DOI: 10.24938/kutfd.1495765 Kırıkkale Üniversitesi Tıp Fakültesi Dergisi 2024;26(3):308-313
Original Article *Özgün Araştırma*

THE EFFECT OF PREOPERATIVE FLUID REGIMEN ON CARDIAC PERFORMANCE IN BARIATRIC SURGERY

Preoperatif Uygulanan Sıvı Rejiminin Obezite Cerrahisi Geçirecek Olan Hastalarda Kardiyak Performansa Etkisi

Muhammed Emin ZORA[1] Bahar ÖÇ[2] İlhan ECE[3] Hüseyin YILMAZ[3] Oğuzhan ARUN[2] Ateş DUMAN[4]

[1] *Department of Anesthesiology and Reanimation, Faculty of Medicine, Uşak University, UŞAK,TÜRKİYE*
[2] *Department of Anesthesiology and Reanimation, Faculty of Medicine, Selçuk University, KONYA,TÜRKİYE*
[3] *Department of General Surgery, Faculty of Medicine, Selçuk University, KONYA,TÜRKİYE*
[4] *Department of Anesthesiology and Reanimation, Faculty of Medicine, Atlas University, ISTANBUL,TÜRKİYE*

ABSTRACT

Objective: We must strive to minimize the intraoperative and postoperative risks for patients who will undergo surgery. In the treatment of obesity, which is becoming an increasingly pressing issue, bariatric surgery has become a recommended option for suitable patients. This study aimed to minimize potential complications in obese patients by considering the frequency of cardiac problems and using preoperative fluid therapy.

Material and Methods: The study included 31 obese patients with a Body Mass Index of 30 or above, aged 18-50, who were in the American Society of Anesthesiologists Physical Status Classifications 1-2 group and were scheduled to undergo laparoscopic sleeve gastrectomy. Patients were randomly divided into two groups. The first group did not receive fluid therapy during the preoperative period. In the second group, intravenous crystalloid fluid was administered at a rate of 10 ml/kg/hour over 3 hours in the preoperative period, based on their ideal weight. Cardiac output, stroke volume variation, and stroke volume index measurements were taken at specific times intraoperatively in patients from both groups. These parameters were compared between the groups.

Results: Among the cardiac parameters measured with the FloTrac™ sensor, only the stroke volume variation values measured after extubation showed a difference between the groups. There was no statistically significant difference between the groups for the other values.

Conclusion: The cardiac output, stroke volume variation, and stroke volume index values measured at various times during the surgery are similar between patients who received preoperative fluid therapy and those who did not. There is a need for more comprehensive studies that involve different fluid therapy models and more patients in this area.

Keywords: *Obesity, bariatric surgery, cardiac output, fluid therapy, intraoperative monitoring*

ÖZ

Amaç: Opere edilecek olan hastaların intraoperatif ve postoperatif risklerini en aza indirmek için çabalamamız gerekmektedir. Giderek büyüyen bir sorun haline gelen obezite tedavisinde bariyatrik cerrahi, uygun hastalarda önerilen bir seçenek haline gelmiştir. Bu çalışmada, obez hastalarda kardiyak problemlerin sıklığını göz önünde bulundurarak, olası komplikasyonları preoperatif sıvı tedavisi yardımıyla en aza indirmek amaçlanmıştır.

Gereç ve Yöntemler: Amerikan Anesteziyologlar Derneği Fiziksel Statü Sınıflandırmaları 1-2 grubunda, 18-50 yaş arası, laparoskopik sleeve gastrektomi geçirecek olan, vücut kitle indeksi 30 ve üzeri obez 31 hasta çalışmaya dahil edildi. Hastalar kura yöntemiyle iki gruba ayrıldı. 1. gruba preoperatif dönemde sıvı tedavisi uygulanmadı. 2. gruba ise, preoperatif dönemde 3 saatte tamamlanacak şekilde ideal kilosuna göre saatte 10 ml/kg/saat intravenöz kristaloid sıvı uygulandı. 1. grup ve 2. grup hastalarda intraoperatif olarak belirli zamanlarda kardiyak output, stroke volüm varyasyonu, stroke volüm indeksi ölçümleri yapıldı. Bu parametreler gruplar arasında karşılaştırıldı.

Bulgular: FloTrac™ sensörü ile ölçülen kalp parametreleri arasında sadece ekstübasyon sonrası ölçülen stroke volüm varyasyonu değerlerinde gruplar arasında fark bulundu. Diğer değerler için gruplar arasında istatistiksel olarak anlamlı bir fark bulunmadı.

Sonuç: Preoperatif sıvı tedavisi alan ve almayan hastalar arasında, ameliyatın çeşitli zamanlarında ölçülen kardiyak output, stroke volüm varyasyonu ve stroke volüm indeksi değerleri benzerdir. Bu konuda daha farklı sıvı tedavi modellerine ve daha fazla hasta içeren kapsamlı çalışmalara ihtiyaç vardır.

Anahtar Kelimeler: *Obezite bariatrik cerrahi, kalp debisi, sıvı tedavisi, intraoperatif izlem*

Correspondence / Yazışma Adresi: **Dr. Muhammed Emin ZORA**
Department of Anesthesiology and Reanimation, Faculty of Medicine, Uşak University, UŞAK,TÜRKİYE
Phone / Tel: +905382872726 **E-mail** / E-posta: muhammedeminzora@hotmail.com
Received / Geliş Tarihi: 04.06.2024 **Accepted** / Kabul Tarihi: 06.09.2024

KÜ Tıp Fak Derg 2024;26(3):308-313
Doi: 10.24938/kutfd.1495765

INTRODUCTION

Obesity is a multifaceted disease with cultural, environmental, socio-economic, psychological, and genetic components. The prevalence of obesity has significantly increased both in our country and around the world in the last decade (1,2).

It is recommended that obesity be treated to reduce obesity-related comorbid conditions (such as coronary heart disease, dyslipidemia, type 2 diabetes, and hypertension) and mortality rates (3). Since diet and pharmaceutical agents are generally ineffective, the use of surgical treatment has increased.

Despite the low mortality rates of bariatric surgery due to improved postoperative care, complications can still be fatal (4). In laparoscopic bariatric surgery, hemodynamic instability may occur during pneumoperitoneum (5). Therefore, it is important to achieve normovolemia in the patient before the induction of anesthesia.

The FloTrac™ sensor is a minimally invasive device that measures cardiac output (CO), stroke volume variation (SVV), stroke volume index (SVI), and other hemodynamic parameters from changes in arterial pressure waveform. Since the FloTrac™ sensor is less invasive than pulmonary artery catheterization, it is widely used in operating rooms and intensive care units (6).

There are no studies in the literature on the effect of fluid regimens before bariatric surgery on cardiac performance. Therefore, this study aimed to investigate the impact of different fluid treatments administered before bariatric surgery on cardiac stability, as measured by the FloTrac sensor.

MATERIALS AND METHODS

The study was conducted on patients who underwent laparoscopic sleeve gastrectomy in the operating rooms of Selçuk University Faculty of Medicine Hospital between January 16, 2017, and July 15, 2017, following approval from the Selçuk University Faculty of Medicine Ethics Committee (dated January 11, 2017, with decision number 2017/20). This single-center, prospective, and observational study included 31 patients aged 18-50 years. Exclusion criteria were a history of alcohol use, hyperthyroidism, hypothyroidism, systemic infection, heart failure (EF less than 45%), chronic obstructive pulmonary disease, pulmonary hypertension, and previous intra-abdominal or cardiac operations. All patients fasted for at least 8 hours before surgery. Comorbidities, regular drug use, and the cardiopulmonary status of the patients were evaluated. Age, gender, weight, height, body mass index (BMI), ideal body weight and adjusted body weight, smoking status, fasting duration, and preoperative IV fluid intake were recorded. Ethical approval for the study was granted, and written informed consent was obtained from the patients prior to their participation.

Study Groups

Patients were randomly assigned to study groups by drawing lots. The first group (Group 1) did not receive any fluid therapy during the preoperative period, and it was confirmed that these patients exhibited some signs of dehydration, such as thirst, dry mouth, lips, and tongue. The second group (Group 2) received 10 ml kg^{-1} h^{-1} of intravenous (iv) 0.9% sodium chloride fluid, administered over a period of 3 hours based on their ideal body weight (for example, if the ideal body weight is 75 kg, the total fluid administered would be 75x10x3=2250 ml). It was confirmed that the patients in this second group did not show any signs of dehydration.

Anesthesia Procedure

All patients underwent preoperative preoxygenation, followed by the induction of anesthesia with intravenous administration of propofol at a dosage of 3 mg kg^{-1}, fentanyl at 2 µg kg^{-1}, and rocuronium bromide at 0.5 mg kg^{-1}. Anesthesia was maintained with a continuous infusion of propofol at 5 mg kg^{-1} h^{-1}, remifentanil at 2 µg kg^{-1} h^{-1}, and a 50:50 mixture of oxygen and air. An orogastric tube was inserted in all patients. Mechanical ventilation was adjusted according to the ideal body weight, with a tidal volume of 6 ml kg^{-1}, a positive end-expiratory pressure of 5 cm H_2O, and an end-tidal CO_2 maintained between 30-35 mmHg. Active warming devices were used to maintain core body temperature within the range of 36.5-37°C. All patients received an intravenous fluid infusion at a rate of 1000 ml per hour, ensuring adequate urine output (greater than 50 ml per hour). At the conclusion of the procedure, patients were extubated under optimal conditions with the administration of 4 mg kg-1 sugammadex. Prior to extubation, 1 mg kg-1 of intramuscular tramadol was administered for analgesia. Postoperatively, patients were transferred to the ward once their vital signs were stable, and their Visual Analogue Scale scores were 4 or below in the post-anesthesia care unit.

Intraoperative Monitoring

After being transferred to the operating room, all patients were monitored using standard procedures, including ECG, SpO_2, temperature, end-tidal CO_2, and invasive blood pressure via the radial artery. Concurrently, cardiac performance parameters, such as cardiac output (CO), stroke volume variation (SVV), and stroke volume index (SVI), were measured through the invasive blood pressure cannula using the FloTrac sensor. Throughout the operation, the mean arterial blood pressure remained above 60 mmHg in all patients. Anesthesia duration, operative time, and total doses of propofol (mg) and remifentanil (µg) were recorded.

FloTrac is a minimally invasive monitoring system that calculates key hemodynamic parameters from an

KÜ Tıp Fak Derg 2024;26(3):308-313
Doi: 10.24938/kutfd.1495765

invasive arterial cannula every 20 seconds. This system determines CO and other hemodynamic values by analyzing changes in heart rate and arterial pressure waveform. Hemodynamic measurements, including CO, SVV, and SVI obtained from the FloTrac monitoring system, were recorded at three distinct time points: pre-anesthesia induction (PI), post-pneumoperitoneum (PS), and post-extubation (EKS).

Surgical Technique

Patient positioning was accomplished in two stages. The first stage involved placing the patient in a semi-lithotomy position combined with a Trendelenburg tilt of less than 30 degrees. In the second stage, the patient was positioned in a semi-lithotomy position with a reverse Trendelenburg tilt of less than 30 degrees. After skin disinfection and sterile draping, the surgical procedure commenced with the insertion of 4-5 laparoscopic trocars. Intra-abdominal pressure was maintained between 11-15 mmHg throughout the procedure. All patients underwent laparoscopic sleeve gastrectomy. At the conclusion of the operation, a surgical drain was placed in the lower quadrant. No intraoperative or postoperative complications were observed.

Statistical Analysis

Descriptive statistics, including mean and standard deviation, were calculated for the measurements. The Mann-Whitney U test was employed to compare measurements between groups. The normality of variable distribution was assessed both visually (using histograms and probability plots) and analytically (using the Kolmogorov-Smirnov and Shapiro-Wilk tests). For normally distributed data, the Student's t-test was applied, whereas the Mann-Whitney U test was used for non-parametric variables. A significance level of $p<0.05$ was established, and all data were analyzed using SPSS software, version 22 (SPSS, Inc., Chicago, IL).

RESULTS

The comparison of demographic data between the groups revealed no statistically significant difference in terms of age, body weight, height, BMI, ideal weight, adjusted body weight, and fasting duration. Similarly, the comparison of intra-abdominal pressure, anesthesia duration and operative time, intraoperative total propofol dose and total remifentanyl dose between the groups showed no statistically significant difference (p=0.452; p=0.384; p=0.383; p=0.304; p=0.383; p=0.384; p=0.599; p=0.983; p=0.170; p=0.626; p=0.566; p=0.384 (Table 1).

There was no statistically significant difference between the groups in the CO values measured by the FloTrac sensor (p=0.797; p=0.579; p=0.874 (Figure 1, Table 2).

Table 1: Comparison of demographic and other perioperative data between groups

Parameters	Group 1	Group 2	p
Age	38.8 ± 8.3	40.7 ± 13.5	0.452
Weight (kg)	140 ± 26.1	131.5 ± 12.6	0.384
Height (cm)	164.1 ± 7.8	165.8 ± 7.8	0.383
BMI (kg/m²)	52.2 ± 9.1	48.0 ± 5.0	0.304
Ideal weight (kg)	59.1 ± 7.8	60.8 ± 7.8	0.383
Adjusted weight (kg)	56.3 ± 10.5	52.6 ± 5.0	0.384
Fasting time (hour)	10.9 ± 2.1	10.6 ± 1.8	0.599
Intraabdominal pressure (mmHg)	14.0 ± 1.3	13.9 ± 0.9	0.983
Duration of anaesthesia (minute)	80.8 ± 30.8	68.0 ± 19.8	0.170
Operation time (minute)	58.1 ± 20.4	53.0 ± 13.7	0.626
Total dose of propofol (mg)	512.8 ± 231.8	520.0 ± 180.3	0.566
Total dose of remifentanyl (µg)	1986.9 ± 979.5	2080.0 ± 721.1	0.384

Data are expressed as mean ± standart deviation. The difference between groups was analyzed with the Mann Whitney U test. $p<0.05$ was considered statistically significant.

Table 2: Cardiac parameters between groups

	Without fluid	With fluid	p value
PI-CO (l min^{-1})	8.4 ± 2.1	8.8 ± 2.6	0.797
PI-SVV (%)	11.3 ± 3.8	10.1 ± 3.4	0.538
PI-SVI (ml beat^{-1} m$^{2-1}$)	39.7 ± 9.6	40.9 ± 7.3	0.593
PS-CO	5.3 ± 1.2	5.0 ± 1.7	0.579
PS-SVV	15.6 ± 6.9	12.5 ± 5.2	0.112
PS-SVI	30.7 ± 8.6	27.6 ± 6.2	0.342
EKS-CO	8.7 ± 1.8	8.5 ± 2.0	0.874
EKS-SVV	10.6 ± 3.4	6.3 ± 3.0	**0.002**
EKS-SVI	41.3 ± 10.1	42.9 ± 8.6	0.464

Data are expressed as mean ± SD. The difference between groups was analyzed with the Mann Whitney U test. $P < 0.05$ was considered statistically significant.

PI-CO: Pre-anesthesia induction cardiac output, PI-SVV: Pre-anesthesia induction stroke volume variation, PI-SVI: Pre-anesthesia induction stroke volume index, PS-CO: Post-pneumoperitoneum cardiac output, PS-SVV: Post-pneumoperitoneum stroke volume variation, PS-SVI: Post-pneumoperitoneum stroke volume index, EKS-CO: Post-extubation cardiac output, EKS-SVV: Post-extubation stroke volume variation, EKS-SVI: Post-extubation stroke volume index

KÜ Tıp Fak Derg 2024;26(3):308-313
Doi: 10.24938/kutfd.1495765

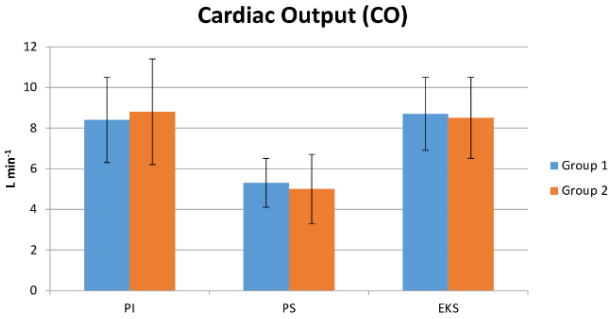

Figure 1: Cardiac output measurements

There was no statistically significant difference between the groups in the SVI values measured by the FloTrac sensor (p=0.593; p=0.342; p=0.464 (Figure 2, Table 2).

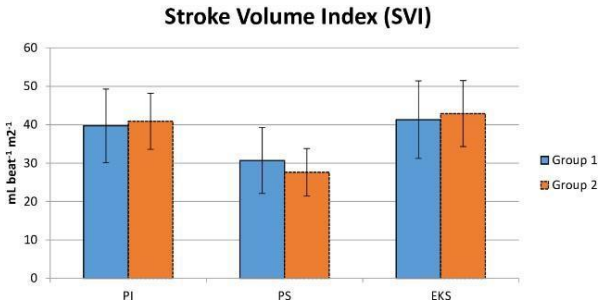

Figure 2: Stroke volume index measurements

There was a statistically significant difference between the groups in only the SVV value measured by the FloTrac sensor after extubation p=0.002 (Figure 3, Table 2).

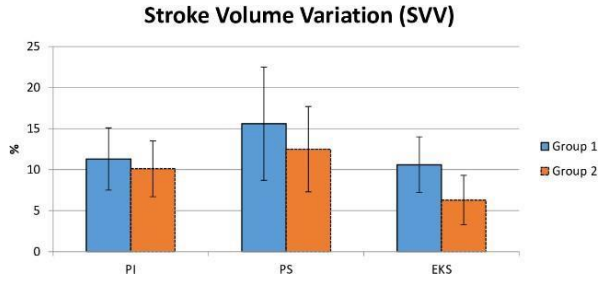

Figure 3: Stroke volume variation measurements

DISCUSSION

Patients with obesity are at an increased risk of comorbidities and complications. When the specific complications associated with bariatric surgery are considered, heightened vigilance and proactive measures are essential to mitigate potential risks in this population. Thus, preoperative fluid therapy in these patients is important for maintaining intraoperative hemodynamics and preventing subsequent complications. The timely and accurate detection of cardiorespiratory changes in these patients, through the use of advanced and less invasive hemodynamic monitoring systems, will significantly enhance intraoperative decision-making, allowing for more precise and responsive adjustments in patient management to optimize outcomes (7,8). This study evaluated the hemodynamic effects of preoperative fluid administration in patients undergoing bariatric surgery, utilizing the FloTrac sensor. The findings revealed no statistically significant differences in hemodynamic parameters between patients who received preoperative fluid therapy and those who did not.

Cardiac involvement is a common finding in patients with morbid obesity. These patients typically exhibit elevated filling pressures in both the left and right ventricles, along with biventricular hypervolemic and hyperdynamic circulation. Consequently, they are at increased risk for left ventricular (LV) hypertrophy, left atrial enlargement, LV diastolic dysfunction, and varying degrees of LV systolic failure. Preoperative dietary regimens in bariatric surgery patients may increase the risk of hypovolemia. In their study, Pösö et al. demonstrated that preoperative weight loss achieved through a low-calorie diet can lead to significant intravascular volume depletion in patients with morbid obesity, thereby increasing the risk of hemodynamic instability. Furthermore, they underscored the potential dangers of rapid and unanticipated intravenous fluid administration in this vulnerable population, which can exacerbate the risk of acute heart failure and pulmonary edema, potentially leading to serious perioperative complications (9). Similarly, Matot et al. emphasized that in perioperative fluid management, insufficient fluid administration may lead to hypovolemia and organ dysfunction, while excessive fluid administration can result in complications such as edema and organ injury, highlighting the importance of fluid balance. However, they concluded that oliguria did not respond to fluid administration during laparoscopic bariatric surgery. They suggested that intraoperative low-volume fluid administration might be beneficial in surgical operations other than bariatric surgery, as indicated by some previous studies (10). In this study, our objective was to prevent potential preoperative hypovolemia in patients receiving fluid therapy based on ideal body weight, while also avoiding the risk of heart failure or pulmonary edema. No cardiac or pulmonary complications were observed among the patients, which we attribute in part to the relatively young age of the study population.

Although laparoscopic sleeve gastrectomy offers significant clinical advantages, carbon dioxide pneumoperitoneum can negatively impact renal function. Patients with pre-existing renal dysfunction or those undergoing prolonged laparoscopic procedures are particularly at risk for postoperative renal failure. The increased intra-abdominal pressure during laparoscopy exerts a direct compressive effect on the renal parenchyma and vessels. Additionally, intraoperative

KÜ Tıp Fak Derg 2024;26(3):308-313
Doi: 10.24938/kutfd.1495765

blood loss and insufficient fluid management further reduce intravascular volume, leading to decreased postoperative urine output. Nguyen et al. conducted a study examining the effects of prolonged pneumoperitoneum on intraoperative urine output during laparoscopic gastric bypass surgery. They found that patients with obesity experienced a significant reduction in urine output during the procedure. This reduction was attributed to the sustained increase in intra-abdominal pressure caused by the prolonged pneumoperitoneum. The elevated intra-abdominal pressure during the laparoscopic surgery likely led to compromised renal perfusion, which in turn resulted in decreased urine production. Their findings highlight the need for careful monitoring of fluid balance and renal function in obese patients undergoing laparoscopic gastric bypass surgery to prevent potential complications associated with low intraoperative urine output (11). In our study, intra-abdominal high pressures were not observed, and the operative times were consistent with those reported in the literature. We believe that these factors contributed to the absence of renal complications in our patient cohort.

Fluid administration in critically ill patients is commonly performed to increase cardiac preload. CO is considered one of the most critical hemodynamic parameters for assessing cardiac function and guiding treatment (12). However, recent studies have demonstrated that approximately 50% of critically ill patients do not exhibit the anticipated therapeutic response (13). Our study aimed to evaluate the effects on hemodynamic parameters and protect patients from potential complications. However, the findings revealed no significant differences between the groups.

SVV represents the variation in stroke volume over a 30-second period. It reflects the impact of respiratory movements on venous return and is considered a reliable parameter, particularly when thoracic integrity is maintained. During inspiration in mechanical ventilation, the rise in intrapulmonary pressure substantially decreases the negative intrapleural pressure, reducing venous return and CO, while during expiration, the opposite occurs, leading to significant fluctuations in SVV between inspiration and expiration when circulating blood volume is insufficient (14). Recently, SVV has gained attention as a dynamic parameter for fluid management, being regarded as a superior alternative to CVP for determining whether fluid loading will increase CO (15). However, this study found no significant difference in overall SVV values between the groups.

The primary cause of organ dysfunction in hypovolemia is tissue hypoperfusion. Depending on the severity of hypoperfusion, all organs may be affected, with particular vulnerability observed in the kidneys, gastrointestinal tract, and lungs. Jain et al. reported that perioperative fluid management can have dual outcomes, noting that while fluid restriction may lead to acute tubular necrosis and organ dysfunction, excessive fluid administration can result in pulmonary edema, hypertension, and the need for respiratory support; however, their study concluded that SVV-guided fluid optimization may reduce blood pressure fluctuations and the requirement for postoperative ventilator support, while simultaneously preventing excessive fluid administration (16). In this study, we aimed to assess the difference between groups receiving and not receiving fluid by performing SVV measurements using the Flotrac sensor; however, no significant difference was observed.

Intravenous fluids are frequently administered to counteract the reduction in venous return caused by anesthetic agents and preoperative fasting. However, there is still no consensus regarding the optimal approach to preoperative fluid management. Physiologically, it is essential to maintain adequate venous return during the induction of anesthesia. Therefore, sufficient fluid should be infused prior to the onset of anesthetic-induced vasodilation to compensate for relative hypovolemia. Myrberg et al. demonstrated that preoperative fluid therapy administered based on ideal body weight significantly enhances hemodynamic stability during the induction of anesthesia. They also suggested that, theoretically, the combined use of preoperative fluids and vasoactive agents might offer a superior approach to maintaining hemodynamic stability during anesthesia induction compared to the use of either method alone (17). In our study, patients were continuously monitored using the Flotrac sensor throughout the surgical procedure. It was observed that the preoperative administration of crystalloid fluids resulted in a significant difference only in the stroke volume variation measured after extubation among cardiac output and other cardiac performance parameters in patients with obesity, while no significant differences were observed in the other parameters. This study involved a relatively young population without significant comorbid conditions. We believe that these two factors contributed to the tolerance of fluid deficits and the prevention of potential cardiac failure in the group that did not receive preoperative fluid administration.

Upon reviewing the existing studies, it is evident that significant uncertainties persist regarding optimal fluid management in bariatric surgery.

Our study has several limitations. Preoperative fluid therapy was calculated based on ideal body weight to prevent volume overload and potential cardiac complications, but current body weight was not considered. The depth of anesthesia was not monitored

using objective methods, such as bispectral index monitoring, which constitutes a limitation of this study. While the FloTrac system is appropriate for use in patients with obesity, its data reliability may be compromised in individuals with morbid obesity due to decreased chest wall compliance, reduced pulmonary compliance, and an enlarged left ventricular wall. Furthermore, increased intra-abdominal pressure could impact the accuracy of SVV measurements. Relying on a single method for perioperative invasive monitoring may have introduced inconsistencies in FloTrac measurements during potential system failures. Additional limitations of our study include the small sample size, the absence of patients with significant comorbid conditions (e.g., heart failure), and the relatively young age of the participants.

The strengths of this study include the use of the innovative and dynamic Flotrac measurement system, as well as its prospective design.

In conclusion, administering crystalloid fluids based on ideal body weight does not influence intraoperative hemodynamic parameters, including CO, SVV, and SVI, in patients undergoing bariatric surgery via the laparoscopic sleeve gastrectomy technique. Further research is required to explore alternative fluid therapy models and to conduct comprehensive studies involving larger patient cohorts.

Conflict of Interest: The authors have no conflicts of interest to declare.

*Contribution Statement***:** Concept/Planning: BÖ, MEZ, HY, İE; Analysis/Interpretation: MEZ, BÖ, OA, AD; Data Provision: MEZ, BÖ, HY, İE; Writing: BÖ, MEZ, AD; Review and Editing: MEZ, BÖ, OA, AD; Approval: BÖ, HY, İE, OA, AD, MEZ

Financial Support And Sponsorship: This study was supported by the scientific research projects (BAP) units of Selçuk University.

Ethics Committe Aproval: The study was approved by Selcuk University Faculty of Medicine Non-Invasive Clinical Research Ethics Committee, 11 January 2017, decision number 2017/20.

*Informed Consent Statement***:** Informed consent was obtained from all patients.

REFERENCES

1. Mokdad AH, Serdula MK, Dietz WH, Bowman BA, Marks JS, Koplan JP. The spread of the obesity epidemic in the United States, 1991-1998. *JAMA*. 1999;282(16):1519-1522.
2. Endokrinoloji T, Metabolizma Derneği. Obezite Tanı ve Tedavi Kılavuzu. 8th ed. Ankara, Miki Matbaacılık; 2019.
3. Paeratakul S, Lovejoy JC, Ryan DH, Bray GA. The relation of gender, race, and socioeconomic status to obesity and obesity comorbidities in a sample of US adults. *Int J Obes.* 2002;26(9):1205-1210.
4. Pories WJ. Bariatric surgery: Risks and rewards. *J Clin Endocrinol Metab*. 2008;93 (11 Suppl 1): s89-s96.
5. Nguyen NT, Wolfe BM. The physiologic effects of pneumoperitoneum in the morbidly obese. *Ann Surg*. 2005;241(2):219-226.
6. Hattori K, Maeda T, Masubuchi T, et al. Accuracy and trending ability of the fourth-generation FloTrac/Vigileo system in patients with low cardiac index. *J Cardiothorac Vasc Anesth.* 2017;31(1):99-104.
7. Ramsingh D, Alexander B, Cannesson M. Clinical review: Does it matter which hemodynamic monitoring system is used? *Critical Care.* 2013;17(2):208.
8. Chamos C, Vele L, Hamilton M, Cecconi M. Less invasive methods of advanced hemodynamic monitoring: Principles, devices, and their role in the perioperative hemodynamic optimization. *Perioper Med (Lond)*. 2013;2(1):19.
9. Pösö T, Kesek D, Aroch R, Winsö O. Rapid weight loss is associated with preoperative hypovolemia in morbidly obese patients. *Obes Surg*. 2013;23(3):306-313.
10. Matot I, Paskaleva R, Eid L, et al. Effect of the volume of fluids administered on intraoperative oliguria in laparoscopic bariatric surgery: A randomized controlled trial. *Arch Surg*. 2012;147(3):228-234.
11. Nguyen NT, Perez RV, Fleming N, Rivers R, Wolfe BM. Effect of prolonged pneumoperitoneum on intraoperative urine output during laparoscopic gastric bypass. *J Am Coll Surg*. 2002;195(4):476-483.
12. Sakka SG, Reinhart K, Meier-Hellmann A. Comparison of pulmonary artery and arterial thermodilution cardiac output in critically ill patients. *Intensive Care Med.* 1999;25(8):843-846.
13. Hofer CK, Senn A, Weibel L, Zollinger A. Assessment of stroke volume variation for prediction of fluid responsiveness using the modified FloTrac™ and PiCCOplus™ system. *Crit Care.* 2008;12(3):1-8.
14. Huan S, Dai J, Song S, Zhu G, Ji Y, Yin G. Stroke volume variation for predicting responsiveness to fluid therapy in patients undergoing cardiac and thoracic surgery: A systematic review and meta-analysis. *BMJ open*. 2022;12(5):e051112.
15. Takahashi H, Shida D, Tagawa K, Suzuki T. Hemodynamics of mesenteric traction syndrome measured by FloTrac sensor. *J Clin Anesth*. 2016;30:46-50
16. Jain AK, Dutta A. Stroke volume variation as a guide to fluid administration in morbidly obese patients undergoing laparoscopic bariatric surgery. *Obes Surg*. 2010;20(6):709-715.
17. Myrberg T, Lindelöf L, Hultin M. Effect of preoperative fluid therapy on hemodynamic stability during anesthesia induction, a randomized study. *Acta Anaesthesiol Scand*. 2019;63(9):1129-36.