Are Patients With Renal Failure Good Candidates for Percutaneous Coronary Revascularization in the New Device Era?

Mark H. Rubenstein, MD; Lari C. Harrell, MS; Boris V. Sheynberg, MD; Heribert Schunkert, MD; Hasan Bazari, MD; Igor F. Palacios, MD

Background—Patients with end-stage renal disease undergoing conventional balloon angioplasty have reduced procedural success and increased complication rates. This study was designed to determine the immediate and long-term outcomes of patients with varying degrees of renal failure undergoing percutaneous coronary intervention in the current device era.

Methods and Results—We compared the immediate and long-term outcomes of 362 renal failure patients (creatinine >1.5 mg/dL) with those of 2972 patients with normal renal function who underwent percutaneous coronary intervention between 1994 and 1997. Patients with renal failure were older and had more associated comorbidities. They had reduced procedural success (89.5% versus 92.9%, \( P = 0.007 \)) and greater in-hospital combined major event (death, Q-wave myocardial infarction, emergent CABG; 10.8% versus 1.8%; \( P < 0.0001 \)) rates. Renal failure was an independent predictor of major adverse cardiac events (MACEs) (OR, 3.41; 95% CI, 1.84 to 6.22; \( P < 0.00001 \)). Logistic regression analysis identified shock, peripheral vascular disease, balloon angioplasty strategy, and unstable angina as independent predictors of in-hospital MACEs in the renal group. Compared with 362 age- and sex-matched patients selected from the control group, patients with renal failure had a lower survival rate (27.7% versus 61.0%, \( P < 0.0001 \)) and a greater MACE rate (51% versus 33%, \( P < 0.001 \)) at long-term follow-up. Cox regression analysis identified age and PTCA strategy as independent predictors of long-term MACEs in the renal group. Finally, within the renal failure population, the dialysis and nondialysis patients experienced remarkably similar immediate and long-term outcomes.

Conclusions—Although patients with renal failure can be treated with a high procedural success rate in the new device era, they have an increased rate of major events both in hospital and at long-term follow-up. Nevertheless, utilization of stenting and debulking techniques improves immediate and long-term outcomes. (Circulation. 2000;102:2966-2972.)

Key Words: renal failure ■ angioplasty ■ stents ■ coronary devices

Patients with varying degrees of renal failure make up an increasing percentage of the population undergoing percutaneous coronary intervention (PCI). This trend is largely due to the prolonged lifespan of renal failure patients combined with a predisposition to accelerated atherosclerosis.1,2 The outcomes of PCI in this broad patient population are unknown. Previous surgical and angioplasty studies have shown that coronary revascularization improves prognosis in patients with end-stage renal failure.3,4 Several small studies, focusing on end-stage renal disease patients undergoing conventional balloon angioplasty, have shown poor procedural success rates and dismal long-term event-free survival.5-7 Patients with renal insufficiency have a higher incidence of complex coronary lesion morphology and therefore may be less amenable to conventional balloon angioplasty.8 Over the last decade, new lesion-specific coronary devices, such as coronary stents and a variety of debulking techniques, have improved the outcome of PCI in complex lesions.9-13 Therefore, the present study was designed to determine the immediate and long-term outcomes of patients with varying degrees of renal failure in the current new device era.

Methods

Patient Population

From a total of 3334 patients who underwent percutaneous coronary revascularization between October 1994 and January 1997, we identified 362 patients with renal failure at the time of admission. These patients comprised the study population (renal group). Renal failure was defined as a preprocedural creatinine >1.5 mg/dL. Of these 362 patients, 27 (7.5%) were on chronic dialysis. The outcomes of PCI in this broad patient population are unknown. Previous surgical and angioplasty studies have shown that coronary revascularization improves prognosis in patients with end-stage renal failure.3,4 Several small studies, focusing on end-stage renal disease patients undergoing conventional balloon angioplasty, have shown poor procedural success rates and dismal long-term event-free survival.5-7 Patients with renal insufficiency have a higher incidence of complex coronary lesion morphology and therefore may be less amenable to conventional balloon angioplasty.8 Over the last decade, new lesion-specific coronary devices, such as coronary stents and a variety of debulking techniques, have improved the outcome of PCI in complex lesions.9-13 Therefore, the present study was designed to determine the immediate and long-term outcomes of patients with varying degrees of renal failure in the current new device era.

Methods

Patient Population

From a total of 3334 patients who underwent percutaneous coronary revascularization between October 1994 and January 1997, we identified 362 patients with renal failure at the time of admission. These patients comprised the study population (renal group). Renal failure was defined as a preprocedural creatinine >1.5 mg/dL. Of these 362 patients, 27 (7.5%) were on chronic dialysis. In the first phase of analysis, baseline characteristics, procedural success, and major in-hospital adverse events of these patients were compared with those of the remaining 2972 patients without evidence of renal
failure (control group). In the second phase, long-term outcome of
the patients in the renal group was compared with that of 362 patients
matched by age and sex selected randomly from the control group
(matched group). Finally, outcomes of the dialysis patients were
compared with those of the remaining nondialysis patients within the
renal group.

Clinical and Periprocedural Variables
Demographic, clinical, and preprocedural data were determined as
part of the routine evaluation before attempted coronary intervention
and entered prospectively in the InterCard database.14 Patient demo-
graphics, coronary risk factors, preprocedural associated major
comorbidities, and clinical admission syndrome, including chronic
stable angina, unstable angina, post-myocardial infarction angina,
cardiogenic shock, evolving myocardial infarction, and congestive
heart failure, were prospectively collected as part of the routine
evaluation before attempted coronary intervention.

Coronary intervention was considered to be complicated by a
major adverse event when death (cardiac and noncardiac) or Q-wave
myocardial infarction occurred during the hospital stay, regardless of
the time that elapsed between the procedure and the event. Coronary
bypass surgery was considered to be a major adverse event when
performed within the first 24 hours after the procedure. A >2-fold
increase in creatine kinase-MB above the upper limit of normal (10
ng/mL), regardless of total creatine kinase, in the absence of new Q
waves in the ECG, was considered to indicate a non–Q-wave
infarction. Patient charts were reviewed daily for adverse events until
hospital discharge or death.

Procedural Variables and Quantitative
Coronary Angiography
Lesion morphology was classified according to the American Heart
Association/American College of Cardiology (AHA/ACC) Classifi-
cation Task Force, with the exception that type B lesions were
further stratified into B1 and B2 lesions according to Ellis and
coworkers.15 Device strategy and utilization, intraprocedural adverse
events, and procedural outcome were recorded. A lesion treatment
was considered to be successful when there was a >20% gain in
luminal diameter and <50% residual diameter stenosis in the
absence of major complications (death, Q-wave myocardial infarction,
or emergency bypass surgery).

Reference and minimal luminal diameter and percent degree of
stenosis were determined by use of a computer-assisted, automated
device detection algorithm (MEDIS, Computer Measurements
System).16

Follow-Up
Follow-up information was obtained by trained medical personnel
using direct telephone interviews with the patients. When necessary,
local physicians were contacted for further information, and medical
records were reviewed. This information included mortality and
major adverse cardiac events (MACEs). MACE at long-term
follow-up was defined as death, myocardial infarction, CABG, or
repeated PCI.

Statistical Analysis
Continuous variables are expressed as mean±SD; categorical vari-
ables, as percent. Student’s t test and χ² analysis were carried out for
comparison of continuous and categorical variables, respectively. A
value of P<0.05 was considered significant. All analyses were
performed with SAS software version 6.10 (SAS Institute). Demo-
graphic, clinical, procedural, angiographic, and periprocedural vari-
ables were tested to determine significant univariate correlates of
both procedural success and combined major adverse events. Uni-
variate correlates with values of P<0.05 were considered significant.
Multiple stepwise logistic regression analysis of all significant
univariate factors was performed to determine both independent
predictors of procedural success and correlates of combined in-
hospital major events. Cox regression analysis was performed to
determine independent predictors of combined major events in the
renal group.

Long-term outcomes of the renal and matched groups were
determined by Kaplan-Meier curves and compared by the log-rank
test. Similar analyses were performed to compare the dialysis and
nondialysis renal groups. Finally, Cox regression analysis was used to
identify independent predictors of both MACEs and mortality at
follow-up in the renal group.

Results
Patients Characteristics
The 362 patients with renal failure represent 11% of the entire
population. The baseline clinical characteristics, associated
comorbidities, admission syndromes, and median creatinine
values of the 3 groups of patients are shown in Table 1. Compared
with the control group, patients with renal failure were older and presented more frequently with clinical
syndromes known to be associated with periprocedural com-
plications, ie, diabetes, hypertension, lower left ventricular
ejection fraction, chronic obstructive pulmonary disease,
vascular disease, congestive heart failure, cardiogenic shock,
multivessel disease, history of prior CABG, and history of
previous myocardial infarction. Compared with the matched
group, patients with renal failure demonstrated the same
statistically significant differences that were noted with the
control group with the exception of age (because they were
more likely to present with myocardial infarction,
cardiogenic shock, and congestive heart failure and less likely
to present with stable or unstable angina.

Angiographic Characteristics
The angiographic characteristics of the 3 groups of patients
are shown in Table 2. Compared with the control and
matched groups, the renal patients were more likely to have
interventions performed on saphenous vein bypass grafts and
on type C lesions. There were no statistically significant
differences in AHA/ACC lesion types A, B1, and B2 or in the
preprocedure and postprocedure quantitative coronary angio-
graphic analysis characteristics among the 3 groups of pa-
tients. There was no statistically significant difference in the
incidence of native target arteries with reference diameter
≤2.5 mm among the 3 groups of patients.

Interventional Strategy
The interventional strategies utilized in the 3 groups of
patients are shown in Table 3. There was no statistically
significant difference in interventional strategy used in the 3
groups. Importantly, the use of stenting dramatically in-
creased in the overall population from a utilization rate of
12.8% in the first half of 1994 to a 65% (P=0.0001)
utilization rate by the end of the study period. This was
associated with a concomitant increase in lesion success rate
from 90.6% to 94.6% (P<0.0001) over the same time period.
Similarly, in the renal group, stent utilization increased from
9% to 56% (P<0.0001), and the procedural success rate
increased from 84% to 95% (P<0.05). Importantly, the
improvement in procedural success was more marked in the
renal group than in the control population (relative risk [RR], 2.4; \( P < 0.0001 \)), suggesting that renal failure patients derive a greater benefit from stenting.

### In-Hospital Results

Procedural success and in-hospital outcomes are shown in Table 4. Procedural success was lower in the renal group than in the control and the matched groups. MACE rate was greater in the renal group than in the control and the matched groups. This difference was entirely attributable to an increased death rate in the renal group. There was no statistically significant difference in emergent CABG or Q-wave myocardial infarction among the 3 groups of patients. When patients in cardiogenic shock were excluded from the analysis, the MACE rate decreased to 6.0% but was still significantly higher than for either the control or matched group (6.0%, 1.4%, and 1.7% for the renal, control, and matched groups, respectively; \( P < 0.001 \)). In addition, renal patients had a higher incidence of blood transfusion and vascular repair. Median postprocedure length of hospital stay was greater in the renal group than in the control and the matched groups. Finally, there were no statistically significant differences in in-hospital outcomes between the dialysis patients and the remainder of the renal group (Table 5). Again, in-hospital MACE rate was almost entirely a function of mortality, with a negligible contribution from emergent CABG and Q-wave myocardial infarction.

### Predictors of In-Hospital MACE in Overall Population

In the overall population, multiple stepwise regression analysis identified the presence of renal failure as an independent predictor of in-hospital MACE (OR, 3.41; 95% CI, 1.84 to 6.22; \( P < 0.0001 \)). Other independent predictors of in-hospital MACE included cardiogenic shock (OR, 19.94; 95% CI, 10.0 to 39.6; \( P < 0.0001 \)), increased age (OR, 7.60; 95% CI, 1.43 to 43.52; \( P = 0.02 \)), type C lesions (OR, 2.60; 95% CI, 1.37 to 4.66; \( P = 0.002 \)), and the presence of congestive heart failure (OR, 1.98; 95% CI, 1.01 to 3.77; \( P = 0.04 \)). Patients with unstable angina (OR, 0.41; 95% CI, 0.20 to 0.80; \( P = 0.01 \)) and those who received stents (OR, 0.23; 95% CI, 0.05 to 0.63; \( P = 0.04 \)) were significantly less likely to experience an adverse outcome.

### Predictors of In-Hospital MACE in the Renal Group

Cardiogenic shock (OR, 17.7; 95% CI, 6.1 to 56.9; \( P < 0.00001 \)), conventional balloon angioplasty strategy (OR, 4.38; 95% CI, 1.4 to 19.4; \( P = 0.02 \)), presence of vascular disease (OR, 2.89; 95% CI, 1.1 to 8.0; \( P = 0.03 \)), and unstable angina (OR, 0.11; 95% CI: 0.02 to 0.4; \( P = 0.004 \)) were

---

### Table 1. Baseline Characteristics

<table>
<thead>
<tr>
<th>Patients, n</th>
<th>Renal</th>
<th>Control</th>
<th>Matched</th>
<th>( P )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, y</td>
<td>72±10</td>
<td>63±12</td>
<td>72±10</td>
<td>&lt;0.001†‡</td>
</tr>
<tr>
<td>Female, %</td>
<td>32</td>
<td>31</td>
<td>32</td>
<td>0.47</td>
</tr>
<tr>
<td>Diabetes, %</td>
<td>36</td>
<td>22</td>
<td>23</td>
<td>&lt;0.001†‡</td>
</tr>
<tr>
<td>Hypertension,%</td>
<td>79</td>
<td>59</td>
<td>63</td>
<td>&lt;0.001†‡</td>
</tr>
<tr>
<td>Cholesterol &gt;200 mg/dL, %</td>
<td>74</td>
<td>74</td>
<td>69</td>
<td>0.99</td>
</tr>
<tr>
<td>Family history, %</td>
<td>53</td>
<td>63</td>
<td>54</td>
<td>&lt;0.05†</td>
</tr>
<tr>
<td>Smoking history, %</td>
<td>62</td>
<td>67</td>
<td>65</td>
<td>0.05†</td>
</tr>
<tr>
<td>LVEF, %</td>
<td>47±16</td>
<td>56±12</td>
<td>57±13</td>
<td>&lt;0.001†‡</td>
</tr>
<tr>
<td>Multivessel disease, %</td>
<td>79</td>
<td>58</td>
<td>64</td>
<td>&lt;0.0001†‡</td>
</tr>
<tr>
<td>Prior CABG, %</td>
<td>24</td>
<td>15</td>
<td>16</td>
<td>&lt;0.0001†‡</td>
</tr>
<tr>
<td>Prior intervention, %</td>
<td>28</td>
<td>27</td>
<td>25</td>
<td>0.44</td>
</tr>
<tr>
<td>Prior MI, %</td>
<td>47</td>
<td>34</td>
<td>36</td>
<td>&lt;0.0001†‡</td>
</tr>
<tr>
<td>COPD, %</td>
<td>14</td>
<td>8</td>
<td>12</td>
<td>0.01†</td>
</tr>
<tr>
<td>Vascular disease, %</td>
<td>37</td>
<td>12</td>
<td>15</td>
<td>&lt;0.0001†‡</td>
</tr>
<tr>
<td>Stable angina, %</td>
<td>4</td>
<td>7</td>
<td>8</td>
<td>0.004‡</td>
</tr>
<tr>
<td>Unstable angina, %</td>
<td>41</td>
<td>51</td>
<td>51</td>
<td>0.006‡</td>
</tr>
<tr>
<td>Post-MI angina, %</td>
<td>13</td>
<td>12</td>
<td>11</td>
<td>0.69</td>
</tr>
<tr>
<td>MI, %</td>
<td>41</td>
<td>35</td>
<td>35</td>
<td>0.048‡</td>
</tr>
<tr>
<td>Evolving MI, %</td>
<td>11</td>
<td>9</td>
<td>6</td>
<td>0.195</td>
</tr>
<tr>
<td>Cardiogenic shock, %</td>
<td>9</td>
<td>1.5</td>
<td>1</td>
<td>&lt;0.001†‡</td>
</tr>
<tr>
<td>Heart failure, %</td>
<td>32</td>
<td>6</td>
<td>8</td>
<td>&lt;0.001†‡</td>
</tr>
<tr>
<td>Creatinine, mg/dL*</td>
<td>1.9 (1.6–2.3)</td>
<td>1.0 (0.9–1.2)</td>
<td>1.0 (0.9–1.2)</td>
<td>&lt;0.001†‡</td>
</tr>
</tbody>
</table>

LVEF indicates left ventricular ejection fraction; MI, myocardial infarction; and COPD, chronic obstructive pulmonary disease.

*Median (25th and 75th percentiles).

†Renal vs control; ‡renal vs matched.
identified as independent predictors of in-hospital MACE rates in the renal failure group. Of note, diabetes mellitus was not an independent predictor of in-hospital MACE in patients with renal failure.

Long-Term Follow-Up Results

Long-term follow-up outcomes are shown in Table 6. Follow-up information was successfully obtained in 78.7% of the renal group patients and in 77.8% of the matched group patients \((P = NS)\). Follow-up MACE rate was significantly greater in the renal group than in the control group. This difference was due to an increased rate of mortality and myocardial infarction in the renal group. Kaplan-Meier analysis showed that both survival (Figure 1) and event-free survival (Figure 2) were significantly worse in the renal failure group. One-year actuarial survival was lower for the renal than the matched group (75% [95% CI, 70 to 80] versus 97% [95% CI, 93 to 99], \(P < 0.00001\)). One-year actuarial event-free survival was also lower for the renal than the matched group (55% [95% CI, 49 to 61] versus 78% [95% CI, 71 to 84], \(P < 0.00001\)). The curves separated very early after the index procedure and continued to diverge over the course of follow-up, with a steeper slope noted in the initial 6 to 10 months. The incidence rate of survival was 0.16% and 1.97% for the renal and the matched groups, respectively \((P < 0.00001)\).

Cox regression analysis identified age \((>74 \text{ years})\) (RR, 1.8; 95% CI, 1.3 to 2.5; \(P = 0.001\)), PTCA strategy (RR, 1.7; 95% CI, 1.1 to 2.5; \(P = 0.01\)), and female sex (RR, 1.4; 95% CI, 1.0 to 2.0; \(P = 0.07)\) as independent predictors of MACE at long-term follow-up in the renal group.

Finally, long-term outcomes were similar in the dialysis patients compared with the remainder of the renal population. Follow-up information was obtained in 74% of the dialysis patients compared with 78% in the nondialysis renal population \((P = NS)\). Kaplan-Meier analyses showed no statistically significant difference in survival or event-free survival between the dialysis and nondialysis renal failure patients (Figure 3).

TABLE 2. Angiographic Data

<table>
<thead>
<tr>
<th></th>
<th>Renal</th>
<th>Control</th>
<th>Matched</th>
<th>(P)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patients, n</td>
<td>362</td>
<td>2,972</td>
<td>362</td>
<td>(\ldots)</td>
</tr>
<tr>
<td>Lesions, n</td>
<td>543</td>
<td>4,366</td>
<td>541</td>
<td>(\ldots)</td>
</tr>
<tr>
<td>Vessel treated, %</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LAD</td>
<td>33.5</td>
<td>36.8</td>
<td>41.4</td>
<td>NS</td>
</tr>
<tr>
<td>Right coronary</td>
<td>27.4</td>
<td>33.4</td>
<td>29.8</td>
<td>NS</td>
</tr>
<tr>
<td>Circumflex</td>
<td>24.5</td>
<td>22.2</td>
<td>19.6</td>
<td>NS</td>
</tr>
<tr>
<td>Left main</td>
<td>1.5</td>
<td>0.9</td>
<td>0.6</td>
<td>NS</td>
</tr>
<tr>
<td>Graft</td>
<td>13.1</td>
<td>6.9</td>
<td>8.7</td>
<td>0.02†</td>
</tr>
<tr>
<td>AHA/ACC lesion, %</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type A</td>
<td>9.6</td>
<td>11.5</td>
<td>11.7</td>
<td>NS</td>
</tr>
<tr>
<td>Type B1</td>
<td>27.6</td>
<td>33.8</td>
<td>28.1</td>
<td>NS</td>
</tr>
<tr>
<td>Type B2</td>
<td>44.0</td>
<td>43.0</td>
<td>47.9</td>
<td>NS</td>
</tr>
<tr>
<td>Type C</td>
<td>17.3</td>
<td>10.2</td>
<td>10.0</td>
<td>(&lt;0.001†))</td>
</tr>
</tbody>
</table>

Quantitative coronary analysis

<table>
<thead>
<tr>
<th></th>
<th>Renal</th>
<th>Control</th>
<th>Matched</th>
<th>(P)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reference diameter, mm</td>
<td>2.9±0.7</td>
<td>2.8±0.7</td>
<td>2.8±0.6</td>
<td>NS</td>
</tr>
<tr>
<td>MLD Pre, mm</td>
<td>0.8±0.4</td>
<td>0.8±0.5</td>
<td>0.8±0.5</td>
<td>NS</td>
</tr>
<tr>
<td>MLD Post, mm</td>
<td>2.2±0.8</td>
<td>2.2±0.8</td>
<td>2.1±1.0</td>
<td>NS</td>
</tr>
<tr>
<td>Stenosis Pre, %</td>
<td>76±16</td>
<td>75±16</td>
<td>76±16</td>
<td>NS</td>
</tr>
<tr>
<td>Stenosis Post, %</td>
<td>26±19</td>
<td>25±17</td>
<td>27±17</td>
<td>NS</td>
</tr>
<tr>
<td>Lesion length, mm</td>
<td>10.3±5.7</td>
<td>10.1±5.3</td>
<td>9.2±4.8</td>
<td>0.003†</td>
</tr>
<tr>
<td>Reference diameter ≤2.5 mm, %</td>
<td>41.9</td>
<td>43.1</td>
<td>46.5</td>
<td>NS</td>
</tr>
</tbody>
</table>
Discussion

The present study demonstrates that patients with varying degrees of renal failure can be treated with a high procedural success rate in the current era of percutaneous coronary revascularization. However, despite this high procedural success rate, these patients continue to suffer significant in-hospital and long-term morbidity and mortality. Importantly, utilization of stenting and debulking techniques improves immediate and long-term outcomes in this complicated patient population.

Although coronary revascularization in end-stage renal disease patients has been studied extensively in the past decade, little is known about the impact of coronary intervention on the complex and diverse population of patients with varying degrees of renal failure. In our study, 92.5% of the patients with renal failure were not on chronic dialysis. Additionally, the renal failure cohort constitutes 11% of the entire population undergoing PCI at our institution during the study period. A thorough assessment of the characteristics, outcomes, and predictors of failure or success in this growing population is long overdue.

The renal failure population was a high-risk group. They were older and presented more frequently with clinical syndromes associated with increased periprocedural complications, such as diabetes, hypertension, chronic obstructive pulmonary disease, congestive heart failure, cardiogenic shock, multivessel coronary artery disease, history of previous CABG, and a higher incidence of saphenous vein graft and AHA/ACC type C lesion interventions.

Consequently, compared with patients with normal renal function, renal failure patients exhibit inferior immediate and long-term outcomes. They have a lower procedural success rate, increased in-hospital MACE rates, and increased noncardiac postprocedural complications. Interestingly, these inferior results are present within both the dialysis cohort and the nondialysis cohort, with no statistically significant differences. These poor outcomes in the overall renal failure population are largely the result of complex lesion morphology and the multitude of comorbid conditions previously identified as factors associated with an increased risk during PCI. Thus, renal failure is a marker for clinical and morphological characteristics associated with lower chances of successful percutaneous intervention and a higher incidence of in-hospital and follow-up adverse events.

Nevertheless, complex lesion morphology and comorbidities do not solely account for the poor outcomes in patients with renal failure. We identified renal disease itself as an independent predictor of in-hospital MACE. In fact, renal disease was the strongest predictor after cardiogenic shock and increased age. Furthermore, this finding was independent of the increased incidence of diabetes mellitus in the renal failure population.

Over the last decade, new lesion-specific coronary devices have resulted in improved angiographic outcomes for complex lesions. Because patients with renal failure have a higher incidence of complex coronary lesion morphology, which is less amenable to conventional balloon angioplasty, these new devices may offer hope to this population. In our study, percuta-

### TABLE 4. In-Hospital Outcome

<table>
<thead>
<tr>
<th>Renal</th>
<th>Control</th>
<th>Matched</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patients, n</td>
<td>362</td>
<td>2,972</td>
<td>362</td>
</tr>
<tr>
<td>Procedural success, %</td>
<td>89.5</td>
<td>92.9</td>
<td>91.5</td>
</tr>
<tr>
<td>Mortality, n (%)</td>
<td>39 (10.8)</td>
<td>33 (1.1)</td>
<td>4 (1.1)</td>
</tr>
<tr>
<td>Emergent CABG, n (%)</td>
<td>0 (0.0)</td>
<td>11 (0.4)</td>
<td>1 (0.3)</td>
</tr>
<tr>
<td>Q-wave MI, n (%)</td>
<td>2 (0.6)</td>
<td>12 (0.4)</td>
<td>2 (0.6)</td>
</tr>
<tr>
<td>In-hospital MACE rate, n (%)</td>
<td>39 (10.8)</td>
<td>5 (1.8)</td>
<td>7 (1.9)</td>
</tr>
<tr>
<td>Non-Q-wave MI, n (%)</td>
<td>24 (6.6)</td>
<td>225 (7.6)</td>
<td>22 (6.1)</td>
</tr>
<tr>
<td>Stroke, n (%)</td>
<td>5 (1.4)</td>
<td>15 (0.5)</td>
<td>2 (0.6)</td>
</tr>
<tr>
<td>Vascular repair, n (%)</td>
<td>34 (9.4)</td>
<td>91 (3.1)</td>
<td>16 (4.4)</td>
</tr>
<tr>
<td>Blood transfusion, n (%)</td>
<td>156 (43.1)</td>
<td>308 (10.4)</td>
<td>50 (13.8)</td>
</tr>
<tr>
<td>Length of stay, d*</td>
<td>5 (3–11)</td>
<td>3 (2–5)</td>
<td>4 (2–6.25)</td>
</tr>
</tbody>
</table>

*Median (25th and 75th percentiles), †Renal vs control; ‡renal vs matched.

### TABLE 5. Renal Outcomes

<table>
<thead>
<tr>
<th>Renal</th>
<th>Dialysis</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patients, n</td>
<td>335</td>
<td>27</td>
</tr>
<tr>
<td>Age, y</td>
<td>72±10.4</td>
<td>69±10.4</td>
</tr>
<tr>
<td>Female, %</td>
<td>32</td>
<td>33</td>
</tr>
<tr>
<td>Procedural success, %</td>
<td>89</td>
<td>95</td>
</tr>
<tr>
<td>Mortality, %</td>
<td>10.8</td>
<td>11.1</td>
</tr>
<tr>
<td>Emergent CABG, %</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Q-wave MI, %</td>
<td>0.6</td>
<td>0</td>
</tr>
<tr>
<td>In-hospital MACE rate, %</td>
<td>10.8</td>
<td>11.1</td>
</tr>
</tbody>
</table>

*Median (25th and 75th percentiles), MI indicates myocardial infarction.

### TABLE 6. Long-Term Follow-up Outcome

<table>
<thead>
<tr>
<th>Renal</th>
<th>Matched</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patients, n</td>
<td>285</td>
<td>179</td>
</tr>
<tr>
<td>Mortality, n (%)</td>
<td>79 (27.7)</td>
<td>11 (6.1)</td>
</tr>
<tr>
<td>Myocardial infarction, n (%)</td>
<td>35 (12.3)</td>
<td>5 (2.8)</td>
</tr>
<tr>
<td>CABG, n (%)</td>
<td>26 (9.1)</td>
<td>19 (10.6)</td>
</tr>
<tr>
<td>Repeated intervention, n (%)</td>
<td>44 (15.4)</td>
<td>36 (20.1)</td>
</tr>
<tr>
<td>Follow-up MACE, n (%)</td>
<td>145 (51)</td>
<td>59 (33)</td>
</tr>
</tbody>
</table>
neous interventional methods changed considerably during the period of observation. In particular, over the 3 years analyzed in the present study, we witnessed the evolution of stent utilization from its limited initial role to its current widespread use. In our population, stent placement in our overall population increased from 12.9% in 1994 to 70% by the beginning of 1997, thus overtaking conventional balloon angioplasty as the principal coronary interventional strategy. Regression analysis showed that those patients who received stents were significantly less likely to experience an adverse outcome.

A similar trend was observed in the renal group during this time period, as stent utilization increased from 9% in 1994 to 56% by the beginning of 1997. This increase in stent utilization in the renal group was associated with a concurrent increase in procedural success from 84% to 95%. Regression analysis identified the use of conventional balloon angioplasty strategy as an independent predictor of in-hospital MACE rates in the renal failure group. In fact, it was the second strongest predictor of a poor outcome after cardiogenic shock. Thus, the use of new devices (ie, stenting and debulking techniques) improves outcomes in the renal failure population.

The long-term results of our patients with renal failure were also inferior compared with a matched group of patients with normal renal function. Despite a high initial procedural success rate, the renal group experienced a significantly lower survival and event-free survival compared with the matched group. These inferior long-term outcomes were experienced by both the dialysis and nondialysis patients within the renal failure population, as evidenced by their almost superimposable Kaplan-Meier curves. Increased rates of mortality and myocardial infarction in the renal population accounted for the disparity between the 2 groups. This difference was evident very early after the index procedure and continued to increase over the course of follow-up. Again, in the renal group, regression analysis identified PTCA strategy as the second strongest predictor of long-term follow-up MACE after age >74 years. Thus, new devices not only affect procedural success and in-hospital outcomes but also improve long-term outcomes. With the advent

![Kaplan-Meier survival curves of patients with renal failure vs matched control subjects.](image1)

![Kaplan-Meier event-free survival curves of patients with renal failure vs matched control subjects.](image2)
Conclusions

Patients with renal failure can be treated with a high procedural success rate in the new device era. Despite this increase in success rate, they have an increased rate of major events, both in hospital and at long-term follow-up. Nevertheless, utilization of stenting and debulking techniques improves immediate and long-term outcomes.

References

Are Patients With Renal Failure Good Candidates for Percutaneous Coronary Revascularization in the New Device Era?
Mark H. Rubenstein, Lari C. Harrell, Boris V. Sheynberg, Heribert Schunkert, Hasan Bazari and Igor F. Palacios

Circulation. 2000;102:2966-2972
doi: 10.1161/01.CIR.102.24.2966

Circulation is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
Copyright © 2000 American Heart Association, Inc. All rights reserved.
Print ISSN: 0009-7322. Online ISSN: 1524-4539

The online version of this article, along with updated information and services, is located on the World Wide Web at:
http://circ.ahajournals.org/content/102/24/2966

Permissions: Requests for permissions to reproduce figures, tables, or portions of articles originally published in Circulation can be obtained via RightsLink, a service of the Copyright Clearance Center, not the Editorial Office. Once the online version of the published article for which permission is being requested is located, click Request Permissions in the middle column of the Web page under Services. Further information about this process is available in the Permissions and Rights Question and Answer document.

Reprints: Information about reprints can be found online at:
http://www.lww.com/reprints

Subscriptions: Information about subscribing to Circulation is online at:
http://circ.ahajournals.org//subscriptions/