Journal of the Korea Convergence Society
Vol. 11. No. 10, pp. 349-353, 2020

ISSN 2233-4890 / eISSN 2713-6353
https://doi.org/10.15207/JKCS.2020.11.10.349

Adequate anesthetic induction dose in a morbidly obese patient based on bioelectrical impedance analysis.
-Case report-

Ki-Jae Lee[1], Seungseo Choi[1], Seon Ju Baek[1],
Dong-Chan Kim[2], Jeongwoo Lee[2], Jun Ho Lee[1*]
[1]M.D., Department of Anesthesiology and Pain Medicine, Jeonbuk National University Medical School and Hospital, Jeonju, Korea
[2]M.D. Ph.D., Department of Anesthesiology and Pain Medicine, Jeonbuk National University Medical School and Hospital, Jeonju, Korea

병적 비만 환자에서 생체 전기 임피던스 분석을 이용한 적절한 마취 유도 용량 -증례보고-

이기재[1], 최승서[1], 백선주[1], 김동찬[2], 이정우[2], 이준호[1*]
[1]전북대학교병원 마취통증의학과 의사
[2]전북대학교병원 마취통증의학과 의학박사

Abstract Background: The dosage of the anesthetic drugs is generally determined by the total body weight of the patients. However, the drugs can be overdosed when the patient is morbidly obese. We have determined anesthetic induction dose based on lean body mass estimated from bioelectrical impedance analysis (BIA). Case: We report a case of morbidly obese patient (161 cm, 138 kg and body mass index 53.1) who had an elective laparoscopic cholecystectomy. The dose of induction agent was determined by lean body mass estimated by BIA, and the sedation was assessed by the observer's assessment alertness/sedation scale. Conclusions: Dose determination through lean body mass measured by BIA is useful in highly obese patients.

Key Words : Morbid obesity, Anesthesia, Anesthetic hypnosis, Body constitution, Bioelectrical impedance

요 약 배경: 마취약제의 용량은 일반적으로 환자의 총체중량으로 결정된다. 그러나 병적 비만 환자에서 그 용량은 과량투여 되기 쉽다. 약물의 적절한 용량을 결정하는 기준은 다소 모호하지만, 마취 유도시 생체 전기 임피던스 분석(BIA)을 통해 마른체중을 구하여 마취 유도용량을 결정할 수 있다. BIA를 통해 총체내수분을 구하고, 체내수분을 제외한 체중을 쉽게 계산할 수 있다. 증례: 복강경 담낭절제술이 예정된 병적 비만 환자(161 cm, 138 kg and 체질량지수 53.1)의 증례를 보고하고자 한다. BIA로 예측한 마른체중을 통해 마취 유도제의 용량을 결정하고, 각성/진정척도를 통해 진정 상태를 평가하였다. 결론: BIA로 측정한 마른체중을 통해 약물 용량을 결정하는 것은 병적 비만 환자에서 유용하다.

주제어 : 병적 비만, 마취유도 용량, 마취, 체내 조성, 생체 전기 임피던스 분석

*Corresponding Author : Jun Ho Lee(gojuno@jbnu.ac.kr)
Received September 2, 2020
Revised October 7, 2020
Accepted October 20, 2020
Published October 28, 2020

1. Introduction

Obesity is a major health problem, and is becoming prevalent worldwide. Recent statistics from western countries suggest that 20% of adults are obese and 1% morbidly obese [1]. Anesthesia for obese patients may have considerable risk. Obesity is a multi-system disorder, involving the respiratory and cardiovascular systems in particular. Obesity is usually defined by body mass index (BMI) calculated as weight (kg) divided by the square of the height (m^2). When the BMI is more than 30 kg/m^2, it is considered obese. BMI over 35 is also considered as morbid obesity. The American Society of Anesthesiologists (ASA) classified patients with BMI over 40 as ASA-physical status III, which would have relatively higher mortality than healthy patients after surgery [2].

Determination of appropriate dosage of the drugs is not easy. Because the pharmacokinetics of most anesthetic drugs are affected by the content of adipose tissue, the effect is less predictable. The dosage of lipophilic drugs such as barbiturates should be adjusted due to changes in volume of distribution (Vd). When Vd increases, the elimination half-life also prolongs. These drugs require lean body mass (LBM) or ideal body weight for determining the dose of anesthetics. Moreover, the doses of drugs used in anesthesia induction differ from those of non-obese patients. Even small doses of the drug may result in insufficient anesthesia and overdose may cause hemodynamic instability [3]. Therefore, the drug is administered based on the LBM for the appropriate dose of the anesthetic inducing agent [4].

A number of formulas have been presented to calculate LBM, but the values quite vary in morbid obesity. In this case, we performed anesthesia after measuring LBM using bioelectrical impedance analysis (InBody S10® body water analyzer) for a morbid obese patient (Fig.1.) [5]. Bioelectrical impedance analysis (BIA) is a commonly used method of estimating body composition such as body fat and muscle mass [6]. In BIA, a weak electric current flows through the body and the voltage is measured in order to calculate impedance of the body. Because most body water is stored in muscle, the electric current through body tissue can be used to estimate total body water by determining the electrical impedance. Here, we report a female morbid obese patient who had a laparoscopic cholecystectomy. The LBM was estimated by BIA, and the dosage of anesthetic drugs was calculated through the estimation of LBM.

Fig. 1. InBody S10® body water analyzer

2. Case Report

A 21-year-old female patient was admitted to our general surgery department for the scheduled laparoscopic cholecystectomy. On preoperative laboratory tests conducted a day before surgery, most of them were within normal range, but white blood cell count was 9,800/μL [4,800-10,800], erythrocyte sedimentation rate was 42 mm/h [< 9 mm/h], and C reactive protein was 43.14 mg/L [< 5 mg/L]. Also, chest PA, electrocardiography (ECG) presented non-specific. Her height was 161cm, the weight was 138kg,

and the body mass index (BMI) 53.2 kg/m^2. Liraglutide, known as incretin mimetics, had been used for 1 month as a treatment of obesity.

Bioelectrical impedance analysis was measured preoperatively, and the LBM was 59.6 kg (Table 1). The amount of LBM according to the formula for estimating LBM was significantly different according to each formula; 38.9kg for James formula [7], 62.6kg for Boer formula [8] and 64.8kg for Hume formula [9].

James formula:

Women: 1.07 x weight - 148 x (weight/height)^2

Men: 1.10 weight - 128 (weight/height)^2

Boer formula:

Women: 0.252 x weight + 0.473 x height - 48.3

Men: 0.407 x weight + 0.267 x height - 19.2

Table 1. Lean body mass (LBM) by bioelectric impedance analysis

	Estimated value	TBW	LBM	Weight
ICW (L)	26.9	44.3	59.6	138.0
ECW (L)	17.4			
Dry Lean mass (kg)	15.3			
Body fat mass (kg)	78.4			

ICW (L): Intracellular water, ECW (L): Extracellular water,
TBW (L): Total body water (TBW = ICW + ECW),
LBM (kg): Lean body mass (LBM = TBW + Dry lean mass)
Weight (kg) = LBM + Body fat mass

At the operating room, ECG, blood pressure, pulse oximetry, bispectral index scale (BIS) and a peripheral nerve stimulator (TOF watch®, Organon Ltd., Dublin, Ireland) were monitored. Initial vital signs were blood pressure 143/88 mmHg, heart rate 78 beats per minute, and oxygen saturation (SpO_2) 98% before anesthesia induction. The bispectral index (BIS) was attached, and the initial value was 94. Thiopental sodium 200mg (5mg/kg) was administered by James formula, and bispectral index (BIS) [10] and the observer's assessment alertness/sedation scale (OAS/S) were evaluated 30 seconds after injection [11]. BIS was 74, and OAS/S was 3, which was not enough for loss of consciousness (LOC). Additional 100 mg of thiopental sodium was injected based on LBM measured by bioelectrical impedance analysis, and LOC was confirmed (BIS 62, OAS/S 0). Then, a neuromuscular blocking agent, rocuronium 60 mg, was added. Endotracheal intubation was performed without any difficulty at train-of-four count 0 after mask ventilation with 8 vol% desflurane and 4 ng/ml remifentanil. There was no hemodynamic instability after induction and no special events during surgery.

The effect-site concentration of remifentanil was maintained at the steady-state levels, 3-3.5 ng/ml. Controlled mechanical ventilation was maintained with a tidal volume 8 ml/kg (based on ideal body weight) and an inspiratory to expiratory ratio 1 : 2 with 10 cmH_2O of PEEP. The ventilatory frequency was set to keep the end-tidal PCO_2 range of 36-40 mmHg. Cuff pressure of the endotracheal tube was monitored and maintained in between 28-30 cmH_2O. Core temperature was monitored at esophageal level and actively warmed to keep the body temperature 36.3-36.4 ℃ by using a forced air warming unit.

The duration of the operation was 90 minutes. The regimen of patient controlled analgesia was fentanyl 600 mcg, ketorolac 180 mg and nefopam 120mg in total 60 ml solution. The operation was done without any complication. After the surgery, muscle relaxant was reversed by sugammadex with checking TOF ratio. After checking spontaneous breathing, the patient was extubated and transferred to post-anesthesia care unit.

3. Discussion

The obese patients may experience various problems during anesthesia. The preoperative evaluation should check for metabolic syndrome and assess whether airway management is not difficult. Obstructive sleep apnea is a common

medical concern in the morbidly obese patients. For those obese patients with sleep apnea, symptoms such as upper airway obstruction may occur after waking from anesthesia. For the treatment of morbid obesity, incretin mimetics such as Liraglutide have been commonly used. However, cholecystitis may occur as a complication after using Liraglutide. The patient received cholecystectomy under general anesthesia for the tretment of cholecystitis after weight control.

In this case, we focus on determining the dose of drugs during anesthesia induction based on the LBM instead of the total body weight. Drug overdose may show cardiovascular deterioration and less administrated drugs may not maintain appropriate anesthesia state [12]. Therefore, it is essential to measure the appropriate weight to determine the induction dose. Various empirical formulas for estimating the LBM such as James, Boer, or Hume LBM calculation have been proposed. However, the value of the LBM varies depending on the calculation methods. The smallest calculated LBM was 38.9 kg by James formula and the largest was 64.8 kg by Hume formula. The variation is quite large compared to the LBM measured by BIA (59.6 kg). We administered anesthetics based on the James formula at the time of induction, but the dose was not enough for loss of consciousness. Additional dose was added based on the LBM measured by BIA, then loss of consciousness appeared. If an additional dose was injected by the Hume formula, overdose would have been administered. Since hemodynamic instability increases when overdose administered, the minimun dose for loss of consciousness is important for patient safty.

Here, the authors have used BIA to measure LBM, and we cosider that the BIA helped to determine the clinically optimal anesthetic dose. According to the existing LBM calculations, the error between the calculations of the LBM values becomes even larger in morbid obese patients.

BIA is a harmless and convenient measuring instrument that can measure LBM by body composition analysis. In a study for female patients, dose of propofol induction should be reduced and individualized based on fat free mass using BIA [13]. LBM can be measured by body composition analysis through dual-energy x-ray absorptiometry (DEXA) [14]. Therefore, in morbid obese patients except for inserting implantable cardioverter defibrillator (ICD), the induction dose can be determined safely by measuring LBM through bioelectrical impedance analysis.

Like the Janmahasatian formula, there is a proven formula through BIA and dual-energy x-ray absorptiometry (DEXA), but it is a case report of anesthesia induction through direct LBM measurement through BIA [15].

It is very important that the induction drug dose of obese patients is calculated by LBM. Direct LBM measurement via BIA, which is simpler and safer than formulated drug injection, is necessary for safe anesthesia induction in patients with very high obesity. Dose determination through LBM measured by BIA is useful in highly obese patients.

REFERENCES

[1] S. Lotia & M. C. Bellamy. (2008). Anaesthesia and morbid obesity. *Continuing Education in Anaesthesia Critical Care & Pain, 8,* 151-6.

[2] O. Visnjevac, S. Davari-Farid, J. Lee, L. Pourafkari, P. Arora, H. H. Dosluoglu. (2015). The effect of adding functional classification to ASA status for predicting 30-day mortality. *Anesth Analg 121,* 110-6.

[3] D. L. Prior, J. Sprung, J. D. Thomas, D. G. Whalley, D. L. Bourke. (2003). Echocardiographic and hemodynamic evaluation of cardiovascular performance during laparoscopy of morbidly obese patients. *Obes Surg, Oct;13(5),* 761-7.

[4] D. J. Morgan & K. M. Bray. (1994). Lean body mass as a predictor of drug dosage. Implications for drug therapy. *Clin Pharmacokinet 26,* 292-307.

[5] K. R. Segal, M. Van Loan, P. I. Fitzgerald, J. A. Hodgdon & T. B. Van Itallie. (1988). Lean body mass estimation by bioelectrical impedance analysis: a

four-site cross-validation study. *Am J Clin Nutr, 47,* 7-14.

[6] U. G. Kyle, I. Bosaeus, A. D. De Lorenzo, P. Deurenberg, M. Elia & J. M. Gómez. (2004). Bioelectrical impedance analysis—part I: review of principles and methods. *Clinical Nutrition, 23,* 1226-43.

[7] Research DMGoO. Research on obesity : a report of the DHSS/MRC group / compiled by W. P. T. James. (1976). *Department of Health and Social Security [and the] Medical Research Council.* London, H.M.S.O.

[8] P. Boer. (1984). Estimated lean body mass as an index for normalization of body fluid volumes in humans. *Am J Physiol, 247,* F632-6.

[9] R. Hume. (1966). Prediction of lean body mass from height and weight. *J Clin Pathol, 19,* 389-91.

[10] A. Pandazi, A. Bourlioti & G. Kostopanagiotou. (2005). Bispectral Index (BIS) monitoring in morbidly obese patients undergoing gastric bypass surgery: experience in 23 patients. *Obes Surg, Jan;15(1),* 58-62.

[11] D. A. Chernik, D. Gillings, H. Laine, J. Hendler, J. M. Silver & A. B. Davidson. (1990) Validity and reliability of the Observer's Assessment of Alertness/Sedation Scale: study with intravenous midazolam. *J Clin Psychopharmacol, 10,* 244-51.

[12] Z. Wu, J. Li, C. Wang, J. Yang, X. Chen & W. Yang. (2018). Characterization of cardiovascular depression effect for propofol during anesthesia induction period on morbidly obese patients. *Biomed Pharmacother, 106,* 618-23.

[13] D. Chassard, K. Berrada, B. Bryssine, M. Guiraud, P. Bouletreau. (1996). Influence of body compartments on propofol induction dose in female patients. *Acta Anaesthesiol Scand, Sep;40(8 Pt 1),* 889-91.

[14] R. B. Mazess, H. S. Barden, J. P. Bisek, & J. Hanson. (1990). Dual-energy x-ray absorptiometry for total-body and regional bone-mineral and soft-tissue composition. *Am J Clin Nutr, 51,* 1106-12.

[15] S. Janmahasatian, S. B. Duffull, S. Ash, L. C Ward, N. M. Byrne & B. Green. (2005). Quantification of lean bodyweight. *Clin Pharmacokinet, 44,* 1051-65.

이 기 재(Ki-Jae Lee) [정회원]

· 2009년 2월 : 전북대학교 의학과(의학사)
· 2017년 2월 : 전북대학교 마취통증의학과 전문의
· 2017년 3월 ~ 2019년 2월 : 전북대학교 마취통증의학과 전임의
· 2019년 3월 ~ 현재 : 전북대학교 마취통증의학과 진료교수
· 관심분야 : 의학, 마취통증
· E-Mail : lovingij1@gmail.com

최 승 서(Seungseo Choi) [정회원]

· 2016년 2월 : 원광대학교 의학과(의학사)
· 2017년 3월 ~ 현재 : 전북대학교 마취통증의학과 전공의
·관심분야 : 의학, 마취통증
·E-Mail : musthaverabbit@gmail.com

백 선 주(Seon Ju Baek) [정회원]

· 2017년 2월 : 전북대학교 의학전문대학원
· 2018년 3월 ~ 현재 : 전북대학교병원 마취통증의학과 전공의
· 관심분야 : 의학, 마취통증
· E-Mail : sj6539@naver.com

김 동 찬(Dong-Chan Kim) [정회원]

· 1983년 2월 : 전북대학교 의과대학 졸업
· 1994년 2월 : 원광대학교 의학박사
· 2002년 10월 ~ 현재 : 전북대학교 의과대학 교수
· 관심분야 : 의학, 마취통증
· E-Mail : dckim@jbnu.ac.kr

이 정 우(Jeongwoo Lee) [정회원]

· 1997년 2월 : 전북대학교 의과대학 졸업
· 2005년 2월 : 전북대학교 마취통증의학과 전공의
· 2019년 3월 ~ 현재 : 전북대학교병원 마취통증의학과 기금교수
· 관심분야 : 의학, 마취통증
· E-Mail : jw88lee@gmail.com

이 준 호(Jun Ho Lee) [정회원]

· 2010년 2월 : 전북대학교 의학전문대학원 졸업
· 2015년 2월 : 전북대학교 마취통증의학과 전공의
· 2017년 3월 : 전북대학교 마취통증의학과 임상교수
· 관심분야 : 의학, 마취통증
· E-Mail : gojuno@jbnu.ac.kr