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Original article

Factors determining achievement of early postoperative cardiac rehabilitation goal in patients with or without preoperative kidney dysfunction undergoing isolated cardiac surgery

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ABSTRACT

Background: The aim of this multicenter study was to evaluate the relationship between preoperative kidney function, postoperative acute kidney injury (AKI), and postoperative fluid balance (POFB) with the progress of early postoperative cardiac rehabilitation (CR) in patients undergoing isolated cardiac surgery.

Methods: Four hundred twenty three consecutive patients (137 females, 286 males, aged 66 ± 13 years) who underwent various elective cardiac surgeries in the participating institutes were selected and divided into 5 groups depending on chronic kidney disease (CKD) stage. We evaluated the effects of CKD stage on the progress of early postoperative CR, and analyzed the factors determining the achievement of Japanese Circulation Society (JCS) early postoperative CR guidelines goal.

Results: Initiation of sitting ($F = 7.59$, $p < 0.01$) and standing ($F = 4.83$, $p < 0.01$), walking ($F = 4.40$, $p < 0.01$), and 100-m unassisted walk ($F = 13.09$, $p < 0.01$) were related with severity of preoperative CKD stage. The proportion of patients who could not achieve JCS early postoperative CR guideline goal was 15.0% in patients with CKD and 12.9% in patients without CKD. Multivariable analyses identified Risk, Injury, Failure, Loss, and End-stage Kidney (RIFLE) classification (of postoperative AKI) and blood urea nitrogen as factors determining achievement of early postoperative CR goal in patients with CKD; and POFB/preoperative body weight (PBW), RIFLE classification as determinants in patients without CKD. Using the receiver-operating characteristics curve analysis to predict achievement of the early postoperative CR goal, POFB/PBW 4.9% was identified as the cut-off value for achievement of the JCS early postoperative CR guideline goal.

Conclusion: Preoperative CKD stage correlated significantly with the progress of early postoperative CR after cardiac surgery. Independent determinants of achieving JCS early postoperative CR guideline goal were postoperative AKI in patients with or without CKD, and POFB/PBW only in patients without CKD.

Introduction

The US National Kidney Foundation (NKF) published the Report of the Task Force on Cardiovascular Disease in 1998, which recommended that patients with chronic kidney disease (CKD) should be considered as the "highest risk group" for subsequent cardiovascular events [1,2]. This report also advocated the importance of CKD classification and treatment according to severity of CKD.

Acute kidney injury (AKI) is a serious complication after cardiac surgery and is associated with increased mortality [3]. In 2004, the Acute Dialysis Quality Initiative (ADQI) group formulated the Risk, Injury, Failure, Loss, and End-stage Kidney (RIFLE) classification as the standardized definition for AKI [4]. Recent studies have also reported a higher prevalence of AKI in patients after cardiac surgery, confirming the association of AKI with short- or long-term mortality [5–7].

On the other hand, studies have also shown that excessive positive postoperative fluid balance (POFB) is independently associated with prolonged critical care, longer hospital stay, and higher mortality [8,9].

However, the relationship between preoperative CKD, postoperative AKI, excessive positive POFB, and performance of early

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postoperative cardiac rehabilitation (CR) has not been reported. We therefore performed a multicenter study with the aim to evaluate the relationship between the severity of preoperative CKD, postoperative AKI, POFB and progress of early postoperative CR in patients who underwent isolated cardiac surgery.

Methods

Subjects

The present study was a multicenter retrospective study. A total of 718 patients who underwent cardiovascular surgery and were discharged alive were identified from 7 institutes in Japan between April 2009 and September 2010. All eligible patients were asked to provide informed consent at each institution. Among these patients, 423 consecutive patients (137 females, 286 males, aged 66 ± 13 years) who underwent elective cardiac surgery, irrespective of the type of surgery, were enrolled in the study. Patients who underwent multiple valve procedures or those with valve procedures and coronary artery bypass graft (CABG) together, CABG and abdominal/thoracic aortic surgery, and emergency cardiac surgery were excluded. When classified by operative procedure, 201 patients underwent isolated CABG, 102 had aortic valve replacement (AVR), 40 had mitral valve replacement (MVR), 50 had mitral valve plasty (MVP), 11 had atrial septal defect (ASD) closure, and 19 had other procedures. When classified by preoperative CKD stages according to kidney disease outcomes quality initiative (KDOQI), CKD stage I consisted of 32 males and 20 females, aged 50 ± 17 years; stage II consisted of 144 males and 60 females, aged 66 ± 11 years; stage III consisted of 79 males and 46 females, aged 71 ± 10 years; stage IV consisted of 12 males and 5 females, aged 72 ± 9 years; and stage V consisted of 19 males and 6 females, aged 67 ± 8 years.

This study complied with principle of the Declaration of Helsinki regarding investigations in humans and was approved by the local institutional board at each participating hospital.

Preoperative renal function

Glomerular filtration rate (GFR) was estimated using prediction equations that take into account the preoperative serum creatinine concentration (sCr), age and gender, as recommended by the Japanese Society of Nephrology [10]. Preoperative estimated GFR (eGFR) was calculated as:

$194 \times \text{serum Cr}^{-1.094} \times \text{age}^{-0.287}$ (female $\times$ 0.739). Preoperative kidney function was classified using the KDOQI stage of kidney disease as follows: stage I, eGFR greater than 90 ml/min/1.73 m^2; stage II, eGFR 60–90 ml/min/1.73 m^2; stage III, eGFR 30–59 ml/min/1.73 m^2; stage IV, eGFR 15–29 ml/min/1.73 m^2; and stage V, eGFR less than 15 ml/min/1.73 m^2 which is kidney failure requiring dialysis or kidney transplant [11].

All the patients with stage V were restricted fluid administration during cardiac surgery to prevent hypervolemia. Therefore, a lot of substitution fluid for hemodiafiltration was used to prevent deterioration of platelet function and preserve the cardiac function. Additionally, continuous hemodiafiltration treatment for the removal of uremic toxin and salvaging kidney function was used in early postoperative periods.

Postoperative acute kidney injury

The RIFLE classification was used to classify the severity of postoperative AKI. The RIFLE classification was defined by the change in sCr within 48 h after cardiac surgery compared with preoperative baseline sCr. Patients who met the RIFLE grade of "risk" or above were classified as "AKI," whereas those who did not meet the RIFLE "risk" criteria were classified as "no AKI." RIFLE grade of "risk" is defined as a 100% increase in sCr; "injury" as a 200% increase in sCr; and "failure" as a 3-fold increase in sCr [4].

Postoperative positive fluid balance

We examined the change in POFB defined as postoperative POFB per preoperative body weight (POFB/PBW; %), which was calculated as [postoperative total positive/negative fluid balance/preoperative body weight $\times$ 100] at the end of cardiac surgery.

Early postoperative cardiac rehabilitation

We examined the initiation of postoperative mobilization exercises consisting of getting out of bed (sitting on the edge of the bed), standing at bed side, walking around the bed, and 100-m walk as early postoperative CR. In addition, we investigated the postoperative duration until the patient completed 100-m waking without assistance. Japanese Circulation Society (JCS) early postoperative CR guidelines recommended completion of the early postoperative CR protocol including 100-m unassisted walk within 8 postoperative days at the latest [12]. This was adopted as the goal of early postoperative CR in the present study.

Statistical analysis

To evaluate the differences in preoperative, intraoperative, and postoperative clinical characteristics among CKD stages as well as the effect of preoperative kidney function on the performance of early postoperative CR, we performed ANOVA, chi-square test, and Fisher exact test as appropriate among the 5 groups.

We performed univariate and multivariate analyses to assess the factors determining whether patients completed 100-m walk within 8 postoperative days, i.e. achieved the JCS early postoperative CR guideline goal. For multivariate analyses, the variables identified as significant in univariate analysis were used as independent variables, and odds ratios (OR) were computed with 95% confidence intervals (CI).

Receiver-operating characteristics (ROC) curve analysis was performed to calculate the sensitivity and specificity, and the area under the curve to select a cut-off value for predicting achievement of the JCS early postoperative CR guideline goal.

Data are expressed as mean $\pm$ standard deviation. A p-value less than 0.05 was considered significant. Statistical analysis was performed using statistical software (SPSS 19.0; Chicago, IL, USA).

Results

Preoperative clinical characteristics according to CKD stage

The clinical characteristics of patients according to preoperative CKD stage are shown in Table 1. Preoperative CKD stage was significantly related to patients' age in this study ($F = 31.75$, $p < 0.01$). Hemodynamic parameters including preoperative left ventricular ejection fraction (LVEF) ($F = 4.28$, $p < 0.01$) and left ventricular end-systolic diameter (LVDs) ($F = 3.14$, $p = 0.02$) were significantly different among the 5 groups. Similarly, preoperative blood biochemical data including serum hemoglobin (Hb) ($F = 4.86$, $p < 0.01$), sCr ($F = 4.05$, $p < 0.01$), blood urea nitrogen (BUN) ($F = 134.32$, $p < 0.01$), and brain natriuretic peptide (BNP) ($F = 30.32$, $p < 0.01$) were significantly different among the 5 groups. The prevalence of concurrent diseases such as diabetes mellitus ($p < 0.01$), hypertension ($p < 0.01$), dyslipidemia ($p = 0.03$), heart failure ($p < 0.01$), and orthopedic disease ($p < 0.01$) increased significantly depending on the severity of CKD.