*Acta Anaesthesiol Scand 2002; **46:** 603–606*
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ACTA ANAESTHESIOLOGICA SCANDINAVICA
0001-5172

Coiling of lumbar epidural catheters

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Background: The difficulties in threading an epidural catheter to vertebral levels remote to the puncture level have been well documented. This study was undertaken to determine the length that a single orifice epidural catheter can be threaded into the lumbar space without coiling (coiling length), and whether this is affected by the direction of the epidural needle bevel.
Methods: Forty-five young male patients scheduled for surgery under epidural analgesia were enrolled. The epidural space was identified using a midline approach at the L_{2-3} or L_{3-4} interspace with the loss of resistance to air technique. A 19-G single-orifice epidural catheter (Flextip Plus™, Arrow International, Inc, Reading, PA, USA) was inserted through a Tuohy needle oriented either cephalad (n=20) or caudad (n=25). During insertion, the path and the position of the catheter tip was determined by fluoroscopy using iohexol dye.
Results: The median coiling length was 2.8 cm, ranging from 1.0 to 8.0 cm. Only 13% of epidural catheters could be threaded 4 cm beyond the tip of the needle without coiling. No significant difference was found in coiling length between the cephalad group (2.9 cm) and the caudad group (2.5 cm).
Conclusion: This study demonstrates that coiling length is independent of whether the bevel of the Tuohy needle is directed cephalad or caudad. We recommend that an optimal insertion depth of an end-hole single orifice catheter is 3 cm.

Received 2 May, accepted for publication 31 December 2001

Key words: epidural anesthesia; catheter technique.

It is generally accepted that inserting epidural catheters 3–4 cm into the epidural space minimizes complications. Although insertion to greater lengths reduces the possibility of dislodgement, it potentially leads to side-effects such as intravenous cannulation, paresthesia, and unilateral sensory analgesia (1, 2). Irrespective of whether the catheter is passed easily into the epidural space through the needle opening, there may be a considerable difference between the distance from the puncture site to the tip of the catheter and the length of catheter inserted as a result of coiling (3–7).

The aim of the present study was to determine the length by which a single orifice end-hole epidural catheter can be threaded into the lumbar epidural space without coiling, and to determine whether this length is affected by the direction of the epidural needle bevel.

Methods

After obtaining institutional approval of the protocol and written informed consent from all patients, a total of 45 male patients (ASA physical status I) scheduled for lower extremity surgery under lumbar epidural anesthesia were enrolled in the study (Table 1). Patients with spinal deformity, mental disorder, or sensory disorder were excluded. All epidural anesthesias and fluoroscopic examinations were performed by the same experienced staff member.

With the patient in the sitting position, lumbar epidural puncture was performed using the midline approach with a 17-G Tuohy needle and the loss-of-resistance to air technique at the L_{2-3} or L_{3-4} interspace. After measuring the distance from the skin to the epidural space, a 19-G end-hole epidural catheter, reinforced with a spring wire coil (Flextip Plus™, Arrow) was inserted with the needle bevel directed either cephalad (n=20) or caudad (n=25). Following a 3 cm insertion into the epidural space, the catheter was filled with 0.22 ml (priming volume without bacterial filter) of iohexol dye (Omnipaque 300®, Nycomed Ireland Ltd, County Cork, Ireland), and its position was determined by fluoroscopy (Fig. 1). In cases where coiling had not occurred, the catheter was inserted further until it began to coil. After noticing coiling, the catheter was inserted a further 3–5 cm to observe the coiling pattern. After removing the Tuohy needle, the catheter was pulled out in increments to the point where the coiling disappeared (coiling length from skin), and was fixed to the skin. The length that was threaded into the epidural space with-

Table 1

Clinical characteristics of the patients, and coiling length of the epidural catheter.

	Cephalad (n=20)	Caudad (n=25)	Total (n=45)
Age (year)	24.3±4.6	23.7±3.5	24.0±4.0
Weight (kg)	66.1±8.4	67.0±6.5	66.6±7.3
Height (cm)	172.4±4.1	173.7±4.1	173.1±4.1
Epidural depth (cm)	4.4 (3.0–5.5)	4.2 (3.0–5.5)	4.3 (3.0–5.5)
Coiling length (cm)	2.9 (1.0–5.5)	2.5 (1.5–8.0)	2.8 (1.0–8.0)

Values are mean±SD or median (range).

out coiling (coiling length) was determined by deducting the 'epidural depth' from the 'coiling length from the skin'. After a negative aspiration test for blood or cerebrospinal fluid (CSF), 25 ml of lidocaine 20 mg · ml^{-1} with epinephrine 5 μg · ml^{-1} was injected, with the patient in the supine position (including a test dose of 3 ml). Thirty minutes after the local anesthetic injection, the extent of sensory blockade was determined by the pinprick method.

Values are expressed as mean±SD or as medians. The Student's *t*-test was used for demographic comparison. Epidural depth and coiling length were compared between the groups using the Mann–Whitney *U*-test. Correlation analysis between coiling length and upper sensory blockade level was performed using Spearman's rank correlation coefficient. $P<0.05$ was considered statistically significant.

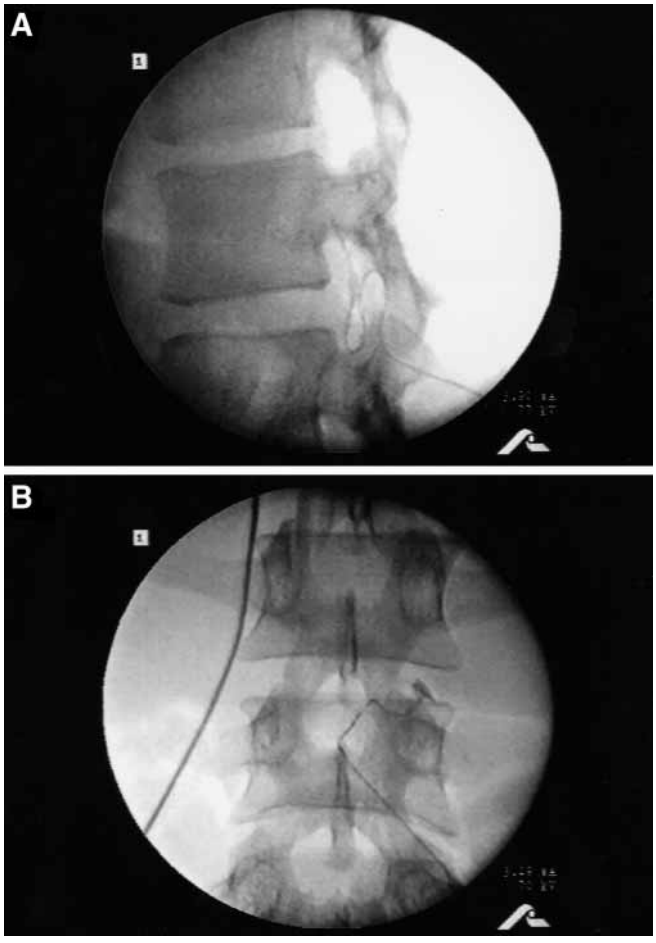

Fig. 1. Fluoroscopy of a catheter in the lumbar epidural space. After a fractional advance, the catheter curled and made a loop with the tip advancing no further into the epidural space. Entrance, course, and the tip of the epidural catheter are visible (A). The catheter tip is located in the right side of the epidural space (B).

Results

The median coiling length was 2.8 cm (range 1.0–8.0 cm) (Fig. 2). At this length, the catheter wedged in the epidural wall, curled and made a loop with the tip advancing no further into the epidural space. Only six out of the total 45 catheters (13%) threaded ≥4 cm beyond the tip of the needle without coiling. Statistical analysis comparing coiling lengths in the cephalad (2.9 cm) and the caudad groups (2.5 cm) did not reveal any significant difference (Table 1). In two patients (4%), the epidural catheters were threaded in the direction opposite to that of the needle bevel.

In the patient, the local anethestic injection through

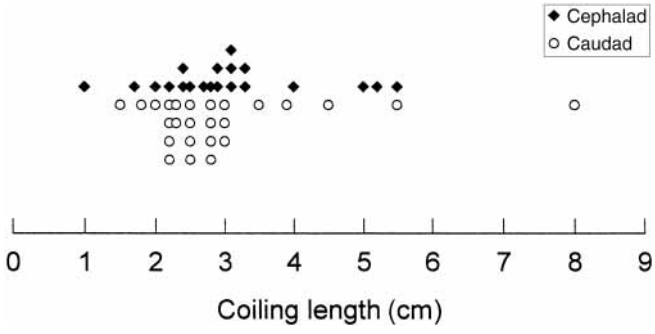

Fig. 2. The length of catheters threaded within the epidural space without coiling (coiling length). Median length was 2.8 cm, ranging from 1.0 to 8.0 cm. In only 13% of the cases did the catheters thread without coiling 4 cm beyond the tip of the needle into the epidural space.

the epidural catheter fixed to the skin at a coiling length of 1.5 cm resulted in incomplete analgesia in the S_{1-5} segments. Missed segments in S_{3-5} occurred in two patients (coiling length 1.0 cm and 2.4 cm). Except for these three patients, epidural anesthesia was successful. Thirty minutes after the local anesthetic injection, sensory blockade extended to a median upper level of T_8 (range T_{4-11}), and no significant correlation was found between the coiling length and the sensory blockade level ($P=0.28$, $\rho=0.17$, $n=42$). During catheter insertion, paresthesia was elicited in one patient. No case of epidural vein cannulation was encountered.

In 23 patients, the position of the catheter tip in the epidural space was observed, and in eight of these (35%) the catheter tip followed straightly the intended cephalic or caudal direction for more than 2 cm in the posterior midline epidural space. In the remaining 15 cases, the tip of the catheter deviated either side of the epidural space immediately after leaving the needle tip. In nine patients the catheter was placed near an intervertebral foramen. A difference in upper sensory block of four segments was noted in two patients; in one the tip of the catheter was located at an intervertebral foramen on the side of the greatest block (coiling length 2.8 cm) whereas, in the other, the catheter tip was located in the midline of the posterior epidural space (2.8 cm). Asymmetric spread of two segments was noted in two patients; these patients had foraminal catheter tips on the contralateral side of the greatest block (2.5 cm and 3.5 cm).

Discussion

We found that the coiling lengths were similar in the two groups. This may be because of the fact that the angulation of the Tuohy needle relative to the back of the patients was almost perpendicular. Hence, the catheter met the structures in the epidural space at a right angle, leading to tenting of the dura by the catheter tip and consequent difficulties in advancing it in the intended direction.

Using radiography, previous studies have shown that in most cases the epidural catheter was not located in the intended position, and also that in approximately 9% of cases the catheter was inserted in a direction opposite to that of the needle bevel (4, 7). Bridenbaugh *et al*. (5), reported that when inserted in the lumbar epidural space, only 14% of epidural catheters could be threaded more than 5 cm without coiling. Muneyuki *et al*. (6) reported in patients subjected to lumbar epidural anesthesia that the probability of the catheter tip being situated three segments beyond the intervertebral space of insertion was only approximately 0.5%. According to Beck (7), 52% of lumbar epidural catheter tips inserted 5 cm did not reach the intended spinal level, but in fact remained within 2 cm from the puncture site. We found that in only 13% of cases could the catheter tip be advanced ≥4 cm without coiling.

The advance of a catheter tends to be deflected by blood vessels, fat tissues, and the median epidural septum in the epidural space (8, 9). Consequently, deviation or coiling of the catheter can occur, preventing the tip of the catheter reaching the intended level. Thus, even if the catheter is inserted without coiling, the actual length of catheter tip advancement in the intended direction is not related to the length of the catheter threaded into the epidural space. In the present study, we attempted to direct the epidural catheter straightly cephalad or caudad, but only eight out of 23 catheters (35%) followed straightly the intended direction for more than 2 cm. Other reports using plain radiography and computed tomography (CT) have also shown that in 58–85%, the catheters deviated to the right or left side of the epidural space (3, 10). They also found that the tips were most often found lateral to the dura in an intervertebral foramen (10), which increases the risk of transforaminal passage or placement of a catheter in the anterior epidural space, the most common cause of unilateral epidural block (11).

In our study, of the four patients in whom the sensory blockade was asymmetric by ≥2 segments, only one displayed sensory block correlated with the side of the catheter tip position. Similar findings were reported by Gielen *et al*. (3) suggesting that the onset of sympathetic blockade does not correlate with the catheter position. Hogan (10) found that a lateral catheter deviation is a more common cause of asymmetric block than anatomic barriers to the spread of the local anesthetic solution. This finding can be explained in part by the volume of the injected solution. With larger volumes, a more uniform spread in the epidural space occurs (10). In common with our study, Gielen *et al*. (3) injected 20 ml prilocaine 20 $mg \cdot ml^{-1}$, which may be a large enough volume to overcome the uneven distribution of local anesthetic.

Catheters deviating from the midline may be more prone to cannulate epidural veins that are chiefly located at the intervertebral foramina or to elicit paresthesia than those advancing in the midline (3, 12). During catheter insertion, the incidence of paresthesia is 20–40%, and that of intravenous cannulation is 5–10% (13, 14). However, in the present study there was only one instance (2%) of paresthesia and no cannulation of epidural veins. This finding may be a result of the Arrow catheter's flexibility, and is consistent with a previous study that reported a low inci-

dence of paresthesia (2.7%) and inadvertent venous cannulation with the Arrow catheter (14).

Three epidural catheters, inserted 1, 1.5, and 2.4 cm, respectively, were associated with inadequate analgesia in the sacral area. A possible reason for inadequate analgesia is that of a properly placed epidural catheter tip being pulled out of the epidural space despite it being secured to the patient's back. In multiorificed epidural catheters with three lateral side ports, 4 cm is considered an optimal insertion length because one or more of the exit holes may be displaced from the epidural space during patient movement (15). In our study, we used an end-hole, single orifice catheter using the midline approach, and found that the majority of catheters coiled when inserted 3 cm into the lumbar epidural space. In order to minimize the risk of inappropriate positioning of the catheter tip and coiling, we recommend that an end-hole epidural catheter (reinforced with spring wire coil) is threaded 3 cm into the lumbar epidural space when the midline approach is applied.

The coiling length is most likely influenced by catheter type and puncture technique. The catheter used in this study features great flexibility and a tip with a sharp end-hole. A more rigid catheter with a round and smooth tip may be less prone to coiling. With the paramedian approach the Tuohy needle is presented at a more acute angle, allowing the epidural catheter to leave the needle with minimal tenting of the dura, and following a straight course near the midline without coiling (16, 17). Further studies of positioning and coiling of different types of catheters inserted by median and paramedian techniques as well as of the distribution of cutaneous anesthesia remain highly desired.

Conclusion

In young males, the median coiling length of a lumbar epidural catheter inserted into the midline is 2.8 cm (range 1.0–8.0 cm), independent of the needle bevel direction. Following the median technique for lumbar epidural anesthesia, we recommend that the optimal insertion depth of an end-hole single orifice catheter is 3 cm.

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