Outcomes of cardiac surgery in chronic kidney disease

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Objective: To identify predictors of early and late outcomes of cardiac surgery in patients with chronic kidney disease.

Methods: Patients (n = 545) with serum creatinine ≥200 μmol/L or renal dialysis were identified from databases maintained by the largest Sydney cardiothoracic surgical units with data consistent with the Australian and New Zealand Society of Cardiothoracic Surgeons data definitions. The patient data were matched against the National Dialysis Database and the New South Wales Register of Births, Deaths, and Marriages. Statistical analysis was used to identify predictors of early and late outcomes.

Results: The Kaplan-Meier estimate of 1-, 5-, and 10-year survival for all patients was 78%, 56%, and 36%, respectively. The outcomes were similar after coronary bypass surgery and valve replacement and were also similar for dialysis and nondialysis patients. The odds ratios for the significant independent predictors of outcomes were, for perioperative death, age (1.4 per decade), emergency surgery (7.0), redo surgery (3.8), left ventricular impairment (moderate, 2.7; severe, 4.4); for new early postoperative dialysis, estimated glomerular filtration rate <20 mL/min (3.8), emergency surgery (2.7), tricuspid valve surgery (4.4); for new permanent dialysis within 6 months of surgery, serum estimated glomerular filtration rate <20 mL/min (odds ratio, 4.6). The hazard ratio for the independent predictors of late death in those alive 6 months after surgery was 1.4 per decade for age and 1.4 for moderate or severe left ventricular impairment.

Conclusions: Left ventricular impairment is a risk factor for perioperative and late death in patients with kidney disease. After cardiac surgery, preoperative dialysis-dependent and dialysis-free patients had similar long-term outcomes. (J Thorac Cardiovasc Surg 2014;148:2167-73)

Chronic kidney disease (CKD) has consistently been found to be an independent risk factor for the development of cardiovascular disease.[1,2] The leading cause of death in patients with CKD is cardiovascular disease. Several studies have identified that CKD increases the risk of mortality in patients undergoing cardiac surgery and that the mortality increases with renal dysfunction severity.[3,4] However, the heterogeneity among these patients will be wide, because the comorbidities, such as diabetes, baseline cardiac function, and symptoms, will vary. Providing individual patients with specific prognostic data and evaluating their suitability for surgery is often a challenge. Patients with advanced kidney disease often request information on whether the surgery will precipitate a requirement for permanent dialysis. In the present study, we aimed to identify the predictors of perioperative and postdischarge mortality in patients with dialysis-dependent (DD) or nondialysis–dependent (NDD) CKD. We also aimed to identify the factors that would predict long-term dialysis in predialysis patients who were discharged after cardiac surgery.

METHODS

In the present multicenter study, we compared and linked the existing cardiothoracic databases with the New South Wales Register of Births, Deaths, and Marriages and with corresponding renal databases in 3 teaching hospitals based in Sydney, Australia. The patients with a last preoperative serum creatinine measurement ≥200 μmol/L or requiring preoperative dialysis were identified from the cardiac surgical databases in 3 of the larger cardiothoracic surgical departments in Sydney. The patients with functioning renal transplants were excluded. The estimated glomerular filtration rate (eGFR) was calculated from the Modification of Diet in Renal Disease formula, where eGFR mL/min = $32{,}788 \times (\text{serum creatinine } \mu\text{mol/L})^{-1.154} \times (\text{age in years})^{-0.203} \times (0.742 \text{ if female})$. The formula does not account for the body surface area and is based on an eGFR of mL/min/1.73 m^2 body surface area. The patients were classified as preoperatively DD or preoperatively NDD. The periods of data collection were January 1996 to June 2010 for Prince of Wales Hospital (POWH), September 2005 to December 2010 for Royal Prince Alfred Hospital (RPAH), and September

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Disclosures: Authors have nothing to disclose with regard to commercial support.

Drs Fernando and Paterson contributed equally to this work.

Received for publication Aug 9, 2013; revisions received Nov 24, 2013; accepted for publication Dec 10, 2013; available ahead of print Feb 9, 2014.

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0022-5223/$36.00

http://dx.doi.org/10.1016/j.jtcvs.2013.12.064

Abbreviations and Acronyms

CAG = coronary artery graft surgery
CKD = chronic kidney disease
DD = dialysis dependent
LVEF = left ventricular ejection fraction
NDD = nondialysis dependent
OR = odds ratio
POWH = Prince of Wales Hospital
RPAH = Royal Prince Alfred Hospital

1999 to March 2009 for Westmead Hospital (WH). The human research ethics committee of each hospital approved the present study.

Surgical Data Acquisition

The data were obtained from cardiothoracic surgical databases in the 3 participating hospitals. All 3 cardiothoracic surgical units collected data, in keeping with the Australian and New Zealand Society of Cardiothoracic Surgeons data definitions. Follow-up data were obtained by matching the names against the hospital dialysis databases and against the New South Wales Register of Births, Deaths, and Marriages. A total of 39 operative and preoperative variables (with major variables listed in Table 1) were analyzed in relation to the following outcomes in the specified patient groups:

1. Perioperative death (during surgery or same admission, all patients)
2. Early postoperative dialysis (NDD patients)
3. New permanent dialysis (within 6 months of surgery for discharged NDD patients)
4. Interval to death for those surviving 6 months after surgery (''late death landmark analysis'')

Long-Term Renal and Mortality Data

The nephrology departments of all 3 hospitals maintained data collected prospectively from dialysis and transplantation patients and provided yearly input to the national data base (Australian and New Zealand Dialysis and Transplant Registry). In the few patients for whom no data were available, the hospital medical records were used. The data were also matched with the New South Wales Registry of Births, Deaths, and Marriages, which is linked to the death registers in the other Australian states. The follow-up of patients through the hospital databases and the New South Wales Register of Births, Deaths, and Marriages has demonstrated a better than 99% accuracy.[5]

Statistical Analysis

The statistical software programs, Statistical Package for Social Sciences, version 21, and S-PLUS, version 8, were used to analyze the data. Two-tailed tests with a significance level of 5% were used throughout. The chi-square or Fisher's exact test, as appropriate, were used to test for an association between the categorical variables. The 2-sample *t* tests were used to test for differences in the age distribution. Kaplan-Meier survival curves were used to illustrate the survival distributions, and log-rank tests were used to test for differences among the subgroups. The 1-, 5-, and 10-year overall survival rates and their 95% confidence intervals ([CI], Greenwood formula) were calculated.

Variables with a univariate association of $P < .1$ were considered candidates for inclusion in multiple logistic regression models for each of the dichotomous outcomes (perioperative death, dialysis in the postoperative period for NDD patients, and new permanent dialysis within 6 months of surgery for discharged NDD patients). The eGFR calculated from the preoperative serum creatinine was separated into 3 groups of NDD patients (<20, 20-25, and >25 mL/min) comprising approximately equal numbers in each group. When statistical significance for eGFR has been expressed, it was relative to the group with eGFR >25 mL/min. All analyses reported were from the use of eGFR values and groups. The preoperative serum creatinine was also used to define 3 groups (200-250, 251-350, and >350 μmol/L), and the analyses were repeated, substituting the serum creatinine values and groups for the eGFR values and groups. When a significance for creatinine has been expressed, it was relative to the group with preoperative serum creatinine 200 to 250 μmol/L. Backward stepwise variable selection was used to identify the independent predictors of each dichotomous outcome. Odds ratios (ORs) and their 95% CIs were used to quantify the strength of the association.

For patients alive 6 months after surgery, a landmark analysis was used to assess the effect of permanent dialysis status at 6 months on late survival and to identify the independent predictors of the interval to ''late death.'' Variables exhibiting $P < .1$ on univariate analysis were considered candidates for inclusion in multiple Cox regression models. Backward stepwise variable selection was used to identify the independent predictors. The hazard ratios and their 95% CIs were used to quantify the strength of association.

RESULTS

Patient Characteristics

A total of 15,816 patients (POWH, 7583; RPAH, 2670; WH, 5563) underwent cardiothoracic surgery in the 3 surgical units during the periods of data collection, with 545 meeting the criteria for preoperative CKD. Of the 545 patients with preoperative CKD, 196 (36%) were DD and 349 (64%) were NDD. Two thirds were male, with a mean age of 65.5 $\pm$ 12.4 years, and the median follow-up period was 8.4 years (95% CI, 7.3-9.5). The major patient characteristics and significant differences between the DD and NDD patients and between the CKD and other cardiac surgery patients are listed in Table 1.

Overall Survival

The data in Figure 1 shows that the 1-, 5-, and 10-year survival estimate for all patients with CKD was 78%, 56%, and 36%, respectively, with no significant difference in overall survival between the DD and NDD groups ($P = .615$). The 1-, 5-, and 10-year survival estimates with 95% CIs for the various subgroups of patients are listed in Table 2.

Perioperative Death

The overall perioperative mortality was 76 of 545 (13.9%), and all 3 hospitals had similar rates (POWH, 14.3%; WH, 13.8%; RPAH, 13.5%). Of the 76 who died, 47 were men and 29 were women ($P = .063$); 57 (16.3%) were NDD patients and 19 (9.7%) were DD patients ($P = .032$). The perioperative mortality for primary, isolated, nonemergency coronary artery graft surgery (CAG) was 5.8%, and for isolated CAG, it was 9.4%. Multiple logistic regression analysis of all patients with