A Novel Understanding of Kidney Failure in Cardiac Surgery

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This research aims to assess the impact of acute kidney injury (AKI) on the outcomes of elective or emergency cardiac surgery patients. The group included 183 aortic disease patients whose serum creatinine (SCr) level was measured at admission, on the first day of intensive care, and upon hospital discharge. The results indicate that SCr levels and immediate mortality during hospitalisation are significantly correlated, but there is no significant correlation between SCr level and long-term mortality at least six months after discharge was detected. These findings are relevant for future research on managing patients with high SCr levels. The study also provides essential information for surgical cardiac patient management.

I. Introduction

Acute kidney injury (AKI), a common complication following cardiac surgery, affects between 30% and 45% of operated patients and is the second most common factor that leads to increased mortality in the intensive care unit (ICU) [1-4]. Acute kidney injury (AKI) is characterised by the kidneys' rapid failure to regulate water and electrolytes [5]. Compared to non-cardiac surgery, cardiac surgery is shown to make patients more susceptible to AKI [6]. Cardiac surgery is characterised by high prevalence rates and exogenous blood product transfusion volumes. The ischemia time is defined as the condition in which the extracorporeal circulation machine exclusively manages the body's oxygenation. In conjunction with the exposure of the blood to foreign surfaces of the extracorporeal equipment, activation of a coagulation cascade and immune system has been observed. This increases the number of immunological complexes and metabolism products which affect kidney function and in consequence increase serum creatinine (SCr) level [7]. Thus, the inappropriate activation of inflammatory markers in patients who undergo cardiac surgery with extracorporeal circulation continues to be a frequent cause of postoperative issues such as AKI [8-11]. The renal insufficiency as a multifactorial aetiology is classified by a glomerular filtration rate (eGFR) of <30-44 (mL/min/1.73m^2). eGFR, based on SCr level, age, gender, and other parameters, calculates the rate at which the kidneys filter waste products from the blood. Previous studies have demonstrated that eGFR is closely related to mortality. For each 10 mL/min decline in eGFR, mortality risk is increased by 14% [2,12-14]. The mortality rate in invasive cardiac surgery ranges from 2 to 7%, depending on factors such as race [15,16]. However, the general mortality risk increases drastically to over 60% when the patient develops postoperative AKI [17-20]. Thus, it is imperative to understand how to lower the mortality risk of AKI.

The SCr level is not a specific kidney marker; it is monitored with other parameters. However, since it positively correlates with in-hospital mortality, it may be used as an indicator of postoperative mortality [16]. Because additional factors and more comprehensive analyses might be useful in evaluating patient outcomes, it is uncertain if isolated SCr levels can be used to predict mortality in patients undergoing cardiac surgery.

In this study, retrospective analysis was conducted on the medical records of 183 patients who had received medical and surgical care for aortic disease in a tertiary centre with the primary objective of establishing whether a high SCr level influences mortality following the treatment of aortic disease. The aims of this study are to discover possible predictive factors that are observable after surgical treatment of aortic disease, considering the disease's high mortality rate [17-20]. Antoher objective is to determine whether better surgical patient outcomes were associated with the study group's preoperative assessment of SCr level rather than the estimated glomerular filtration rate (eGFR). This is used in a tertiary centre in Eastern Europe. Lastly, this study aims to decipher if this indicator of SCr levels may serve as a launch pad for in-depth studies to reduce postoperative mortality in patients undergoing cardiac surgery. If so, this would indicate the appropriate direction for devoting further research efforts.

II. Methods

A total of 185 patients who presented for elective or emergency aortic disease treatment at the Targu Mures Emergency Institute for Cardiovascular Diseases and Transplant between 2019 and 2022 were the subjects of this retrospective study. The main inclusion criteria in the analysed groups were the presence of an ascending aortic disease requiring elective (aortic aneurysms) or urgent (acute aortic syndrome) surgery and SCr value above the reference value of 1.25 mg/dL. Patients whose consent could not be obtained or who refused surgery were excluded from the study (n = 2), as were patients with New York Heart Association (NYHA) class III (severe heart failure) established cardiac failure with functional status, patients with established renal failure necessitating replacement therapy, and patients under 18 years old. All patient data were analysed per the ethical code and current legal requirements. All the procedures were performed per the local standard protocols during surgery and ICU.

The Abbott Creatinine 2 R1 8 × 53.9 mL/R2 8 × 21.4 mL kit for SCr dosing was used with reference values ranging from 0.74 to 1.25 mg/dL for Processing Module Architect c 4000, manufactured by Abbott Diagnostics (USA). The SCr level was assessed in every patient at three different time points: at admission, on their first day in the ICU, and at discharge.

The relationship between SCr level and in-hospital mortality was examined and the relationship between ischemia time and outcome. In-hospital mortality is mortality during hospitalisation, while long-term mortality describes patients who died after more than six months following discharge. The IBM SPSS 23.0 Statistics program was used to perform statistical analysis on the obtained data. The mean ± standard deviation (minimum-maximum) of the collected data was collected, and the Skewness Test was conducted to measure the symmetry of the distribution, as well as the Kurtosis Test to

determine the heaviness of the distribution tails. The Spearman RHO non-parametric test was applied to measure the strength and direction of the linear association relationship between the ranked variables. A total of 183 subjects were analysed to achieve a confidence level of 95% and to ensure that the actual value was within 5% of the value using the Minitab software, highlighted in our analysis by a p=0.005.

III. Results

This research examines how SCr level affects the survival of patients who developed AKI after cardiac surgery. The flattening and skewness tests (Kurtosis and Skewness) found that the data was not parametric. As a result, Spearman's rank correlation coefficient was applied. High SCr level on admission was positively correlated with immediate mortality (r=0.29, p<0.001), while it had no correlation with long-term mortality (r=0.06, p=0.409) (Table 1).

Table 1: Relationship between high serum creatinine (SCr) level on admission with immediate and long-term mortality

			In-hospital mortality	*Long-term mortality*
Spearman's rho	*High level serum creatinine (SCr) on admission*	Correlation Coefficient	0.29**	0.06**
		Sig. (2-tailed)	0.000	0.409

**. Correlation is significant at the 0.01 level (2-tailed).

There were statistically significant negative correlations between aortic disease and high SCr level on the first ICU day (r=-0.15, p=0.041) and also between aortic disease and in-hospital mortality (r=-0.38, p<0.001). Furthermore, a statistically significant positive correlation was found between high SCr levels on the first ICU day and in-hospital mortality (r=0.36, p<0.001). However, there was no statistically significant correlation between high SCr levels on the first ICU day and long-term mortality (r=0.11, p=0.119) (Table 2).

Table 2: Relationship between pathology, high serum creatinine (SCr) level on the first ICU day, immediate mortality, and long-term mortality

			Aortic Disease	*High serum creatinine (SCr) level on 1st ICU day*
Spearman's rho	*High serum creatinine (SCr) level on 1st ICU day*	Correlation Coefficient	-0.15*	
		Sig. (2-tailed)	0.041	
	In-hospital mortality	Correlation Coefficient	-0.38**	0.36**
		Sig. (2-tailed)	0.000	0.000
	Long-term morality	Correlation Coefficient	-0.12	0.116
		Sig. (2-tailed)	0.106	0.119

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Ischemia time had a strong positive correlation with in-hospital mortality (r=0.36, p<0.001) but not with long-term mortality (r=0.01, p=0.847).

IV. Discussion

Acute kidney injury (AKI) is still a relevant side effect of heart surgery. This study shows that a high SCr level on admission is significantly associated with immediate mortality but not late mortality. This can be due to the fact that renal dysfunction can be successfully managed once the patient completes the critical stage of the immediate postoperative period. Therefore, it is necessary to have more carefully monitored postoperative care due to the associated comorbidities and the slightly more extended recovery period [21-24]. To prevent the development of life-threatening complications like AKI, cardiac patients require a multidisciplinary and preventative strategy, according to the results of our study and other interdisciplinary research conducted on patients over time [25-28].

SCr level at admission showed a statistically significant increase with in-hospital mortality rate. The preventive protocols that reduce the kidney stress function include using a preventive renal strategy. This involves delaying elective surgery until the renal problems are resolved, using less nephrotoxic treatments, treating infections and other comorbidities that negatively affect the kidneys and other organs, reducing the time of ischemia, preventing blood pressure variations, and using as little blood transfusions as possible [28-34].

If the patient's postoperative SCr level is maintained within the accepted reference ranges, all the above strategies will directly decrease the patient's mortality rate [35]. Due to our study, there is a direct correlation between high SCr levels on the first day of ICU and in-hospital mortality. The inflammatory processes and cellular immune responses rapidly increase after cardiac surgery. As a result, extracorporeal circulation is necessary to treat this disease. This process could lead to organ dysfunction, such as kidney failure. The SCr level can be managed through preventive and therapeutic measures and prompt therapy. However, if a multi-organ dysfunction occurs, the management aspect evidently becomes more complex because the mortality rate increases for these patients [36-37]. Even so, it has been observed that preventative and curative therapies, including kidney function measures, consistently improve the patient's postoperative recovery.

To enhance outcomes, early detection and effective management are necessary. Even though a lot of information regarding the epidemiology of postoperative AKI exists, many unknown factors still influence AKI's development and outcomes following cardiac surgery [10, 44-45]. Preoperatively, patients at risk can be identified and provided for by adjusting circulatory support during surgery and with renoprotective postoperative therapy [11,15]. This study highlights the importance of high SCr level as a marker of mortality in aortic dissection. The suggested direct correlation between this disease and in-hospital mortality

(but not long-term mortality) is the key in opening a new research horizon.

V. Limitations

This study was conducted in a tertiary centre facility in Eastern Europe. However, national medical education programs are not equivalent to those in Western countries. The lack of national registers of patients who have undergone surgery makes it extremely difficult to keep track of these individuals; therefore, follow-up is only allowed six months after surgery. In this study, I decided to use SCr levels above the reference value as an independent predictor of death rather than evaluating renal function according to the glomerular filtration rate. In the context of this discussion, the SCr level cannot be regarded as the single most crucial variable that determines the course of acute aortic syndrome patients. However, combined with various intrinsic and extrinsic cardiac patient factors, it can likely play a significant role in managing this life-threatening pathology.

VI. Conclusion

This study suggests that a high serum creatinine (SCr) level negatively impacts short-term mortality but not long-term mortality, and a statistically significant relationship exists between elevated SCr level at admission and in-hospital mortality following cardiac surgery. This underlines the importance of meticulously monitoring and managing kidney function in the postoperative period, specifically in patients with high SCr level at admission. Risk factors for renal dysfunction must be recognized and corrected to improve patient outcomes and reduce mortality rates in the postoperative period. These results highlight the need for further study to help improve patient outcomes following cardiac surgery.

VII. References

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