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Difficult Airway Management during Anesthesia: A Review of the Incidence and Solutions

Zhiyong Zeng[1], Woo C Tay[1], Tomoyuki Saito[2], Kyu Kyu Thinn[3*] and Eugene H Liu[3]

[1]Department of Anesthesia, National University Hospital, National University Health System, Singapore

[2]Department of Anaesthesiology, Dokkyo Medical University Koshigaya Hospital, 2-1-50 Minamikoshigaya, Koshigaya, Saitama 343-8555, Japan

[3]Department of Anesthesia, Yong Loo Lin School of Medicine, National University of Singapore, National University Health System, Singapore

***Corresponding author:** Kyu Kyu Thinn, Department of Anesthesia, National University Hospital, National University Health System, 5 Lower Kent Ridge Road, Singapore 119074, Tel: +65-67726965; E-mail: kyu_kyu_thinn@nuhs.edu.sg

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Abstract

Objective: We determined the incidence and predictive factors of difficult airway problems, and the devices used to solve the problems, in patients having general anesthesia.

Methods: We reviewed reported difficult airway cases in 37,805 patients who underwent general anesthesia from May 2011 to October 2013. Data were obtained from a procedural audit system implemented in our institute.

Results and conclusion: There were 885 (2.3%) patients with difficult airway problems. The incidence of difficulty encounter with tracheal intubation, supraglotic airways and mask ventilation were 4.7%, 0.4% and 1.0%, respectively. Of the 805 patients with difficult tracheal intubation, tracheal intubation failed in 11 (0.1%) patients and 3 of these patients needed tracheotomy. The main risk factors of a difficult airway were short thyromental distance (odds ratio 11.3 (9.6-13.4)) and limited neck extension (OR 7.0 (5.5-8.8)). Patients in whom management was anticipated to be difficult had a fourfold higher risk of actual difficulty compared to patients in whom difficulty was not anticipated. The negative predictive value of this simple preoperative evaluation was 98.7%. The most frequently used devices enabling tracheal intubation when difficulty was encountered were bougies and videolaryngoscopes, especially for unanticipated difficulties. Supraglottic airways enabled ventilation and oxygenation when difficult intubation was encountered, but there was a 0.4% incidence with difficult supraglottic airway placement. Our review supports a pre-anesthesia simple airway evaluation, avoiding multiple attempts at tracheal intubation or supraglottic airway insertion when difficulty is encountered and early use of a small and familiar range of alternative methods.

Keywords: Difficult airway; Airway obstruction; Airway management; Difficult intubation; Intratracheal; Laryngeal masks; Laryngoscopes

Introduction

Prediction of difficult airway management and the preparation of advanced equipment and the skill to use them can prevent poor outcomes when difficulties are encountered.

Hence we use a standardized preoperative airway assessment of all patients, comprising Mallampati view, neck movement, thyromental distance, mouth opening and presence of loose teeth or gaps in dentition, to enable adequate preparation. Failure to intubate the trachea is not in itself life threatening, but repeated attempts may traumatize the airway, make airway rescue more difficult, leading to failed oxygenation, and even mortality [1,2]. We emphasized oxygenation, avoiding multiple attempts at device insertion, and changing to an alternative airway management method early.

While the range of available devices is wide, we had identified in our department four core devices to train our staff with, for use in difficult airway management: bougies, supraglottic airways, videolaryngoscopes and flexible bronchoscopes. These would enable our staff to cope with most situations, including the rare 'cannot ventilate - cannot intubate' situations, estimated at 0.01-0.05% [3,4]. These four devices feature in most guidelines for difficult airway management [2]. Cricothyrotomy is in the guidelines, but few anesthesiologists have real life experience of emergency cricothyrotomy [5,6] and we are concerned about iatrogenic injury with this method.

In this review, we studied the incidence of difficult airway situations during general anesthesia, the prediction of difficulty, and the methods which enabled safe and successful airway management.

Materials and Methods

In 2011, we implemented a 100% procedural audit system of all anesthesia work in our department. This was mandated by the hospital and Ministry of Health as part of the continuous quality improvement and patient safety for all procedural and

surgical specialties. The Domain Specific Review Board was informed of our audit work and advised that consent from patients was not required for such audit work. The audit system recorded the patient's characteristics, anesthesia techniques, problems and difficulties encountered and critical and adverse incidents.

In this review, we studied all the reported cases of difficult airway management among 37,805 general anesthesia cases in the period May 2011 to October 2013. Additional information was obtained from the case notes, and where necessary from communication with the anaesthetists involved in the cases. We noted the rates of difficult SGA ventilation, difficult tracheal intubation, difficult mask ventilation, failed SGA insertion, and failed tracheal intubation. Difficult mask ventilation was defined as inability to maintain adequate mask ventilation or mask ventilation requiring two anaesthetists. Difficult SGA ventilation was defined as inability to provide adequate ventilation because of one or more of the following problems: inadequate SGA seal, excessive resistance to the ingress or egress of gas. In our institution, commonly used SGA are LMA Proseal, LMA Supreme and I-gel. Difficult tracheal intubation was defined as Cormack and Lehane grade III or IV by conventional laryngoscopy and/or the need for additional devices to achieve tracheal intubation. We noted the methods used to solve the difficult airway problems, the success of airway management, and any complications that occurred during airway management.

Standardized pre anesthesia evaluation included evaluation of Mallampati view, neck movement, thyromental distance, mouth opening and presence of loose teeth or gaps in dentition. Thyromental distance was considered abnormal if it was less than the "three fingers' breadth" of the patient. We considered the Mallampati class I, II and III predictive of low risk of difficult airway, and Mallampati class IV as high risk. The presence of conditions such as diabetes, obesity (body mass index >27.5 kg/m^2), obstructive sleep apnoea, and whether the patient was at risk of aspiration were noted. A summary evaluation was made: difficult airway 'anticipated' or 'not anticipated'. Whether a difficult airway is anticipated is checked again at the pre-induction "time out", during which the identity of the patient, history of allergies, functioning of monitors, and anticipation of blood loss are also checked. Subsequent preparation of a bougie, videolaryngoscope or other device for difficult airway situations, or no preparation of additional devices, was based on these evaluations.

In our institution, all anesthesia inductions involve an anesthesiologist of at least 3 years' experience, assisted by an anesthesia nurse. When a more junior resident carries out induction of anesthesia, a more senior anesthesiologist is also present in the operating room to supervise the junior doctor.

Statistical Analysis

We calculated the odds ratios (95% confidence intervals) for the risk factors for difficult airway, including limited neck extension, short thyromental distance, limited mouth opening, poor dentition and Mallampati IV oropharyngeal view. We calculated the sensitivity and specificity of these factors in predicting difficulty and also the positive and negative predictive values of the presence of these factors.

Results

During the study period, there were 37,805 patients who had general anesthesia and airway intervention. We note the difficult airway management cases in **Table 1**. Supraglottic airways were the most common airway technique.

Table 1 Incidence of difficult airway management cases.

Airway Management	Number of cases	Difficulty encountered		Failed	
		Number	%	Number	%
Tracheal Intubation	17292	805	4.7	11	0.1
Supraglottic Airway used	18805	63	0.4	34	0.2
Mask Ventilation	1708	17	1	0	0
Total	37805	885	2.3	-	-

A total of 885 patients had difficult airway situations, an incidence of 2.3%. There were no mortalities or hypoxic brain damage in any of these patients. Transient hypoxia with oxygenation <80% occurred in 22 patients, and was rapidly corrected by mask ventilation in between airway instrumentation attempts. We note the incidence of adverse outcomes in patients of difficult airway in **Table 2**.

Table 2 Adverse outcomes in patients with difficult airway.

Adverse Outcome	Number	%
Hypoxia, transient	22	2.5
Bronchospasm	15	1.7
Laryngospasm	10	1.1
Dental trauma	6	0.7
Pulmonary aspiration	5	0.6
Hypercapnia	5	0.6
Airway trauma	4	0.5

Difficult tracheal intubation

There were 805 patients with difficult tracheal intubation; these patients had a poor laryngoscopy grade or could not be intubated with the initial device of choice. In 704 of these patients, a Macintosh laryngoscope was initially used and failed to achieve tracheal intubation. An additional device was

required, and the success rates of these are in **Table 3**. Bougies and videolaryngoscopes were most commonly used.

Table 3 Success rates of rescue devices after failed initial intubation attempts using a Macintosh laryngoscope.

Devices	Number (%)	Success	Failed	Success Rate (%)
Bougie	605 (85.9)	600	5	99.2
Videolaryngoscope	52 (7.4)	40	12	76.9
McCoy laryngoscope	33 (4.7)	16	17	48.5
Supraglottic airway (interim)	8 (1.1)	6	2	75
Fiber-optic bronchoscope	2 (0.3)	1	1	50
LMA Fastrach	2 (0.3)	2	0	100
Tracheostomy	1 (0.1)	1	0	100
Face Mask	1 (0.1)	1	0	100

In 605 cases where the first attempt with direct laryngoscopy was unsuccessful, bougies were the first additional device used. In these patients, some portion of the laryngeal inlet could be seen and there was successful intubation in 600 cases (99.2%). Bougies were also used with other laryngoscopes, and overall, enabled successful intubation in 686 (85.2%) of cases when used with a Macintosh laryngoscope, McCoy laryngoscope or videolarnygoscope. Videolaryngoscopes were the next most common technique used after difficulty with the Macintosh laryngoscope and intubation was successful in 76.9%. Videolaryngoscopes were used as the first device, instead of the Macintosh laryngoscope, for tracheal intubation in 37 patients and was successful in 29 patients (78.4%).

The LMA Fastrach was used for tracheal intubation in seven patients, all successfully. Flexible bronchoscopy was used in six patients as a planned awake procedure prior to induction of anesthesia. In two patients, flexible bronchoscopy was used after failure with direct laryngoscopy and videolaryngoscopy.

In 11 patients (0.06%), failed intubation was diagnosed after attempts with additional devices failed, and further attempts at tracheal intubation were stopped. Three of these 11 patients required urgent tracheotomy, during which mask ventilation was maintained. In eight patients, SGAs were successfully used to maintain oxygenation. In one of these 11 patients, the airway was maintained with mask ventilation throughout anesthesia, after intubation attempts failed. In 2 patients, decisions were subsequently made to stop anesthesia, awaken the patients, and postpone surgery. Transient hypoxia had occurred after difficult intubation in four patients, but no patients had severe hypoxia that resulted in neurological injury.

Difficult supraglotic airway placement

Among patients for whom SGAs were the planned method of airway management, there was difficult placement in 63 (0.4%) patients. Failed SGA placement occurred in 34 (0.2%) patients, where further attempts were stopped, and the patients' airways were managed with mask ventilation or tracheal intubation. There was concurrent difficult tracheal intubation in 9 of these patients. When faced with a difficult SGA placement, a different SGA type was attempted in 21 of these patients and only 11 (52.4%) were successful.

Difficult mask ventilation

Among patients for whom mask ventilation was the planned method of airway management, there was difficult mask ventilation in 17 (1.0%) patients, requiring the assistant to help and the use of additional devices. While there were no patients with impossible mask ventilation, the anesthesiologists did not continue struggling with difficult mask ventilation. SGAs were used to overcome the difficulty in 9 patients, tracheal intubation in 6 patients and flexible bronchoscopic intubation in 2 patients.

Among the 885 patients, difficult airway management had been anticipated in 524 (59.2%) patients after pre anesthesia evaluation. These 524 patients were 5.1% of the 9684 patients in whom difficulty had been anticipated. This incidence was four fold higher than in patients for whom difficulty was not anticipated.

The sensitivity, specificity and predictive values of the indicators used in pre-anesthesia evaluation are noted in **Table 4**. The positive predictive values were low, while the negative predictive values were high. All the indicators: high Mallampati class, short thyromental distance, limited neck movement, limited mouth opening, poor dentition, high BMI, increased the risk of difficult airway management. The magnitude of increased risk was greatest with short thyromental distance and limited neck movement.

Table 4 Predictors of difficult airway.

Difficult airway (n)		Non difficult airway (n)	Odds Ratio (95% CI)	Sensitivity (%)	Specificity (%)	Positive Predictive Value (%)	Negative Predictive Value (%)
Anticipated difficult airway							
Yes	524	9684	4.1 (3.6-4.7)	59.2	73.8	5.1	98.7
No	361	27236	-	-	-	-	-
Body mass index>27.5 kg/m^2							
Yes	101	2464	1.8 (1.5-2.2)	11.4	93.3	3.9	97.8
No	784	34456	-	-	-	-	-
Obstructive sleep apnea							
Yes	44	680	2.8 (2.0-3.8)	5	98.2	6.1	97.7
No	841	36240	-	-	-	-	-
Mallampati classification							
VI	47	330	6.2 (4.5-8.5)	5.3	99.1	12.5	97.8
I, II, III	839	36589	-	-	-	-	-
Thyromental distance							
Short	213	1005	11.3 (9.6-13.4)	24.1	97.3	17.5	98.2
Normal	672	35915	-	-	-	-	-
Mouth opening							
Limited	76	777	4.4 (3.4-5.6)	8.6	97.9	8.9	97.8
Normal	809	36143	-	-	-	-	-
Neck extension							
Limited	92	606	7.0 (5.5-8.8)	10.4	98.4	13.2	97.9
Normal	793	36314	-	-	-	-	-
Teeth							
Loose	127	1675	3.5 (2.9-4.3)	14.4	95.5	7.1	97.9
Normal	758	35245	-	-	-	-	-

Discussion

Our review found an incidence of difficult airways of 2.3% in general anesthesia patients, most of these involved difficult intubation [7,8]. The 4.7% rate of difficult intubation among patients needing tracheal intubation is comparable to that of 5.8% in a meta-analysis [9] and the 0.06% incidence of failed tracheal intubation is comparable to earlier data of 0.05% in a non-obstetric population [10].

Most of the difficult intubation situations were safely and successfully managed using a small range of devices. When some portion of the laryngeal inlet could be seen, bougies were most commonly used first with a very high success rate. When the laryngeal inlet could not be seen at all, videolaryngoscopes were then used. Our review suggests that the availability of and experience with videolaryngoscopes helped reduce the rate of failed intubation. Flexible bronchoscopy and the LMA Fastrach were used in only a very small proportion of cases. Difficulty was minimized or prevented in some patients by immediate use of bougies and videolaryngoscopes at the start, or by using SGAs instead of tracheal intubation. While much preparation may not have been necessary, we suggest that it is better to over prepare, to reduce unexpected difficulties [11].

Videolaryngoscopes have several advantages over the conventional direct laryngoscopes [8,12,13]. In particular, their use requires less extension and flexion of the head and neck, pressure on the neck, and distortion of the upper airway. Videolaryngoscopes enable both operator and assistant to simultaneously view the airway. Adequate mouth opening is still required to use a videolaryngoscope and there can be difficulty inserting the tracheal tube despite a good view of the larynx, and this can cause airway trauma. In some patients, bougies were used to guide the tracheal tube during videolaryngoscopy. We suggest that when conventional laryngoscopy has failed, a

videolaryngoscope should be used early and that bougies be used together with the videolaryngoscope in "can see cannot intubate situations". In our audit, there was no airway trauma caused by the videolaryngoscopes, but we should also avoid multiple attempts with videolaryngoscopes, to prevent swelling and bleeding in the airway [14].

In our patients, the rate of difficult SGA insertion was much lower than that of difficult tracheal intubation. It is possible that many difficult intubation situations were avoided by using SGAs instead. SGAs now feature in all difficult airway algorithms, to enable oxygenation and ventilation [15,16]. While SGAs may not provide the same level of protection against aspiration of regurgitated stomach contents, SGAs such as the LMA Proseal and Igel have channels for insertion of gastric tubes that enable drainage and reduction of the volume of stomach contents. However, we caution against over reliance on SGAs, as difficult SGA insertion can also occur in patients in whom intubation is difficult. An earlier review found the rate of difficult ventilation with an SGA to be 0.5% [17]. The failed SGA insertion cases in our review mostly involved inadequate ventilation due to gas leaks. SGA insertion was abandoned and tracheal intubation used instead, but a substantial proportion of these also had difficult tracheal intubation requiring the use of bougies and videolaryngoscopes. We suggest that it is also important to avoid multiple attempts at SGA insertion, as these attempts can traumatize the airway, making subsequent mask ventilation, tracheal intubation or flexible bronchoscosopy difficult or impossible.

In our study, there were no patients in whom failed mask ventilation, failed SGA placement and failed tracheal intubation all occurred and had not been anticipated. Only a very small number of patients required a subglottic surgical airway. In all three patients, the difficulty had been anticipated and the surgical team was present to carry out emergency surgical tracheotomy. None of the patients had cricothyrotomy by the anesthesiologists, suggesting that it is very unlikely that the anesthesiologists will ever gain adequate personal experience with cricothyrotomy. Training in simulators and animal models are the only pragmatic methods to gain skill.

There were no cases of hypoxic injury in this review. Our department had emphasized that oxygenation took precedence over intubation, and emphasized stopping multiple intubation attempts and changing to alternative methods early. This was to avoid turning a difficult airway into an impossible airway. Failed intubation is not itself life threatening, yet is frequently associated with serious complications [2,7], as repeated attempts can damage the upper airway and make mask ventilation very difficult [8,18]. In 2011, the 4th National Audit project of the Royal College of Anaesthetists in UK estimated an incidence of one serious airway complication per 22000 cases, and that this could be as high as one in 5000 cases [7,11]. Our single centre study population of 37805 patients may be too small to provide a rate of such complications.

In our institution, all patients have a simple standardized evaluation of the airway as part of preoperative evaluation, and this is confirmed at the "time out" prior to the induction of anesthesia. Our emphasis is on reducing the incidence of unanticipated difficult airways, and being prepared. There was low sensitivity and specificity, and very low positive predictive value of the airway evaluation and individual risk factors in our patients. This is similar to other more extensive and complicated airway evaluation systems, which all also had limited sensitivity and specificity [9,19,20]. Many patients in whom difficulty was anticipated eventually had easy airway management, with only 5.1% having difficult airways. Conversely, in patients evaluated as not having a difficult airway, the negative predictive value was very high and 98.7% did not have any problems. The residual 1.3% had unanticipated difficulty.

We suggest that tests not only be directed at difficult laryngoscopy and intubation, but also for difficult mask ventilation, difficult SGA, difficult surgical airway. In our patients, short thyromental distance was the strongest predictor of a difficult airway. Thyromental distance is considered to be an indicator of mandibular space [21] and reflects whether displacement of the tongue by the laryngoscope blade will be easy or difficult. We included checking for limited neck movement, limited mouth opening and poor dentition to prevent unanticipated difficulty due to these factors. In particular, severely limited mouth opening would require alternative methods such as bronchoscopic nasal intubation or subglottic surgical airways. Despite the limitations of this simple evaluation, our results suggest that it prevents unanticipated difficulty with insertion of a laryngoscope or SGA. The patients who did have unanticipated difficult airways had anatomical variations that could be managed with bougies and videolaryngoscopes.

There are a few limitations of our study. As a teaching hospital, we have a wide range of clinical experience and competency and it is possible that some airways diagnosed as difficult by more junior anaesthetists may not be difficult in more experienced hands. Secondly, although difficulty was anticipated in many patients, only a small proportion was eventually reported as being difficult, as SGAs were used instead. Thirdly, the wide use of SGA will result in lower rates of difficult intubation, but this reflects contemporary practice.

Conclusion

In conclusion, most difficult airway incidents were managed by using a small range of methods, and avoiding multiple attempts at tracheal tube or SGA insertion. Bougies and videolaryngoscope enabled successful intubation in a large proportion of difficult intubation patients. A simple standard preoperative airway evaluation, which was confirmed before induction of anesthesia, helped prevent unanticipated impossible airways. While SGAs can be used for rescue oxygenation during difficult intubation, we caution that difficult SGA and difficult intubation can coexist in some patients.

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