Original Article

# Apneic Oxygenation for Morbid Obese Parturient Undergoing Elective Cesarean Section Under General Anesthesia

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## Abstract

**Background:** Maternal obesity is a growing problem worldwide. Pregnancy in addition to obesity renders these parturients markedly vulnerable to rapid desaturation during the apneic phase of anesthesia. In this study, the effects of conventional preoxygenation combined with nasal apneic oxygenation technique are compared to conventional preoxygenation alone in morbidly obese women undergoing elective cesarean sections while receiving general anesthesia.

**Materials and Methods:** This prospective, randomized, controlled trial was conducted at the Obstetrics and Gynecology Hospital of Ain Shams University. Sixty morbid obese parturients were randomly assigned to one of two equal groups. Having a body mass index (BMI) of 40 $kg/m^2$ or higher was regarded as parturient morbid obesity. Eight deep breaths of the vital capacity were taken while breathing 100% $O_2$ at a rate of 15 L/min throughout the preoxygenation process. In conjunction with the pre-oxygenation technique each patient either received 10 L/min $O_2$ via nasal prong (Group O) or not (Group C) according to the assigned group. The primary outcome was the lowest oxygen saturation recorded.

**Results:** When compared to Group C, Group O had significantly greater lowest $SpO_2$ during intubation and less frequent mild hypoxemia. However, maternal complications such as arrhythmias and hypotension in addition to fetal and neonatal wellness were comparable in the two groups.

**Conclusion:** In contrast to conventional preoxygenation, nasal apneic oxygenation boosted the lowest $SpO_2$ and lowered the risk of hypoxemia. Accordingly, nasal apneic oxygenation during preoxygenation of a morbidly obese parturient undergoing an elective cesarean section under general anesthesia may be regarded as a practicable procedure.

**Keywords:** Apneic oxygenation, Morbid obesity, Parturient, Elective cesarean section, General anesthesia

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**Please cite this article as:** Ali RM, Mohamed Abdelwahab WA. Apneic Oxygenation for Morbid Obese Parturient Undergoing Elective Cesarean Section Under General Anesthesia. J Cell Mol Anesth. 2023;8(2):116-23. DOI: https://doi.org/10.22037/jcma.v8i2.39197

# Introduction

The global epidemic of obesity (1) and maternal obesity is a growing problem worldwide (2). Obese parturients are at higher risk for cesarean delivery (CS) (3). Although technically difficult, neuraxial techniques are the recommended anesthetic method for cesarean delivery in obese parturients. Obesity and pregnancy may increase the likelihood of maternal complications from general anesthesia. Intubation or other induction issues, such as aspiration, are the main causes of general anesthesia-related complications. Thus, general anesthesia is usually categorized as a second alternative to neuraxial anesthesia for CS (4). Consequently, general anesthesia may be requested from the start, or even if neuraxial anesthesia is performed, the anesthetic technique can be converted to general anesthesia(5). When general anesthesia is indicated, the anticipation of problems, effective preparation, and appropriate intervention can diminish the risk of complications. Airway management is a crucial part of the anesthetic management of the obese parturient (6). Obesity and pregnancy both increase the risk of difficult intubation, which is linked to difficulty in mask ventilation and a higher risk of rapid desaturation during apnea (7).

During the drug-induced apnoeic phase of anesthesia induction, preoxygenation is a recognized technique for minimizing hypoxia. Pre-oxygenation through apneic oxygenation is often a safe and easy process. Adding apneic oxygenation to the standard practice for pre-oxygenation has a potential benefit to reduce hypoxemia during intubation. The efficacy of apneic oxygenation in preventing desaturation during rapid sequence intubation in the prehospital, emergency department, critical care, and operating room settings have been established (8,9). Applying apneic oxygenation, using nasal prongs at a flow rate of 5 L/min to 15 L/min during the apneic period is recommended for the management of unanticipated difficult intubation (10) and difficult or failed tracheal intubation in obstetrics (11). Further, the clinical efficacy of apneic oxygenation in morbidly obese patients (12) and obese patients during difficult laryngoscopy was supported (13). However, to our knowledge, the morbidly obese parturient sub-population has not been investigated for the clinical use of nasal apneic oxygenation. Consequently, this study was designed to enhance the body of research supporting the usage of this technique. The purpose of this study is to compare the effects of conventional preoxygenation alone to conventional preoxygenation combined with nasal apneic oxygenation technique on oxygen desaturation in morbidly obese pregnant patients undergoing elective caesarean sections while under general anaesthesia.

# Methods

In Ain Shams University, Obstetrics, and Gynecology Hospital, this prospective, randomized, controlled trial was conducted. The trial included sixty morbid obese parturients of the American Society of Anesthesiologists physical status II and aged 18-40 years, who were undergoing elective cesarean section under general anesthesia from May 2021 to February 2022. Body mass index (BMI) of 40 $kg/m^2$ or more was considered to constitute parturient morbid obesity (14). If a morbidly obese parturient refused to have regional anesthesia or in case of failure of regional anesthesia administration or case of presence of contraindication to regional anesthesia, she was designated to undergo general anesthesia and enrolled in the study.

The research ethics committee of Ain Shams University approved the trial protocol, FMASU REC FW A 000017585. The trial is recorded at Clinical Trial. gov under NCT05021549. The parturient was informed about the procedure and provided written informed consent. Exclusion criteria included suspected difficult airway (Mallampati class > 2, reduced neck movement, reduced mouth opening, or Cormack-Lehane grade > 2 observed during the intubation procedure) as well as any contraindication for nasal prong use such as airway tumors, fractures, or oxygen saturation ($SpO_2$) less than 97% before preoxygenation. Sixty morbid obese parturients were randomly assigned to one of two equal groups by using a computer-generated randomization list. Group O: the nasal prong delivered 10 L/min of oxygen. Group C: the conventional preoxygenation group, did not receive any $O_2$ through the nasal prong.

The pre-anesthetic assessment included an airway evaluation. On patient arrival at the operating room, standard monitoring was established, including continuous electrocardiogram, non-invasive blood

pressure, and pulse oximeter. Before preoxygenation, the baseline $SpO_2$ was recorded. Further, cardiotocography was used to assess the fetal condition during preoxygenation and throughout the induction procedure up until the airway was secured.

Preoxygenation was performed using a gently fitting face mask and 8 vital capacity deep breaths over 1 min of 100% $O_2$ at 15 L/min, while the parturient is in a head-up position with left uterine displacement to achieve a 30-degree inclination whereby the external auditory meatus forms a horizontal line with the sternum. According to the assigned group, each patient either received $O_2$ via nasal prong or not, in conjunction with the pre-oxygenation technique. In addition, the assistant anesthesiologist performed a jaw thrust during the apnea period of induction of anesthesia to keep the airway patent.

Once adequate preoxygenation was achieved, anesthetic induction was performed using thiopental 4–5 mg/kg based on lean body weight. Succinylcholine 1mg/kg based on total body weight facilitated tracheal intubation. Auscultation and end-tidal capnography confirmed the correct placement of the endotracheal tube. The recruitment maneuver was promptly performed via continuous positive airway pressure of 30 cm $H_2O$ for 30 seconds. Patients were maintained with 60% $O_2$ in air, nearly 1 vol% isoflurane that is reduced to 0.5 vol% after delivery, 1µ/ Kg fentanyl, and 0.1 mg/kg atracurium for maintenance of muscle relaxation. Ventilation was controlled to maintain an end-tidal carbon dioxide partial pressure of 35 to 40 mmHg.

The primary outcome was the mean lowest oxygen saturation recorded. Secondary outcome parameters were the frequency of mild and severe hypoxemia; $SpO_2$ below 90% and 80% respectively, in addition to the number of intubation attempts and the rates of first-pass success. Also, the adverse events related to the intubation such as arrhythmias, hypotension (reduction of blood pressure 20% of baseline), hypertension (elevation of blood pressure 20% of baseline), aspiration of gastric content, or injury to the teeth or soft tissue were recorded. Fetal distress and neonatal APGAR score <7 at 5 minutes were also recorded.

Using the PASS 11 program for sample size calculation and according to a study carried out by Ramachandran et al., (13) in 2010. The expected mean lowest $SpO_2$ (%) in study group= 94.3 ± 4.4 and in control group = 87.7 ± 9.3. the sample size of 30 women in each group can detect this difference with power 90% and α-error 0.05.

**Statistical analysis:** The collected data were coded, tabulated, and statistically analyzed using IBM SPSS statistics (Statistical Package for Social Sciences) software version 28.0, IBM Corp., Chicago, USA, 2021. Quantitative data is described as mean±SD (standard deviation), then compared using an independent t-test after being tested for normality using the Shapiro-Wilk test. Qualitative data are described as numbers and percentages and compared using the Chi-square test and Fisher's Exact test for variables with small, expected numbers (<5). The intubation rate was compared by a Log-rank test. The level of significance was taken at P value < 0.050 was significant, otherwise was non-significant.

# Results

There were two equal groups of Sixty morbid obese parturients. Regarding their demographic characteristics and baseline Modified Mallampati score, Cormack-Lehane grade, heart rate, mean blood pressure (MBP), and baseline $SpO_2$, the patients in the two groups were comparable (Table 1). As regards the maternal parameters, the lowest $SpO_2$ statistically was significantly greater in Group O than in Group C. Mild and severe hypoxemia was less frequent in Group O than in Group C, but the differences statistically were significant only in mild hypoxemia. $ETCO_2$ immediately after intubation was comparable between the two groups. Statistically, the time to successful intubation was non-significantly shorter in Group O than in Group C. First-attempt success of intubation was non-significantly more frequent in Group O than in Group C (Table 2). Maternal complications, arrhythmias, and hypotension, along with fetal distress and neonatal APGAR score at 5 minutes less than 7 were less frequent in Group O than in Group C, but the differences statistically were non-significant (Table 2).

**Table 1:** Demographic data and baseline characteristics in the two studied groups.

| Variables | | Group O (n=30) | Group C (n=30) | p-value |
|---|---|---|---|---|
| Age (years) | | 28.8±4.0 | 30.1±3.6 | 0.195 |
| Weight (kg) | | 125.5±9.9 | 126.7±11.0 | 0.685 |
| BMI (kg/m$^2$) | | 44.5±2.5 | 45.2±2.2 | 0.321 |
| Modified Mallampati score (n, %) | I | 10 (33.3%) | 11 (36.7%) | 0.787 |
| | II | 20 (66.7%) | 19 (63.3%) | |
| Cormack-Lehane grade (n, %) | I | 12 (40.0%) | 10 (33.3%) | 0.592 |
| | II | 18 (60.0%) | 20 (66.7%) | |
| Baseline heart rate (beat/minute) | | 99.9±7.1 | 102.6±8.4 | 0.178 |
| Baseline MBP (mmHg) | | 90.4±4.9 | 91.9±4.1 | 0.221 |
| Baseline $SpO_2$ (%) | | 97.3±0.5 | 97.4±0.5 | 0.425 |

Data are expressed by either mean±SD or Number (%). n= The number of patients in each group.

BMI: Body mass index. MBP: mean blood pressure. $SpO_2$: peripheral oxygen saturation. P≥0.05 is considered a non-significant difference.

# Discussion

In the present trial, the apneic oxygenation group had significantly greater lowest $SpO_2$ during intubation, and less frequent mild hypoxemia compared to the conventional oxygenation group. However, maternal complications such as arrhythmias and hypotension in addition to fetal and neonatal wellness were comparable in the two groups.

In pregnant women at term as well as in morbidly obese patients, the functional residual capacity is markedly reduced while oxygen consumption is increased. Consequently, both populations are at increased risk of hypoxemia during periods of apnea (15). Saturation levels during apnea remain over 90% as long as hemoglobin is oxygenated in the lungs. When oxygen saturation levels drop to 90%, the partial pressure of oxygen approach 60 mmHg. At lower values of oxygen saturation, the partial pressure of oxygen drops rapidly. The safe apnea period is the time from discontinuation of ventilation to the onset of desaturation ($SpO_2$< 90%) (16). In one study, 9.4% of pregnant women who underwent non-elective cesarean section were found to have hypoxemia ($SpO_2$ < 90%) (17). In another study, it was found that pregnant women needed 2.8 minutes and non-pregnant women needed 4.05 minutes for $SaO_2$ to fall to 95% during apnea (18). In another study, the time required for $SpO_2$ to drop to 90% during apnea was found to be 2.7 minutes in morbidly obese patients and 6 minutes in patients with normal body weight (12). Moreover, it is expected that these subpopulations will have difficulty with tracheal intubation or ventilation. Accordingly, in parturient***s*** receiving general anesthesia or morbidly obese patients undergoing surgery under general anesthesia, rapid sequence induction is commonly performed and preoxygenation becomes a crucial component (15). Standard practice for pre-oxygenation typically involves tidal volume breathing for three minutes through a reservoir bag. As the risk for aspiration is high in such sub-populations, manual ventilation is inappropriate. Eight deep breaths in 1 min with 100% oxygen is another convenient choice that was implemented in the present study (19). Supplementation of apneic oxygenation to conventional preoxygenation technique is an alternative to enhance the effects of preoxygenation during the induction of anesthesia (20).

The prevalence of maternal obesity has grown

worldwide and the number of obese patients undergoing cesarean section has also expanded (21). Pregnancy and obesity render these parturients markedly vulnerable to rapid desaturation during the apneic phase of anesthesia (6). Hypoxemia has harmful adverse impacts on maternal, fetal, and neonatal outcomes. Apneic oxygenation is usually a safe and simple technique of pre-oxygenation. In 2013, the Canadian Airway Focus Group recommended the endorsement of apneic oxygenation for the management of the anticipated difficult airway during tracheal intubation (22). In 2015, the Difficult Airway Society (10) and the Obstetric Anaesthetists' Association (11) emphasized the application of apneic oxygenation for the management of the unanticipated difficult airway and management of the difficult airway in obstetrics after the induction of anesthesia. In 2016, the India Difficult Airway Association recommended apneic oxygenation, 15 L/min oxygen, via nasal cannulae for obstetric general anesthesia (23). Nevertheless, randomized controlled trial is still not available in the morbidly obese parturient sub-population.

During pregnancy, there is capillary engorgement of nasal, oropharyngeal, and laryngeal mucosa (24). Given that nasal instrumentation might be injurious, we hypothesized that apneic oxygenation might be better achieved with nasal prongs rather than nasopharyngeal catheters in morbid obese parturient sub-population. Accordingly, the present study adopted the use of nasal prongs. It is noteworthy that apneic oxygenation necessitates a patent airway to allow $O_2$ delivery to the pharynx. Induction of anesthesia may compromise nasopharyngeal airway patency in obese patients by retropalatal obstruction (25). Different techniques were employed in the present study to maintain a patent airway including jaw thrust performance during the apnea period of induction of anesthesia and aligning the horizontal plane of the patient's external auditory meatus and sternal notch. These maneuvers are based on previous clinical trials (12, 26, 27).

Apneic oxygenation with nasal prongs (5 L/min of oxygen) during simulated prolonged laryngoscopy in obese individuals resulted in prolongation of $SpO_2$ >95% for at least 6 min after apnea and higher minimum $SpO_2$ in 53% of patients when compared with the control group (13). One study compared the effectiveness of nasal prongs versus nasopharyngeal catheters. No patients in the nasopharyngeal catheter group were desaturated below 95% compared with 32% in the nasal prongs group (26). In obese patients, oxygen insufflation at 15 L/min through a nasopharyngeal airway and standard nasal cannula can significantly increase the safe apneic duration during induction of anesthesia (28). However, nasopharyngeal apneic oxygenation can result in substantial barotrauma and tension pneumoperitoneum (29,30).

During an apnea, $CO_2$ production is unaffected, although $CO_2$ elimination is almost paused. As a result, in the first minute of apnea, the partial pressure of $CO_2$ in arterial blood rises from 8 to 16 mmHg, then rises linearly at a rate of about 3 mmHg/min (31)**.** However, hypercapnia-related complications have not been reported with apneic oxygenation (32). If the $O_2$ flow by nasal cannula would be more than 15 L/min, a "stent effect" would be created; hence washing out $CO_2$ from dead space in the lungs and dampening the $CO_2$ rise. (33). In the present study, $ETCO_2$ immediately after intubation was comparable between the apneic oxygenation and the conventional oxygenation group.

High-flow humidified nasal oxygenation (HFNO) appears to be inadequate to ensure optimal preoxygenation in pregnant women, despite encouraging results in the general population (34). Several clinical trials demonstrated that using HFNO as a preoxygenation technique for obese patients prolonged nonhypoxic apnea time (1,35–37). In contrast, one trial demonstrated that using HFNO did not increase the duration of safe apnea in patients with morbid obesity (BMI >40 $kg/m^2$) compared with standard nasal apneic oxygenation (10 L/min) (38). Another trial argued that HFNO carried a higher risk of desaturation during intubation in obese patients (39). Another trial reported HFNO and facemask oxygenation showed a similar incidence of peri-intubation hypoxemia ($SpO_2$ < 80%) in obese patients with hypoxemic respiratory failure (40).

## Conclusion

In conclusion, nasal apneic oxygenation may be considered a practicable technique for preoxygenation of morbid obese parturients undergoing elective

**Table 2:** Outcome parameters in the two studied groups.

| Variables | | Group O (n=30) | Group C (n=30) | p-value | Relative effect | |
|---|---|---|---|---|---|---|
| Lowest $SpO_2$ (%) | | 92.1±2.9 | 88.4±5.2 | 0.002* | Mean±SE | 3.7±1.1 |
| | | | | | 95% CI | 1.5–5.9 |
| Mild hypoxemia | | 5 (16.7%) | 12 (40.0%) | 0.045* | RR | 0.42 |
| | | | | | 95% CI | 0.17–1.04 |
| Severe hypoxemia | | 0 (0.0%) | 4 (13.3%) | 0.112 | RR | Not applicable |
| | | | | | 95% CI | |
| $ETCO_2$ immediately after intubation | | 35.2±0.4 | 35.4±0.5 | 0.104 | Mean±SE | -0.2±0.1 |
| | | | | | 95% CI | -0.4–0.1 |
| Time to successful intubation (seconds) | | 33.6±8.6 | 41.5±24.6 | 0.103 | Mean±SE | -8.0±4.8 |
| | | | | | 95% CI | -17.6–1.7 |
| Attempt success of intubation | First | 27 (90.0%) | 25 (83.3%) | 0.706 | RR | 1.08 |
| | Second | 3 (10.0%) | 5 (16.7%) | 0.145 | 95% CI | 0.88–1.32 |
| Arrhythmias | | 2 (6.7%) | 7 (23.3%) | 0.145 | RR | 0.25 |
| | | | | | 95% CI | 0.06–1.08 |
| Hypotension | | 0 (0.0%) | 6 (20.0%) | 0.103 | RR | Not applicable |
| | | | | | 95% CI | |
| Fetal distress | | 1 (3.3%) | 3 (10.0%) | 0.612 | RR | 0.33 |
| | | | | | 95% CI | 0.04−3.03 |
| Apgar score <7 at 5 minutes | | 1 (3.3%) | 3 (10.0%) | 0.612 | RR | 0.33 |
| | | | | | 95% CI | 0.04−3.03 |

Data were expressed by either mean±SD or Number (%). P≥0.05 is considered a non-significant difference

n= The number of patients in each group. $ETCO_2$= End-tidal carbon dioxide. $SpO_2$: peripheral oxygen saturation.

Effect about control: Apneic oxygenation's impact. The relative rate is RR. The standard error is SE. Confidence interval (CI).”

cesarean section under general anesthesia. Further studies are needed to evaluate the efficacy of nasal apneic oxygenation in comparison to HFNO during preoxygenation of morbid obese parturients undergoing elective cesarean section.

## Acknowledgment

None.

## Conflicts of Interest

The authors declare that they have no conflict of interest.

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