Review Article

Pre-oxygenation and apneic oxygenation in patients living with obesity – A review of novel techniques

ABSTRACT

Morbidly obese patients are in the group of patients, who can desaturate fast because of changes in lung volumes and reduction in Functional Residual Capasity due to obesity. There are novel methods to improve preoxygenation and to maintain oxygneation during intubation efforts. In this paper we present methods of apneic oxygenation for morbidly obese patients.

Key words: Apneic oxygenation, cpap, hfno, obesity

Introduction to Preoxygenation

Preoxygenation is widely regarded as a key technique in anesthetic practice. A high fraction of inspired oxygen (FiO2) is delivered to the patient prior to the induction of anesthesia and subsequent airway management. The relevant physiology is well described,[1] and the basic premise is that preoxygenation increases the oxygen stores of the body and delays arterial oxygenation desaturation. This is also referred to as the safe apneic time and is generally defined as the time from cessation of breathing to the time when the peripheral arterial oxygen saturation (SpO2) declines to 90%. In addition to increasing the fraction of alveolar oxygen (FAO2), preoxygenation also washes out alveolar nitrogen. In the literature, the terms preoxygenation and denitrogenation are sometimes used interchangeably. The above technique and the associated physiology have been reported for many years dating back to 1955,[2,3] but it is now considered so integral to anesthetic practice that in 2015 the Difficult Airway Society Guidelines from the UK mandated "ALL patients should be preoxygenated prior to the induction of general anesthesia."[4]

Classically, several methods have been described to achieve adequate preoxygenation. These were summarized by Baraka *et al*.[5] and include

Tidal volume breathing,

One vital capacity breath followed by tidal breathing,

A single tidal capacity breath,

4–8 deep inspiratory capacity breaths, and

Extended deep breathing of up to 16 inspiratory capacity breaths.

Access this article online	
Website: www.saudija.org	Quick Response Code
DOI: 10.4103/sja.sja_351_22	

How to cite this article: Gaszynski T, McKechnie A. Pre-oxygenation and apnoeic oxygenation in patients living with obesity – A review of novel techniques. Saudi J Anaesth 2022;16:322-6.

Tomasz Gaszynski, Andrew McKechnie[1]

Department of Anesthesiology and Intensive Therapy, Medical University of Lodz, Poland, [1]Lewisham and Greenwich NHS Trust, London, UK

Address for correspondence: Prof. Tomasz Gaszynski,
Department of Anesthesiology and Intensive Therapy, Medical University of Lodz, Poland.
E-mail: tomasz.gaszynski@umed.lodz.pl

Submitted: 30-Apr-2022, **Accepted:** 30-Apr-2022, **Published:** 20-Jun-2022

However, whilst the use of these techniques has long been advocated, variations in patient populations and individual physiology may impact their effectiveness.

Patients living with obesity have a very different physiology in a number of ways. From a respiratory perspective, this population has a decreased Functional Residual Volume (FRC), generally lower tidal volumes, decreased compliance, higher oxygen demand, and a higher risk of atelectasis. All of these factors together result in patients with obesity desaturating significantly sooner after induction than the non-obese group.[6]

In this paper, the authors will look beyond the classic techniques and assess the more novel approaches to preoxygenation in patients living with obesity, with an additional focus on the concept of apneic oxygenation. This is an attempt to maintain oxygen saturations once the patient is apneic, typically prior to subsequent intubation and ventilation.

Patient Positioning

Before considering new techniques, it is worthwhile to assess the importance of patient positioning and the impact on preoxygenation and safe apneic time.

Altermatt *et al*.[7] studied 40 patients with body mass index (BMI) >35 and were assigned to either a sitting or supine group. Preoxygenation was achieved with eight deep breaths of 10 l/min oxygen. The patients were induced, and the trachea was intubated. At this point, they were disconnected from the anesthetic circuit and left apneic until the saturation (SpO2) decreased to 90%. The time taken was recorded. The results showed that the mean time to desaturation was significantly longer in the sitting group. The conclusion is that even in a classic preoxygenation technique, the sitting position alone can significantly extend the tolerance to apnoea in patients with obesity.

Many other studies have shown a similar positional effect. Couture *et al*.[8] concluded that in the obese population, positioning patients with their heads above their feet by tilting the table 25 degrees, significantly increases FRC and oxygen storage capacity.

Novel Techniques

There have been several methods of direct passive oxygen administration recently described in the literature. Oxygenation has been administered via a face mask, nasal cannula, nasopharyngeal catheter, and also via insufflation tubing in laryngoscopes, video laryngoscopes, and bronchoscopes.

In a prospective, randomized study, Ramachandran *et al*.[9] evaluated the efficacy of apneic oxygenation using nasal cannula in a group of 30 male patients with obesity undergoing surgery under general anesthesia. Fifteen patients received oxygen via nasal prongs (flow rate of 5 l min^{-1}). The control group consisted of 15 patients not receiving O_2 via the nasal route. The apnoea time SpO_2 ≥95% in the control group without nasal oxygen was significantly shorter than in the group with oxygen delivered by nasal catheters (3.49 ± 1.33 to 5.29 ± 1.02 min). More patients (n = 8, 53.3%) in the nasal catheter group had SpO_2 ≥95% after six minutes when compared to only one in the group without catheters. In their study, Ramachandran *et al*. demonstrated that nasal O_2 administration in obese patients significantly prolongs the SpO_2 ≥95% time during a simulated difficult laryngoscopy.

A similar study was performed by Moon *et al*.[10] Patients were divided into three subgroups: oxygenation – 15 l/min via standard nasal cannula, air – 15 l/min of air via the same method, and control – no administration of air or oxygen. The oxygen group had a median safe apneic duration that was 103 s longer than the control group. The remaining groups–air insufflation and control–had a similar shorter time of safe apneic period.

Prolonged safe apneic time with the use of nasopharyngeal oxygen insufflation in obese patients was described by Barak *et al*.[11] Two groups of 17 morbidly obese patients were compared. The first group received nasal oxygen supplementation after pre-oxygenation via a nasopharyngeal catheter positioned through the nasal cavity with the tip of the catheter placed in the pharynx, by the entrance to the larynx [Figure 1].

The second group received routine facemask preoxygenation. Preoxygenation was supplemented with O_2 insufflation (via nasopharyngeal catheter) in morbidly obese patients. SpO_2 100% was maintained for four minutes in all but one study participant. In the control group, post-oxygenation apnoea without O_2 supplementation led to a drop of SpO_2 from 100% to 95% in a mean time of 145 s. The authors of this study found that oxygen insufflation to the pharynx after pre-oxygenation in morbidly obese patients significantly delayed desaturation during apnoea.

Another method of apneic oxygenation described by Heard *et al.* is the RAE (Ring-Adair-Elwyn) buccal oxygen delivery system.[12] A preformed pediatric sized 4–5 RAE endotracheal tube was placed via the left corner of the mouth alongside the wall of the buccal cavity [Figure 2]. The flow rate of oxygen through this RAE tube was set to 10 l/min ^{1}. The median

safe apnea time (SpO_2 > 95%) for the buccal oxygen group was 12.5 minutes which was a 2.5-fold increase compared to the control group

In his prospective observational study, Gaszynski evaluated the use of nasal continuous positive airway pressure (CPAP) in obese patients during intubation attempts.[13] The concept of this study was based on the common use of CPAP for the treatment of obstructive sleep apnoea (OSA) in obese patients. 100% oxygen was delivered from an anesthetic machine fresh gas flow outlet titrating flow, and the valve was positioned to maintain an airway pressure of 15 cmH_2O (1.47 kPa). The use of CPAP masks had no apparent negative effect on video laryngoscope-guided intubation [Figure 3]. All patients achieved six minutes of apnea with SpO_2 remaining above 94% after this time. The authors observe that this clearly indicates that this method of apneic oxygenation in patients with obesity increases oxygenation efficacy as well as provides extended safe apnea time, both of which may be of benefit during difficult airway management.

All procedures requiring sedation carry the risk of desaturation, and this is particularly true in patients with obesity. Such procedures include endoscopy, angiography, direct current cardioversion, and others that do not require general anesthesia. The authors suggest that the use of CPAP, including dedicated masks such as the SuperNO$_2$VA™ (Vyaire Medical, Mettawa, IL, USA), may protect the patients against hypoxia [Figure 4].

Although further studies are needed to confirm this view.

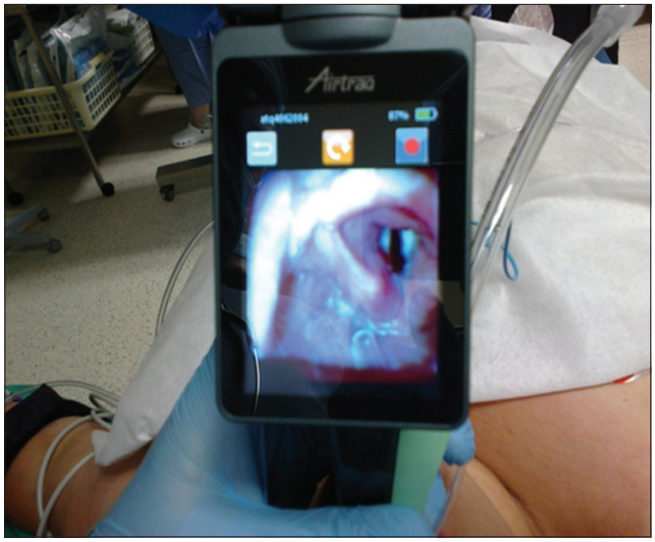

Figure 1: Nasopharyngeal catheter placed by the entrance to the larynx

Figure 2: Buccal oxygen administration via RAE tube

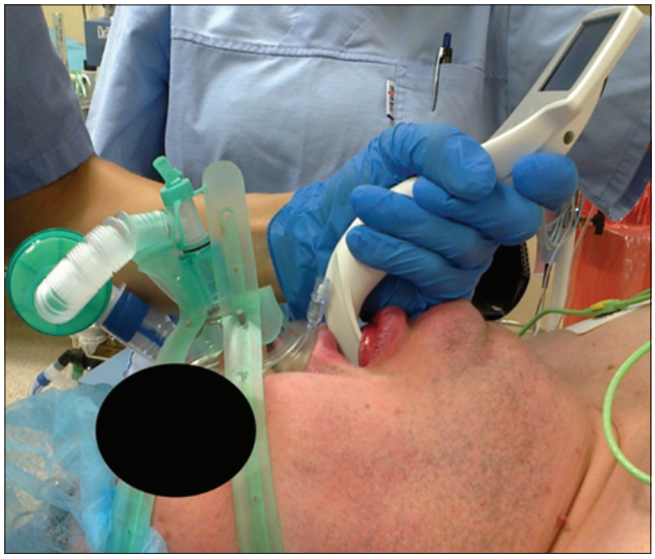

Figure 3: Nasal CPAP during tracheal intubation

Figure 4: SuperNO$_2$VA™ (Vyaire Medical, Mettawa, IL, USA)

This device aims to maintain the patency of the upper airway and assist ventilation by providing a high level of pressure regulated FiO_2. The ability to generate positive airway pressure may minimize upper airway obstruction and thus may reduce the need for tracheal intubation and intubation-related complications.[14] In a study by Kozinn *et al*., they described patients who underwent procedures requiring deep sedation. Airway patency was maintained in all patients throughout the procedure, and the lowest SpO_2 was 98%.[15]

In a study by Bai *et al.*, the previously mentioned CPAP mask was used for airway management in patients undergoing elective colonoscopy.[16] In this randomized study, 134 obese patients were recruited. The investigators compared the number of additional interventions with the evaluated devices, i.e., CPAP mask and nasal cannula. Ventilation conditions and the frequency of hypoxemia were also assessed. Hypoxemia with SpO_2 <90% occurred significantly more often in patients with nasal cannulae (22% versus 5%). In the SuperNO_2VA™ group, a CPAP value close to the target value of 10 cmH_2O was achieved. The need for airway interventions was also reduced, resulting in a decreased incidence of hypoxemia and improved minute ventilation.

Kozinn *et al*. showed the advantage of the CPAP method over standard nasal oxygenation in maintaining adequate ventilation and reducing the risk of hypoxemia. In a published case report of a morbidly obese patient (BMI 47.2) who required deep sedation for esophageal ultrasound examination and DC cardioversion, they successfully used the SuperNO_2VA™ device to achieve immediate relief of airway obstruction and maintenance of SpO_2 at 99% until the end of the procedure.[15] However, it must be remembered that this is one case only and may not be applicable to the patient population until further evidence of benefit is available.

High Flow Nasal Oxygen

High Flow Nasal Oxygen (HFNO) has long been used to treat acute respiratory failure in acute medicine and in intensive care units; commonly, this is referred to as Optiflow.[17] However, it was not until 2015 that anesthetists began to reassess its usefulness in the theater environment.

Patel *et al*.[18] extended the safe apneic times of 25 patients with known difficult airways undergoing general anesthesia for laryngeal surgery. This was achieved through continuous delivery of transnasal high-flow humidified oxygen. This was initially to provide preoxygenation but continued post-induction of anesthesia and neuromuscular blockade (apneic phase) until a definitive airway was secured. The median safe apneic time was 14 minutes, although at least one patient was apneic for 65 minutes. During this period, no patient experience arterial desaturation <90% (1 patient desaturated to 90%), and most maintained saturations above 94%. Furthermore, the rate of increase in end-tidal carbon dioxide was 0.15 kPa per minute, suggesting a ventilatory mechanism was in action. In a number of the patients, this was the only technique used, and no further definitive airway was required to complete the surgical procedure. The team referred to this method as Transnasal Humidified Rapid Insufflation Ventilatory Exchange (THRIVE), and it has subsequently become a standard anesthetic technique at many centers performing laryngeal and head and neck surgery.

HFNO started to be used by many anesthetists for preoxygenation. This was presumably on the basis that if Patel *et al.* could achieve 65 minutes of safe apneic time in a known difficult airway patient, a few extra minutes could be achieved in most other situations.[18]

It is interesting to look at the patients with obesity in the Patel paper. This population was not the ones that achieved 65 mins apneic time. In fact, there was a general trend that as the BMI increased, the safe apneic time decreased. Indeed, the patient that desaturated to 90% within five minutes was a patient with obesity. However, as Patel suggests in the paper, it is likely this patient would have desaturated more rapidly and more severely if a "classic" preoxygenation technique had been employed.

The use of HFNO preoxygenation in patients with obesity has become a well-recognized, commonly used method. The Society for Obesity and Bariatric Anaesthesia (SOBA UK) suggest it as a technique to be considered in this population in their single sheet guidance.[19] The suggested benefits are that the nasal cannula is more comfortable than a facemask, allows a degree of apneic oxygenation if a patent airway is maintained, oxygenation continues during airway manipulations, and the same system can be employed during extubation and in the recovery period.

The evidence base for its effectiveness in the obese is growing. Wong *et al*.[20] studied 40 patients with BMI >40 and split them into an HFNO preoxygenation group and a facemask control group. Both groups were induced using a standard method, and no additional ventilation was undertaken. The primary outcome was safe apneic time, and this was reached if saturations dropped to 95% or six minutes of apnea. Safe apneic time was significantly longer, and the minimum saturations were significantly higher in the HFNO

group. The group concluded that HFNO should be considered in "ALL morbidly obese patients".

A recent paper from Schutzer-Weissmann *et al*.[21] compared HFNO and facemask oxygen delivery on the duration of apnoea in patients with obesity undergoing bariatric surgery. Eighty patients were split between the two groups. After induction, the patients were apneic for either 18 minutes or until oxygen saturation decreased to 92%. Interestingly, the median apnea time in both groups was 18 minutes, but the risk of desaturation was significantly lower in the HFNO group. The authors attribute the longer safe apnea times to patient positioning and the added advantage of using HFNO.

Summary

The importance of preoxygenation in anesthetic practice cannot be overstated. It is a vital step to ensure the safety of all patients. Patients with obesity are particularly at risk of rapid and severe desaturation as a result of certain specific physiological changes.

As a result, the classic methods of preoxygenation may not be adequate or appropriate for this population. The increasing use of novel apneic oxygenation techniques is increasing the safety of anesthesia for patients with obesity undergoing anesthesia. The evidence base is growing, and the authors hope this review goes some way in explaining and highlighting a number of these techniques.

Financial support and sponsorship
Nil.

Conflicts of interest
There are no conflicts of interest.

References

1. Nunn JF. Oxygen. In: Nunn JF, editor. Nunn's Applied Respiratory Physiology. 4th ed. Philadelphia, PA: Butterworth-Heinemann; 1993. p. 247-305.
2. Dillon JB, Darsi ML. Oxygen for acute respiratory depres- sion due to administration of thiopental sodium. JAMA 1955;159:1114-6.
3. Hamilton WK, Eastwood DW. A study of denitrogenation with some inhalation anesthetic systems. Anesthesiology 1955;16:861-7.
4. Frerk C, Mitchell VS, McNarry AF, Mendonca C, Bhagrath R, Patel A, *et al*. Difficult airway society 2015 guidelines for management of unanticipated difficult intu- bation in adults. Br J Anaesth 2015;115:827-48.
5. Baraka AS, Salem MR. Preoxygenation. In: Hagberg CA, editor. Benumof and Hagberg's Airway Management. 3rd ed. Philadelphia, PA: Mosby Elsevier; 2012. p. 657-82.
6. Benumof JL, Dagg R, Benumof R. Critical hemoglobin desat- uration will occur before return to an unparalyzed state fol- lowing 1 mg/kg intravenous succinylcholine. Anesthesiology 1997;87:979-82.
7. Altermatt FR, Muñoz HR, Delfino AE, Cortínez LI. Pre-oxygenation in the obese patient: Effects of position on tolerance to apnoea. Br J Anaesth 2005;95:706-9.
8. Couture EJ, Provencher S, Somma, J, Lellouche F, Marceau S, Bussières JS, *et al.* Effect of position and positive pressure ventilation on functional residual capacity in morbidly obese patients: A randomized trial. Can J Anesth 2018;65:522-8.
9. Ramachandran SK, Cosnowski A, Shanks A, Turner CR. Apneic oxygenation during prolonged laryngoscopy in obese patients: A randomized, controlled trial of nasal oxygen administration. J Clin Anesth 2010;22:164-8.
10. Moon TS, Tai K, Kim A, Gonzales MX, Lu R, Pak T, *et al.* Apneic oxygenation during prolonged laryngoscopy in obese patients: A randomized, double-blinded, controlled trial of nasal cannula oxygen administration. Obes Surg 2019;29:3992-9.
11. Baraka AS, Taha SK, Siddik-Sayyid SM, Kanazi GE, El-Khatib MF, Dagher CM, *et al*. Supplementation of pre-oxygenation in morbidly obese patients using nasopharyngeal oxygen insufflation. Anaesthesia 2007;62:769-73.
12. Heard A, Andrew J, Toner AJ, James R, Evans JR. Apneic oxygenation during prolonged laryngoscopy in obese patients: A randomized, controlled trial of buccal rae tube oxygen administration. Anesth Analg 2017;124:1162-7.
13. Gaszynski T. Nasal continuous positive airway pressure during intubation in superobese patients prolongs safe apnea period. Anesth Analg 2019;129:e3435.
14. Kozinn R, Kim J, Kwan L, Feinleib J. A nasal ventilation mask for a morbidly obese patient with OSA and atrial fibrillation undergoing cardioversion. J Cardiothorac Vasc Anesth 2018;32:945-7.
15. Kozinn R, Foley L, Feinleib J. Super NOVA nasal mask ventilation maintains oxygenation during deep sedation in high-risk patients: A case series. Res Pract Anesthesiol Open J 2018;3:15-9.
16. Bai Y, Xu Z, Chandrashekar M, St Jacques PJ, Liang Y, Jiang Y, *et al*. Comparison of a simplified nasal continuous positive airways pressure device with nasal cannula in obese patients undergoing colonoscopy during deep sedation. Eur J Anaesthesiol 2019;36:633-40.
17. Roca O, Riera J, Torres F, Masclans JR. High-flow oxygen therapy in acute respiratory failure. Respir Care 2010;55:408-13.
18. Patel A, Nouraei SA. Transnasal humidified rapid-insufflation ventilatory exchange (THRIVE): A physiological method of increasing apnoea time in patients with difficult airways. Anaesthesia 2015;70:323-9.
19. Society of Obesity and Bariatric Anaesthesia UK, Anaesthetic Single Sheet Guideline. 2020. Retrieved from: www.sobauk.co.uk/guidelines-1.
20. Wong DT, Dallaire A, Singh KP, Madhusudan P, Jackson T, Singh M, *et al*. High-flow nasal oxygen improves safe apnea time in morbidly obese patients undergoing general anesthesia: A randomized controlled trial. Anesth Analg 2019;129:1130-6.
21. Schutzer-Weissmann J, Wojcikiewicz T, Karmali A, Lukosiute A, Sun R, Kanji R, *et al*. Apnoeic oxygenation in morbid obesity: A randomised controlled trial comparing facemask and high-flow nasal oxygen delivery. Br J Anaesth 2022:S0007-0912 (21) 00800-X. doi: 10.1016/j.bja. 2021.12.011.