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Original Contribution

Evaluation of gum-elastic bougie combined with direct and indirect laryngoscopes in vomitus setting: A randomized simulation trial

Fumihiro Ohchi, Nobuyasu Komasawa *, Ryosuke Mihara, Kazuo Hattori, Toshiaki Minami

Department of Anesthesiology, Osaka Medical College, Japan

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ABSTRACT

Purpose: Videolaryngoscopes may not be useful in the presence of vomitus due to blurred images on the monitor. The objective of our study is to compare the utility of gum-elastic bougie (GEB) application for tracheal intubation with the Macintosh laryngoscope (McL), which is a direct laryngoscope, with that of the Pentax-AWS Airwayscope® (AWS) and McGRATH® MAC (McGRATH) in simulated vomitus settings.
Methods: Sixteen novice doctors performed tracheal intubation on an adult manikin using McL, AWS, and McGRATH with or without GEB under normal and vomitus simulations.
Results: In the normal setting the tracheal intubation was successful with the three laryngoscopes regardless of GEB application. In the vomitus setting, the intubation success rate did not significantly improve using McL, while it did using McGRATH or AWS. In the normal settings, GEB application significantly lengthened the intubation time in all three laryngoscopes. By contrast, in the vomitus settings, GEB application significantly shortened the intubation time in all three laryngoscopes. For the comparison of three laryngoscopes, the intubation time did not differ significantly in normal setting, while it was significantly longer in McG and AWS trials than McL trial.
Conclusion: The GEB application facilitates the tracheal intubation in the vomitus setting using McGRATH and AWS in adult simulation.

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1. Introduction

The Pentax Airwayscope® (AWS; Hoya, Tokyo, Japan) is a videolaryngoscope reported to provide an indirect view of the airway [1,2]. Studies indicate that AWS is useful not only for difficult airway management but also for emergent tracheal intubation during resuscitation by simulation analysis [3,4]. The McGRATH® MAC (McGRATH; Aircraft Medical Ltd., Edinburgh, UK) is a device that has been developed with a high-resolution video camera, providing direct and indirect views of the glottis and reportedly useful for intubating several difficult airways [5,6]. While AWS and McGRATH are both considered convenient tools for difficult or emergent airway management, we have previously reported that their utility is inhibited in the presence of vomitus in the pharynx [7].

The gum-elastic bougie (GEB), a tracheal tube introducer, is commonly used in airway management and its use is recommended by various guidelines at early stages of difficult intubation [8]. Several studies have been published regarding its utility in the context of difficult adult airway management, particularly for addressing difficult laryngoscopy situations. Furthermore, evaluations of GEB application during chest compressions have been reported [9,10].

Application of GEB for tracheal intubation with direct (McL) and indirect laryngoscopes (AWS and McGRATH) for tracheal intubation in the vomitus setting has not yet been validated; therefore, we decided to compare the utility of GEB application for tracheal intubation with McL, AWS, and McGRATH in vomitus settings. Because direct clinical evaluation is unethical, we hypothesized that GEB application may facilitate the tracheal intubation with the three laryngoscopes in vomitus settings using an adult manikin with vomitus simulations.

2. Methods

From April to July 2016, 16 novice doctors performed trials after completing one month of anesthesia training. Written informed consent was obtained before the study. This study was approved by the Osaka Medical College Research Ethics Committee (Approval number 1321).

The Airway Trainer® (Laerdal, Stavanger, Norway), designed to accurately represent an adult male, was used for the study simulations and intubations. We used a 15Fr gum-elastic bougie (Tracheal tube introducer™, Portex, St. Paul, MN, USA) in this study. Tracheal tubes (Portex, St. Paul, MN, USA) with an internal diameter of 7.5 mm were used [11].

* Corresponding author at: Department of Anesthesiology, Osaka Medical College, Daigaku-machi 2-7, Takatsuki, Osaka 569-8686, Japan.
E-mail address: ane078@osaka-med.ac.jp (N. Komasawa).

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Simulated stomach contents (vomitus; Simulated stomach contents®, Laerdal, Norway) were added to the pharynx of the manikin. The contents were prepared by dissolving 10 g of powder in 200 mL of water according to the manufacturer's instructions and were poured into the pharynx to the level of covering the epiglottis to simulate vomitus or hematemesis [7]. The lower esophagus was clamped with forceps to keep these liquids in the pharynx. We also clamped the both bronchus instead of the trachea because clamping the trachea impedes smooth tracheal intubation.

The manikin was placed on a hard, flat table for "on the resuscitation bed" simulation. Each participant was instructed to insert the tracheal tube with the three laryngoscopes (McL, AWS, McGRATH), attach a bag valve mask, and attempt to ventilate the lungs of the manikin. In McL and McGRATH trials, participants used size 4 blade. In AWS trial, standard Intlock® (ITL-SL, HOYA, Japan) was used. Participants were given 10 min to practice intubation, with the instructor available for advice. The appropriate equipment for each trial was placed in a box next to the manikin's head. Intubation started when the participant picked up McL, AWS, or McGRATH and ended at the point of manual ventilation after tube insertion [12]. The number of intubation sessions was recorded for both tracheal and esophageal intubations. At the end of the study, participants rated the difficulty of using each device using a visual analog scale (VAS) from 0 mm (extremely easy) to 100 mm (extremely difficult) [13].

Statistical analysis was performed utilizing JMP® 11 (SAS Institute Inc., Cary, NC, USA). Results obtained from each trial were compared using one-way repeated measures analysis of variance for intubation time and VAS and Fisher's exact test for the success rate. Data are presented as means ± standard deviations (SDs). A P-value of <0.05 was considered statistically significant.

The study was designed as a randomized crossover trial to minimize the order effect. In each McL, AWS, and McGRATH trial, participants performed tracheal intubation in both simulations (normal and vomitus). The order of intervention was randomized for each participant using the random number table, resulting in a total of six interventions per participant.

The sample size was calculated on the basis of our preliminary study on the time required for intubation with McL and McGRATH in the vomitus setting in eight participants. The mean (SD) time was 13.3 ± 3.2 s for McL and 6.9 ± 2.5 s for McGRATH. We considered that 5 s is a significant difference. Using an alpha error of 0.05 and a beta error of 0.2, we estimated that 14 participants would be adequate for each group. Therefore, we planned to recruit 16 participants for each group to adjust for missing data.

3. Results

The number of times the participants had worked before participating in the trial with McL, AWS, and McGRATH were 24.1 ± 5.8 s, 3.7 ± 1.6 s, and 2.4 ± 1.2 s, respectively.

3.1. Intubation success with or without GEB using McL, AWS, and McGRATH

The number of successful tracheal intubations for each device is displayed in Table 1. In the normal setting the tracheal intubation was successful with the three laryngoscopes regardless of GEB application (Table 1a). In the vomitus setting, the intubation success rate did not significantly improve using McL, while it did using McGRATH or AWS (Table 1b).

3.2. Intubation time with or without GEB using McL, AWS, and McGRATH

The intubation time in each setting is shown in Fig. 1. In the normal setting, GEB application significantly lengthened the intubation time in all three laryngoscope trials. In contrast, the GEB application significantly shortened the intubation time in all three laryngoscopes.

Table 1
Tracheal intubation success rates for McL, AWS, and McGRATH in normal (a) and vomitus (b) settings. Numerator: number of participants who were successfully intubated. Denominator: number of participants for whom tracheal intubation was attempted. *P < 0.05 compared to without GEB, #P < 0.05 compared to McGRATH and McL.

	Without GEB (successful/total)	With GEB (successful/total)	P-value
(a)			
McL	16/16	16/16	1.00
AWS	16/16	16/16	1.00
McGRATH	16/16	16/16	1.00
(b)			
McL	12/16	16/16	0.101
AWS	8/16	15/16	0.016*
McGRATH	11/16	16/16	0.043*

AWS, Pentax-AWS Airwayscope®; McGRATH, McGRATH® MAC; McL, Macintosh laryngoscope.

For the comparison among the three laryngoscopes, the intubation time did not differ significantly in normal setting, while it was significantly longer in McG and AWS trials than McL trial.

3.3. VAS scores for difficulty of tracheal intubation with McL, AWS, and McGRATH

As shown in Fig. 2, the subjective difficulty of laryngoscopy tracheal intubation did not differ regardless of GEB application in the normal setting, while it was significantly lowered by GEB application using all three laryngoscopes in the vomitus setting.

In the vomitus setting, the VAS without GEB was significantly higher in the AWS trial than in the McL and McGRATH trials.

4. Discussion

Airway management is considered an essential element, particularly for in-hospital CPR. While conventional direct-view laryngoscopes such as McL are the most widely used for tracheal intubation, it is difficult to master the skills required for use, and the incidence of inaccurate intubation can be unacceptably high for occasional operators [14,15]. A major problem encountered during airway management is vomitus or blood in the pharynx and neck fixation with the cervical collar. A large number of patients exhibit vomiting or hematemesis during sudden cardiac arrest, leading to difficulty in tracheal intubation during resuscitation [16].

Increasing evidence indicates that videolaryngscope is suitable for tracheal intubation during various difficult airway management and emergency situations [17,18]. However, one clinical study showed that AWS did not show superiority to McL in prehospital settings, as opposed to simulated in-hospital situations [19]. We speculate that vomitus or hematemesis may have contributed to the lower success rate of AWS in the prehospital situations. We previously showed the inferiority of AWS to McL in the vomitus setting.

The GEB is a commonly used airway adjunct in intubation and recommended by several guidelines for use at an early stage in cases of difficult tracheal intubation. Evidence from adult patients suggests that doctors can secure the airway with a high success rate when using the GEB [10,20]. In the previous study, we found that intubation time was significantly longer with chest compressions, regardless of GEB use, although the intubation success rate was significantly higher with the GEB. The subjective difficulty for tube passage through the glottis was also lower with the GEB than without during chest compressions.

The present study found that the intubation time with AWS was significantly shortened by GEB application than in the vomitus setting, accompanied by a significant intubation success rate difference. Furthermore, the intubation time was significantly shortened by

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