BJA

British Journal of Anaesthesia, 117 (S1): i83–i86 (2016)

doi: 10.1093/bja/aew191
Advance Access Publication Date: 22 July 2016
Special Issue

A proposal for a new scoring system to predict difficult ventilation through a supraglottic airway

T. Saito[1,*], S. T. H. Chew[2], W. L. Liu[3], K. K. Thinn[4], T. Asai[1] and L. K. Ti[3,4]

[1]Department of Anaesthesia, Dokkyo Medical University Koshigaya Hospital, 2-1-50 Minamikoshigaya, Koshigaya, Saitama 343-8555, Japan, [2]Department of Anaesthesia, Singapore General Hospital, Outram Road, Singapore 169608, [3]Department of Anaesthesia, Yong Loo Lin School of Medicine, National University of Singapore, 21 Lower Kent Ridge Road, Singapore 119077, and [4]Department of Anaesthesia, National University Health System, 1E, Kent Ridge Road, Singapore 119228

*Corresponding author. E-mail: s-tomo@dokkyomed.ac.jp

Abstract

Background: The aim of this study was to propose and validate a new clinical score to predict difficult ventilation through a supraglottic airway device.

Methods: The score was proposed from our previously reported derivation data, and we prospectively validated the score in 5532 patients from November 2013 to April 2014. Predictive accuracy of the score was compared by the area under the receiver operating characteristic (ROC) curve (AUC). We assigned point values to each of the identified four risk factors: male, age >45 yr, short thyromental distance, and limited neck movement, their sum composing the score. The score ranged between 0 and 7 points. The optimal predictive level of the score was determined using ROC curve analysis.

Results: The AUC of the score was 0.75 (95% CI 0.66 to 0.84) in the validation data set, and was similar to that in the derivation data set (0.80; 95% CI 0.75 to 0.86). In derivation and validation data sets, the incidence of low risk categories (scores 0–3) was 0.42% *vs* 0.32% and of high risk categories (scores 4–7) was 3% *vs* 1.7% respectively. A score 4 or greater is associated with a six to seven fold increased risk of difficult ventilation through a supraglottic airway device.

Conclusions: The new score for prediction of difficult ventilation through a supraglottic airway device is easy to perform and reliable, and could help anaesthetists plan for difficult airway management.

Key words: airway management; predictive values of tests; prospective study

Despite availability of several guidelines for difficult airway management,[1–4] unexpected difficulty in airway management at induction of anaesthesia, remains a major cause of anaesthesia-related death and hypoxic brain damage.[5 6] When facemask ventilation and tracheal intubation prove difficult,[1–4 7] existing guidelines recommend insertion of a supraglottic airway device, such as a laryngeal mask airway. However, insertion of or ventilation through a supraglottic airway device may also fail.[8] Therefore, preoperative assessment of not only difficult mask ventilation and tracheal intubation,[7–14] but also difficult ventilation through a supraglottic airway device may decrease the risk of major airway complication during difficult airway management.

Failure to insert of a supraglottic airway device, or to ventilate through it occurs in 0.5–4.7%.[15–21] Reported causes of difficult insertion of and ventilation through a supraglottic airway device include severe anatomical abnormality, swelling of the upper airway, and bleeding after repeated attempts at tracheal intubation.[8] In a previous study, we identified four risk factors for

Accepted: May 31, 2016

Editor's key points

- The authors have developed a scoring system for difficult ventilation through a supraglottic airway.
- In the current study the predictive value of the score was prospectively validated.
- High scores were associated with an increased risk of difficult ventilation.
- Positive prediction value was however low (many patients had easy ventilation despite a high score).

difficult ventilation through a supraglottic airway device: male, age >45 yr, short thyromental distance, and limited neck movement.[16] The purpose of this study was to propose and validate a new clinical score that predicts difficult ventilation through a supraglottic airway device based on the identified risk factors.

Methods

Institutional review board approval (IRB) approval was obtained for this study. Individual patient informed consent was waived by the IRB as no clinical interventions were made, and no patient identifiable data were used. A score for prediction of difficult ventilation through a supraglottic airway device was proposed from data in our previous study.[16] 14 480 patients, aged ≥18 yr, who underwent general anaesthesia with the use of a supraglottic airway device were studied. We identified 74 (0.5%) patients in whom ventilation through a supraglottic airway device was difficult. Multivariate analysis identified four risk factors for difficult ventilation through a supraglottic airway device: male sex (OR 1.75, 95% CI=1.07–2.86, P=0.02); age >45 yr (OR 1.70, 95% CI=1.01–2.86, P=0.04); short thyromental distance (OR 4.35, 95% CI 2.31–8.17, P<0.001); and limited neck movement (OR 2.75, 95% CI=1.02–7.44, P=0.04).

Point values were assigned to each of the four independent risk factors. The points were weighted according to their parameter estimates with the lowest parameter estimate (Age >45 yr) assigned as 1, and the other factors proportionally allocated their points rounded to the nearest integer: one point for male (1.75/1.70=1.03, and thus the nearest integer (1), two points for limited neck movement (2.75/1.70=1.61, and thus the nearest integer (2) and 3 points for short thyromental distance (<5.5 cm) (4.35/1.70=2.55, and thus the nearest integer (3), giving a range of scores of 0–7 (Table 1). Summation of these points allowed for a single score ranging from 0 to 7 points. From this, we defined two overall risk categories for difficult supraglottic airway ventilation that gave both an adequate number of patients in each category and a distinct difference in rates of difficult supraglottic airway device ventilation.

Table 1 The simplified score to predict difficult ventilation through a supraglottic airway device. The points were weighted according to their parameter estimates with the lowest parameter estimate (Age >45 yr (OR 1.70)) assigned as 1, and the other factors proportionally allocated their points rounded to the nearest integer (see the methods for details).

Perioperative variables	Points
Male	1
Age >45 yr	1
Short thyromental distance	3
Limited neck movements	2

The model was then validated on a subsequent cohort of patients who had a supraglottic airway device insertion attempted as part of their anaesthesia management between November 2013 and April 2014. Similar to the derivation cohort reported previously,[16] only patients who were 18 yr of age or older were included. From a total of 15 865 patients who underwent general anaesthesia during that period, 5532 patients met the inclusion criteria and were used as the validation cohort.

The primary endpoint was difficult ventilation through a supraglottic airway device. The types of supraglottic airway used included LMA Classic™, Proseal™ LMA, LMA Supreme™ (LMA™ North America, Inc, San Diego, CA, USA), I-gel™ (Intersurgical Ltd, Wokingham, Berkshire, UK), and The Fastrach™ Intubation Laryngeal Mask Airway® (Laryngeal Mask Company, Jersey, UK). The definition was namely inability to provide adequate ventilation during induction of anaesthesia, because of one or more of the following problems: inadequate laryngeal mask seal, excessive gas leak, excessive resistance to the ingress or egress of gas.[1] Signs of inadequate ventilation include absent or inadequate chest movement, absent or inadequate breath sound, auscultatory signs of severe obstruction, cyanosis, gastric air entry or dilation, decreasing or inadequate oxygen saturation, absent or inadequate exhaled carbon dioxide, absent or inadequate spirometric measures of exhaled gas flow and haemodynamic changes associated with hypoxemia or hypercarbia.

Statistical analysis

The model was evaluated using the Hosmer-Lemeshow goodness-of-fit test and the area under the ROC curve. To measure and compare the predictive accuracy of the model in the derivation and validation data sets, we generated the receiver operating characteristic (ROC) curve and compared their C-statistics (AUC). The optimal predictive level of the score was determined using ROC curve analysis. The AUC provides a global summary statistic of test accuracy, and guidelines suggest that 0.5<AUC≤0.7 represent low accuracy, 0.7<AUC≤0.9 moderate accuracy, and 0.9<AUC≤1.0 represents high accuracy.[22] Statistical analysis was performed using SPSS version 22 (Armonk, NY, US). A P-value of less than 0.05 was considered statistically significant.

Results

Patients' characteristics are shown in Table 2. ROC curve analysis identified two risk categories; where a score of 0–3 signified low risk, and a score of 4–7 signified high risk, of difficult ventilation through a supraglottic airway device (Table 3).

In the validation cohort of 5532 patients, 22 patients experienced difficult ventilation through a supraglottic airway device. The incidence of difficult ventilation through a supraglottic airway device in validation data set was 0.4%, similar to that of the derivation cohort (0.5%).[16] Patients in the high risk group had approximately a six-fold increased risk of difficult ventilation through a supraglottic airway device as compared with those in the low risk group; a similar quantum of increased risk as was seen in the derivation cohort. The AUC of the score in validation data set was 0.75 (95% CI=0.66–0.84) (Figure 1), similar to derivation data set (0.80, 95% CI=0.75–0.86) (Figure 2). The sensitivity of the risk score is 23%, while the specificity is 95%; giving a negative predictive value of 99.6% (Table 4). The Hosmer-Lemeshow goodness of fit statistic was 0.63.

Table 2 Patients' characteristics in validation data set. Data is presented as mean (SD) or number (%).

	Normal ventilation through a supraglottic airway device (*n*=5510)	Difficult ventilation through a supraglottic airway device (*n*=22)	P-value
Male (%)	2774 (50.4)	13 (59.1)	0.415
Age (range)	44 (17)	55 (16)	0.002
Ethnicity			0.941
Chinese (%)	2702 (57.2)	12 (63.2)	
Malay (%)	783 (16.6)	3 (15.8)	
Indian (%)	715 (15.1)	2 (10.5)	
Others (%)	521 (11)	2 (10.5)	
Diabetes (%)	617 (11.2)	4 (18.2)	0.301
Obesity (%)	384 (7)	3 (13.6)	0.196
Obstructive sleep apnoea (%)	69 (1.3)	1 (4.5)	0.245

Table 3 The score risk categories

Risk for difficult ventilation	Derivation data set %	Validation data set %
Low (0–3 points)	0.42	0.32
High (4–7 points)	3	1.7

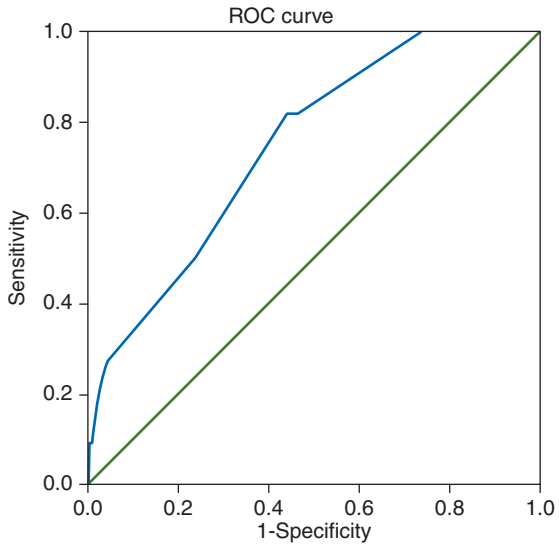

Fig 1 Receiver operating characteristic curve analysis for the validation data set. The area under the curve for the difficult ventilation via a supraglottic airway device ROC curve was 0.75 (95% CI=0.66–0.84).

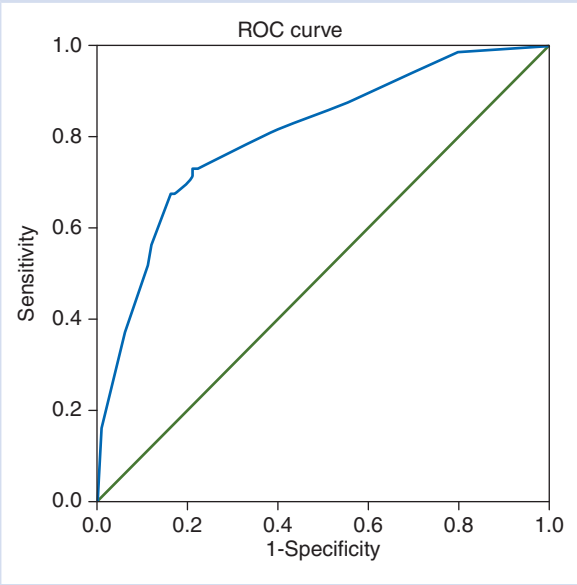

Fig 2 Receiver operating characteristic curve analysis for the derivation data set. The area under the curve for the difficult ventilation via a supraglottic airway device ROC curve was 0.80 (95% CI= 0.75–0.86).

Table 4 Relationship between two risk categories and normal or difficult ventilation through a supraglottic airway in validation data set

Risk for difficult ventilation	Normal ventilation through a supraglottic airway device	Difficult ventilation through a supraglottic airway device
High risk	296	5
Low risk	5214	17

Discussion

We have shown that the incidence of difficult ventilation through a supraglottic airway is 0.42% and by utilizing the four identified risk factors of male sex, age more than 45 yr, short thyromental distance and limited neck movement, we have proposed a new score which can quantify the risk. A score of 4 or greater has a six-to-seven fold increased risk for difficult ventilation through a supraglottic airway device.

There are several methods for the prediction of difficult tracheal intubation, but there has been no reliable method of predicting difficult supraglottic airway ventilation.[23] Supraglottic airway devices are useful adjuncts in the difficult airway and as a backup rescue for the failed intubation. As such, ensuring ventilation through the supraglottic airway is vital to reduce hypoxia. Our study is the first to utilize a risk score to quantify the risk of difficult ventilation through the supraglottic airway device.

The new score is easy to use and highly discriminatory. It has a high specificity with a negative predictive value of 99.6%. This makes the score good for screening, as a low score would mean a 99.6% chance of not having difficulty in ventilation through a supraglottic airway device. Sensitivity with positive predictive value was 23%, nevertheless the score is useful as a screening aid to alert the anaesthetist,[24] which would allow for a coordinated approach to plan for alternative strategies for the difficult airway such as fibre optic intubation, awake intubation and surgical access.

A limitation of our study was the unrestricted use of different supraglottic airway devices. However, this is representative of the actual clinical setting, in which the choice of the supraglottic airway device is based on the preference and skill of the particular anaesthetist. The data were obtained from a single centre and the patients were mainly Asians, who may have different anatomy from non-Asians.[25] Nevertheless, this validation score may have clinical utility worldwide, and future studies using this scoring system on a more heterogeneous group of patients are needed. In addition, adequacy of ventilation through a supraglottic airway was not objectively assessed. Instead it was mainly subjectively assessed using criteria such as inadequate chest movements, and absent or inadequate breath sounds.

In conclusion, we have proposed a new clinical score to predict difficult ventilation through a supraglottic airway device. This new scoring system can be easily performed at the bedside, is practical, and may help the anaesthetist decide on the best airway management strategy for their patients.

Authors' contributions

Study design/planning: T.S., T.A.
Study conduct: L.T.
Data analysis: W.L., K.T., T.A.
Writing paper: T.S., S.C., T.A.
Revising paper: all authors.

Acknowledgements

We thank the staff of the Department of Anaesthesia, National University Health System and Yong Loo Lin School of Medicine, National University of Singapore, for their contribution to this study.

Declaration of interest

None declared.

References

1. Apfelbaum JL, Hagberg CA, Caplan RA, *et al*. Practice guidelines for management of the difficult airway: an updated report by the American Society of Anesthesiologists Task Force on Management of the Difficult Airway. *Anesthesiology* 2013; **118**: 251–70
2. Frerk C, Mitchell VS, McNarry AF, *et al*. Difficult Airway Society 2015 guidelines for management of unanticipated difficult intubation in adults. *Br J Anaesth* 2015; **115**: 827–48
3. Law JA, Broemling N, Cooper RM, *et al*. The difficult airway with recommendations for management–part 1–difficult tracheal intubation encountered in an unconscious/induced patient. *Can J Anesth* 2013; **60**: 1089–118
4. JSA airway management guideline 2014: to improve the safety of induction of anesthesia. *J Anesth* 2014; **28**: 482–93
5. Peterson GN, Domino KB, Caplan RA, Posner KL, Lee LA, Cheney FW. Management of the difficult airway: a closed claims analysis. *Anesthesiology* 2005; **103**: 33–9
6. Cook TM, Woodall N, Harper J, Benger J. Major complications of airway management in the UK: results of the Fourth National Audit Project of the Royal College of Anaesthetists and the Difficult Airway Society. Part 2: intensive care and emergency departments. *Br J Anaesth* 2011; **106**: 632–42
7. Priebe HJ. Assessment of anaesthetists' ability to predict difficulty of bag-mask ventilation. *Br J Anaesth* 2014; **112**: 769–70
8. Asai T. Difficulty in insertion of the laryngeal mask. In: Latto IP, Vaughan RS, eds. *Difficulties in Tracheal Intubation*, 2nd Edn. London: W.B. Saunders Company Ltd, 1997; 197–214
9. Norskov AK, Lundstrom LH, Wetterslev J, Rosenstock CV. Anticipation of the difficult airway. *Br J Anaesth* 2014; **112**: 589–90
10. Kheterpal S, Martin L, Shanks AM, Tremper KK. Prediction and outcomes of impossible mask ventilation: a review of 50,000 anesthetics. *Anesthesiology* 2009; **110**: 891–7
11. Karkouti K, Rose DK, Wigglesworth D, Cohen MM. Predicting difficult intubation: a multivariable analysis. *Can J Anaesth* 2000; **47**: 730–9
12. De Jong A, Molinari N, Pouzeratte Y, *et al*. Difficult intubation in obese patients: incidence, risk factors, and complications in the operating theatre and in intensive care units. *Br J Anaesth* 2015; **114**: 297–306
13. Arne J, Descoins P, Fusciardi J, *et al*. Preoperative assessment for difficult intubation in general and ENT surgery: predictive value of a clinical multivariate risk index. *Br J Anaesth* 1998; **80**: 140–6
14. Cattano D, Killoran PV, Iannucci D, *et al*. Anticipation of the difficult airway: preoperative airway assessment, an educational and quality improvement tool. *Br J Anaesth* 2013; **111**: 276–85
15. Verghese C, Brimacombe JR. Survey of laryngeal mask airway usage in 11,910 patients: safety and efficacy for conventional and nonconventional usage. *Anesth Analg* 1996; **82**: 129–33
16. Saito T, Liu W, Chew ST, Ti LK. Incidence of and risk factors for difficult ventilation via a supraglottic airway device in a population of 14,480 patients from South-East Asia. *Anaesthesia* 2015; **70**: 1079–83
17. Ramachandran SK, Mathis MR, Tremper KK, Shanks AM, Kheterpal S. Predictors and clinical outcomes from failed Laryngeal Mask Airway Unique: a study of 15,795 patients. *Anesthesiology* 2012; **116**: 1217–26
18. Grady DM, McHardy F, Wong J, Jin F, Tong D, Chung F. Pharyngolaryngeal morbidity with the laryngeal mask airway in spontaneously breathing patients: does size matter? *Anesthesiology* 2001; **94**: 760–6
19. Rose DK, Cohen MM. The airway: problems and predictions in 18,500 patients. *Can J Anaesth* 1994; **41**: 372–83
20. Francksen H, Renner J, Hanss R, Scholz J, Doerges V, Bein B. A comparison of the i-gel with the LMA-Unique in non-paralysed anaesthetised adult patients. *Anaesthesia* 2009; **64**: 1118–24
21. Cook TM, Trumpelmann P, Beringer R, Stedeford J. A randomised comparison of the Portex Softseal laryngeal mask airway with the LMA-Unique during anaesthesia. *Anaesthesia* 2005; **60**: 1218–25
22. Swets JA. Measuring the accuracy of diagnostic systems. *Science (New York, NY)* 1988; **240**: 1285–93
23. Asai T. Strategies for difficult airway management–the current state is not ideal. *J Anesth* 2013; **27**: 157–60
24. Yentis SM. Predicting difficult tracheal intubation: Worthwhile exercise or pointless ritual? *Anaesthesia* 2002; **57**: 105–9
25. Lam B, Ip MS, Tench E, Ryan CF. Craniofacial profile in Asian and white subjects with obstructive sleep apnoea. *Thorax* 2005; **60**: 504–10

Handling editor: A. R. Absalom