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.

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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 Anal (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

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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 trachea was intubated in the usual fashion. The endotracheal tubes were lubricated with 2 per cent lidocaine ointment.§ Cuffs were

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

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TABLE 1. Mean Incidence and Severity (Scale 0–3) of Sore Throat in Intubated Patients

		Low-pressure Cuffs				High-pressure Cuffs			
	Mask	Foregget	American	Extracorporeal	Portex	Hadake	Rusch	American	Shiley
Incidence (per cent)	22	48*†	58*†	58*†	54*†	24	38‡	24	25
Severity (0–3)	.26	.64*†	.74*†	.82*†	.68*†	.24	.40‡§	.26	.25

* $P < .01$, † $P < .05$, chi-square test, compared with mask values.
‡ $P < .01$, chi-square test, compared with each of the high-pressure cuffs except the Rusch.
§ $P < .05$, chi-square test, compared with each of the low-pressure cuffs.

filled with air until the trachea was just sealed. Cuff volumes and pressures were measured immediately after intubation and just prior to extubation as previously described.[1] Anesthesia was maintained with halothane (1–2 per cent) or enflurane (1–3 per cent) plus 60 per cent nitrous oxide in oxygen and intermittent doses of pancuronium. All patients had sterile, disposable, Ohio plastic oral airways (size 3 or 4) in place throughout the operation, and some had them in place during the early postoperative period. Extubation of the trachea was accomplished in the operating room.

All patients were interviewed 20–30 hours postoperatively by an anesthesiologist who used a set protocol but did not know what variety of endotracheal tube had been used or whether the trachea had been intubated. Patients were asked whether they had experienced a sore or scratchy throat from the time of their operation until the interview. Any positive response was recorded as a sore throat. For evaluation of severity, patient responses were evaluated and graded on a 0–3 scale as follows: 0 = no sore or scratchy throat at any time since operation and no evidence of hoarseness at the time of interview; 1 = minimal sore or scratchy throat for the same period and no hoarseness at the time of interview; 2 = moderate sore throat and/or some hoarseness; 3 = severe sore throat for the same period and/or obvious hoarseness at the time of interview.

In addition to the above investigation, three 8.0 mm ID tubes of each variety studied were evaluated in an artificial trachea to determine cuff–tracheal surface-contact area during cuff inflation. A section of 1.6 cm ID heavy plastic tubing was used as an artificial trachea and each cuff inflated until a seal withstanding 15 cm H_2O was established. Black enamel paint was then sprayed into the artificial trachea from both ends, coating all areas except where the cuff was in contact with the artificial trachea, thus outlining the area of surface contact. The width of the cuff–tracheal surface area was then measured and correlated with the incidence of postoperative sore throat in patients.

RESULTS

Durations of operations, types of operative procedures, and sex distributions were similar in all groups of patients studied. All endotracheal tube cuffs sustained significant increases in cuff volume and pressure at the end of operation, as had been described.[1]

The incidence and severity of sore throat after use of all low-pressure cuffs were significantly greater, $P < .01$, than after anesthesia by mask or intubation with any of the high-pressure cuffs (table 1). In contrast, with regard to incidence and severity of postoperative sore throat, use of high-pressure cuffs, with the exception of Rusch Red Rubber tubes, was similar to anesthesia by mask (table 1). Correlations of incidences and severities of sore throats in patients with cuff–tracheal surface contact widths in the artificial trachea were high, r = .94 and r = .97, respectively (fig. 1). There was poor correlation, $r < .3$, of intubation time, change in cuff volume or pressure, age, type of operation, anesthetic agent or endotracheal tube size with the incidence or severity of sore throat. The overall incidence of sore throat was higher in women than in men (43 *vs.* 35 per cent), but the difference was not significant.

DISCUSSION

The postoperative "sore-throat syndrome" consisting of sore or scratchy throat and/or

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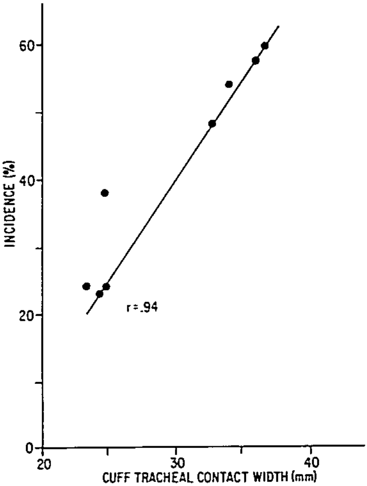

FIG. 1. Incidences of sore throat in intubated patients using eight varieties of cuffed endotracheal tubes correlated with the width of cuff–tracheal surface contact area in an artificial trachea using the same tubes and cuffs.

hoarseness usually lasts only a few days after operation, and is considered a minor complication of anesthesia.[2] Nonetheless, it is a frequent complication after endotracheal intubation as well as after anesthesia by mask.[3] Mechanisms contributing to postoperative sore throat have included: trauma to the tonsillar pillars, pharynx, tongue, larynx and trachea; edema in the structures of the nasal cavity when this route of intubation is used; drying out of mucosal membranes in the trachea with endotracheal intubation or the upper airway following anesthesia by mask. The influence of the endotracheal tube cuff on the development of postoperative sore throat has not been established.

The results of this study demonstrate that low-pressure (high-volume) endotracheal tube cuffs are associated with a markedly higher incidence and greater severity of postoperative sore throat than are high-pressure (low-volume) cuffs. Our findings do not completely delineate the mechanism(s) involved but suggest that cuff–tracheal surface contact area is probably a factor. Cuffs that have the largest cuff–tracheal surface contact area upon inflation in the artificial trachea (American, Hi-Lo, and Extracorporeal, Lanz) produced the highest incidence of sore throat and most severe sore throats in patients. On the other hand, use of high-pressure cuffs with much lower cuff–tracheal surface contact areas (American, Harlake, and Shiley) resulted in an incidence and severity of postoperative sore throat not significantly different from the incidence and severity in patients whose tracheas were not intubated.

Rusch latex Red Rubber cuffs resulted in a higher incidence and greater severity of sore throat after operation than the other high-pressure cuffs (in spite of a cuff–tracheal surface contact area that was not appreciably different from those of the other high-pressure cuffs). The reason for this may be related to the fact that these were the only tubes that were not disposable, and they were subjected to Cidex* cleaning followed by distilled water rinsing after each use. Perhaps some of the disinfectant solution remained in the cuffs in spite of washing and produced an irritative reaction upon contact with the tracheal mucous membrane during the next use.

It is not entirely clear why endotracheal tube cuffs that have large cuff–tracheal surface contact areas produce more sore throat in spite of lower cuff pressures than tubes with smaller cuff–tracheal surface contact areas. One explanation may be that endotracheal tube cuffs produce tracheal–mucosal membrane and/or tracheal cilia damage in direct relation to cuff–tracheal surface contact area. Another may be that low-pressure cuffs, which are usually bulkier and larger than high-pressure cuffs, produce more damage to upper airway structures, *i.e.*, the larynx or pharynx, on intubation and extubation. Finally, low-pressure cuffs have a tendency to fold on themselves and wrinkle in the artificial trachea. If they do the same in the tracheas of intubated patients, points of extremely high pressure with necrosis may develop. The ideal cuff for endotracheal intuba-

* Cidex, Arbrook, Inc., Arlington, Texas.

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tion during operation is one that minimizes cuff–tracheal surface contact area, if the incidence of postoperative sore throat is to be reduced.

References

1. Stanley TH: Nitrous oxide and pressures and volumes of high- and low-pressure endotracheal tube cuffs in intubated patients. Anesthesiology 42:637–640, 1975
2. Riding JE: Minor complications of general anesthesia. Br J Anaesth 47:91–101, 1975
3. Wylie WD, Churchill-Davidson HC: Examination of the respiratory tract and tracheal intubation, A Practice of Anaesthesia. Third edition. Chicago, Year Book Medical Publishers, 1972, pp 368–371

Comparison of Compounds Used for Intradermal Anesthesia

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Lidocaine and procaine, the local anesthetics most commonly used for intradermal anesthesia, cause considerable discomfort upon injection. Physiologic saline solution has been said to be a satisfactory local anesthetic that is free of discomfort.[1] This study compares various compounds used for intradermal injection with regard to discomfort and to intensity and duration of anesthesia. The intent was to determine which drug provides the highest patient acceptability and the best anesthesia.

Method

A randomized, double-blind study was carried out with 20 adult volunteers serving as their own controls after approval from the Human Studies Committee. Sixteen men and four women, ranging in age from 19 to 45 years and in weight from 54 to 95 kg, participated. None was taking analgesics, sedatives, or tranquilizers. All were considered A.S.A. physical status I.

Six solutions were prepared for each subject in single-dose 1-ml ampules: physiologic saline solution; physiologic saline solution with 0.9 per cent benzyl alcohol; lidodaine, 0.5 per cent; lidocaine, 0.5 per cent, with 0.1 per cent methylparaben; lidocaine, 1 per cent; procaine 1 per cent. No other additive was present. Water was the diluent for the local anesthetics.

The dorsum of each hand was cleansed with isopropyl alcohol and allowed to dry. Using a 1-ml syringe with a 25-gauge needle, an intradermal wheal was raised with 0.1 ml of each test solution, three wheals per hand. The order of drug injections was randomized. Subjects were sitting and did not observe the injections.

Once the needle was in place, the subject was instructed to describe the degree of discomfort and the sensation caused by raising the wheal. Discomfort was rated from 0 (no discomfort) to 2 (severe discomfort).

Anesthesia produced by the wheal of intradermal drug was tested by pin prick, initially 15 seconds after injection and at intervals thereafter to a total duration of 20 minutes. It was rated 0 (no anesthesia) to 3 (excellent anesthesia). Injection sites were observed for adverse local effects.

Initial analysis by a two-way analysis of variance at measured values by subject and drug showed significant variation among subjects. Therefore, the data were adjusted‡ to eliminate individual variability and then analyzed by ordinary one-way analysis of variance with *a priori* and *a posteriori* contrasts to examine differences between specific drugs.

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‡ The basic two-way analysis of variance model was

$$M_{ij} = u + S_i + A_j + E_{ij}$$

where M_{ij} is an observed score for subject i given drug j; u is the grand mean; S_i is subject i's mean deviation from u; A_j is drug j's mean deviation from u; and E_{ij} is the error term. The transformation was made by defining

$$M_{ij}' = M_{ij} - S_i$$

so that the one-way model became

$$M_{ij}' = u + A_j + E_{ij}.$$

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