Renal Function and Outcome From Coronary Artery Bypass Grafting
Impact on Mortality After a 2.3-Year Follow-Up

Graham S. Hillis, MBChB, PhD; Bernie L. Croal, MBChB, MD; Keith G. Buchan, MBChB; Hussein El-Shafei, MBChB, MD; George Gibson, MBChB; Robert R. Jeffrey, MBChB; Colin G.M. Millar, MBChB, PhD; Gordon J. Prescott, BSc, MSc; Brian H. Cuthbertson, MBChB, MD

Background—Severe renal dysfunction is associated with a worse outcome after coronary artery bypass graft surgery (CABG). Less is known about the effects of milder degrees of renal impairment, and previous studies have relied on levels of serum creatinine, an insensitive indicator of renal function. Recent studies have suggested that estimated glomerular filtration rate (eGFR) is a more discriminatory measure. However, data on the utility of eGFR in predicting outcome from CABG are limited.

Methods and Results—We studied 2067 consecutive patients undergoing CABG. Demographic and clinical data were collected preoperatively, and patients were followed up a median of 2.3 years after surgery. Estimated GFR was calculated from the Modification of Diet in Renal Disease equation. The primary outcome was all-cause mortality. Mean ± SD eGFR was 57.9 ± 17.6 mL/min per 1.73 m² in the 158 patients who died during follow-up compared with 64.7 ± 13.8 mL/min per 1.73 m² in survivors (hazard ratio [HR], 0.71 per 10 mL/min per 1.73 m²; 95% CI, 0.64 to 0.80; P < 0.001). Estimated GFR was an independent predictor of mortality in both models with other individual univariable predictors (HR, 0.80 per 10 mL/min per 1.73 m²; 95% CI, 0.72 to 0.89; P < 0.001) and the European system for cardiac operative risk evaluation (HR, 0.88 per 10 mL/min per 1.73 m²; 95% CI, 0.78 to 0.98; P = 0.02).

Conclusions—Estimated GFR is a powerful and independent predictor of mortality after CABG. (Circulation. 2006;113:1056-1062.)

Key Words: coronary disease • kidney • surgery • survival

Coronary artery bypass graft surgery (CABG) is a highly successful surgical treatment for the relief of angina and, in selected patients, prolongation of life. It is, however, associated with a significant morbidity and mortality, and several factors have been identified as predictive of complications. These include renal dysfunction and, in particular, the requirement for renal replacement therapy. A worse outcome also has been reported in patients with renal dysfunction not requiring dialysis. These studies have concentrated on patients with moderately to severely elevated serum creatinine who were dichotomized on the basis of an arbitrary cutoff level. Serum creatinine now is generally accepted to be an insensitive indicator of renal function. In contrast, glomerular filtration rate (GFR), a more accurate measure, is recommended for this purpose and identifies patients with mild renal impairment despite normal or nearly normal creatinine levels.

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Recent data demonstrate that estimated GFR (eGFR) is a very powerful predictor of outcome in patients with acute myocardial infarction and is more useful in this respect than serum creatinine. Likewise, in recent large population studies, eGFR was a strong predictor of cardiovascular events and death. There are, however, very limited data on the prognostic utility of eGFR in patients undergoing CABG. The present study addresses this issue.

Methods

Patients and Measures
The study was approved by the Grampian Research Ethics Committee. The study cohort consisted of 2067 consecutive patients who underwent CABG at the Aberdeen Royal Infirmary between April 1, 2000, and March 31, 2004, who did not require preoperative dialysis.

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From the Departments of Cardiology (G.S.H.), Cardiac Surgery (K.G.B., H.E.S., G.G., R.R.J.), Clinical Biochemistry (B.L.C.), Nephrology (C.G.M.M.), and Public Health (G.J.P.), and Health Services Research Unit (B.H.C.), University of Aberdeen and Aberdeen Royal Infirmary, Aberdeen UK.
Correspondence to Dr Graham Hillis, Senior Lecturer in Cardiology, Department of Cardiology, Aberdeen Royal Infirmary, Aberdeen, AB25 2ZZ, UK.
E-mail g.hillis@abdn.ac.uk
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Demographic and clinical data were recorded at the time of surgery by an experienced full-time data collector. This information included prior medical history, cardiac risk factors, operative details, and symptom status, including the preoperative Canadian Cardiovascular Society angina status, NYHA functional class, and the European system for cardiac operative risk evaluation (EuroSCORE). Two hundred thirty patients (11%) had other major procedures performed in addition to CABG. They included 208 valve replacement/repair operations (155 aortic [1 with aortic root replacement], 50 mitral [1 with atrial septal defect closure], and 3 combined aortic and mitral), 5 postinfarct ventricular septal defect closures, 9 left ventricular aneurysm resections, 4 thoracic aortic procedures (without aortic valve replacement), 2 atrial myxoma excisions, 1 isolated atrial septal defect closure, and 1 pericardiectomy.

Preoperative creatinine levels were obtained, and the GFR was estimated from the Modification of Diet in Renal Disease equation: \(\text{eGFR} = 186 \times (\text{serum creatinine level}[\text{mg/dL}]^{-1.154} \times \text{age}^{-0.203})\). The product of this equation was multiplied by a correction factor of 0.742 for women. There were no black patients in the current cohort. In general terms, however, a correction factor of 1.212 is applied for black subjects. Patients were also categorized into 4 groups depending on their eGFR (\(\geq 75, 60 \text{ to } 74, 45 \text{ to } 59, \text{ and } <45 \text{ mL/min per } 1.73 \text{ m}^2\)).

Follow-Up

Patients were followed up during November 2004 through the use of computerized hospital records and a vital events search by the General Register Office for Scotland. The primary study end point was all-cause mortality. In addition, the cause of death was recorded and classified as cardiac when it was documented on the death certificate as the principal cause or a major contributory factor. The duration of postoperative hospitalization and 30-day total mortality were also recorded.

Statistical Analyses

Categorical data are summarized using absolute values (percentage). Normally distributed continuous data are presented as mean (SD) or, where skewed, as median (interquartile range [IQR]). Clinical characteristics in categories of patients with differing eGFRs were compared by use of the \(\chi^2\) test for trend and the Jonckheere-Terpstra test. Characteristics of patients alive or dead at 30 days were compared by use of the \(\text{eGFR (SD), mL/min per } 1.73 \text{ m}^2\)
compared using the \( \chi^2 \) test and logistic regression. Long-term survival was described with the Kaplan-Meier method, and comparisons made by use of the log-rank statistic. Estimations of risk were performed by Cox regression. Potential independent predictors of outcome were identified by univariable analyses. All univariable predictors were then entered in a stepwise manner into a multivariable model of survival, with entry and retention set at a significance level of \( P \leq 0.05 \). Quadratic modeling was used to investigate whether the effect of eGFR on mortality was linear. Receiver-operating characteristic curves were used to assess the most clinically useful level of eGFR in predicting early mortality. SPSS version 13.0 (SPSS Inc) was used for all analyses.

**Results**

**Patient Population**

The study cohort was predominantly male with a median age of 66 years (Table 1). Creatinine levels were obtained a median of 1 day (IQR, 1 to 2 days) before surgery. The cohort had a median creatinine of 1.14 mg/dL (101 μmol/L) and a mean eGFR of 64.1 mL/min per 1.73 m\(^2\) (Figure 1). Thirty-seven percent (765 of 2067) of those undergoing CABG had an eGFR <60 mL/min per 1.73 m\(^2\), signifying significant renal dysfunction. Patients with poorer renal function were older, more often were female, and had a higher prevalence of diabetes and hypertension (Table 2). They also had worse left ventricular systolic function, more cardiac symptoms, and a higher median EuroSCORE. The median postoperative hospital stay of patients with an eGFR <60 mL/min per 1.73 m\(^2\) was 10 days (IQR, 8 to 13 days) compared with 8 days (IQR, 7 to 11 days) for those with an eGFR above this threshold.

**Follow-Up**

Vital status data were obtained on all patients a median of 2.3 years (IQR, 1.4 to 3.4 years) after surgery. The 30-day mortality rate was 3.1% (64 of 2067). There were 94 (4.5%) late (after 30 days) deaths. The 1- and 3-year survival rates were 95% and 91%, respectively. One hundred twenty-two deaths (77%) during follow-up were recorded as being primarily or partially cardiovascular.

**Univariable Predictors of Outcome**

Renal function, whether measured with creatinine or eGFR, was a powerful univariable predictor of long-term and 30-day mortality (Table 1 and Figure 2). In univariable analysis, for every additional 1 mL/min per 1.73 m\(^2\) that eGFR increases, the risk of death decreases by 3% (95% CI, 2 to 4) when all data are considered or by 5% (95% CI, 4 to 7) when 30-day mortality is considered. A 10–mL/min per 1.73 m\(^2\) increase in eGFR was associated with a 5% (95% CI, 3 to 7) decrease in the risk of death when all data are considered.

**TABLE 2. Baseline Characteristics According to eGFR**

<table>
<thead>
<tr>
<th>eGFR, mL/min per 1.73 m(^2)</th>
<th>(&lt;45.0) (n=174)</th>
<th>(45.0–59.9) (n=591)</th>
<th>(60.0–74.9) (n=862)</th>
<th>(\geq 75.0) (n=440)</th>
<th>(P)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, y</td>
<td>73 (68–77)</td>
<td>70 (64–74)</td>
<td>65 (59–70)</td>
<td>61 (53–67)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Male, n (%)</td>
<td>86 (49)</td>
<td>390 (66)</td>
<td>706 (82)</td>
<td>411 (93)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Creatinine (IQR), mg/dL</td>
<td>1.69 (1.40–1.97)</td>
<td>1.31 (1.14–1.41)</td>
<td>1.14 (1.07–1.20)</td>
<td>1.00 (0.93–1.03)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Hypertension, n (%)</td>
<td>114 (66)</td>
<td>380 (64)</td>
<td>487 (56)</td>
<td>250 (57)</td>
<td>0.002</td>
</tr>
<tr>
<td>Diabetes mellitus, n (%)</td>
<td>41 (24)</td>
<td>101 (17)</td>
<td>116 (13)</td>
<td>57 (13)</td>
<td>0.001</td>
</tr>
<tr>
<td>Smoker, n (%)</td>
<td>15 (9)</td>
<td>34 (6)</td>
<td>90 (10)</td>
<td>79 (18)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Previous MI, n (%)</td>
<td>93 (53)</td>
<td>309 (52)</td>
<td>403 (47)</td>
<td>225 (51)</td>
<td>0.29</td>
</tr>
<tr>
<td>Estimated LVEF &lt;50%,* n (%)</td>
<td>69 (41)</td>
<td>221 (38)</td>
<td>291 (34)</td>
<td>138 (31)</td>
<td>0.007</td>
</tr>
<tr>
<td>CCS status III or IV,† n (%)</td>
<td>105 (61)</td>
<td>342 (58)</td>
<td>443 (51)</td>
<td>242 (55)</td>
<td>0.07</td>
</tr>
<tr>
<td>NYHA class III or IV,‡ n (%)</td>
<td>105 (66)</td>
<td>302 (55)</td>
<td>414 (52)</td>
<td>208 (51)</td>
<td>0.003</td>
</tr>
<tr>
<td>EuroSCORE</td>
<td>6 (4–8)</td>
<td>5 (3–7)</td>
<td>3 (2–5)</td>
<td>3 (1–5)</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

Abbreviations as in Table 1. Percentages refer to patients with data available. To convert creatinine values to micromoles per liter, multiply by 88.4.

*Left ventricular ejection fraction was not defined in 16 cases.
†CCS angina status was not accurately recorded in 7 patients.
‡NYHA functional class was not accurately recorded in 152 patients.
eGFR decreased the risk of long-term mortality by 29% (95% CI, 20 to 36) and 30-day mortality by 42% (95% CI, 31 to 51). Other univariable predictors of long-term mortality included increasing age, diabetes mellitus, prior CABG, recent acute myocardial infarction (particularly within the previous week), left ventricular ejection fraction, requirement for other major cardiac surgical procedure in addition to CABG, use of a preoperative balloon pump, and the preoperative EuroSCORE. The predictors of 30-day mortality were broadly similar (Table 1). Estimated GFR also was associated with a longer postoperative hospital stay (Table 3).

### Multivariable Predictors of Outcome

Serum creatinine and eGFR are mathematically related. However, in this cohort, when eGFR was used, creatinine provided no additional prognostic information. Therefore, eGFR was used in subsequent forward conditional multivariable models. The first model included the univariable predictors of long-term mortality shown in Table 1 (age, diabetes mellitus, previous CABG, estimated left ventricular ejection fraction <50%, myocardial infarction in the preceding week, requirement for other major cardiac surgical procedure in addition to CABG, use of a preoperative balloon pump, and eGFR) except EuroSCORE, which is a composite that includes several of these parameters. In this model, the independent predictors of mortality were the requirement for an additional major cardiac surgical procedure, myocardial infarction in the past week, left ventricular ejection fraction <50%, and eGFR (Table 4). Exclusion of age (a component of eGFR) resulted in no changes in the result of this model. Likewise, inclusion of gender (a further component) did not alter the result.

The hazard ratio (HR) for eGFR means that the risk of death at any instant during follow-up is decreased by 2% (95% CI, 1 to 3) for each additional 1–mL/min per 1.73 m² rise in eGFR. Likewise, if we are comparing 2 patients who differ only in that 1 has an eGFR 10 mL/min per 1.73 m² higher than the other, on average, the risk of death will be decreased by 20% (95% CI, 11

### Table 3. Outcomes According to the eGFR

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>&lt;45.0 (n=174)</th>
<th>45.0–59.9 (n=591)</th>
<th>60.0–74.9 (n=862)</th>
<th>≥75.0 (n=440)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Long-term mortality, n (%)</strong></td>
<td>35 (20)</td>
<td>53 (9)</td>
<td>46 (5)</td>
<td>24 (5)</td>
</tr>
<tr>
<td>Unadjusted HR (95% CI)</td>
<td>4.15 (2.47–6.98)</td>
<td>1.76 (1.09–2.86)</td>
<td>1.00 (0.61–1.64)</td>
<td>1</td>
</tr>
<tr>
<td>HR adjusted for age/gender (95% CI)</td>
<td>3.08 (1.71–5.55)</td>
<td>1.43 (0.85–2.39)</td>
<td>0.91 (0.55–1.50)</td>
<td>1</td>
</tr>
<tr>
<td>HR adjusted for EuroSCORE (95% CI)</td>
<td>1.83 (1.04–3.20)</td>
<td>1.12 (0.68–1.84)</td>
<td>0.87 (0.53–1.43)</td>
<td>1</td>
</tr>
<tr>
<td><strong>30-d Mortality, n (%)</strong></td>
<td>19 (11)</td>
<td>26 (4)</td>
<td>12 (1)</td>
<td>7 (2)</td>
</tr>
<tr>
<td>Unadjusted HR (95% CI)</td>
<td>7.58 (3.13–18.39)</td>
<td>2.85 (1.22–6.62)</td>
<td>0.87 (0.34–2.23)</td>
<td>1</td>
</tr>
<tr>
<td>HR adjusted for age/gender (95% CI)</td>
<td>6.80 (2.53–18.28)</td>
<td>2.62 (1.07–6.43)</td>
<td>0.84 (0.33–2.17)</td>
<td>1</td>
</tr>
<tr>
<td>HR adjusted for EuroSCORE (95% CI)</td>
<td>2.11 (0.79–5.61)</td>
<td>1.47 (0.61–3.53)</td>
<td>0.70 (0.27–1.82)</td>
<td>1</td>
</tr>
<tr>
<td>Postoperative hospital stay (IQR), d</td>
<td>11 (8–15)</td>
<td>9 (8–13)</td>
<td>8 (7–11)</td>
<td>8 (7–11)</td>
</tr>
</tbody>
</table>
to 28) in the patient with the higher eGFR. When a quadratic model is used, the hazard associated with a fall in eGFR rises as renal function declines. For example, at eGFRs of 20, 40, and 60 mL/min per 1.73 m², a further decrease in eGFR of 10 mL/min per 1.73 m² is associated with an increase in the risk of death of 67%, 40%, and 17%, respectively (Table 5).

In a model that included just eGFR and EuroSCORE, both were significant predictors of long-term outcome (eGFR HR: 0.99 per 1–mL/min per 1.73 m² increase; 95% CI, 0.98 to 1.00; and 0.88 per 10–mL/min per 1.73 m² increase; 95% CI, 0.78 to 0.98; P = 0.02; EuroSCORE HR: 1.25; 95% CI, 1.19 to 1.31; P < 0.001), suggesting that the former adds incremental prognostic information.

Similar results were evident for 30-day mortality. In a multivariable model including univariable predictors shown in Table 1 (age, estimated left ventricular ejection fraction <50%, myocardial infarction in the prior week, requirement for other major cardiac surgical procedure in addition to CABG, use of a preoperative balloon pump, NYHA functional class III or IV symptoms, and eGFR) except EuroSCORE, the independent predictors of mortality were the requirement for an additional major cardiac surgical procedure, myocardial infarction in the past week, left ventricular ejection fraction <50%, use of a preoperative balloon pump, and eGFR (Table 6). Again, exclusion of age did not change these results, nor did the inclusion of gender. In a model that included just eGFR and EuroSCORE, both were significant predictors of 30-day mortality (eGFR HR: 0.98 per 1–mL/min per 1.73 m² increase; 95% CI, 0.96 to 1.00; and 0.80 per 10–mL/min per 1.73 m² increase; 95% CI, 0.66 to 0.97; P = 0.02; EuroSCORE HR: 1.36; 95% CI, 1.26 to 1.47; P < 0.001).

### Sensitivity and Specificity of eGFR for Predicting Early Mortality

Receiver-operating characteristic curves were constructed using all eGFR measures and the prospectively defined eGFR levels (≥75, 60 to 74, 45 to 59, and <45 mL/min per 1.73 m²). These confirmed that an eGFR level of 60 mL/min per 1.73 m² was the most useful in predicting 30-day mortality. At this level, eGFR had a sensitivity of 70.3% (95% CI, 57.4 to 80.8) with a specificity of 64.1% (95% CI, 61.9 to 66.2). The area under the receiver-operating characteristic curve for eGFR predicting death during 30-day follow-up was 0.70 (95% CI, 0.62 to 0.77; P < 0.001).

### Discussion

The current data demonstrate that renal insufficiency is common in patients undergoing CABG. In addition, renal dysfunction is associated with prolonged hospitalization and, more importantly, is an independent predictor of both short- and long-term mortality. In the present cohort, ~37% of patients undergoing CABG had an eGFR suggestive of chronic kidney disease (<60 mL/min per 1.73 m²). These patients stayed a median of 2 days longer in hospital after CABG, accounted for 70% of all deaths within the first 30 days of surgery, and were twice as likely to die during long-term follow-up.

Renal impairment is associated with a worse prognosis both in patients undergoing CABG and in those treated with percutaneous coronary intervention.15-24 However, prior studies of patients undergoing CABG have generally relied on serum creatinine to determine renal function. It is well recognized, however, that creatinine has significant limitations in this role.16 More discriminatory measures of renal function such as creatinine clearance or GFR are strong predictors of mortality and other cardiac events after percutaneous coronary intervention23 and in patients with an acute coronary syndrome.25-26 Likewise, recent data have confirmed the superiority of eGFR over creatinine as an indicator of prognosis in patients with acute myocardial infarction complicated by heart failure and/or left

### Table 4. Multivariable Predictors of Long-Term Mortality

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>HR</th>
<th>95% CI</th>
<th>Wald χ²</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Additional major cardiac procedure</td>
<td>3.37</td>
<td>2.35–4.83</td>
<td>44.0</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Myocardial infarction in prior week</td>
<td>4.14</td>
<td>2.30–7.45</td>
<td>22.5</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>eGFR*</td>
<td>0.98</td>
<td>0.97–0.99</td>
<td>16.3</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>LV ejection fraction &lt;50%</td>
<td>1.65</td>
<td>1.20–2.27</td>
<td>9.3</td>
<td>0.002</td>
</tr>
</tbody>
</table>

*Hazard ratio per 1–mL/min per 1.73 m² increase. HR per 10–mL/min per 1.73 m² increase, 0.80; 95% CI, 0.72–0.89.

### Table 5. Effects of Changes in eGFR at Differing Underlying Levels of Renal Function

<table>
<thead>
<tr>
<th>Basal eGFR, mL/min per 1.73 m²</th>
<th>20</th>
<th>30</th>
<th>40</th>
<th>45</th>
<th>50</th>
<th>55</th>
<th>60</th>
<th>70</th>
<th>80</th>
</tr>
</thead>
<tbody>
<tr>
<td>HR for 10–mL/min per 1.73 m² increase in eGFR</td>
<td>0.601</td>
<td>0.655</td>
<td>0.715</td>
<td>0.747</td>
<td>0.780</td>
<td>0.815</td>
<td>0.851</td>
<td>0.929</td>
<td>1.014</td>
</tr>
<tr>
<td>Percentage change in HR</td>
<td>−39.9</td>
<td>−34.5</td>
<td>−28.5</td>
<td>−25.3</td>
<td>−22.0</td>
<td>−18.5</td>
<td>−14.9</td>
<td>−7.1</td>
<td>1.4</td>
</tr>
<tr>
<td>HR for 10–mL/min per 1.73 m² decrease in eGFR</td>
<td>1.665</td>
<td>1.526</td>
<td>1.398</td>
<td>1.339</td>
<td>1.282</td>
<td>1.227</td>
<td>1.175</td>
<td>1.076</td>
<td>0.987</td>
</tr>
<tr>
<td>Percentage change in HR</td>
<td>66.5</td>
<td>52.6</td>
<td>39.8</td>
<td>33.9</td>
<td>28.2</td>
<td>22.7</td>
<td>17.5</td>
<td>7.6</td>
<td>−1.3</td>
</tr>
</tbody>
</table>

Negative value for HR denotes decrease and positive value denotes an increase in the instantaneous risk of death.
ventricular systolic dysfunction.17 Despite this, current widely used prognostic scoring systems either do not use renal function at all27 or rely on serum creatinine as a dichotomous variable,21 nonspecific parameters such as renal failure,28 or the need for renal replacement therapy.29 The current data suggest that the use of more accurate measures of renal function might provide greater prognostic information.

Estimated GFR predicts the long-term outcome of patients with severe left ventricular systolic dysfunction who undergo CABG.29a There are, however, limited data on its prognostic utility in the broader population of patients undergoing bypass surgery. A recently published study by Thakar and colleagues30 concentrates primarily on the effects of postoperative renal function (and the change from preoperative levels) on short-term outcome and includes patients undergoing all forms of major cardiac surgery. However, the authors report that, in this setting, preoperative eGFR is a powerful univariable predictor of inhospital mortality (with a median eGFR of 57 mL/min per 1.73 m² in those who died compared with 72 mL/min per 1.73 m² in those surviving to discharge).30 The independence of this effect from the influence of other risk factors is not addressed, and no separate analysis is provided for patients undergoing CABG. Nevertheless, the findings provide supportive evidence for the importance of renal function, particularly eGFR, in determining the outcome of cardiac surgery. They also highlight the importance of any postoperative decline in renal function, an issue not addressed in the present study.

The increased risk associated with renal dysfunction is nonlinear, with the risk of death rising as eGFR declines. This is in keeping with prior population data18,31 and a recent analysis of patients with acute myocardial infarction complicated by heart failure demonstrating a steep rise in the risk of death once eGFR fell to <60 mL/min per 1.73 m².17 This important point should be kept in mind when considering hazard ratios that refer to changes in the estimated risk of death throughout the entire population. Although a 10–mL/min per 1.73 m² rise in eGFR is associated with an average 20% decrease in the risk of death, the implications of a similar difference will be much greater in patients with lower levels of renal function.

Impaired renal function may increase cardiovascular risk in several ways. Renal dysfunction is associated with other disease processes such as diabetes mellitus and hypertension that are themselves determinants of poorer outcome. In addition, renal dysfunction in association with these factors imparts a markedly worse prognosis. A declining GFR is also associated with several other factors that influence outcome in cardiac disease such as impaired left ventricular systolic function and more severe symptoms of heart failure. Nevertheless, in keeping with prior data,17–20,31 the present study demonstrates that renal impairment is a powerful independent risk factor. This may reflect the increased inflammation and oxidative stress associated with poorer renal function. In addition, kidney dysfunction may be associated with multiple other physiological changes. These include high levels of homocysteine, hyperuricemia, hypercalcemia, anemia, and uremia, all of which have detrimental cardiovascular effects.32 Certainly, patients with end-stage renal failure have greatly accelerated vascular disease and a very high cardiac risk.32 Thus, renal function integrates the effects of many factors, all of which affect cardiovascular outcome. In addition, it has been suggested that, given the effects of vascular disease on renal function, this may serve as a useful indicator of vascular health.33 Both of these may underpin its prognostic utility.

Study Strengths and Limitations
The strength of this study is that it assesses outcome in a large contemporary cohort of consecutive patients undergoing CABG in a regional cardiothoracic surgical center. Therefore, the results are likely to be widely generalizable. The large cohort also ensures that all-cause mortality can be used as the primary end point. This has the advantage of being entirely objective.34 However, the absence of data on other important nonfatal outcomes such as myocardial infarction, heart failure, and stroke is a limitation. Other limitations include the lack of data on albuminuria, which is an independent predictor of cardiovascular risk and may contribute to the cardiovascular effects of renal dysfunction.35 In addition, eGFR is based on a single measurement. This may fluctuate, particularly in patients with unstable hemodynamics and varying medical therapy. We do not have data on medications used at the time of GFR estimation or after surgery. This may also affect outcome.

Despite these limitations, our data clearly demonstrate the importance of renal function, particularly eGFR, in predicting the short- and long-term prognosis of patients undergoing CABG. Although the Modification of Diet in Renal Disease equation is complex, eGFR can be estimated rapidly with electronic calculators and can be incorporated easily into standard laboratory reporting systems.33 Further work is required to develop models to integrate such data into existing or novel risk prediction tools. Perhaps more importantly, future studies should determine strategies that can improve the outcome of patients with renal dysfunction in this setting.

Acknowledgment
We are grateful to Eileen Anderson for her help in the prospective collection of data and compilation of the study database.

Disclosures
None.

References
CLINICAL PERSPECTIVE

Estimated glomerular filtration rate (eGFR) is a powerful predictor of outcome in patients with acute myocardial infarction and is more useful in this respect than serum creatinine. Likewise, in recent large population studies, eGFR was a strong predictor of outcome in patients with chronic renal insufficiency. Bypass angioplasty revascularization intervention (BARI) Investigators. Outcomes of patients with chronic renal insufficiency in the Bypass Angioplasty Revascularization Investigation. Circulation. 2002;105:2253–2258.


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