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Fiberoptic Intubation Using Anesthetized, Paralyzed, Apneic Patients

Results of a Resident Training Program

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Background: **There is no consensus about the best way to teach fiberoptic intubation. This study assesses the effectiveness of a training program in which novice anesthetic residents routinely were taught fiberoptic tracheal intubation of anesthetized, paralyzed, apneic patients.**

Methods: **Eight inexperienced anesthetic residents learned fiberoptic and conventional tracheal intubation simultaneously during their first 4 months of training. All intubations were performed using general anesthesia and muscle paralysis. Of these intubations, 223 (23%) were fiberoptic and 743 (77%) were laryngoscopic. Subsequently, their intubation skills with the two techniques were studied in a prospective, single-blind randomized trial involving 131 elective patients. Intubation times, Sp_{O_2}, ET_{CO_2}, hemodynamic changes on intubation, and complications were recorded for 71 fiberoptic and 57 laryngoscopic intubations.**

Results: **There were two failures of the rigid and one failure of the fiberoptic technique due to inability to intubate within 180 s. In cases of failure, the tracheas were intubated successfully after mask ventilation by the alternative technique. No hypoxemia or hypercarbia occurred in any patient. There were no differences in hemodynamic indexes nor incidence of sore throat or hoarseness between the two groups. Mean intubation times were 56 ± 24 s (mean ± SD) for fiberoptic and 34 ± 10 s (mean ± SD) for laryngoscopic ($P < 0.001$).**

Conclusions: **Novices taught fiberoptic intubation and rigid laryngoscopic intubation under similar conditions, with similar volumes of experience, learn both techniques well. The safety and effectiveness of this training regimen commend it for inclusion in any residency program. (Key words: Airway management, intubation: fiberoptic; tracheal. Techniques: anesthetic. Training: intubation.)**

FIBEROPTIC intubation is a valuable technique in management of difficult airways.[1,2] Surveys conducted in Switzerland,[3] northern England,[4] and the United States† confirm that use of the technique is limited more by lack of expertise than lack of equipment. Despite many articles on the teaching of fiberoptic intubation,[3–14,]† a recent review states, "At the time, there is no general agreement on the most satisfactory anesthetic technique for teaching fiberoptic intubation."[2]

Some authors have said that fiberoptic intubation is more difficult to perform in anesthetized patients and should be reserved for the awake patient.[15] However, Schaeffer described a technique of total intravenous anesthesia for teaching fiberoptic intubation and compared the intubation performance of experts at rigid laryngoscopic intubation with that of novices at fiberoptic intubation.[3] We use a similar anesthetic technique routinely to ensure adequate training for our residents in fiberoptic intubation. We describe our teaching program and report a comparison of intubating skills of residents simultaneously trained for 4 months in both techniques. This is the first study to our knowledge to compare performance of novices trained *pari passu* in both techniques.

Materials and Methods

Training Period

Between July 1993 and November 1994, all first-year anesthesia residents at Mount Sinai Hospital were trained simultaneously in the rigid laryngoscopic and

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† Davis KR: Use of the flexible fiberoptic bronchoscope by anesthesiologists in the United States in 1991 (abstract). ANESTHESIOLOGY 1992; 77:A1069.

fiberoptic intubation techniques in anesthetized paralyzed patients during the first 4 months of residency training. All residents had minimal or no prior experience in intubation by either technique.

Two 1-h lectures were given about anatomy of the upper airway and the structure, use, and care of the fiberoptic bronchoscope. This was followed by a 20-min hands-on session with a mechanical model with variable relationships (a "choose-the-hole" model) to teach skill in endoscope manipulation. Each resident used the fiberscope to intubate a mannequin once or twice. Thereafter, the residents were free to practice using the mannequin or the model during their spare time.

To ensure adequate exposure to fiberoptic intubation, this technique was taught whenever the residents were assigned to one of the four authors, who routinely perform fiberoptic intubation in many of their patients. Conventional rigid laryngoscopic intubation was taught by the remaining 12 staff anesthesiologists.

All training in fiberoptic intubation used only fasted ASA physical status 1 or 2 adult patients undergoing elective surgery requiring tracheal intubation. Patients with any indication for a rapid-sequence induction or for awake intubation were excluded from training in fiberoptic intubation under anesthesia. The induction protocol was not standardized during the training period, but intubation was performed after induction of general anesthesia and paralysis. If intubation was prolonged, or if Sp_{O_2} decreased to 95%, ventilation *via* mask was reinstituted immediately and maintained until the ET_{CO_2} was less than 35 mmHg and the Sp_{O_2} at least 97%. Then another attempt was made by the resident. If two such attempts were unsuccessful, the consultant performed the intubation.

During fiberoptic intubation training, we attempted to recreate the open upper airway of the conscious patient. A trained respiratory technologist assigned to the operating room assisted by providing neck extension,[16] jaw thrust,[17] and if necessary, lingual traction.[18] The trainee advanced the fiberscope in the midline through the mouth and pharynx, identifying anatomic landmarks, into the larynx and trachea, until the carina was visualized. The emphasis was on learning to manipulate the endoscope and becoming familiar with endoscopic anatomy rather than on speed of intubation. After visualization of the carina, the endotracheal tube was oriented with the bevel facing posteriorly and advanced over the fiberscope into the trachea.[19]

From a computerized log kept by all residents, the total number of practice intubations and the technique used during the training period were determined.

Study Protocol

During the 5th and 6th months of their training, residents' fiberoptic and laryngoscopic intubation skills were evaluated formally in a randomized single-blind prospective study. Ethical approval from the University of Toronto Human Subjects Review Committee and informed patient consent were obtained.

Exclusion criteria for the study included any anticipated or documented difficult intubation and any indication for awake intubation or rapid-sequence induction of anesthesia. Airway classification according to the Mallampati score was done.[20] Airway class 4 patients were excluded from study. Otherwise, all consenting adult patients, ASA physical status 1–2, requiring intubation for elective surgery were invited to participate.

All patients were unpremedicated. On arrival in the operating room, baseline vital signs were noted: systolic and diastolic blood pressure, heart rate, and oxygen saturation on room air. The induction sequence included preoxygenation *via* tight-fitting mask for 3 min, 1–2 mg intravenous midazolam, 1–2 μg/kg fentanyl, and propofol to loss of consciousness and eyelid reflex. Atracurium (0.5 mg/kg) was administered, and patients' lungs were hyperventilated by mask with 100% O_2 for at least 3 min to an end-tidal p_{CO_2} of 25–34 mmHg. Then patients were randomized by coin toss to either rigid laryngoscopic (group 1) or fiberoptic (group 2) intubation. Residents were assisted in all intubations by an operating room respiratory therapist.

Routine rigid laryngoscopic intubation was performed with the patient's head in the "sniffing" position, using a #3 Macintosh laryngoscope blade, with laryngeal pressure applied by the assistant if necessary.

Fiberoptic intubation subjects received oxygen by insufflation at 5 l/min *via* an endotracheal suction catheter hooked over the lip into the oropharynx. After successful fiberoptic intubation, the resident visually confirmed appropriate tracheal tube position above the carina before withdrawal of the bronchoscope.

Intubation times were measured by stopwatch and rounded off to the nearest second. Intubation time was defined as the apneic interval from removal of the face mask until the reappearance of a normal expired carbon dioxide trace on the capnograph after resumption of ventilation after intubation.

Intubation by either technique was deemed a failure and aborted if (1) intubation time exceeded 180 s or (2) oxygen saturation decreased to 95%. In either of these circumstances, the lungs were ventilated by mask again with 100% O_2, general anesthesia and muscle relaxation were maintained, and intubation was reattempted using the alternative technique.

Heart rate and systolic and diastolic blood pressure were recorded every 2 min during induction, during intubation, and for a further 10 min. Thereafter, routine monitoring (every 5 min) was recorded. Sp_{O_2} was recorded before and after induction, and the lowest Sp_{O_2} observed throughout the intubation and immediate postintubation period (to allow for delayed appearance of hypoxia from apnea) was recorded. ET_{CO_2} immediately before and after apnea was recorded.

Whenever possible, study patients were interviewed in person or by phone on the first postoperative day to determine the incidence and severity of postoperative sore throat and hoarseness, which they rated as mild, moderate, or severe.

The presence or absence of dental trauma was assessed visually and by palpation immediately after intubation.

Means and standard deviations are reported for all parametric data and were analyzed using paired *t* tests. Proportions were analyzed using a chi-square test with Yates continuity correction. A P value < 0.05 was considered statistically significant. Correlation between individual residents' intubation times and number of practice intubations in the training period was calculated by linear regression for continuous data. With 60 patients in each group, analysis predicted a 95% power to detect a 10-s difference in mean intubation times, a 15-mmHg difference in mean systolic or diastolic blood pressure, a 10-beats/min difference in mean heart rate, and an 80% power to detect a 25% absolute increase in incidence of sore throat or hoarseness at a 95% level of confidence.

Results

All eight new residents at our hospital during this study were trained and evaluated. During the training period, rigid laryngoscopic intubation was performed on 743 patients (77% of intubations) and fiberoptic intubation on 223 patients (23% of intubations). Individual resident experience ranged from 58 to 120 conventional intubations and from 16 to 47 fiberoptic intubations.

During the subsequent study period, 131 patients were enrolled. Each resident performed at least 5 conventional study intubations (range 5–10) and 6 fiberoptic intubations (range 6–13). There were three failed intubations, all due to inability to intubate within 180 s. Failure of rigid laryngoscopic intubation occurred in two patients, each after two attempts, because of an inability to visualize the glottis. In both cases, fiberoptic intubation was performed by the resident without difficulty after ventilation *via* mask with oxygen. Failure of fiberoptic intubation occurred on one occasion; this patient's trachea also was intubated by the resident using rigid laryngoscopy after mask ventilation (even though the glottis could not be seen during laryngoscopy). No study patient in either group (including the failed intubations) experienced any hypoxemia (the lowest Sp_{O_2} was 94%), and there was no dental trauma. The three failed intubations (each involving a different resident) were excluded from further analysis.

Demographic data on the remaining 128 study patients are presented in table 1. There were no significant differences between groups in average age, sex distribution, or Mallampati class.

Intubation times and respiratory variables are presented in table 2. Although intubation times averaged 22 s longer in the fiberoptic intubation group, average lowest Sp_{O_2} and highest postintubation ET_{CO_2} did not differ between groups. No patient in either group sustained an Sp_{O_2} less than 94% or a postintubation ET_{CO_2} greater than 46 mmHg. Successful fiberoptic intubation within 60 s or less of apnea was achieved in 73% (52 of 71) of cases. Five of the eight residents achieved mean fiberoptic intubating times of less than 60 s, and no resident's average time exceeded 81 s.

No correlation between mean intubation times and number of practice or study intubations by individual residents was found for either technique. The four fastest residents with lowest fiberoptic intubation times contributed only 34 of the 71 intubations. No corre-

Table 1. Demographic Data

	Group 1 (Rigid Laryngoscopic)	Group 2 (Fiberoptic)
n	57	71
Age (yr) (mean ± SD)	42.2 ± 15.5	43.8 ± 16.6
Male/female	23/34	22/49
Mallampati class		
1	46	51
2 or 3	11	20

Table 2. Intubation Times and Respiratory Variables

	Group 1 (Rigid Laryngoscopic)	Group 2 (Fiberoptic)
n	57	71
Intubation times (s)	34 ± 10 (19–68)	56 ± 24* (23–147)
Lowest O_2 saturation (%)	98 ± 1.0 (95–100)	98 ± 1.0 (94–100)
Highest postintubation ET_{CO_2} (mmHg)	35 ± 5 (21–46)	36 ± 4 (26–43)

Values are mean ± SD (range).

* $P < 0.001$ *versus* group 1.

lation was found between fiberoptic and conventional mean intubation times for individual residents.

No significant differences in average systolic and diastolic blood pressures or heart rates were observed between groups at any time.

Data on postoperative sore throat and hoarseness are presented in table 3. We interviewed 80% (57 of 71) of fiberoptic patients and 74% (42 of 57) of rigid laryngoscopic intubation patients and found no significant difference in incidence or degree of sore throat or hoarseness between the groups.

There was no dental trauma to any patient in the study group. During the training period, one patient sustained a broken permanent dental bridge during a rigid laryngoscopic intubation. There was no dental trauma sustained during the training period from fiberoptic intubation.

Discussion

Although there is general consensus that patients with known or anticipated difficult intubation should undergo awake fiberoptic intubation, there is little research on the best method of teaching this technique. While one recent review concluded, "Where possible, fiberoptic intubation should be performed with the patient awake,"[15] roughly 50% of difficult intubations are not predictable by history or physical examination.‡ This fact, plus the increasing trend toward using intermediate-lasting muscle relaxants to facilitate tracheal intubation, would suggest that expertise in fiberoptic intubation under general anesthesia is a skill that every anesthesiologist should possess. This study was undertaken to assess the performance of novice anesthesiologists who were trained *pari passu* in fiberoptic and laryngoscopic intubation.

Although fiberoptic intubation in our study took approximately 22 s longer on average than did rigid laryngoscopic intubation, the clinical importance of this longer apneic interval with fiberoptic intubation is uncertain, because no episodes of hypoxemia or significant hypercarbia were noted in either group. However, no patients with Mallampati classification IV or with known difficult tracheal intubation were included, and we cannot be certain that our residents would be equally adept at managing the airways of such patients.

Clinically important desaturation episodes during fiberoptic intubation under general anesthesia were reported by Smith *et al.*[21] However, they studied patients with abnormal airway anatomy and used inhalation anesthesia that permitted spontaneous ventilation during tracheal intubation. All the desaturation episodes were associated with either coughing/laryngospasm or with problems in maintaining appropriate depth of anesthesia. Furthermore, they did not preoxygenate their patients before induction. They subsequently modified their technique (as suggested by Schaeffer *et al.*) to use total intravenous anesthesia with paralysis for fiberoptic intubation.[22]

Several other studies compared intubation times using fiberoptic and rigid laryngoscopic techniques in anesthetized patients.[23–26] All these showed laryngoscopic intubation to be faster than fiberoptic, as did we. Comparison of absolute values for intubation times is difficult, because of different definitions of intubation

Table 3. Incidence of Postoperative Sore Throat and Hoarseness

	Group 1 (Rigid Laryngoscopic)	Group 2 (Fiberoptic)
n	42	57
Sore throat	19 (45)	22 (39)
Mild	15 (36)	16 (28)
Moderate	4 (9)	5 (9)
Severe	0 (0)	1 (2)
Hoarseness	20 (48)	30 (53)
Mild	18 (43)	25 (44)
Moderate	2 (5)	4 (7)
Severe	0 (0)	1 (2)

Values are number (%).

‡ Deller A, Schreiber MN, Gramer J, Ahnefeld FW: Difficult intubation: Incidence and predictability, a prospective study of 8284 adult patients (abstract). ANESTHESIOLOGY 1990; 73:A1053.

time. We defined intubation time as duration of apnea. Our trainees' times were similar to those reported by Schaeffer *et al.*[23] using a similar definition to ours, with a similar anesthetic technique. They studied the performance of anesthesiologists expert in both techniques, however, whereas we evaluated trainees.

Like others,[23,25] we found no difference in the hemodynamic response to intubation using either technique. One study that found significantly more sympathetic response to fiberoptic intubation relied on inhalation anesthesia.[24] It has been suggested that the anesthetic induction agents chosen are more important in blunting the hemodynamic response than is the intubation technique.[3]

We found no dental trauma due to fiberoptic intubation during the study or training periods. However, our study had a low power to detect differences in incidence of trauma. It has been suggested that patients in whom there is a risk of damage to teeth and dental work may be suitable candidates for fiberoptic intubation.[7]

Like others[3,23] we found no difference in the incidence of hoarseness and sore throat between the two techniques.

Although we favor use of the anesthetized patient as the best subject for learning fiberoptic intubation, we recognize there are certain problems inherent in this approach.

First, the use of apneic patients imposes a time limit on the learner. However, pre-oxygenation[27] plus oxygen insufflation[28] makes the time limit to prevent hypoxia not too stringent. Similarly, moderate hyperventilation (*e.g.*, to ET_{CO_2} 30 mmHg) would allow up to 3 min of apnea without serious hypercarbia, assuming an average Pa_{CO_2} increase of 5 mmHg/min during apnea.[29] We observed no clinically important hypoxemia or hypercarbia during the training period or the study. This was assured by immediately terminating apnea and ventilating by mask if Sp_{O_2} decreased to 95% or if apnea lasted longer than 180 s. The significance of this is not merely that hypoxemia and hypercarbia can be avoided but rather that the limits placed on the students for intubation do not hinder them in practicing and developing their fiberoptic intubation skills.

A second problem is the potential delay to the surgeons, particularly during the training period. We limited our residents to only two attempts during the training period. Two studies of resident learning curves[3,11] showed that proficiency in fiberoptic intubation under general anesthesia was acquired after only ten practice intubations. We did not study the rate of learning, but the lack of correlation between number of practice intubations and mean study intubating times in our study supports their findings. Another approach to this problem is to train residents in fiberoptic intubation during the surgical procedure. Where there was no competition with surgeons for access to the airway, Cooper and Benumof[13] used various airway aids that permitted ventilation during fiberoptic intubation training under general anesthesia.

Third, a trained assistant is crucial to the success of our technique. Neck extension, jaw thrust, and lingual traction, like cricoid pressure, are not difficult skills to teach or acquire but are best taught in elective situations before they are required. We chose to use a trained assistant to recreate an open upper airway rather than mechanical aids because the latter are not applicable in an awake intubation situation.

Marsch and Schaeffer[14] suggested that training in fiberoptic intubation under general anesthesia may have translated to expertise and better patient acceptance of awake fiberoptic intubation. Further study in this area would be useful.

In conclusion, we found that junior residents were trained easily to perform fiberoptic intubation in anesthetized paralyzed patients with no clinically important prolongation of intubation times and no increase in hemodynamic or respiratory instability or in postoperative side effects. The success of our inexperienced trainees suggests that training in fiberoptic intubation need not be reserved for experienced residents or consultants in anesthesia. Routine training in fiberoptic intubation should be an integral part of any residency program.

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