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Evaluation of Tracheal Intubation Difficulty in Patients with Cervical Spine Immobilization

Fiberoptic (WuScope) Versus *Conventional Laryngoscopy*

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Background: **The WuScope is a rigid, fiberoptic laryngoscope designed to facilitate tracheal intubation without the need for head extension. The study evaluated the WuScope in anesthetized patients with neck immobilization.**

Methods: **Patients were randomized to one of two groups: those receiving fiberoptic laryngoscopy (WuScope, n = 43) and those receiving conventional laryngoscopy (Macintosh blade, n = 44). Manual in-line stablization of the cervical spine was done during intubation. Seven parameters of intubation difficulty were measured (providing an intubation difficulty scale score): number of operators, number of attempts, number of techniques, Cormack view, lifting force, laryngeal pressure, and vocal cord position.**

Results: **Successful intubation occurred in 95% of patients in the fiberoptic group and in 93% of patients in the conventional group. There were no differences in number of attempts. In the fiberoptic group, 79% of patients had an intubation difficulty scale score of 0, representing an ideal intubation: that is, one performed by the first operator on the first attempt using the first technique with full glottic visualization. Only 18% of patients in the conventional group had an intubation difficulty scale score of 0 ($P < 0.001$). More patients had Cormack grade 3 or 4 views with conventional than with fiberoptic laryngoscopy (39 *vs.* 2%, $P < 0.001$). Intubation times in patients with one attempt were slightly longer in the fiberoptic (median, 25th–75th percentiles: 30, 23–53 s) compared with the conventional group (24, 17–30 s, $P < 0.05$). Corresponding times in patients requiring > one attempt were 155 (range, 112–201) s and 141 (range, 95–186) s in the fiberoptic and conventional groups, respectively (P value not significant).**

Conclusions: **Compared with conventional laryngoscopy, tracheal intubation using the fiberoptic laryngoscope was associated with lower intubation difficulty scale scores and better views of the laryngeal aperture in patients with cervical immobilization. However, there were no differences in success rates or number of intubation attempts. (Key words: Cervical trauma; Cormack view.)**

FAILURE to immobilize the neck during tracheal intubation in patients with cervical spine injuries can result in devastating neurologic outcome.[1] One method to immobilize the neck during laryngoscopy and oral tracheal intubation is manual in-line axial stabilization (MIAS).[2] With MIAS, however, it is often more difficult to visualize the larynx using conventional laryngoscopy.[3] Rigid fiberoptic devices (*e.g.*, Bullard laryngoscope) have been successfully used to intubate the trachea in patients with known or suspected cervical spine injury[4] and require less neck movement than the MacIntosh or Miller laryngoscope blade to optimally visualize the glottic aperture.[5] However, some cervical spine extension may still occur with the Bullard laryngoscope during exposure of the arytenoids or during the course of obtaining the best possible laryngeal view, and there is occasional difficulty advancing the endotracheal tube (ETT) off of the rigid stylet and into the trachea.[5,6]

The WuScope (Pentax Precision Instruments, Orangeburg, NY) is a combination fiberoptic laryngoscope system that is composed of a tubular, curved, bivalved rigid blade portion and a flexible fiberscope portion to facilitate placement of the ETT with the patient's head and neck in the neutral position.[7] The blade portion forms a

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tubular exoskeleton, which provides a passageway through which the ETT can be advanced through the glottic opening without the need for an intubating stylet.

The purpose of this randomized, prospective study was to evaluate the use of the WuScope in normal patients with neck immobilization using MIAS. The primary hypotheses were that compared with conventional direct laryngoscopy, fiberoptic laryngoscopy using the WuScope would be associated with lower intubation difficulty scale (IDS) scores, shorter intubation times, and better visualization of the glottic opening.

Methods

The study was approved by the MetroHealth Medical Center Institutional Review Board. Written informed consent was obtained from the patients. Eighty-seven patients undergoing elective surgery requiring general anesthesia and tracheal intubation were randomized into two groups using a table of random numbers: (1) fiberoptic laryngoscopy (WuScope, n = 43) and (2) direct laryngoscopy (Macintosh blade, n = 44). Exclusion criteria were history of difficult intubation, abnormal airway anatomy (*e.g.*, Mallamapati class 3 or 4, thyromental distance < 6.5 cm, mouth opening < 3.5 cm, cervical spine disease, anteriorly protruding incisors), and risk factors for aspiration. Monitoring included electrocardiogram, pulse oximeter, capnography, and automatic noninvasive blood pressure measurement. Premedication was with midazolam, 1-2 mg intravenously. Following preoxygenation, anesthesia was induced with thiopental, 3-5 mg/kg, or propofol, 1.5-2.0 mg/kg, and fentanyl, 1-3 μg/kg. Neuromuscular blockade was with rocuronium, 0.6-0.9 mg/kg, or cisatracurium, 0.2 mg/kg. Antisialagogues were not used. Each patient's lungs were manually ventilated with oxygen and isoflurane 0.6-1.0% inspired. After onset of neuromuscular blockade, as evidenced by loss of all four orbicularis oculi twitches in response to train-of-four supramaximal stimulation of the facial nerve,[8] the pillow was removed and the neck was immobilized using MIAS applied by an experienced individual holding the sides of the neck and the mastoid processes, thus preventing movement of the head and neck. Tracheal intubation was then carried out according to the assigned group.

In the fiberoptic group, the technique was as follows: The WuScope was assembled according to the manufacturer's instructions (fig. 1). Antifog (SL cleaner for gastrolens; Pentax) was applied to the tip of the fiberscope.

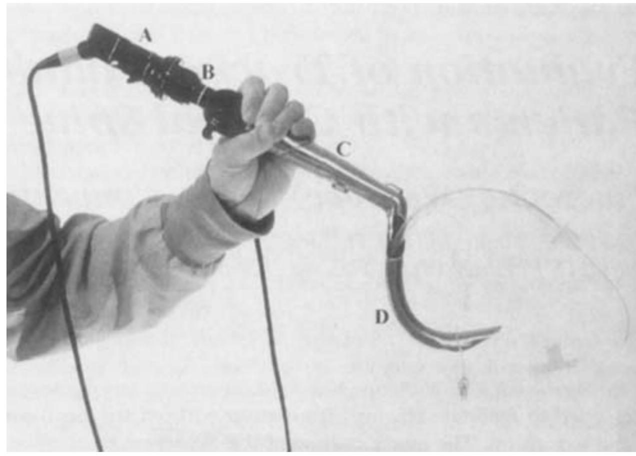

Fig. 1. View of the WuScope, large adult blade. A = camera connector, B = fiberscope, C = handle, D = main blade joined together with bivalve element, creating a passageway for the endotracheal tube (ETT). The WuScope is held in the left hand. The right hand is free to apply suction *via* the suction catheter inside the lumen of the ETT and advance the tube through the vocal cords.

The ETT was soaked in warm water or lubricated to facilitate smooth insertion within the rigid tube passageway. A suction catheter was inserted through the ETT. A fiberoptic light source was used (Pentax Xenon LX-300 P, LH-150, or Olympus XLS, Shirakawa Olympus, Japan). The intubation sequence was displayed on a color video monitor (Olympus or Sony Trinitron, Sony, Tokyo, Japan) using a camera connector with focusing ring (Olympus OTV-S5 or Pentax Endovision 3000) that attached to the fiberscope, or it was viewed directly through the fiberscope if the video monitor and camera connector were not available.

The scope was introduced into the patient's mouth at the midline. The handle was then gradually rotated toward the operator and the blade advanced until the epiglottis and larynx were seen. The suction catheter inside the ETT was used to remove secretions and as a guide for ensuring proper alignment of the ETT and glottic opening. Gentle manipulation of the blade sideways with or without slightly advancing or withdrawing the blade was occasionally necessary to ensure alignment. The ETT was then advanced by the operator through the passageway created by the main blade and bivalve element, over the suction catheter, through the vocal cords, and into the trachea. Large-adult Wu blades were used for males >70 kg, whereas adult blades were used for females and smaller males. All operators (C.E.S., T.S.S., B.R.) had performed a minimum of 10 WuScope intubations prior to the study after reading the instruction manual, watching the teaching video, and practicing on a mannequin.

In the conventional group, a size 3 or 4 MacIntosh blade was used depending on patient size and operator preference. A stylet was preloaded for the first attempt. Operators (C.E.S., T.S.S., A.C.P., B.R.) had all performed more than 3,000 intubations with conventional laryngoscopy. In the event of an unsuccessful intubation, one additional attempt using the original technique was permitted before changing to another method. Manual bag-mask ventilation of the patient's lungs with oxygen and isoflurane was done in between attempts. For the initial intubation in both groups, size 8.0 mm internal diameter cuffed tracheal tubes were used for males, and size 7.0 mm internal diameter tubes were used for females (Mallinckdrodt Medical, St Louis, MO).

The following measures were recorded by an independent observer after each intubation:[9] N_1, the number of supplementary intubation attempts, with an attempt defined as the entire process of inserting and removing the blade from the patient's mouth; N_2, the number of supplementary operators; N_3, the number of alternative intubation techniques used; N_4, glottic exposure as defined by the Cormack and Lehane grade -1 (grade 1 = complete visualization of the vocal cords, grade 2 = visualization of the inferior portion of the glottis, grade 3 = visualization of only the epiglottis, and grade 4 = nonvisualized epiglottis), evaluated by the first operator during the first attempt; N_5, the lifting force applied during laryngoscopy ($N_5 = 0$ if little effort was necessary, $N_5 = 1$ if subjectively increased lifting force was used); N_6, the necessity of applied external laryngeal pressure for improved glottic exposure ($N_6 = 0$ if no external pressure was applied and $N_6 = 1$ if external laryngeal pressure was necessary); N_7, position of the vocal cords at intubation ($N_7 = 0$ if the vocal cords were in abduction, $N_7 = 1$ if the cords were adducted blocking the tube passage; if the cords were not visualized, $N_7 = 0$). The IDS score was the sum of N_1 through N_7.[9] A score of 0 represented an ideal intubation: that is, one performed by the first operator on the first attempt using the first technique with full visualization of the glottis and little effort. An IDS score between 2 and 5 represented slight difficulty and IDS > 5 represented moderate to major intubation difficulty.[9] In the case of impossible intubation, the IDS takes the value attained before abandonment of intubation attempts.

Intubations were timed by the independent observer. Time to intubation was from the moment the blade touched the patient until visualizing the ETT entering the glottis and cuff inflation. In the case of unsuccessful glottic visualization, the time continued to run until a successful intubation was performed, as confirmed by sustained presence of end-tidal carbon dioxide on the capnogram. Because IDS score, Cormack views, and intubation times were not normally distributed, nonparametric statistical analyses were done. The Cochran–Mantel–Haenszel test was used for intergroup comparisons of IDS score and Cormack grade views. The Kruskall–Wallis test was used to compare intubation times between groups. The Student *t* test and chi-square analysis were used for the remainder of comparisons. A *P* value < 0.05 was considered statistically significant.

Table 1. Patient Data

	Conventional Laryngoscopy (n = 44)	Fiberoptic Laryngoscopy (n = 43)
Age (yr)	39 ± 15	40 ± 11
Gender (m/f)	19/25	17/26
Weight (kg)	80 ± 20	77 ± 15
Height (cm)	164 ± 18	166 ± 14
ASA physical status (1/2/3)	7/28/9	7/28/8
Mallamapati class (1/2)	30/13	29/14
Type of surgery		
General	11	12
Gynecology	4	5
Orthopedics	23	17
Other	6	9

Data are mean ± SD or number of patients. There were no significant differences between groups.

Results

Patient data were similar between groups (table 1). The number of attempts required for successful intubation were similar between groups (table 2). Successful intubation occurred in 95% of patients in the fiberoptic group and in 93% of patients in the conventional group (*P* value nonsignificant). Two patients in the fiberoptic group and three patients in the conventional laryngoscopy group were unable to be intubated using the assigned technique. Reasons for failed intubation in the fiberoptic group were persistent fogging of the fiberscope in one patient, and inability to advance the ETT into the trachea despite adequate glottic visualization in a female patient using the large-adult blades (table 2). Each of these patients had the trachea intubated with direct laryngoscopy while neck stabilization was maintained. The reason for failed intubation in the conventional group was grade 4 view in all three patients. Two

Table 2. Number of Attempts Required for Successful Intubation and Reasons for More Than One Attempt

	Conventional Laryngoscopy (n = 44)	Fiberoptic Laryngoscopy (n = 43)
First attempt successful	35 (80)	34 (79)
Second attempt successful	6 (14)	7 (16)
Required another technique	3 (7)	2 (5)
Reasons for attempt > 1		
Secretions obscuring view	0	4 (9)
Fogging	0	4 (9)
Grade 3/4 view	7 (16)	4 (9)
Esophageal intubation	4 (9)	0
Blades too long	0	1 (2)
Δ angle stylet	1 (2)	0
Smaller endotracheal tube	1 (2)	0

Data are number of patients (%). There could be more than one reason for intubation attempt > 1.

of these patients had their tracheas intubated with the WuScope (MIAS), and one patient had their trachea intubated in the sniff position with direct laryngoscopy. Fiberoptic laryngoscopy was not attempted in this patient.

In the fiberoptic group, 79% of patients had an IDS score of 0 (median IDS, 0; range, 0-6; fig. 2). Only 18% of the patients in the conventional group had an IDS score of 0 (median IDS, 3; range, 0-8; $P < 0.001$ *vs.* the fiberoptic group). The number of patients with moderate to major difficulty with intubation (IDS score > 5) was similar between groups (fig. 2). Fewer patients in the fiberoptic group had Cormack grade 3 or 4 views after the first or second attempt (9% and 2%) compared with patients in the conventional group (39%, both first and second atttempts, $P < 0.001$; fig. 3). In the conventional group, 13 patients had increased lifting force and 25 had external laryngeal pressure. Only one patient needed extra lifting force and laryngeal pressure in the fiberoptic group.

Median time to intubation in patients requiring one attempt was slightly shorter in the conventional compared with the fiberoptic group (24 *vs.* 30 s, $P < 0.05$; table 3). There was no difference in intubation time between groups if more than one attempt was required (table 3).

Discussion

This study demonstrated that MIAS was associated with a high incidence of grade 3 and 4 views using conventional laryngoscopy (39% of patients), which accounted for the higher IDS scores, the four instances (9%) of esophageal intubation, and the three instances (7%) of impossible intubation in this group. In contrast, fiberoptic laryngoscopy was associated with better views of the laryngeal aperture (98% grade 1 after the first or second attempt), lower IDS scores, and no instances of esophageal intubation. Two patients, however, could not be intubated with the fiberoptic technique.

Previous studies have shown that cervical spine immobilization is associated with a high incidence of poor glottic views using conventional laryngoscopy. For example, the incidence of grade 3 or 4 views of the larynx in anesthetized, paralyzed patients with MIAS, direct laryngoscopy, and a MacIntosh blade ranged from 22 to 34%.[3,10-12] The increased incidence of poor glottic views is because MIAS prevents head extension and neck flexion, which are necessary for optimal alignment of the three airway axes and exposure of the vocal cords.[13,14] The incidence of grade 3 and 4 views with conventional laryngoscopy may be as high as 64% if the patient's cervical spine is immobilized using rigid collar, tape, and sandbags. owing to the combination of decreased interincisor distance and cervical spine immobility.[10]

Laryngeal view is a major factor involved with difficult intubation.[15] For example, 84% of patients requiring at least three laryngoscopies to intubate the trachea had grade 3 or 4 view, and all patients with failed laryngoscopy had grade 4 view.[16] Of patients with moderate to

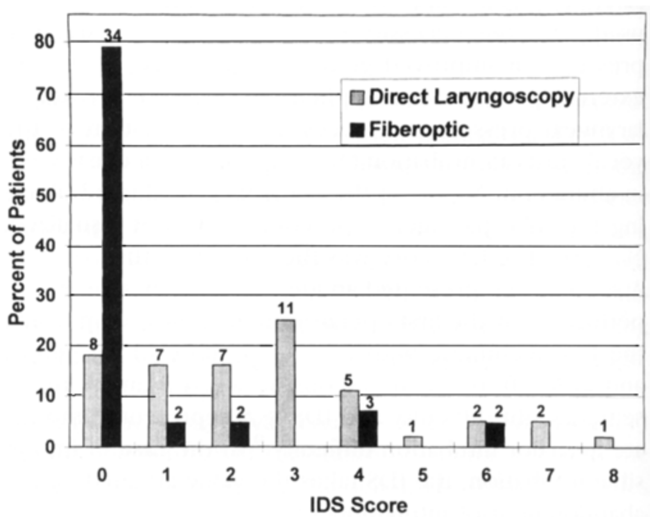

Fig. 2. Comparison of intubation difficulty scale (IDS) score distributions with fiberoptic *versus* conventional laryngoscopy. Number of patients is shown above each bar. $P < 0.001$ between groups, Cochran–Mantel–Haenszel test.

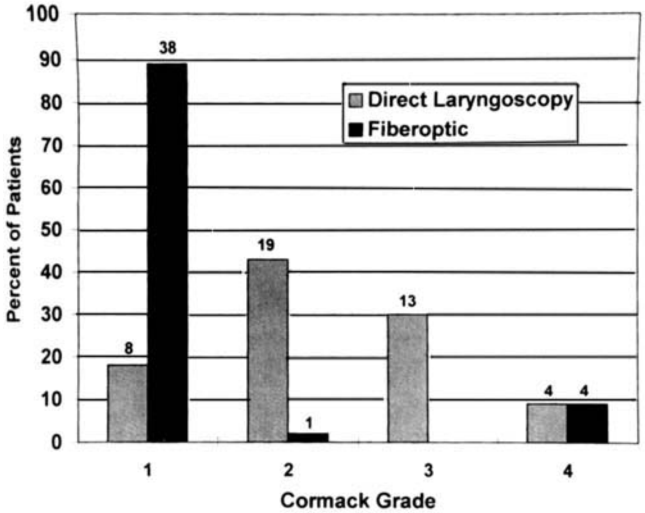

Fig. 3. Cormack grade view during the first intubation attempt with fiberoptic *versus* conventional laryngoscopy. Number of patients is shown above each bar. $P < 0.001$ between groups, Cochran–Mantel–Haenszel test.

major intubation difficulties (IDS > 5), 71% had grade 3 or 4 views.[9] The reason for failed intubation in the current study using conventional laryngoscopy was grade 4 view in all three patients. If the epiglottis cannot be exposed, then tracheal intubation is virtually impossible with conventional laryngoscopy.[17] If the epiglottis but no part of the glottis can be seen, then there may be fairly severe difficulty with conventional laryngoscopy[17] unless the distal end of the ETT can be inserted underneath the epiglottis and directed anteriorly using a stylet in the shape of a hockey stick[15] or inserted by using the gum-elastic bougie technique.[3] Intubation difficulties with conventional laryngoscopy and grade 3 view may be accentuated in patients with small laryngeal aperture area.[18] In the current study, blind probing with a styletted tracheal tube during conventional laryngoscopy in patients with poor views resulted in the tube being initially placed in the esophagus in four instances and ultimately did not result in successful intubation in three instances.

Although the Cormack and Lehane laryngoscopy grading system is a quantifiable, easy, and widely used system and is an important component of the IDS score,[9] it is recognized that this grading system was initially defined on the basis of direct laryngoscopy, with the operator looking along the laryngoscope blade through the mouth and toward the larynx.[17] The fiberoptic WuScope, in essence, bypasses this and effectively puts the operator's eye inside the mouth much closer to the epiglottis and glottis. Thus, it may not be entirely valid to use a grading system designed for direct laryngoscopy with a fiberoptic system. Nonetheless, it is our experience that poor visualization of the laryngeal aperture with a fiberoptic technique (flexible or rigid) makes tracheal intubation difficult if not impossible, thus supporting the usefulness of the Cormack and Lehane grading system in conditions of difficult intubation. In the current study, if the glottis was able to be visualized with the fiberoptic laryngoscope during the first or second attempt, then tracheal intubation was accomplished in all but one instance.

The evaluation of degree of tracheal intubation difficulty is problematic. Although we measured seven parameters that have been shown to be associated with difficult intubation, there is no true border between an easy and a moderately difficult intubation, or between a moderately difficult and a truly difficult intubation.[9] The IDS score represents only a total difficulty and is very much dependent on choice of intubation method, sequencing of methods, and other factors.[19] Furthermore, the IDS score alone does not identify the problem or cause of an increased IDS score.[19] Therefore, it is important to record the reasons for high IDS score, such as poor view of the glottis.

Despite the high incidence of poor glottic views in the conventional laryngoscopy group, it was still possible to intubate the tracheas of 93% of patients within two attempts. Moreover, intubation time was approximately 6 s faster with conventional *versus* fiberoptic laryngoscopy if successful intubation occurred on the first attempt. Thus, difficulty with laryngeal exposure does not necessarily imply difficulty with tracheal intubation if experienced operators perform direct laryngoscopy. Moreover, there is no need under many circumstances to obtain a Cormack grade 1 view to successfully insert the tube into the trachea, as long as some part of the posterior arytenoids are visible. This likely explains the popularity and relative safety of

Table 3. Time to Tracheal Intubation (s) in Patients Requiring One or More Intubation Attempts

	Conventional Laryngoscopy (n = 44)	Fiberoptic Laryngoscopy (n = 43)
One attempt required (median)	24	30*
25th–75th percentile	17–30	23–53
Range	8–67	13–110
> One attempt (median)	141	155
25th–75th percentile	95–186	112–201
Range	60–275	72–350

* $P < 0.05$ *versus* conventional laryngoscopy.

MIAS, rapid sequence induction, direct laryngoscopy, and oral tracheal intubation in multiple trauma patients with known or potential cervical spine injuries requiring emergency intubation.[20,21]

In the present study, there was a relatively high incidence (79%) of "intubation without any problem" (IDS score = 0) using the WuScope. There were, however, several technical difficulties encountered with the fiberoptic instrument. Fogging and secretions were responsible for poor initial views of the glottis in four patients and for failed intubation in one patient. Incorrect choice of the large adult Wu blades in a smaller patient accounted for the other failed intubation in the fiberoptic group. Even though the glottic views were superior with the fiberoptic instrument, intubation time was slightly longer than with conventional laryngoscopy. The longer intubation time was likely because of blade manipulations that were required to correctly align the ETT with the glottic opening.

A variety of techniques to intubate the trachea in patients requiring cervical spine immobilization has been described utilizing flexible fiberoptic endoscopes, rigid fiberoptic laryngoscopes (*e.g.*, Bullard), McCoy laryngoscope, blind nasotracheal intubation, gum-elastic bougies, light wands, retrograde intubation, and creation of a surgical airway.[6,22] Although it is not possible to make any direct comparisons of the WuScope with these techniques, advantages of the WuScope include the oropharyngeal airway-shaped blade to allow glottic visualization without the need for head extension (not measured in the present study), tongue lifting, or forceful jaw opening; modified handle-to-blade angle (110 degrees) for easy entry into the oropharynx; tubular blade structure to protect the fiberscope from secretions, blood, or redundant soft tissue; built-in ETT passageway through which the ETT can be advanced without a stylet; and continuous viewing of the ETT as it advances past the vocal cords into the trachea.[7] Disadvantages of the WuScope include high cost of the equipment (handle, main blade, bivalve blade, extender, and fiberscope, $9800 US), requirement for a fiberoptic light source, fragility of the fiberscope and cost of repairs, time required for cleaning and disinfecting the fiberscope, and requirement for learning the necessary skills to assemble the device, manipulate the scope, and disassemble the device. Complications from rigid laryngoscopy, although not observed in the present study, are also possible, such as chipped teeth, mucosal injury, and sore throat.

Currently, there are no clear guidelines for the optimal method to intubate the trachea in patients with cervical spine injuries, with the exception that the head and neck must be kept in a neutral position throughout the intubation procedure.[23,24] At our institution, the WuScope has proven to be useful for the management of patients with known or suspected cervical spine injuries, although the use of intubating adjuncts such as the gum-elastic bougie[3] and McCoy articulating laryngoscope blade[11,12,25] may represent a less costly alternative to fiberoptic techniques. Further studies are required to evaluate the safety and efficacy of the WuScope under other circumstances (*e.g.*, cricoid pressure, anatomic factors associated with difficult airway, awake intubation).

In conclusion, despite the better view and lower IDS score with fiberoptic laryngoscopy, the successful intubation rate and time to intubation were similar between groups. Further, the number of patients requiring multiple attempts and number of patients requiring another technique to accomplish tracheal intubation was no different for the two methods of intubation. Thus, the results of the present study cannot be used to support the routine use of fiberoptic over conventional laryngoscopy in patients with MIAS.

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