J Anesth (2013) 27:152–156
DOI 10.1007/s00540-012-1520-5

JA SYMPOSIUM

How can we improve mask ventilation in patients with obstructive sleep apnea during anesthesia induction?

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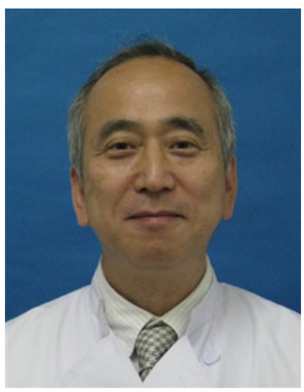
Received: 23 October 2012 / Published online: 5 December 2012



S. Isono

Abstract Recent evidence suggests the possible development of difficult mask ventilation in patients with obstructive sleep apnea. Based on our current understanding of the pathophysiology of pharyngeal airway obstruction in obstructive sleep apnea patients, we conclude that anesthesiologists can decrease respiratory complications during anesthesia induction by conducting careful pre-induction preparations, including body and head positioning and sufficient preoxygenation, and by using the two-hand mask ventilation technique with effective airway maneuvers and appropriate ventilator settings while continuously assessing ventilation status with capnography.

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Introduction

Respiratory depression or cessation during the induction of general anesthesia results in severe hypoxemia and fatal outcome without proper mask ventilation and/or successful tracheal intubation. Two very important tasks of the anesthesiologist are to secure the airway and ventilate the lung. However, difficult mask ventilation and difficult trachea intubation still occurs in 2–7 [1] and 6 % [2], respectively, of cases in which general anesthesia is used. While neither mask ventilation failure nor trachea intubation failure alone is a life-threatening event, the simultaneous occurrence of difficult mask ventilation and trachea intubation is a very frightening event for anesthesiologists. Keterpal et al. [3] reported that the situation of difficult or impossible mask ventilation and difficult intubation is not rare and happens in four of 1,000 anesthesia cases. Limited jaw protrusion, a thick and obese neck anatomy, habitual snoring, and a body mass index (BMI) of >30 kg/m^2 have been identified as independent risk factors for the simultaneous failure of both systems. Notably, all these are features characterize patients with obese obstructive sleep apnea (OSA). Proper airway management of patients with OSA, particularly proper mask ventilation, is therefore mandatory for safe anesthesia induction [4].

OSA patients have higher closing pressures under anesthesia and paralysis

Pharyngeal airway patency is impaired during anesthesia induction mainly due to significant reduction of pharyngeal dilator muscle activity. Anesthesiologists compensate for this reduction by performing airway maneuvers. Compared with non-OSA subjects, patients with OSA have significantly higher pharyngeal airway collapsibility. Isono et al. [5] found that the passive closing pressures (P_{close}) of OSA patients under general anesthesia and complete paralysis are above the atmospheric pressure (2 ± 3 cmH_2O), whereas those of non-OSA subjects are below the atmospheric pressure (−4 ± 4 cmH_2O). Accordingly, anesthesiologists need to reduce the P_{close} by approximately 10 cmH_2O more in OSA patients than in non-OSA subjects [6].

How can the pharyngeal closing pressure be decreased?

Before and during anesthesia induction anesthesiologists need to utilize any procedure possible that may lead to a reduction of pharyngeal closing pressures and improvement of mask ventilation (Fig. 1). It is also advised to avoid any manipulation that may lead to the increased chance of severe hypoxemia and adverse outcomes.

Preparation for anesthesia induction

Proper positioning of the patient and adequate denitrogenation before the induction of general anesthesia are essential. Inhalation of pure oxygen for more than 3 min with the fitted mask eliminates nitrogen from the lung and maximizes the apnea tolerance period [7]. The sitting position or reversed Trendelenburg position prolongs the apnea tolerance time by increasing the functional residual capacity of the lung [8]. The sitting position also decreases the P_{close} by approximately 6 cmH_2O and is advantageous for mask ventilation [9]. The sniffing position or ramping position in obese patients decreases the closing pressure by approximately 4 cmH_2O and is advantageous for both mask ventilation and tracheal intubation; as such, a standard head and neck position should be used for anesthesia induction [10]. Proper preparation is particularly important in obese OSA patients because it is difficult or possibly too late to change body and head positions in obese patients once the difficult airway situation occurs.

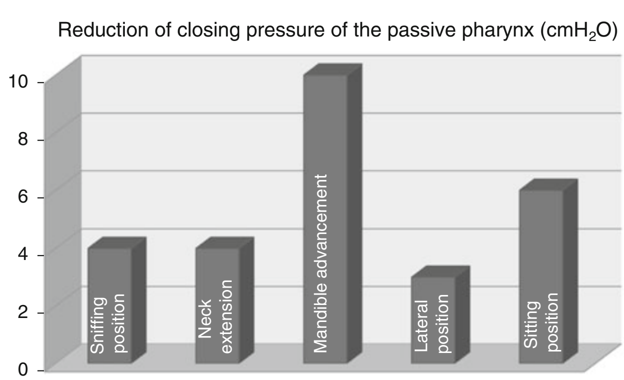

Fig. 1 Reduction of closing pressures of the passive pharyngeal airway in response to various mechanical airway interventions

Capnography for diagnosing the appropriateness of mask ventilation

Use of capnography for anesthesia management is mandatory. Anesthesiologists should use a capnograph to continuously monitor the performance of mask ventilation during anesthesia induction. Most hypoxemic episodes during this critical period are caused by apnea or alveolar hypoventilation. Both ventilation and oxygenation status is foreseen by capnography. A plateau on the capnogram assures the anesthesiologist that both oxygenation and ventilation are adequate, whereas the absence of a capnography wave represents dead space ventilation, indicating the possible development of hypoxemia and hypercapnia unless ventilation is improved. The appearance of a capnography wave without a plateau indicates the development of hypercapnia and the marginal maintenance of oxygenation under ventilation with pure oxygen. This wave form represents an alarm regarding ventilation status if the situation is difficult to improve despite the anesthesiologist's efforts. Careful and continuous assessments of the capnography waves could increase performance of the airway and respiratory management during the perioperative period.

Techniques for anesthesia induction: is awake intubation safe?

Awake intubation is advised in patients with possible difficult airways because patent airway or maximized pharyngeal airway size is expected in fully awake subjects [11]. Regional airway anesthesia and/or sedation are often provided because patients are unable to tolerate the painful and stressful tracheal intubation procedures. However, it should be recognized that airway anesthesia depresses the upper airway reflex that is useful for pharyngeal airway maintenance and, in fact, severe airway narrowing is reported in OSA children after pharyngeal airway anesthesia [12]. Although conscious sedation is appropriate and targeted, inappropriate sedation which significantly depresses the arousal response does not guarantee patent pharyngeal airway and oxygenation.

Should spontaneous breathing be preserved?

No study has systematically examined whether slow induction while maintaining spontaneous breathing or rapid induction with possible apnea is the safest approach for the induction of patients with difficult airways. From the view of pharyngeal airway maintenance, spontaneous breathing is not advantageous over positive pressure ventilation because the negative inspiratory pressure produces constricting forces which can progressively increase during pharyngeal obstruction to over −50 cmH_2O. In order to offset the negative inspiratory pressure, the application of continuous positive airway pressure (CPAP) is advised during spontaneous breathing. However, CPAP is not greatly helpful in the situation of pharyngeal obstruction and greater inspiratory efforts. In contrast, the elimination of spontaneous breathing ensures that the expiratory pressure is at the minimum airway pressure; in addition, no airway constricting forces are developed from the airway lumen during positive pressure ventilation. Accordingly, it is our belief that for OSA patients the rapid induction method is more advantageous than the slow induction technique.

Advantages of using the anesthesia ventilator in pressure controlled ventilation mode

In our series of experiments measuring closing pressures in OSA patients, none exceeded 10 cmH_2O of closing pressure, suggesting that the application of 10 cmH_2O positive end-expiratory pressure (PEEP) during positive pressure ventilation possibly prevents complete pharyngeal airway closure even in severe OSA patients. In addition, the increased lung volume due to PEEP application improves oxygenation and possibly decreases pharyngeal collapsibility through a tracheal traction mechanism [4, 13]. Higher positive pressure during the inspiratory phase further dilates the pharyngeal airway, but it should be limited to less than the pressure at the upper esophageal sphincter under paralysis to prevent gastric gas insufflations. Excessive gastric gas decreases the functional residual capacity and decreases thoracic compliance, leading to difficult and inadequate mask ventilation in addition to increasing the risk of pulmonary aspiration. In this context, the use of the anesthesia ventilator is advised to accurately regulate the airway pressure with pressure controlled ventilation mode. This strategy allows the anesthesiologist to use two hands for performing airway maneuvers, which further improves the efficacy of mask ventilation [14].

Is the administration of muscle relaxants unsafe?

Muscle relaxants should be administered cautiously in the case of difficult or impossible mask ventilation because of an inability to restore spontaneous breathing—even for a short-acting muscle relaxant such as succinylcholine and even when sugammadex is available for prompt reversal. It should be noted, however, that the administration of muscle relaxant per se does not significantly increase pharyngeal airway collapsibility when the pharyngeal airway motor neurons are already profoundly depressed after anesthesia induction. In this context, whether a muscle relaxant can be safely used for patients with difficult airways remains a controversial issue. Although there is no conclusive evidence to address this clinically significant issue, both difficult and impossible mask ventilation have been shown to improve after the administration of succinylcholine [15]. In support of the safety of paralysis during anesthesia induction, several recent studies have confirmed the absence of mask ventilation impairment following the administration of non-depolarizing muscle relaxants [16, 17].

Possible advantages of using succinylcholine

Succinylcholine is a short-acting depolarizing muscle relaxant currently available in the clinical setting. Because of its possible adverse side effects, this drug is not routinely used in most institutes, particularly in Japan. However, its potential usefulness for difficult mask ventilation has been suggested and recently supported by the results of two studies [15, 18]. In one of these, Ikeda et al. examined the effects of muscle relaxants on the efficacy of mask ventilation in adults with a normal airway. These researchers found that succinylcholine significantly increased the tidal volume during mask ventilation, particularly through the oral airway route, whereas the administration of rocuronium did not significantly change the efficacy of mask ventilation [18]. Oropharyngeal endoscopy revealed dilation of the pharyngeal isthmus in association with pharyngeal muscle fasciculation. The interesting results of this study should be interpreted with caution until the favorable succinylcholine effect is confirmed in patients with difficult airways.

Triple airway maneuvers with using two hands

Based on series of extensive studies carried out in the 1950s, Safar proposed mouth-to-mouth ventilation with triple airway maneuvers consisting of a combination of mandible advancement, neck extension, and mouth opening as an effective airway maintenance technique in unconscious subjects [19] (Fig. 2). Both neck extension and mandible advancement are reported to decrease the pharyngeal closing pressure by approximately 4 and 10 cmH_2O, respectively, in OSA patients [20, 21]. As such, these are apparently effective techniques for improving mask ventilation. However, it should be noted that mandible advancement did not restore retroplatal airway patency in obese subjects, suggesting a difficulty in nasal mask ventilation [22]. Despite the fact that mouth opening per se does not improve pharyngeal airway patency and rather increases the closing pressures by approximately 2

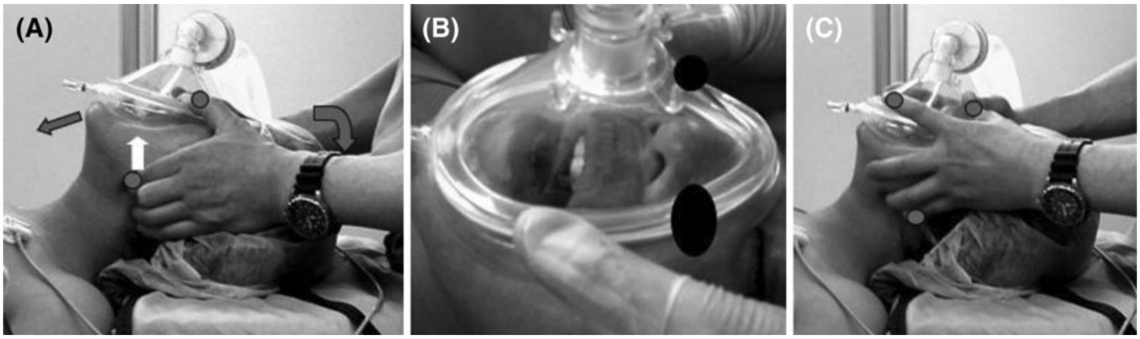

Fig. 2 Triple airway maneuvers (mandible advancement, neck extension, and mouth opening) with two hands in the sniffing position. **a** Only thumbs and forefingers are used for the triple airway maneuvers (Chiba University technique). **b** Mouth opening is easily maintained in the Chiba University technique. **c** Mouth opening is often difficult in the two-hand EC-clamp technique

cmH_2O [20], mouth opening is an important component of the airway maneuvers for mask ventilation in order to select the oral airway route for ventilation. Safar [19] attributed the failure of mouth-to-nose ventilation to mainly partial expiratory obstruction that was possibly caused by the valve-like behavior of the soft palate. We endoscopically confirmed Safar's speculation (unpublished), and Buffington et al. [23] recently reported that in their study anesthesiologists experienced expiratory obstruction in 34 % of 90 adult surgical patients during anesthesia induction and that this phenomenon more frequently occurred in patients with impaired retropalatal space. These researchers identified advanced age, large tongue, and large uvula—all common features of OSA patients—as risk factors. These results clearly support the effectiveness of oral and nasal ventilation with the triple airway maneuver during facemask ventilation. Anesthesiologists should also recognize the fact that the use of two hands can appropriately perform the triple airway maneuver and maximize ventilation efficacy [14, 24]. Very interestingly, Jiang et al. [25] recently demonstrated that nasal ventilation is more effective than oral ventilation in non-paralyzed anesthetized subjects in a neutral head position. They did not find any difference between oral and nasal ventilations when the neck was extended, and this experiment was performed in subjects with possibly normal airways. Future studies in OSA patients are necessary to address which airway should be used for effective mask ventilation.

In conclusion, anesthesiologists can decrease the incidence of respiratory complications during anesthesia induction by carrying out careful pre-induction preparations, including proper body and head positioning and sufficient preoxygenation, and by performing two-hand mask ventilation with effective airway maneuvers and appropriate ventilator settings, while continuously assessing the ventilation status with capnography.

Acknowledgments This work was carried out in the Department of Anesthesiology, Graduate School of Medicine, Chiba University and was supported by grant-in-aid No. 24390363 from the Ministry of Education, Culture, Sports, Science and Technology, Tokyo, Japan.

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