The Effect of Biophysical Characteristics and Dosing on Pediatric Oral Sedation Outcome

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Abstract

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Purpose: For patients who are overweight or obese dosing sedation medications at actual weight may result in a relative overdose. These patients require special consideration because of physiologic differences in the volume of distribution, metabolism, and clearance of drugs. [1, 2] No single dosing scalar has been recommended for procedural sedation dosing. This study examined the biophysical characteristics of pediatric dental sedation patients to determine the effect of child weight and the impact of medication dose on sedation success.

Methods: Records of pediatric dental sedations performed at a university-based dental clinic over the course of 5 years (2/2/11 – 2/1/16) were reviewed to determine eligibility for inclusion. Healthy children aged 24 -144 months, who received an oral preparation of meperidine (1.5mg/kg), midazolam (0.3mg/kg), and hydroxyzine (1.0mg/kg) whose treatment was supervised by the same attending pediatric dentist were included in the study. Sedation dose for all eligible cases was calculated using the lesser of actual weight or the Centers for Disease Control and Prevention (CDC) 50th weight for age percentile

(Ideal Body Weight). Patient demographics and biophysical characteristics (age, height, and weight) were recorded and used to calculate body mass index (BMI) percentiles. Sedation dose for each case was compared with the child's actual weight to determine if the dose delivered was therapeutic or sub-therapeutic. The outcome variables of sedation success and failure were analyzed to determine association with the dose delivered.

Results: The sample population consisted of 427 children aged 24 – 144 months (mean = 76.8 months, SD = 21.6 months). The overall sedation success rate as measured by the Houpt scale was 74% (N=315). There was not a significant difference in success rate by gender, ASA status, insurance status, CDC BMI percentile for age, CDC weight for age percentile, or dose delivered (therapeutic or sub-therapeutic). Older age category and simple treatment type were significantly associated with sedation success ($P = 0.036$ and $P = 0.045$ respectively). The calculated ideal body weight (IBW) and lean body weight (LBW) of the study participants was significantly greater than the dosing weight used ($P < 0.001$ and $P < 0.001$ respectively).

Conclusions: The majority of children who received oral sedation for dental care in this study were classified as having a healthy weight. However, patients were on average heavier than the CDC 50^{th} weight for age percentile. For patients who are overweight or obese dosing sedation medications at actual weight may result in a relative overdose, therefore BMI percentile should be considered in case selection for oral sedation.

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DEDICATION

For my parents who taught me how to dream and to my husband who supports my dreams.

I. INTRODUCTION

Pediatric Behavior Guidance

The majority of children have successful dental appointments using non-pharmacologic behavioral guidance.[3] For children unable to successfully navigate the dental experience with these basic techniques an effective treatment option may include treatment with oral sedation. Although sedation is an effective method to manage pediatric anxiety, safety concerns, and variable treatment success have made this an area of contention.[4, 5] To reduce adverse outcomes and improve success rates, clinicians and researchers have focused on treatment variables such as gender, age, drug regimen, temperament, and dosing. [6-10]

Overweight/Obesity Prevalence

The widespread presence of overweight and obesity is a significant medical and dental issue. Since the 1980s, the prevalence of obesity has increased in both developed and developing countries.[2] Data from the 2014 World Health Statistics show that over 21% of 5 to 9 year olds are overweight and over 15% are obese. Given the abundance of overweight and obese children in the general population there is a corresponding increase in these children presenting for treatment with sedation or anesthesia.[11]

Pharmacokinetics of Drug Dosing

An overweight or obese patient is not simply a thin patient covered with a fatty coat. These patients require special consideration because of physiologic differences in the volume of distribution, metabolism, and clearance of drugs. [1, 2] For example, in overweight and obese patients both adipose tissue and lean body weight (LBW) is increased.[2] The increase in fat mass can increase the volume of distribution of lipophilic

(having an affinity for oil or fat) medications, while simultaneously an increase in lean body mass may increase drug clearance due to the enhanced liver and kidney function.[12] In order to account for the complex physiology of overweight and obese patients it has been suggested that medication not be dosed on total body weight (TBW). Instead, a number of dosing scalars have been proposed[1, 12-15].

Dosing Scalars

Dosing based upon TBW is reasonable for children who are at or near normal weight because the TBW, LBW, and ideal body weight (IBW) are similar.[13, 16] For heavier patients with BMI deviating towards overweight and obesity, dosing based upon TBW may increase the likelihood of administering doses of sedation medications that are greater than the therapeutic concentration or maximum dose (supra-therapeutic). Dosing for patients with greater fat mass is also more complicated because fat mass and LBW do not increase proportionately.[14]

Despite the pharmacokinetic differences between adults and children the calculations for IBW and LBW have been extrapolated from studies of overweight and obese adults. This is due to the paucity of pharmacokinetic studies of overweight and obese children.[1] Because children are actively growing, this calculation is more complicated than for adults. These calculations facilitate appropriate dosing, but they can complicate clinical practice.[17] Furthermore, pharmacokinetic (PK) and pharmacodynamics (PD) data are lacking for many drugs that are used in children, and package inserts and published guidelines are scaled to TBW, not LBW.[13] Consequently, dosing practice has largely been at the discretion and experience of the clinician.[13, 16] The most commonly used IBW calculation dictates that all patients of the same height receive

the same dose.[15] This scalar does not account for changes in body composition associated with obesity.[14] Consequently the IBW calculation is not accurate for these children.

BMI is different from weight percentile charts; it is an estimate of tissue mass measured as weight (in kilograms) divided by height squared (in meters). The distribution of BMI changes with age. Therefore, percentiles specific to age/gender are appropriate metrics to define underweight, healthy weight, overweight, and obesity in children.[18] When considering patients for oral sedation it is important to consider altering dosage weight with the appropriate scalar for children with high BMI. Table 1 lists common dosing scalars and their calculations.

Standard of Care for Pediatric Sedation Dosing

There is no universally accepted standard of care for pediatric oral sedation dosing. Consequently, in order to prevent overdose, clinicians have resorted to the use of arbitrary, unscientific dose reduction for children who fall outside average weight for age values.[17] While this may help avoid administration of supra-therapeutic doses of medication, excessive reduction in dosing weight may result in doses less than the amount required for a therapeutic effect (sub-therapeutic) or may be at a dose that provides some, but not all benefits, of the drug's sedative properties. The American Academy of Pediatrics (AAP) and The American Academy of Pediatric Dentistry (AAPD) reaffirmed the most recent sedation guidelines in 2011 requiring pre-operative documentation of patient's age/weight but not height.[19] Without height data BMI cannot be calculated, and consequently the extent of a patient's overweight or obesity cannot be determined.[20]

Purpose

The purpose of this study was to determine (1) the effect of child weight on oral sedation success (2) the impact of medication dose on oral sedation success.

II. METHODS

Sample

This was a retrospective cross-sectional study of patient records of children who had oral sedation procedures at the University of Washington Center for Pediatric Dentistry, from February 2, 2011 through February 1, 2016.

The sample included children aged 24 – 144 months, who received sedation supervised by the same attending pediatric dentist (30 different pediatric dental residents were the primary providers), using the oral preparation of: meperidine (1.5mg/kg), midazolam (0.3mg/kg), and hydroxyzine (1mg/kg) in a sugary suspension. Only patients recorded as ASA I or II, who were able to take diagnostic radiographs, had Brodsky grade I or II tonsils, whose caregivers believed he/she would swallow oral medication were eligible to receive sedation in the study clinic. If a child had multiple procedures with sedation, only data from their first procedure was used. The study was approved by the Institutional Review Board at the University of Washington (#51082).

Sedation Procedure

During the study period the standard of practice for the clinic was to dose sedation medication at the Centers for Disease Control and Prevention (CDC) 50^{th} weight for age percentile for patients who weighed at or above the 50^{th} weight for age percentile by gender. Patients weighing less than the 50^{th} percentile were dosed at their TBW. For analysis patients were assigned to one of four dosing regimen categories: dosed at TBW, sub-therapeutically dosed by less than 10% of their TBW, sub-therapeutically dosed by l0 - < 20% of their TBW, and those sub-therapeutically dosed by ≥ 20% of their TBW.

According to the child's age and gender, each patient was separately assigned to one of four arbitrary weight percentile categories: $< 25^{th}$, 25^{th} - $< 50^{th}$, 50^{th} - $< 75^{th}$, and $\geq 75^{th}$ of the CDC standardized weight percentile charts. Children were also categorized by the CDC's four BMI categories, defined by percentile: underweight $\leq 5^{th}$, healthy weight = 5^{th} - $< 85^{th}$, overweight = 85^{th} - $< 95^{th}$, and obese $\geq 95^{th}$ percentile.[21]

Variables

Data collected from the electronic health record included: date of treatment, date of birth, gender (male, female), insurance status (public, private, none), ASA classification, actual weight (kg), weight used for dosing calculations (kg), height (cm), treatment type (simple: intra-coronal restorations, sealants, space maintainer insert; or complex: stainless steel crowns, pulp therapy, and/or extractions), duration of procedure (< 30 minutes, 30 - 60 minutes, > 60 minutes), and sedation outcome measured on the Houpt Behavior Overall Rating Scale (excellent, very good, good, fair, poor, aborted).

The major explanatory variables were weight percentile, BMI percentile by age and gender, and dosing regimen. Control variables collected were age, gender, ASA status, insurance status, treatment type, and duration of procedure. The dependent variable was the oral sedation outcome.[22]

Data Collection

Qualifying cases were determined by searching the electronic health record software (AxiUm) for code D9248 (Non-IV Conscious Moderate Sedation) in association with a single attending pediatric dentist's provider number. All electronic health records

(EHR) of the patients who received oral sedation under the supervision of the attending pediatric dentist during the five-year inclusion period were reviewed (N = 921). Of these records, 427 cases met the inclusion criteria.

Data Analysis and Statistics

Study data were collected and managed using research electronic data capture (REDCap) tools hosted at University of Washington[23] and then exported for analysis in Stata 13 © for Windows (StataCorp LP, College Station, Texas, USA). The following variables were calculated: i) age in years (date of treatment – date of birth)/365.25; ii) BMI = weight (kg) / [height (m)]^2; iii) BMI percentile was calculated using the gender specific U.S. CDC BMI for age growth chart percentiles; iv) IBW = BMI 50th percentile for age x [height (m)]^2; v) dosing regimen = [(TBW - 50th percentile for weight and age)/TBW] x 100; and vi) LBW = IBW+ 0.3 x (TBW – IBW). Categories were created for i) BMI categories according to the 2014 U.S. CDC definition; and ii) sedation success, categorized as yes (excellent, very good, and good) or no (fair, poor and aborted).

Descriptive statistics (i.e. counts, and percentages) were calculated for all variables. Chi-squared tests were used to evaluate the association between the categorical variables and sedation outcome. Multivariate linear regression with robust standard errors was used to evaluate the association between the dosing weight and the calculated IBW and LBW. Significance was set to a priori to $\alpha = 0.05$.

III. RESULTS

Demographic and treatment variables

From the clinic study population, 427 patients' records met the inclusion criteria, with nearly equal numbers of males (N=210) and females (N=217). (Table 2) Of these, height data was available for 339 of the records. The majority of patients were aged 24 to 84 months (67%), ASA I (88%), and insured by public insurance (68%). Most required complex dental treatment (70%), defined as stainless steel crowns, pulp therapy, and/or extraction. The duration of the procedure was between 30 and 60 minutes for 68% of the patients (N=288) and the overall sedation success rate was 74% (N=315). (Table 2)

There was not a statistically significant difference in sedation success rate with respect to gender, ASA status, insurance status, CDC BMI percentile for age, or CDC weight for age percentile. Age, treatment type, and duration of treatment were associated with sedation success. (Table 2)

Over 70% of patients in both age categories were considered to be of healthy weight (as defined by the CDC). However, of the 339 patients with recorded heights, 22.1% of patients were considered to be overweight or obese. (Figure 1) The mean weight for age percentile of patients was 62.5 (SD: 26.1). Nearly 40% of the patients had weights listed greater than the 75^{th} percentile of the CDC weight for age reference. (Figure 2)

Dosing Regimen

Only approximately 20% of children were dosed at TBW. The remainders were under dosed according to the study dosing scalar. Of patients who were under dosed,

nearly half received a reduction of <10%. The remainder received dosages at weights that were reduced by ≥ 10% of the patient's TBW. There was no statistically significant difference in sedation success rates with respect to the dosing category, defined by the percent of their weight at which they were dosed. (Table 3)

Dosing Scalars

The difference between the patients' calculated dosing weights and the CDC 50th weight for age percentile is presented in Table 4. After adjusting for age and gender, the dosing weight for study participants' IBW and LBW were calculated to be on average 1.96 kg ($p < 0.001$) and 2.35 kg ($p < 0.001$) more than the dosing weight (CDC 50th weight for age percentile) respectively. (Table 4 and Figure 3)

IV. DISCUSSION

Overall Sedation Success

The overall sedation success rate as assessed using the Houpt Behavioral Rating Scale (HBRS) for the study population was 74%. The HBRS was chosen by the study clinic because of its reliability and frequent use in the sedation literature.[24-26] In general, the success rate of this study is in line with what others have reported, though there is wide variation in published success rates in pediatric oral sedation.[26] For example, this study's sedation success rate was substantially higher than the 56% success rate Sheroan et al. presented using the same drug regimen.[27] Conversely, Lane et al. showed a higher rate of successful sedations using this drug combination, however the sample size in that study was considerably smaller.[25] Variations in study methodology, patient age, latent period, treatment needs, and previous dental experiences may account for these differences. [6-10, 28-30] Due to considerable variation in methodology it is difficult to compare sedation success rates between studies.[26]

Demographic and Treatment Variables

Children in the study ranged from 24 – 144 months of age. For analysis, the study population was divided into two groups at an age of 84 months. Children in the older age category had a significantly higher sedation success rate (80% versus 71%). This supports the idea that younger children may have less success with oral sedation, presumably because they have not yet developed the necessary coping skills.[26] However, the current evidence regarding the effect of age on sedation success is contradictory. Some studies have reported greater success in younger cohorts, while others have shown the opposite.[6, 31, 32]

In this study the complexity of the treatment was divided into simple and complex based on the level of irritation that the treatment would cause. We found that less complex treatment was associated with greater sedation success. This finding is similar to what Lane et al. reported. Based on their findings, they recommended starting the sedation appointment with the less stimulating treatment because behavior ratings of children undergoing dental treatment with procedural sedation were lowest during extractions, a more stimulating treatment.[25]

In this sample, shorter treatment duration was associated with sedation failure. This is almost certainly related to shorter treatment times that are experienced in cases with poor or aborted sedation outcomes. In cases where sedation outcome was reported as poor or aborted either non-definitive treatment or no treatment was rendered and treatment was stopped prematurely.

Biophysical Characteristics

The purpose of this study was to determine if the child's weight had an effect on sedation success. This study did not show a statistically significant difference in sedation success rate with respect to the CDC BMI percentile for age or the CDC weight for age percentile (see Table 2).

The study clinic measured weight of all children who received dental treatment with oral sedation, however 21% were missing the height information. This was due to a change in sedation clinic protocol that occurred during the five-year study period. The weight was recorded as per the AAPD sedation guidelines, and sedation medications were dosed according to the CDC 50th weight for age percentile or TBW (if the weight was less than the CDC 50th weight for age percentile). Since the CDC recommends the

use of BMI percentiles to determine childhood overweight/obesity,[33] BMI percentiles were retrospectively calculated for the purposes of this study.

The majority of patients in both age categories had weight for age percentiles that were on-average heavier than the published norms.[21] (Figure 3) The study participants' average TBW for all age groups was greater than the CDC 50th weight for age percentile. However, the majority of study participants' were a healthy weight when classified by the CDC BMI Percentile for Age. (Figure 1) This finding supports the idea that standard weight percentiles may not be the most appropriate dosing scalar.[19- 21] Furthermore, this reinforces the point made by Kang et al. that patient weight percentiles do not predict oral sedation success or risk of an adverse sedation event.[20] Professional guidelines that incorporate use of pediatric BMI information are needed.

Obesity as a Sedation Risk Factor

Although oral sedation is an effective method to manage pediatric anxiety during dental treatment, it is not without risk.[34, 35] Children who are overweight or obese are at higher risk for prolonged recovery time and upper airway obstruction.[11, 19, 30, 36] Baker and Yagiela reported that obesity is a condition associated with chronic extrinsic restrictive lung disease, obstructive sleep apnea, and respiratory depression. This implicates obesity as a risk factor for a hypoxic adverse event during procedural sedation.[30] Obese patients also pose increase risk during emergencies because starting an IV and providing adequate rescue ventilation may be problematic due to increased adipose tissue.[11]

Of the study participants' a total of 35 (8%) were classified as obese according to the U.S. CDC BMI percentile for age classification. Although small, the fact that there

was this many obese patients who received dental treatment with oral sedation was surprising even to the study team. During the study period, clinic protocol was to only take height and weight data for sedation patients on the date of treatment. As a result BMI was not calculated preoperatively by other referring dentists within the university system, and these 35 patients were scheduled for oral sedation. On the day of treatment the attending pediatric dentist made the decision to proceed based upon a professional opinion of the patient's health and fitness to undergo the sedation procedure.

The 2016 AAPD Sedation Guidelines suggest that an ASA III status (due to moderate obesity[37]) is a relative contraindication to administering moderate and/or deep sedation in a dental office setting,[38] yet they do not require a height measurement or calculation of patient BMI. Based upon these findings, we suggest that BMI be calculated at the preoperative visit, and that overweight and obese patients be considered for alternatives to in-office procedural sedation. Calculating BMI at the consultation visit enables practitioners to make informed decisions regarding sedation versus general anesthesia and also informs choice of surgical venue (e.g. in-office, surgery center, or hospital). It also helps eliminate frustrations created by cancelling cases on the day of service.

Dosing Scalars

Although in this study sedation was provided to a number of obese children, there were no procedure-related adverse events. The incidence of adverse events of this study population was not analyzed as there were no de-saturation events and only three patients had an episode of emesis during the procedure. This may be due to two important criteria of the current study 1) relatively low milligram per kilogram doses were used for each of

the sedation medications (0.3mg/kg midazolam, 1.5mg/kg meperidine, and 1.0mg/kg hydroxyzine); and 2) dosing weight for overweight and obese children was lowered to the CDC 50th percentile weight for age. Consequently, these children received medication dosages that were considerably lower than they would have been if calculated using the higher end of the dosing range or at TBW. Interestingly, there was not a statistically significant difference in sedation success rate when comparing the children who received a dose calculated according to TBW versus those who received a dose calculated according to the dose scalar (Table 3). This finding supports Kain et al.'s (2007) finding that children with the same plasma concentration of a sedation medication do not always have the same rate of sedation success.[8] Therefore, practitioners who dose oral sedation medications at the upper end of the recommended dosing range may experience an increased incidence of adverse events, without significant improvement in success rates.

While obese patients in this study received a relative under dose, the lack of association between the dose scalar and sedation success may be in part because a dosing scalar was used to approximate the patients' LBW. In children who are obese, an increase in muscle, bone, and other lean body tissues accounts for 20-40% of the excessive weight.[1] Therefore, the absolute LBW of obese children is increased but not as much as the TBW.[12] Figure 3 shows that the average calculated LBW was always slightly greater than the average calculated IBW. This supports the concept that the LBW increases along with the adipose tissue in overweight and obese children. However, the large range of lean body tissue increase that occurs in obesity makes it very difficult to dose oral sedation medications in overweight and obese children. The related unpredictability in pharmacodynamics and pharmacokinetics of oral sedation medications is therefore a

contraindication to using oral sedation in overweight and obese children in a dental clinic setting.

Currently, there is limited evidence supporting appropriate dosing for oral sedation in pediatric patients.[1] The dosing scalars IBW, LBW, BSA, and BMI percentile have been suggested as methods of dosing oral sedation medications (Table 5).[12] These recommendations are based on extrapolations from adult studies.[1, 12, 13, 39] It may take many years before the function of each drug is studied in children who are heavier than the IBW. In the interim, clinicians should attempt to dose appropriately using methods that can be practically applied in a clinic setting. Recently, Callaghan et al. showed that determination of IBW using the nomogram method was quicker and less likely to result in a mistake, than the equation method.[17] The benefit of using a nomogram is that the patient's age, total body weight, and height must be measured. While future research is needed to determine the BMI percentile at which there is an increased risk of adverse events with oral sedation, a clinic that records patient height for this purpose is capable of completing a BMI calculation and establishing an appropriate cutoff for sedation.

Study Limitations

A limitation of this study was the number of providers who assessed patients preoperatively, performed the dental treatment, and evaluated patient behavior. During moderate sedation, the patient is interactive and influenced by communication based behavioral techniques. Operators during this study's sedation appointments were pediatric dental residents with varying behavior guidance and technical skill levels. Including numerous operators introduced variation in behavioral severity rating and provider ability. The Houpt scale metrics were used to limit subjectivity; however

evaluation and treatment by multiple providers may have decreased the reliability of behavioral rating and overall sedation outcome. To mitigate these effects, only treatment supervised by the same attending pediatric dentist was included.

Other variables that have been shown to have an association with oral sedation success are child temperament and indication for oral sedation. These variables were not recorded in the electronic health records and thus could not be evaluated.

Future multi-site research should be conducted to measure associations between sedation success, sedation adverse events, and the various proposed dosing scalars for pediatric oral sedation patients. This information could be used to formulate pediatric oral sedation guidelines that include appropriate use of BMI information.

V. CONCLUSIONS

1. The overall success rate of sedations in this study was 74%. Success rate was not significantly associated with gender, ASA status, insurance status, CDC BMI percentile for age, CDC weight for age percentile, or dosing regimen as related to TBW.
2. Patients in the study population had greater average weight for age than indicated by published CDC growth curves.
3. A number of obese patients were sedated in this study, however none experienced adverse events.
4. Guidelines with BMI cut-off points for safe sedation are needed to prevent adverse events that may occur during sedation of overweight or obese children.

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APPENDIX

Table 1: Dosing scalars and calculations.

Dosing Scalar	Description and Common Usage	Calculation for children	Citation
Total Body Weight (TBW)	Also called Actual Body Weight (ABW)	Weight (kg)	Kendrick et al., 2010
Lean Body Weight (LBW)	Difference between TBW and fat mass	IBW + 0.3 x (TBW – IBW)	Mortensen et al., 2011
Body Surface Area (BSA)	Used for chemotherapy dosing	[height (cm) x weight (kg)/3600]$^{1/2}$	Mosteller, 1997
Ideal Body Weight (IBW)	A description of the ideal weight associated with a given height.	Several methods have been proposed	
McLaren method	Most common method.	50th percentile for height (cm)	Kendrick et al., 2010
Moore method		Weight percentile for height	Kendrick et al., 2010
BMI Method		BMI 50th percentile for age x [height (m)]^2	Mortensen et al., 2011

Table 2: Description of study participants by oral sedation failure.

		Sedation Success		
Demographic variables	**Total N (%)**	**Yes N (%)**	**No N (%)**	**P value***
Total	427 (100)	315 (73.8)	112 (26.2)	
Gender				0.119
Female	217 (50.8)	153 (70.5)	64 (29.5)	
Male	210 (49.2)	162 (77.1)	48 (22.9)	
Age (months)				**0.036**
24 - 84	286 (67.0)	202 (70.6)	84 (29.4)	
85 - 144	141 (33.0)	113 (80.1)	28 (19.9)	
ASA Status				0.324
I	377 (88.3)	281 (74.5)	96 (25.5)	
II	50 (11.7)	34 (68.0)	16 (32.0)	
Insurance status				0.576
Public	289 (67.7)	209 (72.3)	80 (27.7)	
Private	111 (26.0)	86 (77.5)	25 (22.5)	
None	27 (6.3)	20 (74.1)	7 (25.9)	
CDC BMI Percentile for Age				0.534
Missing Recorded Height	88 (20.6)	62 (70.5)	26 (29.5)	
Under / Healthy Weight	264 (61.8)	200 (75.8)	64 (24.2)	
Overweight	40 (9.4)	27 (67.5)	13 (32.5)	
Obese	35 (8.2)	26 (74.3)	9 (25.7)	
CDC Weight for Age Percentile				0.14
< 25	44 (10.3)	36 (81.8)	8 (18.2)	
25 - 50	88 (20.6)	61 (69.3)	27 (30.7)	
51 - 75	128 (30.0)	88 (68.8)	40 (31.3)	
≥ 75	167 (39.1)	130 (77.8)	37 (22.2)	
Treatment Variables				
Treatment Type				**0.045**
Simple	127 (29.7)	102 (80.3)	25 (19.7)	
Complex	300 (70.3)	213 (71.0)	87 (29.0)	
Duration of Procedure				**< 0.001**
< 30 min	43 (10.1)	9 (20.9)	34 (79.1)	
30 - 60 min	288 (67.5)	222 (77.1)	66 (22.9)	
> 60 min	96 (22.4)	84 (87.5)	12 (12.5)	

* P-value calculated by Chi squared test.

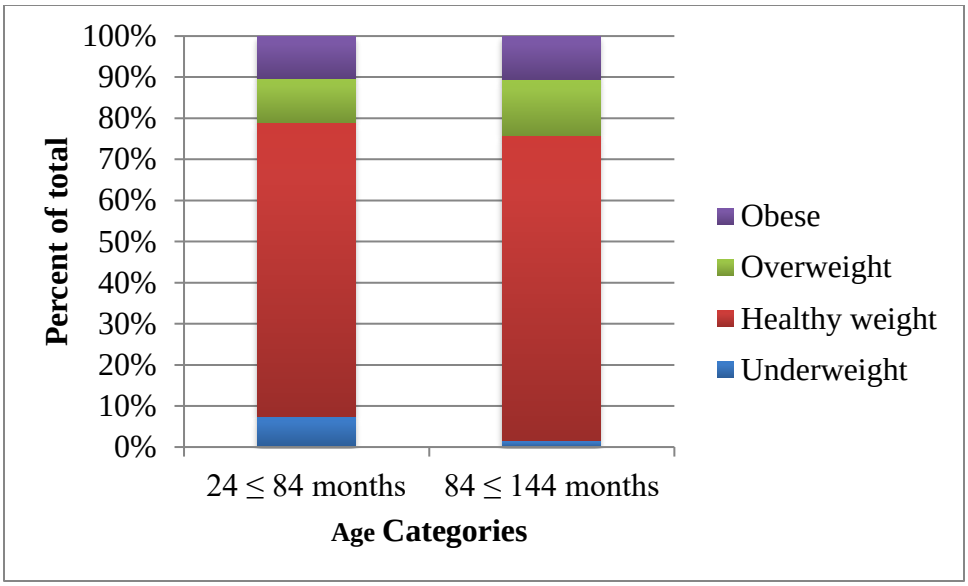

Figure 1. Distribution of study participants as classified by CDC BMI Percentile for Age.

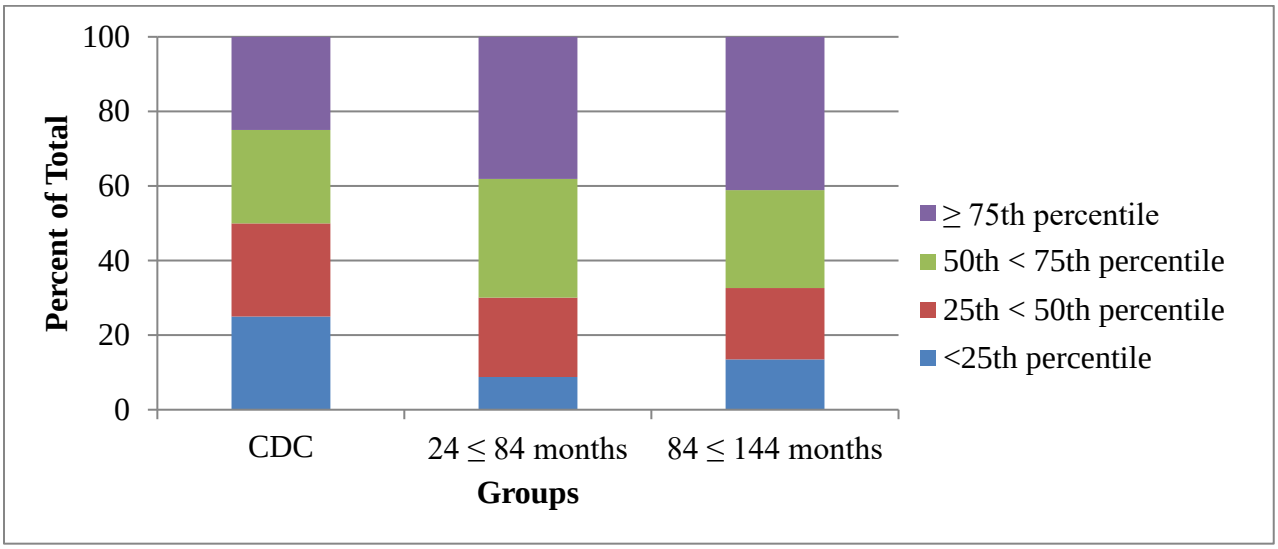

Figure 2. Distribution of the study participants' percentile weight-for-age compared to the CDC weight-for-age distribution

Table 3: Study participants' dosing regimen as related to sedation success.

		Sedation Success		
Characteristics	**Total N (%)**	**Yes N (%)**	**No N (%)**	**P value***
Dosing Category				0.819
Dosed at TBW	80 (18.7)	60 (75.0)	20 (25.0)	
Underdosed by 1% < 10%	172 (40.3)	123 (71.5)	49 (28.5)	
Underdosed by 10% < 20%	97 (22.7)	72 (74.2)	25 (25.8)	
Underdosed by ≥ 20%	78 (18.3)	60 (76.9)	18 (23.1)	

* P-value calculated by Chi squared test.

Table 4: Association between type of body weight calculation and dosing weight using adjusted linear regression adjusted for age and gender.

Variables	Adjusted Slope	95% Confidence Interval	P value
CDC 50th Weight for Age Percentile	reference	--	--
Ideal Body Weight (kg)	1.96 kg	1.48, 2.44	< 0.001
Lean Body Weight (kg)	2.35 kg	1.83, 2.87	< 0.001

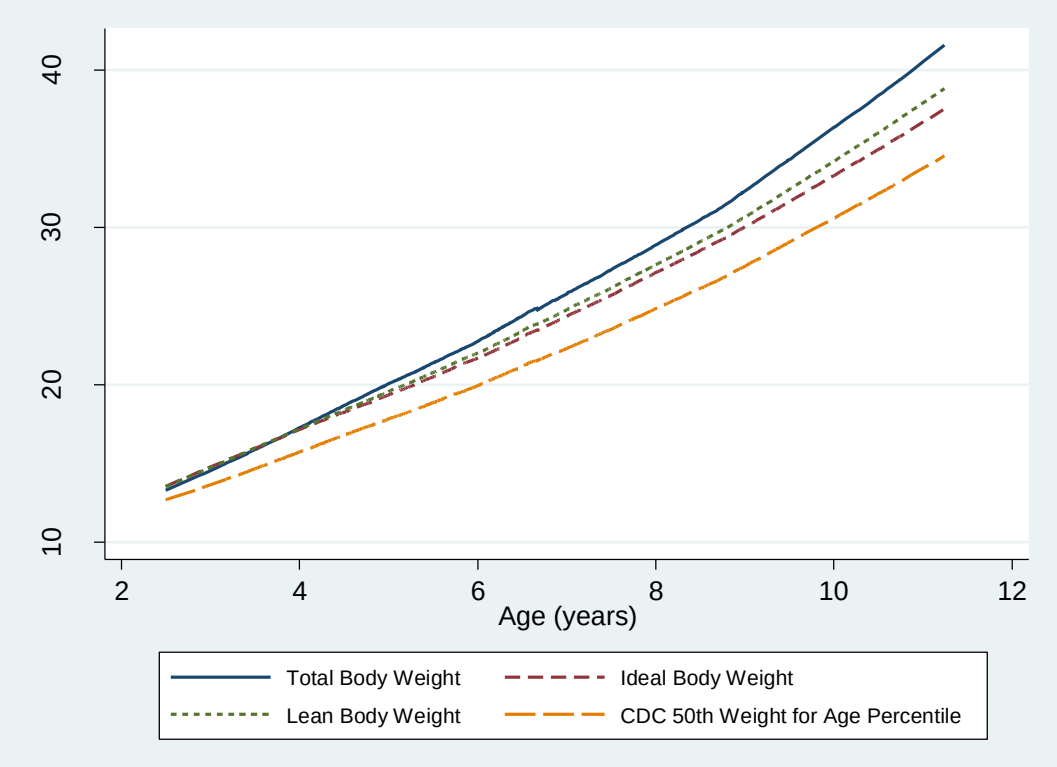

Figure 3. The plotted locally weighted regression of the actual and calculated weights by age of the study participants.

Table 5: Accepted dosing schemes for pediatric sedation medications.

	Overweight/Obese Adult	Overweight/Obese Child
Benzodiazepines (ie. Midazolam)	IBW[1]	IBW*
Opioids (ie. Meperidine)	IBW[1]	IBW*
Antihistamine (ie. Hydroxyzine)	Not dosed by weight	Not dosed by weight

1. Reference: Kendrick et al., JPPT, 2010
*extrapolated from adults