pain score was found at all study timings. Motor and sensory blockade was also statistically insignificant. Unilateral sensory analgesia developed in one patient in the 7 cm group and epidural catheter dislodgement was observed in four patients in the 3 cm group. In order to minimise catheter-related complications for postoperative analgesia, the most appropriate length that an epidural catheter should be left in the epidural space is 5 cm.

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Continuous epidural analgesia is considered one of the most effective techniques for postoperative analgesia [1]. The position of an epidural catheter and the distribution of local anaesthetic drugs in the epidural space are two of the most important determining factors for successful epidural analgesia. The incidence of failed or inadequate epidural analgesia has been reported as 4.2–6.3% in one study, because of suboptimal placement of the epidural catheter within the epidural space [2]. In our institution, regular audit of the acute pain service also showed that catheter-related problems are one of the main reasons for failed or incomplete epidural analgesia.

In current practice, controversy exists regarding the length of epidural catheter that should be left within the epidural space for successful pain management. Inserting a limited length of the epidural catheter, i.e. 3–4 cm, may result in an increased incidence of migration of the epidural catheter out of the epidural space. However, if a longer length of epidural catheter is left in the epidural space, this may increase the likelihood of a unilateral block or intravenous cannulation [3]. Clinical trials have shown that even if the epidural catheter was left 2–5 cm in the epidural space, this was found to provide satisfactory analgesia. However, one trial has shown that if more than 3 cm of the epidural catheter is left in the epidural space, this increases the risk of transforaminal escape [4].

The length of the epidural catheter that should be left in the epidural space has not been standardised. The main aim of this study was to determine the most appropriate length of epidural catheter that should be inserted into the epidural space for postoperative analgesia. The secondary aim was to determine the complications associated with different lengths of epidural catheter.
Methods

After ethical approval from the ethics committee of Aga Khan University hospital, we conducted this prospective, randomised, double-blinded trial. Informed written consent was obtained from all patients. We recruited female patients between 40 and 60 years of age, with ASA physical status 1–3 scheduled for total abdominal hysterectomy. Exclusion criteria included patients with any contraindication to regional anaesthesia and with a known history of allergy to radio-opaque dye. All patients had an epidural catheter inserted and were randomly assigned into three study groups: 3, 5, or 7 cm inside the epidural space. Randomisation was performed using a computerised table of random numbers.

All patients were premedicated with 7.5 mg oral midazolam, 1 h before surgery. Patients were preloaded with 7–8 ml.kg\(^{-1}\) crystalloid solution. Baseline heart rate, blood pressure and oxygen saturation were recorded. Using a full aseptic technique, the epidural space was localised at the L2-3 or L3-4 level with a 16-G Tuohy needle (Portex; Smith Medical ASD, Weston, MD, USA), with the bevel of needle facing cephalad, and using loss of resistance to air in the lateral decubitus position. A median approach was used in all patients. A multi-orifice epidural catheter was inserted into the space according to the group allocation. Patients were randomly assigned to have the epidural catheter inserted either 3, 5, or 7 cm in the epidural space. Patients were placed in the supine position after withdrawing the Tuohy needle and securing the catheter.

Figure 1 gives an overview of the study design. Any epidural catheter that was found on test dose to be either intrathecal or intravascular was removed before the induction of general anaesthesia. For epidurography, 2–3 ml non-ionic, iso-osmolar contrast medium Omnipaque (GE-Health, Ireland) was injected via the epidural catheter, to ascertain the level of entry into the epidural space and to ascertain the location of the epidural catheter. This was followed by injection of 12–15 ml contrast medium to demonstrate the spread and number of segments covered above or below the

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**Figure 1** Overview of the study design.

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point of entry. Anterior and lateral images were taken under fluoroscopy (Figs 2 and 3). All these findings of epidurography were interpreted and recorded in the data collection form.

After epidurography, the patient was handed over to the primary anaesthetist, who was blinded to the allocation of the study group. The epidural block was then established with a total of 12–15 ml bupivacaine 0.25% with 50 μg fentanyl over a period of 10 min, to achieve a block to T8–T10. Two additional 5-ml boluses of 0.25% bupivacaine were also given if the block level was not achieved in 15–20 min. The epidural was considered failed if the sensory level was not achieved in 30 min, and the patient was then given rescue analgesia in the form of intravenous morphine or pethidine. During establishment of the epidural block, if systolic blood pressure dropped more than 25% from the baseline or less than 90 mm Hg, 50–100-μg boluses of phenylephrine were given intravenously. A heart rate of less than 50 beats.min⁻¹ was treated with 0.5–1 mg atropine. After establishment of epidural analgesia, anaesthesia was induced with propofol 1.5–2 mg.kg⁻¹ and fentanyl 2 μg.kg⁻¹. Atracurium 0.5–0.6 mg.kg⁻¹ was given to facilitate tracheal intubation. Isoflurane was used for maintenance of anaesthesia. Intra-operative analgesia was maintained with an epidural infusion of 12–15 ml bupivacaine 0.0625% with fentanyl 2 μg.ml⁻¹. Morphine 0.1 mg.kg⁻¹ or pethidine 1 mg.kg⁻¹ was used as rescue analgesia and was administered at the discretion of the primary anaesthetist. Postoperatively, pain relief was maintained with an infusion of 12–15 ml.b.h⁻¹ bupivacaine 0.0625% with fentanyl 2 μg.ml⁻¹ for 48 h. Postoperative pain scores at rest (visual analogue scale 1–10), sensory level (pinprick method) and motor power of lower limbs (0–3 on Bromage scale) were assessed by the acute pain service, every 4 h for 48 h. A pain score of more than 3 was treated with additional boluses of 5–7 ml bupivacaine 0.25%. If pain was not relieved, then intravenous rescue analgesia was given as per departmental guidelines. Complications associated with the catheter including dislodgment, unilateral analgesia and nausea and vomiting were also monitored.

For the study, we defined an intravenous catheter as a catheter from which blood could be aspirated or that was associated with central neurological symptoms after the administration of local anaesthetic. An intrathecal catheter was defined as a catheter from which cerebrospinal fluid could be aspirated or that was associated with motor block after administration of a test dose. Unilateral sensory analgesia was defined as any epidural catheter associated with more than 2 dermatomes, sensory disparities. Dislodgement of the epidural catheter was defined as any catheter that functioned well and subsequently ceased to function despite additional boluses. A failed epidural in our study was one that failed to achieve the desired level of sensory block at the time of establishment of epidural analgesia.

At the end of 48 h, all patients were asked to rate the overall pain management as excellent/good/satisfactory/unsatisfactory. A total of 30 subjects per group achieved 80% power, with a minimum 20% difference in average pain score between any of the two groups, a maximum of 30% variability in pain scores and 5% level of significance [3]. An interim analysis supervised by an independent statistician led to an adjustment of the total number of patients to 102, to increase the power of the study. Data were entered twice in epidata software by two different data operators. Data entry was verified by re-examining at 5% the data collection form manually. For analysis purpose, data were

Figure 2 Lateral and anteroposterior and lateral images after epidurography in a patient who had an epidural inserted for a total abdominal hysterectomy (after 3 ml contrast medium). The arrow indicates the catheter tip in the epidural space.
converted into spss version 13.0. Analysis of variance was used for continuous variables e.g. age, weight and mean pain scores. Cross-tabulation using chi-squared analysis was used for categorical variables e.g. unilateral block and patients’ satisfaction.

Results

A total of 102 patients were enrolled with 34 patients in each group. One patient from the 3 cm group was not studied, in whom the epidural catheter tip was found outside the epidural space on epidurography.

There was no difference in age, weight and height between the three groups (Table 1). No intravenous or intrathecal catheter placement was found on routine test dose. The spread of radio-opaque contrast medium in the epidural space with the details of epidurography are shown in Table 2. The difference was insignificant among the three groups for the total number of segments covered above or below the level of catheter insertion or to the right and left of the midline.

Sensory blockade at T10 was successfully achieved in all groups before the induction of general anaesthesia and the intra-operative course was unremarkable in all cases. No statistically significant difference was found for mean postoperative pain scores among the groups at all study timings (Fig. 4). Motor and sensory blockade was also statistically insignificant among all three groups.

Unilateral sensory analgesia developed in one patient in the 7 cm group in the first postoperative period. This patient was successfully managed according to our routine departmental guidelines, which are to withdraw the catheter by 1–2 cm and re-administer the local anaesthetic dose accordingly. Epidural catheter dislodgement was observed in four patients in the 3 cm group (p < 0.05). These dislodgements happened in the wards in the first 24 h and resulted in repeated epidural boluses and increased demands for rescue analgesia (p < 0.05). There were no differences between the groups for other postoperative complications, including nausea and vomiting. No statistically significant difference was found for patients’ satisfaction among the three groups.

Table 1 Characteristics of patients who had an epidural catheter inserted 3, 5 or 7 cm before total abdominal hysterectomy. Values are mean (SD).

<table>
<thead>
<tr>
<th></th>
<th>3 cm (n = 33)</th>
<th>5 cm (n = 34)</th>
<th>7 cm (n = 34)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age; years</td>
<td>45.5 (12.2)</td>
<td>43.0 (7.9)</td>
<td>46.0 (8.3)</td>
</tr>
<tr>
<td>Weight; kg</td>
<td>65.9 (13.0)</td>
<td>67.8 (9.3)</td>
<td>69.7 (13.5)</td>
</tr>
<tr>
<td>Height; cm</td>
<td>153.6 (5.7)</td>
<td>155.6 (6.0)</td>
<td>155.7 (5.6)</td>
</tr>
</tbody>
</table>
This study was designed to determine the most appropriate length of epidural catheter that should be inserted into the epidural space for postoperative analgesia with minimum catheter related complications. The gold standard for identification of the epidural space is the loss-of-resistance technique [4, 5]. At the time of this study, we considered the best method to confirm the catheter position in the epidural space. Epidural stimulation test was one option, which in current practice has been promoted as a simple, fast and reliable method. However, in a recent study, the epidural stimulation test was found less feasible than expected, and whether it improves the quality of analgesia is still not determined [6]. By contrast, radiological images to confirm epidural catheter position or epidurography to evaluate the spread of drug has been in practice for a long time [7–9]. We choose epidurography under fluoroscopy as a tool to confirm the placement of epidural catheter in this study.

Performing epidurography and its interpretation in terms of catheter tip position and contrast medium spread was found to be a reliable process, as two of the investigators in this study were familiar with these procedures, due to their routine interventional pain practice. In this study, the epidural catheter tip was found in the epidural space in all patients except one in the 3 cm group. Successful sensory level was also achieved in all confirmed catheter positions. This showed that fluoroscopy reliably indicates the catheter position, inside the epidural space, resulting in successful analgesia.

Epidurography has been claimed to be reliable in predicting the dermatomal distribution of contrast medium, specifically cephalic and caudal spread [9, 10]. This has been examined previously by Magides et al. with multi-orifice versus single-orifice catheters. They found no difference in the total number of vertebral segments covered by contrast medium, above or below the level of catheter insertion (at lumbar level), when a standard length of catheter was inserted into the epidural space [11]. In the present study, we examined the spread of contrast medium, with different lengths of multi-orifice catheter inserted into the epidural space. We were anticipating variable patterns with different lengths, but did not find any significant differences. The number of segments covered, both cranially and caudally, with all catheter lengths, was well matched.

Another important finding from this study is regarding catheter-related complications. In this study, catheter dislodgment was observed in four patients out of 33 in the 3 cm group. This is contrary to the study of D’ Angelo et al., where dislodgment was more often within the 2 cm group than the >2 cm groups and they recommended inserting 6 cm, when prolonged labour was expected or caesarean section was likely [12]. In our study, we chose a minimum length of 3 cm considering previous literature supporting dislodgment with 2 cm. Despite this, we found dislodgment with the 3 cm group resulting in an increased demand for rescue analgesia. Thus, a 3-cm length of epidural catheter may be appropriate for short-term use (e.g. rapidly progressing labour) but for a longer period of time, e.g. postoperative analgesia, the length of the epidural catheter should be more than 3 cm. This finding is consistent with the result of the study by

<table>
<thead>
<tr>
<th>Spread of contrast material</th>
<th>3 cm (n = 33)</th>
<th>5 cm (n = 34)</th>
<th>7 cm (n = 34)</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Longitudinal</td>
<td>33 (100%)</td>
<td>30 (88%)</td>
<td>33 (97%)</td>
<td>NS</td>
</tr>
<tr>
<td>• Horizontal</td>
<td>–</td>
<td>2 (6%)</td>
<td>1 (3%)</td>
<td></td>
</tr>
<tr>
<td>• Patchy/Spotting</td>
<td>–</td>
<td>2 (6%)</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Contrast material crossing the midline</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Both right and left</td>
<td>33 (100%)</td>
<td>34 (100%)</td>
<td>34 (100%)</td>
<td>NS</td>
</tr>
<tr>
<td>• Only right</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>• Only left</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>No. of segments covered by contrast material above the level of epidural anaesthesia</td>
<td>3 (1)</td>
<td>3 (2)</td>
<td>4 (2)</td>
<td>NS</td>
</tr>
<tr>
<td>No. of segments covered by contrast material below the level of insertion</td>
<td>5 (1)</td>
<td>4 (1)</td>
<td>3 (1)</td>
<td>NS</td>
</tr>
</tbody>
</table>

Table 2: Findings of epidurography in patients who had an epidural catheter inserted 3, 5 or 7 cm for total abdominal hysterectomy. Values are number (proportion) or mean (SD).
Bhiston et al. who found that the epidural catheter has a tendency to migrate both further into and out of the epidural space after it has been secured. They found that 22% of the catheters migrated more than 1 cm out of the epidural space [13].

Current literature suggests that threading too much of the epidural catheter into the epidural space may direct the catheter right or left, rather than into the middle of the space. In this study, only one case of unilateral analgesia after 24 h was reported in the 7 cm group. This may be attributed to catheter migration or prolonged positioning of the patient on one side, causing the drug spread to spread unilaterally.

Interestingly, mean pain score trends were similar in all groups at all study timings despite reported catheter-related complications in the 3 and 7 cm groups. This may be explained by provision of intravascular rescue analgesia and appropriate action of the departmental acute pain management guidelines in the study protocol. As a result of ethical consideration, these were strictly followed to ensure that patients were pain-free.

In summary, if there are no anatomical abnormalities within the epidural space, all lengths of epidural catheter i.e. 3–7 cm may cause similar spread of local anaesthetic within the epidural space. However, if the catheter is as short as 3 cm or as long as 7 cm, then this may lead to performance problems of the epidural catheter. Although epidurography is not a routine procedure for routine epidural catheter placement, it is a definitive tool to confirm the position of the epidural catheter and may be used in difficult cases. Considering the overall findings of this study and the supporting literature available, 5 cm of epidural catheter is the most appropriate length for postoperative analgesia, with minimum catheter-related complications such as dislodgment and unilateral analgesia.

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Competing interests
No external funding or competing interests declared.

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