Comparison of body surface area and weight based dosing for common anesthesia drugs

Amy Elizabeth Nedley

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Acknowledgements

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Table of Contents

Introduction

There are three general approaches to drug dosing: fixed dosing (FD), weight based (WB) dosing, and body surface area (BSA) based dosing. FD means that every patient gets the exact same dose. WB dosing is common in clinical practice because most dosages are given in milligram per kilogram (mg/kg) or microgram per kilogram (μg/kg). BSA based dosing is based on a patient's total body surface area. Each approach has its advantages and disadvantages.

With approximately 68% of Americans in the obese category according to body mass index (BMI) (Polso, Lassiter, & Nagel, 2014), the type of dose selection becomes a problem. In obese patients, using a WB dosing strategy is more likely to result in drug overexposure and excessive toxicity. In drugs with a narrow therapeutic window this could be life threatening. An extreme example of the error in solely using WB dosing was observed in 1962 in an elephant at a zoo in Oklahoma City. A WB approach based on prior dosing for lysergic acid diethylamide used in cats was extrapolated to treat the elephant. The elephant died (Pai, 2012). WB dosing assumes that the absorption, distribution, metabolism or excretion of a drug (pharmacokinetics) increase in proportion with increasing body size (Pai, 2012). A disadvantage is that physiologic parameters responsible for drug disposition, including renal function and energy expenditure are not taken into account with this method (Frazier & Price, 1998). A dose based solely on weight may only be appropriate if the weight is associated with other normal physical dimensions (Lack & Stuart-Taylor, 1997).

The choice of BSA versus WB dosing is made on the premise that metabolic rate per unit body weight decreases with increased body weight, but remains similar when calculated in terms of BSA (Hughes et al., 2014). This approach, like the WB approach, assumes that drug pharmacokinetic parameters increase in proportion with increasing body size. The assumption

that larger patients require more drug to induce the same effects is based upon the theory that larger patients have a larger volume of distribution and a higher metabolic capacity. A correlation between BSA and some physiologic parameters, such as glomerular filtration rate (GFR), blood volume, left ventricular mass and basal metabolic rate exists (Dooley & Poole, 2000; Sawyer & Ratain, 2001). The volume of distribution of lipophilic drugs and the clearance of hydrophilic drugs can also be increased in obese patients (Sawyer & Ratain, 2001). A high BSA would also reduce terminal distribution to poorly diffused tissues and delay elimination, clearance and ultimately recovery (Undevia, Gomez-Abuin, & Ratain, 2005).

Propofol and fentanyl are two drugs in anesthesia that are traditionally administered using WB dosing. Both drugs are intravenous, short acting, and highly protein bound (lipophilic); properties that allow them to distribute quickly from the blood to the target receptors. The highly lipophilic properties also allow for large volumes of distribution and high metabolic clearance. Propofol specifically is a hypnotic agent with the pharmacokinetic profile of rapid onset and recovery. It has a narrow therapeutic index and lacks a reversal agent. Propofol can be used for sedation but in larger doses can be used as an induction agent for general anesthesia. Fentanyl is a narcotic analgesic that inhibits ascending pain pathways therefore increasing a patient's pain reaction threshold (Eilers & Yost, 2015). It is recommended that propofol and fentanyl be coadministered to increase the quality of sedation (Turk et al., 2013).

WB dosing may have been very acceptable for dosing in the past but with the increasing obesity in the US population maybe it is time that we look at an alternative. The goal of this research is to report calculated BSA dosing based upon actual WB dosing in patients, and to evaluate BSA dosing as an alternative to WB dosing.

Literature review

BSA based dosing is based on a patient's total body surface area. A practical clinical method to measure the three dimensional surface area of the body does not exist, so formulas have been developed. The Dubois method (1916) was the first formula for calculating an estimated BSA in humans and is relatively accurate for normal weight individuals. The DuBois formula, using measurements of height and weight, was derived based on data from only 9 patients, one of whom was a child (Sacco, Botten, Macbeth, Bagust, & Clark, 2010). Other formulas to calculate BSA include, but are not limited to, the Mosteller, Livingston and Scott, Haycock, Gehan and George, Boyd, Yu et al. and Fujimoto. The DuBois formula is considered the western standard formula.

BSA based dosing is used most frequently in calculating the dose in cancer chemotherapy. It was first recommended by the United States Food and Drug Administration (FDA) over fifty years ago to convert animal doses into safe starting doses in first in-human clinical trials (Blanchard & Smoliga, 2015). It was an attempt to normalize the physiologic parameters responsible for drug disposition and to avoid toxicity in initial clinical trial doses. Disadvantages of using BSA based dosing is that it may not be possible to derive a clinically effective therapeutic dose from animal models and a human equivalent dose may not equal a pharmacologically active dose, because interspecies differences in drug distribution, metabolism, peak plasma concentration and excretion pathways are not taken into account (Blanchard & Smoliga, 2015; Frazier & Price, 1998). The relationship between renal and hepatic function and BSA may also be weak or nonexistent (Dooley & Poole, 2000; Sawyer & Ratain, 2001).

Drug dosages for chemotherapeutics are usually determined by multiplying the patient's BSA by a constant that has been derived for each drug in clinical research trials (Sacco et al.,

2010). Capping the BSA in calculations or an arbitrary dose cutoff value is also common practice and may be the result of fear of overdosing the patient (Sparreboom, 2005). Some researchers suggest that BSA scaling in the practice of oncology has limited justification, but may be used in an effort to normalize drug concentrations. BSA based dosing has also been utilized in patients receiving growth hormone, steroids and some therapeutic monoclonal antibodies (Hughes et al., 2014) (Dassopoulos et al., 2014; Gupta, Zhao, Hui, Esseltine, & Venkatakrishnan, 2015; Saadeh et al., 2011). Research and application in clinical practice is limited for BSA based dosing for other medications. In 2012, only 65 drugs had a BSA based dosing recommendation for adults; 85% being antineoplastic drugs (Pai, 2012).

BSA based dosing continues to be controversial. The FDA does not advocate BSA or any specific method for determining therapeutic dosage range in patients (Blanchard & Smoliga, 2015) and for many new drugs, the use of BSA is not included in dose calculations in the early phases of drug development. The United States FDA also does not recognize obesity as a special population and does not require pharmaceutical companies to conduct studies specific to obese patients. There are now an increasing number of post-approval studies due to the increase in the number of obese people (Polso et al., 2014).

The potential benefits of BSA based dosing include more individualized treatment and lower costs compared to dosing based solely on body weight. BSA is the most reliable method for calculating drug doses for children after 6 months of age (Bartelink, Rademaker, Schobben, & van den Anker, 2006). Once in adolescence, WB dosing may be indicated because weight increases more than BSA. In adults and obesity, weight increases without a proportional increase in height. The concern, however, is that if volume of distribution or clearance of certain drugs can be increased in obese patients, it can be difficult to ensure adequate drug concentrations for

them. Researchers need to examine and consider different dosing strategies. It is for this reason that this study was initiated.

Methods

After obtaining Biomedical Institutional Review Board expedited approval (IRB #201214), this single center retrospective analysis proceeded at the University of Toledo Medical Center (UTMC) Department of Anesthesiology. Subject anesthesia care records were reviewed from the electronic medical record (EMR) for the time frame from 01/01/2010-02/01/2016, for patients that had received the general anesthetic induction agents propofol and fentanyl. A total of 50 patients were randomly selected for inclusion in this study. This sample may have included minorities, elderly patients and students and employees of the University of Toledo. Patients were excluded if a complete data set was not available due to inaccurate filing and missing or unavailable information.

Data collection included patient demographics (age, gender, height, weight) and dosage administration information for propofol and fentanyl. BSA was calculated using the Mosteller formula, BSA (m^2) = (ht in cm X wt in kg/3600) ^{½} (Mosteller, 1987). BMI was calculated using the formula, BMI = weight (kg) / [height (m)]^2(Center for Disease Control and Prevention, 2016).

The above data were entered into an Excel 2010 (Microsoft Corporation) spreadsheet with limited access. After reviewing the 50 cases one patient was excluded because it was determined that it was a monitored anesthesia care case; the patient was not given an induction dose of propofol and fentanyl.

Data analysis on the 49 subjects was completed using statistical package for social sciences (SPSS) [SPSS, Inc., IL, version 23] software. Descriptive statistics were used to summarize and tabulate data. T-tests were used to compare two means. Correlation and /or

regression analysis was used to find association between two variables. Analysis of variance (ANOVA) test was used to compare means of three or more means.

Results

The records of 50 patients were assessed. Of these, a total of 49 patients (16 males and 33 females), aged 15-82, were included in the study and ultimately in the statistical analyses. The demographic data for patients included in the analyses are illustrated in Table 1.

Patients were categorized according to BMI (Center for Disease Control and Prevention, 2016). There were no patients in the BMI category of underweight (BMI < 18.5 kg/m^2), 10 patients in the normal range (BMI 18.5 – 24.9 kg/m^2), 15 in the overweight range (BMI 25-29.9 kg/m^2) and 24 in the obese range (BMI $\geq$ 30). The group sizes were unequal, with 49% being obese. The mean BMI was 31.5 kg/m^2 for all patients with no significant difference between males and females. Males were significantly taller (p=0.000) and heavier (p=0.013) than female patients.

Using Mosteller's formula (Mosteller, 1987), the overall mean BSA for the patient population was 2.04 m^2. A 1-sample t-test comparing the mean BSA of our sample to the average US population BSA of 1.73 m^2 (Ogden, Fryar, Carroll, & Flegal, 2004) was statistically significant (p=0.00) with a mean difference of 0.312 m^2 and a 95% confidence interval of 1.95 – 2.13 m^2. BSA was significantly higher for the male patients (p=0.002).

A regression analysis showed no relationship between the patient's age and BSA. BSA did not increase with increased age as shown in Fig. 1.

The calculated WB dose is significantly correlated with the actual dose of propofol (p<0.01). Using paired t-test, there is no significant difference between the mean of the calculated WB dose propofol (180.4 mg) and the mean of the actual dose of propofol (174.4 mg)[p>0.05] [Figs. 2,3]. The mode for the actual dose of propofol was 200 mg.

There is no correlation between the calculated WB dose and the actual dose of fentanyl ($p>0.05$). Using paired t-test, there is no significant difference between the mean of the calculated WB dose fentanyl (135.3 μg) and the actual dose of fentanyl (147.4 μg) [$p>0.05$][Fig. 4,5]. The mode for the actual dose of fentanyl was 150 μg.

The mean BSA based dose for propofol was 85.7 mg/m^2 (SD 13.4) [Fig. 4]. The mean BSA based dose for fentanyl was 73.7 μg/m^2 (SD 38.7). The mean BSA based dose of each drug was used to calculate the expected BSA based dose for each patient. Using paired samples statistics, the actual dose of propofol is significantly correlated with the calculated BSA based dose ($p<0.01$). Using a paired t-test, there is no difference between the mean of the actual dose of propofol (174.5 mg) and the mean calculated BSA based dose of propofol (175.0 mg).

Using paired samples statistics, the actual dose of fentanyl is significantly correlated with the calculated BSA based dose ($p<0.01$). Using a paired t-test, there is no significant difference between the mean of the actual dose of fentanyl (147.4 μg /m^2) and the mean calculated BSA based dose of fentanyl (150.5 μg /m^2) [$p<0.01$].

The one-way analysis of variance (ANOVA) for the BSA based dose of propofol and fentanyl between BMI groups was significant ($p<0.01$) [Fig. 6]. The comparisons were most significant for propofol between the obese category and the normal categories ($p<0.01$). The comparison for propofol doses between overweight and obese were not statistically significant ($p>0.01$). The comparisons were statistically significant for fentanyl between all BMI categories ($p<0.01$) [Fig. 7].

Discussion

This retrospective analysis at the UTMC was based on 49 general anesthetic interventions using the induction agents propofol and fentanyl. Propofol and fentanyl were selected because patients receive a standardized WB dose of both drugs. Both drugs are also excreted in the urine and feces, a property that makes them more suited to dose scaling in terms of BSA. (Hughes et al., 2014). The analysis was limited to the Department of Anesthesia's WB protocol of 2 mg/kg propofol and 1.5 μg/kg fentanyl. The goal of this research was to report calculated BSA dosing based upon actual WB dosing in the sample, aged 15-82 years, and to evaluate BSA dosing as an alternative to WB dosing.

This study determined the mean BSA based dose for propofol as 85.7 mg/m^2 (SD 13.4). There was no significant difference between the mean of the actual dose and the mean of the calculated WB and BSA based dose of propofol ($p<0.01$). These findings confirm that the department of anesthesia is following WB dosing guidelines and these correlate, as expected, with BSA based dosing.

The mean BSA based dose for fentanyl was determined as 73.7 $\mu g/m^2$ (SD 38.7). There was no significant difference between the mean of the actual dose and the mean of the calculated WB and BSA based dose of fentanyl ($p<0.01$). These findings confirm that WB dosing guidelines are also being used for fentanyl. The decrease in actual dose for the obese category may be per provider preference or its characteristics as a coadministered drug and its postoperative effects on recovery. Dose adjustments may also be made based on patient age and comorbidities. Obese patients are at an increased risk of respiratory complications following extubation so acceleration of recovery is important.

The findings that BSA based dosing may be an alternative dosing strategy may be a result of our sample having a significantly large BSA compared to the US population average. We were expecting that the BSA based doses would be lower. It is possible that if true BSA measurements had been obtained these results would be different. We thought BSA would be more stable than weight, but it turns out the reverse may be true.

A limitation of this study is that some height values were self-reported values, may not have been collected properly, may have been taken on different types of scales or not measured by 2 different observers; all of these factors can affect the accuracy of the recorded measurements and subsequent calculations. No universal guidelines exist in clinical practice for obtaining actual height and weight measurements (Tipton et al., 2012).

BSA and BMI of a patient cannot always be reflective of body composition. BMI is a simple metric to aid weight categorization of patients and correlates with percentage of body fat (Pai, 2012). Increases in weight may be due to increased fat tissue and the nonlinear increases in the size of other organs, such as muscle, liver, etc. (Coetzee, 2014). An increase in weight may not correlate with an increased BSA. The use of lean body mass (LBM) may therefore be more reflective of a patient's fat-free weight and volume of distribution (Pai, 2012). Future research may include LBM calculations and data for the distribution in body fat.

A disadvantage of our sample was that none of the patients were in the underweight BMI category and eight of the patients were morbidly obese (BMI > 40kg/m^2), a separate category not included in the data analyses (Echevarria et al., 2012). The number of obese, morbidly obese, and cachectic or underweight patients undergoing surgery is increasing therefore patients at the extremes of BSA values are necessary to further validate our results.

Direct measurements of BSA involving three-dimensional scanning were not available and three-dimensional derived formulas are not used in the Department of Anesthesia at UTMC. This study used the Mosteller formula, a more simplified calculation for BSA using height and weight only, because it can be applied in pediatric and adult patients and because future studies will examine a pediatric population (Jastaniah & Aseeri, 2010; Mosteller, 1987). Regardless, several formulas will adequately predict BSA over a wide range of patient populations and The American Society of Clinical Oncology (ASCO) has concluded that any formulae is acceptable (Griggs, 2012). This explanation, however, may not be true for propofol and fentanyl.

Authors may also question the accuracy of using the same formula to calculate BSA for different ethnic groups, although this data was not included. Specific patient attributes were also not recorded. For example, if a patient had an amputation the BSA calculation would be in error.

The overall mean BSA of 1.73 $m^{2\ that}$ was used for comparison does not take into account gender specific differences or the increase in obesity in the US. Our sample had a statistically significant larger BSA ($p<0.01$) therefore our sample was not representative of the US population. The BSA value for female patients was systematically lower, which can be the result of group effect because of their smaller height and weight.

The mode was 200 mg for propofol and 150 µg for fentanyl, which may suggest fixed dosing. Fixed dosing may be a reflection of provider preferences. The paired t-tests for correlation of the calculated and actual WB doses for both propofol and fentanyl were statistically significant ($p<0.01$), therefore minimizing the significance of the dose modes. The dose of each drug is also dependent on the coadministered drug.

Patients that may have been predicted to have an abnormal drug handling were not identified. The American Society of Anesthesiologists (ASA) physical status classification

system was not examined. This grading system may be included in future studies because the sicker the patient the lower the induction dose of a drug.

Different types of dosing may be more appropriate based on developmental age. This research was aimed at more adult patients, although two patients in this study were under the age of 18. Rather than omit them, they were included in the data analysis because once in adolescence weight increases without a proportional increase in height.

Clinicians need to look at a patient's weight and BSA to determine the appropriate dosing strategy. As seen in this study sample, BSA did not increase with age, it was variable, therefore BSA based dosing may not be appropriate for adult populations. BSA based dosing may be more appropriate in patients at extremes of BSA values. This sample was not reflective of the US population, therefore our finding that WB and BSA based dosing were comparable may be because 80% of our patients were overweight or obese.

Further appraisal of drug dosing strategies is needed with the increase in obesity in the United States. Dose adjustments to WB dosing in clinical practice may be more frequent in obese adult and pediatric patients. This pilot study was a drug specific review and will contribute to the existing knowledge of BSA based dosing and possibly predict the maximum recommended starting dose of propofol and fentanyl that will not cause an adverse reaction.

Conclusion

For our sample, there was no significant difference in WB and BSA based dosing for the general anesthetic induction agents propofol and fentanyl.

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Authors' contributions

Andrew Casabianca, M.D., Amy E. Nedley, D.D.S., M.S., and Michael P. Nedley, D.D.S., were involved in concept and design of this research. Data analysis and critical revision of this article was performed by all authors. Statistical assistance was provided by Farhang Akbar-Khanzadeh, Ph.D.

Conflicts of interest

None declared

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Table 1. Subjects' demographics

	Breakdown	Min-Max	Mean (SD)	significance
Age, years	Male	15 - 69	44.81 (17.8)	p=0.083
	Female	27 - 82	53.58 (15.47)	
	Total	15 - 82	50.71 (16.6)	
Height, m	Male	1.68 – 1.91	1.78 (0.07)	p=0.000
	Female	1.50 – 1.78	1.64 (0.07)	
	Total	1.50 – 1.91	1.69 (0.09)	
Body Weight (BW), kg	Male	59.60 – 161.00	102.65 (0.14)	p=0.013
	Female	59.00 – 132.00	84.18 (20.33)	
	Total	59.00 – 161.00	90.21 (24.85)	
Body Mass Index (BMI), kg/m^2	Male	20.60 – 50.90	32.39 (8.68)	p=0.561
	Female	21.60 – 45.60	31.08 (6.64)	
	Total	20.60 – 50.90	31.50 (7.30)	
Body Surface Area (BSA), m^2	Male	1.68 – 2.88	2.23 (0.33)	p=0.002
	Female	1.63 – 2.50	1.95 (0.25)	
	Total	1.63 – 2.88	2.04 (0.31)	

Fig. 1 Regression analysis for age and body surface area (BSA)

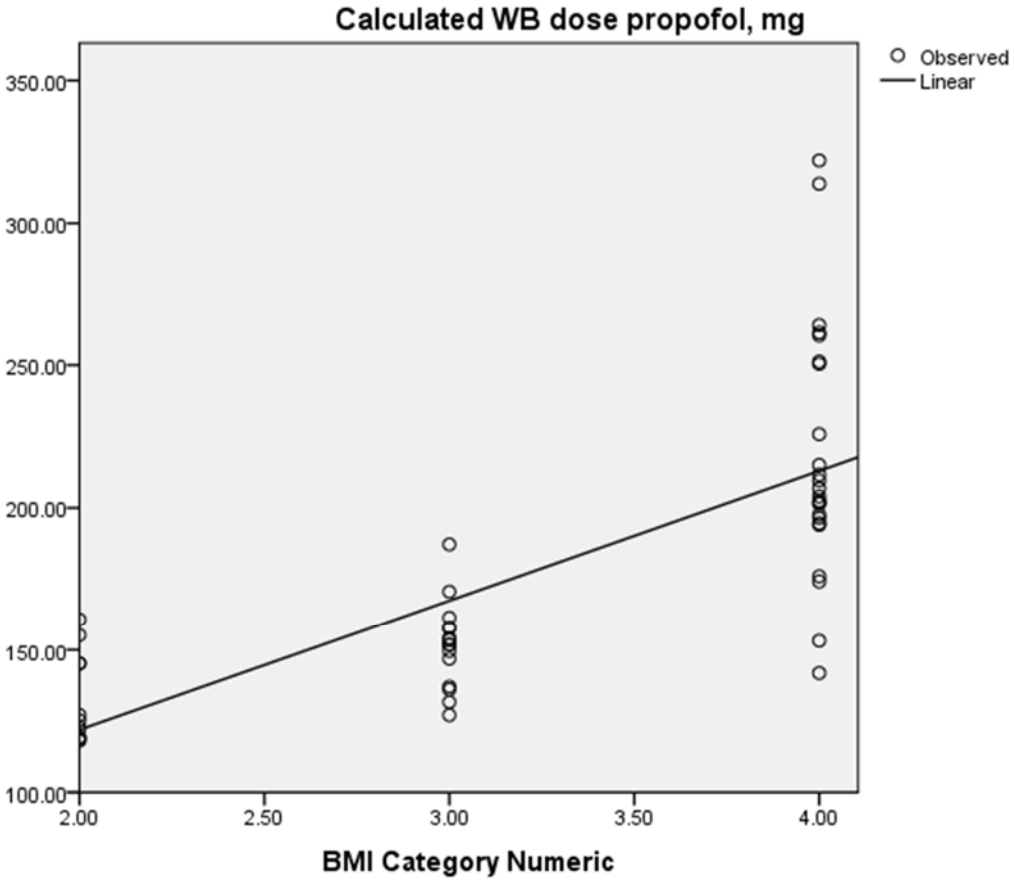

Fig. 2 Mean of calculated weight based (WB) dose of propofol according to BMI
BMI category numerics: 1 = underweight, 2= normal, 3 = overweight, 4 = obese

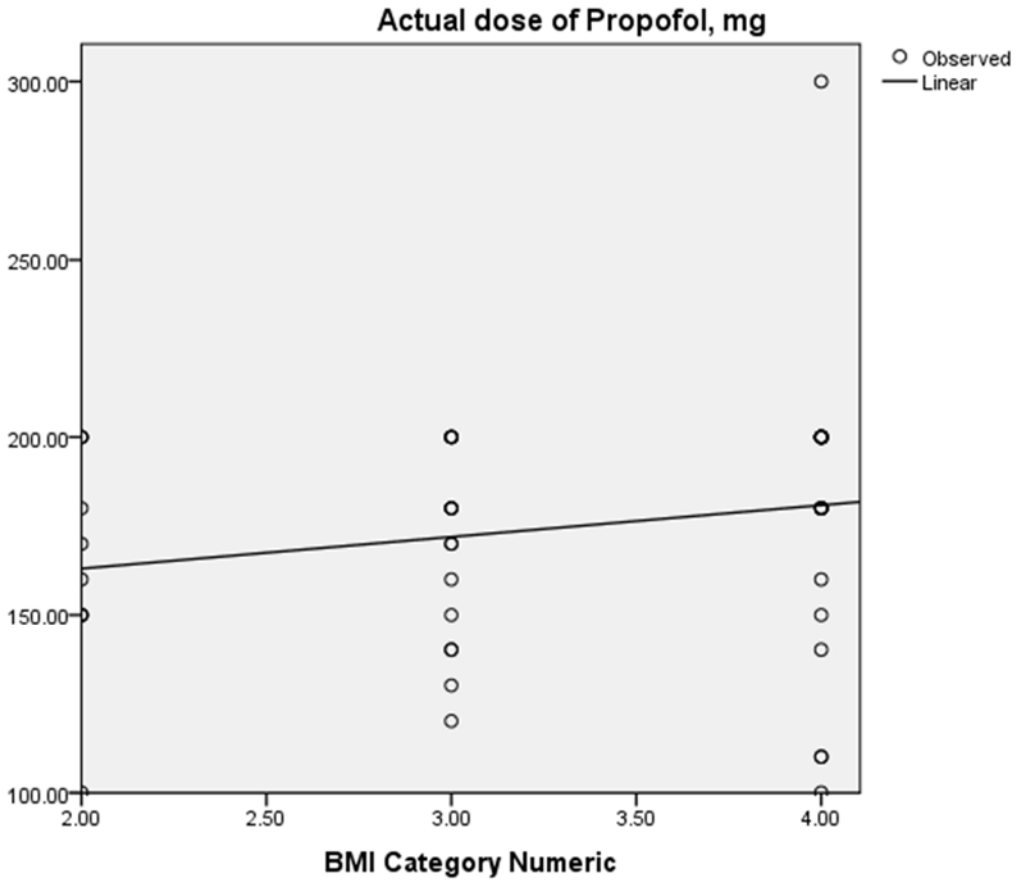

Fig. 3 Mean of calculated actual dose of propofol according to BMI category
BMI category numerics: 1 = underweight, 2= normal, 3 = overweight, 4 = obese

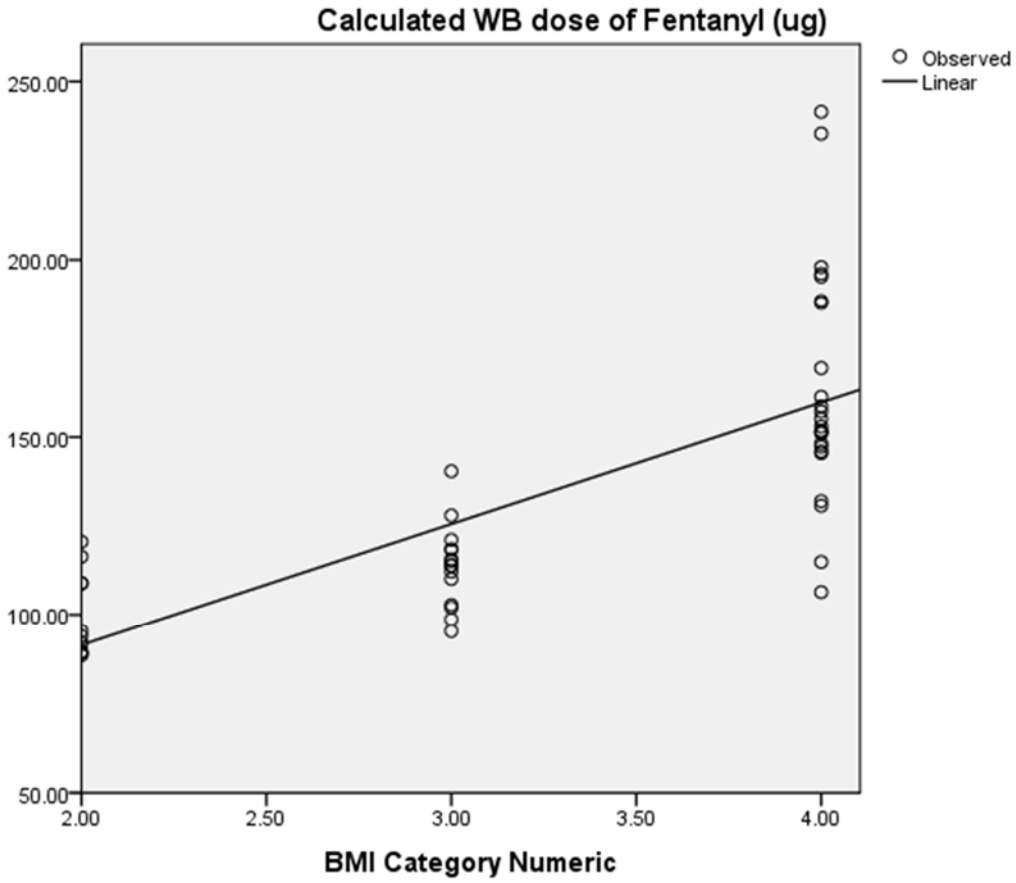

Fig. 4 Mean of calculated weight based (WB) dose of fentanyl according to BMI category
BMI category numerics: 1 = underweight, 2= normal, 3 = overweight, 4 = obese

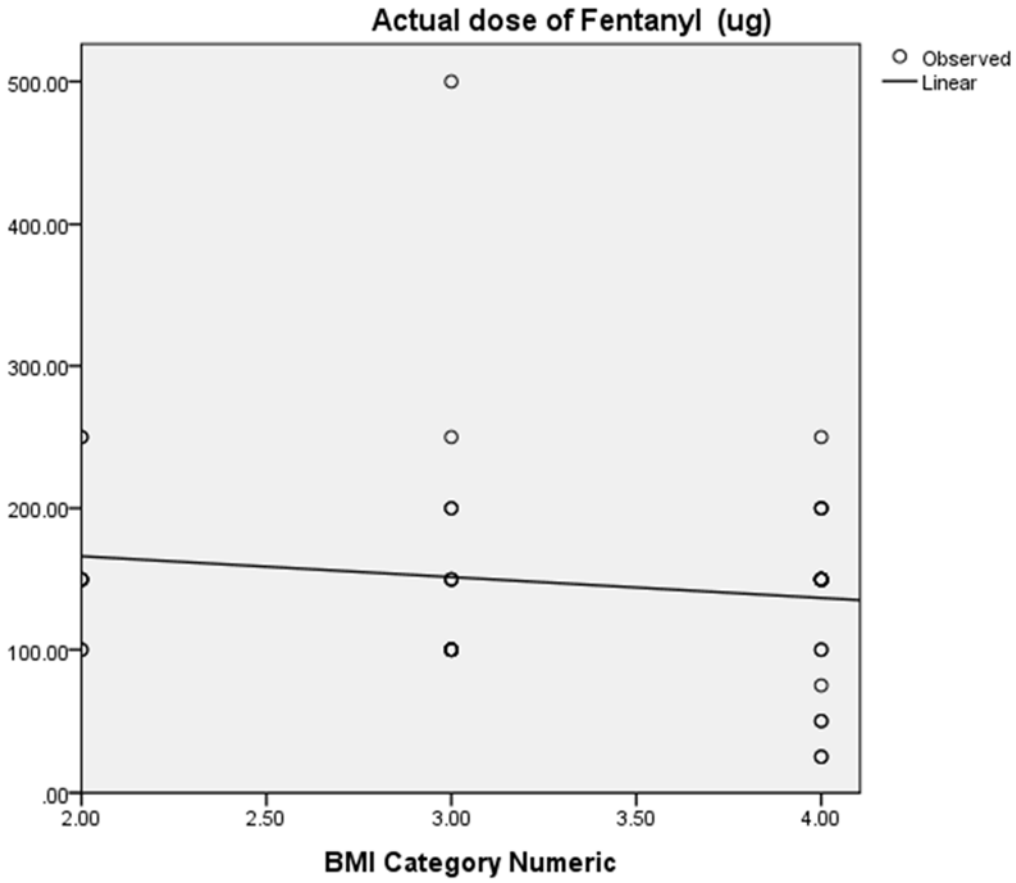

Fig. 5 Mean of actual dose of fentanyl according to BMI category
BMI category numerics: 1 = underweight, 2= normal, 3 = overweight, 4 = obese

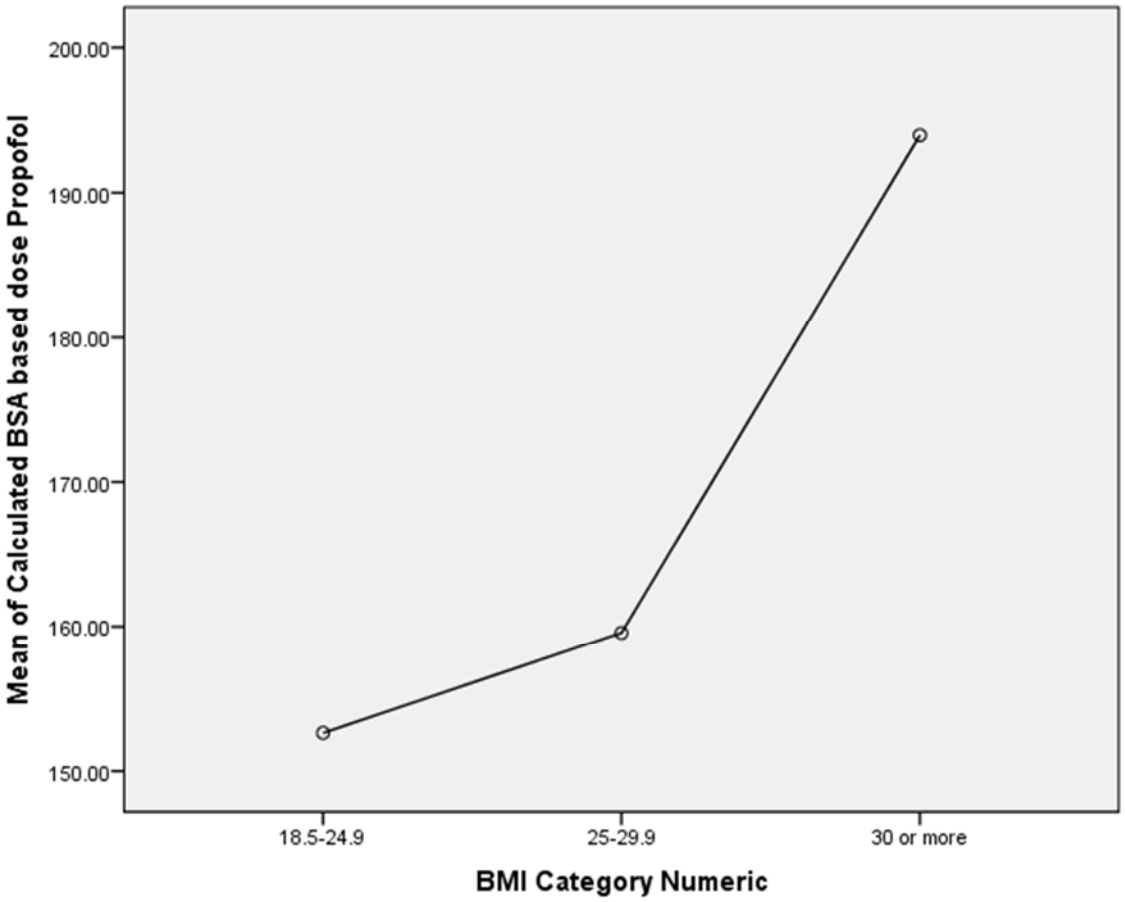

Fig. 6 ANOVA for mean calculated body surface area (BSA) based dose of propofol according to BMI category
BMI category numerics: 1 = underweight, 2= normal, 3 = overweight, 4 = obese

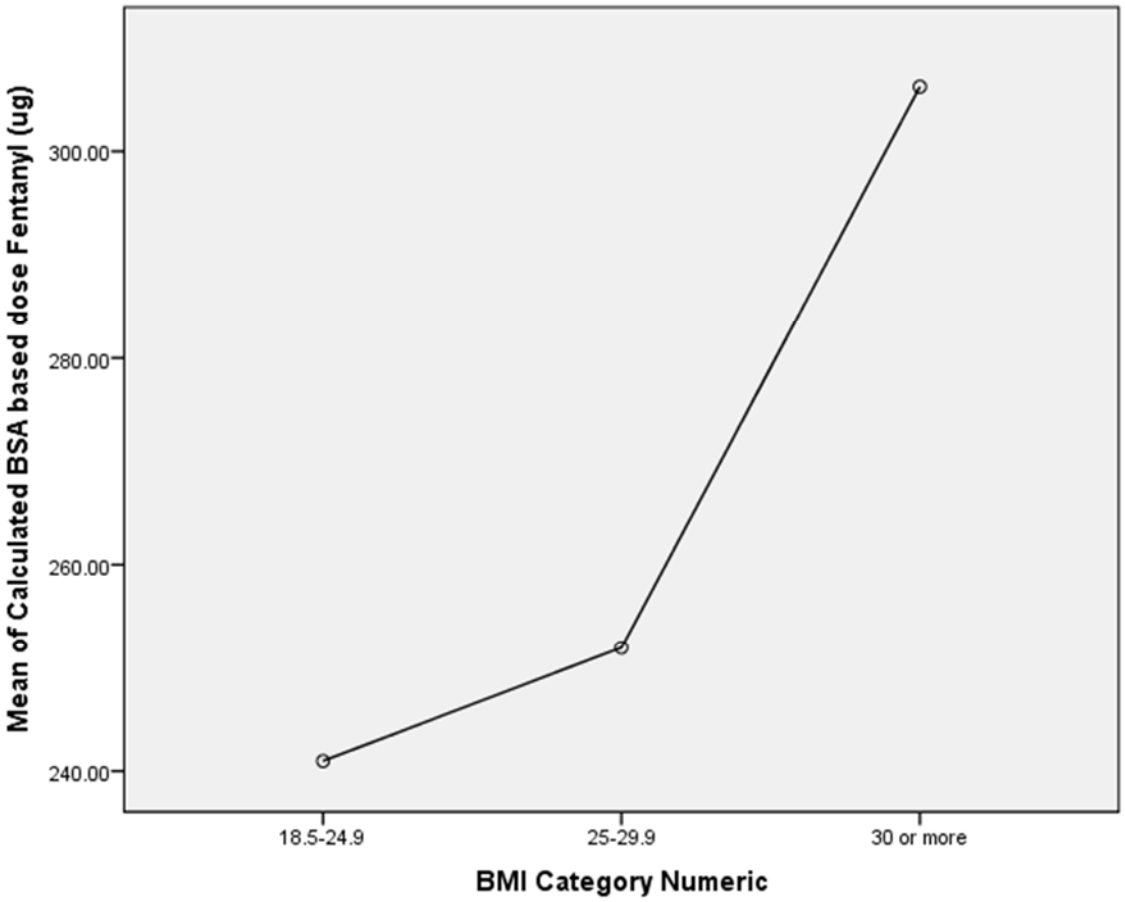

Fig. 7 ANOVA for mean of calculated body surface area (BSA) based dose of fentanyl
BMI category numerics: 1 = underweight, 2= normal, 3 = overweight, 4 = obese

Appendix

Institutional Review Board Final Approval Letter

UT IRB Approved
0000201214

THE UNIVERSITY OF TOLEDO 1872

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Boyd Koffman, M.D., Ph.D., Vice Chair
Susan Pocotte, Ph.D., Vice Chair
Steven Peseckis, Ph.D., Vice Chair
Rachel Rarus, PharmD, Chair Designee
UT Biomedical Institutional Review Board

SIGNED: _____ **DATE** 3/31/16

SUBJECT: **IRB # 201214**
TITLE: Retrospective analysis of body surface area (BSA) and therapeutic dosing for the general anesthetic induction agents propofol and fentanyl in adult patients

The above project was reviewed and **approved** by the Chair and Chair Designee of the University of Toledo Biomedical Institutional Review Board as an **expedited review** (category #5). The requirement to obtain a signed consent/authorization for use and disclosure of protected health information form has been waived as this research is determined to be minimal risk and a signed consent/authorization document would be the only record linking the subject to the data. It was determined that this waiver for signed consent/authorization for use and disclosure of protected health information form will not adversely affect the rights or welfare of the participants. This research is approved for a period of up to one year from the date of this review and approval. The full board will review it at its meeting on 04/21/2016.

Items Included for Review:

- IRB Application Requesting Initial Expedited Review of Research
- Protocol (assigned version date 03/30/2016)
- Data Collection Tools (assigned version dates 03/30/2016)
- Request for Waiver of Individual Authorization For Use and Disclosure of Protected Health Information (PHI) for Purposes of Research

This research is **approved** until the expiration date listed below, unless the IRB notifies you otherwise.

You are approved to enroll up to 200 participants in this study.

APPROVAL DATE: 03/30/2016	**EXPIRATION DATE: 03/29/2017**

Please read the following attachment detailing Principal Investigator responsibilities.

Final Approved Data Collection Tool

Subject number	Age (yrs)	Indication for treatment	Gender (M,F)	Height (in)	Height (m)	Weight (kg)	Calculated lean body mass (LBM) for ht (kg)	Calculated body mass index	Calculated BSA (m^2)	Calculated expected dose	Actual Dose of Propofol (mg)	Difference between expected dose and actual dose Propofol	Dose of Propofol (mg/kg)	Dose of Propofol/BSA (mg/m^2)	Calculated expected dose Fentanyl for LBM (µg)	Actual Dose of Fentanyl (µg)	Difference between expected dose and actual dose Fentanyl (µg)	Dose of Fentanyl/ BSA (µg/kg)	Dose of Fentanyl ($\mu g/m^2$)

Raw Data Spreadsheet

	Age	Gender	Gender_Num	Height	Weight	BMI	BSA	Dose	Actual	Propofol	Propofol_	Fentanyl	VAR00002	VAR00003	VAR00004	VAR00005	filter_$	VAR00006	VAR00007
1	68	F	2	1.65	74.80	27.50	1.85	149.60	180.00	2.40	97.30	112.20	150.00	112.20	81.10	3.00	1	158.50	136.35
2	28	F	2	1.65	77.10	28.30	1.88	154.20	170.00	2.20	90.40	115.70	100.00	115.70	53.20	3.00	1	161.10	138.56
3	51	M	1	1.75	105.80	34.40	2.27	211.60	200.00	1.90	88.10	158.70	150.00	158.70	66.10	4.00	0	194.50	167.30
4	30	M	1	1.78	77.60	24.60	1.96	155.20	200.00	2.60	102.00	116.40	250.00	116.40	127.60	2.00	0	168.00	144.45
5	45	M	1	1.91	166.90	43.20	2.88	313.80	300.00	1.90	104.20	235.40	150.00	235.40	52.10	4.00	0	246.80	212.26
6	37	M	1	1.80	93.60	28.80	2.16	187.20	200.00	2.10	92.60	140.40	100.00	140.40	46.30	3.00	0	185.10	159.19
7	43	F	2	1.75	125.20	40.80	2.47	250.40	200.00	1.60	81.00	187.80	150.00	187.80	60.70	4.00	1	211.70	182.04
8	43	F	2	1.58	65.80	26.50	1.70	131.60	140.00	2.10	82.40	98.70	200.00	98.70	117.60	3.00	1	145.70	125.29
9	58	F	2	1.50	98.20	43.70	2.02	196.40	180.00	1.80	89.10	147.30	50.00	147.30	24.80	4.00	1	173.10	148.87
10	60	F	2	1.60	87.10	34.00	1.97	174.20	180.00	2.10	91.40	130.70	150.00	130.70	76.10	4.00	1	168.80	145.19
11	63	F	2	1.75	101.20	33.00	2.22	202.40	180.00	1.80	81.10	151.80	150.00	151.80	67.60	4.00	1	190.30	163.61
12	27	F	2	1.63	59.00	22.30	1.63	118.00	150.00	2.50	92.00	88.50	100.00	88.50	61.30	2.00	1	139.70	120.13
13	55	F	2	1.60	75.90	29.60	1.84	151.80	180.00	2.40	97.80	113.90	100.00	113.90	54.30	3.00	1	157.70	135.61
14	42	F	2	1.73	97.30	32.60	2.16	194.60	200.00	2.10	92.60	146.00	150.00	146.00	69.40	4.00	1	185.10	159.19
15	51	F	2	1.65	63.50	23.30	1.71	127.00	170.00	2.70	99.40	95.30	100.00	95.30	58.50	2.00	1	146.50	126.03
16	20	M	1	1.88	130.20	36.80	2.61	260.40	200.00	1.50	76.60	195.30	25.00	195.30	9.60	4.00	0	223.70	192.36
17	62	F	2	1.70	132.00	45.60	2.50	264.00	200.00	1.50	80.00	198.00	250.00	198.00	100.00	4.00	1	214.30	184.25
18	68	F	2	1.63	68.50	25.90	1.76	137.00	120.00	1.80	68.20	102.80	100.00	102.80	56.80	3.00	1	150.80	129.71
19	69	M	1	1.68	78.90	28.10	1.92	157.80	170.00	2.20	88.50	118.40	500.00	118.40	260.40	3.00	0	164.50	141.50
20	58	M	1	1.78	161.00	50.90	2.82	322.00	200.00	1.20	70.90	241.50	150.00	241.50	53.20	4.00	0	241.70	207.83
21	64	F	2	1.58	63.50	25.60	1.67	127.00	140.00	2.20	83.80	95.30	200.00	95.30	119.80	3.00	1	143.10	123.08
22	55	F	2	1.60	75.90	29.60	1.84	151.80	180.00	2.40	97.80	113.90	100.00	113.90	54.30	3.00	1	157.70	135.61
23	65	F	2	1.78	72.60	23.00	1.89	145.20	160.00	2.20	84.70	108.90	150.00	108.90	79.40	2.00	1	162.00	139.29
24	17	M	1	1.70	59.60	20.60	1.68	119.20	150.00	2.50	89.30	89.40	150.00	89.40	89.30	2.00	0	144.00	123.82
25	37	F	2	1.58	73.40	29.60	1.79	146.80	150.00	2.00	83.80	110.10	250.00	110.10	139.70	3.00	1	153.40	131.92
26	82	F	2	1.60	88.00	34.40	1.98	176.00	110.00	1.30	55.60	132.00	100.00	132.00	50.50	4.00	1	169.70	145.93
27	32	F	2	1.65	80.70	29.60	1.92	161.40	200.00	2.50	104.20	121.10	150.00	121.10	78.10	3.00	1	164.50	141.50
28	36	F	2	1.70	62.60	21.60	1.72	125.20	180.00	2.90	104.70	93.90	150.00	93.90	87.20	2.00	1	147.40	126.76
29	76	F	2	1.58	76.60	30.90	1.83	153.20	100.00	1.30	54.60	114.90	50.00	114.90	27.30	4.00	1	156.80	134.87
30	50	F	2	1.65	59.40	21.80	1.65	118.80	150.00	2.50	90.90	89.10	150.00	89.10	90.90	2.00	1	141.40	121.61
31	33	M	1	1.83	80.40	24.10	2.02	160.80	200.00	2.50	99.00	120.60	250.00	120.60	123.80	2.00	0	173.10	148.87
32	44	M	1	1.73	103.40	34.70	2.23	206.80	200.00	1.90	89.70	155.10	200.00	155.10	89.70	4.00	0	191.10	164.35
33	75	F	2	1.65	102.00	37.40	2.16	204.00	110.00	1.10	50.90	153.00	25.00	153.00	11.60	4.00	1	185.10	159.19
34	27	F	2	1.60	98.80	38.60	2.10	197.60	200.00	2.00	95.20	148.20	150.00	148.20	71.40	4.00	1	180.00	154.77
35	55	M	1	1.78	100.90	31.90	2.23	201.80	180.00	1.80	80.70	151.40	200.00	151.40	89.70	4.00	0	191.10	164.35
36	76	F	2	1.63	76.70	29.00	1.86	153.40	160.00	2.10	86.00	115.10	100.00	115.10	53.80	3.00	1	159.40	137.08

	Age	Gender	Gender_Num	Height	Weight	BMI	BSA	Dose	Actual	Propofol	Propofol_	Fentanyl	VAR00002	VAR00003	VAR00004	VAR00005	filter_$	VAR00006	VAR00007
37	49	F	2	1.68	78.90	28.10	1.92	157.80	200.00	2.50	104.20	118.40	150.00	118.40	78.10	3.00	1	164.50	141.50
38	64	M	1	1.80	85.30	26.20	2.07	170.60	200.00	2.30	96.60	128.00	100.00	128.00	48.30	3.00	0	177.40	152.56
39	65	F	2	1.50	70.90	31.60	1.72	141.80	140.00	2.00	81.40	106.40	100.00	106.40	58.10	4.00	1	147.40	126.76
40	32	F	2	1.68	107.50	38.20	2.24	215.00	200.00	1.90	89.30	161.30	200.00	161.30	89.30	4.00	1	192.00	165.09
41	46	F	2	1.65	112.90	41.40	2.27	225.80	200.00	1.80	88.10	169.40	150.00	169.40	66.10	4.00	1	194.50	167.30
42	51	M	1	1.68	130.70	46.50	2.47	261.40	200.00	1.50	81.00	196.10	150.00	196.10	60.70	4.00	0	211.70	182.04
43	71	F	2	1.63	68.00	25.70	1.75	136.00	130.00	1.90	74.30	102.00	100.00	102.00	57.10	3.00	1	150.00	128.98
44	54	F	2	1.58	61.20	24.70	1.64	122.40	100.00	1.60	61.00	91.80	150.00	91.80	91.50	2.00	1	140.50	120.87
45	15	M	1	1.80	72.60	22.30	1.91	145.20	200.00	2.80	104.70	108.90	150.00	108.90	78.50	2.00	0	163.70	140.77
46	58	F	2	1.75	125.60	40.90	2.47	251.20	180.00	1.40	72.90	188.40	150.00	188.40	60.70	4.00	1	211.70	182.04
47	61	M	1	1.73	100.70	33.80	2.20	201.40	200.00	2.00	90.90	151.10	150.00	151.10	68.20	4.00	0	188.50	162.14
48	50	F	2	1.78	97.00	30.70	2.19	194.00	150.00	1.50	68.50	145.50	75.00	145.50	34.20	4.00	1	187.70	161.40
49	67	M	1	1.83	104.80	31.30	2.31	209.60	160.00	1.50	69.30	157.20	150.00	157.20	64.90	4.00	0	198.00	170.25

Abstract

Objectives: The goal of this research was to investigate whether using calculated body surface area (BSA) based dosing could be an alternative to weight based (WB) dosing for two commonly used anesthesia drugs, propofol and fentanyl.

Method: This was a retrospective analysis of BSA and therapeutic dosing for the general anesthetic induction agents propofol and fentanyl conducted at the University of Toledo Medical Center Department of Anesthesia. Data analysis on 49 patients was completed and included descriptive and graphical statistics.

Results: There was significant correlation between the actual dose, calculated WB dose and calculated BSA based dose for propofol and fentanyl ($p<0.01$). The actual mean BSA based dose is 85.7 mg/m^2 for propofol and 73.7 $\mu g/m^2$ for fentanyl.

Conclusions: BSA based dosing may be an alternative dosing strategy for propofol and fentanyl in our sample.