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Original Article

Factors Associated with Prolonged ICU Stay in the Postoperative Period of Cardiac Surgery in a Reference Hospital in Angola

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Abstract: Cardiac surgery is a complex procedure, and the number of patients with high surgical risk has increased due to the rise in elderly patients with a greater number of comorbidities. Several risk factors influence the length of stay in the intensive care unit (ICU). This study aimed to evaluate risk factors associated with prolonged ICU stay in patients undergoing cardiac surgery with cardiopulmonary bypass (CPB). A retrospective study was conducted from January to December 2024 with adult patients undergoing surgery with CPB. Data related to pre-, intra-, and postoperative variables were collected. Prolonged ICU stay exceeding four days was considered. Among the 47 patients included, the median age was 47 years; 26 (55.3%) were male. Valvular surgery was the most frequent procedure (66%). Nine (19.2%) presented with prolonged ICU stay. The median age was higher in the TIP group (33.06 years vs. 21.86; p=0.027). There was a positive correlation between TIP and mechanical ventilation (r=0.30; p=0.04), intubation time (r=0.30; p=0.04), neutrophil/lymphocyte ratio (r=0.30; p=0.01), and a negative correlation with the absolute lymphocyte count (r=-0.39; p=0.005). Pre- and postoperative variables, including age, mechanical ventilation, intubation time, INL, and lymphocyte count, were associated with TIP in the ICU.

Keywords: Cardiac Surgery; Intensive Care Unit; Cardiopulmonary Bypass; Angola.

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1. Introduction

Major cardiac surgery is a highly complex procedure that emerged in the mid-20th century as a treatment option for selected severe cases of heart disease in adults [1]. Despite advances in medical therapy and percutaneous interventions, the need for cardiac surgery is increasing globally, especially in emerging economies and developing countries [2]. The number of high-risk patients undergoing cardiac surgery has risen due to population aging and the growing burden of comorbidities [3].

It is estimated that around 75% of the world's population does not have access to cardiac surgery when needed, due to limited infrastructure, shortages of human resources, and lack of financial coverage [2]. More than 17 million people die every year from surgically preventable diseases, and only 6% of the 313 million surgical procedures performed annually occur in the poorest third of the global population, where the need for surgical care is greatest [4, 5].

Although cardiac surgery with cardiopulmonary bypass (CPB) has been an established technique for decades, it remains widely used in open-heart procedures, enabling

the maintenance of tissue perfusion and systemic oxygenation while the heart is temporarily arrested [6]. However, the use of CPB is associated with activation of a systemic inflammatory response and endothelial dysfunction, which may impair organ function. These adverse effects are considered an "inevitable cost" considering the benefits provided during the procedure [7]. Additionally, factors such as advanced age, presence of comorbidities, duration of mechanical ventilation, and continuous use of vasoconstrictors, sedatives, and analgesics can negatively influence clinical outcomes, contributing to increased postoperative morbidity and mortality [8, 9].

Identifying factors that influence the length of stay in the Intensive Care Unit (ICU) provides valuable information that can help anticipate specific needs, facilitate strategic planning aimed at improving care quality and patient safety, reduce failure to rescue in patients with reversible complications, and enhance interaction between the ICU and the operating room. This allows for better prediction of ICU occupancy time, bed availability, and improved resource planning. This study aims to identify factors associated with prolonged ICU stay among patients undergoing cardiac surgery in a referral center in Angola.

2. Methods

2.1 Study Design and Setting

A retrospective, chart-based study was conducted with patients who underwent cardiac surgery between January and December 2024 at the Complexo Hospitalar de Doenças Cardio-Pulmonares Cardeal Dom Alexandre do Nascimento, in Luanda, Angola. A total of 60 adult patients (aged 18 years or older) who underwent cardiac surgery via sternal approach with cardiopulmonary bypass (CPB) and were admitted to the ICU were consecutively included. Four patients were excluded due to leukocytosis (defined as ≥15,000 leukocytes per microliter of blood) and nine due to insufficient data. The final sample analyzed consisted of 47 patients.

2.2 Variables and Definitions

Demographic, clinical, laboratory, and perioperative variables were collected, including age, sex, body mass index (BMI), comorbidities, leukocyte count, neutrophil count, lymphocyte count, platelet count, neutrophil-to-lymphocyte ratio (NLR), systemic inflammation index (SII), urea, creatinine, type of surgery, duration of surgery, CPB time, aortic cross-clamp time, mechanical ventilation (MV), and length of hospital and ICU stay. Regarding hematologic data, the last complete blood count obtained before surgery (within 48 hours before the procedure) was considered.

ICU length of stay was categorized as non-prolonged (≤ 4 days) and prolonged (> 4 days). NLR and SII were calculated using complete blood count data according to the formulas: absolute neutrophil count / absolute lymphocyte count, and (absolute neutrophil count × platelets) / absolute lymphocyte count, respectively. BMI was categorized as underweight (<18.5 kg/m²), normal weight (≥18.5 to <25 kg/m²), overweight (≥25 to <30 kg/m²), and obesity (≥30 kg/m²), using the formula weight/height².

2.3 Statistical Analysis

Data were analyzed using the Statistical Package for Social Sciences, version 24 (IBM Corporation). Data distribution was assessed using the Kolmogorov-Smirnov test. Continuous variables were expressed as mean and standard deviation or as median and interquartile range, and categorical variables as frequencies and percentages. Group comparisons were performed using the chi-square test or the Mann-Whitney U test. Associations were assessed using Spearman's correlation coefficient. A two-tailed p-value < 0.05 was considered statistically significant.

3. Results

3.1 Patient Demographics

This study included a total of 47 adult patients who underwent cardiac surgery with CPB; 21 (44.7%) were female. The median age was significantly higher in the prolonged ICU stay (P-ICU) group (33.06 years) compared with the non-prolonged ICU stay group (21.86 years; p = 0.027). The number of comorbidities was associated with prolonged ICU stay (p = 0.03), as were the absolute lymphocyte count (p = 0.007) and NLR (p = 0.009). Of the 47 patients, 38 (80.8%) had a non-prolonged ICU stay, while 9 (19.2%) presented prolonged ICU stay. The clinical and laboratory data of the participants are presented in Table 1.

Table 1. Socio-demographic, clinical, and laboratory characteristics of patients according to ICU length of stay.

Variables	UCI Stay		Total (n=47)	p-value
	≤ 4 days (n=38)	> 4 days (n=9)		
Age, median (IQR)	21.86	33.06	47 (25 - 66)	0.027
Sex, n (%)				0.98
Male	21	5	26 (55.3%)	
Female	17	4	21 (44.7%)	
BMI, n (%)				0.84
Underweight	7	2	9 (19.1%)	
Normal weight	21	5	26 (55.3%)	
Overweight	7	2	9 (19.1%)	
Obesity	3	0	3 (6.4%)	
Number of Comorbidities, n (%)				0.03
None	21	1	22 (46.8%)	
One	6	5	11 (23.4%)	
Two	9	3	12 (25.5%)	
Three or more	2	-	2 (4.3%)	
Chronic Pulmonary Disease (CPD), n (%)				0.25
Yes	5	0	5 (10.6%)	
No	33	9	42 (89.4)	
Complete Blood Count Parameters				
Hemoglobin, g/dL, median (IQR)	24.47	22	12.1 (11 - 12.90)	0.62
Leukocytes ×10⁹/L, median (IQR)	23.92	24.33	6.1 (4.83 - 8.05)	0.93
Neutrophils ×10⁹/L	22.97	28.33	2.97 (2.49 - 3.91)	0.29
Lymphocytes x10⁹, median (IQR)	26.63	12.89	2.07 (1.60 - 2.58)	0.007
Platelets x10⁹, median (IQR)	25.82	16.33	204 (177 - 279)	0.06
NLR, median (IQR)	21.47	34.67	1.48 (0.98 - 2.06)	0.009
SII, median (IQR)	22.18	31.67	309 (233 - 555)	0.06

Legend. CPD. Chronic pulmonary disease. IQR. Interquartile range. BMI. Body mass index. NLR. Neutrophil-to-lymphocyte ratio. SII. Systemic inflammation index. ICU. Intensive care unit.

Regarding intraoperative variables, among the 31 patients who underwent valvular surgery, seven (22.5%) presented prolonged ICU stay, while 24 (77.5%) had a non-prolonged stay. The duration of cardiac surgery (p = 0.81), CPB time (p = 0.83), and

aortic cross-clamp time (p = 0.17) were similar between the groups; therefore, no differences were observed regarding surgical time, CPB duration, or aortic cross-clamp time. With respect to postoperative variables, the duration of mechanical ventilation (p = 0.04) and the duration of intubation (p = 0.04) were associated with ICU length of stay. Intraoperative and postoperative variables are presented in Tables 2 and 3, respectively.

Table 2. Intraoperative factors associated with ICU length of stay.

Variables	ICU Stay		Total (n=47)	p-value
	≤ 4 days (n=38)	> 4 days (n=9)		
Type of surgery, n (%)				0.40
CABG	14	2	16 (34%)	
Valvular	24	7	31 (66%)	
Surgery duration, median (IQR)	22.30	31.17	300 (270 - 367)	0.81
CPB time, median (IQR)	22.32	31.11	110 (83 - 151)	0.83
Aortic cross-clamp time, median (IQR)	22.16	29	94 (71.25 - 133)	0.17

Legend. CABG - Coronary Artery Bypass Grafting. IQR - Interquartile Range. CPB - Cardiac Exhaustion Therapy. ICU - Intensive Care Unit.

Table 3. Postoperative factors associated with ICU length of stay.

Variables	ICU Stay		Total (n=47)	p-value
	≤ 4 days (n=38)	> 4 days (n=9)		
Fármacos vasoativos, n (%)				0.22
≤ 24 horas	32	6	38 (80.9%)	
>24 horas	6	3	9 (19.1%)	
Ventilação mecânica, n (%)				0.04
≤ 24 horas	35	6	41 (87.2%)	
>24 horas	3	3	6 (12.8%)	
Intubação, n (%)				0.04
≤ 24 horas	35	6	41 (87.2%)	
>24 horas	3	3	6 (12.8%)	
Tempo de internamento Hospitalar, mediana (IIQ)	21.58	28.67	28 (18 - 39.50)	0.14

Legend. ICU. Intensive care unit.

Spearman's correlation analysis revealed an association between ICU length of stay and age (r = 0.38; p = 0.02), lymphocyte count (r = –0.39; p < 0.05), mechanical ventilation (r = 0.30; p = 0.04), duration of intubation (r = 0.30; p = 0.04), and NLR (r = 0.30; p = 0.01). The correlation analysis results are presented in Table 4.

Table 4. Spearman correlation analysis of factors associated with ICU length of stay.

Variáveis	Tempo de internamento na UCI	
	r	p
Idade	0.38	0.02
Número de comorbidades	0.23	0.11
Índice Neutrófilo-linfócito	0.30	0.01
Índice de Inflamação Sistémica	0.27	0.06

Linfócitos	-0.39	0.005
Ventilação Mecânica	0.30	0.04
Tempo de Intubação	0.30	0.04
Tempo de CEC	0.25	0.08
Tipo de cirurgia	-0.002	0.98
Tempo de pinçamento da aorta	0.25	0.81

Legend. CPB. Cardiopulmonary bypass. ICU. Intensive care unit.

4. Discussion

The main findings of this study showed that 1) older age, lower absolute lymphocyte count, prolonged mechanical ventilation, higher NLR, and longer intubation time were associated with LOS in the ICU. 2) No association was found between LOS and the number of comorbidities, SII, CPB time, surgery time, or aortic cross-clamp time. The association between advanced age and LOS is documented in the literature and can be justified by the higher risk of frailty, higher prevalence of comorbidities, as well as reduced physiological reserve, which compromises the ability to withstand the stress associated with the entire perioperative process and consequently increases the risk of adverse outcomes [10, 11]. The study by Azarfarin et al. showed that patients of older age had a higher risk of prolonged ICU stay [12]. Other studies with the same design found similar results, although the definition of prolonged ICU stay varied from 4 to 7 days [13–15]. In the study by Almashrafi et al., age did not influence ICU LOS [16].

Our results did not demonstrate an association between the number of comorbidities and ICU LOS. Previous studies have shown associations between diseases such as diabetes, obesity, and COPD and severe postoperative complications [17, 18]. In a prospective study that included 27,239 patients undergoing cardiac surgery, nearly two-thirds were hypertensive, 30.1% were diabetic, and 24.6% had severe obesity [11]. Mahesh et al. found that in patients undergoing cardiac surgery, comorbidities such as chronic obstructive pulmonary disease, obesity, and diabetes mellitus were predictors of prolonged ICU stay [19]. Comorbidities such as diabetes mellitus and obesity are associated with sternal dehiscence, respiratory failure, postoperative acute kidney injury, atrial arrhythmias, surgical site infection, and the need for transfusion. These complications require specialized care, which consequently increases hospital and ICU length of stay [20, 21].

In recent years, hematological indices derived from simple complete blood count parameters, such as the NLR, platelet-to-lymphocyte ratio (PLR), and SII, have emerged as accessible and promising tools for assessing systemic inflammation, demonstrating greater stability compared with isolated hematological parameters that may be influenced by physiological or pathological conditions such as dehydration, hemodilution, surgical stress, the use of drugs such as corticosteroids and myelosuppressive agents, and subclinical infections, which may temporarily alter leukocyte, neutrophil, lymphocyte, and platelet counts. The indices, by combining different pathways of the immune and inflammatory response, provide a more comprehensive and sensitive assessment of the systemic inflammatory state [22].

Our results showed an association between ICU LOS and NLR, but the same was not observed with SII. The study by Güntürk et al. demonstrated that in patients undergoing cardiac surgery, although SII predicted mortality in these patients, it was not associated with ICU length of stay [23]. However, the study by Parmana et al., which included patients undergoing off-pump coronary artery bypass grafting, showed that higher SII values were predictors of prolonged mechanical ventilation and prolonged ICU stay (greater than 48 hours) [24]. Differences between the results may be associated with methodological heterogeneity among studies.

A systematic review and meta-analysis that included more than 13,000 patients showed that elevated preoperative NLR levels were associated with higher short- and long-term mortality, whereas elevated postoperative NLR levels were associated only with long-term mortality and other adverse events [25]. The analysis of 1,694 patients undergoing cardiac surgery showed that elevated NLR levels are associated with prolonged ICU stay and prolonged mechanical ventilation [26]. In our study, lower lymphocyte values were associated with prolonged ICU stay. One study evaluated the prognostic value of the preoperative total lymphocyte count (TLC) on the survival of patients undergoing cardiac surgery with CPB and showed that patients with lower TLC levels had longer ICU stays and higher mortality [27], indicating that higher lymphocyte values may serve as protective factors against adverse events in these patients.

During cardiac surgery with CPB, factors such as blood contact with the inert surface of the CPB circuit and ischemia–reperfusion injury of organs trigger multiple inflammatory mechanisms [7]. Prolonged CPB duration has been a predictor of postoperative mortality, pulmonary, renal, and neurological complications, multiple organ failure, and reoperation due to bleeding [28]. These complications result in greater need for patient support and, consequently, prolonged hospitalization (both overall and in the ICU). One study compared the frequency of complications in the immediate postoperative period of cardiac surgeries according to CPB duration and showed that most complications were not associated with CPB time [29]. In our study, no association was observed between CPB duration and ICU length of stay.

In low- and middle-income countries, cardiac surgery programs are still in a consolidation phase and face significant constraints related to infrastructure, human resources, and care capacity. It is estimated that about 93% of individuals with an indication for cardiac surgery do not have access to treatment in these settings. While high-income countries have approximately 7.15 adult cardiac surgeons per million inhabitants, low-income countries have only 0.04 per million [4,5]. This disparity also extends to intensivists and specialized nursing professionals, compromising not only the volume of procedures performed but also the quality of postoperative care and subsequent clinical outcomes [30].

Our results showed an association between mechanical ventilation time and prolonged ICU stay. Since the publication in 2001 of the task force guidelines on the discontinuation of mechanical ventilation, weaning protocols have become increasingly popular [31]. Studies have shown that weaning protocols reduce total mechanical ventilation duration, weaning duration, and ICU length of stay [32,33]. A meta-analysis demonstrated that ventilator weaning protocols led by nurses significantly reduce ICU length of stay and mechanical ventilation duration. This study also showed that these nurse-led protocols are effective and safe for implementation in the ICU [34].

It is important to consider that the study had limitations such as 1) The reduced number of participants limits the statistical power and the precision of estimates, which may affect the stability of coefficients and p-values; 2) This was a single-center study. Therefore, perioperative and surgical management factors such as hospital conditions, service characteristics, and the experience of surgical teams may influence the results; 3) It was a retrospective study, dependent on records documented in clinical charts. On the other hand, the main strength of this study is that, to the best of our knowledge, it is the first study in Angola to evaluate factors associated with prolonged ICU stay and to describe the usefulness of indices easily calculated from the complete blood count in this specific population.

4. Conclusion

In the present study, factors such as age, absolute lymphocyte count, need for mechanical ventilation, NLR, and intubation time were associated with the occurrence of prolonged ICU stay. These findings suggest potential targets for optimization of perioperative management, and the implementation of inflammatory marker screening and

ventilator weaning protocols could reduce ICU length of stay. In the Angolan context, characterized by limited resources and scarcity of intensive care beds, low-cost and high-impact interventions, such as standardized checklists, multiprofessional team education, and simple monitoring of hematological parameters, represent feasible and sustainable approaches.

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Supplementary Materials: None.

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