Anesthesiology
2000; 92:1631–6

The Fiberscopic Findings of the Epidural Space in Pregnant Women

Takashi Igarashi, M.D., Yoshihiro Hirabayashi, M.D.,† Reiju Shimizu, M.D.,‡ Kazuhiko Saitoh, M.D.,† Hirokazu Fukuda, M.D.,† Hideo Suzuki, M.D.**

Background: **The spread of epidural analgesia is facilitated by pregnancy. Changes in the epidural structure during pregnancy may affect the spread of analgesia in pregnant women. To investigate the changes in the epidural space produced by pregnancy, the authors performed epiduroscopy in pregnant women.**

Methods: **Using a flexible fiberscope, the authors evaluated the epidural space in 73 women undergoing lumbar epidural anesthesia. Patients were classified into three groups: a nonpregnant group (n = 21), a first trimester pregnant group (8–13 weeks, n = 23), and a third-trimester pregnant group (27–39 weeks, n = 29). A 17-gauge Tuohy needle was inserted using the paramedian technique and the loss-of-resistance method with 5 ml air. The epiduroscope was introduced into the lumbar epidural space via the Tuohy needle and was advanced approximately 10 cm in a cephalad direction from the needle tip within the epidural space. The differences in the epidural space among the three groups then was evaluated.**

Results: **The epiduroscopy showed that the epidural pneumatic space, after injection of a given amount of air, was narrower and the density of the vascular network greater in the third-trimester group than in the other two groups. The amount of engorged blood vessels was greater in the third and first trimester groups than in the nonpregnant group. The amount of bleeding at the needle tip and the amount of fatty and fibrous connective tissue did not differ among the three groups.**

Conclusions: **Epidural blood vessels become engorged in the first trimester; the density of the vascular networks increase in the third trimester. These changes in the epidural space during pregnancy may affect the spread of epidural analgesia in pregnant women. (Key words: Blood vessel; endoscope; epidural structure; obstetric; parturient.)**

MANY investigators have reported facilitation of the spread of epidural anesthesia in pregnant women.[1–4] Hormonal[5–7] and mechanical changes[8,9] induced by pregnancy have been cited as the reasons for such facilitation. Aortocaval compression[10,11] and increased maternal blood volume[12] can result in engorgement of the epidural veins, which is likely to enhance the spread of local anesthetics.[1–4] Investigating the epidural space in a pregnant woman has been difficult because of the hazards of radiation to the fetus. We used epiduroscopy to investigate the differences in the epidural structure among nonpregnant women and women in various stages of pregnancy because this technique is free from the hazards of radiation and provides a clear view of the epidural space.[13–16]

Materials and Methods

This study was approved by the ethics committee of our institution, and informed consent was obtained from all patients. We evaluated the epidural space with a flexible fiberscope in 73 patients undergoing epidural anesthesia for a variety of gynecologic or surgical procedures including hysterectomy, oophorectomy, arthroscopy of the knee, appendectomy, procedures to correct cervical incompetency, and cesarean section. Patients with histories of prior epidural anesthesia, neurologic disease, abnormalities of vertebral column, or coagulopathy were excluded. Patients were classified into three groups: a nonpregnant group (n = 21), a first trimester pregnant group (8–13 weeks, n = 23), and a third-trimester pregnant group (27–39 weeks, n = 29).

Each patient was placed in the right lateral decubitus position on a horizontal operating table. A 17-gauge Tuohy needle (Becton Dickinson, Franklin Lakes, NJ) was introduced in the L2–L3 space, using the paramedian technique. The epidural space was identified using the loss-of-resistance method with 5 ml air. If no cerebrospinal fluid or blood flowed from the needle, these patients underwent examination of the lumbar epidural space with a flexible fiberscope measuring 0.7 mm in diameter (MS-501, Igarashi Ika Kogyo, Tokyo, Japan),

* Staff Anesthesiologist.

† Lecturer.

‡ Professor and Chair.

Received from the Department of Anesthesiology, Jichi Medical School, Tochigi, Japan. Submitted for publication August 30, 1999. Accepted for publication January 24, 2000. Support was provided solely from institutional and/or departmental sources.

Address reprint requests to Dr. Igarashi: Department of Anesthesiology, Jichi Medical School, 3311-1 Yakushiji, Minamikawachi, Kawachi, Tochigi 329-0498 Japan. Address electronic mail to: igat@jichi.ac.jp

Table 1. Patient Data

	Nonpregnant Group (n = 21)	First Trimester Group (n = 23)	Third Trimester Group (n = 29)
Age (yr)	31 ± 4 (22–39)	29 ± 4 (20–36)	31 ± 4 (23–39)
Height (cm)	157 ± 6 (147–169)	159 ± 6 (143–171)	156 ± 6 (140–168)
Weight (kg)	55 ± 8 (42–76)*	54 ± 8 (40–75)	63 ± 9 (48–85)
Gestational age (week)	—	12 ± 1 (7–13)	37 ± 2 (33–39)

Mean ± SD (range).
* $P < 0.05$ for the groups.

which was connected to a television monitor system (FV-2000E; Igarashi Ika Kogyo). The epiduroscope was introduced approximately 10 cm in a cephalad direction into the epidural space *via* the Tuohy needle. No air was injected after the insertion of the epiduroscope in each patient. If paraesthesia or resistance was noted during the epiduroscope insertion, no attempt was made to advance the epiduroscope through the area of resistance. Epiduroscopic findings were recorded continuously by a video recorder during the fiberscopic examination in each patient. After the epiduroscopic evaluation, an epidural catheter (OD, 0.85 mm; B. Brown Japan, Tokyo, Japan) was inserted 5 cm in a cephalad direction into the epidural space. All procedures were performed by the same anesthetist. After the patient was placed in the supine position, he or she received local anesthetics *via* the catheter during the planned therapeutic or surgical procedure, with or without general anesthesia. Analgesia was induced in all patients successfully.

The epiduroscopic findings in the 73 patients were analyzed by two independent investigators who had no knowledge of the patients' medical histories. The epiduroscopic findings were divided into seven categories for analysis: size of the pneumatic space created by 5 ml air, density of the vascular network, amount of engorged blood vessels, water content (edema or engorgement) in the connective tissue, degree of bleeding at the needle tip, amount of fatty tissue, and amount of fibrous connective tissue. The size of the space made by 5 ml air was scored using the following grading system: 1 = very narrow, 2 = patent, 3 = widely patent. The other six areas of analysis were scored using the following grading system: 1 = none or extremely little, 2 = moderate, 3 = considerable. If a discrepancy between the two observers' findings was noted, the difference was resolved by a third experienced investigator.

Statistical analyses were carried out using a statistical software package (StatView V4.5; SAS Institute, Cary, NC) on a personal computer (Macintosh Quadra 650; Apple Computer, Cupertino, CA). The mean and SD for age, weight, and height and the medians and ranges for each epiduroscopic finding among the three groups were compared using the Kruskal-Wallis test and the Mann-Whitney U test. $P < 0.05$ was considered statistically significant.

Results

Age and height were comparable among the three groups (table 1). Body weight was greater in the third-trimester group than in the other two groups. The epiduroscopic procedure was performed successfully in all patients. We encountered no accidental dural punctures and observed no signs of neurologic injury in any of our patients.

Epiduroscopic examination (fig. 1) revealed that the size of the pneumatic space of epidural space after injecting air was smaller ($P = 0.0347$) and that the density of the vascular network ($P = 0.0001$) was greater in the third-trimester group than in the other two groups. The amount of engorged blood vessels was greater in the first and third-trimester groups than in the nonpregnant group ($P = 0.0001$). The water content in the connective tissue was greater in the third-trimester group than in the nonpregnant group ($P = 0.0237$). No significant differences were detected among the three groups in the degree of bleeding ($P = 0.9259$) and amount of fatty ($P = 0.8270$) and fibrous connective tissue ($P = 0.4290$). We observed no massive bleeding that would fill the epidural space.

Figure 2A shows the epidural space in a 32-yr-old nonpregnant woman. The right part was identified as fatty tissue; the left part, appearing as a white membrane, was identified as the dura mater. The epidural pneumatic space was seen to be patent because of the small amount of air that had been injected during the loss-of-resistance method. The few stretched fibrous connective tissues were scattered among the epidural space.

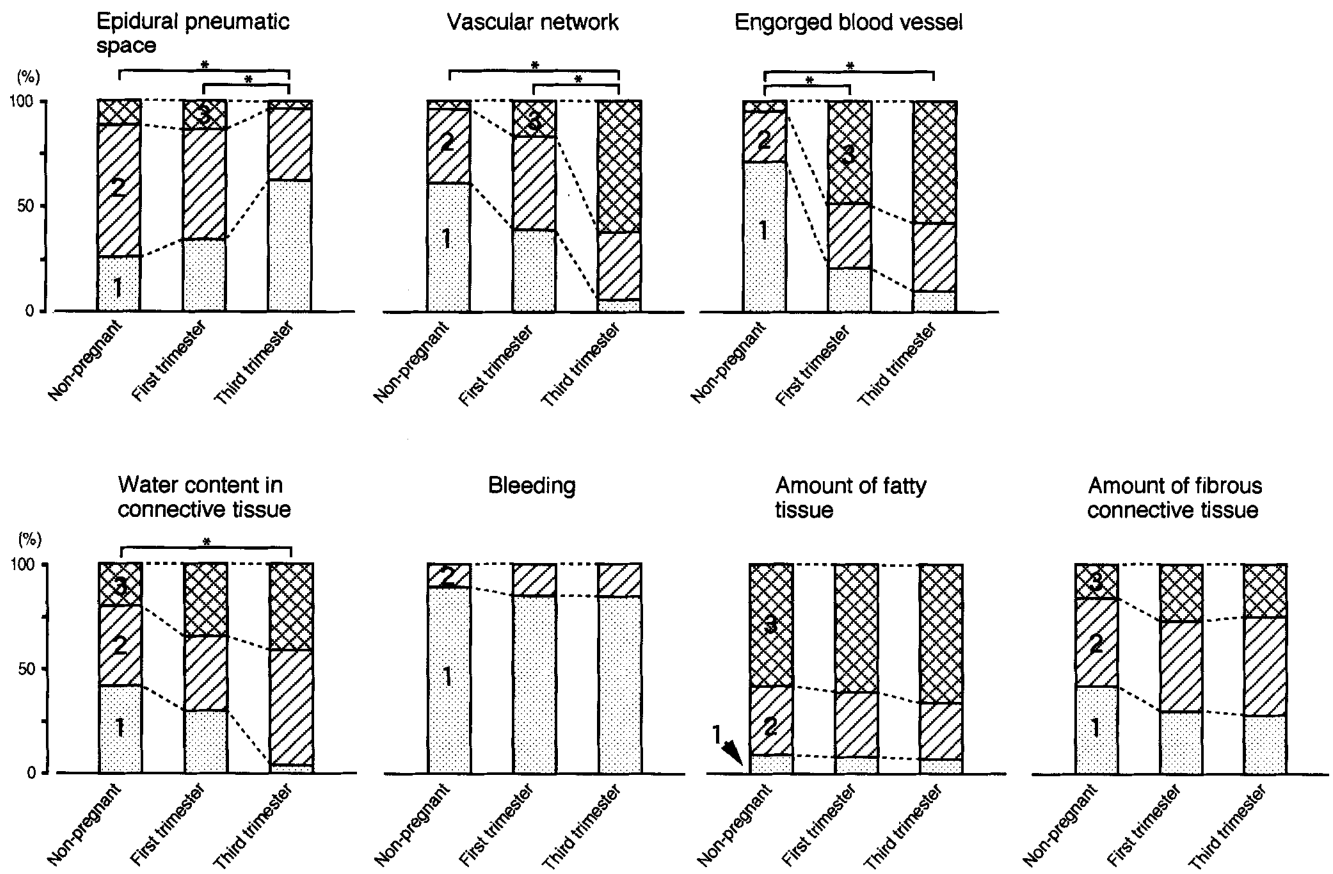

Fig. 1. Percentages of patients according to the epiduroscopic findings among the three groups. The size of the pneumatic space after injecting air was smaller (P = 0.0347) and the density of vascular network (P = 0.0001) was greater in the third-trimester group than in the other two groups. The amount of the engorged blood vessels was greater in the first and third-trimester groups than in the nonpregnant group (P = 0.0001). The water content in the connective tissue was greater in the third-trimester group than in the nonpregnant group (P = 0.0237). Stippled bars = score 1 (narrow or none or extremely little); hatched bars = score 2 (patent or moderate); cross-hatched bars = score 3 (widely patent or considerable).

Fine blood vessels were associated with fatty tissue. Figure 2B shows the epidural space in a 29-yr-old woman at 12 weeks' gestation. The lower left part was identified as dura mater; the upper right part was identified as fatty tissue. The epidural pneumatic space made by a small amount of air is seen clearly between the dura mater and fatty tissue. Engorged blood vessels overhang the epidural space and run meandering through the fatty tissue. Figure 2C shows the epidural space in a 30-yr-old woman at 37 weeks' gestation. The lower left part was identified as the dura mater; the upper right part was identified as fatty tissue. The size of epidural pneumatic space is reduced. Blood vessels associated with fatty tissue are engorged and form remarkable vascular networks.

Discussion

Epiduroscopy showed the changes in the epidural structure during pregnancy. In the first trimester, engorged blood vessels appeared within the epidural space. In the third trimester, the amount of engorged blood vessels increased, and the vascular network became more dense. The size of the pneumatic space made by a given amount of air became narrow in the third trimester. We suggest that pregnancy alters the epidural structure, which may affect the spread of local anesthetics within the epidural space in pregnant women.

We observed that blood vessels within the epidural space became engorged in the first trimester and remained so through the third trimester. A possible expla-

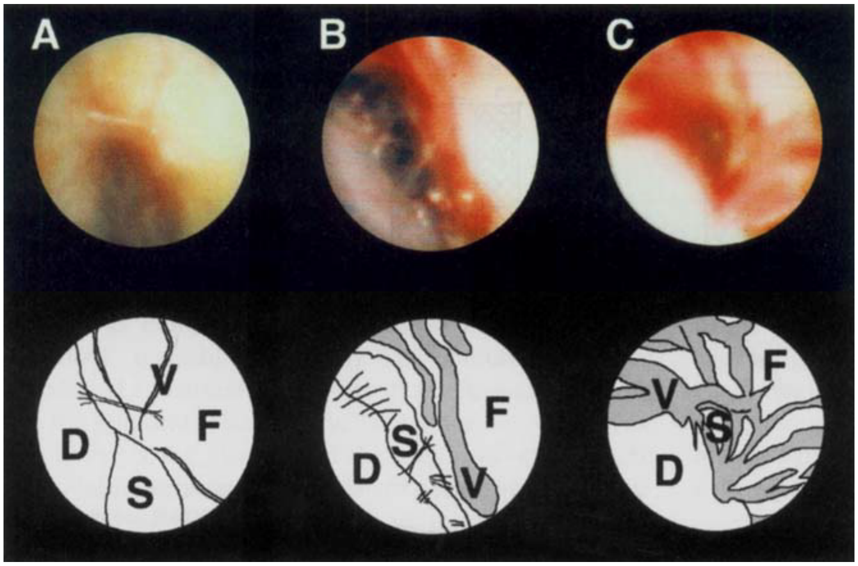

Fig. 2. Photographs (*top*) and schematic drawings (*bottom*) of the epidural spaces in a 32-yr-old nonpregnant woman (*A*), in a 29-yr-old woman at 12 weeks' gestation (*B*), and in a 30-yr-old woman at 37 weeks' gestation (*C*). Dura mater (D), fatty tissue (F), epidural space (S), and blood vessels (V) can be observed. Engorged blood vessels appeared in the first trimester. The pneumatic space became narrow and the vascular networks became dense in the third trimester.

nation for the occurrence of engorged blood vessels in the first trimester is the increased systemic blood volume associated with pregnancy.[12,17] In the third trimester, the gravid uterus becomes enlarged enough to obstruct the inferior vena cava,[18] and the epidural venous flow, which is collateral to the inferior vena cava,[19] further increases. Systemic circulating blood volume, which peaks in the third trimester,[12] may contribute further to the venous flow within the epidural space. We suggest that the epidural vein becomes engorged as early as the first trimester.

Blood vessel trauma at the tip of Tuohy needle was observed in approximately one fifth of the patients. The incidence of blood vessel trauma showed no relation to the gestational age. Our results, however, clearly showed the distention of the epidural vein in the pregnant women. Intravascular placement of an epidural catheter is reported in 2–43% of pregnant women,[20,21] in comparison with 1% in nonpregnant persons.[22] Although pregnancy itself is not an independent risk factor for the development of epidural hematoma associated with epidural or spinal anesthesia,[23,24] pregnant women may have a risk of intravascular placement of the epidural catheter.

In the epidural space in the near-term pregnant women, the pneumatic space made by a given amount of air was narrow. The movement of the dural sac concomitant with the venous plexus engorgement may play an important role in diminishing the transverse size of the epidural pneumatic space. The engorged blood vessels in the posterior epidural space suggest the marked engorgement of venous plexus in the anterior epidural space.[8,25] Because the epidural venous plexus exists mainly in the anterior epidural space, the engorged venous plexus in the anterior epidural space may induce the movement of the dural sac toward the dorsal direction. We suggest that the diminished size of epidural pneumatic space may be related to the facilitation of longitudinal spread of epidural analgesia in the pregnant women.[1-4]

Similar to the physiologic tissue edema that developed during the third trimester,[18] pregnancy may increase the amount of interstitial fluid within the epidural space. The connective tissue was seen to be soft and sticky, and the reflected lights against these tissues were brighter in the near-term women. We propose that these findings indicate an increase in water content in the connective tissue. The increased water content of the tissue may be related to pregnancy-induced physiologic changes: the increase in the circulating blood volume,[12] the increased collateral blood flow to the epidural vein,[19] the decreased colloid osmotic pressure resulting from the hydremia induced by pregnancy,[12] and transient reduction of the renal filtration during the near-term.[26,27] Although we did not obtain independent confirmation such as biopsy results, we propose that water content in the connective tissue could change during pregnancy, and that the changes may affect the spread of epidural analgesia in the pregnant women.

In the lumbar and lower thoracic segments, the epidural space has been suggested to be divided transversely into three compartments: anterior, dorsal, and dorsolateral.[28,29] If the epiduroscope advances through the dorsal compartment into other compartments, nerve irritations, which are closely associated with the contact of epiduroscope with the nerve roots after the migration of the epiduroscope, would occur during the epiduroscopic procedures. In this study, the tip of the Tuohy needle was introduced into the epidural space at midline as precisely as possible, and no evidence was detected that the epiduroscope advanced into other compartments in any of our patients. Therefore, the findings observed in this study presumably revealed the dorsal compartment within the epidural space.

In this study we performed epiduroscopy with the patient in the lateral position. Compared with the supine position, the lateral position attenuates the effects of the gravid uterus on the inferior vena cava[10] and on the epidural venous plexus[9] in pregnant women. If we could have observed the epidural space with the patient in the supine position, the distention of the blood vessels or the reduction of the pneumatic space of the epidural space would have been more remarkable compared with those obtained in this study. The enlarged gravid uterus in the lateral position puts a certain pressure on inferior vena cava.[18] Other factors that may affect the epidural structure, such as systemic blood volume, are the same in the lateral position as in the supine position. Although we must consider the differences in the epidural structure between lateral and supine positions, we suggest that pregnancy can affect the epidural structure.

We observed the epidural space after injecting a small amount of air. The epidural space sometimes is described as a potential space, rather than a true cavity.[30,31] The injected air, which is not present in the normal epidural space, expands the epidural space and stretches the connective tissues. In our study, however, all patients received identical epidural punctures, and the effects of the air introduced into the epidural space should have been similar in all patients. We believe that this factor had no influence on our comparative study.

Before beginning this study, we considered whether air was an appropriate injectate in the epidural space. We could not obtain a clear view of the epidural space using the loss-of-resistance method with saline because the saline adhered to the tip of the fiberscope. Therefore, we used air and minimized its amount to 5 ml.

We evaluated the epiduroscopic findings by appearance. The epiduroscopic findings would have been more rigorous if some objective measurements, such as a ratio of the object's area over the visible area, had been made. Because of the performance characteristics of the magnifying lens, however, the ratio may change according to the portion of the visible area or the distance between the tip of the fiberscope and the objects. Therefore, we opted for a semiquantitative analysis with an arbitrary type of scoring rather than precise measurements. To make sure of objectivity, the epiduroscopic findings were reviewed by independent investigators who did not have access to the patients' medical histories.

Epiduroscopy showed pregnancy-induced changes in the epidural structures; the epidural space became narrow, the vascular network became dense, blood vessels became engorged, and water content in the connective tissue increased in pregnant women in comparison with nonpregnant women. It is noteworthy that blood vessels became engorged in the first trimester. These changes in the epidural space may affect the spread of epidural analgesia in the pregnant women.

References

1. Bromage PR: Continuous lumbar extradural analgesia for obstetrics. Can Med Assoc J 1961; 85:1136-40

2. Bromage PR: Spread of analgesic solutions in the epidural space and their site of action: A statistical study. Br J Anaesth 1962; 34:161-78

3. Hirabayashi Y, Shimizu R, Saitoh K, Fukuda H: Spread of subarachnoid hyperbaric amethocaine in pregnant women. Br J Anaesth 1995; 74:384-6

4. Fagraeus L, Urban BJ, Bromage PR: Spread of extradural analgesia in early pregnancy. Anesthesiology 1983; 58:184-6

5. Butterworth JF, Walker FO, Lysak SK: Pregnancy increases median nerve susceptibility to lidocaine. Anesthesiology 1990; 72:962-5

6. Datta S, Hurley RJ, Naulty JS, Stern P, Lambert DH, Concepciom M, Tulchinsky D, Weiss JB, Ostheimer GW: Plasma and cerebrospinal fluid progesterone concentrations in pregnant and nonpregnant women. Anesth Analg 1986; 65:950-4

7. Hirabayashi Y, Shimizu R, Saitoh K, Fukuda H: Cerebrospinal fluid progesterone in pregnant women. Br J Anaesth 1995; 75:683-7

8. Hirabayashi Y, Shimizu R, Fukuda H, Saitoh K, Igarashi T: Soft tissue anatomy within the vertebral canal in pregnant women. Br J Anaesth 1996; 77:153-6

9. Hirabayashi Y, Shimizu R, Fukuda H, Saitoh K, Igarashi T: Effects of the pregnant uterus on the extradural venous plexus in the supine and lateral positions, as determined by magnetic resonance imaging. Br J Anaesth 1997; 78:317-9

10. Scott D: Inferior vena caval occlusion in late pregnancy and its importance in anaesthesia. Br J Anaesth 1968; 40:120-8

11. Bieniarz J, Crottogini J, Curuchet E, Romero-Salinas G, Yoshida T, Poseiro J, Caldeyro-Barcia R: Aortocaval compression by the uterus in late human pregnancy: II. An arteriographic study. Am J Obstet Gynecol 1968; 100:203-17

12. Bonica JJ: Maternal anatomic and physiologic alterations during pregnancy and parturition, Principles and Practice of Obstetrics Anes-

thesia, 2nd edition. Edited by Bonica JJ, McDonald JS. Baltimore, Williams and Wilkins, 1995, pp 45–82

13. Blomberg R: The dorsomedian connective tissue band in the lumbar epidural space of humans: An anatomical study using epiduroscopy in autopsy cases. Anesth Analg 1986; 65:747–52

14. Blomberg RG, Olsson SS: The lumbar epidural space in patients examined with epiduroscopy. Anesth Analg 1989; 68:157–60

15. Igarashi T, Hirabayashi Y, Shimizu R, Saitoh K, Fukuda H, Mitsuhata H: The lumbar extradural structure changes with increasing age. Br J Anaesth 1997; 78:149–52

16. Igarashi T, Hirabayashi Y, Shimizu R, Saitoh K, Fukuda H: Thoracic and lumbar extradural structure examined by extraduroscope. Br J Anaesth 1998; 81:121–5

17. Adams JQ: Cardiovascular physiology in normal pregnancy: Studies with the dye dilution technique. Am J Obstet Gynecol 1954; 67:741–59

18. Scott D, Kerr M: Inferior vena caval pressure in late pregnancy. J Obstet Gynaecol 1963; 70:1044–9

19. Gershater R, St Louis EL: Lumbar epidural venography: Review of 1200 cases. Neuroradiology 1979; 131:409–21

20. Naulty JS, Ostheimer GW, Datta S, Knapp R, Weiss JB: Incidence of venous air embolism during epidural catheter insertion. ANESTHESIOLOGY 1982; 57:410–2

21. Collier CB, Gatt SP: Epidural catheters for obstetrics. Terminal hole or lateral eyes? Reg Anesth 1994; 19:378–85

22. Bromage PR: Continuous epidural analgesia, Epidural Analgesia. Edited by Bromage PR. Philadelphia, WB Saunders, 1978, pp 215–57

23. Wulf H: Epidural anaesthesia and spinal haematoma. Can J Anaesth 1996; 43:1260–71

24. Rosaeg OP: The obstetrical anaesthesia assessment clinic: A review of six years experience. Can J Anaesth 1993; 40:346–56

25. Meijenhorst GCH: Computed tomography of the lumbar epidural veins. Radiology 1982; 145:687–91

26. Dunlop W: Serial changes in renal haemodynamics during normal human pregnancy. Br J Obstet Gynaecol 1981; 88:1–9

27. Ezimokhai M, Davison JM, Philips PR, Dunlop W: Non-postural serial changes in renal function during the third trimester of normal human pregnancy. Br J Obstet Gynaecol 1981; 88:465–71

28. Seeling W, Tomczak R, Merk J, Mrakovcic N: CT-epidurography: A comparison of conventional and computed tomographic epidurography with contrast medium using thoracic epidural catheters. Anaesthesist 1995; 44:24–36

29. Savolaine ER, Pandya JB, Greenblatt SH, Conover SR: Anatomy of the human lumbar epidural space: New insights using CT-epidurography. ANESTHESIOLOGY 1988; 68:217–20

30. Harrison GR: The epidural space (letter). Anaesthesia 1989; 44:361–2

31. Parkin IG, Harrison GR: The topographical anatomy of the lumbar epidural space. J Anat 1985; 141:211–7