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Determinants of Postoperative ICU Admission in the Elderly: A Prospective Multicenter Study of Elective Surgeries in Indonesia

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ABSTRACT

Introduction: The increasing global geriatric population presents significant challenges for surgical care, particularly regarding the allocation of Intensive Care Unit (ICU) resources. This study aimed to identify determinants of postoperative ICU admission among elderly patients in Indonesia, a setting with a rapidly aging demographic. **Methods:** We conducted a prospective, multicenter cohort study across 15 Indonesian hospitals from February to April 2021. Patients aged ≥60 years undergoing elective surgery were enrolled via consecutive sampling. Data on patient demographics, American Society of Anesthesiologists (ASA) physical status, Charlson Comorbidity Index (CCI), and type of anesthesia (general vs. regional) were collected. The primary outcome was postoperative ICU admission. Multivariate logistic regression was used to identify independent predictors. **Results:** Of 893 patients enrolled, 18.8% required postoperative ICU admission. The final multivariate model revealed that a higher ASA physical status was the strongest predictor of ICU admission (Odds Ratio [OR] 4.13; 95% CI 2.88-5.92; p < 0.001). The administration of general anesthesia was also independently associated with a significantly increased likelihood of ICU admission compared to regional anesthesia (OR 2.77; 95% CI 1.83-4.19; p < 0.001). While the CCI was a significant factor in unadjusted analyses, its effect was attenuated after inclusion of the ASA score. **Conclusion:** ASA physical status and the choice of general anesthesia are powerful, independent determinants of postoperative ICU admission in the Indonesian geriatric surgical population. These findings highlight the critical role of preoperative physiological assessment and suggest that the choice of anesthetic technique has significant implications for postoperative resource needs.

1. Introduction

The 21st century is defined by a profound and irreversible demographic shift: the rapid aging of the global population.[1] The World Health Organization projects that the proportion of individuals aged over 60 will nearly double by 2050, a trend that is particularly accelerated in developing nations.[2] Indonesia, as the world's fourth most populous country, stands at the forefront of this transformation, with its elderly population expanding at an unprecedented rate.[3] This demographic evolution carries immense implications for national healthcare systems, as advancing age is inextricably linked with an increased prevalence of chronic, multimorbid disease states that frequently necessitate surgical intervention.[4] Consequently, perioperative care teams are increasingly faced with the formidable challenge of safely guiding a burgeoning population of older, more complex patients through the physiological rigors of surgery and anesthesia. Geriatric patients constitute a uniquely vulnerable cohort within the surgical domain. The biological process of senescence is characterized by a progressive, multisystem decline in physiological reserve, a state that is often compounded by the clinical syndrome of frailty.[5] This decline is not merely a chronological inevitability but a functional reality, encompassing reduced cardiovascular compliance, diminished pulmonary elasticity, impaired renal filtration, and altered metabolic and immune responses.[6] This inherent erosion of organ capacity renders the elderly patient exquisitely sensitive to the profound homeostatic disruptions induced by surgical trauma and anesthetic administration. The result is a markedly elevated risk profile for a wide spectrum of adverse postoperative outcomes, including major cardiac and cerebrovascular events, respiratory failure, acute kidney injury, postoperative delirium, prolonged functional dependency, and mortality.[7]

A central pillar in the management of these high-risk patients is the judicious use of the Intensive Care Unit (ICU).[8] The ICU provides a critical safety net, offering a level of advanced organ support and continuous, invasive monitoring that is indispensable for stabilizing patients during the vulnerable immediate postoperative period.[9] However, the ICU is a finite, technologically demanding, and exceptionally costly resource. In healthcare systems worldwide, and particularly in resource-variable settings such as Indonesia, the demand for critical care often outstrips supply. Unplanned or reactive ICU admissions can strain hospital capacity, compromise the quality of care, and be associated with poorer patient outcomes. Therefore, the ability to accurately stratify risk and prospectively identify patients who will most likely require postoperative intensive care is no longer a clinical luxury but a strategic imperative. Accurate prediction is the cornerstone of effective resource planning, transparent patient counseling, and the development of proactive, systems-based approaches to perioperative care.[10] While numerous risk factors have been identified in international literature, there remains a critical knowledge gap regarding the specific drivers of ICU admission within the Indonesian healthcare context. The novelty of this study is anchored in its large-scale, prospective, multicenter design—the first of its kind in Indonesia—providing a robust and generalizable evidence base that moves beyond single-center observations. By focusing exclusively on the geriatric population, this research directly confronts a national public health priority. The primary aim of this study was to identify the key determinants among patient-level risk factors (specifically, ASA physical status and cumulative comorbidity burden) and process-of-care factors (anesthetic management) that independently predict the need for postoperative ICU admission. By elucidating these predictors, we seek to equip clinicians with validated, locally relevant tools for risk assessment and to inform national health policy on the strategic development of perioperative services for the elderly.

2. Methods

This investigation was conducted as a prospective, multicenter, observational cohort study, forming an integral part of the Indonesian Anesthesiology and Intensive Care (KATI) research collaboration. The study was executed across a geographically diverse network of 15 tertiary referral hospitals located in major urban centers throughout Indonesia, a design choice intended to maximize the external validity and national representativeness of the findings. The protocol underwent rigorous ethical review and received full approval from the institutional review board at the coordinating center, Dr. Saiful Anwar Regional General Hospital (Reference No: 400/366/K.3/102.7/2024), with reciprocal approval from all participating sites. The study was conducted in strict adherence to the principles of the Declaration of Helsinki. Written informed consent was obtained from all participants or their legally authorized representatives prior to any study-related procedures. The study population comprised all geriatric patients (defined as age ≥60 years, consistent with Indonesian national law) scheduled for elective, non-cardiac surgery under anesthesia between February 1st, 2021, and April 30th, 2021. A consecutive sampling strategy was employed, whereby every eligible patient presenting during the study period was invited to participate in order to minimize selection bias. The sole exclusion criterion was the refusal or inability to provide informed consent. A complete case analysis approach was planned; all enrolled patients with complete data for the primary predictor and outcome variables were included in the final analysis. We confirm that no patient was excluded due to missing data for the key variables of interest.

Standardized data were prospectively collected at each center by trained research personnel using a secure, web-based electronic data capture platform (REDCap). Patient confidentiality was maintained through de-identification of all data prior to analysis. The primary outcome was postoperative admission to the ICU, recorded as a binary variable (Yes/No). The decision to admit was made by the attending clinical team based on the patient's clinical status and prevailing institutional protocols. Primary Predictor Variables: ASA Physical Status: Classified preoperatively by the attending anesthesiologist on the I-V scale; Comorbidity Burden: The Charlson Comorbidity Index (CCI) was calculated for each patient. The CCI is a validated scoring system that weights 19 different comorbid conditions based on their association with mortality. This provided a more objective and granular measure of comorbid disease burden than a simple count or binary assessment; Anesthetic Technique: The primary anesthetic was categorized as General Anesthesia or Regional Anesthesia. The regional group included spinal, epidural, and major peripheral nerve blocks used as the primary anesthetic. Cases involving a planned combination of general and regional anesthesia were classified under the General Anesthesia group for this primary analysis. The regional anesthesia subgroup consisted of spinal anesthesia (n=272), epidural anesthesia (n=22), and peripheral nerve blocks (n=7). Data were also collected on patient age, gender, and Body Mass Index (BMI), calculated as weight (kg) / height $(m)^2$.

All statistical analyses were conducted using IBM SPSS Statistics, Version 27.0. A two-tailed p-value < 0.05 was considered statistically significant. Descriptive statistics were used to summarize the cohort's characteristics. Bivariate analyses using the chi-square test for categorical variables and t-tests or Mann-Whitney U tests for continuous variables were performed to assess unadjusted associations with ICU admission. To identify independent predictors of the primary outcome, a multivariate logistic regression model was constructed. Variables were selected for inclusion based on clinical relevance and statistical significance in the bivariate analyses. Given the known statistical collinearity between the CCI and ASA scores (as both measure aspects of patient health), we planned to include both in the initial model to assess their independent contributions. The final model's goodness-of-fit was assessed using the Hosmer-Lemeshow test. Results are presented as Odds Ratios (ORs) with 95% Confidence Intervals (CIs).

3. Results

Figure 1 provides a comprehensive and multi-faceted graphical summary of the baseline demographic and critical clinical characteristics of the 893 geriatric patients who constituted the cohort for this prospective multicenter study. This visual abstract serves as the foundational evidence upon which the study's subsequent analyses are built, offering an immediate and informative overview of the patient population, the clinical practices employed, and the primary outcome of interest. Through a combination of clear statistical callouts and intuitive data visualizations, the figure effectively communicates the inherent complexity and vulnerability of elderly patients undergoing elective surgery in the Indonesian healthcare context. The top-level statistics immediately establish the scale and focus of the investigation. The cohort size of 893 patients underscores the robustness of the study, providing substantial statistical power to draw meaningful conclusions that are generalizable beyond a single institution. The mean age of 67.4 years, with a standard deviation of 6.2 years, firmly situates the population within the geriatric classification, a demographic characterized by age-related physiological decline and diminished organ reserve. This is not a cohort on the cusp of old age, but one squarely within it, where the challenges of perioperative management are most pronounced. The gender distribution reveals a near-equipoise, with females constituting 52.0% and males 48.0% of the cohort. This balanced representation is crucial, as it allows for an unbiased assessment of risk factors independent of sex-based physiological or pathological differences. The core of the figure, however, lies in its depiction of the key clinical variables that form the nexus of the research question. The bar chart illustrating the American Society of Anesthesiologists (ASA) Physical Status is particularly illuminating. It paints a stark picture of a patient population with a significant burden of systemic disease. The vast majority of patients were classified as either ASA II (63.5%), indicating the presence of mild systemic disease, or ASA III (34.1%), signifying severe systemic disease that confers functional limitations. The negligible proportion of healthy ASA I patients (less than 3%) highlights that elective surgery in the elderly is rarely performed on individuals without pre-existing health conditions. This distribution is the single most critical piece of baseline data, as it provides a quantifiable measure of the cohort's intrinsic physiological vulnerability and sets the stage for the subsequent finding that this classification is the most powerful predictor of postoperative outcomes. Complementing the patient-level risk assessment is the visualization of a key process-of-care variable: the Anesthetic Technique. The data show a clear predominance of General Anesthesia (66.3%) over Regional Anesthesia (33.7%). This distribution likely reflects a combination of factors, including surgical requirements, patient comorbidities, and prevailing clinical practice patterns across the 15 participating tertiary care centers. It establishes the central comparison of the study and provides the necessary variation to statistically evaluate the differential impact of these two fundamentally different anesthetic approaches on the need for advanced postoperative care. Finally, the figure culminates in the depiction of the study's primary outcome: Postoperative ICU Admission. The doughnut chart reveals that a substantial 18.8% of this geriatric cohort required admission to an Intensive Care Unit following their elective surgery. This is a clinically significant finding, illustrating the immense demand for high-acuity, resource-intensive care that this patient population generates. It quantifies the clinical problem at the heart of the study and serves as the critical endpoint against which all predictor variables are measured.

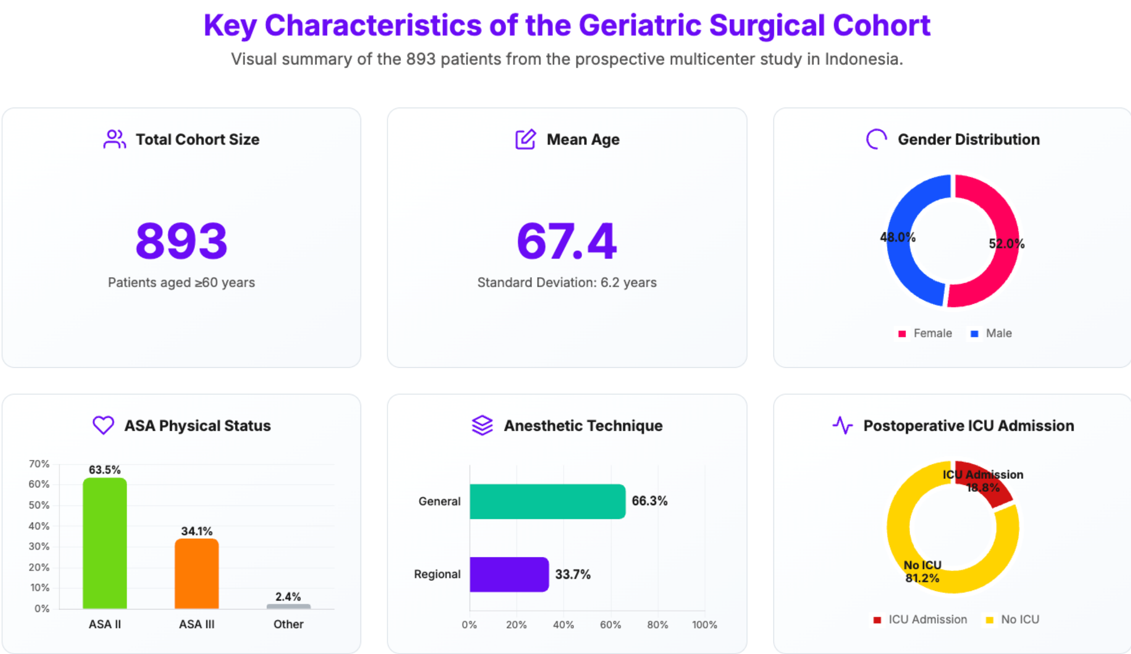

Figure 1. Demographic and clinical characteristics of the study cohort (N=893).

Figure 2 presents the foundational stratum of the study's analytical framework: a comprehensive bivariate analysis designed to unearth the unadjusted associations between key patient and clinical characteristics and the primary outcome of postoperative Intensive Care Unit (ICU) admission. The most striking and statistically robust association elucidated by this figure is that of the American Society of Anesthesiologists (ASA) Physical Status. The chart for this variable reveals a dramatic and compelling dose-response relationship between a patient's baseline physiological impairment and their likelihood of ICU admission. For patients classified as ASA II, representing those with mild systemic disease, the rate of ICU admission was a relatively modest 10.4%. However, this risk escalates sharply for patients classified as ASA III (severe systemic disease), with 31.5% of this group requiring intensive care. The trend culminates in the highest-risk category, ASA IV, where an overwhelming majority—84.6% of patients—were admitted to the ICU postoperatively. This steep gradient underscores the profound predictive power of the ASA classification as a holistic measure of a patient's capacity to withstand surgical stress. The highly significant p-value ($p < 0.001$) confirms that this observed difference is not a product of chance, establishing the patient's intrinsic physiological reserve as a paramount determinant of their postoperative trajectory. Equally significant, though perhaps more nuanced, are the findings related to the Anesthetic Technique. The analysis draws a stark contrast between the outcomes associated with general versus regional anesthesia. Among patients who received general anesthesia, 22.9% required subsequent ICU admission. This figure is more than double the rate observed in the regional anesthesia group, where only 10.6% of patients needed intensive care. This pronounced disparity, validated by a p-value of less than 0.001, provides strong initial evidence that the choice of anesthetic modality is deeply intertwined with postoperative resource requirements. While this bivariate analysis does not control for confounding factors—such as the possibility that sicker patients or more complex surgeries preferentially receive general anesthesia—the magnitude of the difference strongly implicates the anesthetic technique as a critical variable of interest, demanding further investigation in the multivariate context. The analysis of Comorbidity further reinforces the theme of patient vulnerability. The data clearly show that the presence of one or more pre-existing chronic conditions is significantly associated with an increased need for ICU care. Patients with comorbidities had an ICU admission rate of 21.9%, nearly double the 11.8% rate observed in patients with no documented comorbidities. This statistically significant finding ($p < 0.001$) aligns with established clinical understanding that a higher burden of chronic disease erodes a patient's physiological resilience, making them more susceptible to postoperative decompensation.

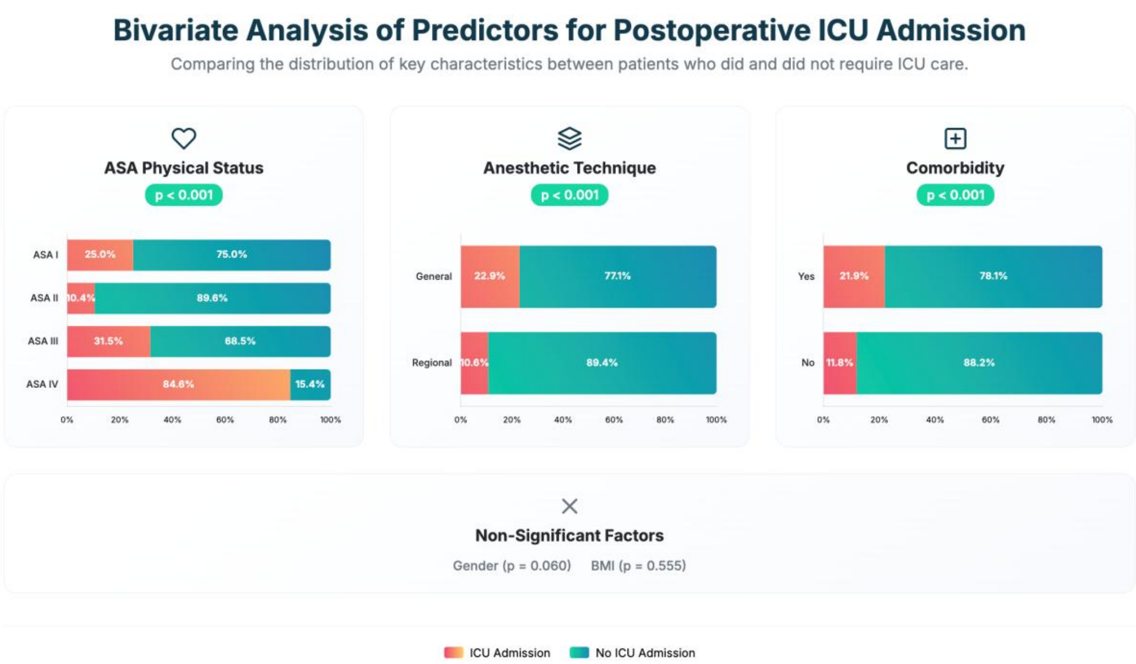

Figure 2. Bivariate analysis of predictors for postoperative ICU admission.

Figure 3 represents the statistical culmination of this investigation, transitioning from the exploratory nature of bivariate analysis to the explanatory power of multivariate logistic regression. This elegant schematic and graphical representation does not merely present data; it tells a compelling scientific story about causality and risk stratification. It visually distills the complex interplay of multiple patient and clinical factors down to the two most powerful, independent drivers of postoperative Intensive Care Unit (ICU) admission. By controlling for the confounding effects of other variables, this analysis isolates the true statistical impact of each predictor, providing a clear and actionable hierarchy of risk. The figure is structured as a forest plot, a sophisticated and standard method for displaying the results of regression modeling in high-impact scientific literature. At its core are the Odds Ratios (OR), which quantify the strength of the association between a predictor and an outcome. An odds ratio greater than 1.0 indicates an increased likelihood of the outcome, while the "no effect" line at 1.0 represents the null hypothesis. The accompanying 95% Confidence Interval (CI), depicted as a horizontal line, provides a measure of the precision of this estimate. The crucial interpretive element is that if the confidence interval for a predictor does not cross the 1.0 line, the association is statistically significant. The most commanding finding, both visually and statistically, is the impact of the American Society of Anesthesiologists (ASA) Physical Status. The model reveals an odds ratio of 4.13 for each one-class increase in a patient's ASA score. This is a remarkably strong effect, indicating that with each step up in physiological impairment—from ASA II to III, or III to IV—the odds of that patient requiring postoperative ICU care increase by more than fourfold. The 95% confidence interval is narrow and far from the null, ranging from 2.88 to 5.92. The graphical representation powerfully conveys this: the purple marker for the odds ratio is positioned far to the right of the 1.0 line, and its corresponding confidence interval is entirely contained within the domain of increased risk. This finding provides definitive, statistically robust evidence that a patient's baseline physiological reserve, as holistically captured by the ASA classification, is the single most important determinant of their postoperative trajectory and need for intensive care. The second, and equally significant, independent predictor is the Anesthetic Technique. The analysis demonstrates that, even after accounting for the patient's underlying health status via the ASA score, the choice of anesthesia remains a powerful determinant of the outcome. Patients who received general anesthesia had an odds ratio of 2.77 for ICU admission compared to those who received regional anesthesia. This means their odds of requiring intensive care were nearly three times higher. The statistical significance of this finding is unequivocal, with a 95% confidence interval of 1.83 to 4.19, which, like the ASA score, is located entirely to the right of the no-effect line. The teal-colored graphical element for this predictor, while closer to the 1.0 line than the ASA score, still represents a very strong and clinically meaningful effect. This result moves beyond a simple correlation to suggest that the physiological insults and systemic effects inherent to general anesthesia likely contribute directly to a patient's risk of requiring a higher level of postoperative care, independent of their pre-existing conditions. Figure 3 provides a clear, scientifically rigorous, and visually compelling summary of the study's core message. It demonstrates that the need for postoperative ICU admission in this geriatric cohort is not a random event but is powerfully predicted by two key factors: one reflecting the patient's intrinsic vulnerability (ASA Status) and the other reflecting a major clinical intervention (Anesthetic Technique).

Figure 4 provides a crucial validation of the study's logistic regression model, moving beyond the identification of predictors to rigorously assess the model's overall performance and reliability. This schematic and graphical representation details the results of the Hosmer-Lemeshow Goodness-of-Fit test, a cornerstone statistical procedure for evaluating the calibration of a predictive model. The infographic begins by providing a clear and concise explanation of the test's Purpose, Method, and Interpretation, making this complex statistical concept accessible. It clarifies that the primary goal is to check the reliability of the model's predictions.

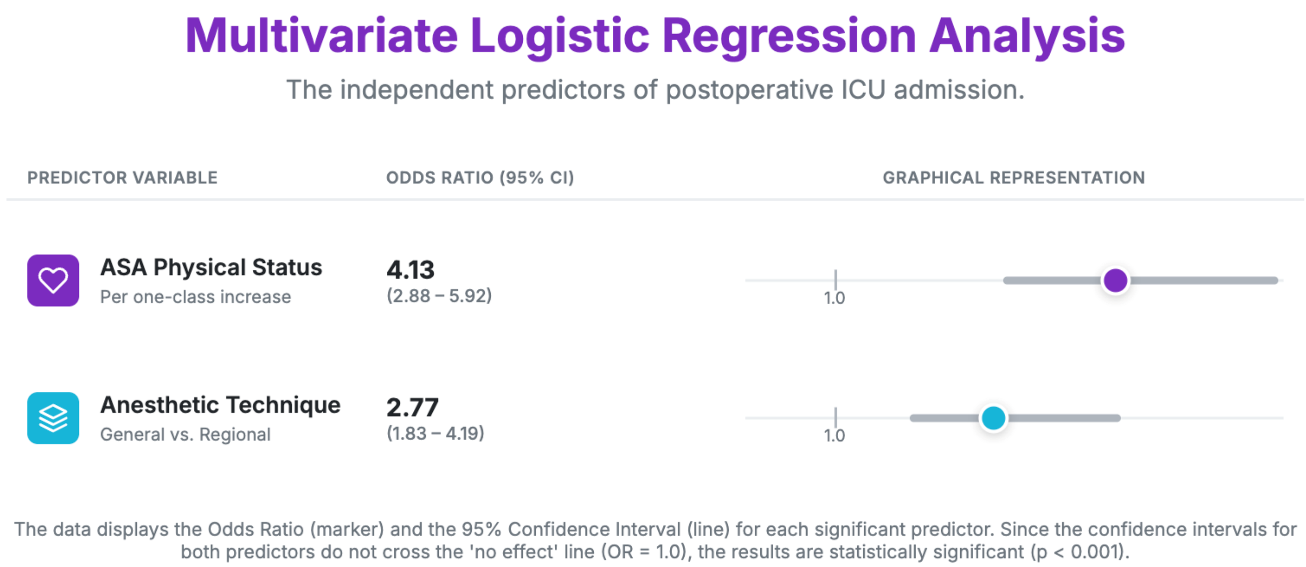

Figure 3. Multivariate logistic regression analysis for independent predictors of postoperative ICU admission.

The method involves a sophisticated form of internal validation: the entire cohort of 893 patients is sorted by their model-predicted risk of ICU admission and then grouped into deciles (ten groups of increasing risk). Within each of these groups, the test compares the number of ICU admissions that the model *expected* to see versus the number of ICU admissions that were actually *observed*. The key to interpretation lies in the p-value; a non-significant result ($p > 0.05$) is the desired outcome, as it signifies that there is no statistically significant difference between the predicted and observed frequencies, thereby confirming the model is well-calibrated. The most prominent feature of the figure is the "Excellent Model Fit Confirmed" verdict, which immediately communicates the main conclusion. This assertion is substantiated by the key statistical outputs: a Chi-Square (x^2) value of 3.628 and, most importantly, a p-value of 0.821. This high p-value overwhelmingly indicates a lack of significant discrepancy between the model's predictions and the actual data, providing strong evidence for the model's robustness and reliability. This statistical conclusion is powerfully reinforced by the central bar chart, which graphically plots the observed versus expected ICU admissions for each risk decile. The visual concordance between the two sets of bars is striking. The orange bars, representing the observed number of ICU admissions, track the pink bars, representing the expected number, with remarkable fidelity across the entire spectrum of risk. In the lower-risk deciles on the left, both observed and expected counts are low. As one moves to the higher-risk deciles on the right, both counts rise in close synchrony, culminating in the highest-risk group where the model predicted a large number of events, and a large number of events indeed occurred. This close visual alignment is the graphical signature of a well-calibrated model. It demonstrates that the model is not systematically over- or under-estimating risk at any point along the continuum, but is instead providing a reliable and well-fitted estimation of the probability of postoperative ICU admission. Figure 4 serves as the scientific seal of approval for the study's predictive model. It moves beyond simply stating that ASA status and anesthetic choice are predictors, and demonstrates that the model built upon these predictors is statistically sound, well-calibrated, and accurately reflects the reality of the clinical data. This confirmation of goodness-of-fit is essential, as it imbues the study's conclusions with a much higher degree of confidence and validity.

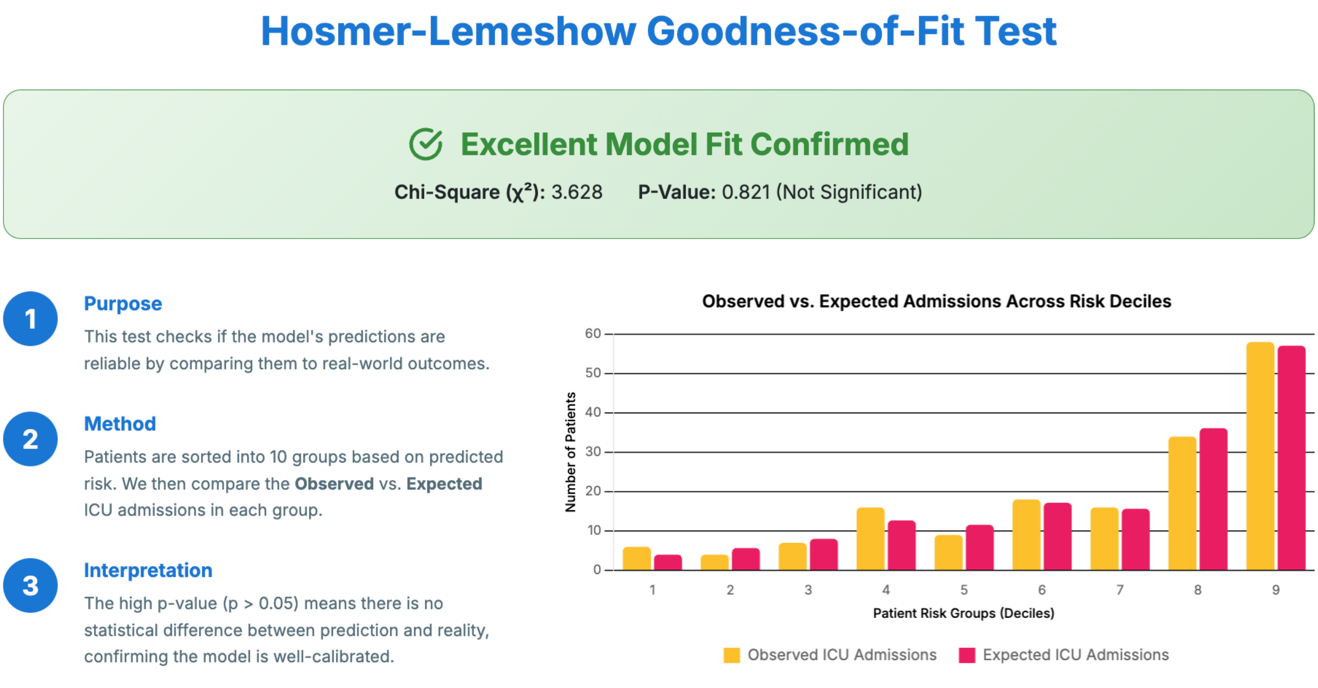

Figure 4. Hosmer-Lemeshow Goodness-of-Fit test.

4. Discussion

This large, prospective multicenter study, the first of its kind in Indonesia, provides a robust and nuanced analysis of the factors driving postoperative ICU admission in a geriatric surgical population. Our findings unequivocally identify two dominant determinants: the patient's preoperative physiological status, as encapsulated by the ASA classification, and the choice of anesthetic technique. Figure 5 presents a conceptual framework that synthesizes the statistical findings of this study into a cohesive and scientifically grounded pathophysiological narrative. This schematic model is designed to move beyond mere statistical correlation and provide a plausible, mechanistic explanation for why the identified predictors—high ASA status and the administration of general anesthesia—converge to significantly increase a geriatric patient's likelihood of requiring postoperative Intensive Care Unit (ICU) admission.[11] The figure illustrates a cascade of events, beginning with baseline vulnerabilities and acute clinical insults, which are then amplified by the universal stress of surgery, ultimately culminating in a common final pathway of organ system decompensation that necessitates intensive care.[12] The model begins with two distinct but synergistic inputs, each representing a core finding of the multivariate analysis. The first input, depicted in a cautionary red, is "High ASA Status." This represents the patient's intrinsic, pre-existing condition before they even enter the operating room. It is not merely a score but a clinical gestalt that encapsulates the cumulative impact of aging and chronic disease. This state of "Pre-existing Patient Vulnerability" is further broken down into three key physiological consequences: Diminished Organ Reserve, which is the hallmark of the high-risk geriatric patient.[13] With advancing age and comorbid disease, organs such as the heart, lungs, and kidneys lose their functional capacity. A healthy individual's heart can increase its output five-fold to meet demand; a geriatric patient with cardiac comorbidities may have almost no cardiac reserve. Their kidneys may have a baseline glomerular filtration rate that is only just adequate for homeostasis, and their lungs may have minimal capacity to compensate for increased work of breathing. This lack of reserve means that even a minor physiological insult can push an organ system beyond its functional limit and into a state of failure.[14] Homeostatic Fragility, this refers to the blunting of the body's normal compensatory mechanisms. In a healthy person, a drop in blood pressure is met with a swift and robust baroreceptor-mediated increase in heart rate and systemic vascular resistance. In the elderly, these reflexes are often sluggish and attenuated. Their ability to regulate temperature, blood glucose, and fluid balance is similarly impaired. This "homeostatic fragility" renders them incapable of effectively counteracting the profound physiological derangements that occur during surgery, making them prone to prolonged hypotension, hypothermia, and metabolic instability. While it may seem paradoxical, the elderly often exhibit both a blunted and an exaggerated stress response. The initial autonomic and neuroendocrine response to the surgical incision can be dysregulated, leading to exaggerated swings in heart rate and blood pressure.[15] Concurrently, the downstream cellular mechanisms to cope with stress, such as the production of heat shock proteins and the mounting of an effective immune response, are often impaired (a state known as immunosenescence). This combination creates a volatile internal environment where the patient is both hyper-reactive to the initial insult and ill-equipped to manage its downstream consequences. The second input, shown in a clinical blue, is "General Anesthesia." This represents the acute, iatrogenic insults that are introduced by the clinical team as a necessary component of the surgical procedure. While essential for enabling surgery, the state of general anesthesia is a profound and multi-system physiological disruption. The model highlights three primary pathways through which it contributes to risk: Hemodynamic Instability. Nearly all general anesthetic agents, both intravenous and inhalational, are vasodilators and myocardial depressants. In a vulnerable geriatric patient, this combination can lead to significant and persistent hypotension. The management of this hypotension often requires large volumes of intravenous fluids, which can overwhelm a non-compliant heart and lead to pulmonary edema, or the use of vasopressors, which can increase myocardial oxygen demand and precipitate ischemia.[16] Respiratory Compromise, General anesthesia fundamentally interferes with the mechanics of breathing. It obtunds the patient's airway reflexes, necessitating the use of an endotracheal tube or other airway device, which bypasses the natural filtering and humidifying functions of the upper airway. The use of positive-pressure ventilation alters normal lung mechanics, and the recumbent position promotes atelectasis (collapse of lung tissue). Furthermore, the residual effects of neuromuscular blocking agents can persist postoperatively, leading to subtle but significant respiratory muscle weakness, an impaired cough, and a high risk of aspiration and pneumonia.[17] Neuroendocrine Disruption, General anesthesia profoundly alters the body's central control systems. It disrupts the normal sleep-wake cycle, interferes with the hypothalamic-pituitary-adrenal axis, and blunts the normal neuroendocrine response to physiological stress. This disruption is a key contributor to postoperative delirium, a state of acute brain dysfunction that is strongly associated with poor outcomes and is itself a common reason for ICU admission.[18] This combined state of baseline vulnerability and acute anesthetic-induced insult then meets the central, unavoidable catalyst: Perioperative Physiological Stress. This is the crucible of the surgical experience, a maelstrom of tissue trauma, inflammation, pain signals, and psychological stress. A patient with high physiological reserve can navigate this storm. However, for the vulnerable geriatric patient whose system has already been destabilized by general anesthesia, this stressor is often the final push that overwhelms their fragile homeostatic mechanisms. The model shows this overwhelming stress leading to a Common Final Pathway: Organ System Decompensation & Failure. This is the critical juncture where physiological derangement transitions into clinical catastrophe. The hypotensive heart may become ischemic and fail; the compromised lungs may be unable to maintain adequate oxygenation; the kidneys, underperfused, may shut down; and the brain, assailed by inflammation and metabolic disturbance, may descend into delirium. This is the state of multi-organ dysfunction, and its management—requiring mechanical ventilation, invasive monitoring, and pharmacological organ support—is the very definition of intensive care.

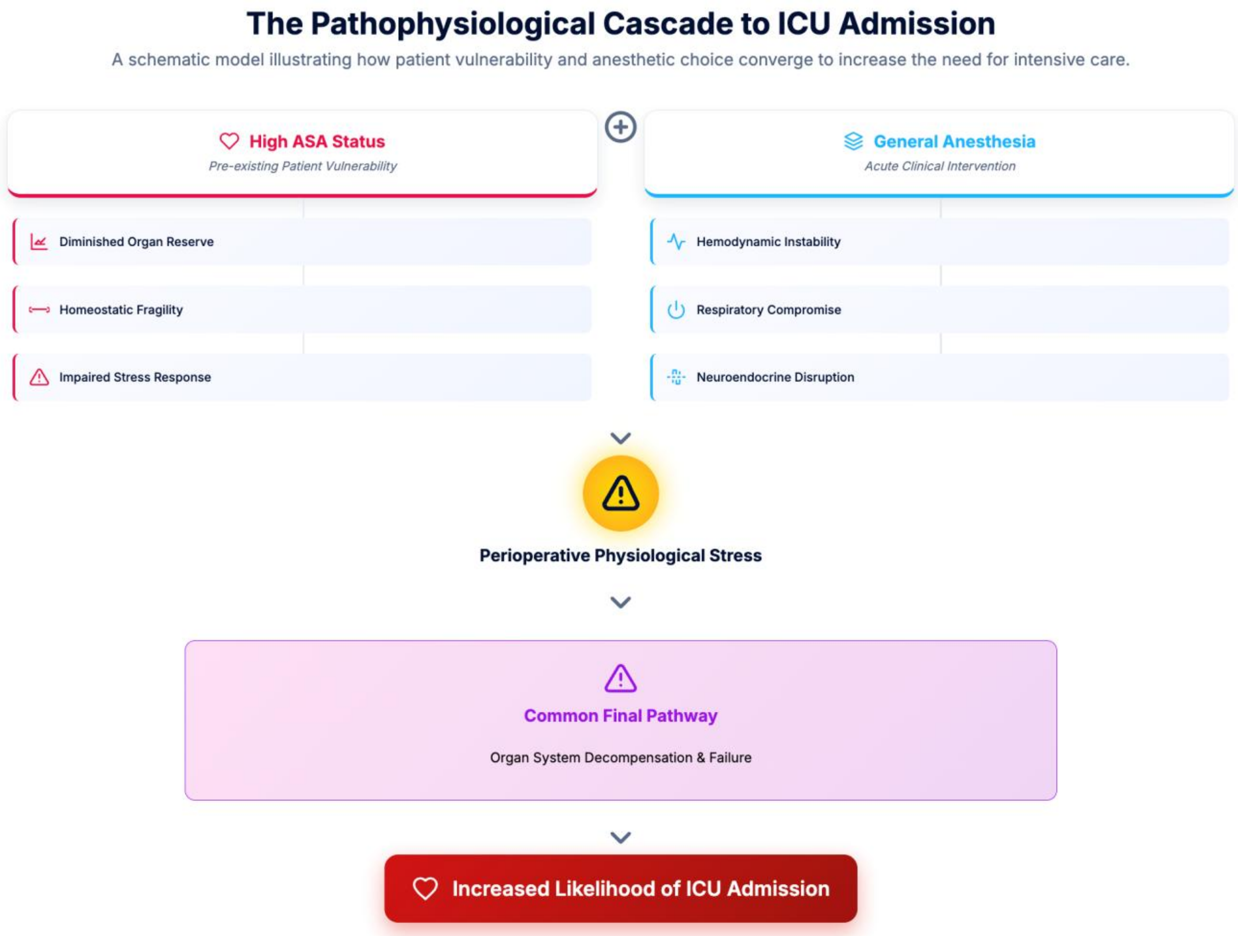

Figure 5. The pathophysiological cascade to ICU admission.

The most potent predictor identified in our analysis was the ASA physical status, with each incremental class increase conferring a more than fourfold rise in the odds of ICU admission. This affirms the enduring utility of the ASA score as a cornerstone of perioperative risk assessment. However, its power lies not merely in cataloging diseases, but in its function as a holistic clinical judgment of a patient's integrated physiological reserve. In the geriatric context, the ASA score serves as a practical, albeit imperfect, proxy for the syndrome of frailty—a state of diminished homeostatic capacity and increased vulnerability to stressors. From a pathophysiological perspective, a high ASA score (III or IV) signifies that a patient's organ systems are functioning with minimal reserve. For example, an ASA III patient with chronic heart failure has a stiff, non-compliant ventricle (diastolic dysfunction) that is highly sensitive to both volume overload and hypovolemia. The fluid shifts and inflammatory cascades inherent to major surgery can easily overwhelm this fragile cardiovascular balance, precipitating pulmonary edema and cardiogenic shock.[19] Similarly, an elderly patient with severe COPD (ASA III) has severely limited pulmonary reserve; the atelectasis, diaphragmatic dysfunction, and impaired cough reflex associated with anesthesia and surgery can rapidly progress to hypercarbic respiratory failure. The ICU is the only environment equipped to manage the advanced inotropic, vasopressor, and mechanical ventilatory support required in such states of decompensation.[20] Our finding that the ASA score's predictive power subsumed that of the Charlson Comorbidity Index in the final model highlights this critical distinction: it is not the mere presence of diseases, but their cumulative impact on a patient's functional capacity, that truly determines postoperative risk. From a systems perspective, the ASA score also functions as a crucial triage tool. In the 15 tertiary centers in our study, which operate within a resource-variable healthcare system, a high ASA score may trigger a *de facto* policy of planned or "prophylactic" ICU admission. This decision is often based not on an existing state of organ failure, but on an informed anticipation of its high probability. The clinical team recognizes that the general surgical ward may lack the nursing ratios and monitoring capabilities to safely manage a high-risk patient, making the ICU the default disposition for risk mitigation. Therefore, the strong association we observed reflects both the patient's intrinsic physiological vulnerability and the system's response to that vulnerability.

Our second major finding—that general anesthesia is independently associated with a nearly threefold increase in the odds of ICU admission—is more complex and warrants a multi-faceted interpretation. This association is likely driven by a combination of the direct physiological insults of general anesthesia, confounding by indication, and the capabilities of the downstream recovery systems. The direct physiological impact of general anesthesia on the vulnerable geriatric patient is substantial. Volatile anesthetics and intravenous induction agents cause vasodilation and myocardial depression, which can precipitate profound hypotension in elderly patients with blunted baroreceptor reflexes and stiff vasculature. Furthermore, the necessity of airway instrumentation and positive-pressure ventilation bypasses natural airway defenses and can lead to postoperative atelectasis and pneumonia. The frequent use of neuromuscular blocking agents can result in residual muscle weakness, impairing respiratory effort and cough efficacy post-extubation. These well-described physiological derangements are common precipitants for ICU admission. However, we must rigorously acknowledge the high potential for confounding by indication. Despite our statistical adjustment for ASA status and comorbidity, it remains highly probable that general anesthesia was preferentially selected for patients undergoing intrinsically higher-risk, longer, or more complex surgical procedures (such as major abdominal, thoracic, or vascular operations). These procedures, by their very nature, carry a higher independent risk of requiring intensive care, regardless of the anesthetic used. Our study, lacking granular data on surgical severity, cannot fully disentangle the effect of the anesthetic from the effect of the surgery for which it was chosen. This finding must also be viewed through the lens of the perioperative system of care. The disposition of a patient after surgery is heavily influenced by the capabilities of the Post-Anesthesia Care Unit (PACU). In many centers, PACUs may not be resourced with the low nurse-to-patient ratios or the equipment (such as advanced respiratory monitors or non-invasive ventilators) to safely manage a "borderline" patient recovering from general anesthesia. In such settings, a lower threshold may exist for transferring these patients to the ICU for a period of extended observation, a decision that might be avoided in a hospital with a high-acuity PACU or a dedicated surgical step-down unit.

It is crucial to situate our findings within their temporal context. Data collection occurred from February to April 2021, during the COVID-19 pandemic. This global health crisis placed unprecedented strain on hospital resources, particularly ICU capacity. It is plausible that this environment influenced clinical decision-making. For instance, ICU beds may have been preferentially reserved for the most critically ill patients, potentially raising the threshold for admitting a postoperative patient. Conversely, there may have been a lower threshold for admitting patients with any respiratory concerns after general anesthesia due to heightened vigilance. While the net effect is difficult to quantify, this unique environmental stressor must be acknowledged as a potential influence on the observed 18.8% ICU admission rate. The lack of association for BMI in our model is consistent with a growing body of literature highlighting its limitations in the elderly. BMI does not differentiate between lean muscle mass and adipose tissue. A geriatric patient with a "normal" BMI may suffer from sarcopenia (age-related loss of muscle mass), a key component of frailty, which is a far more powerful predictor of poor outcomes. This underscores the need for more nuanced assessments of nutritional and functional status, such as gait speed or grip strength, in future geriatric perioperative research.

5. Conclusion

This large, multicenter study provides the first robust, national-level evidence from Indonesia on the determinants of postoperative ICU admission for the elderly. Our findings lead to a clear, two-pronged conclusion. First, patient-level risk, as holistically captured by the ASA physical status, is the single most powerful predictor of the need for intensive care. This reaffirms its central role in preoperative assessment and triage. Second, the choice of general anesthesia is strongly and independently associated with an increased likelihood of ICU admission. This association, while likely influenced by surgical complexity, highlights the significant physiological impact of anesthetic choice on the postoperative trajectory of vulnerable patients. These results have profound implications for the evolution of geriatric surgical care in Indonesia and similar settings. They call for a dual strategy: enhancing patient-level risk stratification by embedding tools like the ASA score and more formal geriatric assessments into routine preoperative workflows, and investing in system-level resources, such as high-acuity post-anesthesia care units and geriatric co-management services, to build systemic resilience and reduce the reliance on reactive ICU admissions. Ultimately, by understanding these determinants, we can move towards a more proactive, patient-centered, and resource-conscious paradigm of perioperative care for our aging population.

6. References

1. Yerli M, Erkurt N, Bayraktar TO, Saygılı MS, Yüce A, Gürbüz H. Can geriatric nutrition risk index predict postoperative 90-day complications and mortality in elderly patients with hip fracture? Eur J Geriatric Gerontol. 2024; 6(1): 8–11.
2. Tantigate D, Jansatjawan N, Adulkasem N, Ramart P, Riansuwan K. Risk factors for postoperative urinary retention in fragility hip fracture patients: a prospective study. BMC Geriatr. 2024; 24(1): 483.
3. Pekovska K, Mitevska I. Analysis of risk factors for postoperative delirium in geriatric patients at Skopje Macedonia Hospital: an observational study. J Anesth Clin Res. 2024; 5(2): 575–9.
4. Li X, Sun Y, Chen L, Li Y. The impact of the Geriatric Nutritional Risk Index on postoperative cognitive dysfunction and complications after total hip arthroplasty under general anesthesia: a retrospective study. Rejuvenation Res. 2025.
5. Markovic D, Jevtovic-Stoimenov T, Stojanovic M, Vukovic A, Dinic V, Markovic-Zivkovic B, et al. Addition of clinical risk scores improves prediction performance of American Society of Anesthesiologists (ASA) physical status classification for postoperative mortality in older patients: a pilot study. Eur Geriatr Med. 2018; 9(1): 51–9.
6. Chung J-Y, Ting P-C, Wu C-L, Yu H-P. An analysis of the risk factors for postoperative complications and their effects on hospital stay in Taiwanese geriatric surgical patients. Asian J Anesthesiol. 2021; 59(2): 58–68.
7. Wu L, Yan Q, Mai H, Song J, Ye L, Che X, et al. Does the geriatric nutritional risk index play a predictive role in postoperative atrial fibrillation and outcomes in cardiac surgery? J Cardiothorac Vasc Anesth. 2023; 37(1): 58–64.
8. Chen Y, Chen H, Zhuang Y, Wang Y, Dai Z. Association between the geriatric nutritional risk index and postoperative delirium in gastric surgery patients: an analysis of the MIMIC-IV database. BMC Anesthesiol. 2024; 24(1): 477.
9. Ye WK, Wang J, Zheng J, Jiang M, Zhou YN, Wu ZX. Predictive value of the nutritional risk index for postoperative complications in individuals with pancreatic cancer undergoing pancreaticoduodenectomy. Geriatr Nurs. 2025; 61: 605–12.
10. Lu S, Liang H, Fang J, Chen R, Liao H, Xu M, et al. Construction and validation of a risk prediction model for postoperative frailty in older adults: a multicenter study. BMC Geriatr. 2025; 25(1): 88.

11. Zhao W, Liu L, Zhang J, Shi L, Zhang C, Ma Y, et al. Preoperative geriatric nutritional risk index predicts prognosis and postoperative complications in elderly patients undergoing non-cardiac surgery: a retrospective cohort study. BMC Geriatr. 2025; 25(1): 101.
12. Wattanaboot N, Kuawatcharawong W, Permsakmesub P. Perioperative risk factors for postoperative delirium in non-dementia older patients after non-cardiac surgery and anesthesia: a prospective study. Ann Geriatr Med Res. 2025; 29(1): 45–52.
13. Shih C-A, Yang D-C, Wang W-M, Wu Y-L, Yang Y-C, Ku H-C. Incidence and risk factors of postoperative delirium in elderly patients following hip fracture surgery: a nationwide retrospective cohort study in Taiwan. Int J Geriatr Psychiatry. 2025; 40(5): e70094.
14. Masionis P, Bobina R, Utkus S, Martinaitytė R, Uvarovas V, Šatkauskas I. Accuracy of the ACS-NSQIP risk calculator, Nottingham hip fracture score and CRP/albumin ratio in predicting adverse postoperative outcomes in the hip fracture surgery: a Lithuanian single-centre prospective study. Geriatr Orthop Surg Rehabil. 2025; 16: 21514593251352336.
15. Igarashi T, Kamo T, Miyata K, Tamura S, Kobayashi S, Kaizu Y, et al. Impact of frailty risk on postoperative activities of daily living and in-hospital events in older patients with hydrocephalus using a nationwide Japanese database. Geriatr Gerontol Int. 2025; 25(7): 960–6.
16. Guo Y, Guan Y, Chen Y, Zhang S. Risk stratification management of postoperative thyroid bleeding based on evidence-based nursing and optimization of the emergency nursing process. Asian J Surg. 2025.
17. Lupei MI, Chipman JG, Beilman GJ, Cristina Oancea S, Konia MR. The association between ASA status and other risk stratification models on postoperative intensive care unit outcomes. Surv Anesthesiol. 2014; 58(6): 276–7.
18. Lupei MI, Chipman JG, Beilman GJ, Oancea SC, Konia MR. The association between ASA status and other risk stratification models on postoperative intensive care unit outcomes. Anesth Analg. 2014; 118(5): 989–94.
19. Stefani LC, Gutierrez CDS, Castro SM de J, Zimmer RL, Diehl FP, Meyer LE, et al. Derivation and validation of a preoperative risk model for postoperative mortality (SAMPE model): An approach to care stratification. PLoS One. 2017; 12(10): e0187122.
20. Tridente A, Bion J, Mills GH, Gordon AC, Clarke GM, Walden A, et al. Derivation and validation of a prognostic model for postoperative risk stratification of critically ill patients with faecal peritonitis. Ann Intensive Care. 2017; 7(1): 96.