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## Desaturation in procedural sedation for children with long bone fractures: Does weight status matter?

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## ABSTRACT

**Introduction:** Childhood obesity remains a serious problem in the United States. Significant associated adverse incidents have been reported with sedation of children with obesity, namely hypoxemia. The objective of our study was to determine if overweight and obesity were associated with increased desaturations during procedural sedation compared with patients of healthy weight.

**Methods:** This was a single-center retrospective chart review of data from a three-year period of patient's age 2–17 years. Of the 1700 charts reviewed 823 of these patients received procedural sedation and met the study inclusion criteria. Weight status was classified based on age and gender specific body mass index (BMI) percentiles: underweight, healthy weight, overweight, obese.

**Results:** Among all weight categories there was no statistical significance, however children with obesity had greater desaturation rates (9.9%) compared with children of underweight, healthy weight, or overweight combined (5.4%),  $\chi^2 = 4.46$ ,  $p = 0.035$ .

**Discussion:** The results indicate that children with obesity are almost twice as likely to have a desaturation related to procedural sedation compared with children of other weight status. Providers should be aware that children with obesity may be more likely to desaturate than other children, and therefore be skilled at recognizing this.

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### 1. Introduction

Childhood obesity remains a serious problem in the United States. According to the Center for Disease Control and Prevention (CDC) the prevalence of childhood obesity is 17% which affects about 12.7 million children and adolescents between 2 and 19 years of age [1]. Each year, obesity leads to >300 000 premature deaths and more than \$100 billion dollars in health care costs [2–4].

The body mass index (BMI) is used to define overweight and obesity in adults. However in children BMI criteria for overweight and obesity vary by age and gender and thus are defined in percentiles [2]. CDC defines four BMI categories for children: (1) underweight is less than the fifth percentile, (2) healthy weight is the fifth percentile to less than the eighty-fifth percentile, (3) overweight is eighty-fifth percentile to less than the ninety-fifth percentile, and (4) obese is equal to or greater than the ninety-fifth percentile [5].

When children present to the emergency department with a long bone fracture they often require procedural sedation to reduce the fracture. During procedural sedation, sedative or dissociative agents are administered to induce a state that allows the patient to tolerate

unpleasant procedures but still maintain cardio-respiratory function independently [6]. Procedural sedation is utilized in the emergency department to accomplish diagnostic and therapeutic procedures by relieving pain and alleviating anxiety [7].

Significant associated adverse incidents have been reported with sedation of children with obesity, namely hypoxemia [2]. Inadequate ventilation in the pediatric population commonly involves healthy patients [2,8]. However, loss of breathing and acute hypoxia more commonly occur in patients with pre-existing conditions that affect respiration including restrictive and obstructive lung disease [2,8]. Patients with obesity are more prone to these pre-existing lung conditions as well as cardiovascular and gastrointestinal conditions [2].

Limited data are published related to pediatric patients with obesity and procedural sedation, and the majority is documented in the dental literature [9]. In patients with obesity, volume of distribution as well as the binding and elimination of sedation drugs may be unpredictable due to excess adiposity which can alter the pharmacokinetic process, namely the volume of distribution and the lipophilic nature of medications [9]. One study found that increasing BMI was a risk factor for hypoxemia in a cohort of subjects undergoing endoscopic procedures for a variety of indications [10]. Although it is thought that children with obesity may have increased adverse event risks with procedural sedation compared with healthy weight children, there are limited empirical data to support this [11]. Thus, the objective of our study was to

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determine if overweight and obesity BMI were associated with increased desaturations during procedural sedation compared with patients of healthy weight. We hypothesized that patients with BMI that is overweight or obese will desaturate more during procedural sedation for long bone fracture than healthy weight patients.

## 2. Methods

We conducted a single-center retrospective chart review of data from a three-year period of January 1, 2012 through December 31, 2014. We examined patients with a diagnosis of long bone fracture requiring procedural sedation. Long bone fracture patients were chosen as our study subjects because many of these patients undergo procedural sedation. Additionally, our emergency department is the only level 1 pediatric trauma center in the region seeing approximately 45 000 pediatric patients a year. Patients included in this study either initially presented to the pediatric emergency department or were transferred to the pediatric emergency department from a community hospital or an urgent care center with a diagnosis of a long bone fracture. Long bone fractures include: femur, tibia/fibula, humerus, and radius/ulna. Patients were excluded if they fractured the foot, hand, or clavicle, or if the fracture was associated with head or multisystem trauma. Hypoxemia was defined as an oxygen saturation level of 90% or less as recorded by pulse oximeter as capnography was not available in our facility during the time of the study. Ninety percent or less was chosen as our criteria for desaturation based on literature supporting this as a point in which an intervention would be required to improve the patient's saturations [12,13]. The determination of desaturation was noted by the provider performing the sedation or the nurse who was monitoring vital signs during the sedation and was documented in the patient's chart.

After obtaining IRB approval, approximately 1700 charts of patients with long bone fractures were reviewed. 823 of these patients received procedural sedation and met the study inclusion criteria. Categorical variables documented included gender, weight status, and whether or not the patient had a desaturation of 90% or less. Medication used for the procedural sedation was reported as a percentage of available options for procedural sedation: (1) ketamine alone, (2) ketamine with a benzodiazepine, (3) ketamine with an opiate, (4) propofol alone, (5) propofol with a benzodiazepine, (6) propofol with an opiate, (7) ketofol, which is a combination of ketamine plus propofol, or a (8) benzodiazepine plus an opiate. Medication for each procedure was chosen by the pediatric emergency physician or the pediatric nurse practitioner as they were the ones performing the procedural sedation while the Orthopedic physicians were the ones performing the reduction. Continuous level variables were reported as means and standard deviations. Children's weight status was classified as underweight, healthy weight, overweight or obese based on the age- and gender-specific BMI percentile [5]. A Chi-square test of independence was used to assess the relationship between desaturation and children's weight status. Separate Chi-square tests were used to assess whether desaturations varied by medication and age category. Age was categorized as 2–4 years, 5–11 years, and 12–17 years. All analyses were conducted with SYSTAT 13 (SYSTAT Software, 2004), and alpha was set at 0.05.

## 3. Results

Of the 823 patient charts reviewed there were 7 patients who required procedural sedation more than once, as a result of presenting on different dates for a new fracture. Of the patients with complete data needed to compute weight status, there were a total of 814 patient charts: underweight ( $n = 53$ ); healthy weight ( $n = 449$ ); overweight ( $n = 140$ ); and obese ( $n = 172$ ). There was no statically significant difference in desaturation rates when based on all weight categories: underweight (1.9%), healthy weight (5.8%), overweight (5.7%), and obese

(9.9%),  $\chi^2 = 5.69$ ,  $p = 0.128$ . However, when combining the three non-obese weight classes, children with obesity had the highest desaturation rates among weight groups, we examined desaturation rates for children with obesity compared to desaturation rates for children in the other three categories. Children with obesity had greater desaturation rates (9.9%) compared with non-obese children (5.4%),  $\chi^2 = 4.46$ ,  $p = 0.035$ .

When examining the association between medications and desaturation, we found that propofol used as propofol alone, propofol with an opiate or propofol with a benzodiazepine compared to the other medications had the greatest desaturation for patients,  $\chi^2 = 9.179$ ,  $p = 0.027$ . After further evaluating the medications used for sedation, propofol used with an opiate (23.5%) or propofol with a benzodiazepine (33.3%) had higher percentages of desaturation than propofol alone (9.5%) (Table 1). It is important to note that the number of patients who received propofol with an opiate ( $n = 1$ ) were much smaller compared with propofol alone ( $n = 21$ ) or propofol plus a benzodiazepine ( $n = 17$ ) and this is because the choice of medication was decided by the provider performing the sedation.

In order to assess if desaturation was related to extra medication given secondary to actual body weight of obese children dosing versus ideal weight dosing we computed ideal body weight for each obese child. The dosing differences were then calculated for what would have been given based on ideal body weight (IBW) compared with what was actually given. Independent *t*-testing indicated there was no significant difference in the degree of dosing difference among children with obesity that desaturated versus those that did not desaturate.

We noted differences in desaturation rates based on age. Eleven percent of patients 12 years of age and older had desaturations of 90% or less compared with 5.5% of patients age 5 to 11 years and only 3.2% of children 2 to 4 years,  $\chi^2 = 11.093$ ,  $p \leq 0.01$  (Table 2).

## 4. Discussion

This study represents an evaluation of the association between childhood weight status and the association with desaturation related to procedural sedation. The results indicate that children with obesity are almost twice as likely to have a desaturation related to procedural sedation compared with children of other weight status. These data add to the limited research on this topic that supports similar associations between obesity and other negative outcomes with procedural sedation. Providers should be aware that children with obesity may be more likely to desaturate and therefore are a higher risk for sedation. This should be considered when choosing medications (lipophilic, volume of distribution, age, BMI, etc.), consenting, and ensuring airway adjuncts are nearby.

The medications used for procedural sedation have an effect on the central respiratory drive and airway muscle tone. Therefore, it is not surprising that both the dental and anesthesia literature conclude that children with obesity are more likely than non-obese peers to experience an increase in oxygen desaturation, bronchospasms, laryngospasm, and

**Table 1**  
Desaturations by medication type.

Medication	No desaturation	Desaturation	Total
Ketamine alone	7 (100%)	0 (0%)	7
Ketamine + benzodiazepine	691 (94.1%)	43 (5.9%)	734
Ketamine + opiate	1 (100%)	0 (0%)	1
Propofol alone	19 (90.5%)	2 (9.5%)	21
Propofol + benzodiazepine	13 (76.5%)	4 (23.5%)	17
Propofol + opiate	2 (66.7%)	1 (33.3%)	3
Ketofol	24 (92.3%)	2 (7.7%)	26
Benzodiazepine + opiate	5 (100%)	0 (0%)	5
	762 (93.6%)	52 (6.4%)	814

Chi-squared: 13.64,  $p$ -value: 0.05.

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