of the effects of cyanide toxicity may be achieved by limiting the hourly or total dose of SNP,[6,12] by administration of thiosulfate,[13,14] hydroxocobalamin[15] or cystine,[16] although additional studies are needed to evaluate these methods.

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Postoperative Sore Throat—Importance of Endotracheal Tube Conformity Versus Cuff Design

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Recent investigations have suggested that both conformity of an endotracheal tube to the anatomic contour of the pharynx[1] and the design of the cuff[2] may have profound effects on the incidence and magnitude of postoperative sore throat. In this study, endotracheal tube anatomic conformity was evaluated and compared with cuff design as a factor in the occurrence of postoperative sore throat.

Methods

Postoperative sore throat was evaluated in 250 patients who had undergone abdominal or extremity operations. Patients had their tracheas intubated with 7.0–8.5-mm ID National Catheter Company "Lindholm" pharyngeal molded endotracheal tubes with high-residual-volume, high-tracheal-contact, low-pressure cuffs or low-residual-volume, low-tracheal-contact, higher-pressure cuffs. National Catheter Company standard, unmolded endotracheal tubes with both of the above types of cuffs, as well as Bivona Surgical Instruments Company "Kamen-Wilkinson" foam-filled cuffs (which are not actively inflated) were also studied.[3] Fifty patients were randomly selected to be intubated with each of the five varieties of tubes and cuffs.

All patients were similarly premedicated. Anesthesia was induced with thiopental, 3–4 mg/kg, and maintained with halothane, 1–2 per cent, or enflurane, 1.5–3 per cent and nitrous oxide, 60 per cent, in oxygen. Following administration of succinylcholine, 1.5 mg/kg, the tracheas were atraumatically intubated in the usual fashion. The endotracheal tubes were lubricated with lidocaine ointment, 5 per cent, and each had a plastic aluminum stylet in place during intubation. With the exception of the foam-filled cuffs, all cuffs were filled with air until the trachea was just

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sealed. Cuff volumes and pressures were measured in all cuffs immediately after intubation and just prior to extubation as previously described.[4] The foam-filled cuffs were deflated prior to intubation and allowed to self-inflate passively after intubation by maintaining the cuff catheter open to room air. An adequate seal was obtained in every case. 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 after cuff gas volumes and pressures were measured and the cuffs slowly deflated. Patients who needed a nasogastric tube, or in whose cases endotracheal intubation was difficult, *i.e.*, more than one attempt at passage of the tube was necessary or the patient coughed after intubation or before extubation, were excluded from the study.

Patients were interviewed 20–30 hours postoperatively by an anesthesiologist who utilized a set protocol but did not know what variety of endotracheal tube had been used. Patients were asked whether they had experienced a sore or scratchy throat from the time of their operation until the interview. Patient responses were evaluated and graded on a 0–3-degree scale (0 = no sore or scratchy throat and no evidence of hoarseness; 1 = minimal sore or scratchy throat and no hoarseness; 2 = moderate sore throat and/or some hoarseness; 3 = severe sore throat and/or obvious hoarseness).

The severity index was determined by dividing the total score for all tubes by the number of patients intubated with that tube.

Duration of intubation (average 135.9 ± 66 min), types of operative procedures and sex distributions were similar in all groups of patients studied. The incidence and severity values for the cuffs were compared using the chi-square test with those for the National Catheter Company standard tube with the low-residual-volume, low-tracheal-contact, high-pressure cuff.

Results

All endotracheal tube cuffs except the foam-filled cuffs sustained significant increases in cuff volume and pressure at the end of the operation, as had been previously described.[4] The National Catheter Company standard tube with low-residual-volume, low-tracheal-contact, high-pressure cuffs was associated with the lowest incidence and least severity of postoperative sore throat (table 1). Pharyngeal molded Lindholm tubes, with the same cuff, were associated with a significantly higher incidence and greater severity of sore throat postoperatively. Both the standard and Lindholm National Catheter Company tubes with high-residual-volume, high-tracheal-contact cuffs caused markedly higher incidences and greater severities of postoperative sore throat than either the standard or the Lindholm tube with low-residual-volume, low-tracheal-contact cuffs. The Kamen-Wilkinson tubes with large foam-filled cuffs and the highest tracheal cuff contact area were associated with the highest incidence and greatest severity of postoperative sore throat.

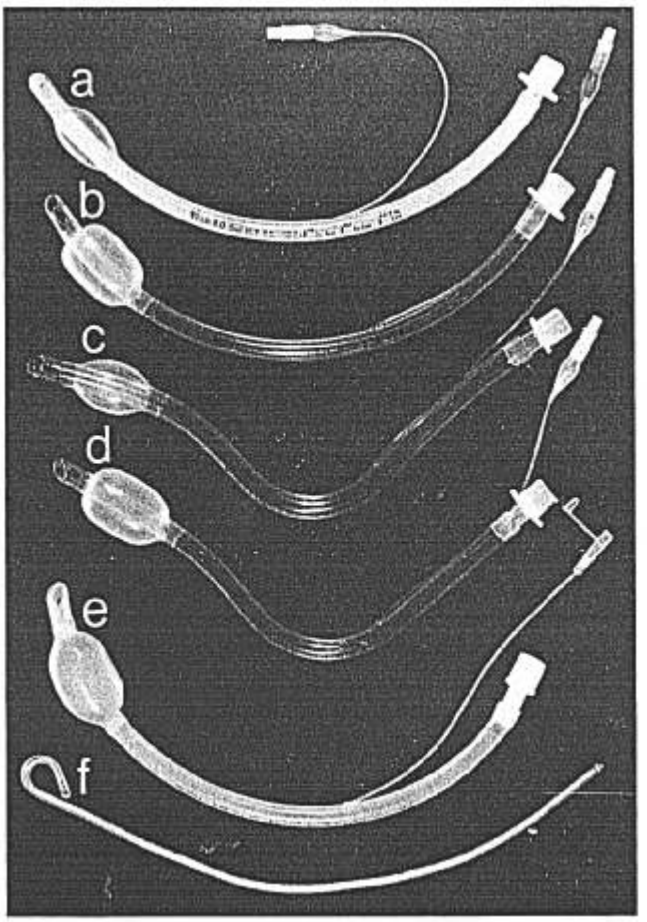

FIG. 1. Endotracheal tubes employed in this study: *a*, National Catheter standard tube with standard cuff; *b*, National Catheter standard tube with "Hilo" cuff; *c*, National Catheter Lindholm tube with standard cuff; *d*, National Catheter Lindholm tube with "Hilo" cuff; *e*, Kamen-Wilkenson tube with foam-filled cuff; *f*, aluminum stylet.

Discussion

These data demonstrate that endotracheal tubes with pharyngeal conformity due to preformed molding, Lindholm tubes, or flexible tubes with foam-filled cuffs passively filled with room air pressure (Kamen-Wilkinson tubes) do not decrease but rather actually increase the incidence of postoperative sore throat.

TABLE 1. Mean Incidence and Severity (0–3, ±SD) of Postoperative Sore Throat

	Low-residual-volume; Low-tracheal-contact; High-pressure Cuff		High-residual-volume; High-tracheal-contact; Low-pressure Cuff		
	Standard Tube	Pharyngeal Molded Lindholm Tube	Standard Tube	Pharyngeal Molded Lindholm Tube	Kamen-Wilkinson (Foam-filled Cuff)
Incidence (per cent)	24	44*	58*	54*	65*
Severity (0–3)	.26 ± .5	.54 ± .7*	.74 ± .7*	.75 ± .8*	.90 ± .8*

* $P < .05$, chi-square test, compared with National Catheter Company standard tubes with low-residual-volume, low-tracheal-contact, high-pressure cuffs.

Thus, these tubes provide no advantage for short-term tracheal intubation as required for most operations. Because these tubes require a stylet for placement into the trachea, they are also more awkward to use in routine clinical anesthesia practice. No conclusion can be offered with regard to long-term intubation (days to weeks), where less pressure on pharyngeal and tracheal surfaces because of better tube conformity and lower cuff-tracheal pressure might result in less tissue erosion and associated morbidity than standard tubes and cuffs.

It has been suggested that greater increases in intracuff pressures secondary to greater diffusion of nitrous oxide into the cuff lumen may be one explanation for the higher incidence of postoperative sore throat obtained after intubation with high-residual-volume, low-pressure cuffs than with low-residual-volume, high-pressure cuffs.[5] It is thought that these increases in pressures may be transmitted onto the tracheal mucosal and cause increased mucosal damage. However, a previous report from this laboratory demonstrated that changes in endotracheal tube cuff volume and pressure from nitrous oxide diffusion into cuffs are similar in low-residual-volume, high-pressure and in high-residual-volume, low-pressure cuffs.[4] Our results with the foam-filled (Kamen-Wilkinson) cuffs in this study present additional evidence that greater increases in intracuff pressure in high-residual-volume, low-pressure cuffs are not an explanation for the higher incidence of postoperative sore throat obtained after intubation with these cuffs. The foam-filled cuffs sustained no change in cuff volume or pressure from the time of intubation until extubation, yet patients whose tracheas were intubated with these cuffs experienced the highest incidence and greatest severity of sore throat in the post-operative period. Since the foam-filled cuffs had the highest cuff–tracheal contact area of any of the cuffs studied, our data add additional support to the concept that cuff–tracheal contact area is an important factor in the development of postoperative sore throat. Why patients intubated with Lindholm pharyngeal molded tubes experienced a higher incidence and greater severity of postoperative sore throat than patients intubated with the same cuff on a standard tube is unknown. Perhaps the greater contact of the pharyngeal molded type of tube with mucosa throughout the upper airway produces a greater area of mucosal damage than does the standard tube.

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