J Anesth (2017) 31:483–486
DOI 10.1007/s00540-017-2333-3

EDITORIAL

Progress in difficult airway management

Takashi Asai[1]

Received: 24 January 2017 / Accepted: 22 February 2017 / Published online: 3 March 2017

Introduction

Difficulty in airway management is the main cause of anesthesia-related death or permanent brain damage. In intensive care units and emergency departments, the incidence of life-threatening complications associated with airway management is even higher than in patients in the operating rooms [1–3]. To reduce the incidence of such serious complications, several major efforts have been made. In addition to the development of new reliable airway devices and routine use of oximetry and capnography, guidelines regarding difficult airway management have been formulated by several different societies [4–6]. Nevertheless, the current strategies for airway management are still not ideal [7–11] and, therefore, we need to update our knowledge to improve airway management further. This editorial describes some new findings which would reduce serious complications associated with airway management.

Adequate planning

One effective method of avoiding serious airway complications after induction of anesthesia is to predict the ease of airway management, and to make a clear preoperative plan for each patient. Although efforts have been made to find reliable predictive tests for difficult airways [12–14], these tests may frequently fail to predict the difficulty. Because of this, some authors consider that predictive tests are futile; however, prediction tests should be performed, as they frequently do identify difficult airways, and would reduce the incidence of serious airway complications after induction of anesthesia [13].

Sufficient pre-oxygenation of the patient is crucial, particularly when difficult airway management is predicted. The traditional method is to provide oxygen via a facemask for a minimum of three minutes. Recently, a high-flow nasal oxygen delivery system has been shown to be effective in reducing the risk of hypoxia during attempts at awake fiberoptic intubation [15].

Some authors consider that a neuromuscular blocking agent should not be given after induction of anesthesia until adequate ventilation via a facemask has been confirmed, but there is considerable evidence to support this practice being unsuitable. It is now clear that injection of a neuromuscular blocking agent immediately after induction of anesthesia facilitates mask ventilation and reduces the incidence of hypoxia [16]. During laryngoscopy, oxygen may be insufflated to the posterior pharynx to delay the time to become hypoxic [17].

Avoidance of repeated attempts at tracheal intubation

It is now clear that repeated attempts at tracheal intubation should be avoided, because such attempts may make mask ventilation difficult and increase the risk of pulmonary aspiration [1, 18, 19]. Videolaryngoscopes, which have potential roles in patients with difficult airways, may reduce repetitive attempts at intubation [20–22]. A large observational study has indicated that in patients in whom tracheal intubation using a conventional direct laryngoscope

✉ Takashi Asai
asaita@dokkyomed.ac.jp

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

had failed, a videolaryngoscope was most frequently used as a second-line treatment, and was associated with a high success rate of intubation, compared with other intubation devices (e.g., supraglottic airways and fiberoptic bronchoscope) [23]. Another study has also shown that compared with the use of a supraglottic airway, the use of a videolaryngoscope may be able to prevent repeated attempts at tracheal intubation and reduce complications [24].

Suitable videolaryngoscopes are likely to differ in patients with different causes of difficult airways. For example, in a study of patients with restricted neck movement and limited mouth opening, the McGrath™ or C-MAC™ D-blade provided a higher success rate and a lower incidence of tissue injury, when compared with the A.P. Advance [21].

Videolaryngoscopes have roles in patients with difficult airways, but they may fail [21, 25, 26] and may not be able to reduce the incidence of anesthesia-related death [3]. Reported difficulties include limited mouth opening, a large tongue, a tumor in the oropharynx, laryngospasm, and blurred vision [22]. Recent studies [25, 26] have added several other risk factors—suboptimal head and neck position, cricoid pressure, inexperience, and patients undergoing otolaryngologic or cardiac surgery.

Therefore, we should know when videolaryngoscopes are more likely to fail, should avoid repeated attempts at the use of videolaryngoscopes, and should take the next steps (attempts at ventilation via a supraglottic airway or via an invasive airway) without delay. It is not clear whether tracheal intubation using a videolaryngoscope is less likely to traumatize the airway or to prolong apnea time, both of which may lead to serious airway complications [22]. Clarification of these would establish the true role of videolaryngoscopes in patients with difficult airways, particularly in patients receiving rapid-sequence induction of anesthesia and in those undergoing emergency Cesarean section [27, 28].

Videolaryngoscopes are theoretically useful for non-experienced persons who may need to perform tracheal intubation outside the operating room. One study, however, has shown that, compared with novice paramedics who had no experience with the use of a Macintosh laryngoscope, those with previous training of tracheal intubation using a Macintosh laryngoscope had a lower success rate of tracheal intubation using a videolaryngoscope [29]. This report indicates that training with a videolaryngoscope is necessary, and we need to find an appropriate training method [30].

'Rescue device'

Although the supraglottic airway is regarded as a 'rescue device' in the 'cannot intubate, cannot ventilate' scenario [4–6], it may fail in some patients, particularly in those in whom repeated attempts at intubation have been made [3]. A validation study of a new clinical score to predict difficult ventilation through a supraglottic airway (based on the risk factors of male, age >45 years, short thyromental distance, and limited neck movements) [31] indicated that a high score is associated with a six- to sevenfold increased risk of failure. When a supraglottic airway has been inserted, its cuff should not be overinflated as it would increase the risk of pulmonary aspiration [32].

Invasive access to the infraglottic airway (such as cricothyrotomy or tracheostomy) is regarded as the last resort [4–6], but recent large-scale studies have shown that the success rate may be low [1, 33]. Therefore, it is necessary to find which method is most effective [34–36]. There is growing evidence that percutaneous cricothyrotomy using a narrow-bore cannula (once advocated for use for its simplicity) may frequently be ineffective [1, 37]. A systematic review [37] has shown that the use of jet ventilation is associated with a high incidence of serious complications (e.g., device failure or barotrauma), particularly when it is used during 'cannot intubate, cannot oxygenate' emergency situations.

Studies using cadavers and animal models have shown that, compared with percutaneous cricothyrotomy (with Seldinger or Trocar method), surgical cricothyrotomy was associated with a higher success rate and a lower incidence of complications [38, 39]. Because of these reasons, it is now recommended that surgical cricothyrotomy should be regarded as the most reliable method, and should be learned and regularly rehearsed by all anesthesiologists [4, 40]. One major reason of failed cricothyrotomy is difficulty in identifying the cricothyroid membrane [35, 38, 41], and the use of ultrasonography will minimize the incidence of failed identification [42] (Fig. 1).

Training

It has repeatedly been pointed out that airway complications are commonly associated with poor standards of care [1, 33]. Therefore, regular training for routine and emergency airway management (including cognitive, psychomotor, and behavioral areas) has been stressed [43–45].

The fiberoptic bronchoscope is regarded as the most reliable tool in patients with difficult airways, but considerable skill and knowledge are required to achieve smooth tracheal intubation [46, 47]. A bronchoscopy simulator (ORSIM® bronchoscopy simulator) [47] allows training and assessing subjects on both normal and abnormal airway simulations. As the use of a fiberoptic bronchoscope for tracheal intubation has been reduced

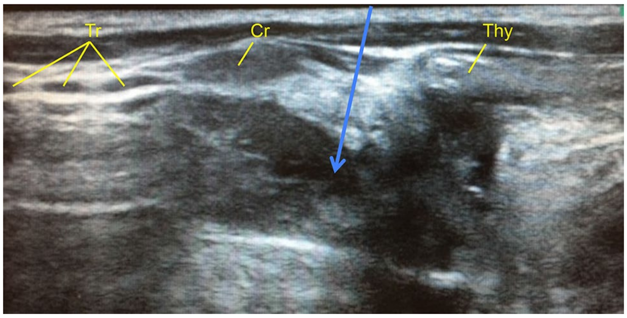

Fig. 1 Identification of the cricothyroid membrane with ultrasonography (longitudinal view). The ultrasound transducer placing longitudinally in the *midline*, indicating the puncture site of cricothyroid membrane (*arrow*) between the thyroid cartilage (*Thy*) and cricoid cartilage (*Cr*), together with tracheal cartilages (*Tr*)

(due partly to use of alternative devices such as videolaryngoscopes), training using this kind of a simulator may be necessary. A simple procedure (traction of the tongue) may facilitate fiberoptic intubation [48].

One reliable method of training is to use a suitable model and setting. Compared with a manikin model, a cadaver with lifelike conditions (Thiel embalming technique) [49, 50] or a porcine model of an obese neck or a neck with a burn [43] has been shown to be a better model for training. A new visually based cognitive aid ('Vortex') [51], which is designed to be used in real-time during emergency airway management, has been devised to support team function and target recognized failings in airway crisis management.

Conclusions

This brief summary of recently published articles indicates that there has been a considerable progress in difficult airway management. By updating our knowledge and skills, we should keep attempting to achieve trouble-free airway management.

References

1. Cook TM, Woodall N, Frerk C. 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 1: anaesthesia. Br J Anaesth. 2011;106:617–31.
2. Cook TM, Woodall N, Frerk C, 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.
3. Tachibana N, Niiyama Y, Yamakage M. Incidence of cannot intubate-cannot ventilate (CICV): results of a 3-year retrospective multicenter clinical study in a network of university hospitals. J Anesth. 2015;29:326–30.
4. Frerk C, Mitchell VS, McNarry AF, Mendonca C, Bhagrath R, Patel A, O'Sullivan EP, Woodall NM, Ahmad I, Difficult Airway Society intubation guidelines working group. Difficult Airway Society 2015 guidelines for management of unanticipated difficult intubation in adults. Br J Anaesth. 2015;115:827–48.
5. Apfelbaum JL, Hagberg CA, Caplan RA, Blitt CD, Connis RT, Nickinovich DG, Hagberg CA, Caplan RA, Benumof JL, Berry FA, Blitt CD, Bode RH, Cheney FW, Connis RT, Guidry OF, Nickinovich DG, Ovassapian A, American Society of Anesthesiologists Task Force on Management of the Difficult Airway. 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.
6. Japanese Society of Anesthesiologists. JSA airway management guideline 2014: to improve the safety of induction of anesthesia. J Anesth. 2014;28:482–93.
7. Asai T. Strategies for difficult airway management—the current state is not ideal. J Anesth. 2013;27:1521–4.
8. Ono Y, Shinohara K, Goto A, Yano T, Sato L, Miyazaki H, Shimada J, Tase C. Are prehospital airway management resources compatible with difficult airway algorithms? A nationwide cross-sectional study of helicopter emergency medical services in Japan. J Anesth. 2016;30:205–14.
9. Ono Y, Tanigawa K, Shinohara K, Yano T, Sorimachi K, Sato L, Inokuchi R, Shimada J, Tase C. Difficult airway management resources and capnography use in Japanese intensive care units: a nationwide cross-sectional study. J Anesth. 2016;30:644–52.
10. Lockey DJ, Healey B, Crewdson K, Chalk G, Weaver AE, Davies GE. Advanced airway management is necessary in prehospital trauma patients. Br J Anaesth. 2015;114:657–62.
11. De Jong A, Molinari N, Pouzeratte Y, Verzilli D, Chanques G, Jung B, Futier E, Perrigault PF, Colson P, Capdevila X, Jaber S. 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.
12. Nørskov AK, Wetterslev J, Rosenstock CV, Afshari A, Astrup G, Jakobsen JC, Thomsen JL, Bøttger M, Ellekvist M, Schousboe BM, Horn A, Jørgensen BG, Lorentzen K, Madsen MH, Knudsen JS, Thisted BK, Estrup S, Mieritz HB, Klesse T, Martinussen HJ, Vedel AG, Maaløe R, Bøsling KB, Kirkegaard PR, Ibáñez CR, Aleksandraviciute G, Hansen LS, Mantoni T, Lundstrøm LH. Effects of using the simplified airway risk index vs usual airway assessment on unanticipated difficult tracheal intubation—a cluster randomized trial with 64,273 participants. Br J Anaesth. 2016;116:680–9.
13. Teoh WH, Kristensen MS. Prediction in airway management: what is worthwhile, what is a waste of time and what about the future? Br J Anaesth. 2016;117:1–3.
14. Healy DW, LaHart EJ, Peoples EE, Jewell ES, Bettendorf RJ Jr, Ramachandran SK. A comparison of the Mallampati evaluation in neutral or extended cervical spine positions: a retrospective observational study of >80,000 patients. Br J Anaesth. 2016;116:690–8.
15. Badiger S, John M, Fearnley RA, Ahmad I. Optimizing oxygenation and intubation conditions during awake fibre-optic intubation using a high-flow nasal oxygen-delivery system. Br J Anaesth. 2015;115:629–32.
16. Priebe HJ. Should anesthesiologists have to confirm effective facemask ventilation before administering the muscle relaxant? J Anesth. 2016;30:132–7.
17. Windpassinger M, Plattner O, Gemeiner J, Röder G, Baumann A, Zimmerman NM, Sessler DI. Pharyngeal oxygen insufflation

during AirTraq laryngoscopy slows arterial desaturation in infants and small children. Anesth Analg. 2016;122:1153–7.
18. Liu EH, Asai T. Cannot intubate cannot ventilate—focus on the 'ventilate'. J Anesth. 2015;29:323–5.
19. Asai T. Avoiding repeated attempts at tracheal intubation: can videolaryngoscopes be the answer? Anesthesiology. 2016;125:615–7.
20. Suppan L, Tramèr MR, Niquille M, Grosgurin O, Marti C. Alternative intubation techniques vs Macintosh laryngoscopy in patients with cervical spine immobilization: systematic review and meta-analysis of randomized controlled trials. Br J Anaesth. 2016;116:27–36.
21. Kleine-Brueggeney M, Greif R, Schoettker P, Savoldelli GL, Nabecker S, Theiler LG. Evaluation of six videolaryngoscopes in 720 patients with a simulated difficult airway: a multicentre randomized controlled trial. Br J Anaesth. 2016;116:670–9.
22. Asai T. Videolaryngoscopes: do they truly have roles in difficult airways? Anesthesiology. 2012;116:515–7.
23. Aziz MF, Brambrink AM, Healy DW, Willett AW, Shanks A, Tremper T, Jameson L, Ragheb J, Biggs DA, Paganelli WC, Rao J, Epps JL, Colquhoun DA, Bakke P, Kheterpal S. Success of Intubation rescue techniques after failed direct laryngoscopy in adults: a retrospective comparative analysis from the multicenter perioperative outcomes group. Anesthesiology. 2016;125:656–66.
24. Arslan ZI, Alparslan V, Ozdal P, Toker K, Solak M. Face-to-face tracheal intubation in adult patients: a comparison of the Airtraq™, Glidescope™ and Fastrach™ devices. J Anesth. 2015;29:893–8.
25. Aziz MF, Bayman EO, Van Tienderen MM, Todd MM, Brambrink AM, StAGE Investigator Group. Predictors of difficult videolaryngoscopy with GlideScope® or C-MAC® with D-blade: secondary analysis from a large comparative videolaryngoscopy trial. Br J Anaesth. 2016;117:118–23.
26. Komasawa N, Kido H, Miyazaki Y, Tatsumi S, Minami T. Cricoid pressure impedes tracheal intubation with the Pentax-AWS Airwayscope®: a prospective randomized trial. Br J Anaesth. 2016;116:413–6.
27. Asai T. Videolaryngoscopes: do they have role during rapid-sequence induction of anaesthesia? Br J Anaesth. 2016;116:317–9.
28. Asai T. Airway management in patients undergoing emergency Cesarean section. J Anesth. 2016;30:927–33.
29. Ota K, Sadamori T, Kusunoki S, Otani T, Tamura T, Une K, Kida Y, Itai J, Iwasaki Y, Hirohashi N, Nakao M, Tanigawa K. Influence of clinical experience of the Macintosh laryngoscope on performance with the Pentax-AWS Airway Scope(®), a rigid video-laryngoscope, by paramedics in Japan. J Anesth. 2015;29:672–7.
30. Asai T. Are video laryngoscopes useful for paramedics during cardiopulmonary resuscitation? J Anesth. 2015;29:651–3.
31. Saito T, Chew STH, Liu WL, Thinn KK, Asai T, Ti LK. A proposal for a new scoring system to predict difficult ventilation through a supraglottic airway. Br J Anaesth. 2016;117(Suppl 1):i83–6.
32. Hensel M, Schmidbauer W, Geppert D, Sehner S, Bogusch G, Kerner T. Overinflation of the cuff and pressure on the neck reduce the preventive effect of supraglottic airways on pulmonary aspiration: an experimental study in human cadavers. Br J Anaesth. 2016;116:289–94.
33. Rosenstock CV, Nørskov AK, Wetterslev J, Lundstrøm LH. Emergency surgical airway management in Denmark. A cohort study of 452 461 patients registered in the Danish Anaesthesia Database. Br J Anaesth. 2016;117(Suppl 1):i75–82.
34. Noppens RR. Ventilation through a 'straw': the final answer in a totally closed upper airway? Br J Anaesth. 2015;115:168–70.
35. Asai T. Emergency cricothyrotomy: toward a safer and more reliable rescue method in "cannot intubate, cannot oxygenate" situation. Anesthesiology. 2015;123:995–6.
36. Paxian M, Preussler NP, Reinz T, Schlueter A, Gottschall R. Transtracheal ventilation with a novel ejector-based device (Ventrain) in open, partly obstructed, or totally closed upper airways in pigs. Br J Anaesth. 2015;115:308–16.
37. Duggan LV, Ballantyne Scott B, Law JA, Morris IR, Murphy MF, Griesdale DE. Transtracheal jet ventilation in the 'can't intubate can't oxygenate' emergency: a systematic review. Br J Anaesth. 2016;117(Suppl 1):i28–38.
38. Heymans F, Feigl G, Graber S, Courvoisier DS, Weber KM, Dulguerov P. Emergency cricothyrotomy performed by surgical airway–naive medical personnel: a randomized crossover study in cadavers comparing three commonly used techniques. Anesthesiology. 2016;124:295–303.
39. Chrisman L, King W, Wimble K, Cartwright S, Mohammed KB, Patel B. Surgicric 2: a comparative bench study with two established emergency cricothyroidotomy techniques in a porcine model. Br J Anaesth. 2016;117:236–42.
40. Asai T. Surgical cricothyrotomy, rather than percutaneous cricothyrotomy, in "cannot intubate, cannot oxygenate" Situation. Anesthesiology. 2016;124:269–71.
41. Siddiqui N, Arzola C, Friedman Z, Guerina L, You-Ten KE. Ultrasound improves cricothyrotomy success in cadavers with poorly defined neck anatomy: a randomized control trial. Anesthesiology. 2015;123:1033–41.
42. Kristensen MS, Teoh WH, Rudolph SS. Ultrasonographic identification of the cricothyroid membrane: best evidence, techniques, and clinical impact. Br J Anaesth. 2016;117(Suppl 1):i39–48.
43. Howes TE, Lobo CA, Kelly FE, Cook TM. Rescuing the obese or burned airway: are conventional training manikins adequate? A simulation study. Br J Anaesth. 2015;114:136–42.
44. Kristensen MS, Teoh WH, Baker PA. Percutaneous emergency airway access; prevention, preparation, technique and training. Br J Anaesth. 2015;114:357–61.
45. Timmermann A, Chrimes N, Hagberg CA. Need to consider human factors when determining first-line technique for emergency front-of-neck access. Br J Anaesth. 2016;117:5–7.
46. Jagannathan N, Sequera-Ramos L, Sohn L, Huang A, Sawardekar A, Wasson N, Miriyala A, De Oliveira GS. Randomized comparison of experts and trainees with nasal and oral fibreoptic intubation in children less than 2 year of age. Br J Anaesth. 2015;114:290–6.
47. Baker PA, Weller JM, Baker MJ, Hounsell GL, Scott J, Gardiner PJ, Thompson JMD. Evaluating the ORSIM® simulator for assessment of anaesthetists' skills in flexible bronchoscopy: aspects of validity and reliability. Br J Anaesth. 2016;117(Suppl 1):i87–91.
48. Ching YH, Karlnoski RA, Chen H, Camporesi EM, Shah VV, Padhya TA, Mangar D. Lingual traction to facilitate fiber-optic intubation of difficult airways: a single-anesthesiologist randomized trial. J Anesth. 2015;29:263–8.
49. Van Zundert AA, Kumar CM, Van Zundert TC. Malpositioning of supraglottic airway devices: preventive and corrective strategies. Br J Anaesth. 2016;116:579–82.
50. Szűcs Z, László CJ, Baksa G, László I, Varga M, Szuák A, Nemeskéri Á, Tassonyi E. Suitability of a preserved human cadaver model for the simulation of facemask ventilation, direct laryngoscopy and tracheal intubation: a laboratory investigation. Br J Anaesth. 2016;116:417–22.
51. Chrimes N. The Vortex: a universal 'high-acuity implementation tool' for emergency airway management. Br J Anaesth. 2016;117(Suppl 1):i20–7.