Anesthesiology
1997; 86:778-84

Changes in the Position of Epidural Catheters Associated with Patient Movement

Catherine L. Hamilton, M.D., Edward T. Riley, M.D.,† Sheila E. Cohen, M.B., Ch.B.‡*

Background: **Epidural catheter movement has been noted with change of patient position and can result in inadequate anesthesia. This study was designed to measure movement and to develop a technique that minimizes catheter displacement.**

Methods: **In 255 parturients requesting epidural anesthesia for labor or cesarean section, a multiorificed lumbar epidural catheter was inserted with the patient in the sitting flexed position. The distance to the epidural space, length of catheter inserted, and amount of catheter position change as the patient moved from the sitting flexed to sitting upright and then to the lateral decubitus position were measured before the catheter was secured to the skin. Adequacy of analgesia, the need for catheter manipulation, and whether the patient was considered obese were noted. Data were grouped according to body mass index (BMI): < 25, 25–30, and > 30 kg/m^2.**

Results: **The groups did not differ with respect to the length of catheter initially inserted or changes in catheter position between initial taping and removal. The distance to the epidural space differed significantly among the groups, increasing with greater BMI. Catheters frequently appeared to be drawn inward with position change from the sitting flexed to lateral decubitus position, with the greatest change seen in patients with BMI > 30. Only nine catheters were associated with inadequate analgesia, four of which were replaced. No analgesic failures occurred in the BMI > 30 group. In patients judged by the anesthesiologist to be obese or to have an obese back, BMI was greater, and the distance to the epidural space and the magnitude of catheter movement with position change were greater than in those who were not obese.**

Conclusions: **Epidural catheters moved a clinically significant amount with reference to the skin in all BMI groups as patients changed position. If catheters had been secured to the skin before position change, many would have been pulled partially out of the epidural space. To minimize the risk of catheter displacement, particularly in obese patients, we recommend that multiorificed catheters be inserted at least 4 cm into the epidural space and that patients assume the sitting upright or lateral position before securing the catheter to the skin. (Key words: Anesthesia: obstetric. Anesthetic techniques: epidural. Equipment: peridural catheters.)**

ALTHOUGH continuous lumbar epidural anesthesia is a safe and effective method of pain relief during labor or cesarean section, unsatisfactory analgesia sometimes occurs. Inadequate analgesia has been reported to occur in 1.5[1]-23%[2] of obstetric patients, and in morbidly obese parturients, initial failure in one study was 42%.[3] Among the reasons proposed to explain block failure is that properly placed epidural catheters may become displaced after being secured as a result of patient movement.[4,5] In a previous study of obstetric patients, Hamza *et al.*[6] found that the distance to the epidural space was greater when blocks were performed in the lateral position compared with in the sitting position, although the reasons for this are unclear. These authors speculated that if epidural catheters were inserted and securely taped to the skin while the patient was sitting, when the lateral decubitus position was assumed, (where the distance to the epidural space was greater) catheter displacement may occur. If an insufficient length of catheter remained in the epidural space, unsatisfactory analgesia would result. The goal of the present study was to determine whether this displacement phenomenon occurs with patient movement and whether it is of clinical significance.

Three hypotheses relative to epidural blocks performed in the sitting position were tested in this study: 1) the position of unsecured epidural catheters would change relative to the skin as patients moved from the sitting to the lateral decubitus position; 2) this change would be greater in obese patients; and 3) that block success rate would be high when epidural catheters were not secured to the skin until the patient assumed the lateral position.

Materials and Methods

After institutional review board approval, 255 women requesting epidural anesthesia for labor or cesarean sec-

This article is accompanied by a highlight. Please see this issue of ANESTHISIOLOGY, page 29A.

* Fellow in Obstetric Anesthesia.

† Assistant Professor of Anesthesia.

‡ Professor of Anesthesia.

From the Department of Anesthesia, Stanford University School of Medicine, Stanford, California. Submitted for publication August 13, 1996. Accepted for publication November 26, 1996. Presented at the annual meeting of the American Society of Anesthesiologists, Atlanta, Georgia, October 21-25, 1995.

Address correspondence to: Dr. Cohen, Department of Anesthesia, Stanford University School of Medicine, Stanford, California 94305.

tion were enrolled in the study after receiving an information sheet describing the purpose and methods of the study. Demographic data collected included patient age, height, weight, gestational age, and any pertinent medical history regarding back problems. Epidural catheters were placed by resident and attending anesthesiologists with the patient in a sitting flexed position. The technique used a midline approach at the L2-L3, L3-L4, or L4-L5 interspace and loss of resistance to air or saline via an 18-gauge, winged Tuohy needle (Perifix®, B. Braun Medical, Inc., Bethlehem, PA); the shaft of this needle has nine 1-cm markings. The distance from the patient's skin to the epidural space was estimated to the nearest 0.5 cm by viewing the calibrated Tuohy needle. For example, if 4 cm of the needle shaft remained visible outside of the patient's back, the distance to the epidural space would be estimated to be 5 cm. A more precise measurement of the depth of the needle was made for use in subsequent calculations by measuring the distance from the skin to the wing of the Tuohy needle using the barrel of a sterile tuberculin (TB) syringe, which is calibrated in 0.01-ml gradations (0.01 ml = 0.53 mm). A 20-gauge, closed-tip polyamide epidural catheter with three lateral sideports and calibration markings at 1-cm intervals (Perifix®, B. Braun Medical, Inc.) was inserted to leave 3 or 4 cm in the epidural space. If, after needle removal, the catheter was more than 4 cm in the epidural space, it was withdrawn until the appropriate marking was at the exit site. If the epidural catheter remained less then 3 cm into the epidural space (*e.g.*, because the patient was experiencing a persistent paresthesia), the reason was noted.

Before applying adhesive tape, the position of the epidural catheter relative to the skin was measured as subjects successively assumed three positions: 1) sitting flexed (patient sat on the bed with legs dangling over the side with her back maximally flexed); 2) sitting upright (patient sat as in #1 but straightened the back; patients were instructed to "sit up as straight as you can"); and 3) lateral decubitus (patient lied on her side with legs extended and spine in a neutral position). During patient movement, the epidural catheter was gently supported and sterility was maintained, but free movement of the epidural catheter relative to the skin was allowed. In each consecutive position, the TB syringe was used to measure the distance from the epidural catheter exit point at the skin to a standard reference mark on the epidural catheter (the 12-cm mark, unless this was submerged below the skin, in which case a more distal mark was selected). After performing these measurements and with the patient in the lateral position, the epidural catheter was firmly secured to the skin with broad adhesive tape applied over a folded sterile 2-inch gauze square placed over the exit site. The epidural catheter was looped to prevent direct traction on the exit site and was taped up the patient's back and over her shoulder. The patient was allowed to assume a position of comfort with uterine displacement for the duration of her labor or operation.

Anesthetic drug regimens were at the discretion of the anesthesiologist. Most laboring patients received an initial 3-ml test dosage of lidocaine, 1.5%, with epinephrine followed by a bolus of 8-12 ml of bupivacaine, 0.125 or 0.25%, with 10 μg sufentanil. Continuous infusions typically included bupivacaine, 0.0625%, with 0.33 μg sufentanil per ml, administered at 12-15 ml/h. If the epidural catheter was placed as part of a combined spinal-epidural technique, the epidural catheter was tested and dosed only after the patient requested additional analgesia for labor. For surgery, patients usually received lidocaine, 2%, with 1: 200,000 epinephrine with added sodium bicarbonate and fentanyl, 100 μg. If a laboring patient complained of unsatisfactory analgesia, the block was assessed, and appropriate dosages of bupivacaine, 0.125% or 0.25%, were administered. Epidural blockade was considered adequate if the patient was satisfied and if the anesthesiologist observed the expected responses to the anesthetic drugs administered. Surgical blocks were assessed by sensation to pinprick. The incidence of completely failed blocks (no evidence of drug effect at any time) and patchy, unilateral, or sacral sparing blocks was recorded. Any necessary manipulation of the epidural catheter after initial placement was recorded, as was the need for epidural catheter replacement. Complications such as intrathecal or intravascular catheter placement also were noted. In each case, the anesthesiologist performing the procedure assessed whether, in his or her judgment, the patient was obese or had an obese back. After delivery, epidural catheters were removed with the patient sitting up in bed. The tape and gauze were carefully removed, and the position of the epidural catheter at the skin exit site was recorded to the nearest 0.5 cm using the epidural catheter markings.

Based on body mass index (BMI, kg/m^2), subjects were assigned to one of three groups for comparison: < 25, 25-30, and > 30 kg/m^2. Measurements made with the TB syringe were converted from milliliter to centimeter using the appropriate conversion factor (1

Table 1. Demographic Data

	Body Mass Index (kg/m²)		
	<25 n = 46	25–30 n = 116	>30 n = 92
Height (cm)	165 ± 9	163 ± 8	162 ± 7
Weight (kg)*	64 ± 7.5	73 ± 7.2	90 ± 15.9
Gestational age (wk)	39 ± 2	39 ± 2	39 ± 3

Values are mean ± SD.

* $P < 0.05$ for all possible comparisons among groups.

ml = 5.3 cm). Data were analyzed with analysis of variance (ANOVA), Student's *t* test, chi square analysis, and coefficient of correlation as appropriate. Intergroup comparisons were further investigated with Fisher's progressive least squares difference test and the Scheffe's F test. $P < 0.05$ was considered significant. Unless noted otherwise, data are presented as the mean ± SD.

Results

Data were collected on 255 patients. There were no differences in patient age, height, or gestational age among the groups, although as expected, weight differed significantly (table 1). The distance from the skin to the epidural space was significantly greater in the > 30 BMI group (table 2). The length of catheter initially threaded into the epidural space (calculated using the TB syringe measurement) did not differ among the groups (table 2).

Table 3 shows the mean changes in epidural catheter position in the three groups as patients moved from the flexed to upright position and then from the upright to lateral position and the total epidural catheter position change that occurred as patients moved through these two positions, *i.e.*, flexed to lateral. In each case, the > 30 BMI group was significantly different from one or both of the other groups. Epidural catheter position changed relative to the skin with patient movement in all but two patients. In 252 patients, the epidural catheter appeared to be drawn toward the epidural space, *i.e.*, a greater length of epidural catheter was located beneath the skin in the final lateral position compared with the initial flexed position. One patient in the > 30 BMI group had a change in the opposite direction, wherein 0.11 cm of the epidural catheter appeared to move outward in the lateral position. The maximum epidural catheter position change was 4.28 cm in a patient in the > 30 BMI group weighing more than 180 kg (table 3).

The difference between the final epidural catheter position at the skin after placement and its position on removal (estimated to the nearest 0.5 cm using the epidural catheter markings) was calculated. Although the change in epidural catheter position tended to increase with BMI, this did not reach statistical significance (table 2). Two patients who had an epidural catheter placed as part of a combined spinal-epidural technique delivered without use of the epidural catheter. In the remaining patients, there were no complete block failures. One patient in the 25-30 BMI group developed a persistent unilateral block. The remaining 252 catheters were initially associated with satisfactory pain relief for labor or cesarean section. Subsequently, nine epidural catheters failed to provided adequate labor analgesia or surgical anesthesia (table 4). In two of these patients, analgesia was restored after withdrawing the epidural catheter slightly and redosing with local anesthetic. Four epidural catheters required replacement, giving an overall replacement rate of 1.6%. No epidural catheter required manipulation or replacement in the > 30 BMI group. One epidural catheter inserted

Table 2. Epidural Catheter Position Estimates and Measurements

	Body Mass Index (kg/m²)		
	<25 n = 46	25–30 n = 116	>30 n = 92
Estimated distance to epidural space (cm)*	3.9 ± 0.57	4.2 ± 0.55	5.0 ± 0.85
Measured distance to epidural space (cm)*	3.7 ± 0.58	4.1 ± 0.51	5.0 ± 0.88
Amount of EC in epidural space (cm)	4.3 ± 0.57	4.3 ± 0.55	4.3 ± 0.59
Change of EC position at skin from taping to removal (cm)	0.25 ± 0.65	0.58 ± 1.2	0.61 ± 1.2

Values are mean ± SD.

* $P < 0.05$ for all possible comparisons among groups.

EC = epidural catheter.

Table 3. Epidural Catheter Movement With Change In Patient Position

	Body Mass Index (kg/m²)		
	<25 n = 46	25–30 n = 116	>30 n = 92
Change FLEX to UP (cm)	0.23 ± 0.17	0.33 ± 0.28	0.38 ± 0.30*
Change UP to LAT (cm)	0.48 ± 0.41	0.51 ± 0.41	0.69 ± 0.68†
Change FLEX to LAT (cm)	0.67 ± 0.42	0.75 ± 0.48	1.04 ± 0.69†
Ranges of Change FLEX to LAT (cm)	0–1.9	0–2.72	−0.11–4.28

Values are mean ± SD except as noted.

$P < 0.05$.

* *vs.* < 25.

† *vs.* both groups.

FLEX = flexed; UP = upright; LAT = lateral.

4 cm into the epidural space yielded blood with aspiration; it was withdrawn 0.5 cm, reinjected, and provided successful analgesia. There were no intrathecal catheters.

The epidural space was deeper, and greater changes in epidural catheter position occurred with patient movement in patients judged by the anesthesiologist to be obese (table 5) or to have an obese back.

Discussion

In this study, we systematically examined the position of unsecured epidural catheters relative to the skin as patients moved from the sitting flexed to sitting upright and lateral positions. We consistently observed that catheters seemed to be drawn toward the epidural space, "disappearing" beneath the skin of the back. The mean length of catheter "movement" in the three groups ranged from 0.67 to 1.04 cm, with a maximum change of 4.28 cm in one obese patient. Mean catheter position change increased with BMI; however, even in the lowest and intermediate BMI groups, maximum changes of 1.9 and 2.72 cm, respectively, occurred.

These findings confirm the anecdotal reports of Webster[4] and Gartrell,[5] who observed similar phenomena, particularly in obese patients. In a large observational study of 2,123 parturients, Hamza *et al.*[6] found a greater distance from the skin to the epidural space when epidural puncture was performed in the lateral position compared with in the sitting position. Although this difference was independent of patient height and weight, positive correlations were found between the

Table 4. Outcome of the Nine Epidural Blocks with Inadequate Analgesia

BMI Group	Problem Encountered	Outcome
<25	Elective cesarean section. Adequate block to pinprick but pain with visceral manipulation.	Received supplemental epidural local anesthetic.
<25	Patchy block, sacral sparing for labor analgesia.	EC withdrawn slightly and redosed successfully.
<25	Adequate labor analgesia for several hours, then EC found to be completely out of epidural space.	EC replaced.
<25	Adequate labor analgesia. EC dosed for emergency surgery. Pain with uterine manipulation.	Received low dose supplemental inhaled anesthesia.
25–30	Initial unilateral block.	EC replaced after manipulations failed.
25–30	Adequate for 15 h, then patchy, midline sparing.	EC replaced after manipulations failed.
25–30	Adequate for labor and attempted forceps delivery. Pain during cesarean section.	Received inhaled nitrous oxide.
25–30	Adequate for 8 h of labor, then failed, and EC found to be completely out of epidural space.	EC replaced.
25–30	Late unilateral block in labor.	EC withdrawn slightly and redosed successfully.

EC = epidural catheter; BMI = body mass index.

Table 5. Catheter Position Change and Distance to ES *vs.* Body Habitus

	Obese Habitus n = 46	Normal Habitus n = 206
Change FLEX to LAT (cm)	1.27 ± 0.77*	0.75 ± 0.49
Distance to ES (cm)	5.3 ± 0.84*	4.2 ± 0.71

Values are mean ± SD.

* $P < 0.05$.

FLEX = flexed; LAT = lateral; ES = epidural space.

distance to the epidural space and patient weight and BMI. These findings, along with those in the present investigation, suggest that as a patient moves from the flexed to the lateral position, the distance from the skin to the epidural space increases.

If, as in the current study, the block is performed in the sitting position and if the epidural catheter is not secured to the skin, it will appear to be drawn toward the epidural space as the patient moves from the sitting to the lateral position. If, however, the epidural catheter is firmly taped to the skin while the patient is still in the sitting position, the epidural catheter may be pulled out of the epidural space toward the skin equal to the increased distance to the epidural space in the lateral position. We are not aware of any work describing exactly what "grips" an epidural catheter, but we speculate that the catheter may be fixed at two points: by the adhesive tape at the skin and by the 3- to 5-mm thick ligamentum flavum external to the epidural space. Our observations of the tissues of the back moving as much as several cm along the catheter exit point support the assumption that the unsecured catheter is gripped by the ligamentum flavum. Although the catheter appears to be "drawn into" the tissues of the back, we believe it actually is tissue movement.

What are the clinical implications of our findings? By allowing our patients to assume the position in which the distance to the epidural space was greatest before securing the epidural catheter (*i.e.*, the lateral position with spine deflexed), we believe that the length of epidural catheter initially threaded into the epidural space remained the same, despite epidural catheter position change relative to the skin with movement from the sitting position. If catheters had been secured before moving, the epidural catheters may have "migrated" from the epidural space. At our institution, we use closed-end, multiorificed epidural catheters with three lateral side ports situated 6 mm, 10 mm, and 14 mm from the tip of the catheter. If, as many authors suggest,[7,8] such catheters are threaded only 3 cm into the epidural space and secured with the patient in the flexed position, one or more of the exit holes may be displaced from the epidural space when the patient assumes the lateral position.

To illustrate the previous, we calculated the length of epidural catheter that hypothetically would have remained in the epidural space if we had inserted all epidural catheters only 3 cm into the epidural space, secured them with the patient in the flexed position, and then had the patient assume the lateral position after taping. We did this by subtracting from 3 cm the distance measured in each patient that the epidural catheter moved relative to the skin when she moved from the flexed to lateral position. Based on these calculations, only 4 of 255 catheters would have remained 3 cm in the epidural space; 251 (98%) would have been in less than 3 cm, 77 (31%) less than 2 cm, 7 (3%) less than 1 cm, and 1 would have been pulled out completely from the epidural space. After further changes in patient position during the course of labor or surgery, a significant number of these multiorificed epidural catheters ultimately may have been positioned with one or more holes located outside of the epidural space. Unsatisfactory analgesia could result.

Other authors have studied epidural catheter migration with varying results. In a study of 211 parturients, Crosby[9] noted catheter position at the skin by visual inspection of catheter markings before taping and later on removal. He reported a 54% incidence of catheter migration, with 70% of catheters moving out of the epidural space. Patient position during catheter placement, taping, and removal was not stated. Bishton *et al.*[10] prospectively examined 153 women whose catheters were inserted, secured, and later removed in the left lateral decubitus position. They measured catheter migration by visual inspection of the needle and catheter markings and used three methods of catheter fixation (various combinations of gauze, plastic adhesive spray or transparent dressing, and adhesive tape). Catheters had moved from their initial position in 36% of patients: 13.7% had migrated inward at least 1 cm, and 22.2% had migrated outward a similar distance. Outward catheter migration was positively correlated with increased weight, BMI, and depth of the epidural space, with no relationship to fixation method. Three failed epidural blocks were associated with outward catheter migration of at least 2.5 cm. We cannot directly compare our results with those of these other studies be-

cause they provide insufficient information regarding the degree of spine flexion on taping. If these authors had secured the catheters while the spine was maximally flexed in either the sitting or lateral decubitus positions, a firmly applied adhesive dressing may have pulled the catheter out of the epidural space as tissue depth increased with patient movement. In contrast, in the current study, we found no significant differences between epidural catheter position at initial taping and on removal, suggesting that patients were in the position of maximum tissue depth when we secured the epidural catheter.

Changes in epidural catheter position may affect the success of epidural analgesia. Although we did not compare our success rates with a control group of patients in whom we secured the epidural catheter with the patient sitting, we believe our initial success rate (252 of 253 blocks) and our overall epidural catheter replacement rate of 1.6% indicate excellent clinical results. With insertion of 3 or 4 cm of epidural catheter into the epidural space using the technique we described, our patients had few complications, such as intravascular catheters or patchy blocks requiring manipulation.

Of particular note was the zero failure or complication rate in our BMI $>$ 30 group, given the known increased risk for epidural block failure in obese parturients.[3] In a study of parturients weighing more than 300 lb, initial block failure occurred in 42% of obese women compared with 6% in nonobese control subjects.[3] The precise details of positioning during catheter placement and taping were not reported in this study, but it is likely that most blocks were performed in the sitting position. On assuming the lateral recumbent position, marked catheter movement out of the epidural space may have occurred if catheters were taped to the skin before the move. Block failure is particularly important in morbidly obese parturients because the cesarean section rate may exceed 60%[3] and because anesthetic morbidity and mortality in this population is increased, especially with administration of general anesthesia.[11]

Based on our findings, we recommend that multiorificed epidural catheters be placed at least 3 or 4 cm into the epidural space. We believe that catheter movement in the epidural space will be minimized if, after placement, the patient deflexes the spine and, in selective cases, assumes the lateral recumbent position with the spine deflexed before securing the epidural catheter at the skin. Patients who are estimated to be either obese or to have an obese back should lie down before epidural catheter taping because epidural catheter movement is greater in these patients. Assumption of the lateral position is especially important in those morbidly obese patients and normal weight patients in whom the epidural catheter cannot be advanced to the usual depth in the epidural space. In patients with normal BMI, the epidural catheter should remain an adequate distance in the epidural space when it is threaded 4 cm, even if a small amount of catheter movement occurs. We now routinely introduce the epidural catheter at least 4 cm into the epidural space and adopt the techniques used in this study for all patients.

Some may suggest that inserting epidural catheters with the patient in the lateral decubitus position could circumvent the problem of catheter misplacement. We chose not to study that particular question because we believe there are many advantages to performing epidural blockade in the sitting position, especially in obese patients. The sitting position eases identification of the midline of the spinal column[12] and may prevent the exaggeration of minor directional errors when the distance to the epidural space is greater.[13] These factors may increase the success rate in identifying the epidural space. Regardless of which position is chosen for epidural catheter insertion, the spine should be deflexed before securing the epidural catheter.

An alternative to the previous approach is to insert an additional length of catheter into the epidural space, thus allowing for displacement on patient movement. The ideal depth to insert catheters has been studied by several investigators. Beilin et al[14] suggested 5 cm as the optimal insertion depth for multiorificed epidural catheters in their study comparing insertion depths of 3, 5, and 7 cm. Because we did not insert catheters 5 or 7 cm, we cannot compare those depths. However, they did observe incomplete analgesia in 24 of 100 patients and one late catheter failure in the 3 cm group. Because they secured epidural catheters with the patient sitting, we believe that epidural catheter "movement" may have affected the success of their blocks. Introduction of excessive lengths of epidural catheter may increase the risk of intravascular placement and unilateral or ineffective blocks[15] and therefore may be a less effective strategy than taping the epidural catheter in the lateral position. Recently, D'Angelo *et al.*[16] recommended inserting open-ended epidural catheters either 2 or 6 cm into the epidural space, depending on the expected progress of labor, with manipulation of intravenous or unsatisfactory catheters. Again, we cannot compare their results with ours because we used multi-

orificed in contrast to their open-ended epidural catheters and did not study similar insertion depths.

We do not know if the problem of catheter displacement from the epidural space and subsequent inadequate or failed analgesia could be avoided by using open-ended epidural catheters instead of the multiorificed catheters used in our study. Multiorificed catheters have been found to be easier to place and yield a significantly higher analgesic success rate.[2]

In summary, we found that the position of epidural catheters can change significantly with patient movement from the flexed to upright and lateral positions before securing them at the skin. These findings were most striking in obese patients (BMI $>$ 30). Taping the epidural catheter to the skin in the position in which the distance to the epidural space was greatest (lateral position) resulted in a high degree of successful blockade and a low complication rate.

The authors thank Emily Ratner, M.D., and the many faculty and residents who assisted in data collection for this study.

References

1. Ducrow M: The occurrence of unblocked segments during continuous lumbar epidural anesthesia for pain relief during labour. Br J Anaesth 1971; 43:1173–4

2. Michael S, Richmond MN, Birks RJS: A comparison between open-end (single hole) and closed-end (three lateral holes) epidural catheters: Complications and quality of sensory blockade. Anaesthesia 1989; 44:578–80

3. Hood DD, Dewan DM: Anesthetic and obstetric outcome in morbidly obese parturients. ANESTHESIOLOGY 1993; 79:1210–8

4. Webster SG: Migration of epidural catheters (letter). Anaesthesia 1986; 41:654

5. Gartrell P: Disappearing epidural catheters (letter). Anaesth Intensive Care 1992; 20:121–2

6. Hamza J, Smida M, Benhamou D, Cohen SE: Parturients's posture during epidural puncture affects the distance from skin to epidural space. J Clin Anesth 1995; 7:1–4

7. Shnider SM, Levinson G, Ralston DH: Regional anesthesia for labor and delivery, Anesthesia for Obstetrics. Edited by Shnider SM, Levinson G. Baltimore, Williams and Wilkins, 1993, p 143

8. Glosten B: Local anesthetic techniques, Obstetric Anesthesia, Principles and Practice. Edited by Chestnut DH. St. Louis, Mosby, 1994, p 357

9. Crosby ET: Epidural catheter migration during labour: A hypothesis for inadequate analgesia. Can J Anaesth 1990; 37:789–93

10. Bishton IM, Martin PH, Veron JM, Liu WHD: Factors influencing epidural catheter migration. Anaesthesia 1992; 47:610–2

11. Endler GC, Mariona FG, Sokol RJ, Stevenson LB: Anesthesia-related mortality in Michigan 1972–1984. Am J Obstet Gynecol 1988; 159:187–93

12. Dewan D: Obesity, Obstetric Anesthesia, Principles and Practice. Edited by Chestnut DH. St. Louis, Mosby, 1994, p 947

13. Narang VPS, Linter SPK: Failure of extradural blockade in obstetrics. Br J Anaesth 1988; 60:402–4

14. Beilin Y, Bernstein HH, Zucker-Pinchoff B: The optimal distance that a multiorifice epidural catheter should be threaded into the epidural space. Anesth Analg 1995; 81:301–4

15. Bromage PR: Continuous epidural anesthesia, Epidural Analgesia. Edited by Bromage PR. Philadelphia, WB Saunders, 1978, p 219

16. D'Angelo RD, Berkebile BL, Gerancher JC: Prospective examination of epidural catheter insertion. ANESTHESIOLOGY 1996; 84:88–93