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ORIGINAL ARTICLE

RISK FACTORS FOR PROLONGED INTENSIVE CARE UNIT STAYS IN ELDERLY PATIENTS AFTER CARDIAC SURGERY: A RETROSPECTIVE OBSERVATIONAL STUDY

Abstract

Introduction: With the increase in life expectancy and developments in surgical and anesthetic techniques, intensive care follow-up, and treatment methods, the number of patients undergoing open-heart surgery has increased.

Methods: The clinical files of 220 patients who underwent cardiovascular surgery were retrospectively reviewed. The patients were divided into two groups: group 1 (those who stayed for one day or less) and group 2 (those who stayed for more than one day). In addition, the reason for hospitalization for five days or more was investigated. The effect of patient variables on the length of stay in the intensive care unit was investigated by logistic regression analysis.

Results: Hemoglobin values, ejection fraction values, and intensive care unit hospitalizations were significantly lower ($p<0.05$) than those in the group with intensive care unit hospitalizations of <24 h. The sodium value was significantly higher ($p<0.05$) in the group with intensive care unit hospitalizations >24 h than in the group with intensive care unit hospitalizations <24 h. The pacemaker requirement rate in the group with intensive care unit hospitalizations >24 h was significantly ($p<0.05$) higher than the group with intensive care unit hospitalizations < 24 h. The sinus rhythm in the group with intensive care unit hospitalizations >24 h was significantly lower ($p<0.05$) than that in the group with intensive care unit hospitalizations <24 h. Intensive care transfusion of erythrocyte suspension, fresh frozen plasma, and platelet suspension were significantly higher ($p<0.05$) in the group with intensive care unit hospitalizations >24 h than in the group with intensive care unit hospitalizations <24 h.

Conclusion: In our study; We found that factors such as preoperative low ejection fraction (EF), hypernatremia, female gender, inotrope requirement, delirium, extubation time, intraoperative-postoperative transfusion, drainage revision affect the length of stay in the intensive care unit In the intraoperative period, methods to protect myocardial and kidney functions and provide hemostasis bleeding control reduce the duration of intensive care hospitalization

Keywords: Thoracic Surgery; Length of Stay; Critical Care; Aging.

INTRODUCTION

The prevalence of cardiovascular diseases has increased worldwide in recent years. Cardiovascular diseases (CVD), including coronary artery disease and stroke, are the most common mortal noncontagious diseases globally, accounting for an estimated 18.6 million deaths in 2019 (1). The burden of cardiovascular disease in an increasingly aging population has resulted in a shift in the demographics of cardiac surgery patients to include those who are older, increasingly frail, and have multiple comorbidities (2, 3). As a result, the number of patients undergoing cardiac surgery has been on the rise. Advanced age, female gender, decreased left ventricular function, arrhythmia, inotropic agent use, and the need for an intra-aortic balloon pump (IABP) have been identified as risk factors for prolonged intensive care unit (ICU) stays, and these variables have been found to prolong the length of stay in the ICU (4,5). However, the complex nature of these patients means that they face a longer and more complex postoperative process, which often requires a longer period of time. Long stays in the intensive care unit have been reported in 4–11% of cardiac patients, with some sources claiming as many as 36% (6,7). Therefore, it is critical to identify risk factors and closely monitor patients with these characteristics to shorten and minimize the length of stay in intensive care units (8). With this increase, the cost calculations for patients undergoing cardiac surgery have begun. Caring for critically ill patients requires significant expenditure of time, money, and resources, including specialist staff, one-on-one nursing care, and advanced equipment and treatments (9).

This study aimed to investigate the risk factors associated with prolonged ICU stay in patients who underwent cardiac surgery. Many factors affect the length of hospital stay of patients who have undergone open-heart surgery.

METHOD

Adult patients undergoing cardiac surgery between January 2012 and August 2021 were reviewed retrospectively after obtaining approval from the Clinical Research Ethics Committee (Date: April 27, 2021; Ethics Committee Number:2021/25).

Data were obtained by examining the anesthesia and surgery information obtained from the files of patients who were followed up in the Cardiovascular Surgery Intensive Care Unit (CVS ICU), intensive care follow-up forms, and hospital epicrisis reports. Demographic characteristics, American Society of Anesthesiologists (ASA) scores, and comorbidities (hypertension [HT], hyperlipidemia [HL], diabetes mellitus [DM], chronic obstructive pulmonary disease [COPD], peripheral arterial disease [PAD], renal dysfunction, and left ventricular ejection fraction [LVEF]) were examined during preoperative evaluation. The intraoperative anesthesia method, cardiopulmonary bypass, aortic cross-clamp, operation times, and type of operation (emergency or elective) were evaluated. In the postoperative period, the amount of drainage, need for inotropic support, use of an intra-aortic balloon pump (IABP), re-exploration for bleeding, amount of blood product used, time to intubation, prolonged mechanical ventilation (>24 h), respiratory system complications (pneumonia), neurological events (stroke, transient ischemic attack), renal failure requiring dialysis, atrial fibrillation (AF), permanent pacemaker requirement, presence of delirium are evaluated. The Richmond Agitation-Sedation Scale (RASS) was used to evaluate agitation and sedation routinely in our hospital. The RASS scores range from -5 (unrousable) to +4 (very agitated), with 0 representing a state of calmness. This assessment aids in understanding patient disposition and its impact on ICU stay duration. Moreover, lactate levels were recorded before the operation, when the patient first came to the ICU after the operation, and at the 24th hour.

Laboratory parameters were recorded before and after surgery. The laboratory parameters evaluated were HbA1C, hemoglobin (Hb), hematocrit, sodium, calcium, potassium, glomerular filtration rate (GFR), blood urea nitrogen (BUN), and creatinine levels. The lowest and highest GFR values were also recorded in the ICU. Using these parameters, we determined whether there was a difference between young (65–74 years) and very elderly (>75 years) patients. Using the G*Power (v3.1.9) program for sample size determination and power analysis, we employed the data provided by Demir et al. (10) concerning various age groups. The calculation was grounded in the length of intensive care stay percentage effects, resulting in a determined effect size of w=0.326. Consequently, we achieved 80% power at an α=0.05 significance level. The analysis indicated a necessity for a minimum of 182 cases, In accordance with this, our study encompassed a total of 220 cases.

Intensive Care Management

A mechanical ventilator with a tidal volume of 8–10 mL/kg was set to 40% FiO_2 in the volume- or pressure-controlled ventilation mode. Routine blood gas analyses were performed, and FiO_2 and respiratory frequency settings were adjusted to ensure that PaO_2 was greater than 80 mmHg and $PaCO_2$ was 35–45 mmHg. The patients were warmed up so that their stable temperature reached 37 °C. Normothermic patients with controlled pain and no excessive bleeding (>80 ml/h) were extubated.

Statistical Method

For the descriptive statistics of the data, the mean, standard deviation, median, lowest/highest frequency, and ratio values were used. The distribution of variables was measured using the Kolmogorov-Smirnov test. The Mann-Whitney U test was used to analyze independent quantitative data. The Chi-square test was used to analyze independent qualitative data, and the Fisher's test was used when the Chi-square test conditions were not met. The effect level was investigated using single and multivariate logistic regressions. We used the SPSS 28.0 program for the analysis.

RESULTS

Female patients admitted to the intensive care unit for more than 24 hours had a significantly higher rate ($p<0.05$) than female patients admitted for less than 24 hours. Hemoglobin (Hb) values, ejection fraction (EF) values, and ICU hospitalizations were significantly lower ($p<0.05$) in the group with > 24 hours of ICU hospitalization than in the group with < 24 hours of ICU hospitalization. (Table 2)

Postoperatively, the lowest GFR, highest BUN, Creatinine, aortic clamp time, and HbA1c values were observed in groups with ICU hospitalization for less than or more than 24 hours. The sodium level was significantly higher ($p<0.05$) in the group with >24 hours of ICU hospitalization than in the group with <24 hours of ICU hospitalization. (Table 3)

Pacemaker requirements were significantly higher ($p<0.05$) in the group with ICU hospitalization >24 hours than in the group with ICU hospitalization <24 hours. The sinus rhythm (SR) rate in the group with >24 hours of ICU hospitalization was significantly lower ($p<0.05$) than that in the group with <24 hours of ICU hospitalization. (Table 3)

When intensive care inotropic support was compared, the adrenaline dopamine (DA) and noradrenaline (NA) ratios were significantly higher ($p<0.05$) in the group with ICU stay >24 hours than in the group with ICU stay <24 hours. (Table 3)

When comparing the use of blood products in the ICU, the use of erythrocyte suspension (ES), fresh frozen plasma (FFP), and platelet suspension was significantly higher ($p<0.05$) in the group with >24 h of ICU hospitalization than in the group with <24 h of ICU hospitalization. Intraoperative ES transfusion was significantly ($p<0.05$) higher in the

Table 1. Demographic values

		Min	-	Max	Median	Mean	±	SS /n-%
Age		65.0	-	84.0	70.5	71.3	±	4.7
Age	< 75(65-74)					164		74.5%
	> 75(75-84)					56		25.5%
Gender	Female					87		39.5%
	Male					133		60.5%
ASA (American Society of Anesthesiologists)	II					23		10.5%
	III					141		64.1%
	IV					56		25.5%
HT (Hypertension)						176		80.0%
DM (Diabetes mellitus)						127		57.7%
Goiter						27		12.3%
COPD (Chronic obstructive pulmonary disease)						52		23.6%
Elective						215		97.7%
Urgent						5		2.3%

group with >24 h of ICU hospitalization than in the group with <24 h of ICU hospitalization. (Table 4)

The postoperative first-day drainage was significantly higher ($p<0.05$) in the >24 h ICU hospitalization group than in the <24 h ICU hospitalization group. (Table 4)

The revision rate and postoperative agitation rate were significantly higher ($p<0.05$) in the group with a duration of >24 hours in the intensive care unit than in the group with a duration of <24 hours. The extubation time and time of stay in the ICU were significantly higher ($p < 0.05$) in the group with >24 h in the intensive care unit than the group with <24 h (Table 4).

Patients with respiratory failure, SVO, kidney failure, sepsis, IABP, arrhythmia, and an ejection fraction <35% stayed in the ICU for ≥ 5 days (Table 5).

Regression Analysis Results

Multivariate logistic regression analysis was performed to determine the factors affecting long hospitalization (>1 d). The model obtained from the analysis performed using the backward elimination method was statistically significant [2 = 147.887, P <0.001]. In the model, the variables of extubation time, drainage on the first day, and erythrocyte suspension during intensive care follow-up were significant ($p<0.001$) (Table 6).

Table 2. Preoperative blood and background information of patients hospitalized in cardiovascular surgery intensive care for more than 24 hours and less

		ICU Stay ≤ 24 h				ICU Stay > 24 h				P	
		Mean	±	SD/n-%	Median	Mean	±	SD/n-%	Median		
Age		70.6	±	4.5	70.0	71.6	±	4.7	71.0	0.113	m
Age	< 75	54		80.6%		110		71.9%		0.173	x^2
	> 75	13		19.4%		43		28.1%			
Gender	Female	19		28.4%		68		44.4%		0.025	x^2
	Male	48		71.6%		85		55.6%			
ASA Score	II	7		10.4%		16		10.5%		1.000	x^2
	III	43		64.2%		98		64.1%			
	IV	17		25.4%		39		25.5%			
HT		53		79.1%		123		80.4%		0.826	x^2
DM		34		50.7%		93		60.8%		0.165	x^2
Goiter		8		11.9%		19		12.4%		0.921	x^2
COPD		11		16.4%		41		26.8%		0.095	x^2
Elective		67		100.0%		148		96.7%		0.181	x^2
Urgent		0		0.0%		5		3.3%		0.326	x^2
Preoperative Laboratory Values											
Hb		13.0	±	2.1	12.9	12.4	±	2.0	12.2	0.034	m
Hematocrit		38.4	±	5.8	38.3	37.3	±	5.6	37.4	0.174	m
GFR		77.6	±	22.2	77.5	69.5	±	20.7	70.6	0.052	m
BUN		19.0	±	5.5	18.0	22.7	±	13.8	19.0	0.100	m
Cr (Creatinine)		1.0	±	0.2	0.9	1.1	±	0.7	0.9	0.899	m
Na (Sodium)		136.1	±	4.1	135.0	135.2	±	4.5	136.0	0.489	m
K (Potassium)		4.4	±	0.4	4.4	4.3	±	0.6	4.4	0.933	m
Lactate Pre-anesthesia		1.1	±	0.4	0.9	1.0	±	0.4	0.9	0.107	m
Lactate ICU First ABG		1.6	±	0.6	1.5	1.5	±	0.6	1.4	0.250	m
Lactate ABG After 24 Hours		1.8	±	0.7	1.7	2.2	±	1.7	1.8	0.148	m
Preoperative EF (Ejection Fraction)		54.6	±	9.3	60.0	51.4	±	10.3	55.0	0.021	m

^{m} Mann-Whitney U test / $^{X^2}$ Chi-square test

ABG: Arterial Blood Gas; ICU: Intensive Care Unit; GFR: Glomerular Filtration Rate; BUN: Blood Urea Nitrogen; HT: Hypertension; DM: Diabetes Mellitus.

Table 3. Postoperative laboratory values of patients hospitalized more than 24 hours and less in cardiovascular surgery intensive care unit.

		ICU Stay ≤ 24 h				ICU Stay > 24 h				p	
		Mean	±	SD/ n-%	Median	Mean	±	SD/ n-%	Median		
ICU 24-Hour Laboratory Values											
Hb		9.5	±	1.2	9.3	9.1	±	1.0	9.2	0.198	m
Hematocrit		27.9	±	3.7	28.1	27.2	±	3.1	27.5	0.373	m
GFR (Glomerular filtration rate)		70.9	±	19.0	69.6	65.1	±	20.4	66.3	0.140	m
BUN (Blood Urea Nitrogen)		20.0	±	6.1	20.0	22.9	±	11.8	21.0	0.104	m
Cr		1.0	±	0.2	1.1	1.2	±	0.8	1.0	0.708	m
Na		141.3	±	3.3	142.0	144.1	±	9.3	143.0	0.001	m
K		4.4	±	0.7	4.3	4.4	±	0.6	4.4	0.250	m
Lowest postoperative period GFR		62.1	±	22.7	64.1	55.2	±	23.4	55.1	0.068	m
Highest postoperative period GFR		81.5	±	19.5	88.2	77.4	±	24.3	85.4	0.393	m
Aortic clamp Time		141.2	±	181.3	72.0	166.1	±	239.6	82.0	0.422	m
HbA1c (Hemoglobin A1C)		7.3	±	1.9	6.5	7.0	±	1.6	6.4	0.725	m
ICU Rhythm	Yok	1		1.5%		0		0.0%		0.305	x^2
	Var	66		98.5%		153		100.0%			
AF (Atrial fibrillation)		1		1.5%		7		4.6%		0.268	x^2
PACE		1		1.5%		22		14.4%		0.004	x^2
SR (sinus rhythm)		53		80.3%		90		58.8%		0.002	x^2
PR (PACE rhythm)		1		1.5%		8		5.2%		0.204	x^2
SB (Sinus Bradycardia)		6		9.1%		5		3.3%		0.070	x^2
ST (Sinus Tachycardia)		4		6.1%		19		12.4%		0.159	x^2
SVT (Supraventricular Tachycardia)		0		0.0%		1		0.7%		1.000	x^2
SNT (Sinus node tachycardia)		0		0.0%		1		0.7%		1.000	x^2

m Mann-Whitney U test / X^2 Chi-square test

CPB: Cardiopulmonary Bypass, EFLV: Ejection Fraction of the Left Ventricle

Table 4. Causes of patient hospitalization for more than 24-hours and less in intensive care

	ICU Stay ≤ 24 h				ICU Stay > 24 h					
	Mean	**±**	**SD/n-%**	**Median**	**Mean**	**±**	**SD/n-%**	**Median**		
Intensive Care Transfusion										
ES (Erythrocyte suspension)	0.55	±	0.78	0.00	2.37	±	2.70	2.00	0.000	m
FFP (Fresh Frozen Plasma)	0.58	±	1.07	0.00	1.48	±	2.12	1.00	0.001	m
Apheresis	0.03	±	0.25	0.00	0.23	±	0.82	0.00	0.018	m
Intraoperative Transfusion										
ES	0.57	±	1.05	0.00	0.81	±	0.99	0.00	0.034	m
FFP	0.29	±	0.70	0.00	0.52	±	1.01	0.00	0.121	m
Apheresis	0.03	±	0.17	0.00	0.05	±	0.25	0.00	0.582	m
Drainage Day 0	444.5	±	224.0	400.0	499.3	±	377.9	400.0	0.870	m
Drainage Day 1	102.2	±	111.6	100.0	309.6	±	231.7	250.0	0.000	m
Intensive Care Inotrope Support										
Adrenaline	6		9.0%		33		21.6%		0.024	x^2
NE (norepinephrine)	1		1.5%		38		24.8%		0.000	x^2
DA (Dopamine)	27		40.3%		95		62.1%		0.003	x^2
Dobutamine	0		0.0%		4		2.6%		0.316	x^2
Revision	2		3.0%		22		14.4%		0.013	x^2
Agitation	0		0.0%		13		8.5%		0.014	x^2
Extubation / Hour	9.2	±	3.0	8.0	21.9	±	21.2	17.0	0.000	m
Service Release Day	1.0	±	0.0	1.0	5.2	±	6.7	3.0	0.000	m

^{m} Mann-Whitney U test / X^2 Chi-square test

DISCUSSION

Advancements in surgical and anesthesia techniques, coupled with innovations in extracorporeal circulation mechanisms and comprehensive monitoring, have notably curtailed intensive care unit stays. This has rendered open-heart surgery a viable and accessible treatment across all age groups. However, the prevalence of cardiac diseases remains substantial, entailing considerable morbidity and mortality. The majority of these procedures involve cardiopulmonary bypass (CPB). Despite considerable strides in recent years, postoperative morbidity and mortality rates in cardiac surgery persist, spanning from 5% to 75% contingent upon the specific procedure, patient comorbidities, and frailty factors (11). In patients following cardiac surgery complications that develop lead to deterioration in the quality of life of patients and, in some cases, mortality. In this study, the factors that prolonged the length of stay in the intensive care unit of 220 patients who underwent open-heart surgery were investigated. 80% and 57.7% of the patients were diagnosed with hypertension and DM, respectively. In addition, although the length of stay on a mechanical ventilator and the length of hospital stay due to DM-related complications did not increase significantly, it was observed that they had an increased length of hospital stay (Table 1).

A recent study by Herman et al. (12) of 3489 patients who had undergone CABG surgery at a Canadian hospital concluded that a history of renal failure was among the independent predictors of prolonged hospitalization in the ICU setting. The study revealed that a higher creatinine level, which is a sign of renal failure, is an indicator of a longer ICU stay; however, age alone was not a negative factor in the evaluations made according to different age groups.

Cislaghi et al. (13) found that in a large study with 5123 patients who were followed up, the ventilation time was prolonged 2.2 times more in patients with an EF of 30%. In our study, we found that having an EF of <35% or poor LV function increased both the duration of ventilation and the length of stay in the intensive care unit (Table 2).

One of the factors that prolongs stay in the intensive care unit is the use of a cardiac pacemaker postoperatively. Pacemakers are effective treatments for symptomatic bradycardia and are widely used in modern cardiology (14). The length of stay in the intensive care unit was found to be longer in patients who required pacemakers (AF: 3.7%; PACE: 10.5%; SR: 65%, sinus bradycardia: 11%; sinus tachycardia: 23%; and supraventricular tachycardia: 1%). Patients with SR remained in the intensive care unit less frequently (Table 3).

Hein et al. (7) stated in their retrospective study involving 2683 patients that 26% of the patients stayed in the intensive care unit for more than 3 days. Advanced age, renal failure, respiratory failure, heart failure, and re-exploration were associated with prolonged intensive care. In our study, prolonged intensive care hospitalization was defined as ≥ 24 h. The routine stay in the intensive care unit of our hospital was 24 hours. A total of 220 patients were discharged to the inpatient ward: 67 on the first day and 177 on the fourth. The reason for the prolonged hospitalization may be that very complicated patients were admitted, and these patients were older. We found that 27.6% of the patients were hospitalized for more than three days (Table 4). We divided patients whose hospitalization period was prolonged into two groups: those who were hospitalized for more than one day and those who were hospitalized for five or more days. We found that the majority of patients hospitalized for five days or more were due to renal failure, arrhythmia, low ejection fraction, and respiratory failure (Table 5).

In contrast, Osinaike et al. (15) discovered that staying in the intensive care unit for more than four days increased the risk of pulmonary hypertension, mean CPB time, inotropic agent use, and surgical re-exploration; however, inotropic agent use remained the only independent variable in the multiple regression analysis. Garcia-Delgado et al. (16) stated that cardiac surgery causes widespread lung damage and respiratory distress by triggering an intense systemic inflammatory syndrome and increasing lung capillary permeability. Extubation and weaning times from the mechanical ventilator are prolonged in these patients, and exit from the intensive care unit and hospital is delayed. In our study, an increase of 1h in extubation time increased the probability of prolonged hospitalization by 1.361 times. An increase of 1 unit in the value of the erythrocyte suspension given in the intensive care follow-up increased the probability of prolonged hospitalization by 2.946 times, and a 1 unit increase in the drainage value on the first day increased the probability of prolonged hospitalization by 1.010 times.

Table 5. Those who stayed for five days or more

	Respiratory Failure	CVO	Kidney failure	Sepsis	IABP	Arrhythmia	EF: under %35 (20 out of 220 patients ≤ %35)
CABG: 5 patients	0	0	4	2	1	0	3
CABG+1 (Valve): 8 patients	3	1	5	1	0	2	1
CABG+ 2: 9 patients	4	1	3	2	0	2	
CABG+3 and more: 7 patients	3	0	2	1	1	1	4
Re-operated valve: 2 patients	2	0	1	1	1	1	1
1 valve: 1 patient	0	0	1	1	0	1	0
2 valves: 7 patients	6	1	5	3	0	2	3
3 valves: 4 patients	3	0	3	0	1	2	2

CABG: Coronary Artery Bypass Grafting; SVO: Cerebrovascular Disease; IABP: Intra-aortic Balloon Pump

Table 6. Results of the regression analysis

	OR (95 % GA)	Wald	P value
Constant	-	36.513	<0.001*
Extubation time	1.361 (1.202, 1.541)	23.564	<0.001*
ICU ES	2.946 (1.746, 4.969)	16.400	<0.001*
Drainage 1st day	1.010 (1.006, 1.014)	23.887	<0.001*

Gender remains a controversial variable in postoperative complications. Some studies have shown that women undergoing CABG are at a higher risk of morbidity and mortality than men (17). In our study, women stayed in intensive care longer than men, even after controlling for other disease factors.

Postoperative delirium, which is common in elderly patients, has been shown to be associated with poor outcomes, with delirium being 1.8 times more common in frail patients. Factors that accelerate the risk and development of delirium include advanced age and basic cognitive impairment (18). In our study, it was observed that the length of stay in the intensive care unit of patients with delirium increased.

In a study published by De Bruin et al. (19) in 2019, with the participation of 947 intensive care physicians, 53% of the participants stated that there was a transfusion protocol established by their hospitals and that the threshold Hb value for transfusion in the intensive care unit was 7 g/dL. A study conducted on Intensive Care transfusion rates found that ES, FFP, and apheresis platelet suspension were significantly higher ($p<0.05$) in the group hospitalized in the ICU for more than 24 h than in the group hospitalized for less than 24 h. Intraoperative transfusion of ES was significantly higher ($p<0.05$) in the groups with ICU hospitalizations of less than or more than 24 hours (Table 4).

Hypernatremia is a common problem, defined as a serum sodium concentration >145 mmol/L. Hypernatremia leads to an increase in serum osmolality and a loss of water from cells. An increase in serum sodium concentration manifests as a negative water balance. It may develop as an iatrogenic complication in elderly patients with a poor general condition or during hospitalization. It has the potential to be fatal (20). In our study, the Na value in the group with more than 24 h of ICU hospitalization was significantly higher ($p<0.05$) than that in the group with less than 24 h of ICU hospitalization.

Based on these findings, it was determined that open-heart surgery within the "65 years and older" patient cohort exhibited no impact on hospital stay length. This conclusion was drawn considering the thorough assessment of patient comorbidities, elective surgery circumstances, utilization of suitable anesthesia and surgical methodologies, and the potential for enhanced survival rates through meticulous intensive care monitoring.

This study has some limitations. This study used a theory-driven approach to identify risk factors and was evaluated in two stages at a research institute. Although the first stage examined the reasons for longer stays (>24 hours) in the ICU and the second used stratified random sampling to represent the prevalence rate of 5-day or longer stays in the ICU, the findings may be center-specific based on the data.

Conflict of Interest

The authors have no financial conflicts of interest and have nothing to disclose.

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