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GUIDELINE

JSA airway management guideline 2014: to improve the safety of induction of anesthesia

Japanese Society of Anesthesiologists

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Purposes of this guideline

Induction of general anesthesia significantly impairs control of the respiratory system, particularly upper-airway maintenance mechanisms. To ensure patient safety, anesthesiologists need to secure the airway during induction of anesthesia. Nevertheless, failure of airway control is a major cause of cardiac arrest and death attributable to anesthetic management [1–3]. The purpose of this airway management guideline is to assist anesthesiologists to achieve safe airway management in the daily practice of clinical anesthesia for all patients, regardless of their age. Maintenance of oxygenation during induction of anesthesia is a primary focus of the guideline. Recommendations for safe procedures during recovery from anesthesia should be added to this guideline in the near future (Q1: 96 %)[1].

The Japanese Society of Anesthesiologists (JSA) recommends that anesthesia providers, including but not limited to JSA members, should follow this guideline. Our recommendations may be adopted, modified, or rejected according to clinical needs and constraints: these are not intended as standards or absolute requirements. This airway management guideline cannot guarantee any specific outcome and is subject to revision as warranted by the evolution of the knowledge, technology, and practice of perioperative airway management.

Formulation processes and evidence levels of the guideline

Formulating an ideal, evidenced-based airway guideline is not easy, because severe complications (such as death, brain death, and cardiac arrest) associated with difficult airways (DA) occur only rarely and often unexpectedly during induction of anesthesia, and because high-level evidence supporting specific airway management strategies is frequently lacking. As many other existing DA guidelines, this JSA airway management guideline has been formulated principally based on the opinions of 26 experts in airway and safety management [4–6]. These experts analyzed and discussed the fundamentals of and common structures in existing DA algorithms and recent scientific evidence that supports specific airway management strategies by means of a series of active discussions at the symposia of annual JSA meetings. Current trends in DA management by JSA members were assessed by a JSA questionnaire survey on "cannot ventilate, cannot intubate" cases in the 536 JSA-certified institutes (unpublished). Accordingly, lack of a high level of evidence is a major limitation of this guideline, and its appropriateness and effectiveness therefore need to be scientifically assessed in the near future. Nonetheless, the airway experts have agreed to make this potentially effective airway management strategy available to all anesthesia providers (Q2: 100 %).

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[1] (Q#: %) The percentage of the authors who agree with the sentence is shown.

Levels of evidence and expert recommendations for specific airway management strategies

Despite the scarcity of strong evidence supporting specific strategies for managing DA situations, key evidence from recent, large, retrospective clinical studies of the DA was actively sought and incorporated into this JSA guideline, provided the experts considered that the clinical benefits exceeded potential risks. Similarly, recent advances in knowledge about the mechanisms of DA, clarified by physiological clinical investigations, have also been included in this guideline. Furthermore, specific strategies for maintenance of oxygenation and airway patency, supported by human physiological experiments and clinical observational studies, are used although none of these has been systematically tested with regard to their effectiveness in decreasing the incidence of severe complications associated with the DA during induction of anesthesia. Because of a lack of strong evidence in this field, recommendation levels for the specific strategies outlined in this guideline differ among the 26 experts, and the percentage of the experts who agree with each strategy is shown. In their opinion, both disagreement on the specific strategy and uncertainty about its appropriateness based on expert knowledge and experience are regarded as nonagreement.

Diagnosis and grading of ventilation status during induction of anesthesia

Life-threatening hypoxemia may occur during induction of anesthesia if delivery of oxygen into the alveoli of the lung becomes insufficient, despite adequate preoxygenation and ventilation attempts with a high concentration of oxygen [7–9]. Accordingly, adequacy of ventilation should be accurately assessed and continuously monitored. Arterial oxygen saturation measured by pulse oximetry (SpO_2) monitoring is apparently not ideal because there is a relatively long "silent" period despite progressive oxygen consumption without an oxygen supply, and the monitor indicates a sudden critical desaturation period with the potential for life-threatening arrhythmias and cardiac arrest. In this guideline, we do not adopt a threshold SpO_2 value such as 90 %, as with the criteria of other guidelines that aim to change airway management techniques, because our goal is to maintain oxygenation throughout induction of anesthesia (Q3: 88 %). In this context, accurate monitoring of breath-by-breath ventilation is appropriate for continuously diagnosing ventilation status and immediately moving to more effective techniques for maintaining oxygenation (Q4: 100 %).

Clinical assessments of efficiency of ventilation

According to the JSA monitoring guideline for safe anesthesia, ventilation status is clinically assessed by thoracic movements, breath sounds, capnography, and tidal volume measurements (http://www.anesth.or.jp/guide/pdf/monitor2.pdf). However, none of these indicators is perfect in the setting of clinical anesthesia. For example, accuracy of inspection of thoracic movements and auscultation of breath sounds depends significantly on the skill and experience of the anesthesiologists, although these may be the only measures available, particularly during massive leakage. Use of a capnograph as an anesthetic monitor is mandatory during anesthesia in many countries, including Japan. Although tidal volume measurements may be more accurate and objective, not all anesthesia machines and patient monitoring systems measure tidal volume. We recommend the use of a capnogram waveform as a reliable diagnostic tool for assessing the efficiency of ventilation during anesthesia (Q5: 81 %).

Definitions of three ventilation grades using the capnogram waveform

The time-capnogram waveform consists of three distinct phases (Fig. 1) [10, 11]. When all phases including phase III, which is characterized by a plateau, are identified on the waveform, ventilation status can be diagnosed as normal (V1), assuming normal ventilation frequency. When the phase II waveform characterized by a rapid upswing alone is identified (lack of phase III), ventilation status can be diagnosed as subnormal (V2). Lack of the waveform (baseline alone) indicates abnormal ventilation (V3), such as apnea or hypoventilation less than dead space. In addition to difficulty in maintaining a patent airway, ventilation status significantly depends on the driving pressure applied to the airway and efforts by the anesthesia provider.

Ventilation status is clinically graded by the maximum achievable capnogram waveforms, and therefore an intentional small tidal ventilation (V2) to avoid gastric insufflation is acceptable. The V1, V2, and V3 ventilation status grades are likely to result from easy, difficult, and impossible airway maintenance, respectively. Accordingly, the patterns of a capnogram waveform allow anesthesia providers to continuously and instantaneously grade ventilation status and to predict the possibility of severe hypoxemia and hypercapnia, as summarized in Fig. 1.

This guideline recommends anesthesia providers monitor the capnogram waveform during either mechanical ventilation or spontaneous breathing (Q6: 96 %). This grading system can be applied to anesthetized patients during facemask (FM) ventilation, ventilation through a supraglottic airway (SGA), or a tracheal tube. Notably, the

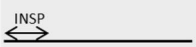
	Ventilation status grades with anesthesia provider's best effort		
expression of ventilation status	V1	V2	V3
ventilation status	normal	subnormal	abnormal
difficulty of airway maintenance	easy	difficult	impossible
potential development of severe hypoxemia	No	possible but unlikely	Yes
potential development of severe hypercapnia	No	Yes	Yes
expected tidal volume range	greater than 5 ml/kg	2 to 5 ml/kg	less than 2 ml/kg
capnogram waveform	all phases	lack of phase III	none
typical capnogram waveform			

Fig. 1 Definitions of three grades of ventilation and their clinical interpretations. This grading system can be applied to anesthetized patients during mechanical or spontaneous breathing through a facemask, a supraglottic airway, or a tracheal tube. See the text for detailed explanations. *INSP* inspiratory phase

capnogram waveform provides only limited information in the neonatal and pediatric population, and therefore the ventilation status grades in these groups of patients should be determined together with any other clinical information available. In addition, the waveform does not accurately indicate ventilation status in patients with cardiac arrest, with massive air leakage from the respiratory circuit, and with ventilation through a small-bore tube such as a cricothyroidotomy tube.

Concept and principles for formulating this guideline

Inclusion of recommendations for daily practice of anesthesia

Current airway management guidelines developed by various anesthesia societies and associations around the world provide recommendations for managing unanticipated DA but not for routine airway management during induction of anesthesia [4–6]. Although prediction of DA is not perfect and DA does occur unpredictably [12], the existing guidelines appear to have reduced the mortality and morbidity associated with airway management [2, 3, 13]. We consider that starting with the best available airway management technique for daily anesthesia induction may assist early recognition of, and responses to, the DA situation, and ultimately decrease the incidence of DA and severe hypoxemia (Q7: 92 %). Accordingly, this guideline includes recommendation of strategies for routine induction of anesthesia, as well as those for managing DA.

Simplification of the airway management algorithm

Because anesthesia providers may not be able to remember a complicated airway algorithm that attempts to cover all possible DA conditions, a low adherence rate can result [2, 3, 13–15]. The JSA airway management algorithm (JSA-AMA) (Fig. 2) represents the essence of the guideline and is simplified by defining three different zones, depending on the degree of patient risk and on the ventilation status grading system as already defined.

The three patient risk zones are characterized by the colors of a traffic signal: green for a safe condition, yellow for a semi-emergency condition, and red for a critical emergency condition. Oxygenation is assured by FM ventilation in the green zone, ventilation with an SGA in the yellow zone, and a surgical airway in the red zone. When ventilation within each zone is graded to be subnormal or abnormal, the patient risk zone shifts to a higher level, irrespective of arterial oxygen saturation (Q8: 96 %). Particular airway devices are not specified in the JSA-AMA, because not all of these are available in every operating room and because even the most effective and successful device may be subject to change over time and may vary depending on the anesthesia providers, the institute, and the patients to be managed (Q9: 96 %). However, we believe that SGAs and surgical airways should be regarded as fundamental rescue airway devices for oxygenation. We recommend that they be prepared in all anesthesia cases and be used appropriately when necessary (Q10: 88 %) [4–6].

The JSA-AMA is appropriate for all anesthesia providers and institutes and allows modification of the algorithm according to the airway techniques available at each institute and for each individual anesthesia provider (Q11: 92 %). Accordingly, so-called DAM (difficult airway management) practice can be fundamentally consistent with JSA-AMA principles. For example, the anesthesia provider is asked to handle unstable ventilation established temporarily using an SGA and a surgical airway in the yellow and red zones (Q12: 85 %). Anesthesiologists should improve their skills for appropriately handling unstable situations through daily practice, or by attending airway seminars, workshops, and simulations of the practice of DAM (Q13: 92 %).

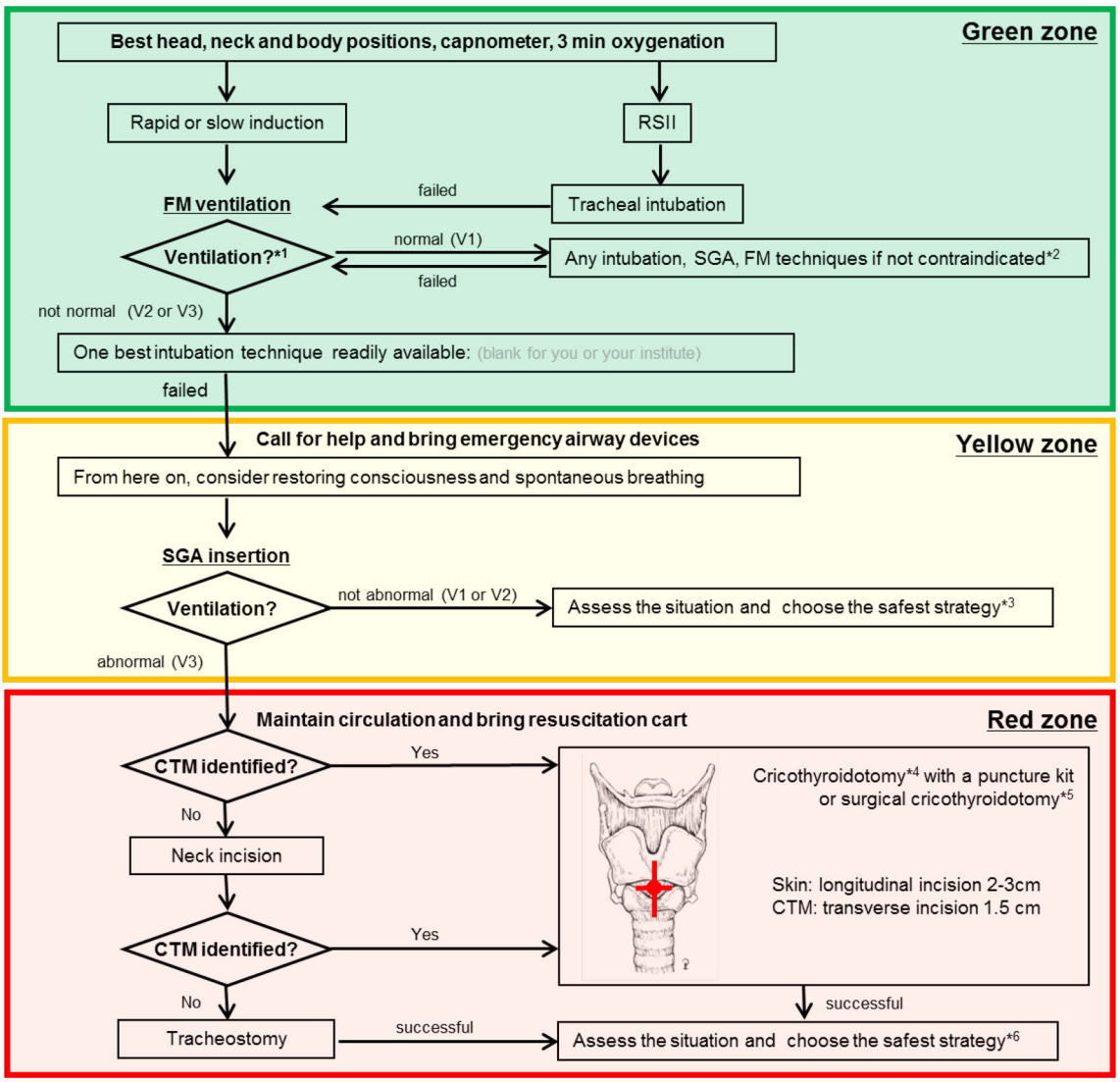


Fig. 2 Japanese Society of Anesthesiologists (JSA) airway management algorithm (JSA-AMA) during induction of anesthesia. *RSII* rapid sequence induction and intubation, *FM* facemask, *SGA* supraglottic airway, *CTM* cricothyroid membrane. **1* Try to improve FM ventilation using the techniques listed in Fig. 5. **2* The attempts should not be repeated more than twice for each anesthesia provider and for each airway device, particularly for direct or indirect laryngoscopy. Consider the risk of pulmonary aspiration particularly during RSII. **3* The strategies may include (1) restoring consciousness and spontaneous breathing, (2) intubation through the device with or without aid of a fiberscope, (3) surgery with the SGA, (4) changing the size and/or type of the SGA, (5) a surgical airway, and (6) other appropriate techniques. **4* Refrain from needle puncture with a large-bore intravenous catheter and emergency jet ventilation. **5* Insert a smaller-diameter tube. **6* Strategies include (1) restoring consciousness and spontaneous breathing, (2) tracheostomy, and (3) tracheal intubation attempts

Rescue airway devices to be provided in or near operating rooms

Delay of several tens of seconds in the provision of rescue airway techniques may lead to life-threatening hypoxemia and cardiac arrest. We recommend that rescue airway devices, which may be used in the yellow and red zones of the JSA-AMA, should be readily available in an area as close as possible to the anesthesia provider [4, 5] (Q14: 100 %). These devices can be stored in a DAM cart, with the full range of various types and sizes of airway devices, placed so as to be accessible within seconds from any operating room (Q15: 92 %). Alternatively or concurrently, the minimum essential devices can be more effectively kept within each operating room, reducing time wasted in bringing these from outside the operating room (Q16: 85 %). Frequently used SGA(s), a needle cricothyroidotomy kit, and a surgical knife for surgical cricothyroidotomy may be essential in the adult population (Q17: 92 %).

Pre-anesthetic airway assessments and choice of anesthesia induction techniques and airway devices

Airway assessment before anesthesia

Anesthesia providers must always prepare for an unanticipated DA because predicting a DA is difficult [12]. Nevertheless, a pre-anesthetic airway assessment should be performed for each patient who will undergo anesthesia to determine airway management strategies (Q18: 92 %). Airway assessment should not be limited to assessments of difficult tracheal intubation with direct laryngoscopy. Potential difficulties with every possible airway management technique including FM ventilation, alternative intubation techniques, SGA insertion, and surgical airway establishment are to be assessed in addition to obtaining a history of DAM, vulnerability to hypoxemia, and the risk of pulmonary aspiration (Q19: 96 %). Recent large epidemiological studies in adult populations have identified the incidence and risk factors associated with various types of DA, as shown in Figs. 3 and 4, but there is no validated systematic method for predicting DA [12, 16–18]. In these studies, a model for predicting the combination of difficult FM ventilation and direct laryngoscopy that takes into account 12 factors may be useful, although its accuracy and clinical value need to be assessed in the Japanese anesthesia population [18] (Fig. 4) (Q20: 77 %).

For example, if seven factors are present, the preoperative risk class is determined to be class V, and consequently the likelihood of a critical condition occurring is predicted to be 18 times higher than with class I patients. The anesthesia provider may decide to perform an awake intubation based on the high preoperative risk. It should be noted that the actual incidence is significantly low even in class V patients (3.31 %), indicating a large false-positive rate. Most importantly, combined difficult FM ventilation and direct laryngoscopy should be anticipated in patients with apparent upper airway abnormalities even without prediction from the model. This model is helpful for determining induction techniques and preparation of the airway devices, although the threshold risk level for the decision should be individually determined (Q21: 85 %).

Choice of airway management strategies and preparation of airway devices

Based on pre-anesthetic airway assessments, anesthesia providers should make a plan for airway management in

Fig. 3 Incidence of various types of difficult airway (DA). *FM* facemask, *DL* direct laryngoscopy

patterns of DA	incidence (study size)	reference
difficult FM	5% (1502)	16
difficult DL	5.8% (50760)	12
difficult FM combined with difficult DL	0.4% (176679)	18
impossible FM	0.15% (53041)	17

Fig. 4 A modified Kheterpal's model for predicting combined difficult facemask ventilation and direct laryngoscopy using 12 preoperative assessment factors [18]

12 factors to be assessed preoperatively

- Mallampati III or IV
- neck radiation changes or mass
- male sex
- limited thyromental distance
- presence of teeth
- body mass index 30 kg/m^2 or more
- age 46 years or more
- presence of beard
- thick neck
- diagnosed sleep apnea
- unstable and/or limited cervical spine mobility
- limited or severely limited jaw protrusion

Kheterpal's prediction of difficulties of facemask ventilation and direct laryngoscopy

Preoperative Risk Class	Incidence within the class	Odds (95% CI)
I (0-3 risk factors)	0.18 %	1.0
II (4 risk factors)	0.47 %	2.56 (1.83-3.58)
III (5 risk factors)	0.77 %	4.18 (2.95-5.96)
IV (6 risk factors)	1.69 %	9.23 (6.54-13.04)
V (7-11 risk factors)	3.31 %	18.4 (13.1-25.8)

each patient [19]. Direct laryngoscopy is the most prevalent intubation technique although it is not necessarily a gold standard for tracheal intubation (Q22: 92 %). This guideline does not recommend specific intubation devices because an optimal intubation technique and airway device may vary depending on circumstantial and anesthesia factors (availability of the devices and skilled supervisors, and types of tracheal tubes to be intubated), anesthesiologist-related factors (skill and preference for certain airway devices), and patient factors (co-operation, susceptibility to hypoxemia, and presence of cardiovascular diseases) (Q23: 100 %). However, we recommend anesthesiologists actively include various alternative intubation techniques and devices available such as videolaryngoscopy [20, 21] (Q24: 100 %), the use of a bougie [22, 23] (Q25: 96 %), intubation through an SGA [24–27] (Q26: 100 %), light-guided intubation [28] (Q27: 77 %), and fiberoptic intubation [29] (Q28: 100 %) in their airway management strategies, particularly when difficulty with direct laryngoscopy is predicted. Anesthesiologists should keep an eye on development and clinical availability of new airway devices that might change and improve the safety and quality of airway management during induction of anesthesia. There is no single, perfectly correct answer in clinical airway management.

Fundamental principles of awake tracheal intubation

In patients with either possible difficulty with FM ventilation or an increased risk of pulmonary aspiration, awake tracheal intubation rather than intubation after induction of anesthesia should be considered [30] (Q29: 92 %). This strategy is, however, difficult in small children and uncooperative patients. The model for predicting combined difficult FM ventilation and difficult laryngoscopy is helpful for deciding on awake intubation (Fig. 4) (Q30: 88 %). Awake tracheal intubation is, in general, safer because awake patients can preserve compensatory and protective mechanisms to maintain a patent upper airway and prevent pulmonary aspiration (Q31: 85 %). Anesthesiologists should recognize that these compensatory mechanisms are depressed, impaired, or even abolished by sedatives depending on the level of sedation [31–34] (Q32: 100 %). Deep sedation resulting in unresponsiveness of the patient should be avoided for "awake" tracheal intubation (Q33: 85 %). Maintenance of spontaneous breathing efforts (contraction of the diaphragm) does not guarantee normal ventilation and oxygenation, particularly during deep sedation (Q34: 100 %). Although topical anesthesia of the upper airway mucosa depresses upper airway functions [35–37], this depression is minimal in patients with a normal upper airway if consciousness is maintained (Q35: 96 %). Awake intubation is not absolutely safe, and life-threatening hypoxemia can develop, particularly in patients with preexisting, severe airway stenosis and dyspnea [38, 39] (Q36: 96 %). Surgical airway devices (and on rare occasions, extracorporeal membrane oxygenation) should be prepared and be readily available when patency of the airway is lost during the trial of awake intubation (Q37: 100 %).

Airway management strategies after induction of general anesthesia: JSA-AMA

JSA-AMA Green Zone: a safe condition

The JSA airway management algorithm (JSA-AMA) (Fig. 2) consists of three different color zones. The green zone includes recommendations of strategies for daily induction of anesthesia. Before induction of general anesthesia, this guideline recommends that anesthesiologists use a capnometer to continuously assess ventilation status (Q38: 100 %). A 3-min inhalation of a high concentration of oxygen with a fitted facemask can effectively replace nitrogen in the lungs with oxygen and delays development of hypoxemia [7–9, 40–42] (Q39: 88 %). Appropriate head and neck positioning can maximize the efficacy of FM ventilation and the success rate of preplanned airway management techniques. The sniffing position, head extension, and the ramp position are effective unless contraindicated [43–45] (Q40: 100 %). The reversed Trendelenburg or sitting position can increase FM ventilation efficacy as well as apnea tolerance time and is recommended particularly in obese, parturient, and currently hypoxemic patients [46, 47] (Q41: 92 %).

General anesthesia, regardless of the type of induction of anesthesia and airway device, begins with the green zone in which patient safety is assured by V1 FM ventilation. Urging the patient to breathe until complete loss of consciousness can shorten apnea time (Q42: 85 %). Positive pressure FM ventilation with airway maneuvers before confirming unresponsiveness is unpleasant and may be unsafe for the patient (Q43: 77 %). No evidence supports the necessity for confirmation of adequate FM ventilation before administration of a neuromuscular blocking agent [48] (Q44: 88 %). Use of an appropriate dose of either depolarizing or nondepolarizing neuromuscular blocking agent improves the success rate of direct tracheal intubation [49] (Q45: 92 %), and possibly the efficacy of FM ventilation [50–52] (Q46: 92 %). A peak inspiratory pressure >20 cmH_2O produces gastric gas inflation, possibly impairing oxygenation and airway protective mechanisms [53–55] (Q47: 88 %). The anesthesia provider should assess FM ventilation status using the capnogram waveform (Q48: 88 %). When V1 FM ventilation is confirmed,

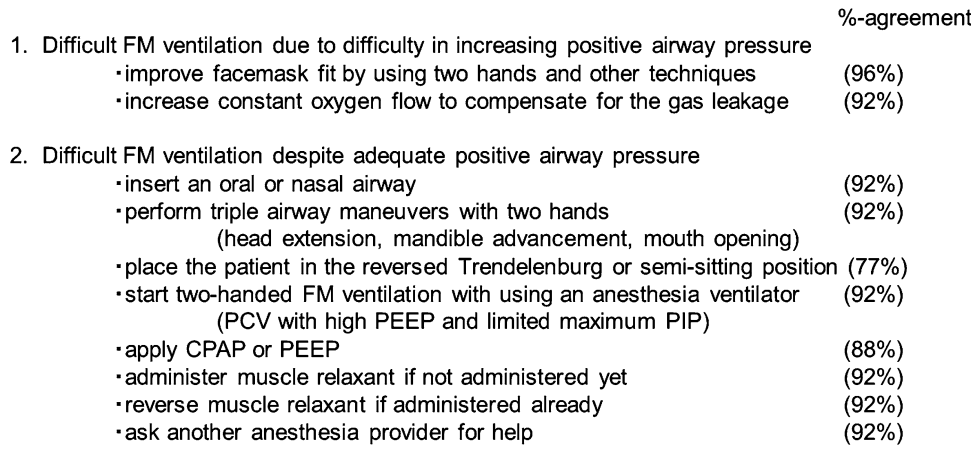


Fig. 5 Techniques to improve facemask (FM) ventilation status. *PCV* pressure controlled ventilation, *PIP* peak inspiratory pressure, *CPAP* continuous positive airway pressure

planned tracheal intubation or SGA insertion can be performed but only under deep anesthesia or complete paralysis (Q49: 85 %).

So long as FM ventilation status remains V1, failure of tracheal intubation or SGA insertion does not directly indicate an increase in patient risk (Q50: 92 %). The anesthesia provider can attempt tracheal intubation, SGA, and FM ventilation if not contraindicated (Q51: 100 %). However, the attempts should not be repeated more than twice for each anesthesia provider and for each airway device, particularly for DL, because of possible development of upper-airway edema, leading to deterioration of FM ventilation and increased mortality [2, 3, 56, 57] (Q52: 96 %). When difficult tracheal intubation and SGA insertion is anticipated, alternative techniques should be prepared before induction of anesthesia (Q53: 100 %). FM ventilation status should be checked whenever an intubation attempt fails (Q54: 100 %). Movement to the yellow zone while calling for senior anesthesiologists and bringing emergency airway devices is indicated when maximum efforts to improve V2 or V3 FM ventilation status fail (Q55: 96 %). The "maximum efforts" can vary depending on the airway devices and anesthesia providers available for the individual case. Anesthesia providers are encouraged to maximize the resources and skills for DAM (Q56: 96 %).

Difficult FM ventilation is possibly caused by leakage of ventilation gas, increased airway resistance, and reduced thoracic compliance. Figure 5 lists techniques for improving ventilation status [58].

In particular, two-handed FM ventilation with a pressure-controlled ventilator is superior to one-handed manual FM ventilation and is recommended particularly when V2 FM ventilation is actually observed [59, 60] (Q57: 85 %). When FM ventilation status remains V2 or V3 despite these maximum efforts and no tracheal intubation is attempted, the anesthesia provider is allowed to perform one trial of best intubation before entering the yellow zone (Q58: 96 %). A high success rate for tracheal intubation is reported when a gum-elastic bougie and/or video laryngoscope are used [20–23, 61]. However, one technique for best intubation is not limited to the use of a particular airway device and must be determined for the individual case and anesthesia provider (Q59: 100 %). When this trial fails, the anesthesia provider should move to the yellow zone (Q60: 100 %).

When tracheal intubation fails during rapid-sequence induction and intubation, FM ventilation with relatively lower positive pressure should be started while applying appropriate cricoid pressure [62] (Q61: 88 %). Application of cricoid pressure may be ineffective and impair airway patency and laryngeal visualization during laryngoscopy in some patients [63–65]. Tracheal intubation should not be attempted under light anesthesia or incomplete neuromuscular blockade because of possible pulmonary aspiration and regurgitation of gastric contents [66] (Q62: 88 %). When V1 FM ventilation is achieved, the anesthesia provider is allowed to re-attempt tracheal intubation with the same technique or an alternative intubation technique while weighing the risk of aspiration and difficulty of tracheal intubation [67] (Q63: 92 %). When FM ventilation status is V2 or V3, movement to the yellow zone is indicated (Q64: 100 %).

JSA-AMA Yellow Zone: a semi-emergency condition

When FM ventilation status is V2 or V3 despite maximum efforts, movement to the yellow zone, a semi-emergency condition, is indicated. Other medical staff including senior anesthesia providers should be called for help (Q65: 100 %), and emergency airway devices including an appropriate size of SGA should be readily available (Q66: 92 %). The SGA is regarded as a reliable rescue ventilation device in this zone and should be inserted when ready [22, 61] (Q67: 92 %).

When the muscles are not paralyzed, administration of a neuromuscular blocking agent may improve FM ventilation. However, when V2 or V3 FM ventilation status continues despite complete neuromuscular blockade, restoration of consciousness and spontaneous breathing should be considered when the patient is at risk for development of severe hypoxemia (Q68: 100 %). Sugammadex (16 mg/kg) is more effective than neostigmine for reversal of neuromuscular blockade [68, 69] (Q69: 88 %). Recovery of spontaneous breathing alone does not assure restoring of ventilation. A patent airway is best established when the patient recovers consciousness [31, 70, 71] (Q70: 88 %). Reversal of opioids and/or benzodiazepines possibly serves to restore both consciousness and spontaneous breathing [72, 73] (Q71: 96 %).

Particularly when anesthesia providers face V3 FM ventilation with difficult intubation, a SGA should be inserted without delay (Q72: 92 %). In accordance with the goal of this guideline, we recommend earlier SGA insertion, when FM is at V2, and even when the patient is not severely hypoxemic [74] (Q73: 96 %). To succeed with the first SGA insertion, anesthesia providers should improve their skill for SGA insertion through daily anesthesia practice (Q74: 96 %). Although we do not recommend a specific SGA device, SGA devices with high success rates and high leak pressures are appropriate [2, 75–77] (Q75: 92 %). An SGA that allows intubation through it, with or without the aid of a fiberscope, will increase options after SGA insertion [24–26] (Q76: 88 %). When the ventilation status remains V2 despite SGA insertion, another type or size of a SGA may be inserted (Q77: 88 %). When anesthesia providers face V3 SGA ventilation despite maximum efforts to improve the situation and anticipate development of severe hypoxemia, they should move to the red zone without delay (Q78: 100 %). When FM ventilation was V2 before movement to the yellow zone in patients with V3 SGA ventilation, restoration of consciousness and spontaneous breathing are to be considered while maintaining oxygenation by FM ventilation [69, 73] (Q79: 92 %).

When V1 or V2 ventilation status is achieved by SGA insertion in the yellow zone, anesthesia providers should consider the available next steps to improve the situation (Q80: 100 %). For V1 SGA ventilation, restoration of consciousness and spontaneous breathing (Q81: 92 %), tracheal intubation through the SGA (Q82: 100 %), and surgery under ventilation with the SGA (Q83: 100 %) are options. V2 SGA ventilation should still be considered a semi-emergency situation (Q84: 96 %). In addition to restoration of consciousness and spontaneous breathing and tracheal intubation through the SGA, changing the size or type of the SGA, or a surgical airway, may improve the situation (Q85: 81 %). Endoscopic observation through the SGA may provide useful information regarding the position of the SGA and development of severe vocal cord swelling and occlusion (Q86: 92 %).

JSA-AMA Red Zone: an emergency condition

When the SGA ventilation status is V3 despite maximum efforts, movement to the red zone, an emergency condition, is indicated before development of severe hypoxemia (Q87: 100 %). Anesthesia providers should request surgical airway devices and an emergency cart to prepare for the possibility of severe arrhythmias and cardiac arrest as a consequence of severe hypoxemia and hypercapnia (Q88: 96 %). Although compensatory tachycardia and hypertension are common, subsequent bradycardia and severe hypotension should be considered more critical and should be pharmacologically treated (Q89: 92 %). Chest compressions should be started immediately when cardiac performance is severely impaired (Q90: 100 %). Temporary cessation of chest compressions for airway management procedures is acceptable because an undesired outcome is expected without restoration of oxygenation (Q91: 96 %). Despite its invasiveness and possible severe complications, anesthesia providers are encouraged to secure a surgical airway without delay if indicated (Q92: 96 %). Any possibilities such as restoration of consciousness and spontaneous breathing, ventilation with oxygen, continuous attempts at tracheal intubation, and SGA ventilation could be tried by another anesthesia provider provided they do not interfere with the surgical procedures (Q93: 96 %). It should be recognized that very limited evidence from case reports and results of simulation studies are available for this zone, and most recommendations are based on expert opinions [78, 79]. This caveat is particularly true for the pediatric population in which surgical airway devices are severely limited because of the wide range of body size in addition to lack of evidence and experience.

Correct identification of the cricothyroid membrane (CTM) is a key for successful emergency surgical airway procedures [80] (Q94: 96 %). When the membrane is palpable from the skin, the use of commercially available needle cricothyroidotomy kits is recommended [81, 82] (Q95: 92 %). In general, direct puncture and insertion types are quick, but severe complications such as misdirected insertion outside the trachea are reported, although more recent devices have safeguards [81]. In contrast, indirect Seldinger-guidewire types require more time to complete the procedures than the direct puncture types but are considered to lead to severe complications less frequently [81, 82]. This guideline recommends equipment with a needle cricothyroidotomy kit of any type be made readily available within or near the operating room (Q96: 92 %). Most of the adult cricothyroidotomy kits have a 4-mm internal diameter tube with a 22-mm outer diameter

connector and allow inflation of the lung for oxygenation with limited ventilation immediately after successful placement of the tube into the trachea. Skin sterilization can be skipped for the emergency CTM puncture (Q97: 73 %). This guideline does not recommend needle punctures with large-bore intravenous catheters when other techniques are available [78, 83, 84] (Q98: 81 %). Use of emergency jet ventilation technique should be limited to skilled anesthesia providers because of the potential for severe complications despite its effectiveness [79] (Q99: 92 %).

When the CTM cannot be identified or the puncture kits are unavailable, surgical cricothyroidotomy allows insertion of a cuffed tracheal tube of a relatively smaller diameter [78, 85, 86] (Q100: 88 %). A longitudinal skin incision of 2–3 cm in the presumed region of the CTM using a surgical knife may accurately reveal the position of the CTM and allows it to be incised transversely for insertion of either a CTM puncture kit tube or a small-bore tracheal tube [87]. If the CTM cannot be identified after neck incision, surgical tracheostomy is indicated (Q101: 92 %). Compared to needle or surgical cricothyroidotomy, surgical tracheostomy takes longer to complete and should not be the first choice (Q102: 88 %). However, the potential necessity for surgical tracheostomy should be considered and prepared for while attempting the CTM approaches. Little evidence currently supports the usefulness of percutaneous tracheostomy using a guidewire as a first-line technique for non-experts, and the device available in Japan is contraindicated in an emergency situation [88, 89] (Q103: 81 %).

Emergency surgical airways, except for tracheostomy, should be considered a temporary rescue airway and inappropriate for maintaining oxygenation and ventilation during the scheduled surgical procedure (Q104: 84 %). Anesthesia providers might choose cancellation of surgery (Q105: 96 %), restoration of consciousness and spontaneous breathing (Q106: 96 %), or trials of tracheal intubation [83] (Q107: 76 %).

When no improvement of oxygenation or ventilation is achieved despite "successful" placement of a surgical airway, reassessment of their correct placement and severe lower airway obstruction caused by bronchospasm or tracheal occlusion should be considered (Q108: 85 %). Pharmacological treatment and endoscopic airway examination may improve the situation (Q109: 92 %).

Acquisition and enhancement of knowledge and techniques for airway management

Every anesthesia provider is encouraged to continue extensive efforts to acquire and enhance their airway management skills and knowledge (Q110: 100 %). Fundamental knowledge of the anatomy and physiology of the upper airway is essential for understanding and implementing this guideline (Q111: 100 %). Through daily anesthesia practice, the success rate and quality of airway management within the green zone should be improved: this includes preoperative airway assessment, safe awake intubation techniques, safe techniques for induction of anesthesia, various intubation techniques, and appropriate use of SGAs (Q112: 96 %). In daily clinical practice, however, anesthesia providers rarely encounter yellow or red zones and therefore should actively participate in DAM workshops and other activities (Q113: 96 %). In particular, they should be familiar with using the CTM kits available at their institutes and practice using them on airway models [90–92] (Q114: 96 %).

Accumulation of airway management data and sharing information with patients

All airway management data including preoperative airway assessments and airway management during induction of anesthesia should be systematically and objectively documented in the anesthesia record (Q115: 100 %). Particularly, details of yellow and red zone events should be recorded for future anesthesia management and should be reported to the JSA for analysis and future revision of this guideline (Q116: 92 %). A history of DAM is the most reliable source of information for anesthesia providers. Details of yellow and red zone events should be provided to the patient and their families and should be shared with future anesthesia providers (Q117: 100 %).

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