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How to preoxygenate in operative room: Healthy subjects and situations "at risk"☆,☆☆

Comment preoxygéner au bloc : sujets sains et situations à risque

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ABSTRACT

Intubation is one of the most common procedures performed in operative rooms. It can be associated with life-threatening complications when difficult airway access occurs, in patients who cannot tolerate even a slight hypoxemia or when performed in patients at risk of oxygen desaturation during intubation, as obese, critically-ill and pregnant patients. To improve intubation safety, preoxygenation is a major technique, extending the duration of safe apnoea, defined as the time until a patient reaches an arterial saturation level of 88% to 90%, to allow for placement of a definitive airway. Preoxygenation consists in increasing the lung stores of oxygen, located in the functional residual capacity, and helps preventing hypoxia that may occur during intubation attempts. Obese, critically-ill and pregnant patients are especially at risk of reduced effectiveness of preoxygenation because of pathophysiological modifications (reduced functional residual capacity (FRC), increased risk of atelectasis, shunt). Three minutes tidal volume breathing or 3–8 vital capacities are recommended in general population, mostly allowing achieving a 90% end-tidal oxygen level. Recent studies have indicated that in order to maximize the value of preoxygenation (i.e, oxygenation stores) obese and critically-ill patients can benefit from the combination of breathing 100% oxygen and non-invasive positive pressure ventilation (NIV) with end-expiratory positive pressure (PEEP) in the proclive position (Trendelenburg reverse). Recruitment manoeuvres may be of interest immediately after intubation to limit the risk of lung derecruitment. Further studies are needed in the field of preoxygenation in pregnant women.

Mots clés :
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RÉSUMÉ

L'intubation est un des gestes les plus fréquemment réalisés au bloc opératoire. Elle peut être associée à la survenue de complications vitales en cas de ventilation et/ou d'intubation difficile, chez les patients ne pouvant pas tolérer une hypoxémie même légère et chez les patients particulièrement à risque de désaturation comme les patients obèses, de réanimation ou les femmes enceintes. Pour diminuer les complications liées à l'intubation, la préoxygénation est fondamentale, permettant d'augmenter la durée de l'apnée sans désaturation (saturation artérielle supérieure à 88–90 %). La préoxygénation consiste à augmenter les réserves pulmonaires en oxygène, localisées dans la capacité résiduelle fonctionnelle, et permet de prévenir l'hypoxémie qui pourrait survenir durant la tentative d'intubation. Les patients obèses, de réanimation et les femmes enceintes sont particulièrement à risque d'une efficacité réduite de la préoxygénation à cause de modifications physiopathologiques : diminution de la capacité résiduelle

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fonctionnelle, risque augmenté d'atélectasies, shunt. La ventilation spontanée pendant 3 minutes à volume courant ou 3 à 8 capacités vitales sont recommandés dans la population générale, permettant le plus souvent d'atteindre un seuil d'oxygène expiré de 90 %. Des études récentes ont montré que pour maximiser la préoxygénation, les patients obèses et de réanimation pourraient bénéficier d'une préoxygénation à 100 % en ventilation non invasive, avec une pression expiratoire positive, en position proclive. Les manœuvres de recrutement présentent un intérêt juste après l'intubation pour limiter le risque de dérecrutement pulmonaire. Chez la femme enceinte, d'autres études dans le domaine de la préoxygénation sont nécessaires.

1. Introduction

In operating room (OR), airway management is one of the most challenging procedures [1]. Hypoxemia and cardiovascular collapse are the initial most serious life-threatening complications associated with intubation, both in planned intubations and in emergency intubations [2,3]. To prevent hypoxemia following intubation, several preoxygenation techniques have been implemented, as breathing manoeuvres and high-inspired oxygen fraction (FiO_2) [4,5]. However, these techniques may be associated with adverse effects and complicated by post-intubation atelectasis [6]. Their effectiveness in reducing hypoxemia may vary considerably according to the patient's history. The objectives of this article are to describe the patients at risk of oxygen desaturation during and following intubation, to identify in which patients' conventional preoxygenation may have a limited efficacy, and to describe the different strategies of preoxygenation according to patient's history.

2. How to identify patients "at risk" of desaturation during intubation?

There is a low risk of desaturation after standard 3-minute preoxygenation in patients with low metabolic demands, without pulmonary pathology and adequate hemoglobin. Some patients are at particularly risk of oxygen desaturation during intubation. Supine position decreases FRC (0.8 to 1.0 L on average) through multiple mechanisms, including the lungs' weights in a rigid chest wall, and the heart and chest wall weights decreasing the transverse thoracic diameter [7]. Abdominal contents are also moved upwards, causing a cranial shift of the diaphragm, thereby impairing lung volumes. Obesity is therefore also associated with a reduction in FRC [8]. Obesity and pregnancy are the two main situations where FRC is decreased and where the risk of atelectasis is increased [6]. Moreover, oxygen consumption is increased in the obese and pregnant patients. Other "at risk" patients include those who cannot safely tolerate a mild degree of hypoxemia (epilepsy, cerebrovascular disease, coronary artery disease, sickle cell disease etc.). Patients considered to be "difficult to intubate" are also at risk of desaturation during intubation [9]. Difficult intubation is a major risk factor of complications such as hypoxemia in OR [10]. These patients difficult to intubate can be detected before intubation procedure by searching risk factors of difficult intubation.

Critically-ill patients intubated in the OR often experience both acute respiratory failure [2,3], low hemoglobin level, high oxygen consumption, low pulmonary volume and low ventilation/perfusion ratio. In these cases, the risk of hypoxemia and cardiovascular collapse during the intubation process (often crucial) is particularly elevated. Respiratory muscle weakness ("ventilatory insufficiency") and gas exchange impairment ("respiratory insufficiency") are often present. Moreover, incidence of difficult intubation is higher in these critically patients than in OR [11]. It is then worth anticipating life-threatening complications that may occur during intubation [3,11].

3. In which patients conventional preoxygenation has limited efficacy?

Rapid sequence induction was developed to care for patients at high risk of aspiration. After rapid sequence induction, desaturation is likely to occur in the 45 to 60 seconds following neuromuscular blockers administration, if the patient breathes room air before rapid sequence tracheal intubation. Heller and Watson [12] first revealed an increased time to desaturation if the patients received 100% oxygen preoxygenation before tracheal intubation, in comparison with room air. Preoxygenation allow for placement of a definitive airway, extending the duration of safe apnea, i.e. the time until a patient reaches an arterial saturation level of 88% to 90%.

3.1. Obese patients

Standard preoxygenation may be ineffective in obese patients, because of cardiorespiratory severe changes. Indeed, the FRC, which is the main store of oxygen, is limited. The FRC decreases with increasing body mass index (BMI) and is reduced by two-third compared to non-obese patients in morbidly obese patients [13]. Entire expiratory residual volume is used during spontaneous breathing in obese patients, because of the elevation of the diaphragm (increased intra-abdominal pressure and amount of fatty tissue in the thorax). FRC may fall within the range of the closing capacity resulting in small airway closure. The FRC is decreased in sitting or supine position compared to the upright position, and it is still reduced in the anti-Trendelenburg position (procline position) [14]. Moreover, the perfusion-ventilation ratio and the pulmonary circulation abnormalities explain a shunt of non-oxygenated blood in the lung (up to 10–20%) [15].

3.2. Hypoxemic critically-ill patients

The critically-ill patient is at particular risk for hypoxemia during emergency airway management [2,16,17]. Critically-ill patients who require tracheal intubation may suffer from a variety of preexisting cardiopulmonary pathologies, ventilation/perfusion imbalances, anemia, hypermetabolic states, low cardiac output, airway obstruction, pain, and depressed respiratory efforts. Consequently, they have a suboptimal response to preoxygenation efforts combined with an increase propensity of suffering desaturation as compared with their normal counterparts [16]. Their care is further complicated by an increased risk for difficulties in managing their airway placing the critically-ill patient at a higher risk for morbidity and mortality [2,11].

Finally, in case of pulmonary edema or pneumonia, some alveoli (collapsed or filled with fluid) are perfused but not ventilated. The effect is an increased shunt with non-oxygenated blood from the pulmonary arteries, decreasing the efficacy of preoxygenation.