The impact of aortic endografts on renal function

Jean-Marc Alsac, MD, a Christopher K. Zarins, MD, a Maarit A. Heikkinen, MD, a John Karwowski, MD, a Frank R. Arko, MD, a Pascal Desgranges, MD, b Françoise Roudot-Thoraval, MD, b and Jean-Pierre Becquemin, MD, b Stanford, Calif; and Creteil, France

Objective: To determine the impact on late postoperative renal function of suprarenal and infrarenal fixation of endografts used to treat infrarenal abdominal aortic aneurysm (AAA).

Methods: Retrospective analysis of 277 patients treated from 2000 to 2003 with three different endografts at two clinical centers. Five patients on dialysis for preoperative chronic renal failure were excluded. Group IF of 135 patients treated with an infrarenal device (Medtronic AneuRx) was compared with group SF of 137 patients treated with a suprarenal device (106 Cook Zenith and 31 Medtronic Talent). Renal function was evaluated by calculating preoperative and latest postoperative creatinine clearance (CrCl) using the Cockcroft formula. Patients who developed a >20% decrease in CrCl were considered to have significantly impaired renal function.

Results: There were no significant differences in patient age, sex, aneurysm size, preoperative risk factors, dose of intra- and postoperative contrast, or baseline CrCl (IF: 69.3 mL/min, SF: 71.7 mL/min, P = .4). Follow-up time of 12.2 months was the same in both groups. CrCl decreased significantly during the follow-up period in both groups (IF: 69.3 mL/min to 61.7 mL/min, P < .01; SF: 71.7 mL/min to 64.9 mL/min, P < .03). Postoperative CrCl (IF: 61.7 mL/min, SF: 64.9 mL/min, P = .3), and the rate of CrCl decrease during the follow-up period (IF: −10.9%, SF: −9.5%, P = .2) was not different between the two groups. The number of patients with a >20% decrease in CrCl was not different between the two groups (IF: n = 35 [25.9%], SF: n = 41 [29.9%], P = .46). However, the magnitude of decrease in CrCl in patients with renal impairment was greater in patients treated with suprarenal fixation endografts (SF: −39%) compared with those treated with infrarenal endografts (IF: −31%, P = .005). This greater degree of renal impairment was not due to identifiable differences in preoperative risk factors, age, or baseline CrCl. No patients in these series required dialysis.

Conclusions: Regardless the type of endograft used, there is a 10% decrease in CrCl in the first year after endovascular aneurysm repair. Suprarenal fixation does not seem to increase the likelihood of postoperative renal impairment. Decline in renal function over time after endovascular aortic repair is probably due to multiple factors, and measures known to be effective in protecting kidneys should be considered for these patients. Long-term follow-up with measurement of CrCl, along with renal imaging and regular blood pressure measurements, should be performed to detect possible late renal dysfunction. Prospective studies comparing suprarenal versus infrarenal fixation are needed to confirm those results. (J Vasc Surg 2005;41:926-30.)
Table I. Patient demographic data, aneurysm size, and preoperative risk factors

<table>
<thead>
<tr>
<th></th>
<th>Infra = AneuRx</th>
<th>Supra = Talent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(N = 135)</td>
<td>(N = 137)</td>
</tr>
<tr>
<td>Age (y)</td>
<td>75.6 (48-100)</td>
<td>73.5 (47-89)</td>
</tr>
<tr>
<td>Sex (% male)</td>
<td>88.9</td>
<td>94.2</td>
</tr>
<tr>
<td>Diameter AAA (mm)</td>
<td>54.3 (32-90)</td>
<td>56.1 (35-109)</td>
</tr>
<tr>
<td>Diabetes (%)</td>
<td>5.9</td>
<td>7.3</td>
</tr>
<tr>
<td>Hypertension (%)</td>
<td>53.3</td>
<td>56.1</td>
</tr>
</tbody>
</table>

AAA, Abdominal aortic aneurysm.

Baseline patient demographic data, preoperative aortic aneurysm size, and risk factors as defined by the Society for Vascular Surgery/American Association for Vascular Surgery reporting standard,10 were obtained for all patients. Renal function was evaluated by calculating the creatinine clearance (CrCl) using the Cockroft et al formula11:

\[
\text{CrCl} = \frac{140 - \text{age}}{\text{wt}} \times \frac{\text{Scr}}{72}
\]

where age is years, wt is absolute body weight in kilograms, Scr is serum creatinine in mg/100 mL.

Changes in renal function were evaluated by comparing the preoperative and the latest available postoperative CrCl. The observation period was defined as the interval from surgery to the most recent follow-up examination. Only patients with a ≥20% decrease in CrCl were considered to have impaired renal function.8

Both institutions used the same methods for pretreating patients with renal insufficiency. The protocol used was based on intravenous hydration for 48 hours postoperatively, and for patients with a creatinine clearance <40 mL/min, an antioxidant supplementation was added 2 days preoperatively. A similar postoperative surveillance with contrast computed tomography (CT) scan (at 1, 3, 6, and 12 months and annually thereafter) was performed for all patients in both institutions.

Statistical analyses were performed using the \( \chi^2 \) test and Student’s \( t \) test. Multiple logistic regression analysis was used to determine the factors independently associated with postoperative renal impairment. Independent factors that were included in multiple logistic regression modeling were the type of fixation, age, sex, diameter of the abdominal aortic aneurysm (AAA), preoperative risk factors, preoperative CrCl, and follow-up period. A Kaplan-Meier life-table analysis of survival free from renal impairment, using ≥20% decrease in CrCl as the event, was performed in both groups, with a log-rank (Mantel-Cox) test to compare them. Differences were deemed significant at \( P < .05 \).

RESULTS

There were no significant differences in patient age, sex, aneurysm size, preoperative risk factors, or baseline CrCl (IF: 69.3 mL/min, SF: 71.7 mL/min, \( P = .4 \)) between the two groups (Table I). The amount of intraprocedural contrast media and the number of postoperative contrast-enhanced CT scans were similar in both groups (Table II). Follow-up time was 12.2 months in both groups (range, 1 to 46 months), with similar variance. CrCl decreased significantly during the follow-up period in both groups (IF: 69.3 mL/min to 61.7 mL/min, \( P < .01 \); SF: 71.7 mL/min to 64.9 mL/min, \( P < .003 \)). Postoperative CrCl decrease during the follow-up period (IF: -10.9 %, SF: -9.5 %, \( P = .2 \)) were comparable between the two groups (Table III).

The number of patients with a >20% decrease in CrCl was not different between the two groups (IF: \( n = 35 \) [25.9%], SF: \( n = 41 \) [29.9%], \( P = .46 \)). The magnitude of decrease in CrCl in patients with renal impairment was significantly greater in patients treated with suprarenal fixation endografts (SF: -39%) compared with those treated with infrarenal endografts (IF: -31%, \( P = .005 \)). This greater degree of renal impairment was not due to identifiable differences in preoperative risk factors, age, sex, AAA size, baseline CrCl, or follow-up length (Table IV).

The multiple logistic regression modeling showed that site of fixation, age, sex, AAA size, preoperative risk factors, and the amount of intra- or postoperative contrast media were not associated with renal impairment, but the preoperative CrCl and the length of follow-up were independently associated with renal impairment (Table V).

Kaplan-Meier life-table analysis of survival free from renal impairment showed no difference between the two groups. Mean survival was 31.1 months in group IF and 29.2 months in group SF (\( P = .48 \) with log-rank test) (Fig 1). No patient in this series required dialysis.

DISCUSSION

This study analyzed two large series of patients treated with EVAR in two separate institutions during the same period of time. Both institutions routinely treated patients with infrarenal aneurysms using EVAR with the same range of indications. This may explain why both series are very comparable in terms of number of patients, age, sex, aneurysm size, preoperative risk factors, baseline CrCl, and follow-up period. All patients treated with the three most commonly implanted commercial endograft devices were reviewed at both institutions. The AneuRx stent graft is now the most commonly implanted infrarenal device.12 The Zenith and the Talent devices represent the most commonly implanted endografts with suprarenal fixation.13,14 These two endografts have similar systems of bare metal transrenal fixation, with differences in uncovered stent configuration regarding length and number of crowns and bars. It should be noted that stents used to support endografts vary in construction, and their configuration may influence their ability to affect renal function.18 At Stanford, Talent endografts were used more likely for patients with shorter necks, but there were no strict anatomic selection criteria. At Henri-Mondor, the Zenith endograft was the only implanted device during this period.

Long-term CrCl was used as the main end point to define the evolution of renal function. Many authors have
suggested that renal function can be adequately assessed only with measurements of CrCl. More sensitive tests can be applied to determine the true effect of EVAR on renal function, such as measurement of glomerular filtration rate by renal scintigraphy, but such tests may not be practical as routine investigations in large series of patients. Short-term CrCl may be influenced by many factors during the perioperative period such as the duration of the procedure, anesthetic agents, nephrotoxic contrast media, and thus may not be used as reliable evidence of definite renal impairment. For this reason, we recorded the latest postoperative CrCl at least 1 month after the procedure. We noted an overall decrease in long-term CrCl of 10.2% (P = .0005), which is comparable with other series in the literature. We found no significant difference between patients treated with infrarenal compared with those treated with suprarenal fixation endovascular devices (10.9% vs 9.5%, P = .2). The long-term decline in renal function after EVAR was comparable with the decline after open repair of aortic aneurysms reported by Greenberg et al. In our experience, long-term CrCl decreases of 6.4% after open surgery. Only part of the decrease can be related to the effect of age on CrCl, as Tiao et al have shown that after the of age 75 years, patients lose about 2% of CrCl per year. Regardless the type of endograft used, there is a significant

**Table II.** Amount of intravenous contrast media during the procedure and follow-up period

<table>
<thead>
<tr>
<th></th>
<th><em>Infra = Aneur</em>X (N = 135)</th>
<th><em>Supra = Talent+ Zenith</em> (N = 137)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intraoperative contrast (mL)</td>
<td>137.5 (30-300)</td>
<td>157.9 (40-600)</td>
<td>.36</td>
</tr>
<tr>
<td>Number of control CT scans</td>
<td>2.8 (0-7)</td>
<td>2.4 (0-6)</td>
<td>.15</td>
</tr>
<tr>
<td>Postoperative contrast (mL)</td>
<td>466.9 (0-1155)</td>
<td>406.8 (0-990)</td>
<td>.15</td>
</tr>
</tbody>
</table>

CT, Computed tomography.

**Table III.** Preoperative and postoperative CrCl and variations

<table>
<thead>
<tr>
<th></th>
<th><em>Infra = Aneur</em>X (N = 135)</th>
<th><em>Supra = Talent+ Zenith</em> (N = 137)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preoperative CrCl (mL/min)</td>
<td>69.3 (15-148)</td>
<td>71.7 (28-156)</td>
<td>.41</td>
</tr>
<tr>
<td>Postoperative CrCl (mL/min)</td>
<td>61.7 (16-145)</td>
<td>64.9 (20-163)</td>
<td>.26</td>
</tr>
<tr>
<td>CrCl variation (mL/min)</td>
<td>-7.6 (-40 to 54) (P &lt; 0.01)</td>
<td>-6.8 (-95 to 61) (P = .02)</td>
<td>.74</td>
</tr>
<tr>
<td>CrCl variation rate (%)</td>
<td>-10.9 (-52 to 59)</td>
<td>-9.5 (-70 to 91)</td>
<td>.21</td>
</tr>
</tbody>
</table>

CrCl, Creatinine clearance.

**Table IV.** Patients with >20% decreased CrCl, demographic data, aneurysm size, preoperative risk factors, and CrCl evolution

<table>
<thead>
<tr>
<th></th>
<th><em>Infra = Aneur</em>X (N = 135)</th>
<th><em>Supra = Talent+ Zenith</em> (N = 137)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of patients with &gt;20% decreased CrCl</td>
<td>35 (25.9%)</td>
<td>41 (29.9%)</td>
<td>.46</td>
</tr>
<tr>
<td>Mean age (y)</td>
<td>73.7 (61-87)</td>
<td>75.2 (63-89)</td>
<td>.37</td>
</tr>
<tr>
<td>Sex (% male)</td>
<td>91.4</td>
<td>90.2</td>
<td>.86</td>
</tr>
<tr>
<td>Diameter AAA (mm)</td>
<td>53.1 (34-76)</td>
<td>56.6 (40-90)</td>
<td>.20</td>
</tr>
<tr>
<td>Diabetes</td>
<td>54.3%</td>
<td>53.7%</td>
<td>.65</td>
</tr>
<tr>
<td>Preoperative CrCl (mL/min)</td>
<td>74.7 (35-119)</td>
<td>80.0 (32 to 135)</td>
<td>.43</td>
</tr>
<tr>
<td>Postoperative CrCl (mL/min)</td>
<td>51.6 (24 to 82)</td>
<td>48.8 (20 to 85)</td>
<td>.46</td>
</tr>
<tr>
<td>CrCl Variation rate</td>
<td>-30.9% (-52 to -21)</td>
<td>-39% (-70 to -20)</td>
<td>.005</td>
</tr>
<tr>
<td>Follow-up period (mo)</td>
<td>15.4 (1.2-40.2)</td>
<td>16.5 (1.3-40.1)</td>
<td>.59</td>
</tr>
</tbody>
</table>

AAA, Abdominal aortic aneurysm; CrCl, creatinine clearance.

**Table V.** Logistic regression table for patients with >20% decrease in CrCl

<table>
<thead>
<tr>
<th></th>
<th>Exp (coefficient)</th>
<th>95% lower</th>
<th>95% upper</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fixation</td>
<td>.2613</td>
<td>.682</td>
<td>.350</td>
</tr>
<tr>
<td>Age</td>
<td>.1741</td>
<td>1.026</td>
<td>.989</td>
</tr>
<tr>
<td>Sex</td>
<td>.3798</td>
<td>1.602</td>
<td>.560</td>
</tr>
<tr>
<td>Diameter AAA</td>
<td>.7064</td>
<td>1.005</td>
<td>.978</td>
</tr>
<tr>
<td>Diabetes</td>
<td>.6850</td>
<td>.782</td>
<td>.239</td>
</tr>
<tr>
<td>Hypertension</td>
<td>.4265</td>
<td>1.255</td>
<td>.717</td>
</tr>
<tr>
<td>Intraoperative contrast</td>
<td>.1043</td>
<td>1.004</td>
<td>.999</td>
</tr>
<tr>
<td>Postoperative contrast</td>
<td>.5204</td>
<td>1.121</td>
<td>.791</td>
</tr>
<tr>
<td>Preoperative CrCl</td>
<td>.0034</td>
<td>1.022</td>
<td>1.007</td>
</tr>
<tr>
<td>Follow-up period</td>
<td>.0015</td>
<td>1.001</td>
<td>1.000</td>
</tr>
</tbody>
</table>

AAA, Abdominal aortic aneurysm; CrCl, creatinine clearance.
The magnitude of decrease of CrCl in patients who experienced significant renal impairment was significantly greater for patients treated with suprarenal fixation endografts (SF: $-39\%$) compared with those treated with infrarenal endografts (IF: $-31\%$, $P = .005$). These results do not take into account the inherent inaccuracy of the Cockcroft formula (correlation coefficient $= .83$).11 In the group of patients who had a $>20\%$ decrease in CrCl, the infrarenal fixation group had a lower mean age than the suprarenal fixation group, and this difference may have also affected the calculations of the mean CrCl for each group. Patients who experienced the greatest postoperative renal impairment may have had renal infarctions, but the exact cause of decline in renal function was not clearly defined in most patients. However, significant renal parenchymal tissue loss28 or renal artery stenosis can occur without a significant effect on CrCl.7,29,30 The exclusion of accessory renal arteries secondary to endograft deployment does not appear to be responsible for renal function impairment if the parenchyma loss is $<25\%$.31 In previous studies,22-34 the small number of diagnosed renal infarctions that occurred was clinically benign. No patient in these series required dialysis or had any symptoms of renal dysfunction.

One limitation of our study is that we were unable to accurately report on postoperative changes in blood pressure (renovascular hypertension) that might have resulted from suprarenal stenting. Two series in the literature reported no significant change in average recorded blood pressure at 6 and 12 months after suprarenal fixation.3,35 We believe that patients with significant renal impairment should be followed more closely with regular CrCl measurements; adapted imaging such as noncontrast-enhanced CT scans, infrarenal color duplex examinations,19 and magnetic resonance angiography; and screening of renovascular hypertension. Close follow-up will help to detect possible late renal dysfunction and to prevent its clinical symptoms such as renovascular hypertension.

In conclusion, regardless the type of endograft used, there is approximately a $10\%$ decrease in CrCl in the first year after EVAR. Suprarenal fixation does not seem to increase the likelihood of postoperative renal impairment. Decline in renal function over time after EVAR is probably due to multiple factors, and measures known to be effective in protecting kidneys should be considered for patients treated with EVAR. Long-term follow-up with measurement of CrCl, along with renal imaging and regular blood pressure measurements, should be performed to detect possible late renal dysfunction. Prospective studies comparing suprarenal versus infrarenal fixation are needed to confirm these results.

REFERENCES


