BULLETIN OF STOMATOLOGY AND MAXILLOFACIAL SURGERY
Volume 21, Issue 7

DOI: 10.58240/1829006X-2025.21.7-309

ORIGINAL RESEARCH

COMPARATIVE ANALYSIS OF CHANGES IN INTESTINAL FATTY ACID-BINDING PROTEIN (I-FABP) LEVELS IN LAPAROSCOPIC SURGERY:TOTAL INTRAVENOUS ANASTHESIA WITH PROPOFOL VERSUS SEVOFLURANE INHALATION

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Received: *Jul 8. 2025;* ***Accepted:*** *Jul. 28, 2025;* ***Published:*** *Aug. 19, 2025*

ABSTRACT

Background: Laparoscopy is a popular minimally invasive surgical method due to its low surgical risk and postoperative complication rates. Laparoscopic surgery requires pneumoperitoneum conditions with CO2 gas which potentially increases intraperitoneal pressure and can cause ischemic injury to the gastrointestinal tract. Intestinal Fatty Acid-Binding Protein (I-FABP) is a sensitive biomarker for detecting gastrointestinal ischemia.

Aim: This study aims to compare changes in I-FABP levels in laparoscopic surgery with TIVA Propofol anesthesia maintenance versus Sevoflurane inhalation.

Materials and Methods: A cross-sectional analytical observational study was conducted at Universitas Airlangga Hospital, involving 20 adult patients scheduled for elective laparoscopic procedures. Participants were randomized into two groups: TIVA propofol (n=10) and sevoflurane inhalation (n=10). Exclusion criteria included abdominal trauma, gastrointestinal obstruction or perforation, COVID-19, and severe comorbidities. Serum I-FABP levels were measured after intubation (baseline, prior to pneumoperitoneum) and 30 minutes after extubation using enzyme-linked immunosorbent assay (ELISA). Statistical analyses included paired t-tests for within-group comparisons and independent t-tests for between-group differences, with significance set at $p<0.05$.

Results: Both groups demonstrated a significant reduction in I-FABP levels postoperatively ($p<0.001$). The sevoflurane group exhibited a greater mean reduction in I-FABP (27.2 ± 5.07 ng/mL) compared to the TIVA propofol group (19.19 ± 3.95 ng/mL), with the inter-group difference reaching statistical significance ($p<0.05$). No severe hemodynamic or respiratory complications were observed in either group.

Conclusion: Sevoflurane inhalation anesthesia was associated with a significantly greater reduction in postoperative serum I-FABP levels than TIVA propofol, suggesting superior protection against gastrointestinal ischemic injury during laparoscopic surgery. Both anesthetic techniques were safe and effective, supporting their use according to patient-specific considerations.

***Keywords*:** Intestinal Fatty Acid-Binding Protein, Laparoscopy, TIVA Propofol, Sevoflurane, Gastrointestinal Ischemia.

INTRODUCTION

Minimally invasive surgery has transformed the landscape of modern surgical practice, with laparoscopic procedures now considered the gold standard for a wide range of abdominal operations.[1] Laparoscopy is favored over open surgery due to its well-documented advantages, including reduced

postoperative pain, lower complication rates, shorter hospital stays, and faster patient recovery. These benefits have contributed to its widespread adoption in general surgery, gynecology, urology, and other medical fields. However, despite these advantages, laparoscopic surgery is not without its unique physiological challenges and potential risks.

A key component of laparoscopic surgery is the creation of a pneumoperitoneum, typically through the insufflation of carbon dioxide (CO_2) gas into the abdominal cavity.[2] While this technique provides the necessary operative field and visualization, it also increases intra-abdominal pressure (IAP), which can compromise splanchnic blood flow and disrupt the perfusion of gastrointestinal organs. Elevated IAP has been associated with a reduction in mesenteric blood flow, potentially leading to ischemic injury of the intestinal mucosa.[3] Such ischemic events, even if subclinical, may adversely affect patient outcomes by impairing gut barrier function, promoting bacterial translocation, and increasing the risk of postoperative complications.

Detecting intestinal ischemia early is difficult in clinical practice because there are no specific signs and conventional lab markers have their limitations. In the past few years, Intestinal Fatty Acid-Binding Protein (I-FABP) has shown potential as a useful biomarker for spotting enterocyte damage in the early stages.[4] This protein is found in high levels in the mature enterocytes of the small intestine. Upon ischemic or hypoxic insult, I-FABP is rapidly released into the circulation, making its serum concentration a sensitive and specific indicator of acute intestinal epithelial damage. Several studies have demonstrated the diagnostic and prognostic value of I-FABP in various clinical settings, including abdominal surgery, trauma, and critical illness.

Anesthetic management during laparoscopic surgery may further influence the extent of gastrointestinal ischemia. Two commonly used maintenance anesthesia techniques are total intravenous anesthesia (TIVA) with propofol and inhalational anesthesia with sevoflurane. Propofol is recognized for its anti-inflammatory properties and its ability to stabilize the intestinal mucosal barrier, while sevoflurane is known for its systemic vasodilatory effects, which may enhance splanchnic perfusion. However, comparative data regarding the impact of these anesthetic agents on intestinal ischemic injury, as measured by changes in serum I-FABP levels, remain limited and inconclusive.

Given the increasing prevalence of laparoscopic procedures and the critical importance of optimizing perioperative outcomes, it is essential to elucidate the effects of anesthetic choice on intestinal integrity during surgery. This study aims to analyze and compare the changes in serum I-FABP levels in patients undergoing laparoscopic surgery with either TIVA propofol or sevoflurane inhalation anesthesia. By investigating the relationship between anesthetic regimen and intestinal ischemic stress, as reflected by I-FABP dynamics, this research seeks to provide evidence-based recommendations for anesthetic management that may minimize gastrointestinal complications and improve patient recovery following laparoscopic surgery.

METHODS

STUDY DESIGN AND SETTING

This cross-sectional analytical observational study was performed at the Central Operating Theatre of Universitas Airlangga Hospital, Surabaya, from February to April 2025.

PARTICIPANTS

Twenty adult patients (aged 18–64 years, ASA physical status I–II) scheduled for elective laparoscopic surgery were enrolled. Exclusion criteria included a history of abdominal trauma, gastrointestinal obstruction or perforation, COVID-19, celiac disease, and significant comorbidities.

INTERVENTION

Patients were allocated to either the TIVA propofol group or the sevoflurane inhalation group (n=10 per group). Anesthetic induction and maintenance followed standardized protocols for each group.

DATA COLLECTION

Serum I-FABP was measured at two time points:

1. After intubation, prior to pneumoperitoneum (baseline)
2. 30 minutes after extubation (postoperative)

Blood samples were analyzed using ELISA. Additional data collected included demographic characteristics, hemodynamic parameters, duration of pneumoperitoneum, and perioperative complications.

STATISTICAL ANALYSIS

For normality, the Shapiro-Wilk test was applied. Paired t-tests were used to compare I-FABP level between different groups, and independent t-tests were applied to gauge the deviation Fashion score and natural logarithm equivalent calculation(s). A p-value<0.05 indicated statistical significane.

RESULTS

PATIENT CHARACTERISTICS

The baseline demographic and clinical traits were similar in both groups, such as age, BMI, blood pressure, heart rate, and length of pneumoperitoneum.

Table 1. Data on Characteristics of Research Subjects

Subject Characteristics	Value (mean ± standard deviation)	
	Inhalation	TIVA
Age (year)	49.4 ± 11,59	46 ± 13.3
Body Mass Index (kg/m^2)	23.35 ± 4.71	25.8 ± 9.12
Systolic Blood Pressure (mmHg)	135 ± 22.6	134.2 ± 12.8
Diastolic Blood Pressure (mmHg)	73.8 ± 7.78	70.8 ± 13.1
Mean Arterial Pressure (mmHg)	94.2 ± 15	91.9 ± 8.3
Heart Rate (beats/minute)	46 ± 13.3	46 ± 13.3
Pneumoperitoneum Duration (minutes)	82.7 ± 9.12	82.1 ± 12.5

Table 1 displays the attributes of the study participants categorized by age, weight, height, BMI, blood pressure measurements, heart rate, and the duration of pneumoperitoneum.

Table 2. Types of procedures

Procedure	Total
Myomectomy	2
Hysterectomy	1
Cystectomy	1
Salpingectomy	2
AFF IUD	1
Cholecystectomy	13

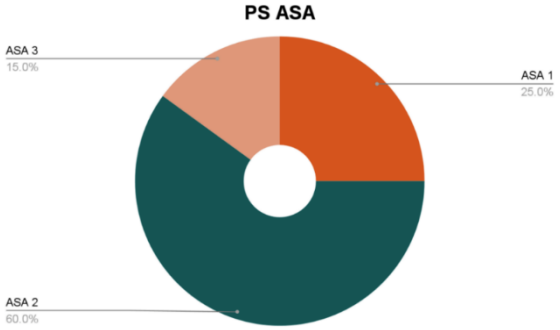

Figure 1. Percentage diagram of research subjects based on ASA PS score

The features of the research participants in relation to laparoscopic procedures are illustrated in Table 2. In contrast, Figure 1 depicts the attributes of the research subjects based on the Physical Status American Society of Anesthesiologists (PS ASA). The data was subjected to normality testing through the utilization of the Shapiro-Wilk test. Data are deemed normally distributed when the p-value exceeds 0.05, and non-normal if it is below 0.05. For normally distributed data, results are reported as mean ± standard deviation, whereas non-normally distributed data is exhibited as median (range).

I-FABP LEVELS

Table 3. Differences in I-FABP levels before and after laparoscopic surgery.

Variable	Mean ± Standard Deviation (ng/mL)		p-value		Normality p-value	
	Inhalation	TIVA	Inhalation	TIVA	Inhalation	TIVA
Preoperative I-FABP levels	66.62 ± 20.41	58.00 ± 18.58	<0.001*		0.296	0.154
Postoperative I-FABP levels	39.4 ± 21.65	38.8 ± 17.1	<0.001*		0.127	0.258

*p significant if p<0.05

Table 4. Comparison of I-FABP level changes before and after laparoscopic surgery

Variable	Mean ± Standard Deviation (ng/mL)		p-value		Normality p-value	
	Inhalation	TIVA	Inhalation	TIVA	Inhalation	TIVA
Change in I-FABP levels preoperative and postoperative	27.2 ± 5.07	19.19 ± 3.95	<0.001*		0.200	0.200

*p significant if p<0.05

Both groups revealed meaningful decreases in I-FABP levels postoperatively ($p<0.001$).

1. Sevoflurane group: mean reduction 27.2 ± 5.07 ng/mL
2. TIVA propofol group: mean reduction 19.19 ± 3.95 ng/mL

The difference in mean reduction between groups (7.01 ng/mL) was statistically significant ($p<0.05$), reflecting a greater decline in the sevoflurane group. No severe hemodynamic or respiratory complications occurred in either group.

Table 3 above shows the correlation among I-FABP levels before and after laparoscopic surgery. Using a paired T-test, a significant difference was found between I-FABP levels before and after laparoscopic surgery with a mean reduction of 27.2 ± 5.07 ng/mL ($p<0.001$) in the inhalation anesthesia method and a reduction of 19.19 ± 3.95 ng/mL ($p<0.001$) in the TIVA anesthesia method. The paired T-test was performed to determine whether preoperative and postoperative data in both variables had significant differences. Results showed p-values of $p<0.001$ for both variables, indicating significant differences. Table 4 compares changes in I-FABP levels using an independent T-test between inhalation anesthesia and TIVA anesthesia with a p-value of $p<0.001$, implying substantial difference within these anesthetic techniques.

The information was subjected to a normality assessment using the Shapiro-Wilk test. Data that follows a normal distribution is shown as the mean plus or minus the standard deviation. On the other hand, data that does not follow a normal distribution is represented by the median within a specified range. Figure 2 shows a boxplot representation of I-FABP levels before and after laparoscopic surgery, demonstrating the difference in data distribution between the two time points.

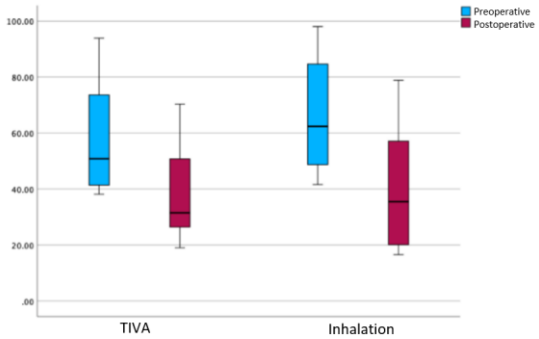

Figure 2. Boxplot of I-FABP levels before and after laparoscopic surgery

DISCUSSION

The findings demonstrate that both TIVA propofol and sevoflurane inhalation anesthesia significantly reduce serum I-FABP levels after laparoscopic surgery, suggesting effective protection against gastrointestinal ischemic injury. However, sevoflurane was associated with a significantly greater reduction, which may be attributed to its vasodilatory effects on splanchnic circulation and modulation of inflammatory pathways.

These results align with previous studies indicating the potential for inhalational anesthetics to better preserve gastrointestinal perfusion during procedures involving increased IAP. Yet, the anti-inflammatory properties of propofol may still offer advantages in specific patient populations, such as those at risk for exaggerated inflammatory responses.

This research has limitations due to the small number of participants and the emphasis on short-term changes in biomarkers instead of long-term effects on patient health. More studies with larger groups and longer observation periods are needed to confirm these results and understand the predictive significance of I-FABP in postoperative recovery and complication rates.

Previous evidence indicates that intestinal fatty acid-binding protein (I-FABP) serves as a sensitive biomarker for enterocyte injury and intestinal ischemia. A study by Tahapary et al. demonstrated a significant age-related increase in circulating I-FABP concentrations, suggesting greater intestinal injury in older individuals compared with younger counterparts[5]. Similarly, Hendriks et al. reported that advanced age is associated with higher postoperative I-FABP levels, particularly among patients who develop postoperative complications[6]. Potential underlying mechanisms include alterations in gut microbiota composition, impaired intestinal barrier integrity, and lipid metabolism dysregulation.

Throughout this investigation, the majority of participants exhibited an American Society of Anesthesiologists (ASA) physical status score of II (60%), while 15% were classified as ASA III. Previous findings by Nendl et al. indicate that postoperative I-FABP elevation is significantly correlated with higher ASA scores, reflecting more pronounced intestinal injury in patients with greater

baseline physiological compromise[7]. This association is modulated by preoperative nutritional status, comorbidities, and surgical technique. Malnutrition and chronic inflammatory states may potentiate I-FABP release during perioperative stress, thereby limiting the predictive accuracy of ASA scores for postoperative intestinal outcomes.

Anthropometric assessment in the current cohort revealed a mean body mass index (BMI) of 23.35 ± 4.71 kg/m² in the inhalational anesthesia group and 25.8 ± 9.12 kg/m² in the TIVA group. Obesity, as reflected by elevated BMI, has been implicated in impaired intestinal barrier function, increased permeability, and heightened mucosal injury.[5] Obese individuals also exhibit a proinflammatory milieu that may exacerbate epithelial damage and augment I-FABP release.

The researchers analyzed the changes in I-FABP levels before and after surgery in patients who were given total intravenous anesthesia with propofol and those who received inhalational anesthesia during a laparotomy procedure. I-FABP was quantified pre- and postoperatively in both groups. The analysis revealed a statistically significant difference in the magnitude of postoperative change between groups, with TIVA consistently associated with a reduction in I-FABP levels relative to preoperative values. This pattern suggests that the surgical protocols employed particularly in laparoscopic cases effectively minimized intestinal ischemia, and that CO_2 insufflation pressures were maintained within safe thresholds. Alternatively, elevated preoperative I-FABP may indicate pre-existing intestinal endothelial injury in some patients.

Mechanistically, both propofol and sevoflurane possess organ-protective properties via attenuation of oxidative stress and modulation of inflammatory pathways.[8,9] While meta-analyses, such as that by O'bryan et al. report consistent differences in systemic inflammatory markers between TIVA and inhalational anesthesia, randomized trials have produced mixed results.[10] For example, Hirvonen et al. observed no significant differences in endothelial injury markers (syndecan-1) between anesthetic techniques in minimally invasive surgery.[11] Similarly, cytokine profiling studies have not demonstrated anesthesia-related variability in systemic inflammatory responses.[12,13] These findings collectively support the neurophysiological safety of both modalities.

Importantly, FABPs are relatively specific to neuronal and enterocyte injury and may not reliably reflect systemic surgical stress unless secondary insults such as hypoxia, hypotension, or neuroinflammation occur.[14,15] The present results represent short-term postoperative changes; thus, future longitudinal investigations incorporating additional biomarkers (e.g., S100B, GFAP, IL-6) are warranted to better elucidate delayed or subclinical inflammatory responses.

From a surgical perspective, laparoscopic techniques confer distinct physiological advantages over open laparotomy, including reduced tissue trauma, minimal blood loss, and faster restoration of bowel function.[16,17] Laparoscopy also limits direct visceral manipulation and environmental exposure, thereby mitigating systemic inflammatory activation and preserving intestinal microcirculatory stability. Multiple studies have demonstrated that postoperative I-FABP levels are lower following laparoscopic procedures particularly when intra-abdominal pressure remains <15 mmHg compared with open surgery.[18] Elevated I-FABP levels have been correlated with injury severity in severe abdominal trauma[19], validated as a diagnostic tool for differentiating between simple and strangulated intestinal obstruction[20], and linked to the extent of tissue damage in abdominal injuries.[21]

In conclusion, the present findings reinforce existing evidence that anesthetic modality influences perioperative metabolic and inflammatory profiles, with propofol-based TIVA demonstrating a consistent trend toward lower postoperative I-FABP levels in laparotomy patients. These results underscore the potential benefits of TIVA in attenuating intestinal ischemic injury while affirming the neurophysiological safety of both TIVA and inhalational anesthesia.

CONCLUSION

In patients undergoing laparoscopic surgery, sevoflurane inhalation anesthesia leads to a greater reduction in serum I-FABP levels compared to TIVA propofol, suggesting superior protection against gastrointestinal ischemic injury. Both anesthetic techniques are safe and effective, and the choice should be individualized based on patient characteristics and institutional protocols.

DECLARATIONS

Ethics approval and consent to participate

Not applicable

Consent for publication

Not applicable.

Competing interests

The authors certify that they have no conflicts of interest.

Funding

No external financial assistance was provided for this research.

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