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Original Research Article

Mortality prediction in patients with acute kidney injury requiring renal replacement therapy after cardiac surgery

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ABSTRACT

Background and objective: Acute kidney injury (AKI) is a common and potentially serious postoperative complication after cardiac surgery, and it remains a cause of major morbidity and mortality. The aim of our study was to assess the prognostic illness severity score and to estimate the significant risk factors for poor outcome of patients with AKI requiring renal replacement therapy (RRT) after cardiac surgery.

Materials and methods: We retrospectively analyzed data of adult (>18 years) patients (n = 111) who underwent open heart surgery and had developed AKI with need for RRT. Prognostic illness severity scores were calculated and perioperative risk factors of lethal outcome were assessed at the RRT initiation time. We defined three illness severity scores: Acute Physiology and Chronic Health Evaluation (APACHE II) as a general score, Sequential Organ Failure Assessment (SOFA) as an organ failure score, and Liano score as a kidney-specific disease severity score. Logistic regression was also used for the multivariate analysis of mortality risk factors.

Results: Hospital mortality was 76.5%. More than 7% of patients remained dialysis-dependent after their discharge from the hospital. The prognostic abilities of the scores were assessed for their discriminatory power. The area under the receiver-operating characteristic (ROC) curve of SOFA score was 0.719 (95% CI, 0.598–0.841), of Liano was 0.661 (95% CI, 0.535–0.787) and 0.668 (95% CI, 0.550–0.785) of APACHE II scores. From 16 variables analyzed for model selection, we reached a final logistic regression model, which demonstrated four variables significantly associated with patients' mortality. Glasgow coma score < 14 points (OR = 3.304; 95% CI, 1.130–9.662; P = 0.003), mean arterial blood pressure (MAP) < 63.5 mmHg (OR = 3.872; 95% CI, 1.011–13.616; P = 0.035), serum creatinine > 108.5 μmol/L (OR = 0.347; 95%

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CI, 0.123–0.998; $P = 0.046$) and platelet count $< 115 \times 10^9/L$ (OR = 3.731; 95% CI, 1.259–11.054; $P = 0.018$) were independent risk factors for poor patient outcome.

Conclusions: Our study demonstrated that SOFA score estimation is the most accurate to predict the fatal outcome in patients with AKI requiring RRT after cardiac surgery. Lethal patient outcome is related to Glasgow coma score, mean arterial blood pressure, preoperative serum creatinine and postoperative platelet count.

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1. Introduction

Approximately 2 million cardiac surgeries are performed around the world each year [1]. Acute kidney injury (AKI) is a common and potentially serious postoperative complication after cardiac surgery [2]. The common occurrence of AKI is attributed to factors like perioperative hemodynamic alterations, comorbid conditions predisposing renal injury and pharmacological toxins associated with cardiac surgery [3]. The incidence of cardiac surgery associated AKI varies from 5% to 45% depending on the diagnostic AKI criteria, the type of cardiac surgery [4–6]. Frequency of AKI requiring dialysis is generally lower, ranging between less than 1% and 6% [7]. The mortality rate among AKI patients after cardiac surgery is high, with a wide range of 2.4–19.0% [8]. In case of dialysis-dependent AKI, mortality increases significantly in more than 50% of the total count of affected individuals [9]. Because AKI is associated with high mortality, prolonged hospital stay and increased post-hospital morbidity [10–12], the majority of studies focuses on early detection of AKI and prediction of AKI progression [13]. In patients, who have undergone cardiac surgery, damage of renal function is often associated with multiple organ failure. Under these circumstances, it seems that the choice of renal replacement therapy (RRT) should be based on the severity of illness and associated organ dysfunctions. However, the treatment selection is based on subjective criteria. Several prognostic tools have been developed to assess disease severity and the risk of poor outcome, but none of them account for risk factors, specific to patients who have undergone cardiac surgery, such as cardiopulmonary bypass (CPB) duration and surgery type. Both, general illness severity scores and kidney specific disease severity scores, do not identify these risk factors [14].

The aim of our study was to estimate poor outcome risk factors and to determine which clinical prognostic score has the highest predictive values in patients with AKI requiring RRT after cardiac surgery.

2. Materials and methods

We performed a retrospective analysis of patients older than 18 years who underwent heart surgery and were admitted to the Intensive Care Unit (ICU) of cardiac surgery in the Hospital of Lithuanian University of Health Sciences Kauno Klinikos within a 5-year period. All patients receiving RRT due to AKI (AKI Network (AKIN) stage 3) after cardiac surgery were assessed for

inclusion to the study. Exclusion criteria were preoperative need for RRT, including those with chronic renal failure requiring dialysis and those with non-renal indications for RRT. The indications to start dialysis treatment in the cases of severe AKI were clinical symptoms of uremia, hypervolemia, hyperkalemia, metabolic acidosis, high levels of serum creatinine ($>600 \mu\text{mol/L}$) and urea ($>30 \text{mmol/L}$). The indications for slow continuous RRT were refractory arterial hypotension and pronounced hyperhydration and/or hypercatabolism.

We examined four groups (16 variables) of possible risk factors for poor outcome: (1) demographic data (age, gender), (2) preoperative serum creatinine level and estimated glomerular filtration rate (eGFR) using MDRD on the day before surgery, (3) surgical data (CPB duration, types of cardiac surgery) and (4) postoperative variables (temperature, mean arterial pressure (MAP), oliguria, Glasgow coma score, sepsis, serum creatinine level before initiation of RRT, white blood cell (WBC) and platelet count, mechanical lung ventilation, vasopressors administration) on the day of the initiation of RRT.

Severity scores were calculated at the time of the initiation of RRT. We estimated the predictive ability of three well-known severity scores: Acute Physiology and Chronic Health Evaluation (APACHE) II as a general score, Sequential Organ Failure Assessment (SOFA) as an organ failure score and Liano score as a kidney-specific disease severity score.

2.1. Definitions

AKI was diagnosed if serum creatinine increased to $\geq 26.5 \mu\text{mol/L}$ within 48 h or 1.5-fold from the baseline, which was known or presumed to have occurred in the preceding 7 days. AKIN stage 3 was diagnosed, if RRT in patients with AKI was started [15].

Patient survival was defined as survival 30 days after cardiac surgery. Moreover, the hospital mortality rate for the study population was assessed

Microbiologically documented sepsis was defined as a combination of positive blood culture and two of following four criteria: (1) core body temperature $> 38.3^\circ\text{C}$ or $< 36^\circ\text{C}$, (2) heart rate > 90 beats/min, (3) respiratory rate > 20 breaths/min or $\text{PaCO}_2 < 32 \text{mmHg}$, (4) WBC $> 12,000/\text{mm}^3$ or $< 4000/\text{mm}^3$ or normal WBC count with $> 10\%$ immature forms [16].

Risk factor of AKI was defined such as history of chronic kidney disease, arterial hypotension without inotropic drugs, sepsis, X-ray contrast media, administration of nephrotoxic medications and vasopressors.

Liano score was determined using the formula: probability of death = 0.032 (age in decades) – 0.086 (sex) – 0.109 (nephrotoxicity) + 0.109 (oliguria) + 0.116 (hypotension) + 0.122

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