Journal of MTU 2022;1(3):105-112
ISSN: 2822-4094

Araştırma Makalesi / Research Article

Journal of Medical Topics & Updates (Journal of MTU)

Doi: 10.5281/zenodo.7476099

Predictors of mortality and complications in patients treated in intensive care following non-cardiac emergency surgery

Non-kardiak acil cerrahiyi takiben yoğun bakımda tedavi gören hastalarda mortalite ve komplikasyonların tahmin edicileri

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ABSTRACT

Background: Due to the increasing population and life expectancy, the number of patients undergoing emergency surgery is expected to increase. However, different surgical diagnoses that require emergency surgery cause various complications and morbidity. This study examines outcomes in patients undergoing emergency surgery, including in-hospital mortality and morbidity predictors.
Materials and Methods: A retrospective study was conducted of patients who underwent emergency surgery in a tertiary healthcare institution between 2014 and 2019 and were indicated for post-surgical intensive care unit (ICU). Demographic data, comorbidities, surgical indications and perioperative risk assessment data of the patients were collected. Outcomes included length of stay in ICU, need for inotrope agents, discharge status, and in-hospital mortality and morbidity. Multivariate logistic regression was used to identify predictors of in-hospital mortality.
Results: The mean age of 886 patient admissions was 52.3 years. The mortality rate (38.1%) of patients aged 65 and over who underwent emergency surgery was statistically significantly higher than other patients ($p < 0.001$). The American Society of Anesthesiologists (ASA) physical condition classification mean was 3E. The mortality rate was found to be higher in patients with high ASA, Acute Physiology and Chronic Health Evaluation (APACHE) II, Simplified Acute Physiology Score (SAPS) III scores and preoperative leukocyte and neutrophil values ($p <0.001$).
Conclusions: Apart from APACHE II and SAPS III classifications and preoperative laboratory parameters such as leukocytes and lymphocytes, the ASA score can also predict mortality in the critically ill population requiring emergency surgery, and can be used to guide patient and family counseling.

Keywords: Emergency, Surgery, Critical care, Mortality, ASA score

ÖZET

Amaç: Artan nüfus ve yaşam süresi nedeniyle acil cerrahi geçiren hastaların sayısının artması beklenmektedir. Bununla birlikte acil cerrahi gerektiren farklı cerrahi tanılar farklı komplikasyonlara ve morbiditeye neden olmaktadır. Bu araştırma, hastane içi mortalite ve morbidite öngörücüleri de dahil olmak üzere, acil cerrahi uygulanan hastalardaki sonuçları incelemektedir.
Materyal ve Metot: 2014 ve 2019 yılları arasında üçüncü basamak bir sağlık kuruluşunda acil cerrahi geçiren ve cerrahi sonrası yoğun bakım endikasyonu konulan hastaların retrospektif bir çalışması yapıldı. Hastaların demografik verileri, komorbiditeleri, cerrahi endikasyonları ve perioperatif risk değerlendirme verileri toplandı. Sonuçlar, yoğun bakımda kalış süresi, inotrop ihtiyacı, taburculuk durumu ve hastane içi mortalite ve morbiditeyi içeriyordu. Hastane içi mortalite belirleyicilerini belirlemek için çok değişkenli lojistik regresyon kullanıldı.
Bulgular: 886 hasta başvurusunun ortalama yaşı 52.3 idi. Acil cerrahi uygulanan 65 yaş ve üstü hastaların mortalite oranı (%38.1) diğer hastalara göre istatistiksel açıdan anlamlı olarak yüksekti ($p < 0.001$). Amerikan Anesteziyologlar Derneği (ASA) fiziksel durum sınıflandırması ortalaması 3E idi. ASA, Akut Fizyoloji ve Kronik Sağlık Değerlendirmesi (APACHE II), Basitleştirilmiş Akut Fizyoloji Skoru (SAPS) puanlamaları ve preoperatif lökosit, ve nötrofil değerleri yüksek olan hastalarda mortalite oranı daha yüksek saptandı ($p <0.001$).
Sonuç: APACHE II ve SAPS III sınıflamaları ve lökosit, lenfosit gibi preoperatif bakılan laboratuar parametreleri dışında ASA skoru da acil cerrahi gerektiren kritik hasta popülasyonunda mortaliteyi öngörebilir, ayrıca hasta ve aile danışmanlığına rehberlik etmek için kullanılabilir.

Anahtar Kelimeler: Acil, Cerrahi, Yoğun bakım, Mortalite, ASA skoru

Received / Geliş Tarihi: 21.06.2022, Accepted / Kabul Tarihi: 22.08.2022
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INTRODUCTION

It is estimated that human life will last close to 100 years, especially in socio-economically developed countries (Christensen et al., 2009). The increasing population and the number of elderly people create a severe burden on the health system regarding the number of patients, the number of surgical procedures and the need for intensive care (Rosenberg & Moore, 1997; Merani et al., 2014). Comparative studies in the literature indicate that with increasing age, survival is associated with worse health, and the risk of mortality and complications after surgery increases with age (McIsaac et al., 2017). This may be due to the risk of fragility that generally increases with age. Especially patients aged 80 and over suffer from fragility. However, frailty is not only related to advanced age; it is also affected by many factors such as medical comorbidity, nutritional status, mental health and social support (Bettelli, 2011; Jayanama et al., 2018). Therefore, frailty may appear to determine mortality in younger patients with these negative factors. In the current studies, age and fragility were prominent factors in the development of mortality and complications after emergency surgery. However, the type and area of emergency surgery are among the factors affecting mortality. The fact that the surgical field is included in many surgical risk scorings such as the Acute Physiology and Chronic Health Evaluation (APACHE) II, the Assess Respiratory Risk in Surgical Patients in Catalonia (ARISCAT), the American College of Surgeons - National Surgical Quality Improvement Program (ACS-NSQIP) is the proof of this hypothesis (Godinjak et al., 2016; Nithiuthai et al., 2021; Huda et al., 2022).

Over the past decade, there has been increasing evidence regarding the outcomes of emergency general surgical management of elderly patients (Akinbami et al., 2011; Alcock & Chilvers, 2012; Fariña-Castro et al., 2019; Gabriel et al., 2018). However, data on outcomes of patients undergoing emergency surgical procedures are limited, regardless of the type of operation and age. Elective surgery; provides medical care, a comprehensive preoperative evaluation and optimization of comorbid diseases. However, emergency surgery lacks these optimization conditions due to the limited time, and the detailed anamnesis of the patients admitted to the emergency department due to acute surgery often cannot be taken. Therefore, their comorbidities cannot be adequately recognized. This situation increases patients' vulnerability to medical problems that develop both during surgery and in the postoperative period (Inouye, 2000). Furthermore, in the postoperative intensive care unit, additional invasive procedures such as arterial placement, central venous catheter cannulation, multiple drug use such as sedative agents, antibiotics, inactivity, and medical requirements such as bladder catheterization, such as sepsis, kidney failure, urinary tract infection, ventilator-associated pneumonia and delirium may cause additional complications (Turrentine et al., 2006).

This study aimed to characterize patients who underwent emergency surgery and were indicated for intensive care and to examine surgical outcomes, including the identification of factors associated with in-hospital mortality and morbidity. We hypothesized that age, number of medical comorbidities, baseline blood gas and hemogram parameters, and the American Society of Anesthesiologist (ASA) physical status, APACHE II and the Simplified Acute Physiology Score (SAPS) III classifications would be the strongest predictors of poor outcomes.

MATERIALS AND METHODS

Patient Selection

A retrospective cohort study was conducted on patients who underwent emergency surgery in a tertiary education and research hospital between 2015 and 2020 and were treated in the intensive care unit postoperatively. Inclusion criteria included patients aged 18 years or older who required at least one emergency surgical procedure upon arrival to the emergency department. We defined emergency surgery as a surgical procedure that does not have any outpatient reservations, presents directly to the emergency department, and requires an unplanned operation as a result of the examinations performed after admission to the hospital. Exclusion criteria were defined as patients under 18 years of age, with a recent history of surgery, who would undergo a secondary surgery, and who required urgent cardiovascular surgery.

After obtaining approval from the Clinical Research Ethics Committee of the training and research hospital where the study will be conducted (2022/206), the data of 886 patients who received intensive care treatment in a single center between January 15, 2015, and December 15, 2020, were evaluated retrospectively. First, patient data were obtained from EMRall-QlinICUImdSoftMetavision Clinical Decision Support System with Structured Query Language (SQL) queries. In addition, demographic data such as age, gender and comorbid diseases of the patients, surgical procedure and region, laboratory data, length of stay in the intensive care unit, and mortality data were evaluated.

Furthermore, data from SAPS III, APACHE II, and ASA physical status scoring systems, which are the most commonly used disease severity determination scores, were included in the study. The study was carried out in accordance with the principles set out in the 1995 Declaration of Helsinki. (as revised in Brazil, 2013).

Statistical Analysis

The data collected in the study were evaluated with the SPSS 22.00 program for Windows 10. The Kolmogorov-Smirnov test was used to check the normality of the data distributions. For descriptive statistics, categorical variables are given as percentage (%) and numerical variables as mean ± standard deviation. The Two-Sample Independent T-test was used to compare the quantitative data of the two groups when the normality conditions were met. In contrast, the Chi-square test was used when the variables were qualitative. Mann-Whitney U test was used for quantitative variable data comparisons where normality conditions were not met. The statistical significance level of alpha was accepted as $p<0.05$. For further analysis, Binary Logistic Regression analysis is assessed in order to explore a relationship between mortality scores of patients with some other independent variable scores.

RESULTS

During the five years (2015-2020) retrospectively analyzed, the number of patients who applied to the emergency department with an indication for emergency surgery and needed an intensive care unit in the postoperative period was 3954. However, 3068 patients who did not meet the admission criteria were excluded from the study, and a total of 886 patients were analyzed. Of these patients, 294 were aged 65 and over, and 592 were under the age of 65. The mean age of the patients was 52.3, the male sex ratio was 61.5%. The comorbid disease was present in 59.1% of patients over 65 years of age. The most common were hypertension, diabetes, chronic obstructive pulmonary disease, and heart failure (Table 1). At the preoperative anesthesia consultation, the mean ASA class of the patients was 3E (97.5% of the patients) (Table 1). The most common emergency surgical procedure diagnoses were intracranial hemorrhage (31.3%), colorectal diseases (24.3%), and trauma (22.8%), respectively (Table 1).

The diagnoses of trauma and intracranial hemorrhage in patients under 65 years of age, and colorectal surgery, gastrointestinal bleeding, and mesenteric ischemia diagnoses in patients over 65 years of age were statistically significantly higher ($p<0.001$). The mortality rate of patients over 65 years of age who underwent emergency surgery was 38.1%, which was unitstatistically significantly higher than younger patients ($p<0.001$) (Table 2).

Table 1. Admission of patient and characteristics of ICU (n=886).

Variables	
Age (Mean=52.3±21.6)	
< 65 years	592 (66.8%)
> 65 years	294 (33.2%)
Gender	
Female	341 (38.5%)
Male	545 (61.5%)
ASA class	
1E	-
2E	14 (1.6%)
3E	834 (94.1%)
4E	38 (4.3%)
Comorbidity	
Hypertension	326 (36.8%)
Diabetes	163 (18.4%)
Congestive heart failure	258 (29.1%)
COPD	79 (8.9%)
Chronic kidney disease	64 (7.2%)
Stroke	59 (6.6%)
Preoperative laboratuary parameters	
Leukocytes ($x10^9$ /L)	13.38±6.09
Hemoglobin (g/L)	11.72±3.03
Neutrophil count (10^9 cells/L)	11.08±5.37
Lymphocyte count (10^9 cells/L)	1.26±1.33
pH	7.34±0.41
Lactates (mg/dL)	2.71±2.32
Surgery Diagnosis	
Mezenteric ischemia	33 (3.7%)
Appendicitis	2 (0.2%)
Gastroduodenal perforation	13 (1.5%)
Gastrointestinal bleed	34 (3.8%)
Colon Obstruction-Ileus	215 (24.3)
Intracranial hemorrhage	277 (31.3%)
Necrotizing fasciitis	4 (0.5%)
Postoperative bleed	10 (1.1%)
C-section	11 (1.2%)
Trauma	202 (22.8%)
Stab injury	40 (4.5%)
Firearm injury	45 (5.1%)
Re-operation	145 (16.4%)
Vasoactive agents administration	
Norepinephrine	380 (42.9%)
Dopamine	189 (21.3%)
Epinephrine	84 (9.5%)
APACHE II	19.1±8.7
SAPS III	47.12±15.38
LOS - ICU	8.64 (1.2-198.3)
Discharge	636 (71.8%)
Mortality	250 (28.2%)

Data are presented as mean±standard deviation (SD) or number (%).

Abbreviations: ASA: American Society of Anesthesiologist; APACHE: acute physiology and chronic health evaluation; SAPS: simplifed acute physiology; COPD: Chronic obstructive pulmonary disease; LOS: length of stay; ICU: intensive care

The mortality rates of patients who received vasoactive agents support therapy in the intensive care unit were found to be significantly higher than those who did not (p< 0.001). Patients who received norepinephrine and dopamine treatment were found to be significantly higher over the age of 65 (p <0.001, p=0.019, respectively).

There was no statistical difference between the patients receiving epinephrine (p=0.648) (Table 3). Similarly, patients with higher APACHE II and SAPS scores during preoperative ASA scores and postoperative intensive care hospitalization had higher mortality (p<0.001). Patients with highpreoperative leukocyte and neutrophil levels had a fatal course (p=0.028, p=0.013, respectively).

Table 2. Comparison of preoperative characteristics of patients undergoing emergent surgery.

		Discharge (n=636)	Ex (n=250)	p
Age (year)		49.44±21.68	59,60±19.70	**< 0.001**
Gender	Male	394-61.9%	151-60.4%	0.670
	Female	242-38.1%	99-39.6%	
ASA	2	11-1.7%	3-1.2%	0.333
	3	621-97.6%	243-97.2%	
	4	4-0.6%	4-1.6%	
Preoperative laboratuary parameters				
Leukocytes ($x10^9$/L)		13.01±5.24	14.33±7.77	**0.028**
Hemoglobin (g/dL)		11.81±2.94	11.67±3.12	0.184
Neutrophil count (10^9 cells/L)		10.68±4.49	12.07±7.06	**0.013**
Lymphocyte count (10^9 cells/L)		1.28±1.48	1.19±0.81	**0.037**
pH		7.35±0.27	7.34±0.53	0.163
Lactates (mmol/L)		2.59±2.23	2.83±2.41	**0.041**
Operative procedure diagnosis				
Mezenteric ischemia		20-3.1%	13-5.2%	0.340
Appendicitis		2-0.3%	0-0%	
Gastroduodenal perforation		11-1.7%	2-0.8%	
Gastrointestinal bleed		25-3.9%	9-3.6%	
Colon Obstruction-Ileus		154-24.2%	61-24.4%	
Intracranial hemorrhage		193-30.3%	84-33.6%	
Necrotizing fasciitis		3-0.5%	1-0.4%	
Postoperative bleed		10-1.6%	0-0%	
C-section		9-1.4%	2-0.8%	
Trauma		150-23.6%	52-20.8%	
Stab injury		31-4.9%	9-3.6%	
Firearm injury		28-4.4%	17-6.8%	

Data are presented as mean±standard deviation (SD) or number (%).
Abbreviations: ASA: American Society of Anesthesiologist.

Table 3. Comparison of postoperative outcomes of patients undergoing emergent surgery.

		Discharge (n=636)	Ex (n=250)	p
Re-Operation	**Yes**	80-12.6%	65-26.0%	**< 0.001**
	No	556-87.4%	185-74.0%	
Epinephrine administration	**Yes**	18-2.8%	66-26.4%	**< 0.001**
	No	618-97.2%	184-73.6%	
Epinephrine dose (μg/kg/min)		0.676±0.89	1.081±0.96	**0.027**
Epinephrine infusion time (min)		638.55±915.53	466.68±464.09	0.800
Dopamine administration	**Yes**	67-10.6%	122-48.8%	**< 0.001**
	No	568-89.4%	128-51.2%	
Dopamine dose (mg/kg/min)		11.26±6.65	16.33±8.49	**< 0.001**
Dopamine infusion time (min)		3176.97±4535.48	1991.33±2405.47	0.311
Norepinephrine administration	**Yes**	172-27.0%	208-83.2%	**< 0.001**
	No	464-73.0%	42-16.8%	
Norepinephrine dose (μg/kg/min)		0.354±0.73	0.969±0.74	**< 0.001**
Norepinephrine infusion time (min)		6898.40±12762.10	7113.45±9223.62	0.468
APACHE II		18.29±8.51	21.40±8.80	**< 0.001**
SAPS III		49.28±14.18	53.32±12.46	**< 0.001**
Procalsitonin (μg/L)		4.65±12.25	7.51±16.09	**0.001**
LOS (ICU)		8.15±16.97	9,61±13.19	**0.001**

Data are presented as mean±standard deviation (SD) or number (%).
Abbreviations: APACHE: acute physiology and chronic health evaluation; SAPS: simplifed acute physiology; LOS: length of stay; ICU: intensive care unit.

Overall, 71.8% of the patients were discharged from the intensive care unit. The mean postoperative stay of the patients in the intensive care unit was 8.6 days. The hospitalization period was significantly longer in patients with a mortal course (p=0.001). 24% of discharged patients required inpatient care, such as transfer to another hospital, assisted care facility, rehabilitation center, or home care. Two-thirds of the patients were discharged home without receiving service.

Multivariate logistic regression analysis was used to identify variables associated with in-hospital mortality (Table 4). Of these, ASA class (OR 1.22, 95% CI 0.751-1.191, p=0.031) APACHE II (OR 1.033, 95% CI 1.000-1.067, p=0.003), and Leukocytes (OR 1.034, 95% CI 1.001-1.067, p= 0.04), predicted statistically significant in-hospital mortality (r = 0.469) (Table 4). Most patients were ASA class 3 (n=578, 58%). Mortality rates for each ASA class were 2 (21.4%), 3 (28.1%), and 4 (50%).

Table 4: Factors associated with in-hospital mortality - multivariable logistic regression analysis.

Covariations	p value	OR	95% CI	p adj	OR adj	95% CI adj
Age	< 0.001	1.026	1.012-1.036	0.005	0.026	1.017-1.036
Gender	0.230	1.268	0.860-1.870	0.198	0.802	0.543-1.184
ASA	0.031	1.227	0.751-1.191	0.046	1.009	0.946-1.066
Re-operation	0.014	2.066	1.160-3.681	0.295	0.726	0.891-2.764
Leukocytes (x10^9 /L)	0.040	1.034	1.001-1.067	0.044	1.054	0.874-1.272
Neutrophil (10^9 cells/L)	0.734	0.966	0.790-1.180	0.991	0.999	0.821-1.215
Lymphocyte (10^9 cells/L)	0.350	0.855	0.616-1.187	0.494	0.889	0.634-1.246
Procalsitonin (μg/L)	0.045	1.013	1.000-1.067	0.053	1.012	1.000-1.025
APACHE II	0.003	1.033	1.011-1.056	0.004	1.013	0.987-1.041
SAPS III	0.058	1.042	0.999-1.088	0.034	1.049	1.004-1.097

Abbreviations: ASA: American Society of Anesthesiologist; APACHE: acute physiology and chronic health evaluation; SAPS: simplifed acute physiology; OR: odds ratio; CI: confidence interval

DISCUSSION

World's population will reach 9.7 billion in 2050 (World Population Prospects, 2019), and more than 25% will be comprised of the geriatric age group, defined as over 65 years of age (Projections of the Population by Age and Sex for the United States: 2010 to 2050, 2008). With the population's rapid growth and life expectancy increase, there is a parallel increase in the elderly population. This situation has revealed the necessity of better understanding the results of patients undergoing emergency surgery and determining the factors affecting mortality and morbidity in patients treated in the intensive care unit in the postoperative period. This study demonstrates that the majority of patients aged 65 years and older presenting for emergency surgery have a pre-existing comorbidity and an ASA physical status of 3E or greater. In addition, it has been determined that patients with ASA 3E and above, regardless of age, need postoperative intensive care. In this study, 250 patients died in the postoperative intensive care unit. In our intensive care follow-up after surgery, the mortality rate was 28.2%, and the discharge rate was 71.8%. A study conducted on the geriatric age group, reported that 50% of the patients who underwent abdominal surgery survived after three years and had a long-term survival (Gazala et al., 2013). In terms of the health system, if we can determine the need of this population for intensive care beds, the treatment and rehabilitation process required in intensive care, and then the long- term need for service beds, budget and resource use planning can be made in the early period.

The lack of studies examining patients requiring emergency surgery makes it difficult to determine outcomes in this patient population. Adverse outcomes reported in outpatient and elective surgery are generally associated with cognitive impairment, malnutrition, functional limitations, and depression (Dasgupta, 2009). In an emergency, it is difficult to carry out a comprehensive clinical evaluation and detailed analysis of existing risk factors and comorbidities.

ASA and APACHE II scores are the most commonly used scoring systems to predict outcomes and mortality in patients who have undergone surgery and continue to be treated in the intensive care unit (Minne et al., 2011; Paul et al., 2013). However, since the APACHE II score is predictive only for critically ill patients in the ICU, it may be challenging to apply to all patients undergoing emergency surgery. Since only the patients treated in the intensive care unit after emergency surgery were included in our study, we had no difficulty using the APACHE II score. APACHE II is a scoring system applied to critically ill patients in the intensive care unit within the first 24 hours. Therefore, this scoring system evaluates the effect of the patient's condition on mortality in the first 24 hours of admission to the intensive care unit. It does not take into account the health problems and complications that patients may experience later.

In addition, in our study, the preoperative arterial blood gas was typically considered as a part of the study, and the effects of arterial blood gas parameters on mortality and duration of intensive care hospitalization were investigated.

The present study shows that mortality is higher in patients with high ASA class after emergency non-cardiac surgery. In this way, specifically, ASA 3 (severe, life-threatening systemic disease) patients had a 28.1% mortality rate in intensive care, while ASA 4 patients had the highest mortality risk of 50%. Anesthesiologists frequently use this assessment, but this study shows that the ASA class cannot be restricted only to preoperative risk stratification but may also be related to evaluating postoperative intensive care mortality. So, this result indicates that anesthetists can use the ASA score to predict mortality and morbidity in patients' families before surgery and during the intensive care unit. In the present study, in addition to the existing scores, it was found to be effective on mortality in advanced age. However, the effect of age-related frailty on mortality is known. Therefore, evaluating the impact of age on mortality with frailty scales, rather than directly by age, may yield more accurate results (Lin et al., 2016). In studies, frailty scales were found to be more valuable than age in evaluating mortality (Kojima et al., 2018).

Also, our analysis shows that chronological age alone can not be a determining factor in mortality in the geriatric age group. Because when evaluation tests such as ASA, APACHE II, and preoperative laboratory tests are taken into account together with age, the mortality estimation can be made more accurate. For this purpose, a more comprehensive assessment test including these laboratory parameters can be developed.

Although maximum efforts are always made to prevent complications, it is impossible to avoid complications' development completely. Especially in emergency surgical interventions, the lack of time to solve problems such as hemodynamic instability, fluid and electrolyte imbalance and wait for the fasting time, and then the use of multiple drugs, immobility, and the presence of additional invasive interventions in the intensive care unit exposes the patient to a high risk of postoperative complications. The most of factors are unchangeable, but precautions and practices such as catheter care in the intensive care unit, removal as soon as the need arises, and good management of the weaning process, especially antibiotic de-escalation, is essential in terms of preventing postoperative complications (Campion & Scully, 2018; BouAkl et al., 2012). Because there is a significant relationship between postoperative complications and mortality (Rosero et al., 2021; Portuondo et al., 2019), these types of precautions should be included in daily intensive care practice.

The limitations of the presented study are its retrospective design and data from a single hospital. However, sequential inclusion of patients who met the inclusion criteria, regardless of sample size, type of surgery, and surgeon, is one of the best aspects of this study.

CONCLUSION

In addition to existing methods, additional preventive strategies should be developed to improve the care of these patients in order to reduce the risk of complications and mortality in patients who are transferred to the intensive care unit after emergency surgery. For instance, it may be helpful to use the ASA class in addition to age, the number of comorbidities, and APACHE II score to estimate this patient group's postoperative intensive care mortality. Accurate estimation can provide more precise information for the patient's family regarding expectations and assist physicians in setting treatment goals.

Acknowledgement

Thanks to: We thank Assoc. Prof. Dr. Gülsüm Oya HERGÜNSEL for their support of our study.

Ethics Committee Approval: Approval was obtained from Health Science University, Bakırköy Dr. Sadi Konuk Training and Research Hospital Non-Interventional Clinical Research Ethics Committee (Approval No: 2022/206).

Financial Resource/ Sponsor's Role: The authors have no sources of funding to declare for this manuscript.

Conflict of Interest: The authors declare that there is no conflict of interest regarding the publication of this article.

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