Prognostic value of high-sensitivity troponin I after cardiac surgery according to preoperative renal function

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Abstract
Cardiac troponin levels can be elevated without myocardial injury in patients with renal impairment. However, the prognostic value of elevated troponin levels after cardiac surgery has not been well evaluated in patients with renal impairment. We evaluated the relationship between postoperative troponin levels and mortality following cardiac surgery according to preoperative renal function.

Among 3661 patients underwent cardiac surgery between March 2005 and December 2015, 1909 patients were analyzed after excluding those with insufficient laboratory data, preoperative myocardial infarction, underwent Cox-Maze or redo surgery, or with a follow-up period <30 days. The primary outcome was risk of 30-day mortality according to elevated postoperative high-sensitivity cardiac troponin I (hs-cTnI) levels in varying degrees of renal function. Secondary outcomes included long-term cardiac-cause and all-cause mortality during the median follow-up of 52 months.

After adjustment for risk factors, elevated peak postoperative hs-cTnI was associated with 30-day mortality [adjusted odds ratio 1.028, 95% confidence interval (CI) 1.013–1.043, \( P < .001 \)], long-term cardiac-cause [adjusted hazard ratio (HR) 1.013, 95% CI 1.009–1.017, \( P < .001 \)] and all-cause mortality (adjusted HR 1.013, 95% CI 1.009–1.016, \( P < .001 \)), in patients with preoperative normal renal function [estimated glomerular filtration rate (eGFR) ≥60 ml/minute/1.73 m\(^2\)]. However, in patients with renal impairment (eGFR < 60 ml/minute/1.73 m\(^2\)), hs-cTnI levels were not associated with mortality following cardiac surgery.

Elevated hs-cTnI levels following cardiac surgery did not predict short- and long-term mortality in patients with preoperative renal impairment.

Abbreviations: AKI = acute kidney injury, CABG = coronary artery bypass graft, CI = confidence interval, COPD = chronic obstructive pulmonary disease, CPB = cardiopulmonary bypass, CRRT = continuous renal replacement therapy, cTnI = cardiac troponin I, cTnT = cardiac troponin T, EF = ejection fraction, eGFR = estimated glomerular filtration rate, EMR = electronic medical records, GFR = glomerular filtration rate, hs-cTnI = high-sensitivity cardiac troponin I, HR = hazard ratio, ICU = intensive care unit, IDMS = isotope dilution mass spectrometry, IRB = institutional review board, IQR = inter-quartile range, KDIGO = Kidney Disease: Improving Global Outcomes, LOS = length of stay, LV = left ventricular, MDRD = modification of diet in renal disease, MI = myocardial infarction, OR = odds ratio, SD = standard deviation.

Keywords: cardiac surgery, mortality, renal impairment, troponin I
1. Introduction

An elevated troponin level is known to be related with adverse outcomes after cardiac surgery.\(^1\) However, in patients with chronic renal disease troponin levels can be consistently elevated without myocardial injury.\(^2,3\) Although cardiac troponin I (cTnI) is a sensitive and specific detector of myocardial injury even in renal insufficiency,\(^4\) elevated troponin levels may not correlate with postoperative outcomes in patients with renal dysfunction following cardiac surgery. However, there are no sufficient data on the prognostic value of postoperative cTnI levels after cardiac surgery in patients with preoperative renal impairment. We hypothesized that the prognostic value of postoperative cTnI levels would differ according to different preoperative renal function in patients undergoing cardiac surgery.

To evaluate our hypothesis, we conducted a retrospective analysis of postoperative cTnI levels and short- as well as long-term mortality in patients undergoing cardiac surgery according to varying degrees of preoperative renal function.

2. Methods

2.1. Study design and setting

This retrospective study was approved by the Institutional Review Board (IRB) of Seoul National University Hospital (approval number 1804-117-939 on April 25, 2018) and was registered at ClinicalTrials.gov (identifier NCT03540511). The IRB did not require informed patient consent for a retrospective study. The study followed the STROBE statement.

Electronic medical records (EMR) of adult patients (age ≥20 years) who underwent cardiac surgery at Seoul National University Hospital between March 1, 2005, and December 31, 2015, were reviewed. During this period, all medical records were recorded in electronic manner. All laboratory results, including radiologic and echocardiographic images and readings, and all medical documents made by medical personnel were recorded by the electronic medical recording system, which is independently validated. Cardiac surgery included coronary artery bypass grafting (CABG), cardiac valve surgery, and their combined surgery. The exclusion criteria included a Cox-Maze procedure or cryoablation, redo surgery, preoperative myocardial infarction (MI) defined according to the existing guidelines,\(^5\) and no preoperative creatinine levels or high-sensitivity cTnI (hs-cTnI) levels checked less than 2 consecutive values within the first 5 postoperative days. Patients who had follow-up period <30 days were also excluded.

2.2. Baseline characteristics and data collection

Baseline characteristics, including sex, age, height, weight, type of surgery, emergency procedures, comorbidities, smoking history, laboratory results, and medications were obtained from EMR. Perioperative data included the durations of operation and anesthesia, intraoperative transfusion, as well as records on cardiopulmonary bypass (CPB). Postoperative variables included new onset continuous renal replacement therapy (CRRT), postoperative reintubation, re-exploration, postoperative delirium, new onset atrial fibrillation, postoperative acute kidney injury (AKI), intensive care unit (ICU) and postoperative hospital length of stay (LOS). Postoperative AKI was defined as an increase in serum creatinine ≥0.3 mg/dl within 48 hours or an increase to ≥1.5 times baseline within 7 days following surgery as per the criteria of the Kidney Disease: Improving Global Outcomes (KDIGO) Clinical Practice Guideline for Acute Kidney Injury.\(^6\)

2.3. Assessment of renal function

The baseline glomerular filtration rate (GFR) was determined using preoperative serum creatinine concentration. Isotope dilution mass spectrometry (IDMS) was used to calibrate the measured serum creatinine level. The estimated GFR (eGFR) was calculated using the modification of diet in renal disease (MDRD) prediction equation\(^7\):

$$\text{IDMS MDRD } e\text{GFR} = 175 \times \left(\frac{\text{serum creatinine}}{0.742}\right)^{-0.203} \times \left(\frac{\text{age} - 20}{203}\right)^{-1.154}$$

Baseline renal function was categorized based on the 2012 KDIGO Clinical Practice Guideline\(^8\) as follows: normal renal function was defined as an eGFR ≥90 ml/minute/1.73 m\(^2\); while mild, moderate and severe renal dysfunction were defined as 60–89, 30–59, and <30 ml/minute/1.73 m\(^2\), respectively. Patients with a baseline eGFR ≥60 ml/minute/1.73 m\(^2\) were categorized as having normal renal function in this study due to the bias of the equation when the eGFR is ≥60 ml/minute/1.73 m\(^2\).\(^9\)

2.4. High-sensitivity cardiac troponin I measurements

Levels of hs-cTnI after cardiac surgery were identified from EMR. The hs-cTnI levels were evaluated at 6 hours, 12 hours, 24 hours, and then daily up to 7 days postoperatively and also by the discretion of clinicians in charge of postoperative patient care according to the postoperative status of the patients. Measurements of hs-cTnI were performed using an Abbott Architect Plus Analyzer (i2000SR; Flex Ltd., San Jose, CA), which has a limit of detection of 0.0011 μg/L and a limit of blank of 0.0007 to 0.0013 μg/L. The 99th percentile in the normal population was 0.028 μg/L, with a sex-specific upper reference range of 0.033 μg/L for men and 0.013 μg/L for women. The peak hs-cTnI value during the first 5 postoperative days was determined.

2.5. Study outcomes

The primary outcome of the study was 30-day mortality after cardiac surgery. The secondary outcomes included long-term cardiac-cause and all-cause mortality after the surgery. Cardiac-cause mortality was defined as death from MI, cardiac arrhythmia, worsening heart failure, cardiogenic shock or sudden death. Data on death were obtained from EMR and the National Population Registry of the Korean National Statistical Office. In South Korea, all citizens are obligated to register to the National Population Registry both at birth and death.

2.6. Statistical analyses

Data are expressed as means ± standard deviation (SD), the median (inter-quartile range [IQR]) or number (proportion). Continuous data were compared using the Kruskal–Wallis test or analysis of variance according to the distribution of data; categorical variables were compared using the χ² test. For time-to-event variables, survival functions were estimated using the
Kaplan–Meier method. Comparisons were made by the log rank test. The mortality risks of elevated peak hs-cTnI levels as continuous variables for varying degrees of renal function were evaluated using a binomial logistic regression for 30-day mortality and a Cox proportional hazard regression analysis for long-term mortalities. The relationship between the renal function groups and the peak postoperative hs-cTnI was analyzed with interaction terms between them in the regression models due to the small numbers and events in eGFR subgroups. To identify independent risks for the association between preoperative renal function, postoperative peak hs-cTnI and mortality, multivariable logistic and Cox regression models included all potential covariates based on previously defined risk factors known to affect postoperative outcomes after cardiac surgery.\(^{10–12}\) Risk factors were adjusted and a significance level of 0.2 was used to enter a variable into the multivariable model or to remove it from the model. For multivariable model 1, odds ratios (ORs) for 30-day mortality were adjusted for age, emergency, type of surgery, duration of operation, preoperative left ventricular (LV) ejection fraction (EF) and hematocrit, chronic obstructive pulmonary disease (COPD) or asthma, atrial fibrillation, use of aspirin, beta-blockers, and statin, intraoperative transfusion. Hazard ratios (HRs) for cardiac-cause mortality were adjusted for sex, age, BMI, emergency, type of surgery, duration of operation, preoperative LV EF and hematocrit, COPD or asthma, atrial fibrillation, use of aspirin, diuretics, digoxin, and statin, intraoperative transfusion. HRs for all-cause mortality were adjusted for sex, age, BMI, emergency, type of surgery, duration of operation, preoperative LV EF and hematocrit, COPD or asthma, atrial fibrillation, use of aspirin, diuretics, digoxin, and statin, intraoperative transfusion. The patients baseline characteristics are presented in Table 1. More patients with preoperative renal impairment received digoxin, and statin, intraoperative transfusion. In multivariable model 2, postoperative variables were included along with the variables in model 1: for ORs for 30-day mortality, postoperative CRRT, re-exploration, AKI, and ICU LOS; and for HRs for cardiac-cause and all-cause mortality, postoperative CRRT, re-exploration, delirium, AKI, and ICU and postoperative hospital LOS were included. Normal renal function (eGFR ≥ 60 ml/minute/1.73 m\(^2\)) was used as the reference group for different degrees of renal impairment. All results are reported as either ORs or HRs with 95% confidence intervals (CIs). The effect of the peak postoperative hs-cTnI in each renal function group was tested using Bonferroni-corrected significance level of 0.0167 (0.05/3) for each outcome.

To plot long-term survival curves, the best cut-off limits of postoperative peak hs-cTnI to predict mortality were obtained from patients with follow-up period ≥3 years (n=937) by using receiver operating characteristic (ROC) curve analysis. The cut-off for hs-cTnI associated with maximum sensitivity and specificity was estimated with Youden J index. The area under the ROC curve, corresponding 95% CI and P-values were calculated. Statistical analyses were performed using SPSS (version 21.0; IBM Corp., Armonk, NY) and R software (version 3.4.3; R Development Core Team, Vienna, Austria) for Microsoft Windows. A P value <.05 was considered statistically significant.

3. Results

3.1. Study population

A total of 3661 patients EMR were reviewed. Patients with no data on preoperative creatinine (n=136), who underwent Cox-Maze or cryoablation (n=464), redo surgery (n=331), preoperative MI (n=172), postoperative hs-cTnI less than 2 consecutive results (n=630) and those with a follow-up period <30 days (n=19) were excluded. Finally, 1909 patients were included in the final analyses (Fig. 1). A total of 1309 (69%) patients had preoperative normal renal function, 459 (24%) moderate and 141 (7%) severe preoperative renal impairment.

3.2. Patients’ baseline characteristics

The patients baseline characteristics are presented in Table 1. More patients with severe renal impairment had hypertension, diabetes mellitus and atrial fibrillation. Patients with renal impairment experienced longer durations of operation, anesthesia and CPB. More patients with preoperative renal impairment received emergency surgery and transfused with red blood cells intraoperatively than did those with normal renal function. The use of angiotensin receptor blockers, calcium channel blockers, and diuretics were more common in patients with renal impairment (see Table S1, Supplemental Content, http://links.lww.com/MD/E159, which shows medications of included patients).

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**Figure 1.** Study flow.
Table 1
Baseline characteristics of patients.

| Demographics and medical history | eGFR (mL/min/1.73 m²) | ≥60 (n = 1309) | 30 – 59 (n = 459) | <30 (n = 141) | P value |
|----------------------------------|----------------------|----------------|-----------------|--------------|--------|
| Age (y)                          |                      | 65 (57–71)     | 71 (64–76)      | 68 (61–72)   | <.001  |
| Male                             |                      | 953 (73%)      | 267 (58%)      | 100 (71%)    | <.001  |
| Body mass index (kg/m²)          | 24.4±3.2             | 24.7±3.3       | 23.5±2.7       | .001         |
| Current smoker                   | 314 (24%)            | 65 (14%)       | 30 (21%)       | <.001        |

Comorbidities

- Hypertension: 729 (56%) 309 (67%) 111 (79%) <.001
- Diabetes mellitus: 456 (55%) 221 (48%) 91 (65%) <.001
- Dyslipidaemia: 385 (29%) 121 (26%) 30 (21%) <.001
- Chronic obstructive pulmonary disease or asthma: 36 (3%) 12 (3%) 6 (4%) .563
- Current smoker: 314 (24%) 65 (14%) 30 (21%) <.001

Operative data

- Duration of operation (min): 368±80 381±84 391±89 <.001
- Duration of anaesthesia (min): 441±82 454±85 470±94 <.001
- Use of cardiopulmonary bypass: 540 (28%) 120 (26%) 37 (26%) <.001
- Duration of cardiopulmonary bypass (min): 196±5 204±7 235±7 <.001
- Emergency operation: 216 (17%) 84 (18%) 42 (30%) <.001
- Intraoperative use of RBC (unit): 1 (0–3) 3 (1–4) 3 (2–5) <.001

Type of surgery

- CABG: 998 (76%) 352 (77%) 108 (76%) <.001
- Valve surgery: 268 (21%) 70 (15%) 25 (18%) <.001
- CABG + valve surgery: 43 (3%) 37 (8%) 6 (4%) <.001
- Peak postoperative hs-cTnI (µg/L): 1.00 (0.37–5.50) 1.70 (0.47–7.47) 1.62 (0.67–7.20) <.001

Values are reported as median (inter-quartile range), number (%), or mean ± standard deviation. CABG = coronary artery bypass grafting, eGFR = estimated glomerular filtration rate, hs-cTnI = high-sensitivity cardiac troponin I, LV EF = left ventricular ejection fraction, RBC = red blood cell.

Table 1
Baseline characteristics of patients.

3.3. Postoperative troponin levels and in-hospital events

The renal impairment groups experienced higher postoperative peak hs-cTnI values compared to the normal renal function group (Table 1). New onset postoperative CRRT, reintubation, reexploration, delirium, atrial fibrillation, and AKI were more common in preoperative renal impairment groups compared with the normal renal function group (see Table S2, Supplementary Content, http://links.lww.com/MD/E160, which shows postoperative events after cardiac surgery). The ICU and postoperative hospital LOS increased with increasing degrees of renal impairment (see Table S2, Supplementary Content, http://links.lww.com/MD/E160).

3.4. Study outcomes

Thirty three (1.7%) patients died within 30 days after cardiac surgery. During long-term follow-up of median (IQR) 52 (22–87) months (maximum 131 months), cardiac-cause mortality was 6.0% (115/1909) and all-cause mortality was 19.1% (364/1909). According to the degree of preoperative renal function, patients with renal impairment (eGFR <60mL/minute/1.73 m²) had higher mortality rates compared to those with normal renal function (Table 2).

Unadjusted and adjusted risks for mortality following cardiac surgery with increasing peak postoperative hs-cTnI in varying preoperative renal function groups are presented in Table 2. After adjustment, increased postoperative peak hs-cTnI was an independent predictor of 30-day, and long-term cardiac- and all-cause mortality following cardiac surgery in patients with preoperative normal renal function (all P < .001, Fig. 2 and Table 2). However, in patients with preoperative renal impairment (eGFR <60mL/minute/1.73 m²) elevated postoperative hs-cTnI was not related to short- or long-term mortality after cardiac surgery.

In additional analysis for impact of postoperative AKI on outcome, mortality after cardiac surgery was higher in patients with postoperative AKI than in those without (see Table S3, Supplementary Content, http://links.lww.com/MD/E161). After adjustment, increased postoperative hs-cTnI had predictive value for 30-day, and long-term mortality in patients developed postoperative AKI. However, it was not related to mortality in the absence of postoperative AKI, after adjustment for confounding variables.

In ROC curve analysis, the best cut-off limits to predict long-term cardiac-cause and all-cause mortality in normal renal function group were 1.055 µg/L and 1.365 µg/L, respectively (see Fig., Supplementary Content, http://links.lww.com/MD/E162, which illustrates ROC curve of long-term mortality). The cut-off value for predicting 30-day mortality was 7.345 µg/L. Survival curves according to increased postoperative hs-cTnI with cut-off limits in patients with preoperative normal renal function during the follow-up period are presented in Figure 3.

4. Discussion

Increased peak postoperative hs-cTnI following cardiac surgery was independently associated with increased 30-day mortality, and long-term cardiac-cause and all-cause mortality in patients with normal preoperative renal function. However, in patients with impaired preoperative renal function, postoperative hs-cTnI
had no prognostic value in regard to short- and long-term mortality.

Patients with renal impairment often exhibit elevated serum troponin levels, even in the absence of apparent myocardial injury.\(^\text{[13]}\) Of patients visiting nephrology clinics with an eGFR <60 ml/min/1.73 m\(^2\), 38%, and 68% had abnormally elevated cTnI and cardiac troponin T (cTnT), respectively, without acute coronary disease.\(^\text{[2]}\) However, it is not conclusively known whether the primary contributor to elevated troponin concentrations associated with renal dysfunction is reduced elimination or increased release.\(^\text{[13]}\) Renal dysfunction therefore affects the diagnostic value of hs-cTnI for MI. Specificity and positive predictive values of hs-cTnI decreased with renal impairment, particularly at an eGFR <30 ml/min/1.73 m\(^2\), in patients presenting symptoms suggesting myocardial ischaemia.\(^\text{[14]}\) Additionally, it has been proposed that the cut-off values for hs-cTnT in diagnosing acute MI should be increased with increasing stages of chronic kidney disease.\(^\text{[3]}\) In this context, the interpretation of elevated troponin levels in patients with renal impairment can be case-specific but not conclusive.

Troponin levels are well-known indicators predicting adverse outcomes in various clinical settings.\(^\text{[15,16]}\) Increased troponin levels corresponded significantly with morbidity and mortality in non-surgical and non-cardiac surgical settings. Even in patients with chronic renal dysfunction with an eGFR <60 ml/min/1.73 m\(^2\) undergoing coronary angiography, hs-cTnI was a strong predictor of death, cardiac death and major adverse cardiac events during the median follow-up of 4.8 years.\(^\text{[17]}\) Elevated troponin levels in the early postoperative period after non-cardiac surgery were associated with 30-day mortality.\(^\text{[18]}\) Similarly, after intermediate- or high-risk non-cardiac surgery (orthopedic, gynecological, urological, vascular or other general surgery), elevated postoperative hs-cTnI was associated with a dose-dependent increase in 30-day and long-term mortality risk during the median follow-up of 2 years, in patients with preoperative cGFR ≥30 ml/min/1.73 m\(^2\).\(^\text{[19]}\) However, there are insufficient data on prognostic value of postoperative troponin levels in patients with renal dysfunction undergoing cardiac surgery.

Following cardiac surgery, postoperative troponin release can be caused by intraoperative heart manipulations, which may increase serum cardiac troponin levels after the surgery.\(^\text{[20]}\) Thus, increased troponin levels in the early postoperative period after cardiac surgery can be considered as a non-significant phenomenon that likely will not adversely impact patient outcomes. Nevertheless, postoperative cardiac troponin levels well predicted 30-day, 1-year, and 3-year mortality following cardiac surgery after adjusting for potentially confounding variables.\(^\text{[21,22]}\) Elevated postoperative cTnI was also an independent predictor of death after CABG over a 2-year follow-up.\(^\text{[23]}\) However, the relationship between preoperative renal function and postoperative troponin levels was not fully evaluated in previous studies.\(^\text{[23]}\) Thus it is unclear whether the prognostic value of postoperative troponin maintains in patients with preoperative renal impairment undergoing cardiac surgery.

Evaluation of cardiac troponin release is an important part of post-cardiac surgery patient management that is widely used in clinical practice. Previous authors found that the best cut-off value was 4.25 μg/L of cTnI at 1 hour after CABG or valve surgery to predict hospital mortality from their registry database, without consideration of preoperative renal function.\(^\text{[24]}\) Increased peak cTnI level until the next morning after aortic or mitral valve surgery was an independent risk factor for hospital mortality, but the results were not stratified with the degree of preoperative renal function.\(^\text{[25]}\) In another study, elevated cTnI at 20 hours after CABG or valve surgery independently predicted inhospital death, but the authors did not evaluate the influence of patients renal function.\(^\text{[26]}\) In that study, the baseline creatinine clearance was 68 and 58 ml/minute in survivors and non-survivors, respectively (P = .06).

In the current study, elevated postoperative hs-cTnI was an independent predictor of 30-day, as well as long-term cardiac-cause and all-cause mortality following cardiac surgery only in
patients with normal renal function. The best cut-off value for predicting 30-day mortality was 7.345 μg/L in patients with preoperative normal renal function, which was partly corresponds to the optimal cTnI cut-off level of 7.97 μg/L within 12 hours after CABG surgery to identify MI related to surgery previously.\(^\text{[27]}\) Therefore, the patients with higher than the cut-off limits in the early postoperative period would have increased risks for short- and long-term mortality following cardiac surgery if their preoperative renal function was normal.

However, in patients with renal impairment (preoperative eGFR <60 mL/minute/1.73 m\(^2\)), elevated postoperative hs-cTnI values were not associated with mortality following cardiac surgery in this study. It is partly explained that the renal dysfunction influences the diagnostic accuracy of cardiac troponin levels in detecting perioperative MI related to cardiac surgery.\(^\text{[28]}\) Our results are in accordance with a previous study in high-risk patients for AKI (preoperative serum creatinine >2 mg/dL [177 μmol/L]) undergoing CABG or valve surgery, in which postoperative hs-cTnI was not correlated with 1- or 3-year mortality following surgery.\(^\text{[29]}\) Therefore, according to these results, increased cardiac troponin levels may have little predictive value for postoperative short- or long-term mortality after cardiac surgery in patients with preoperative renal impairment. Elevated hs-cTnI levels following cardiac surgery in these patients should be interpreted in consideration of this relationship.
In our sub-analysis, elevated postoperative hs-cTnI was an independent predictor for short- and long-term mortality in patients who developed postoperative AKI. Therefore, post-cardiac surgery patients superimposed with AKI may have greater risk for death with increasing postoperative hs-cTnI levels. However, hs-cTnI itself did not predict mortality after cardiac surgery after adjustment for other confounding variables in the absence of AKI.

Figure 3. Kaplan-Meier survival curves depicting freedom from (A) cardiac-cause and (B) all-cause death according to the peak postoperative troponin I levels using the cut-off limits in patients with normal renal function. hs-cTnI = high-sensitivity cardiac troponin I.

5. Limitations

The limitations of this study include the insufficient data on preoperative troponin levels in this cohort. However, it is a practical aspect of real clinical practice because not all patients undergo troponin measurement preoperatively. We excluded patients with recent history of myocardial ischemia from analyses, therefore we believe that those with acutely elevated
troponin levels might have not been included in this study. Moreover, not only changes in troponin levels between the preoperative and postoperative periods but also the absolute value of postoperative troponin levels was an independent predictor of short-term mortality in a previous study.[10] EuroSCORE or STS risk scores were not included in this analysis due to the lack of information at the time of hospital admission from EMR. However, we included variables, many of which are the mostly components of those risk evaluation systems, in our multivariable analysis. Lastly, approximately 17% (630/3661) of patients were excluded because consecutive postoperative troponin levels were not available during the early postoperative period. Similarly, in a previous study evaluated the prognostic value of postoperative troponin levels in non-cardiac surgery,[19] about 27% (1287/4825) of cases were excluded because postoperative troponin levels were not obtainable. We believe that our study evaluated the relationship of currently available postoperative hs-cTnI levels and outcomes following cardiac surgery according to varying degrees of preoperative renal function in best clinical practice. Nevertheless, these results should be applied cautiously to other surgical patients and should be interpreted in consideration of practical limitations of the study. For further evaluation, prospective studies are required including preoperative troponin assessment and serial data on postoperative troponin measurements.

6. Conclusions

In conclusion, the peak hs-cTnI level in the early postoperative period following cardiac surgery had no prognostic value in patients with preoperative renal impairment (eGFR < 60 ml/minute/1.73 m²), while it was an independent predictor of mortality in patients with normal renal function. During management of patients undergoing CABG or cardiac valve surgery, elevated hs-cTnI levels in the early postoperative period should be interpreted in consideration of patients’ preoperative renal function.

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Author contributions

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