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Supraglottic airway device versus a channeled or non-channeled blade-type videolaryngoscope for accidental extubation in the prone position

A randomized crossover manikin study

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Abstract

Background: It is very rare but challenging to perform emergency airway management for accidental extubation in a patient whose head and neck are fixed in the prone position when urgently turning the patient to the supine position would be unsafe. The authors hypothesized that tracheal intubation with a videolaryngoscope would allow effective airway rescue in this situation compared with a supraglottic airway device and designed a randomized crossover manikin study to test this hypothesis.

Methods: The authors compared airway rescue performances of the 3 devices—the ProSeal laryngeal mask airway (PLMA; Teleflex Medical, Westmeath, Ireland) as a reference; the Pentax AWS (AWS; Nihon Kohden, Tokyo, Japan) as a channeled blade-type videolaryngoscope; and the McGRATH videolaryngoscope (McGRATH; Medtronic, Minneapolis, MN) as a nonchanneled blade type in a manikin fixed to the operating table in the prone position. Twenty-one anesthesiologists performed airway management on the prone manikin with the 3 devices, and the time required for intubation/ventilation and the success rates were recorded.

Results: The median (range) intubation/ventilation times with the PLMA, AWS, and McGRATH were 24.5 (13.5–89.5) s, 29.9 (17.1–79.8) s, and 46.7 (21.9–211.7) s, respectively. There was no significant difference in intubation/ventilation times between the PLMA and AWS. The AWS permitted significantly faster tracheal intubation than did the McGRATH ($P = 0.006$). The success rates with the PLMA (100%) and AWS (100%) were significantly greater than that with the McGRATH (71.4%). Airway management performance of the PLMA and AWS was comparable between devices and better than that of the McGRATH in the prone position.

Conclusions: Considering that tracheal intubation can provide a more secure airway and more stable ventilation than the PLMA, re-intubation with a channeled blade-type videolaryngoscope such as the AWS may be a useful method of airway rescue for accidental extubation in patients in the prone position.

Abbreviations: AWS = Pentax AWS, McGRATH = McGRATH videolaryngoscope, PLMA = ProSeal laryngeal mask airway.

Keywords: accidental extubation, prone position, supraglottic airway device, videolaryngoscope

1. Introduction

Prone positioning of the patient is standard practice in neurosurgical operations on the cervical spine and posterior fossa lesions. Accidental extubation of a patient with the head and neck fixed in the prone position would be extremely rare, but can lead to a life-threatening anaesthesia-related complication. We identified 6 case reports and a review addressing this issue,[1–7] which confirm that this event is extremely rare, but, nevertheless, can be of great concern to anesthesiologists. To the best of our knowledge, the incidence of this life-threatening anesthesia-associated event remains unclear; however, there is little doubt of its occurrence in clinical settings. When such an event occurs, urgently turning the patient to the supine position would be required for re-intubation. However, when intracranial or cervical spine surgery is in progress, turning a patient may compromise the sterility of the surgical field and the stability of the cervical spine potentially leading to spinal cord injury. Moreover, turning and managing the patient would result in a substantial amount of time without a secured airway and ventilation, potentially leading to hypoxic damage in the patient. We consider it important to urgently secure the airway to protect the patient against hypoxia without turning the patient supine in such a situation.

Previous reports have shown the efficacy of supraglottic airway devices (SGAs) for emergency airway management of accidental extubation in the prone position.[1–5] In these reports, emergency airway management was performed with SGAs without

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interfering with the surgery while the patient was kept in the prone position. In contrast to the previous reports using SGAs, Hung et al[6] performed re-intubation with fiberoptic bronchoscopy as emergency airway management in a similar situation. Thiel et al[7] reported that turning the patient supine was required to re-intubate after accidental extubation occurred in the prone position because the patient experienced a serious difficult airway situation at induction of anesthesia. These reports suggest that the methods of emergency airway management for accidental extubation in the prone position were not uniform. SGAs may be a reasonable choice as a rescue device and will be life-saving in establishing oxygenation and ventilation in this condition.[1–5] In the Practice Guidelines for Management of the Difficult Airway of the American Society of Anesthesiologists, when facemask ventilation is not adequate after an initial failed tracheal intubation, the use of a SGA is recommended.[8] However, evidence is currently lacking regarding the use of SGAs for the emergency airway management of accidental extubation in the prone position.[5] Airway assistance with a SGA without tracheal re-intubation may not be safe enough to allow resumption of surgery lasting for a long period in the prone position.

Until videolaryngoscopes became available in clinical practice, intubation with an intubating laryngeal mask and/or fiberoptic bronchoscope was commonly used for difficult airway management.[9–11] However, it has been shown that tracheal intubation via fiberoptic guidance is generally more time-consuming than that via videolaryngoscopes.[12–14] Furthermore, videolaryngoscopes were reported to have more advantage in difficult airway management than conventional techniques in manikin and clinical studies. [12–15] Although there have been no case reports regarding emergency airway rescue with videolaryngoscopes for accidental extubation in the prone position, we hypothesized that tracheal intubation with a videolaryngoscope would allow effective airway rescue in this situation. Therefore, in the present study, we compared airway rescue performances of the 2 types of videolaryngoscopes—the channeled and the nonchanneled types, with that of SGAs in a prone manikin simulating accidental extubation in the prone position of a patient with a fixed flexed neck during neurosurgical procedures performed on the cervical spine and posterior fossa lesions.

2. Materials and methods

The study and protocol were approved by the Teikyo University Research Committee (Tokyo, Japan; Teirin 17-048). The study protocol was also registered in the UMIN clinical trial registry (registry number: UMIN000028481). After written informed consent was obtained from all study participants, the authors recruited 21 anesthesiologists with more than 5 years of clinical experience at random from the list of staff members at our institution. The anesthesiologists participated entirely voluntarily, could choose not to participate, could withdraw at any time, and could not be identified from the data collected.

2.1. Study protocol

To reproduce the prone position with a fixed flexed neck in a manikin, the head of an intubation manikin (Airway Trainer, Laerdal Medical, Stavanger, Norway) was fixed to a flat board with nonelastic tape similar to that described in a previous publication.[12] Then, the manikin was fixed tightly to the operating table in the prone position with nonelastic tape to produce a simulation model of neurosurgical operations (Fig. 1). Use of SGAs and tracheal intubation requires different algorithms in airway management. However, the goal of both techniques is the same—to maintain ventilation. Therefore, in this study, we chose airway management performance using the ProSeal laryngeal mask airway (PLMA; Teleflex Medical, Westmeath, Ireland) as the reference of a SGA for airway rescue in the prone position and compared this with the tracheal intubation performance provided by the Pentax AWS (AWS; Nihon Kohden, Tokyo, Japan) as a channeled blade type and the McGRATH videolaryngoscope (McGRATH; Medtronic, Minneapolis, MN) as a nonchanneled blade type in this prone manikin. All study participants had previously used these devices more than 10 times in their clinical practice. They were visually instructed once on how to use them in the prone position before participating in the study. Participants performed airway rescue in the prone manikin from underneath with each device in a random order using random numbers computer-generated by one of the authors (KY). For airway rescue with the PLMA, the device was already attached to the dedicated introducer before the study. For AWS-aided intubation, the device was already preloaded with a cuffed 8.0-mm tracheal tube before the study. For McGRATH-aided intubation, a cuffed 8.0-mm tracheal tube with a stylet was prepared before the study. A Mallinckrodt Oral/Nasal tracheal tube with TaperGuard Cuff 8.0-mm was used in this study.

2.2. Data collection

We recorded the time to established intubation/ventilation, the success rates, and the number of esophageal intubations with the 2 videolaryngoscopes. Intubation/ventilation time was defined as the time from when the operator took hold of the assigned airway device until the lungs of the manikin were inflated after connecting the tracheal tube to a self-inflating bag. Failed intubation/ventilation was defined as an intubation/ventilation time >90 s or esophageal intubation. At the end of each sequence, we asked each participant to rate the degree of difficulty using a 5-point Likert scale for each device, which we defined in this study as the Grading Scale of Difficulty: very easy, easy, moderate, difficult, and very difficult.[12,16] The primary outcome measure was the comparison of the ventilation time using the PLMA with the intubation times using the 2 videolaryngoscopes. The intubation/ventilation times >90 seconds were included in the

Figure 1. Reproduction of the simulation model during neurosurgery with the manikin (Airway Trainer, Laerdal Medical, Stavanger, Norway) in the prone position by fixing the head in a neutral position and then tightly fixing the manikin on the table in the prone position using non-elastic tape.

comparison. Secondary outcome measures included the success rates and the Grading Scale of Difficulty scores; and the number of esophageal intubations with the 2 videolaryngoscopes. The study was conducted and the data were collected in the operating room at our institution from July 21 to September 30, 2017.

2.3. Statistical analysis

After collecting all data on intubation/ventilation times and the Grading Scale of Difficulty scores, the distribution of these data was evaluated with the Shapiro–Wilk test, which indicated that all of the data showed non-normal distribution. Therefore, the Kruskal–Wallis test followed by the Mann–Whitney *U* test with Bonferroni correction as post hoc tests was used for the comparison of intubation/ventilation times and the Grading Scale of Difficulty scores between the 3 groups. The success rates and the incidence of esophageal intubation between groups were compared by chi-square tests. Two-tailed tests were used in all comparisons. A value of $P<.05$ was considered statistically significant in the Kruskal–Wallis test and chi-square tests. In the post hoc tests requiring Bonferroni correction, a value of $P<.0167$ (0.05/3) was considered statistically significant for comparisons between 3 sets of paired data. The data for intubation/ventilation times and the Grading Scale of Difficulty scores are expressed as median (interquartile range [range]). Statistical analyses were performed with SPSS 11.0J for Windows (SPSS Inc., Chicago, IL).

Sample size was calculated based on our pilot study of measurements of intubation/ventilation time. In this pilot study, normal distribution of the data for intubation/ventilation time was confirmed by the Shapiro–Wilk test. Because a previous study[12] showed that tracheal intubation using AWS was significantly faster by approximately 15 seconds than those using other airway devices in a simulated difficult intubation, we assumed that a 15-second difference in intubation/ventilation time was significant in this study. Based on an expected maximum SD of 14 seconds for intubation/ventilation time in the pilot study, a sample size of 19 in each group would have 80% power to detect a 15-second difference in intubation/ventilation times between the 3 groups, assuming a 0.017 (0.05/3) α level of significance. To ensure a safety margin, 21 participants were recruited in this study.

3. Results

The 21 anesthesiologists recruited successfully completed this study (Fig. 2). Fig. 3 shows a comparison of intubation/ventilation times for each of the airway devices. We found 1 case of esophageal intubation in the McGRATH group, resulting in 20 data points for intubation time in this group. The Kruskal–Wallis test revealed that intubation/ventilation time was significantly affected by the airway device ($P=.001$). Ventilation time with the PLMA (24.5 [19.3–31.6 (13.5–89.5)] seconds) was significantly shorter than the intubation time with the McGRATH (46.7 [40.7–85.5 {21.9–211.7}] seconds) ($P=.001$). Also, intubation time with the AWS (29.9 [24.9–40.1 {17.1–79.8}] seconds) was significantly shorter than that with the McGRATH (46.7 [40.7–85.5 {21.9–211.7}] seconds) ($P=.006$). Interestingly, there was no significant difference in intubation/ventilation time between the PLMA group and the AWS group.

Intubation/ventilation was felt to be easier with the PLMA than with the McGRATH ($P<.001$). However, there was no significant difference in the Grading Scale of Difficulty scores between the AWS and PLMA or McGRATH (Table 1). The success rates and number of esophageal intubations are shown in Table 2. The success rate was significantly greater with the PLMA (100%) and the AWS (100%) than with the McGRATH (71.4%) ($P<.001$). No esophageal intubations occurred with the AWS. In contrast, one esophageal intubation was found with the McGRATH ($P<.001$).

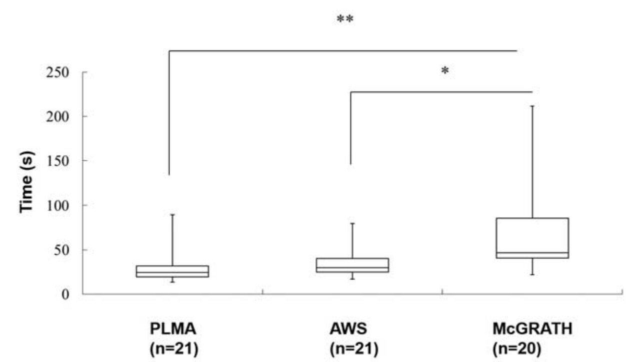

Figure 3. Comparison of time to successful intubation/ventilation using the ProSeal laryngeal mask airway (PLMA; Teleflex Medical, Westmeath, Ireland), Pentax AWS (AWS; Nihon Kohden, Tokyo, Japan), and McGRATH video laryngoscope (McGRATH; Medtronic, Minneapolis, MN). The horizontal bars, boxes, and whiskers represent the median, interquartile range, and ranges, respectively. One incidence of esophageal intubation occurred in the McGRATH group. Therefore, the total number of data points for intubation time was 20 in the McGRATH group. $^{*}P=.006$ and $^{**}P=.001$. $P<.05/3=.0167$ was considered statistically significant.

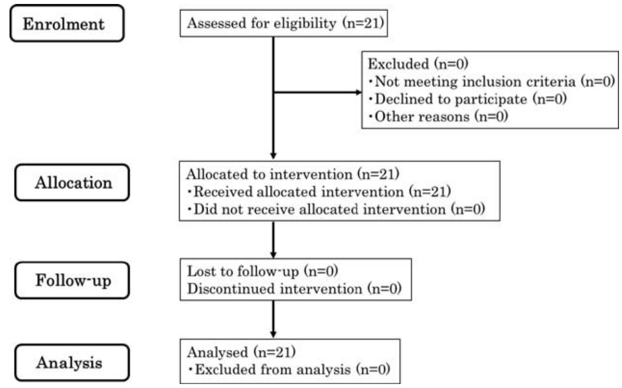

Figure 2. Flow diagram of the participants included in this study.

4. Discussion

In this study, the airway management performances of the PLMA and AWS were comparable to each other and better than that of the McGRATH in the prone manikin simulating accidental

Table 1

Grading scale of difficulty scores for the 3 devices.

PLMA (n=21)	AWS (n=21)	McGRATH (n=21)	P
2 (1–2 [1–3])	2 (2–3 [1–4])	3 (2–4 [1–5])*	.001

Difficulty scores: 1, very easy; 2, easy; 3, moderate; 4, difficult; and 5, very difficult. Devices: PLMA, ProSeal LMA; AWS, Pentax AWS; McGRATH, McGRATH videolaryngoscope.

Values are expressed as median (interquartile range [range]). *P* value shows the result of a Kruskal–Wallis test between the 3 groups. $P<.05$ is considered statistically significant.

AWS, Pentax AWS; McGRATH, McGRATH videolaryngoscope; PLMA, ProSeal laryngeal mask airway.

$^{*}P<.001$ in comparison with PLMA. $P<.05/3=.0167$ is considered statistically significant.

Table 2

Success rate and incidence of esophageal intubation.

	PLMA (n=21)	AWS (n=21)	McGRATH (n=21)
Overall success	21 (100%) [86.7%–100%]	21 (100%) [86.7%–100%]	15 (71.4%)*,† [47.8%–88.7%]
Esophageal intubation	—	0 (0%)	1 (4.8%)#

AWS, Pentax AWS; McGRATH, McGRATH video laryngoscope; PLMA, ProSeal LMA.
Values are number (proportion) with [95% confidence interval].
* $P<.001$ in comparison with PLMA.
† $P<.001$ in comparison with AWS, respectively.
# $<.001$ in comparison with AWS.
$P<.05/3=.0167$ is considered statistically significant for overall success. $P<.05$ is considered statistically significant for the incidence of oesophageal intubation.

extubation in the prone position of a patient with a fixed flexed neck during neurosurgical operations on the cervical spine and posterior fossa lesions.

Figure 4 shows a patient with the head fixed with a 3-point cranial fixation device with pins in the prone position. If accidental extubation occurs in such a patient, airway rescue is extremely difficult without releasing the 3-point cranial fixation device (Fig. 4a) from the patient's head or disconnecting the fixation device (Fig. 4a) from the support device (Fig. 4b), because these devices hinder airway management from underneath. Our personal discussion with neurosurgeons revealed that they would require re-intubation of the patient after the immediate disconnection of the 3-point cranial fixation device from the support device while holding the patient's head over the drape from backward with an in-line stabilization maneuver. This procedure would not take as long a time to accomplish as would urgently turning the patient supine to re-intubate the trachea. Furthermore, it would not compromise the stability of the cervical spine or the sterility of the surgical field.

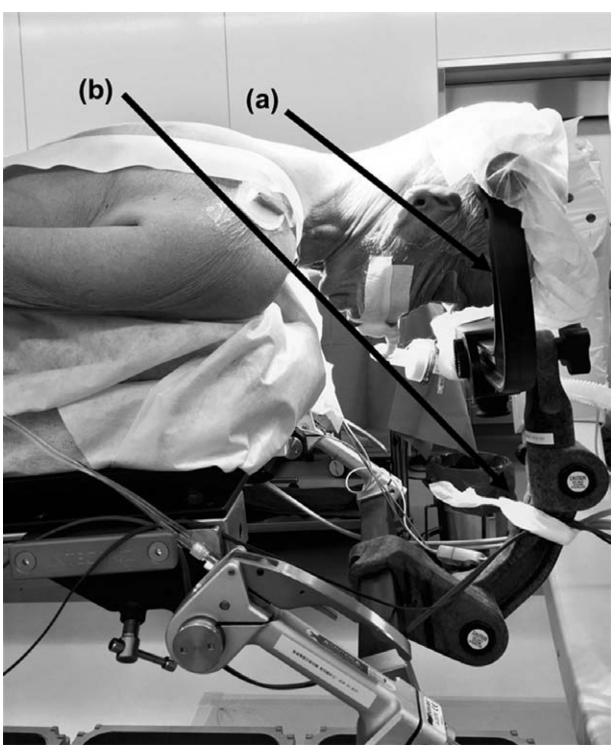

Figure 4. A patient in the prone position with head fixed with a 3-point cranial fixation device with pins. The cranial stabilization system consists mainly of 2 parts: a 3-point cranial fixation device (a) and a support device that facilitates attachment of skull clamps to the operating table (b).

Airway rescue with SGAs is probably the most commonly used technique for accidental extubation in the prone position.[1–5] Furthermore, the literature suggests that turning a patient supine may not be necessary as a first-line response in such cases.[1–7,17] We identified only 1 crossover manikin study that compared airway rescue performances using the various SGAs in the prone position.[18] There are only a few case reports of airway rescue with tracheal intubation in this situation.[6,7] However, no randomized control trials have investigated the efficacy of airway rescue with tracheal intubation in the prone position. Hence, we conducted the present randomized study comparing the airway rescue performances of different strategies using a manikin to simulate accidental extubation in the prone position during neurosurgical operations.

We used ventilation with the PLMA as the reference of a SGA in the prone position in this study, because it allows a more effective seal and higher airway pressure ventilation than the classic LMA and i-gel, and it facilitates gastric tube placement,[19–21] suggesting that the PLMA provides more stable ventilation. Videolaryngoscopes can be divided into 2 groups according to the type of blade: channeled blade type and nonchanneled blade type. The AWS as a channeled blade type and the McGRATH as a nonchanneled blade type were used in this study. Each participant had considerable previous experience with the 2 scopes (more than 10 times) in clinical practice. Furthermore, all the study participants have had sufficient previous experience with the PLMA. Thus, these 3 devices were used in this study.

The intubation times for the AWS in the prone position in a manikin shown by Komasawa et al[22] were comparable to our data, suggesting that they are reasonable. When considering the reason why SGAs may be most commonly used for rescue in such situations,[1–5] we assumed that most of the anesthesiologists recognized that SGA insertion was relatively easy compared with tracheal intubation with videolaryngoscopes. However, the time taken for tracheal intubation using the AWS was equivalent to that for securing the airway using the PLMA in the prone position, the success rate was 100% for both techniques, and the Grading Scale of Difficulty score were comparable between the 2 techniques in this study. These results suggest that airway rescue with tracheal intubation using a channeled blade type videolaryngoscope such as the AWS may be superior to securing the airway with a SGA in this situation because tracheal intubation provides a more secure airway and more stable ventilation compared with a SGA. Ventilation was reported to be maintained successfully in 83.3% to 100% of the patients with SGAs in the prone position, suggesting that SGAs may not provide successful ventilation in all patients in the prone position.[5]

The AWS with its channeled blade enabled the study participants to intubate faster than did the McGRATH with its nonchanneled blade in the prone position. It has been shown that the intubation performance of experienced personnel in a simulated difficult airway in the supine position did not differ between nonchanneled and channeled blades of videolaryngoscopes.[23] However, for inexperienced personnel, a channeled blade-type videolaryngoscope resulted in better intubation performance than did the nonchanneled blade type.[16,24,25] None of the participants recruited in this study had previous experience with tracheal intubation in the prone position and, therefore, were inexperienced with this situation. In the prone position, intubation with the nonchanneled blade-type videolaryngoscope may require more skill to adapt to the altered orientation, although the operator can introduce a tracheal tube into the trachea easily by simply advancing it with the channeled blade of the AWS.

A success rate of at least 90% would be required for the airway devices on the first attempt at tracheal intubation in simulated difficult airways.[23] Therefore, our result indicates that the McGRATH (success rate, 71.4%) would not be a good choice for tracheal re-intubation compared with the AWS (success rate, 100%) in the prone position. Furthermore, the study participants felt that tracheal intubation with the AWS was easier than with the McGRATH in this situation. This result also lends further support to the superiority of a channeled blade-type videolaryngoscope such as the AWS in this situation.

There are several limitations in this study. First, we acknowledge that a study of this type can never be conducted with human subjects for ethical reasons and patient safety; nevertheless, the use of manikins for simulation remains problematic.[26] Consequently, we could not investigate the actual condition in a patient's upper airway, such as how tongue edema, secretions, or protruding teeth would affect intubation performance in the prone position. Thus, further simulation studies could be considered under various conditions of upper airway using SimMan (Laerdal Medical, Stavanger, Norway) which can reproduce tongue edema, cervical spine rigidity, pharyngeal obstruction, or jaw trismus.[15] Second, the airway management performance of only 3 devices was analyzed in this study, but there are many other airway devices including other SGAs and other videolaryngoscopes of both blade types. Thus, our results may be biased. Further studies are warranted to evaluate other intubation devices for airway rescue in the prone position. Third, we did not record the time required to prepare the airway devices and a tracheal tube before attempting each airway management, although the preparation time of these devices is an absolute factor affecting overall intubation/ventilation time. From our results, it could be recommended to have a channeled blade-type videolaryngoscope such as the AWS with an appropriate tracheal tube ready for use in the operating room during this type of surgery. Furthermore, it could also be worthy of consideration to practice emergency airway rescue with tracheal intubation in a manikin in this situation using a videolaryngoscope that each anesthesiologist is familiar with.

5. Conclusions

In conclusion, tracheal re-intubation using a channeled blade-type videolaryngoscope such as the AWS may be useful for accidental extubation in a patient in the prone position with the head and neck fixed during neurosurgical operations, when urgently turning the patient to the supine position would be unsafe.

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