Pioneers in Epidural Needle Design

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Epidural anesthesia is an integral part of today's practice of anesthesiology. Present methods reflect a long process of change, largely in response to the limitations and complications of early techniques. A change in needle design was significant among these improvements. In this article we identify several physicians who made significant improvements in the design and use of epidural needles. We describe their interest in the problem, the modifications that they made and, when possible, the rationale behind their work. We also acknowledge other epidural needle designers.

The identification of these pioneers and their association with the technical modification credited to them is important because manufacturers and physicians alike often use eponyms inappropriately. For example, epidural needles are often very broadly referred to as "Tuohy needles" even though their needle tip configuration is much closer to that of a Hustead needle design.

We briefly explain the transition of biomaterials used for epidural catheters because this development is, at least in part, responsible for the widespread acceptance of continuous epidural anesthesia.

Historical Overview

The intentional administration of epidural anesthesia began a century ago, in 1901, with two French physicians: Jean-Anthanase Sicard and Fernand Cathelin. Radiologist Jean-Anthanase Sicard (1) described injecting dilute solutions of cocaine through the sacral hiatus to treat patients suffering from severe intractable sciatic pain or lumbago. Working independently, Cathelin (2) reported similar work 3 wk later. He recognized that sacral injections of cocaine might also be used for surgery (Table 1).

In 1921, 20 yr after the papers by Sicard and Cathelin, a Spanish surgeon, Fidel Pagés (3), described a lumbar approach to epidural anesthesia. Pagés died soon after his work was published, and his idea of lumbar epidural anesthesia lay fallow until 1933, when an Italian surgeon, Archile Mario Dogliotti, resurrected and popularized the idea. Dogliotti (4) performed abdominal surgery with single-shot lumbar epidural anesthesia. Most medical historians date the regular use of epidural anesthesia from his article. In doing so, however, they overlook work by the Romanian obstetrician Eugene Aburel.

In 1931, Aburel (5) injected chinocaine through a silk ureteral catheter to block the lumboaortic plexus of laboring women. Aburel deserves recognition not only for using a lumbosacral approach, but also for suggesting a method for obtaining a continuous peridural (epidural) block (6). In the United States, Hingson and Edwards (7) showed the potential of continuous epidural anesthesia. Working at a Staten Island hospital during World War II, they devised a method for continuous caudal anesthesia and used it on 33 laboring patients in 1942. For this they adapted a method first developed for continuous spinal anesthesia by W. T. Lemmon (8), an American anesthesiologist.

Two years later, in 1944, Hingson (9) published a second paper, this time in collaboration with the surgeon James Southworth. It described a lumbar approach for continuous epidural anesthesia. This time Hingson did not use a malleable needle as he had for laboring women, but rather a "large," probably a 15-gauge, Barker spinal needle (Fig. 1), and a silk ureteral catheter advanced "to but not into the peridural space" was used. This was essentially the same approach that Aburel had tried several years before. This trial was far less successful than the first. They obtained satisfactory anesthesia in only 10 of 16 patients. Placing the sharp pointed needle in the epidural space, not to mention maintaining the position of the catheter, must have been a challenge in and of itself. Not surprisingly, Hingson pronounced the method "impractical for continuous

Supported, in part, by a fellowship grant from the Wood Library Museum of Anesthesiology, Park Ridge, IL.

Presented in part at the European Society of Anaesthesiologists, Vienna, Austria, April 2, 2000.

Accepted for publication

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0003-2999/01

Table 1. Historical Milestones in the Development of Continuous Catheter Lumbar Epidural Anesthesia

Year	Development	Clinician
1899	Successful demonstration of spinal anesthesia (Germany)	August Bier
1901	Sacral epidural local anesthetic injections to treat chronic pain (France)	Jean-Anthanase Sicard
1921	Single-shot lumbar epidural anesthesia (published in Spain)	Fidel Pagés-Miravé
1933	Single-shot lumbar epidural anesthesia (published in the United States)	Archile Mario Dogliotti
1938	Continuous lumbar epidural anesthesia (Romania)	Eugen Bogdan Aburel
1944	Continuous lumbar epidural anesthesia (United States)	Robert A. Hingson
1949	First report of successful continuous lumbar epidural anesthesia (published in the United States)	Manuel Martinez Curbelo

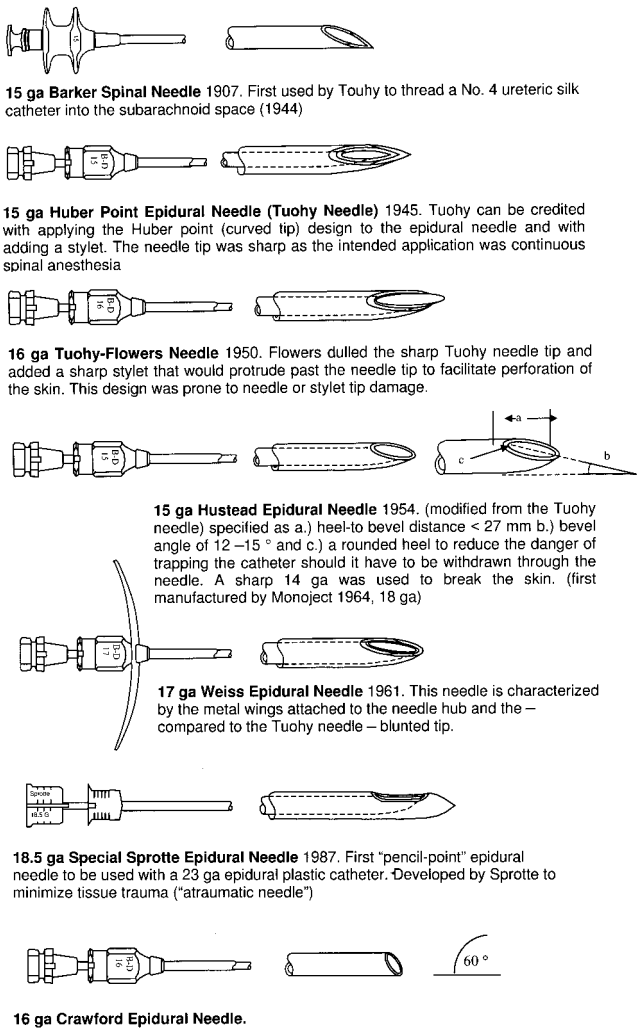

Figure 1. Different epidural needle designs.

peridural anesthesia." Credit for resolution of these problems probably belongs to the Cuban anesthesiologist Manuel Martinez Curbelo, although this came about in a rather circuitous manner. Curbelo's contribution was a byproduct of a visit that he made to the Mayo Clinic in 1947. There he watched Edward B. Tuohy (Fig. 2) perform continuous spinal blocks.

The Tuohy Needle

Edward B. Tuohy, a prominent figure in anesthesiology, had trained at the Mayo Clinic. An enthusiastic advocate of neuraxial blockade, Tuohy influenced many others through his involvement in early academic societies and as president of the American Society of Anesthesiologists (10). Tuohy knew of early clinical work by Paget and Dogliotti on epidural blocks, but he was more interested in continuous spinal anesthesia. For this he initially used a 15-gauge Barker needle and a No. 4 silk catheter rather than Lemmon's malleable needle (Fig. 1) (11). Later on he made a significant change when he replaced the sharp Barker needle with a needle that had been designed by Ralph L. Huber (1890–1953) (University of Oregon Alumni Association, personal communication, October 1999). Huber's needle had a directional tip, which allowed anesthesiologists to direct the catheter as it exited the needle tip.

A Seattle dentist, Huber had a flair for invention. In the course of his career he devised a system of three-dimensional cinematography and a special stethoscope that enabled a woman to listen to the heartbeat of her own fetus. However, he was most widely known for his hypodermic needle. The long, sharp, curved tip was designed to lessen the pain of an injection and decrease the risk of depositing plugs of skin into underlying tissues (12). Although Huber intended this needle for IV and tissue injections, Tuohy recognized that the directional point might facilitate placement of spinal catheters (11). As a further embellishment, Tuohy added a stylet, thereby hoping to further decrease the risk of skin plugging. But it was Curbelo, not Tuohy, who realized how the directional needle might facilitate the placement of epidural catheters. In 1949, 2 yr after his visit to the Mayo Clinic, Curbelo published an article (13) describing how he had used a 16-gauge Tuohy needle with 3.5F silk ureteral catheter for continuous segmental lumbar peridural anesthesia.

Other physicians made further modifications, not all of them successful, in needle design. Charles E. Flowers, a prominent obstetrician and contemporary of Hingson at Johns Hopkins University (14), was

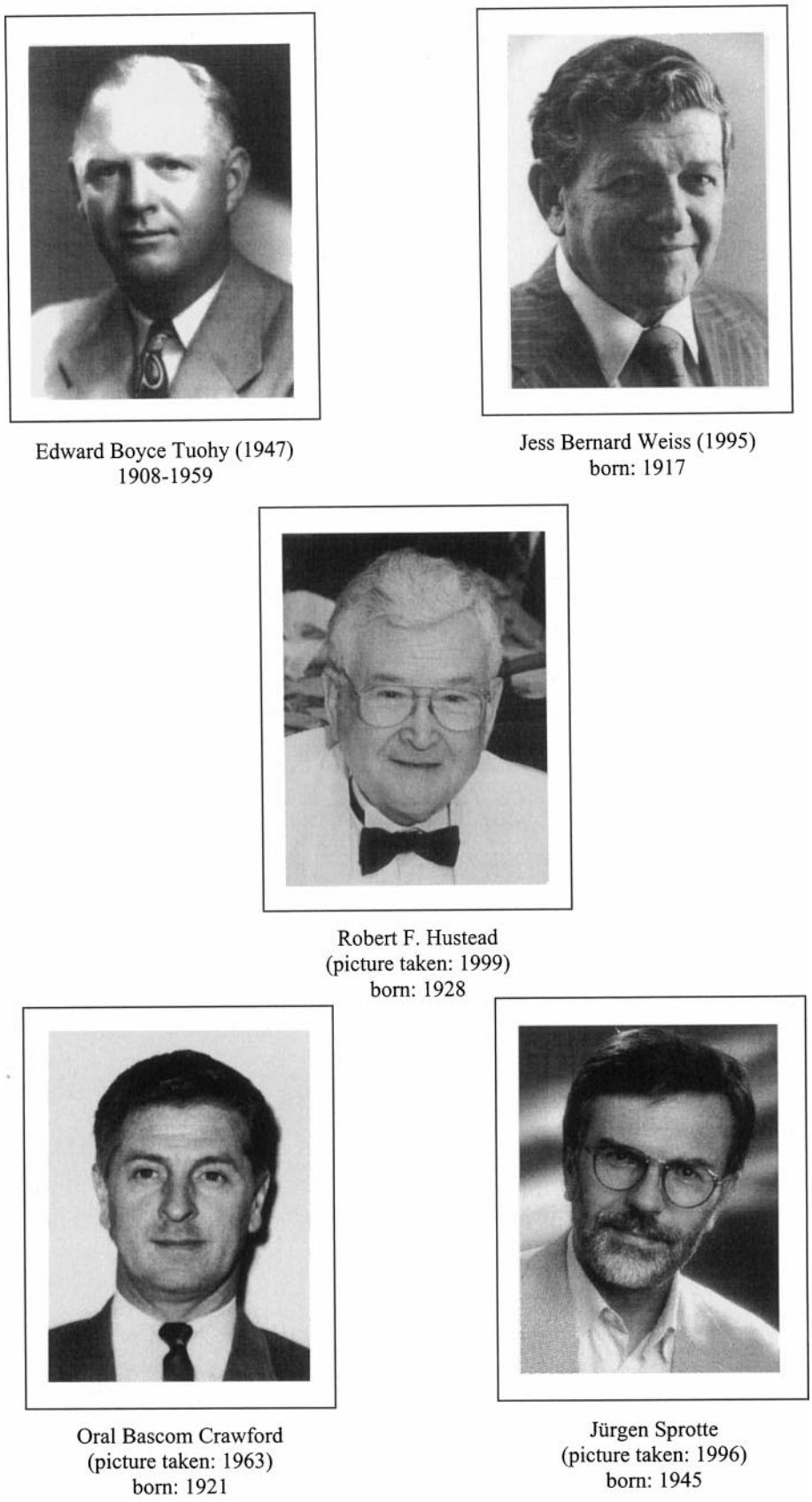

Figure 2. Pioneers in epidural needle design.

probably the first to alter the Tuohy-Huber needle by blunting the bevel and designing the stylet to protrude past the needle tip. He reasoned that the blunt tip would further reduce the risk of dural puncture. He also thought that the sharp protruding stylet would make it easier to pierce the skin (Fig. 1). It did not work. The needle tended to bend at the tip, making it difficult, if not impossible, to remove the stylet or to thread the catheter. Robert Hustead, another Hopkins colleague, called the Tuohy-Flowers modification a "technical nightmare" (R. Hustead, personal communication, March 12, 2000). However, Flower's idea of a blunt tip did have appeal, and it became part of further needle enhancements by Crawford, Weiss, Sprotte, and even Hustead (Fig. 2).

The Hustead Needle

Robert Hustead first practiced anesthesiology as a student at Yale University (1952–1954). After special training, he provided anesthesia service on nights and weekends in the labor and delivery suite during his last 2 yr of medical school and during his internship, a common practice at that time. As a first-year anesthesiology resident under Nicholas M. Greene, Hustead made his own modifications to the Tuohy-Huber needle by hand by using a stone and a needle sharpener (R. Hustead, personal communication, November 1999). He sanded off the sharp tip of the original Tuohy-Huber needle (i.e., he eliminated the secondary bevel of the needle tip) and changed the angle of the bevel. The result was a needle opening that did not exceed 2.7 mm in length, with an angle of the needle bevel of 12°–15°. In addition, he smoothed the heel of the needle bevel to reduce the danger of trapping and cutting the tubing should it have to be withdrawn (15). Not until 1965, however, did he find a manufacturer (Monoject) willing to produce a needle to his specifications. Hustead, like Hingson, was also a strong advocate of lumbar epidural anesthesia for labor, and he was a founding member of the Society for Obstetric Anesthesia and Perinatology. In 1956, Hustead met Oral B. Crawford at a national meeting of the American Society of Anesthesiologists (Oral B. Crawford, personal communication, September 1999).

The Crawford Needle

Born in Brookfield, Missouri (1921), O. B. Crawford trained in anesthesiology in Chattanooga, TN, and later practiced in Springfield, MO. In 1964, he was elected second vice president of the American Society of Anesthesiologists (Fig. 2). Crawford preferred a needle with a straight tip. For this purpose he developed a Quincke-type epidural needle with an extremely short, and thus a very blunt, bevel (Fig. 1). The bevel of his needle was very flat (60° if measured from the longitudinal axis of the needle), and Crawford used it to identify the epidural space with the needle bevel turned down. When the Crawford epidural needle was inserted in the high thoracic area with a cephalad direction approximately 60° from the patient's back, the opening of the needle would be parallel to the longitudinal ligaments, thus very unlikely to perforate the dura. After the epidural space was identified, he rotated the bevel of the needle 180°, which brought the needle bevel into a position from which the catheter would be likely to exit with a cephalad direction. Dr. Crawford also preferred a "hanging drop" method to identify the epidural space. In an article published in 1951, he described 677 surgical cases, mostly thoracoplasties, in which he had used cervical or thoracic epidural blocks as the sole anesthetic (16).

Another person who favored the "hanging drop" method to identify the epidural space was Jess B. Weiss. This led to another modification of the Tuohy-Huber needle.

The Weiss Needle

Weiss dulled the needle tip and added "wings" to make it easier to grasp the needle with both hands for placement (R. Hustead, personal communication, March 12, 2000). This needle hub design is preferred by many anesthesiologists who use the loss-of-resistance technique. For Jess Weiss, who practiced the "hanging drop" method, the addition of wings was crucial because it allowed him to slowly advance the needle with both hands while observing the fluid drop disappearing as the tip of the needle entered the epidural space. Sanjay Datta, Weiss's successor as Chief of Obstetric Anesthesia at the Brigham and Women's hospital, would argue that the hand-dulled tip of the Weiss needle was equally important; after entering the epidural space with the needle tip, it would allow the practitioner to push the dura mater forward without perforating it, thus artificially creating the negative epidural pressure necessary for the "hanging drop" method in the pregnant woman (Sanjay Datta, personal communication, May 1995). Like Tuohy, the man whose needle he had modified, Weiss also became president of the American Society of Anesthesiologists. In 1960, Hustead met Weiss. They became good friends, but neither admittedly became reconciled to the other's design because they favored different methods of identifying the epidural space.

The Sprotte Spezial Needle

A last significant change in needle design came from an entirely different tradition. In 1989, Jürgen Sprotte

of Würzburg, Germany, successfully implemented the continuous catheter technique in combination with a pencil-point needle. Born in 1945 in Heigenbrücken, Germany, Sprotte studied medicine in Munich and trained in anesthesiology at Würzburg University, where he also joined the staff in 1977. Sprotte made several contributions. In 1979 he developed a pencil-point needle for spinal anesthesia, similar to one designed by Hart and Whitacre but with a noticeable difference in its needle tip geometry; the original Whitacre needle had a short, cylindrical-tip configuration, whereas Sprotte used the olive-shaped, rounded-tip geometry. Sprotte proposed that this modification would minimize tissue damage because his needle would spread rather than cut tissue fibers. In 1987, Sprotte started to experiment to make his needle more suitable for epidural use. He added a special plastic wedge to the inside of the needle tip that would direct an epidural catheter toward the lateral needle hole. Although it used a different needle-tip geometry, this so-called Sprotte Spezial needle has the very blunt tip of the original Crawford, Hustead, and Weiss needle design.

Other Epidural Needles

Many epidural needles have been designed. For one reason or another, they have received less attention over the years and shall only be mentioned briefly: there is the Wagner needle (1957), the Cheng needle (1958), the Crawley needle (1968), the Foldes needle (1973), and the Bell needle (1975)—all variants of the Huber design with a blunted tip of varying sharpness. Among these needles, the Cheng design is most remarkable, because it was the first epidural needle with centimeter markings to indicate depth (17). Unfortunately, this needle was described as "cumbersome" to use and "extremely difficult to effect" by Cheng's contemporary, P.C. Lund, and like many other needles, it is not available for use today. There is the Brace needle, a Crawford variant; the Lutz epidural needle (1963), with a pencil-point design for single-shot epidural use; the Scott needle (1985), a Tuohy needle with a Luer lock hub; and the Eldor needle (1993), designed for use with combined spinal epidural anesthesia. Improvements in needles altered practice. No less significant, however, were improvements in catheters. Perhaps the greatest single innovation was the replacement of cumbersome silk catheters with plastic; plastic catheters facilitated placement, were more reliable, and were less expensive.

Epidural Catheters

The first technical advancement over the early years of epidural anesthesia was the downsizing of the catheter and needle combination used. Tuohy's idea of using a lacquered silk catheter for continuous spinal anesthesia was stimulated by his neurosurgical colleague, Dr. Love, who already used this catheter for subarachnoid drainage at the Mayo Clinic (18). Whereas Love had advocated the use of a 5F ureteral catheter in combination with a 13-gauge Barker needle, Tuohy used a 15-gauge Barker needle and a 4F ureteral catheter (1944). Some years later (1949), Curbelo advocated the use of a 3.5F silk catheter with a 16-gauge Tuohy needle. Lacquered silk catheters had to be boiled rather than autoclaved to avoid heat damage. This characteristic made sterilization difficult, and sepsis was relatively common in the early series (19).

The use of plastic catheters was first described by Flowers et al. (20) in 1949. The first polymer (plastic) was polyethylene, which had been introduced as biomaterial for epidural catheters. This material was soon replaced by polyvinyl chloride because of its low melting point, which, similar to the lacquered silk catheters, made it prone to swelling and deformity with sterilization. More recent polymers are nylon, Teflon, polyurethane, and silicone, which have stood the test of time well. The use of these materials enabled manufacturers to produce a thin, yet kink-resistant, catheter with desirable stiffness and tensile strength (21).

Summary

Epidural anesthesia, once thought to be impractical and cumbersome, has become an essential part of today's anesthesia practice. Part of this success can be attributed to modifications in needle design and material. Most of the aforementioned innovations were not patented; thus, manufacturers apply names freely to their needles. This article sheds light on the development of several important needle modifications and acknowledges their inventors, thus providing anesthesiologists with important background information about equipment frequently used in our specialty.

The author is indebted to the trustees of the Wood Library Museum of Anesthesiology, Park Ridge, IL, for their fellowship support for the primary author to complete this project, and to Mr. Harry Alessi, Mr. Udo Göbel, and Mr. Hans-Joachim Otto for their advice and encouragement. The authors would like to thank Anita Yaeger for her editorial work on this manuscript.

References

1. Sicard A. Les injections medicamenteuses extra-durales par voie sacrococcygienne. Compt Rend Soc De Biol 1901;53:396–8.
2. Cathelin F. Une nouvelle voie d'injection rachidienne: methode des injections epidurales par le procede du canal sacre—applications a l'homme. Compt Rend Soc De Biol 1901;53:452–3.
3. Pagés F. Anesthesia metamerica. Rev Esp Chir 1921;3:3–30.

4. Dogliotti AM. A new method of block: segmental peridural spinal anesthesia. Am J Surg 1933;20:107–18.
5. Aburel E. L'anesthésie locale continue (prolongée) en obstétrique. Bull Soc Obstet Gynecol Paris 1931;20:35–9.
6. Atanasiu NRS. Analgesia peridurala segmentara cu percaina in travaliu (Procedeul Prof. Aburel) [thesis for doctoral degree in medicine and surgery]. No. 1860. Iassy, Romania, Iassy Faculty of Medicine, 1938.
7. Hingson RA, Edwards WB. Continuous caudal anesthesia during labor and delivery. Curr Res Anesth Analg 1942;21:301–11.
8. Lemmon WT. A method of continuous spinal anesthesia. Ann Surg 1940;111:141–4.
9. Hingson RA, Southworth JL. Continuous peridural anesthesia. Curr Res Anesth Analg 1944;23:215–7.
10. Tuohy EB. Newer developments in anesthesia. Minn Med 1937; 20:362–8.
11. Tuohy EB. Continuous spinal anesthesia: its usefulness and technique involved. Anesthesiology 1944;5:142–8.
12. Huber RL. Hypodermic needle. US patent 2 409 979. October 22, 1946.
13. Curbelo MM. Continuous peridural segmental anesthesia by means of a ureteral catheter. Curr Res Anesth Analg 1949;28: 12–23.
14. Flowers CE. Continuous peridural anesthesia and analgesia for labor, delivery and cesarean section. Curr Res Anesth Analg 1949;28:181–9.
15. Monoject [product data sheet]. St. Louis: Sherwood Medical, 1974;PD-222,4.
16. Crawford OB, Ottsen P, Buckingham WW, Brasher CA. Peridural anesthesia in thoracic surgery: a review of 677 cases. Anesthesiology 1951;12:73–84.
17. Cheng PA. Blunt-tip needle for epidural anesthesia. Anesthesiology 1958;19:556–9.
18. Love JG. Continuous subarachnoid drainage for meningitis by means of a ureteral catheter. JAMA 1945;128:262–4.
19. Manalan SA. Caudal block anesthesia in obstetrics. J Indiana Med Assoc 1942;35:564–70.
20. Flowers CE, Hellman LM, Hingson RA. Continuous peridural anesthesia for labor, delivery and cesarean section. Curr Res Anesth Analg 1949;28:181–9.
21. Ates Y, Yucesoy CA, Unlu MA, et al. The mechanical properties of intact and traumatized epidural catheters. Anesth Analg 2000;90:393–9.