Density of Tetracaine–Water Mixtures and the Effectiveness of 0.33 Per Cent Tetracaine in Hypobaric Spinal Anesthesia

HENRY ROSENBERG, M.D.*

Solutions commonly used for producing hypobaric spinal anesthesia are light dibucaine (0.66 per cent) or tetracaine diluted to 0.1 per cent with distilled water.[1] Such a dilution of tetracaine will usually produce adequate analgesia. However, large volumes of solution are necessary, and muscle relaxation is often incomplete. Kallos and Smith,[2] in studying patients undergoing hip surgery with hypobaric spinal anesthesia, used a concentration of 0.15 per cent tetracaine to prevent patient movement.

The present study was designed to define the range of dilutions of 1 per cent tetracaine (Winthrop) that will provide effective, but still hypobaric, tetracaine mixtures. A second objective of the study was to determine whether the characteristics of spinal anesthesia with concentrations of tetracaine other than 0.1 per cent (in distilled water) were different from those with 0.1 per cent tetracaine.

METHODS

Using a 2-ml or 5-ml syringe, commercially available 1 per cent tetracaine solution was diluted with distilled water. Final concentrations ranged from 0.1 to 1 per cent. Density was determined with either a 2-ml pycnometer or a Digital Density Meter (DMA 10, Mettler Instrument Co., Princeton, N.J.). Density determinations were done at 23–25 C. Both pycnometer and the Digital Density Meter were calibrated with sterile distilled water.

I also sought to compare the characteristics of spinal anesthesia with 0.1 per cent tetracaine with that produced by a solution of 0.33 per cent tetracaine. This tetracaine concentration (0.33 per cent) was selected because it was the lowest whole-number ratio of water to anesthetic representing a hypobaric mixture at 23–25 C (see below). Spinal anesthesia was induced in male patients between 20 to 70 years old undergoing anorectal surgery in the jacknife prone position. The spinal needle was inserted at the L3–4 interspace. Fourteen patients were anesthetized with 10 ml of 0.33 per cent tetracaine in water (3 mg) and 14 patients were anesthetized with 8–10 mg of 0.1 per cent tetracaine (8–10 ml). After a period of 20 to 40 minutes, but not exceeding one hour, the patient was turned supine and the maximum level of sensory analgesia to pinprick was determined.

RESULTS

Density Determination

As expected, tetracaine density in water was a linear function of dilution (fig. 1). At 23–25 C, concentrations of tetracaine less than approximately 0.33 per cent were hypobaric while concentrations in the approximate range of 0.33 to 0.9 per cent were isobaric with cerebrospinal fluid (CSF). Comparison is made with CSF density at 37 C[3] in order to simulate clinical conditions. *In vitro*, the anesthetic solution equilibrates with CSF temperature in about a minute.[4] However, information as to whether this occurs *in vivo* is not available. In any event, increasing the temperature of the solution lowers its density, making it even more hypobaric to CSF.

CLINICAL STUDY

The two patient groups were similar in terms of height, weight, and age. The mean final level of anesthesia was approximately 4 dermatomes less in those anesthetized with 0.33 per cent tetracaine. This difference was significant as determined by Student's t test

* Assistant Professor of Anesthesia, Hospital of the University of Pennsylvania, 3400 Spruce Street, Philadelphia, Pennsylvania 19104.

Accepted for publication July 21, 1976. Supported in part by USPHS Grant #GM-15430-09. Presented in part at the Annual Meeting of the American Society of Anesthesiologists, October 11, 1976, San Francisco, California.

Address reprint requests to Dr. Rosenberg.

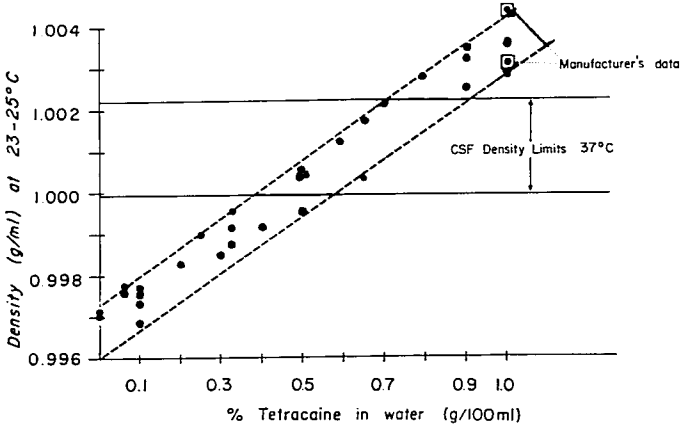

FIG. 1. Effect of dilution of 1 per cent tetracaine in distilled water upon density determined at 23–25 C. CSF density limits (mean ± 3 SD) are those found by Davis and King.[3]

All patients in this study anesthetized with 0.1 per cent tetracaine achieved a final level of analgesia higher than or equal to T10, while only 50 per cent of those anesthetized with 0.33 per cent had a level higher than T10. Anesthesia was satisfactory in both groups.

DISCUSSION

This study demonstrates that hypobaric spinal anesthesia may be achieved with concentrations other than the customary 0.1 per cent tetracaine. By increasing the concentration and thereby limiting the volume of anesthetic used, it was found that the level of anesthesia with 10 mg tetracaine was less likely to extend above T10 with 0.33 per cent tetracaine than with 0.1 per cent tetracaine. However, in any one patient it is difficult to predict what the final anesthetic level will be. Other measures, such as reduced dose of tetracaine,[2] slow injection, injection at a lower interspace, and urging the patient not to cough, speak or otherwise increase abdominal pressure, are of value in limiting the spread of anesthesia.

TABLE 1. Characteristics of the Patients (Mean ± SE) and Levels of Anesthesia

	Tetracaine Dilution	
	0.1 Per Cent (n = 14)	0.33 Per Cent (n = 14)
Age (years)	44.46 ± 4.0	44.46 ± 3.7
Weight (pounds)	169.5 ± 6.5	158 ± 5.5
Height (inches)	69.2 ± 0.8	68.5 ± 1.8
Uppermost dermatome level (Range)	T5.7 ± 0.9 (T2–L1)	T9.6 ± 1.2* (T4–L4)
Percentage with dermatome levels, T2–T10	100	50*

* $P < .01$ compared with 0.1 per cent dilution.

This study did not assess the difference in durations of anesthesia between the two groups, nor did it assess the degree of muscle relaxation. However, using concentrations of tetracaine greater than 0.1 per cent for hypobaric spinal anesthesia, others have found that the muscle relaxation achieved during orthopedic procedures is greater than that achieved with 0.1 per cent.[2] A possible practical advantage of using 0.33 per cent tetracaine is that most commercially prepared spinal anesthesia trays do not have 10-ml syringes. Utilizing 0.33 per cent tetracaine avoids the use of a second separate sterile 10-ml syringe to mix the anesthetic solution.

Effective hypobaric spinal anesthesia may be achieved by dilutions of tetracaine in distilled water other than the standard 1 mg/ml solution. Using higher concentrations and lower volumes, it is possible to limit the spread of hypobaric tetracaine while obtaining satisfactory analgesia.

Maryann Mueller provided able technical assistance.

References

1. Snyder JJ: Hypobaric spinal anesthesia: A review of the literature and some clinical observations. ANESTHESIOLOGY 12:301–307, 1951
2. Kallos T, Smith TC: Continuous spinal anesthesia with hypobaric tetracaine for hip surgery in lateral decubitus. Anesth Analg (Cleve) 51:766–773, 1972
3. Davis H, King W: Densities of common spinal anesthetic solutions at body temperature. ANESTHESIOLOGY 13:184–188, 1952
4. Ernst EA: *In vitro* changes of osmolality and density of spinal anesthetic solutions. ANESTHESIOLOGY 29:104–109, 1968
5. Dye FC, Vaugh JA: Hypobaric spinal anesthesia for proctological surgery. ANESTHESIOLOGY 10:489–493, 1949

Endotracheal Tube Cuff Design and Postoperative Sore Throat

EDWARD A. LOESER, M.D.,* DANIEL L. ORR, II, D.D.S.,† GEORGE M. BENNETT, M.D.,* THEODORE H. STANLEY, M.D.‡

Severe tracheal damage after prolonged endotracheal intubation with high-pressure endotracheal or tracheostomy tube cuffs has led to the development of endotracheal tubes with a variety of low-pressure cuffs. Presumably, low-pressure-cuffed endotracheal tubes should cause less tracheal trauma and fewer and less severe postoperative sore throats than high-pressure-cuffed tubes. This study was conducted to compare the incidences and severities of postoperative sore throats in patients intubated with low-pressure- and high-pressure-cuffed endotracheal tubes and those whose tracheas were not intubated.

Methods

Eight commercially available 7.0–8.5 mm ID low-pressure- and high-pressure-cuffed endotracheal tubes were studied. Four of the tubes had high-residual-volume, low-pressure cuffs (Foregger, Soft-Cuff; American, Hi-Lo; Extracorporeal, Lanz; Portex) and four had low-residual-volume, high-pressure cuffs (Rusch, Red Rubber; Harris Lake, Harlake; American; Shiley). Fifty tubes of each type were studied in 400 anesthetized adult patients, 19–64 years of age, undergoing abdominal or lower-extremity orthopedic operations. An additional 50 patients undergoing similar operations without endotracheal intubation were also evaluated. Patients who needed a nasogastric tube, sustained difficult intubation, *i.e.*, more than one attempt at passage of the tube, or coughed after intubation or before extubation, were excluded from the study.

All patients were similarly premedicated, and anesthesia was induced with thiopental (3–4 mg/kg). Patients were paralyzed with succinylcholine, 1.5 mg/kg, and the tracheas were intubated in the usual fashion. The endotracheal tubes were lubricated with 5 per cent lidocaine ointment.§ Cuffs were

* Instructor in Anesthesiology.
† Resident in Anesthesiology.
‡ Associate Professor of Anesthesiology/Surgery.
Received from the Department of Anesthesiology, University of Utah College of Medicine, 50 North Medical Drive, Salt Lake City, Utah 84132. Accepted for publication July 21, 1976.
Address reprint requests to Dr. Loeser.

§ Astra, Inc., Worcester, Mass. (5 per cent Xylocaine in polyethylene glycols and propylene glycol).