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Comparison of McGrath Series 3 and Macintosh Laryngoscopes for Tracheal Intubation in Patients With Normal Airway by Inexperienced Anesthetists

A Randomized Study

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Abstract: Difficult and failed intubations account for the major causes of morbidity and mortality in current anesthetic practice. Several devices including McGrath Series 3 videolaryngoscope are available which may facilitate tracheal intubation by improving view of the larynx compared with Macintosh blade laryngoscopy. But no studies demonstrate whether McGrath Series 3 performs better than Macintosh laryngoscope in normal airway intubations by inexperienced anesthetists so far. We therefore designed this randomized controlled study to compare McGrath with Macintosh in routine tracheal intubation performed by inexperienced anesthetists.

In total, 180 adult patients with normal-appearing airways requiring orotracheal intubation for elective surgery were randomly allocated to be intubated by 9 inexperienced anesthetists with McGrath or Macintosh. The primary outcome was time to intubation. Ease of intubation was assessed by a 5-point ordinal scale. Intubation attempts/failures, best laryngoscopy view using the Cormack–Lehane grade, associated complications and hemodynamic changes during intubation were recorded.

We found that there was no significant difference between McGrath and Macintosh in the median time to intubation ($P=0.46$); the Cormack–Lehane views attained using McGrath were superior ($P<0.001$); the difference of ease of intubation was statistically significant ($P=0.01$). No serious trauma occurred in both groups. And there was statistically significant difference in the systolic blood pressure changes between 2 groups ($P<0.05$).

We demonstrated that in orotracheal intubation in patients with normal airway by inexperienced anesthetists, McGrath compared with the Macintosh allows superior glottis views, greater ease of intubation, less complications, and hemodynamic changes with noninferior intubation time. And it remained a potential selection for inexperienced anesthetists in uncomplicated intubation.

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Abbreviations: ASA = American Society of Anesthesiologists, BMI = body mass index, IQR = interquartile range, SBP = systolic blood pressure, SD = standard deviation.

INTRODUCTION

Airway management remains among the most important responsibilities of an anesthetist. Problems with intubation may cause serious complications, and on occasion, life-threatening. Failure of oxygenation is the most common cause of death and permanent brain damage under anesthesia.[1,2] Conventional direct laryngoscopy with Macintosh blade is considered to be the standard technique for placing an endotracheal tube. However, this skill is not easy to acquire and requires adequate training.[3,4] Difficulty in tracheal intubation is often unanticipated and moreover is most frequently encountered by more inexperienced anesthetists. They may even have some difficulties in intubation of normal airway because of lack of proficient technique and experience. Therefore, the less experienced anesthetists are more likely to encounter difficult or failed tracheal intubation which may lead to prolonged intubation time, anoxia and even more adverse outcomes, particularly when working without direct supervision.[5]

Videolaryngoscopy is becoming a widely accepted airway management technique. It can offer better views of the glottis when compared with standard direct laryngoscopy for the management of both normal and difficult airways.[6–8] The McGrath Series 3 videolaryngoscope (Aircraft Medical, Edinburgh, Scotland) is a novel, self-contained videolaryngoscope, containing a sterile, transparent, acrylic single-use blade with a 45° angle (110 mm × 12 mm × 15 mm). It has a tiny camera and a light source at the tip of the blade powered by a battery contained within the handle and therefore offers advantages as a stand-alone unit, without separate power units, screens, or cables. The McGrath offers a clear view of the glottis, vocal cords and surrounding airway anatomy on an LCD screen attached to the handle without requiring alignment of the oral, pharyngeal and laryngeal axes in patients with both normal and potential difficult airways.[9,10] It is also used in the management of failed tracheal intubation by Macintosh and other laryngoscopy.[11,12]

However, information about its use by inexperienced anesthetists is limited. The McGrath was similar with Macintosh in blade structure and shape, and maybe easy to grasp for beginners. Moreover, the superior anesthetists could observe and direct the real intubation process from the screen.[13,14] So it appears to be a good teaching tool and would potentially be safer and easier intubation instrument for less experienced anesthetists.

In this study, the performance of McGrath was examined when used by inexperienced anesthetists during uncomplicated orotracheal intubation comparing with Macintosh (Diamond Fibrelight, Penlon, Abingdon, UK). We hypothesized that McGrath might be a better choice with shorter intubation time and superior visualization when compared with Macintosh. Additionally, we aimed to assess the safety of the devices regarding hemodynamics and intubation complications, as well as the ease of intubation evaluated by the inexperienced anesthetists themselves.

METHODS

Patients

It was a single center, randomized controlled trial, with approval under the local research ethics committee. From November 1 to December 31, 2013, we enrolled 180 patients ages $\geq$18 year of ASA classification 1 to 2 undergoing elective surgery under general anesthesia requiring routine orotracheal intubation at Peking Union Medical College Hospital. The tracheal tube was finished by first-year trainee anesthetists with the supervision of senior colleagues. Patients met the exclusion criteria if they had predictors of potential difficult airway, including body mass index (BMI) $\geq$ 35 kg/m^2, modified Mallampati score 3 to 4,[15] limited mouth opening <3 cm, thyromental distance <6 cm, loose cutting teeth or extreme long superior teeth, restricted neck motion (<80°, from full flexion) and history of difficult airway or obstructive sleep apnea-hypopnea syndrome. Patients at risk of regurgitation or aspiration and patients with cervical spine instability were not included.

After obtaining written informed consent from participating patients, they were allocated to groups undergoing intubation using either McGrath or Macintosh laryngoscope by a computer-generated block randomization method. The principal investigator performed the computer randomization and the allocation resulting in different numbers. Sealed opaque envelopes were used to conceal the assignment and were opened only on arrival of the patient in the anesthetic room, shortly before tracheal intubation.

The intubations were performed by 9 first-year trainee anesthetists who had just graduated from medical college. Before this study, they had been trained with high strength for 1 to 2 months and finished 10 to 30 tracheal intubations with Macintosh blade. So they were capable of direct laryngoscopy with Macintosh blade in uncomplicated airways, though not skilled in it. All trainee anesthetists involved received a standardized training for use of McGrath before commencement of study. They were given instructions by the same experienced anesthetist and practiced McGrath on manikins. Thereafter, they had to achieve a minimum of 5 successful attempts with McGrath on manikins independently before practicing it on real patients.

Patients' baseline characteristic data were collected before operation. After admission to the operation room, an intravenous catheter was inserted. Routine monitoring was established before induction of anesthesia, including electrocardiography, noninvasive blood pressure monitoring, fingertip oximetry, and capnography. After adequate preoxygenation with 100% oxygen and end-tidal oxygen concentration $\geq$70% ensured, induction medicine was administered. Being a pragmatic trial, the choice of drug, including neuromuscular blocking drug was at the discretion of senior anesthetist. Patients were then positioned in the "sniffing" position and received bag-and-mask ventilation with 100% oxygen until muscle relaxation was achieved completely. Thereafter, laryngoscopy was performed with either McGrath or Macintosh (blade size 3 or 4) according to the research randomization allocation. A standard Mallinckrodt oral tracheal tube was used (size 7.0 or 7.5 for females and size 7.5 or 8.0 for males). The use of a stylet was at the discretion of the anesthetist. If the operator removed the laryngoscope from mouth, this was counted as an additional attempt at intubation. Data during intubation were observed and recorded by an independent observer.

The primary outcome of this study was the time to finish tracheal intubation. Secondary outcomes included the number of intubation failures, the best laryngoscopic views by the Cormack–Lehane grade,[16] ease of intubation, associated complications, and the hemodynamic changes during intubation. The time taken for successful tracheal intubation was defined as the time from the laryngoscope placed into the mouth until end-tidal carbon dioxide detected, including time between attempts. If a second attempt of tracheal intubation was needed, the anesthetized patient would receive ventilation via facemask between attempts and any helpful maneuver could be used, including the use of a stylet and external laryngeal pressure. An intubation failure was defined as the trainee anesthetist could not achieve tracheal intubation after 2 attempts or prolonged intubation taking $\geq$120 s. And the airway was subsequently managed using any technique by senior anesthesiologists. The ease of intubation was graded by the trainee anesthetist immediately after laryngoscopy on a numerical rating scale (1 = the easiest, 5 = the most difficult). Complications associated with tracheal intubation were recorded, such as, injury to oral mucosal, lips or dentition, postoperative sore throat, and hoarseness. Hemodynamic values including blood pressure and heart rate were recorded before laryngoscopy, just after laryngoscopy and at 1-min interval thereafter for 3 min. Other data collected were: operation time, lowest SpO_2 during intubation from the start of intubation to 1 min after intubation.

Statistical Analysis

The mean intubation time for McGrath was 51.3 s with a standard deviation of 31.8 s based on previous studies.[10] So the standard deviation of the time to intubation was estimated to be approximately 32 s (the longest found in literature). Power analysis showed that to demonstrate a difference of intubation time by 10 s, which we considered the shortest to be clinically significant, 87 patients in each group were required for an experimental design to achieve 90% power at the 0.05 level of significance. Therefore, we recruited 180 patients in total to account for possible drop-outs or missing data.

Categorical data are presented as numbers (percentages), and continuous variables are presented as the mean and standard deviation (SD) or the median and interquartile range, depending on the type of distribution. The Mann–Whitney *U* test was used to analyze the time taken for intubation and the ease of intubation in view using each technique. Categorical data were analyzed with chi-squared test to examine the Cormack–Lehane grade in each study group, the first attempt success rate and the incidence of complications. Hemodynamic changes during the intubations were assessed with the *t* test. SPSS 17.0 (SPSS Inc., Chicago, IL) software was used to perform statistical analysis. The 2-tailed *P* value of <0.05 were considered statistically significant.

RESULTS

One hundred eighty patients were eligible for the study and contributed clinical data to the primary outcome. They were

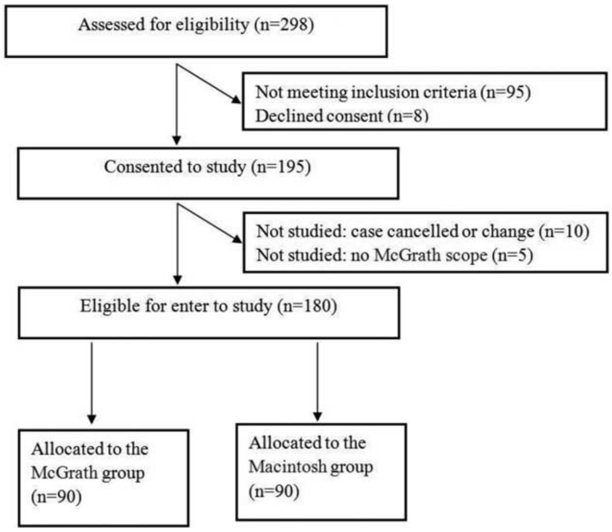

FIGURE 1. Flow diagram showing recruitment into study.

TABLE 1. Baseline Data

Characteristics	McGrath Group (n = 90)	Macintosh Group (n = 90)
Age, y	43.0 ± 12.4	44.1 ± 12.3
Male, n (%)	18 (20)	13 (14)
BMI, kg/m^2	23.7 ± 3.4	23.4 ± 3.4
ASA 1/2, %	76/24	68/32
Mallampati score 1/2, %	47/53	49/51
Mouth opening, cm	5.3 ± 0.7	5.1 ± 0.8
Thyromental distance, cm	6.9 ± 0.9	6.9 ± 1.1
Using stylet, n (%)	23 (26)	26 (29)
Operation time, min	103 ± 60	107 ± 53

Values are mean ± standard deviation unless otherwise indicated.
ASA = American Society of Anesthesiologists, BMI = body mass index.

randomized, 20 by each of the 9 inexperienced anesthetists (Figure 1). The baseline characteristics were similar in both groups (Table 1).

There were 2 intubation failures (2.2%) within 120 s while using McGrath, compared with 1 intubation failure (1.1%) with Macintosh. All of these failures were attributed to the trainee's lack of experience in visualizing glottic structures or passage of the endotracheal tube. The senior anesthesiologists subsequently achieved successful intubation in all 3 patients easily on the first attempt using alternative methods.

The median time taken to achieve successful intubation was slightly longer in McGrath group compared with the Macintosh group, although not significantly different existed (median 28 vs 25 s, $P = 0.46$; Table 2). Considering Mann–Whitney test may lack statistical power as a nonparametric method, an exploratory analysis of parametric method (T test) was performed further to compare intubation time between groups. There was no significant difference showed between the 2 groups (mean 30.6 vs 28.7 s; Table 2). The difference of the mean time required for successful intubation was 1.9 s in favor of Macintosh (95% confidence interval of the difference: −2.1 to 6.0 s; $P = 0.34$). A Kaplan–Meier curve was established for illustration of success rate of intubation as a function of time (Figure 2).

Most intubations were successful within the first attempt in both groups, and there was no difference in the first-attempt success rate ($P = 0.38$; Table 2). McGrath was superior to Macintosh in Cormack–Lehane grade ($P < 0.001$; Table 2). Fewer patients showed Cormack–Lehane grade I views with Macintosh than with McGrath (48 vs 71, respectively). The difference in the ease of intubation was statistically significant (median 2 vs 2, $P = 0.01$; Table 2; Figure 3). No serious trauma occurred during intubations in the McGrath group, but 8 patients had sore throat postoperatively. Comparably, the Macintosh group had 18 intubation complications in total, including 1 minor oropharyngeal mucosal injury, 1 dental injury, 14 postoperative sore throat, and 2 hoarseness. All the sore throat and hoarseness were improved within 72 h and none of the patients required further management.

During the period from intubation to 3 min after intubation, patients showed significant changes in heart rate and blood

TABLE 2. Intubation Data

Variable	McGrath Group (n = 88)	Macintosh Group (n = 89)	Statistical Test	*P* Value
Time to intubation (s), median (IQR)	28 (20.0–36.5)	25 (20–33)	Mann–Whitney	0.46
Time to intubation (s), mean (SD) (exploratory analysis)	30.6 (14.8)	28.7 (12.3)	*T* test	0.34
First attempt success rate, n (%)	80 (91)	84 (94)	Chi-squared	0.38
Cormack–Lehane grade, n (%)				
1	71 (80)	48 (54)	Chi-squared	0.00
2	17 (19)	34 (38)		
3	0 (0)	7 (8)		
Ease of intubation on a 5-point scale median (IQR) (1 = the easiest, 5 = the most difficult)	2 (1–2)	2 (2–3)	Mann–Whitney	0.01
Intubation complications, n (%)	8 (9)	18 (20)	Chi-squared	0.04
Hemodynamic change from baseline*				
Heart rate elevation (%), mean (SD)	11.2 (15.4)	11.9 (19.2)	*T* test	0.80
SBP elevation (%), mean (SD)	12.1 (21.6)	21.0 (29.5)	*T* test	0.02

Percentages may not add to 100% due to rounding.
IQR = interquartile range, SD = standard deviation, SBP = systolic blood pressure.
* Hemodynamics: heart rate and blood pressure were measured at 1-min intervals from intubation to 3 min after intubation.

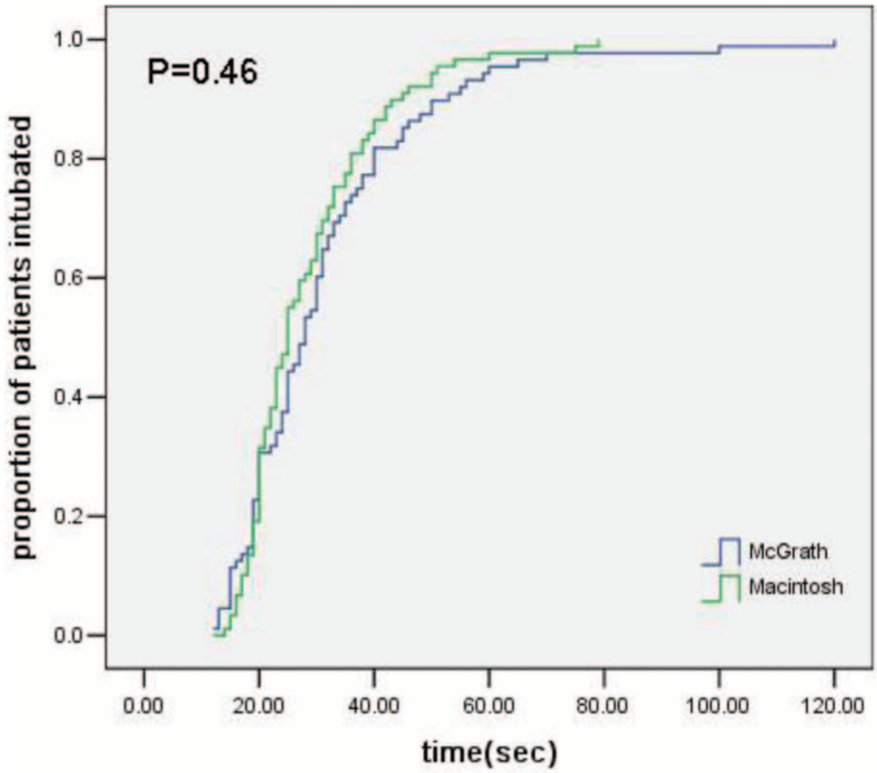

FIGURE 2. Kaplan–Meier plot demonstrating the proportion of patients successfully intubated vs time. The 3 patients (2 in McGrath group and 1 in Macintosh group) who were assigned times of 120 s (see ''Methods'' section) are not included in the figure; therefore, the proportion of patients successfully intubated was 88/90 (98%) in the McGrath group, and 89/90 (99%) in the Macintosh group. Groups were compared using the Mann–Whitney test.

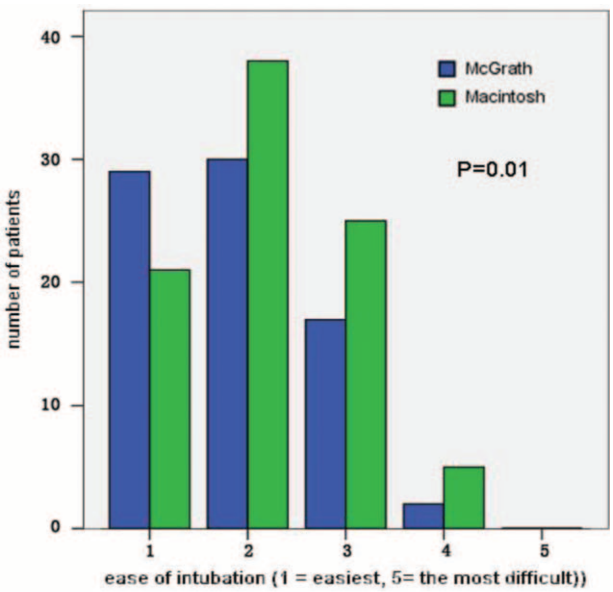

FIGURE 3. Ease of intubation by operators was measured on a 5-point scale, separated by group. The scale of the data collection form was marked ''the easiest'' (1) and ''the most difficult'' (5). Groups were compared using the Mann–Whitney test.

pressure from baseline in both groups. And there was statistically significant difference in the systolic blood pressure changes between the 2 groups ($P < 0.05$; Table 2).

DISCUSSION

Despite numerous studies showed that videolaryngoscopes could provide better views of the glottis when compared with conventional direct laryngoscope,[17,18] this study was the first one that compared the McGrath Series 3 videolaryngoscope and Macintosh laryngoscope in patients with a normal airway undergoing intubation by inexperienced anesthetists. In this study, no difference was demonstrated in the intubation time, the number of intubation attempts and the success rate of intubations between McGrath and Macintosh for inexperienced anesthetists. However, McGrath would provide significantly superior glottis views to Macintosh, improve the ease of intubation, decrease intubation complications, and stabilize the hemodynamics during and short period after intubation.

In our study, the time of routine tracheal intubation in patients with normal airway was similar when using McGrath or Macintosh. The Kaplan–Meier plot cumulating the proportion of patients whose tracheas were intubated successfully as time passed shows overlap at many time points (Figure 2), indicating there is no difference in intubation across different clinical cases encountered in the study. In fact, intubation with McGrath took even longer time than Macintosh in many previous studies, especially in patients with difficult airway.[19,20] In the study of Walker et al,[21] duration of intubation was even 17.5 s longer in the McGrath group than the Macintosh group during routine tracheal intubation.

Intubation time has been defined as a variable until the anesthetist affirms to the passage of tracheal tube through the vocal cords in some previous studies,[22] whereas in our study intubation time was defined from the moment laryngoscope first inserted into patient's mouth to the moment end-tidal carbon dioxide curve was confirmed on monitor. Wherefore, it is the most clinically relevant measure as it reflects the time during that patient is without ventilation; and it can avoid subjectivity as far as possible and allow for situation that the laryngoscopic view is obscured. More importantly, it takes account of any additional steps that are helpful to enable the intubation before effective ventilation established. For instance, the use of a stylet may be required to facilitate the insertion of tracheal tube through vocal cords. Removing the stylet prolongs the time before ventilation of the lungs, but it will have been calculated by the use of this definition.

In this study, McGrath was associated with a greater number of Cormack–Lehane grade-1 views than Macintosh (71 vs 48, Table 2), and the difference was statistically significant. Many previous studies have also demonstrate McGrath using in patients with routine or difficult airway improved glottic views compared with direct laryngoscopy using a Macintosh blade.[12,20] Noppens et al demonstrated that, compared to direct laryngoscopy, McGrath laryngoscopy improved by 2 grades in 80% cases for patients with Cormack–Lehane grade 3 or 4.

Why a better and more adequate laryngeal view does not translate into quicker intubation necessarily? With steeper anterior bend than usual, mounting the tracheal tube onto a stylet and angling the distal tip upwards by 45° to 60° helps to intubate for McGrath.[23] And additional time was taken to remove the stylet before tracheal intubation could be accomplished. But the proportion of stylet using was similar between 2 groups in this study. Furthermore, McGrath blade has a more significant anterior bend and hence requires a modified intubation technique. In this study, most intubations were classified as ''easy''. For cases that were not rated as ''easy'', the main problems included the awkwardness guiding the tracheal tube into position near the larynx, and difficulty inserting the tube even the tip had passed through the vocal cords, in spite of superior laryngeal views. In a recent study, in 40 patients intubated with McGrath, there were 9 occasions when the view was a grade 1, yet there was difficulty for the anesthetists to pass the tracheal tube through the vocal cords.[10] In another article, time to successful intubation with the C-MAC videolaryngoscope (with standard Macintosh blade design) was 17 s shorter when compared with McGrath in patients with potential difficult airways.[24] Finally, hand–eye coordination may be impaired by the indirect view, which is why good view of the glottis on screen does not guarantee easy passage of the trachea tube into the larynx.[20]

In this study, without considering sore throat and hoarseness more associated with tracheal intubation, no airway complication with the McGrath occurred, while there were 2 cases of dental/oral tissue injury in Macintosh group, probably due to inadequate experience in intubation. Currently, few studies describe major intubation complications of McGrath.[12] We can only found 1 case report of palatal perforation with McGrath requiring surgical repair, because the operator distracted attention to screen when introducing the tracheal tube rather than looking directly into the mouth.[25]

Additionally, we also found that hemodynamic change for intubation was slighter in the McGrath group. The lifting power to expose glottis can be significantly decreased when using McGrath, to minimize potential injury and stimulation caused by laryngoscope and to stabilize hemodynamics, especially for inexperienced anesthetists. Although the stress reaction of circulation system only lasts minutes, it could have potential lethal risk for patients with cardio-cerebral vessel lesions. So far, no research has discussed the clinical consequence of difference in hemodynamic change between the 2 laryngoscopes.

There are a few limitations of this study. Firstly, as with all studies of this kind, the study was impossible to blind, as we could not conceal which laryngoscope was being used from the anesthetist performing intubation, nor from the independent observer who was measuring the intubation times. However, all personnel in this study were blinded until the last possible moment in order to minimize any systematic bias. In addition, we monitored and recorded the noninvasive blood pressure just after intubation and 3 min after intubation. The arterial blood pressure will be more detailed and accurate to investigate hemodynamic change, and longer recording time is preferable (eg, from intubation till 10 min). Lastly, since this trial was conducted in patients with normal-appearing airways, the results may not be applicable to patients with difficult airways.

To conclude, the McGrath videolaryngoscope does not allow a faster intubation time or fewer intubation attempts compared with the Macintosh laryngoscope when used by inexperienced anesthetists to perform orotracheal intubation in patients with normal airway. However, McGrath achieves significantly more grade-1 laryngoscopic views, improves the ease of intubation, and decreases complications and hemodynamic fluctuations caused by tracheal intubation. We cannot support one laryngoscope over another. Nevertheless, McGrath is easy to learn, making tracheal intubation safer and more effortless in patients with normal airway, and can improve self-confidence for inexperienced anesthetists. It is potentially a favorable device to use among the beginners.

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