Usefulness of Tulip Airway in Edentulous Elderly Patients

Yasuhiko Imashuku, MD, PhD; Hirotoshi Kitagawa, MD, PhD; and Takayoshi Mizuno, MD
Department of Anaesthesiology, Shiga University of Medical Science, Shiga, Japan

Objective: Mask ventilation can be difficult in elderly edentulous patients. Various solutions have been proposed to address this challenge. This study assessed the use of a new airway-securing device called the Tulip Airway and investigated its application in simulated edentulous patients.
Methods: This pilot study utilized a modified edentulous airway training mannequin and a high-performance simulator. Participants attempted to ventilate the edentulous mannequin using a Guedel oropharyngeal airway and face mask (M method) or the Tulip Airway (T method). Successful inflation of the mannequin model lung was confirmed visually. The time required for the insertion of the Tulip Airway was also assessed. A high-performance simulator was then used to compare ventilation volumes achieved using the M and T methods, and data subsequently analyzed.
Results: In the edentulous mannequin, lung inflation was not achieved by any participants using the M method, but all were successful using the T method. Insertion time for the Tulip Airway was ~8 seconds. Median ventilation volumes achieved using the high-performance simulator were higher for the T method (308 mL) compared with the M method (192 mL; $P < .05$).
Conclusion: The results of this pilot study indicate that the Tulip Airway is an effective airway device for use in edentulous patients with difficult mask ventilation.

Key Words: Edentulous patient; Difficult mask ventilation; Tulip Airway; Laryngeal mask airway; Airway simulator.

Mask ventilation is a common challenge in edentulous elderly patients due to the insufficient mask seal that often occurs following denture removal.[1,2] Many anesthesiologists likely have had the experience of rushing to intubate a patient because of inadequate mask ventilation even after proper placement of an oral pharyngeal airway. With elderly patients, a protracted induction period is often beneficial to ensure adequate anesthetic depth before intubation to avoid extreme swings in blood pressure and heart rate. A gradual induction of general anesthesia can also help prevent excessive hypotension. These considerations are especially important in elderly patients with significant cardiac comorbidities. Maintaining a stable patient airway is critical to slow and safe induction, and the same is true for the anesthetic management of edentulous elderly patients.

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Address correspondence to Yasuhiko Imashuku, Department of Anesthesiology, Shiga University of Medical Science, Seta Tsukinowa-cho, Otsu, Shiga, Japan; imashuku@belle.shiga-med.ac.jp.

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One potential solution is the Tulip Airway (Age of Aquarius), which essentially combines a Guedel oropharyngeal airway with a high-volume inflatable cuff capable of sealing the oropharynx (Figure 1). The Tulip Airway is a new airway-establishing device developed in the United Kingdom in 2009 that can be connected to an anesthesia circuit or manual resuscitator bag via a 15-mm connector (Figure 2) to facilitate positive pressure ventilation. Currently it is available for clinical use only in the United Kingdom and in Japan since 2018.

The Tulip Airway is available in 6 sizes depending on the patient's estimated pharyngeal space. Importantly, this novel device is easy to use and is inserted similarly to a traditional oropharyngeal airway. The purpose of this pilot study was to assess the use of the Tulip Airway as a practical alternative means of mask ventilation for edentulous patients using a modified airway mannequin and high-performance simulator.

METHODS

Permission to conduct this study without a review was obtained from the Ethical Review Office of the Shiga University of Medical Science. To simulate an edentulous patient, a standard airway training mannequin

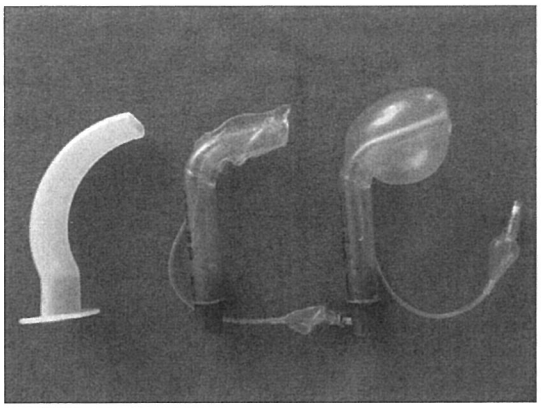

Figure 1. Guedel oropharyngeal airway and the Tulip Airway. The Tulip Airway is similar in shape to the Guedel oropharyngeal airway.

(MW13, Kyoto Kagaku) was modified by unscrewing and removing the dental arches from the mannequin and forming artificial sagging skin (Figure 3).

Seven anesthesiologists (average experience of 7.4 ± 5.1 years) were recruited from Shiga University of Medical Science Hospital and consented to participate after being briefed about the study. None of the participants had used the Tulip Airway before, so a demonstration of its use was provided. Participants were tasked with delivering positive pressure ventilation to the modified mannequin using either a face mask and an oropharyngeal airway (M method) or the Tulip Airway (T method). Inflation of the mannequin's lung was visually confirmed to determine ventilation success with both the M and T methods, respectively. In addition, the time required for insertion of the Tulip Airway (from the start of insertion to the start of ventilation) was measured to assess difficulty of insertion. To inflate the

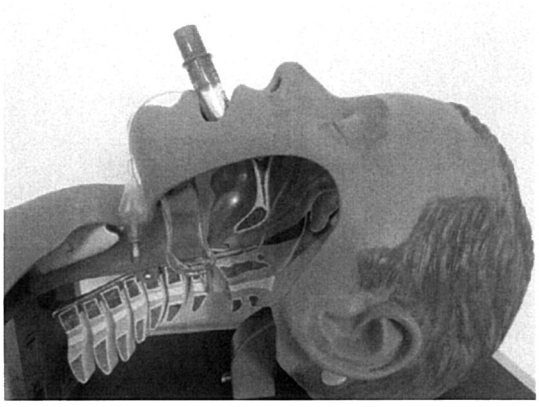

Figure 2. The Tulip Airway inserted in a mannequin. The Tulip Airway has a high volume (50 mL) inflatable cuff at the tip that can provide a seal to allow positive pressure ventilation.

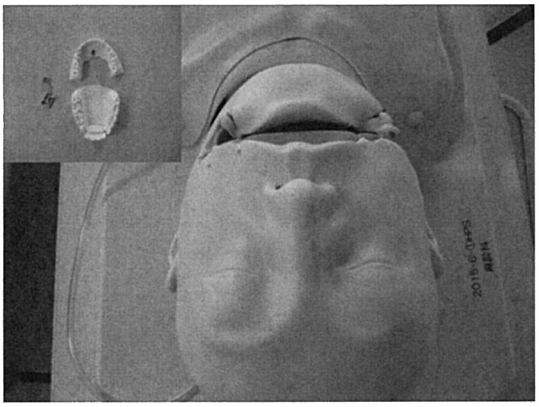

Figure 3. The modified edentulous airway mannequin. The mannequin's teeth were removed, and artificial skin sagging was formed to model an edentulous patient.

Tulip Airway's cuff, ~50 mL of air was injected with a syringe per the manufacturer's instructions.

As ventilation volume could not be measured using the aforementioned mannequin, a high-performance simulator (i-Stan, CAE Healthcare, Inc) was used to measure expired tidal volume for both the M and T methods. This simulator was used only for the purpose of measuring ventilation volume as its teeth could not be removed. Positive pressure ventilation was manually delivered with peak pressure of ~15 cm of H_2O for 1 minute using a standard anesthesia machine and circuit while the maximum expiratory ventilation volume was recorded. Positive pressure ventilation was delivered while referring to the pressure gauge in the circuit of the anesthesia machine.

After examining the normal probability distribution using a χ^2 test for adequate fit, comparisons were made between the 2 groups using the Mann-Whitney U test. $P < .05$ was used to determine statistical significance.

RESULTS

None of the 7 study participants successfully inflated the model lung of the edentulous mannequin using the M method due to poor mask fit and high leakage. Conversely, all 7 study participants were able to inflate the model lung using the T method, although slight leakage was noted. Ventilation of the edentulous mannequin was successful with the T method but failed with the M method.

Using the high-performance simulator, the T method produced a significantly higher median ventilation volumes than the M method (308 mL versus 192 mL; $P < .01$; Table). The T method produced superior ventilation volumes than the M method.

Table. Comparisons Between the M and T Methods

Ventilation parameters	*M method, N = 7*	*T method, N = 7*	*P value*
Ventilation success rate in the edentulous mannequin, % (#)	0 (0)	100 (7)	n/a
Expired tidal volume in a high-performance simulator, median (IQR),* mL	192 (188–210.5)	308 (295–332.5)	<.01

* IQR, interquartile range.

Insertion of the novel airway devices was not overly difficult as the time required for the insertion of the Tulip Airway was 7.2 ± 0.5 seconds. Timing with the M method was not included as part of this study.

DISCUSSION

Mask ventilation is generally difficult in edentulous patients. Improving mask ventilation by adjusting face mask position has been reported, but this may require additional skill and technique.[3] In many cases when mask ventilation proves difficult, ventilation can be improved by using an oropharyngeal or nasopharyngeal airway. However, even with the use of these airway adjuncts, mask ventilation in edentulous patients is often inadequate due to poor mask fit. If excessive airway pressures are used (ie, >20 cm H_2O) to compensate for leakage around the mask, gastric insufflation is possible and can lead to potential gastric regurgitation and aspiration. To improve the seal of the face mask, one technique that may be used involves filling the oral cavity with gauze, or alternatively, leaving the patient's dentures in place during induction.[2] However, inadvertent displacement of the dentures may remain a concern.[3] Since intubation is generally not overly difficult in edentulous patients, tracheal intubation immediately after the induction of anesthesia, thus foregoing mask ventilation, may be a solution. However, tracheal intubation while the patient is inadequately anesthetized (as may occur immediately after induction) could have deleterious cardiovascular effects. Therefore, allowing ample time for anesthetic and paralytic agents to reach adequate blood levels before intubation is desirable, particularly for elderly patients.

In the present study, participants who used the Tulip Airway for the first time were able to successfully insert the device in ~8 seconds, which supports its ease of use. A previous study by Shaikh et al[4] compared the success rate of positive pressure ventilation in adult patients under general anesthesia using the Guedel oropharyngeal airway and face mask to that of the Tulip Airway and found a significantly higher rate of effective ventilation success with the Tulip Airway.[4] Therefore, the current study hypothesized that the Tulip Airway may be useful for edentulous patients with difficult mask ventilation.

The current study found that the Tulip Airway facilitates positive pressure ventilation in an edentulous mannequin. The ventilation volumes using a high-performance simulator was also compared, and Tulip Airway was found to provide more stable ventilation volumes than the combination of the Guedel oropharyngeal airway and face mask. These results suggest that the Tulip Airway is a useful alternative for mask ventilation in edentulous patients with difficult mask ventilation.

An edentulous model airway-establishing mannequin is uncommon, which may be due to the ease of tracheal intubation in edentulous patients. Thus, an edentulous model mannequin was prepared with removed teeth and sagging skin to serve as a useful model for difficult mask fit and ventilation. We believe that this innovative mannequin design effectively replicated the problems commonly encountered during induction in edentulous patients. If such a model is commercially available in the future, it may be useful for training residents in airway management of the edentulous patient.

This study had several limitations. First, visual confirmation rather than quantitative measurement was used to gauge mask ventilation success in the edentulous mannequin because the ventilation volume could not be effectively measured using that mannequin. We also used a high-performance simulator to measure the ventilation volume, but unfortunately, the measured expiratory ventilation volume during mask ventilation likely lacked complete accuracy due to leakage that was attributed to poor mask fit. Second, the degree of necessary sedation, level of invasiveness of the Tulip Airway, and influence on the airway soft tissues remain unclear as this was a simulation study. If the depth of anesthesia is inadequate, there may be a risk of vomiting or laryngospasm during insertion. Excessive positive pressure could result in gastric insufflation, and it remains unclear how much pressure is safe to use with this device. In this study, 50 mL of air was injected into the cuff, but the effects of that volume on patients are unknown. Carefully assessing these disadvantages in patients will be necessary for future studies, although no disadvantages were noted in patients in a preceding study.[5] Third, differences in establishing an airway using the Tulip Airway and other existing supraglottic airway devices were not investigated, such as ease of insertion, ventilation rate, etc. Supraglottic airway devices (eg, a

laryngeal mask airway) are widely used as airway establishing tools. These devices are also very simple to insert, but training is considered necessary to some extent. The Tulip Airway was found to be easy to use—even for the first time— by the physician anesthesiologists who participated in this study. Supraglottic airway devices are generally found to be useful for prolonged positive pressure ventilation. However, this function has not yet been investigated for the Tulip Airway. We were able to evaluate its function as an alternative adjunct for mask ventilation, but a comparative study of the Tulip Airway and existing supraglottic airway devices may be necessary in the future.

CONCLUSION

The Tulip Airway provided significantly more effective ventilation in the edentulous airway model and the high-performance simulator compared with the Guedel oropharyngeal airway and face mask combination. It was also easy to use with short insertion times. This pilot study provides preliminary evidence supporting the Tulip Airway as an effective airway device for edentulous patients with difficult mask ventilation.

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