# The association between preoperative eGFR and outcomes in cardiac surgical patients

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**ABSTRACT**

**Aim:** To study the relationship between preoperative renal function and outcomes in patients undergoing cardiac surgery.

**Design, setting and participants:** A retrospective descriptive study was performed on all patients who had coronary artery bypass, cardiac valve surgery and/or aortic arch surgery at a tertiary-referral hospital between January 2002 and December 2007.

**Main outcome measures:** Clinical and demographic variables were compared across renal dysfunction categories, defined by glomerular filtration rate (eGFR) calculated using the modified Modification of Diet in Renal Disease (MDRD) equation. Logistic regression was used to assess the association between eGFR and outcomes, primarily in-hospital mortality.

**Results:** 7440 patients were included, with a mean age of 64 years and overall mortality of 1.6%. Across worsening renal function states, excluding patients receiving dialysis, patients were older, more likely to be women and to have comorbidities (particularly diabetes and vascular disease), as well as ventricular dysfunction, and to require emergency or more complex surgery. Unadjusted outcomes, as well as univariate and multivariate analysis, consistently demonstrated that odds ratios for adverse events increased with worsening renal function, even at moderate levels of dysfunction.

**Conclusions:** Preoperative renal dysfunction is independently associated with mortality after cardiac surgery. This is consistent with the accumulating evidence supporting preoperative renal dysfunction as a powerful predictor of adverse outcomes.

Crit Care Resusc 2009; 11: 184–190

Cardiac surgery has positive outcomes for most patients, ranging from relief of symptoms and improved quality of life to prolongation of survival.[1] However, preoperative renal dysfunction is a well described risk factor for mortality and adverse outcomes after cardiac surgery.[2-6] A level of serum creatinine (eg, > 200 µmol/L) is often used to denote severely impaired renal function, but mild and moderate levels of renal dysfunction are also associated with poor outcomes after myocardial infarction,[7] coronary artery bypass surgery[8] and valvular heart surgery.[9] Patients with renal disease also have a higher prevalence of risk factors for atherosclerosis, such as diabetes, hypertension and dyslipidaemia.[10]

The level of baseline renal function influences the risk of developing postoperative renal failure and of death.[4] Patients who develop postoperative renal failure have a mortality risk variously reported between 28% and 64%.[3] The risk of developing a new requirement for dialysis in the postoperative period has been reported as between 0.5% and 15%.[3] A clear association has been described between postoperative renal failure and prolonged intensive care unit stay and hospital length of stay, and increased costs of treatment.[11] A higher preoperative glomerular filtration rate (GFR) appears to attenuate the effect of postoperative renal dysfunction on mortality.[4] The high mortality of acute renal failure is independent of other factors, such as coexisting illnesses and comorbidities, including hypertension, diabetes mellitus, liver disease and sepsis.[12]

The National Kidney Foundation (USA)[13] and Kidney Health Australia[14] recommend estimating GFR by the Modification of Diet in Renal Disease (MDRD) formula to assess renal function and stratify the risk of progressing to renal failure. Two formulas exist: the six-variable formula (which includes age, creatinine, urea, albumin, sex and race) and the abbreviated four-variable formula[15,16] (age, creatinine, sex and race), also known as the eGFR. The eGFR was used by Cooper et al[6] in a study of over 500 000 patients undergoing isolated coronary artery bypass graft (CABG) surgery, recorded in the Society of Thoracic Surgeons database.

There are no published Australian data documenting the effect of renal impairment on perioperative outcomes in the cardiac surgical population. Although isolated CABG accounts for 70%–85% of cardiac surgery in large US and European series,[17] it accounts for about 60%–65% of cardiac surgery in Australia.[18] Cardiac valve surgery and thoracic aortic surgery are known risk factors for mortality and adverse events; thus, including this large subset of cardiac surgical patients is important to understanding outcomes.[17] We therefore studied the effect of levels of renal dysfunction on perioperative outcomes in a more heterogeneous cardiac surgical sample.

## Methods

The study was carried out at Prince Charles Hospital, Brisbane, Queensland, a 450-bed tertiary-referral, university-affiliated teaching hospital with a predominantly cardiothoracic casemix. Data were obtained from the cardiac surgery and intensive care unit databases. Patients included were those who had CABG surgery, cardiac valve surgery or thoracic aortic surgery between 1 January 2002 and 31 December 2007. Patients were excluded if they were aged less than 18 years, or were undergoing transplantation, treatment with a ventricular assist device, pulmonary thromboendarterectomy or adult congenital heart surgery.

### Data collection and outcomes

Renal function was described by the serum creatinine level and eGFR. The preoperative creatinine level was defined as the last measurement before surgery.

The eGFR was estimated using the four-variable MDRD formula:

$$\text{eGFR (mL/min/1.73 m}^2\text{)} = 186 \times (\text{serum creatinine } [\mu\text{mol/L}]/88.4)^{-1.15} \times \text{age (years)}^{-0.203} (\times 0.742, \text{ if female}) (\times 1.21 \text{ if African American}).$$

Renal function was classified on the basis of published guidelines and previous studies as:[6,13,14]

- normal if the GFR was > 90 mL/min/1.73 m²;
- mildly impaired if it was 60–90 mL/min/1.73 m²;
- moderately impaired if it was 30–59 mL/min/1.73 m²; and
- severely impaired if it was < 30 mL/min/1.73 m².

Patients on a preoperative dialysis program were excluded from these calculations and were classified as having dialysis-dependent renal failure (DDRF), with an assumed GFR < 30 mL/min/1.73 m².

Returns to the operating room for bleeding or other causes were recorded. Other data collected were defined as per the logistic EuroSCORE,[17] unless otherwise specified.

**Table 1. Patient characteristics, by degree of preoperative impairment of renal function (eGFR category)***

| | Degree of impairment (eGFR, mL/min/1.73 m²) | | | | |
|---|---|---|---|---|---|
| Variable | Normal (>90) (*n* = 1109) | Mild (60–90) (*n* = 3985) | Moderate (30–59) (*n* = 2109) | Severe (< 30) (*n* = 170) | DDRF (*n* = 67) |
| Mean age (years) (SD) | 55 (13) | 64 (11) | 70 (9) | 69 (11) | 60 (13) |
| Sex, no. of women (%) | 252 (23%) | 880 (22%) | 890 (42%) | 78 (46%) | 21 (37%) |
| Mean body surface area (m²) | 1.92 | 1.93 | 1.87 | 1.86 | 1.87 |
| Diabetes | 234 (21%) | 839 (21%) | 593 (28%) | 64 (37%) | 19 (28%) |
| Serum creatinine (mean) (μmol/L) | 70 | 92 | 122 | 251 | 441 |
| Vascular disease | 77 (7%) | 481 (12%) | 404 (19%) | 47 (28%) | 10 (15%) |
| Chronic pulmonary disease | 140 (13%) | 519 (13%) | 348 (17%) | 24(14%) | 11 (16%) |
| Neurological dysfunction | 19 (2%) | 51 (1%) | 44 (2%) | 7 (4%) | 1 (1%) |
| Ejection fraction < 30% | 24 (2%) | 107 (3%) | 101 (5%) | 13 (8%) | 4 (6%) |
| Ejection fraction, 30%–50% | 181 (16%) | 722 (18%) | 475 (23%) | 49 (29%) | 18 (27%) |
| Critical preoperative state | 46 (4%) | 104 (3%) | 96 (5%) | 46 (27%) | 18 (27%) |
| Unstable angina | 48 (4%) | 109 (3%) | 65 (3%) | 5 (3%) | 1 (1%) |
| Previous myocardial infarction | 235 (21%) | 886 (22%) | 490 (23%) | 40 (24%) | 16 (24%) |
| Elective surgery | 686 (62%) | 1575 (65%) | 1312 (62%) | 73 (43%) | 25 (37%) |
| Emergency or salvage surgery | 28 (3%) | 104 (3%) | 73 (3%) | 18 (11%) | 1 (1%) |
| Reoperation | 118 (11%) | 401 (10%) | 268 (13%) | 32 (19%) | 13 (19%) |
| Endocarditis | 31 (3%) | 49 (1%) | 39 (2%) | 23 (14%) | 16 (24%) |
| Pulmonary hypertension | 60 (5%) | 171 (4%) | 165 (8%) | 25 (15%) | 10 (15%) |
| Post-infarct ventricular septal defect | 0 | 4 (0.1%) | 5 (0.2%) | 0 | 0 |
| Preoperative ventilation | 6 (0.5%) | 17 (0.4%) | 31 (2%) | 22 (13%) | 0 |
| Aortic surgery | 91 (8%) | 217 (5%) | 103 (5%) | 11 (6%) | 4 (6%) |
| Logistic EuroSCORE (%) | 4.8% | 5.6% | 9.8% | 23.7% | 17.7% |
| Median APACHE II score (IQR) | 12 (9–14) | 13 (11–15) | 15 (13–17) | 18 (16–20) | 13 (10–15) |

eGFR = glomerular filtration rate calculated with the abbreviated (four-variable) MDRD equation. DDRF = dialysis-dependent renal failure. IQR = interquartile range. * Values are number of patients (%) unless otherwise specified.

**Table 2. Operative characteristics and outcomes, by degree of preoperative impairment of renal function (eGFR category)**

| | Degree of impairment (eGFR, mL/min/1.73 m$^2$) | | | | |
|---|---|---|---|---|---|
| | Normal (> 90) (*n* = 1109) | Mild (60–90) (*n* = 3985) | Moderate (30–59) (*n* = 2109) | Severe (< 30) (*n* = 170) | DDRF (*n* = 67) |
| **Type of surgery** | | | | | |
| CABG only, no. (%) | 670 (60%) | 2560 (64%) | 1131 (54%) | 74 (44%) | 28 (42%) |
| 1 valve, no. (%) | 209 (18%) | 387 (15%) | 312 (15%) | 30(18%) | 19 (28%) |
| 1 valve + CABG, no. (%) | 72 (6%) | 399 (10%) | 357 (17%) | 34 (20%) | 10 (15%) |
| Aortic or complex surgery, no. (%) | 158 (14%) | 439 (11%) | 309 (15%) | 32 (19%) | 10 (15%) |
| **Intraoperative variables** | | | | | |
| Mean cardiopulmonary bypass time (min) | 89.3 | 88.7 | 94.9 | 113 | 87.8 |
| Mean cross-clamp time (min) | 62.7 | 62.9 | 65.6 | 76.1 | 59.2 |
| **Outcomes** | | | | | |
| In-hospital deaths, no. (%) | 7 (0.6%) | 37 (0.9%) | 55 (2.6%) | 20 (11.8%) | 2 (3%) |
| Median ventilation hours (IQR) | 8 (17) | 9 (17) | 11 (31) | 17 (63) | 19 (76) |
| Median ICU LOS hours (IQR) | 23 (37) | 24 (38) | 26 (58) | 65 (110) | 71 (132) |
| ICU readmission (%) | 3.1% | 2.7% | 5.8% | 10.8% | 9.8% |
| Re-ventilation (%) | 3.3% | 2.6% | 3.3% | 7.7% | 4.8% |
| Median postoperative hospital LOS days (IQR) | 7 (9) | 8 (9) | 9 (12) | 11 (16) | 11 (16) |
| Postoperative renal failure (%) | 0.25% | 0.07% | 0.85% | 20.8% | na |
| Return to operating theatre for bleeding (%) | 3.8% | 3.3% | 4.8% | 9.2% | 7.8% |

eGFR = glomerular filtration rate calculated with the abbreviated (four-variable) MDRD equation. DDRF = dialysis-dependent renal failure. CABG = coronary artery bypass graft. LOS = length of stay. IQR = interquartile range.

The primary outcome measure was in-hospital mortality. Secondary outcome measures were prolonged mechanical ventilation in the ICU (defined as mechanical ventilation for longer than 48 hours); prolonged ICU stay (defined as ICU stay longer than 96 hours); and prolonged postoperative hospital stay (defined as discharge more than 14 days after surgery). Postoperative renal failure was defined as two or more of: an increase in creatinine level > 200 mmol/L; a need for new dialysis; or a doubling of serum creatinine level from baseline.

## Data analysis

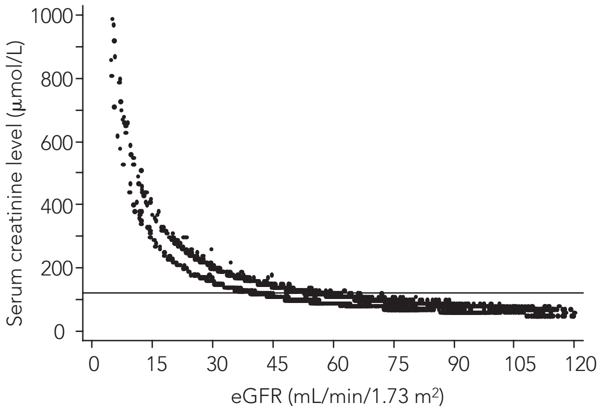
Clinical and demographic variables were compared across renal dysfunction categories with the Kruskal–Wallis test (for continuous variables) or the $\chi^2$ test of general association (for categorical variables).

Logistic regression was used to assess the effect of eGFR on outcomes by univariate and multivariate methods. In the multivariate model, important preoperative risk factors previously identified by the Society of Thoracic Surgeons morbidity and mortality models[6,8] and logistic EuroSCORE[17] perioperative risk of death models were included. Independent variables considered were complexity of surgery, reoperation, ventricular function, vascular disease, recent myocardial infarction, unstable angina, chronic lung disease, pulmonary hypertension, neurological dysfunction, critical preoperative state, urgency status and active endocarditis. Age, sex and serum creatinine level were not included as they are determinants of eGFR.

The models were analysed for goodness of fit using the Hosmer–Lemeshow test, and for their predictive abilities by assessing the area under the receiver operating characteristics curves. Pearson residuals were analysed. Sample size did not allow investigation of interactions between eGFR and other key risk factors. In addition to categorising GFR, we also performed univariate and multivariate analyses in which GFR was treated as a continuous variable. This analysis excluded patients with DDRF.

We assumed that the variables that were predictive of mortality were likely to be predictive of prolonged mechanical ventilation, prolonged ICU length of stay and prolonged hospital length of stay, as previously suggested by Tu et al.[19] We excluded patients who died in the operating room (14 patients) from the length of stay analysis. We examined the relationship between serum creatinine level and MDRD eGFR graphically. We examined the relationship between

**Figure 1. Relationship between preoperative serum creatinine level and eGFR***




eGFR = glomerular filtration rate calculated with the abbreviated (four-variable) MDRD equation.

* Excluding patients receiving dialysis.

eGFR and risk of death both with and without regression splines.

## Results

The study included 7440 patients, with a mean age of 64 years (median, 65 years); 29% were women. The overall mortality was 1.6% (121 deaths). The mean preoperative creatinine level was 104 mmol/L (median, 90 mmol/L; interquartile range [IQR], 80–110 mmol/L). There were 205 patients (2.8%) with a preoperative creatinine level > 200 mmol/L.

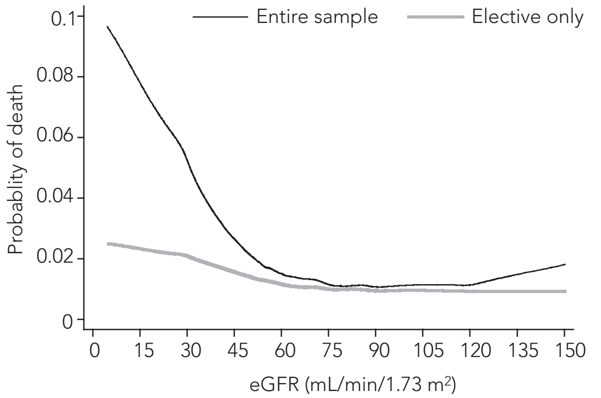
The mean eGFR was 68 mL/min/1.73 m$^2$ (SD, 22 mL/min/1.73 m$^2$). The distribution of eGFR values was: > 90 mL/min/1.73 m² in 1109 patients (15%); 60–90 mL/min/1.73m² in 3985 (54%); 30–59 mL/min/1.73 m² in 2109 (29%); 15 to < 30 mL/min/1.73 m² in 151 (2%); and < 15 mL/min/1.73 m² in 19 who were not receiving dialysis; 67 (1%) had DDRF preoperatively. There were 131 patients with an eGFR > 120 mL/min/1.73 m².

**Table 3. Relationship between impaired renal function and risk–adjusted outcomes for the entire sample and for those undergoing elective surgery only (values shown are odds ratios [95% CI]*)**

| Outcome, by degree of preoperative renal impairment | Entire sample | | Elective surgery group† | |
|---|---|---|---|---|
| | Univariate | Multivariate | Univariate | Multivariate |
| In–hospital mortality | (*n* = 121) | | (*n* = 40) | |
| Mild | 1.5 (0.7–3.3) | 1.6 (0.7–3.7) | 0.8 (0.2–3) | –‡ |
| Moderate | 4.2 (1.9–9.3) | 3.5 (1.6–8) | 4.2 (1.3–14) | – |
| Severe | 21 (8.7–50) | 9.5 (3.6–25) | 13.2 (2.9–60) | – |
| DDRF | 4.8 (1–24) | 3.3 (0.6–17) | – | – |
| Prolonged mechanical ventilation (> 48 h) | (*n* = 392) | | (*n* = 146) | |
| Mild | 1.2 (0.8–1.8) | 1.4 (0.9–2.1) | 1.3 (0.7–2.5) | 1.5 (0.8–2.8) |
| Moderate | 2.7 (1.9–4) | 2.6 (1.7–4) | 3 (1.6–5.6) | 2.9 (1.5–5.4) |
| Severe | 10.4 (6.3–17) | 4.5 (2.5–8.2) | 6.9 (2.7–17.5) | 7.1 (2.7–18.2) |
| DDRF | 7.8 (3.9–15.8) | 3.8 (1.7–8.5) | 2.4 (0.3–20) | 1.9 (0.2–15.6) |
| Prolonged ICU LOS (> 96 h) | (*n* = 500) | | (*n* = 196) | |
| Mild | 1.5 (1–2.2) | 1.7 (1.1–2.6) | 2.3 (1.2–4.6) | 2.6 (1.3–5.2) |
| Moderate | 4.6 (3.2–6.8) | 4.6 (3.1–6.9) | 5.9 (3–11.8) | 5.4 (2.7–10.9) |
| Severe | 13.7 (8.4–22.5) | 6.4 (3.6–11.2) | 9.3 (3.5–25) | 8.1(2.9–22.8) |
| DDRF | 20.1 (10.8–37.2) | 12.2 (6.1–24.5) | 25 (8–78) | 20.5 (6.3–67) |
| Prolonged postoperative hospital LOS (> 14 days) | (*n* = 877) | | (*n* = 380) | |
| Mild | 1.2 (0.9–1.5) | 1.4 (1–1.8) | 1.5 (1–2.3) | 1.6 (1.1–2.5) |
| Moderate | 2.0 (2.3–3.8) | 3.1 (2.4–4.1) | 4.0 (2.6–6.1) | 3.7 (2.4–5.6) |
| Severe | 6.8 (4.6–10.1) | 3.8 (2.4–8) | 5.8 (2.9–11.6) | 5.5 (2.7–11.5) |
| DDRF | 4.9 (2.7–8.7) | 1.8 (0.9–3.8) | 3.5 (1–12) | 2.7 (0.7–10) |

DDRF = dialysis-dependent renal failure. LOS = length of stay. * With normal glomerular filtration rate as the reference group.
† Critical preoperative condition, emergency status and active endocarditis were not considered in the risk-adjustment models for the elective surgery group.
‡ There were too few deaths in the elective subgroup for a multivariate model.

**Figure 2. Relationship between risk-adjusted probability of in-hospital death and eGFR for the entire sample and the subgroup who underwent elective surgery***




eGFR = glomerular filtration rate calculated with the abbreviated (four-variable) MDRD equation.
* The graphs exclude patients with dialysis-dependent renal failure; eGFR was truncated at 150 mL/min/1.73 m$^2$.

**Table 4. Summary of properties of models used in the multivariate analysis of the entire sample***

| Model | *P* for calibration (Hosmer–Lemeshow goodness of fit) | Discrimination (area under ROC curve) |
|---|---|---|
| In-hospital mortality | 0.5 | 0.84 |
| Prolonged ventilation | 0.5 | 0.82 |
| Prolonged ICU stay | 0.5 | 0.82 |
| Prolonged hospital stay | 0.001 | 0.77 |

ROC = receiver operating characteristics.
eGFR = glomerular filtration rate calculated with the abbreviated (four-variable) MDRD equation.
* Variables that were included in the model in addition to eGFR were: reoperation; ejection fraction < 30%; ejection fraction 30%–50%; vascular disease; recent myocardial infarction; chronic lung disease; pulmonary hypertension; neurological dysfunction; critical preoperative condition; emergency status; surgery on aorta; additional major cardiac procedure; and active endocarditis.

Preoperative patient characteristics are shown in Table 1: 1749 patients (24%) were recorded as having diabetes. Of these, 59% were taking oral hypoglycaemic drugs, 22% were being treated with diet control alone, and 18% were taking insulin, with 1% receiving no therapy. Surgery was elective in 63%, urgent in 34%, emergency in 3% and salvage in 13 patients. Cardiac surgery was performed with cardiopulmonary bypass in 7411 patients, with the remainder undergoing CABG surgery without bypass ("off pump"); 61% of patients had CABG surgery only, and the remainder had cardiac valve, valve plus coronary or aortic wall surgery.

Excluding patients receiving dialysis, those with reduced preoperative eGFR were older, more likely to be women, and more likely to have comorbidities (particularly diabetes and vascular disease). They were also more likely to be in a critical preoperative state, to have poor ventricular function and to undergo emergency surgery. The mean logistic EuroSCORE risk of death increased progressively across the renal categories, but dialysis-dependent patients had an overall lower risk of death compared with those with severe renal dysfunction. Those with greater renal dysfunction also underwent surgery that was more complex (eg, double valve or aortic wall surgery). Table 2 shows the operative variables and outcomes. There were two early deaths in the DDRF group.

Figure 1 shows the relationship between preoperative serum creatinine level and GFR using the abbreviated MDRD equation, excluding patients receiving dialysis. It highlights the wide variation in GFR for a single creatinine recording. For example, individuals with a preoperative creatinine level of 100 µmol/L might have a GFR anywhere in the range 50–90 mL/min/1.73 m$^2$, depending on other variables.

The unadjusted outcome measures showed progressively worsening outcomes in those with increasing renal dysfunction, the exception being those with DDRF (Table 2). In the univariate analysis, increasing renal dysfunction was clearly associated with prolonged mechanical ventilation, ICU length of stay and postoperative length of hospital stay (Table 3). There was a progressive increase in risk-adjusted mortality for worsening renal function. Diabetes was not found to be an independent risk factor for short-term adverse outcomes. The odds ratios for mortality with increasing renal dysfunction were similar when cardiopulmonary bypass time was added to the model of preoperative variables (not shown). It can be seen that at moderate levels of renal dysfunction (eGFR, 30–59 mL/min/1.73 m$^2$), risk-adjusted outcomes progressively worsened. When eGFR was analysed as a continuous variable in the univariate analysis, the odds of death were 0.97 (0.96–0.98) per mL/min/1.73 m$^2$ increase in eGFR. In the multivariate analysis, when controlling for the factors described above, the odds were 0.98 (0.97–0.99) per mL/min/1.73 m$^2$. Table 3 also shows the relationship between the outcome variables and eGFR for the subgroup who underwent elective surgery.

A graph of predicted risk of death and GFR using a lowess smoothing curve showed the lowest risk at a GFR of 90 mL/min/1.73 m$^2$, with a linear rise in risk as GFR decreased to 15 mL/min/1.73 m$^2$ (Figure 2). When the elective-only subgroup was plotted, the rise in risk was much less.

All models showed adequate calibration and discrimination, with the exception of a poor fit for prolonged postoperative length of stay (Table 4).

## Discussion

Our results are consistent with the accumulating evidence that preoperative renal dysfunction is independently associated with mortality after cardiac surgery. The risk of mortality increases with the degree of renal impairment but, importantly, exists with even a mild reduction in GFR. Consistent with other studies,[20] it is also evident from Table 1 and Figure 1 that with even minor increases in serum creatinine level, there is a markedly reduced GFR.

Significant independent associations were shown for preoperative GFR and duration of ventilation, ICU length of stay and postoperative hospital length of stay, consistent with results of a large study by Cooper et al.[6] It is not surprising that this single factor is such a powerful discriminator for outcome when its calculation incorporates patient age, sex and creatinine level, which are independent predictive factors for complications after cardiac surgery.[17]

In contrast to the study by Cooper et al,[6] we found that the DDRF group did not have the worst outcomes, and these patients were at a lower risk when using EuroSCORE compared with those with an eGFR < 30 mL/min/1.73 $m^2$. This may be related to the small sample size or differing patient selection practices. Of note, our institution has a practice of returning patients with DDRF to their referring renal unit at another centre, which is likely to account for an apparent reduction in length of stay in our hospital.

Interestingly, a diagnosis of diabetes did not appear to be strongly related to short-term adverse outcomes in this cohort. It is possible that the patients with diabetes were heterogeneous in disease severity and tightness of baseline and perioperative glycaemic control. A more accurate determination of the magnitude of independent risk conferred by diabetes would be facilitated by preoperative assessment of glycated haemoglobin ($HbA_{1C}$) and end-organ micro- or macrovascular diabetic complications, including the presence of microalbuminuria or hyperfiltration.[21] Subgroup analysis of outcomes in patients with diabetes was not possible as this more detailed information is not routinely collected.

We used the MDRD formula to calculate GFR rather than the Cockcroft and Gault formula.[22] This was to ensure that our results could be more accurately compared with similar series of cardiac surgical patients. It has been noted that these measurements may be inaccurate when the GFR is > 60 mL/min and when patients are not in a "steady state" of renal function.[23] Only those undergoing elective surgery were likely to be in this steady state. It should be appreciated that the Cockcroft and Gault formula is also subject to inaccuracy, particularly in patients not in a steady state, such as critically ill patients and those requiring emergency surgery.[24] However, we acknowledge that in certain clinical situations the MDRD GFR is not validated, and creatinine clearance estimated by the Cockcroft and Gault formula is currently recommended for drug-dose calculations.[25] We also found that the group with a high eGFR (> 120 mL/min/1.73 $m^2$), although a small subset, showed a tendency to increased risk. This subset requires further analysis.

The ability to stratify patients based on individual risk is increasingly important for a population that is surviving to older ages, has more comorbidities and is undergoing more complex cardiac surgical procedures. Renal function has emerged as a risk factor of great importance. Institutions should anticipate and allocate appropriate resources — including provisions for renal replacement therapy — proportionate to the needs of the casemix. Studies such as ours enable these needs to be more fully quantified. This study also suggests that risk models that dichotomise renal function based on creatinine level require review. Most patients who developed postoperative renal failure had severely impaired renal function preoperatively. Interventions should be sought that attenuate the development of acute renal failure in patients with preoperative renal impairment. To this end, further elucidation of the pathophysiology of acute renal failure complicating cardiac surgery is essential.

## Acknowledgements

We thank Adrian Barnett (Queensland University of Technology, Brisbane, QLD) for statistical advice.

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