How Should Obesity be Measured and How Should Anesthetic Drug Dosage be Calculated?

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Abstract

The risks involved with being overweight or obese are related to the deposition of adipose tissue (adiposity). There are several ways to assess adiposity and body composition. Current medication dosage recommendations are usually based on weight alone and are intended for normal-weight individuals of varying size. Since drug dosage is based on total body weight, the changed body composition and pathophysiological alterations in obesity are likely to affect the pharmacokinetics and pharmacodynamics of anesthetic drugs. Rather than using weight-based measures of obesity, physicians need to look for methods of assessing adiposity that predict how dysmetabolic an obese individual actual is. Anesthesiologists need to use individualized dosing scalars to take into account these changes.

2.1 Introduction

The medical world has not done a very good job of assessing obesity. The risks involved with being overweight and obese are primarily related to the deposition of adipose tissue, which leads to adiposity or body fatness. It is the excess adiposity that is associated with adverse health conditions such as cardiovascular disease (CVD) and type-2 diabetes mellitus (T2DM). The diagnosis of obesity previously relied on the subjective interpretation of how fat someone appeared and on the absolute mass of the body, as measured in pounds or kilograms. We need to

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move away from the concept of measuring and diagnosing obesity based on body weight or body mass index (BMI) and evolve towards the measurement and clinical assessment of adiposity. The question should be "do we want to measure how obese a person is, or do we want to assess if he/she is at the highest risk of adiposity-related comorbid conditions that can potentially interfere with our management?" [1]. Current dosing recommendations, which are based on milligram-per-kilogram total body weight (TBW), are intended and valid for normal-weight individuals. Population demographics have changed towards obesity becoming more common throughout the world. In morbidly obese (MO) patients, lean body mass (LBM) increases disproportionally with increasing adiposity and these changes can alter drug distribution. For MO patients we need to use an individualized dosing scalar that takes into account the changed body composition. How can assessment of adiposity be used in a dosing scalar for obese patients?

2.2 The Problems with Assessing Excess Adiposity

A substantial body of evidence proves that obese patients as a group are at greater risk of co-morbidities than normal-weight individuals. The presence of abdominal obesity is one of the components of the metabolic syndrome (MetS) and has been associated with stroke, coronary artery disease (CAD) and overall mortality. These comorbidities appear to increase as a continuum as patients go from being overweight to obese.

How do we explain why some obese patients are metabolically healthy whereas others with the same level of obesity (expressed as BMI) have all the metabolic complications associated with obesity? Individuals with normal body weight, as defined by BMI, are still at risk for developing the MetS if they have a high body fat content or a high waist circumference [2–5]. This indicates that obesity is a heterogeneous condition. Although BMI is a useful tool to describe changes in adiposity at the population level, it cannot discriminate the risks of associated disease at the individual level.

In 1947, based on simple clinical observations, Jean Vague introduced the term android obesity to describe the high risk form of obesity in contrast to the gynoid obesity carrying the lower risk [4]. This launched the idea that the common complications of obesity were related more closely to the distribution of fat than obesity per se [5, 6]. In the 1980s, Björntorp and Kissebah reported that the waist to hip ratio (WHR) was related to increased risk of CAD, T2DM, and to a diabetogenic/atherogenic metabolic risk profile [7–10]. The relative accumulation of abdominal fat increases the waist circumference relative to the hip girth. This provided new evidence that body fat distribution deserves more attention as a predictor of comorbidities than simple measures of excess body weight.

With the introduction of computed tomography (CT) and magnetic resonance imaging (MRI), researchers were able to make a distinction between the subcutaneous adipose tissue (SAT) of the abdomen wall and fat located in the abdomen,

which is called visceral adipose tissue (VAT) and includes omental, mesenteric, and retroperitoneal fat. Patients with excess VAT and deep SAT have a higher diabetogenic/atherogenic profile [6, 11]. Specifically, visceral adiposity is definitely more closely associated with severe metabolic disturbances than subcutaneous adiposity [12, 13]. Increases in visceral adiposity are associated with increasing age, gender (men > women), menopause in women, tobacco smoking, high caloric diet, genetic factors, sedentary lifestyle and ethnicity [14, 15]. People of African descent are more prone to SAT than those of European or Hispanic descent, while Asians may be more prone to VAT [16, 17].

There are three main theories attempting to answer the question whether VAT is the cause of the metabolic abnormalities associated with obesity.

1. *The portal free fatty acid model*
   In this hypothesis the intra-abdominal and visceral adipocytes expose the hepatocytes to a continuous overflow of free fatty acids (FFA) which affect the metabolic function of the hepatocyte [18]. This impairment of hepatic metabolism causes a reduced extraction and degradation of insulin resulting in hyperinsulinemia, a reduced degradation of apolipoprotein B resulting in hypertriglyceridemia, and increased hepatic glucose production resulting in impaired glucose tolerance and eventually T2DM [7, 18]. One criticism is the fact that most of the FFA in the portal blood originates from the SAT and not the VAT, indicating that other mechanisms may be involved in the full explanation of the dysmetabolic state found in visceral adiposity [19, 20].
2. *The endocrine function of VAT*
   Adipose tissue is more than an organ specialized for just storage and mobilization of triglycerides. It produces several adipokines (cytokines from adipocytes) that could be at the basis of the dysmetabolic state associated with total adiposity/visceral adiposity [21]. For instance, leptin levels are more closely related to total and subcutaneous adiposity than abdominal adiposity [22]. The levels of adiponectine reflect better VAT than SAT, and its levels are low in men, visceral obese individuals, and those with T2DM [23–26]. When adipose tissue hypertrophies, it is infiltrated with macrophages which are producers of the inflammatory cytokines α-TNF and interleukin-6 (IL-6) [27, 28]. The inflamed hypertrophied adipose tissue feeds high levels of IL-6 to the liver, stimulating the hepatocytes to produce C-reactive protein and possibly impairing hepatic metabolism [29].
3. *Dysfunctional subcutaneous adipose tissue leads to ectopic fat distribution*
   Normally any overload of extra calories will be safely stored as fat in the subcutaneous fat depot which acts like a metabolic buffer. To achieve this safe storage of extra energy, the SAT needs to undergo hyperplasia by multiplication of pre-adipocytes to increase the number of storage cells [30, 31]. Any process, such as adipose tissue hypoxia that limits this ability, could result in accumulation of fat in other organs, a phenomenon called ectopic fat deposition [32]. In this respect, women inherently can handle the dietary fat load better than men due to their higher levels of protective and buffering SAT [33]. Thiazolidines

improve glycemia and the cardiometabolic risks in obese patients because they induce hyperplasia of SAT and decrease liver fat [34]. According to this theory, VAT should be viewed as a marker of dysfunctional adipose tissue with the deposition of ectopic fat. Ectopic deposition of fat in the liver has been studied extensively and is closely related to the features of the MetS and non-alcoholic fatty liver disease [35, 36]. The evaluation of the individual liver fat content has the potential to become an important predictor of the cardio-metabolic abnormalities related to obesity [37].

To summarize, instead of using weight-based measures for obesity, we need to look for ways of assessing adiposity and in particular the VAT and the ectopic liver fat. We need information on body fat deposition and body composition if we want to have clinical and practical predictions on the extent of dysmetabolism in obese patients.

2.3 Methods for Assessing Adiposity

2.3.1 Body Weight and BMI

Absolute body weight is an inappropriate estimate of adiposity because weight is proportional to height. It was Quetelet, a Belgian mathematician from the proud city of Ghent, who had the idea to express the relationship between body weight and height in the Quetelet index, now known as body mass index or BMI [38]. BMI is very simple to calculate and still is an excellent screening tool in the assessment of total body adiposity. Yet, the numerator in the equation is TBW, and this does not discriminate between lean and fat body mass. Normal-weight individuals with excess body fat will not be diagnosed as being overweight and adults with high LBM such as those with increased muscle mass may be classified as obese. Studies and meta-analysis that compared BMI to the World Health Organization (WHO) criteria for obesity (body fat >25% in men and >35% in women as measured by bioelectrical impedance) revealed a pooled sensitivity of 50% to identify excess adiposity and a pooled specificity of 90% indicating that half of the patients with excess body fat were not diagnosed as obese [39]. There is evidence that the BMI criteria used for diagnosing overweight and obesity are not independent of age, gender, and ethnicity [40]. Different population dependent cut-off points for what BMI constitutes as obesity are indicated since Hispanic, black and white women in America all with the same BMI have different percentages of body fat [40]. This difference between BMI and disease risk is most pronounced in Asians, and for Asian subjects a BMI between 23 and 27 $kg \cdot m^{-2}$ is more appropriate in defining obesity than the value of 30 $kg \cdot m^{-2}$ usually used for all patients [41].

2.3.2 Assessing Body Fat Distribution

2.3.2.1 Waist Circumference

Although waist circumference (WC) is an inexpensive way to assess central obesity with excellent correlation with imaging techniques and high association with cardio-vascular disease risk and mortality, it does have some practical limitations including location of measurement and cut-off values [42, 43]. Additionally, it cannot differentiate SAT from VAT. There are eight different measurement locations that have been used and different experts recommend different measuring points [44]. The WHO recommends the use of the midpoint WC measurement (halfway between iliac crest and lowest rib) whereas the National Institutes of Health and the American Heart Association are in favor of measuring WC at the iliac crest. For each measurement site we still need values that predict cardiovascular disease morbidity and mortality.

2.3.2.2 Hip Circumference

Although hip circumference (HC) does not appear to be a significant predictor of all-cause mortality, it is used to calculate the waist/hip ratio (WHR) [45]. It is measured at the level of the widest circumference at the buttocks because wider hips imply functional SAT and thus provide protection against cardiovascular disease [46].

2.3.2.3 Other Body Circumferences

Thigh and calf circumferences have been used to provide an index of upper to lower body adiposity. Larger thigh circumference is associated with lower risk of T2DM both in men and women whereas thigh circumference was negatively associated with mortality in men but not in women [46]. Neck circumference increases the odds of MetS in men and in particular women and can be associated with the severity of obstructive sleep apnea (OSA) [47, 48].

2.3.2.4 Ratios

Various ratios can be computed and have been used to predict the risk of metabolic disorders in obesity. The most common are WHR, waist to height ratio (WHtR) and waist to thigh ratio. Studies have found that BMI, WC and WHR are strongly and independently related to T2DM in both men and women [49]. Taylor et al. were able to demonstrate that BMI, WHR, WHtR and WC correlate with CVD risk factors, with HC being less strongly associated with triglyceride concentrations and insulinemia [50]. WHR, WHtR and WC were superior in predicting the incidence of CAD in white middle-aged women [51]. The use of ratios as indicators of upper to lower body fat distribution has also sparked debate and controversy. In their conclusions, both Gelber et al. and Taylor et al. saw no substantial clinically meaningful difference between the use of BMI or WHR in predicting cardiovascular events, and the routine use of ratios to assess adiposity is not recommended in literature [51, 52]. The importance of WHR and WHtR lie in

the fact that they have the potential to adjust for ethnic differences in body shape and fat deposition when estimating the metabolic risks for the individual [53].

2.3.2.5 Sagittal Abdominal Diameter

Sagittal abdominal diameter (SAD) can be measured by CT or MRI and some studies have found it to be a better marker of abdominal visceral fat, metabolic disorders and CAD than WHR, while other studies found no advantage of SAD over WC [54–57]. SAD measurement still needs to be standardized and validated together with identification of normal thresholds. Measurements in obese patients exceeding the weight and size limits of the CT machinery are a restraint.

2.3.2.6 CT and MRI

A CT scan can compute areas (from a single slice) and even volumes (from repeated 10-cm interval slices) of selected tissues in the body, in particular adipose tissue depots. VAT and SAT content of the body are usually estimated from a single slice CT scan at the L4-L5 level [58]. It is unclear whether VAT and SAT volumes derived from a whole body scan are more predictive of disease and a dysmetabolic state than the estimations of a single image scan [59]. The abdominal wall muscles mark the border between VAT and SAT [60]. CT scans can also assess the ectopic fat deposited in nonadipose tissue like liver and muscle. Universally accepted definitions of exactly what constitutes excess SAT and VAT based on CT scans have yet to be outlined [58].

Assessment of adipose tissue with MRI compares well to CT measurements while avoiding radiation exposure. Single slice MRI is preferred over whole body MRI. There is still ongoing debate over the ideal location of a single slice MRI in order to assess total VAT. Shen et al. concluded that 10 cm above L4-L5 in men and 5 cm above L4-L5 in women had the best correlation with total body VAT and metabolic disorders [61]. Liu et al. found different correlations at other measuring points in individuals from different ethnicity [62]. Use of CT and MRI is mainly restricted to research and limited by costs and sophisticated equipment or data processing. Disappointing is the fact that neither CT nor MRI can accommodate severely obese patients.

2.4 Methods for Assessing Body Composition

Besides percentage of body fat, clinical applications require measurements of body composition like fat distribution, muscle mass, fat-free mass and bone mass. Several techniques can be used including anthropometry, skin fold thickness, near infrared interactance, hydrostatic weighing, air displacement plethysmography, dual energy X-ray absorptiometry, bioelectric impedance and CT/MRI. Some laboratory methods are more precise than field methods but are more expensive, time intensive, and require more skill and technical training. Anthropometry and bioelectrical impedance analysis (BIA) are the most routinely used clinically.

2.4.1 Anthropometry

Measurements of mid-upper arm and mid-thigh circumference can be used as simple indicators of muscle mass [63]. The accuracy and reliability of these measurements are strongly observer dependent and their clinical importance is unclear [64].

2.4.2 Dual-Energy X-ray Absorptiometry

Dual-energy X-ray absorptiometry (DEXA) uses the attenuation of radiation at two different energy levels to determine the two components of the attenuating tissues. These tissues can be bone and soft tissue or lean soft tissue and fat tissue. Many consider DEXA as the gold standard for body fat assessment, even though it might overestimate body fat in adults and children [65]. Abdominal fat measurements with a DEXA scan are highly correlated to CT scan results with a slight underestimation of body fat by the DEXA scan [66]. Since it requires very little radiation DEXA may be more suitable for repeated measures.

2.4.3 Bioelectric Impedance Analysis

The electric conductivity of tissues depends on their water and dissolved ion content. Fat and bone are relatively nonconductive. A small alternating single frequency current is passed through electrodes attached to body extremities like wrist or ankle and the impedance is measured, and an estimation of total body water estimation is obtained. Assuming that 73% of human fat-free mass is water, the total fat free body mass is calculated from the estimation of total body water [67]. The validity of body fat assessment by bioelectric impedance analysis (BIA) is influenced by gender, age, disease state, race and ethnicity level of adiposity, environment, menstrual cycle and underlying medical conditions [68, 69]. For this reason, BIA should be validated for each of these conditions and this limits its reliability to assess body fat distribution.

2.5 How Should These Measurements be Used to Calculate Anesthetic Drug Dosage?

One of the problems in providing anesthesia for MO patients is determining the appropriate and safe dose of anesthetic agents. Dosage recommendations for most anesthetic drugs are based on TBW in normal-weight persons. The assumption is made that dosage is linear with body weight. This would imply that volume of distribution (Vd) and clearance (Cl) for a 160 kg person is double that of an 80 kg person. For lipid soluble drugs, this might be reasonable, but for hydrophilic drugs Vd is more likely to be related to LBW than TBW. Most metabolic reactions occur in LBW, adipose tissue does not metabolize drugs, and liver and kidney metabolic

capacity is not linearly related to TBW [70]. In MO patients we have insufficient knowledge on the way that altered body composition affects pharmacokinetic parameters, and Vd, Cl and protein binding may each be attenuated by obesity [71].

Pathophysiological modifications in obese patients likely to affect drug distribution and elimination include: increased cardiac output, increased LBW, increased fat mass, increased extra cellular fluid compartment, potential hepatocyte dysfunction and changed filtration rate of the kidney. Additionally, protein binding and protein plasma concentrations may be different in the obese. Cardiac output plays an important role in the early pharmacokinetics of drug distribution and dilution and MO patients have an increased cardiac output. However, there is a temporal sequence in the negative effects of obesity on cardiac function. The impairment of left ventricular function is related to the magnitude and the duration of obesity and might lead eventually to cardiac failure. Ideally, the administered dose of a drug in each individual patient should be scaled to the body weight, body composition, age, gender and patient's condition.

In an editorial, Bouillon and Shafer showed which weight approaches (as a function of patient gender, height and total body weight) can be used clinically when we are unsure about the true relation between size and pharmacokinetics [72]. Different strategies of dosing in obese patients include scaling to TBW, LBW, ideal body weight (IBW) with or without addition of some of the excess weight, or even not adjusting at all. Can some of the measurements and assessments of adiposity be incorporated in our dosing scalars for the obese patients?

2.5.1 Total Body Weight

Using TBW could lead to an overdose in obese patients. Anesthesiologists have become highly skilled at titrating toxic drugs within their narrow therapeutic window towards their specific therapeutic and clinical effect by reducing doses in obese patients based on experience and intuition alone. The majority of anesthetic drugs are strongly lipophilic. Increased Vd is expected for lipophilic substances but this is not consistently demonstrated in pharmacological studies because of factors such as end-organ clearance or protein binding [73]. Blouin et al. observed that the Vd of water-soluble agents is less affected by obesity than lipophilic compounds [74]. Drugs with high affinity for fat tend to have an increased Vd in the obese. For some drugs, TBW can be used (Table 2.1).

2.5.2 Lean Body Weight

Lean body weight (LBW) or lean body mass (LBM) is composed of the body cell mass, extracellular water and non-fatty intercellular connective tissue and can be therefore considered a better reflection of the changed body composition. Fat and LBM increase with TBW, but fat tissue keeps on increasing in proportion to TBW while the relative percentage of LBM per TBW decreases. In obese patients, LBW

Table 2.1 Utilization of total body weight (TBW), lean body weight (LBW) or ideal body weight (IBW) to calculate dosing schemes in morbidly obese patients

Drug	Recommended dosing	References[a]
Propofol	Induction: IBW Induction: LBW assessed by BIA Maintenance: TBW or IBW + 0.4 excess weight	Kirby. *Anaesthesia* 1987; 42:1125–1126 Ingrande. *Anesth Analg* 2011; 113:57–62 Servin. *Anesthesiology* 1993; 78:657–665 Albertin. *Br J Anaesth* 2007; 98:66–75
Thiopental	7.5 mg/kg IBW TBW	Buckley. *Can J Anaesth* 1994; 41:R94–R100 Jung. *Anesthesiology* 1982; 56:269–274
Midazolam	TBW for initial dose IBW for continuous dose	Greenblatt. *Anesthesiology* 1984; 61:27–35 Reves. *Anesthesiology* 1985; 62:310–324
Vecoronium	IBW	Weinstein. *Anesth Analg* 1988; 67:1149–1153
Cisatracurium	TBW IBW	Kirkegaard-Nielsen. *Anesth Analg* 1996; 83:1076–1080 Leykin. *Anesth Analg* 2004; 99:1090–1094
Rocuronium	IBW	Leykin. *Anesth Analg* 2004; 99:1086–1089
Succinylcholine	TBW	Bentley. *Anesthesiology* 1982; 57:48–49
Neostigmine	TBW	Kirkegaard-Nielsen. *Can J Anaesth* 1998; 45:39–41
Suggamadex	IBW + 40% excess weight	Van Lancker. *Anaesthesia* 2011; 66:721–725
Alfentanil	IBW or corrected weight TBW	Bentley. *Anesth Analg* 1983; 62:245–262 Salihoglu. *EJA* 2002; 19:125–128 Maitre. *Anesthesiology* 1987; 66:3–12
Fentanyl	TBW Corrected weight = IBW + (0.4x excess weight) pharmacokinetic mass = $52/[1 + (196.4 \times e^{-0.025kg} - 53.66)/100]$	Bentley. *Anesth Analg* 1981; 60:548–551 Salihoglu. *EJA* 2002; 19:125–128 Shibutani. *Anesthesiology* 2004;101: 603–613
Sufentanil	TBW Corrected weight BMI >40	Schwartz. *Anesth Analg* 1991; 73:790–793 Slepchenko. *Anesthesiology* 2003; 98:65–73

(Continued)

Table 2.1 (continued)

Remifentanil	LBM (James equation) LBM (Janmahasatian equation)	Egan. *Anesthesiology* 1998; 89:562–573 La Colla. *Clin Pharmacokinet* 2010; 49:131–139
Morphine	IBW	Choi. *Obes Surg* 2000; 10:154–159
Paracetamol	IBW	Lee. *J Clin Pharmacol* 1981; 21: 284–287

[a] First author, journal abbreviation, year of publication, volume, pages

is a strong determinant of stroke volume and cardiac output, which in turn are important factors in the early distribution kinetics of drugs. Since most metabolic processes occur in the LBW compartment, researchers intuitively agree that drug dosage based on LBW would be more logical. Until recently, few studies have considered using LBW even though as a dosing scalar LBW is valid across all body compositions for many drugs.

LBM can be calculated using the following formulae of James (Research on obesity. London: Her Majesty's Stationery Office, 1976):

For Males: $LBM = 1.1\ (weight) - 128\ (weight/height)^2$
For Females: $LBM = 1.07\ (weight) - 148\ (weight/height)^2$

These formulae contain a flaw. For a given height, as weight increases the LBM will increase until a threshold will be reached beyond which the LBM will decrease (due to the quadratic origin of the function). In 2005, Janmahasatian published LBW equations for patients ranging between 40 and 220 kg [75].

Males: $9270 \times TBW/(6680 + 216 \text{ x } BMI)$
Females: $9270 \times TBW/(8780 + 244 \text{ x } BMI)$

These equations (based on gender, TBW and height) have accurate predictive properties when compared to dual energy X-ray absorptiometry, a gold standard for measurement of LBW. Data obtained using these equations can be easily used to approximate LBW.

Ingrande et al. scaled the induction dose of propofol to LBW or TBW in 60 MO patients and compared dosing with a control group of 30 non-obese individuals receiving propofol scaled to TBW. The results confirmed that LBW is a more appropriate dosing scalar for the induction dose of propofol MO patients and that LBW assessed by BIA is in good agreement with the equations of Janmahasatian [76].

2.5.3 Ideal Body Weight and Corrected Body Weight

The term ideal body weight originated from the height-weight tables used by the Metropolitan Life Insurance Company. For each gender and each height, a desirable weight or ideal body weight (IBW) could be determined that correlated with the maximum life expectancy. Before the use of BMI, obesity was defined as a TBW 20% greater than IBW. In 1974, Devine et al. concluded that the pharmacokinetics of gentamicin correlated well with IBW and he published his equations to calculate IBW [77]. At that time measurements of LBW were expensive and complex so IBW became a surrogate for LBW as a representation of fat-free weight, and this concept still haunts us today. IBW can be useful in patients up to a BMI $< 40\ \text{kg} \cdot \text{m}^{-2}$, but does have the potential of under dosing. IBW as a dosing scalar is somewhat illogical because all obese patients with the same height would get the same dose irrespective of their body composition or TBW.

An attempt to overcome this shortcoming is to add 20–40% of TBW to IBW in order to include the increased LBW in the dosage (%IBW).

2.5.4 Pharmocokinetic Mass

Theoretically, obesity significantly affects the pharmacokinetic profiles of lipophilic drugs including opioids because the peripheral compartment is characterized by a high amount of adipose tissue. In his work on fentanyl, Shibutani et al. investigated the influence of body weight on the predictive accuracy of the Shafer model and the Scott and Stanski model [78–80]. He found that both models overestimated the fentanyl concentrations with increasing weight because these models are not scaled to body weight. Focusing on the Shafer model and using an exponential equation for Shafer's performance error versus TBW, Shibutani et al. managed to derive suggested dosing weights for obese patients over a wide range of TBW ("pharmacokinetic mass" $= 52/[1 + (196.4 \times e^{-0.025\text{kg}} - 53.66)/100]$). Pharmocokinetic mass and TBW are linear for patients <100 kg with a slope of 0.65. For patients weighing 140–200 kg dosing weights of 100–108 kg are recommended.

2.5.5 Allometric Scaling

Allometric scaling is a technique used in pharmacology to extrapolate pharmacokinetic parameters derived from animal studies to man or from adult to pediatric populations based on changes in the characteristics according to body size [81]. In an attempt to develop a pharmacokinetic (PK) model to characterize the influence of obesity on propofol PK parameters, Cortinez et al. found that an allometric model using TBW as the size descriptor of volumes and clearances was superior to other size descriptors to characterize propofol PK in obese patients, including LBW [82].

2.6 Practical Guidelines

Practical guidelines for dosage adjustment with their references are proposed in Table 2.1. In some subgroups, for example, the super-obese (BMI > 55 kg $\cdot$ m^{-2}) or obese patients with several or serious comorbidities, dosage adjustment does not always follow these recommendations. In these patients, pharmacodynamic monitoring can help to titrate anesthetic drug administration towards the desired clinical effect.

2.7 Conclusions

Most dosage recommendations are scaled to weight, without any scientific evidence that pharmacokinetics are weight proportional. MO patients represent a "pharmacological challenge" for the anesthetist as obesity does affect the pharmacokinetics of many of our intravenous anesthetic drugs. IBW can be used for many modern anesthetics (but not all) in order to scale to weight in a range up to

BMI 40 kg · m^{-2}. The use of LBW as determined by BIA or the equations of Janmahasatian is not only logical, but recent studies have confirmed its potential. The Holy Grail for the obese patient is the search for a universal size descriptor that can be used to calculate drug dosage. Until then pharmacodynamic monitoring remains useful and advisable.

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