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Original Contribution

Increasing body mass index and the incidence of intraoperative hypoxemia☆,☆☆

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Abstract

Study objective: Obese patients regularly present for surgery and have greater hypoxemia risk. This study aimed to identify the risk and incidence of intraoperative hypoxemia with increasing body mass index (BMI).

Design: This was a retrospective cohort study.

Setting: Operating room.

Patients: A total of 15,238 adult patients who underwent general anesthesia for elective noncardiac surgery at a single large urban academic institution between January 2013 and December 2014.

Interventions: Unadjusted and risk-adjusted logistic regression analyses explored the relationship between increasing categories of BMI and intraoperative hypoxemia, severe hypoxemia, and prolonged hypoxemia.

Measurements: Intraoperative pulse oximeter readings and preoperative patient characteristics.

Main results: With normal BMI, 731 (16%) patients experienced hypoxemia compared with 1150 (28%) obese patients. Adjusted odds ratio (AOR) of intraoperative hypoxemia increased with each category of BMI from 1.27 (95% confidence interval [CI], 1.12-1.44) in overweight patients to 2.63 (95% CI, 2.15-3.23) in patients with class III obesity. AOR of severe hypoxemia was significant with class I obesity (AOR, 1.32; 95% CI, 1.08-1.60), class II obesity (AOR, 2.01; 95% CI, 1.59-2.81), and class III obesity (AOR, 2.27; 95% CI, 1.75-2.93). AOR of prolonged hypoxemia increased with BMI from 3.29 (95% CI, 1.79-6.23) with class I obesity to 9.20 (95% CI, 4.74-18) with class III obesity.

Conclusions: Despite existing practices to limit hypoxemia in obese patients, the odds of experiencing intraoperative hypoxemia increase significantly with increasing categories of BMI. Further practices may need to be developed to minimize the risk of intraoperative hypoxemia in obese patients.

1. Introduction

An increase in the prevalence and severity of obesity in the general population has led to an increase in the number of obese patients that require anesthesia care for a wide array of surgical procedures. The clinical impact of this disease is not

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trivial. Obese patients are known to be at a greater risk of hypoxemia during anesthesia for a number of reasons: reduced lung and chest wall compliance, increased airway resistance, and reduced functional residual capacity, which result in alveolar collapse, shunting, and ventilation perfusion mismatch [1,2].

Clinically, this often presents as an acute hemoglobin desaturation after induction of general anesthesia during the apneic period [3], or difficulty in maintaining an adequate oxygen saturation intraoperatively without adjustment of ventilator strategy or delivery of an increased inspired oxygen concentration [4,5]. A variety of techniques have been suggested to minimize the risk of hypoxemia in these patients during the induction phase, including head-up positioning and use of continuous positive airway pressure during preoxygenation [6,7]. These have been proposed in addition to the standard techniques of delivering 100% oxygen before induction and minimizing the apneic period by rapidly gaining control of the airway for continued delivery of oxygen.

Despite utilization of these measures, it is still unknown what the actual incidence of hypoxemia is during general anesthesia in obese patients, specifically as body mass index (BMI) increases. Recent studies have explored the incidence of hypoxemia in the general surgical population and in children undergoing surgery [8,9], or postoperatively in obese patients [10]. However, studies of intraoperative hypoxemia within the obese population have thus far been small, used older pulse oximeter technology, or used a simple BMI cutoff to delineate between obese and nonobese patients [1,3]. We aimed to provide data on the incidence of hypoxemia in obese patients and hypothesized that an increase in BMI is associated with an increased incidence of intraoperative hypoxemia.

2. Methods

2.1. Data

This was a retrospective review of a database of adult patients who underwent elective noncardiac surgery under general anesthesia between January 2013 and December 2014. This database was constructed based on discharge demographic data from a single institution in an urban setting that includes multiple facilities, including a large tertiary care hospital, an orthopedic hospital, and multiple offsite facilities that provide ambulatory surgical care. Only adult patients were included because children's physiology differs from that of adults. The database was queried from the electronic health record to include patient age, sex, American Society of Anesthesiologists (ASA) Physical Status score, surgical procedure, BMI, smoking status, Trendelenburg position, and preexisting lung disease. Comorbidities were defined based on *International Classification of Disease, Ninth Revision, Clinical Modification*, codes identifying the diagnosis at the time of the surgery [11,12]. Such databases at our institution contain a "present at admission" marker, and this was used to prevent new diagnoses from being considered preexisting comorbidities. Codes were selected based on previously validated coding algorithms for *International Classification of Disease, Ninth Revision, Clinical Modification*, codes [13]. BMI was reported in kg/m^2. BMI was calculated by the electronic health record based on the most recent available weight in kilograms and height in meters. For elective surgical procedures, height and weight were measured and entered for every patient into the electronic health record upon admission to the presurgical holding area on the day of the procedure. ASA score was defined based on the designation made by the attending anesthesiologist on the day of the procedure. This database was combined with the results of a targeted query of intraoperative vital signs as recorded by the anesthesia information management system (EPIC, Verona, WI) at the time of the procedure, which contained recorded body temperature as well as oxygen saturation (SpO_2) as measured by the pulse oximeter with a resolution of 1 reading per minute. Only adult noncardiac elective surgical procedures under general anesthesia were included. Canceled cases were excluded. Records that did not contain a BMI or contained a physiologically unlikely BMI (>100 kg/m^2 or <10 kg/m^2) were excluded.

2.2. Outcomes

Body mass index was separated into categories based on the classifications as defined by the World Health Organization (Table 1). All SpO_2 measurements were recorded from the time of attaching the pulse oximeter (Nellcor, Boulder, CO) to the patient until disconnection of the pulse oximeter before departure from the procedure area. Recorded oxygen saturations of less than 60% were considered spurious and removed from analysis based on a method used in previous studies [14]. *Hypoxemia* was defined as at least 1 recorded measurement of SpO_2 less than 90% based on previous studies that have explored hypoxemia, as well as the physiologic correlation with arterial oxygen of less than 60 mm Hg [8,9]. *Severe hypoxemia* was defined as at least 1 recorded measurement of SpO_2 less than 85%. Because SpO_2 is recorded in our anesthesia information management systems at a resolution of 1 reading per minute, *total time of hypoxemia* was defined as the sum of SpO_2 measurements less than 90%. *Prolonged hypoxemia* was defined as SpO_2 less than 90% for 5 minutes or greater based on previous studies associating this duration of intraoperative hypoxemia with perioperative adverse events [15,16].

Table 1 Classification of BMI

BMI (kg/m^2)	Classification
<18.5	Underweight
18.5-24.9	Normal range
25-29.9	Overweight
30-34.9	Obese class I
35-39.9	Obese class II
>40	Obese class III