Endovascular repair of abdominal aortic aneurysms: Eligibility rate and impact on the rate of open repair

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Objective: The purpose of this study was to determine the rate of eligibility among patients with abdominal aortic aneurysms (AAAs) considered for endovascular repair and to examine the effect of an endovascular program on the institutional pattern of AAA repair.

Methods: All patients evaluated for endovascular AAA repair since the inception of an endovascular program were reviewed for determination of eligibility rates and eventual treatment. Open AAA repairs were categorized as simple (uncomplicated infrarenal), complex (juxtarenal, suprarenal, thoracoabdominal, infected), or ruptured, and their rates before and after initiation of an endovascular program were compared.

Results: Over 3 years, 324 patients were considered for endovascular AAA repair; 176 (54%) were candidates, 138 (43%) were not candidates, and 10 (3%) did not complete the evaluation. The rate of eligibility increased significantly from 45% (66/148 patients) during the first half of this period to 63% (110/176 patients) during the second half (P < .001). Candidates were significantly younger (74.4 ± 7.6 years) than noncandidates (78.3 ± 6.7 years) (P < .01), and their aneurysm diameter tended to be smaller (57.6 ± 9.2 mm compared with 60.8 ± 12.3 mm; P = .06). The most common reason for ineligibility was an inadequate proximal aortic neck. Of 176 candidates, 78% underwent endovascular repair, and 6% underwent open repair. Of 138 noncandidates, 56% underwent surgical repair. Over a period of 6 years, 542 patients with AAAs (429 simple, 86 complex, 27 ruptured) underwent open repair. The total number and ratio of simple to complex open repairs for nonruptured aneurysms during the 3 years before the initiation of the endovascular program (213 simple, 44 complex) were not significantly different from the repairs over the subsequent 3-year period (216 simple, 42 complex). Similarly, no difference in the total number and the ratio of simple to complex open repairs was found between the first and the second 18-month periods since the initiation of the endovascular program.

Conclusions: The rate of eligibility of patients with AAA for endovascular repair appears to be higher than previously reported. The presence of an active endovascular program has not decreased the number or shifted the distribution of open AAA repair. (J Vasc Surg 2000;32:519-23.)

Estimates regarding the eligibility rates of patients with abdominal aortic aneurysms (AAAs) for endovascular repair vary widely. Computed tomography (CT)-based anatomic studies have estimated the rate from 27% to 82%1-3 and clinical series have reported eligibility rates of 50% to 62% and most recently, less than 20%4-6. This eligibility rate is important for estimating the number of future endovascular procedures and for anticipating the overall effect of endovascular programs on the pattern of institutional and ultimately general practice of AAA repair.

We reviewed all patients who were considered for endovascular aneurysm repair since the inception of the endovascular program at Stanford. We examined
METHODS

An endovascular program for repair of AAAs with the bifurcated AneuRx stent graft has been in place at Stanford since November 1996. This modular stent graft consists of a woven polyester fabric graft attached to an exoskeleton of self-expanding nitinol stents. All patients who were considered for endovascular repair during a 3-year period (November 1, 1996–October 31, 1999) were presented to a panel of vascular surgeons and radiologists who reviewed the clinical data as well as the vascular morphology and decided on the appropriateness of endovascular repair. These patients’ data and scans were often referred in consultation without being evaluated in the clinic, and a large proportion of these patients had severe comorbidities that placed them at very high risk for open AAA repair. Decisions were usually made on the basis of helical CT angiograms, except in severe renal failure when magnetic resonance angiograms were substituted. If a conclusion could not be reached, further tests, most commonly a high-quality helical CT angiogram or a conventional arteriogram, were requested. Eligibility was determined for a bifurcated stent graft, and other configurations such as aortouniliac grafting were used only rarely and were counted as rejection. The criteria for endovascular repair included a proximal aortic neck 26 mm or less in diameter and 10 mm or more in length. The upper limit of common iliac artery diameter was 15 mm, and occlusion of hypogastric arteries was undertaken only in unusual circumstances. Tortuosity was evaluated in a qualitative fashion, and its effects on the insertion of the device and on the eventual position of the stent graft were assessed. The decisions regarding each patient were recorded. Patients who were considered candidates were prepared for endovascular repair. Patients who were considered unsuitable and were acceptable surgical risks were referred for open repair. The reason for disqualification was recorded in 80% of the cases. An attempt was made to record subsequent treatment on all patients. Whenever patients were not referred for treatment after evaluation and a decision to continue observation was reached, this was recorded as “No Treatment.”

For trends to be evaluated in open aneurysm repair, the surgical registry was reviewed for a diagnosis of “repair of abdominal aortic aneurysm” over a period of 6 years (November 1, 1993–October 31, 1999). This period was divided into two 3-year periods. The first period (November 1, 1993–October 31, 1996) was before the initiation of the endovascular program, and the second period (November 1, 1996–October 31, 1999) was subsequent to that. Uncomplicated infrarenal aneurysms were classified as simple aneurysms, and juxtarenal, suprarenal, thoracoabdominal, and infected aneurysms were classified as complex. Ruptured aneurysms were counted separately.

Data were analyzed with the Student t test and the χ² test. A P value less than .05 was considered significant.

RESULTS

Over a period of 3 years, 324 patients were considered for endovascular repair of AAA. There were 176 patients (54%) who were candidates and 138 patients (43%) who were not candidates; 10 patients (3%) did not complete the evaluation (Table I). The rate of eligibility increased significantly from 45% during the first half of this period to 63% during the sec-

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**Table I. Eligibility for endovascular repair**

<table>
<thead>
<tr>
<th>Period</th>
<th>Candidates</th>
<th>Noncandidates</th>
<th>Incomplete evaluation</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>First 18 mo</td>
<td>66 (45%)</td>
<td>78 (33%)</td>
<td>4 (3%)</td>
<td>148</td>
</tr>
<tr>
<td>Second 18 mo</td>
<td>110 (63%)</td>
<td>60 (34%)</td>
<td>6 (3%)</td>
<td>176</td>
</tr>
<tr>
<td>Entire period</td>
<td>176 (54%)</td>
<td>138 (43%)</td>
<td>10 (3%)</td>
<td>324</td>
</tr>
</tbody>
</table>

*The rate of eligibility was significantly higher in the second period (P < .001).
The primary reason for disqualification was related to the proximal aortic neck, which constituted 65% of the reasons for dismissal, and adequate length was the most common problem in the neck in 72% (Table II). In 20 patients an additional reason for ineligibility was stated and was related to the iliac arteries in nine patients and to the renal or visceral artery occlusive disease in seven patients. Candidates were significantly younger (74.4 ± 7.6 years) than noncandidates (78.3 ± 6.7 years) \((P < .01)\), and their aneurysm diameter tended to be smaller (57.6 ± 9.2 mm compared with 60.8 ± 12.3 mm; \(P = .06\)).

Of 176 candidates, 138 (78%) eventually underwent endovascular repair (Table III). The reasons for proceeding with open repair in 10 candidates were emergency repair for rupture or acute symptoms (3 patients), patient preference (3 patients), and unrecorded reason (4 patients). Twenty patients were ultimately not treated because of patient preference in 5 cases, death in 2 cases, and unrecorded reasons in the other cases. Of 138 patients who were not candidates, 75 (54%) underwent open aneurysm repair, and three patients were treated with an aortouniiliac stent graft and a femorofemoral bypass graft. The proportion of the patients who were not treated was higher in those who were not candidates, presumably because of comorbidity and the perceived risk associated with open repair.

Over a period of 6 years, 542 open abdominal aneurysm repairs were performed at Stanford (Table IV). The total number and the ratio of simple to complex open nonruptured aneurysm repairs before the initiation of the endovascular program and afterwards were virtually identical. The only difference was an increase in the number of ruptured aneurysms during the second period. Similarly, no difference in the total number and the ratio of simple to complex repairs was found between the first and the second 18-month periods since the initiation of the endovascular program.

**DISCUSSION**

The rate of eligibility of patients with AAAs for endovascular repair depends on stent graft technology. Early stent grafts of the tubular configuration were applicable in 10% to 14% of patients.\(^4\,7\) Bifurcated stent grafts, which do not require a distal aortic neck, can be used for a larger proportion of patients, but the rate of eligibility is difficult to ascertain. One of the difficulties is extracting a population-based rate from what is usually a referral-based practice of vascular surgery. One solution has been evaluation of CT scans of patients with aneurysms for specific morphologic criteria,\(^1\)\(^-\)\(^3\)\(^,\)\(^8\) but this approach is detached from the actual practice of endovascular aneurysm repair.

The analysis reported here is clearly affected by the biases of a referral-based vascular surgery practice, and some patients may have been preselected. Four rates of eligibility for endovascular repair may be calculated:

1. The number of candidates divided by the number considered for endovascular repair: 176/324 = 54%
2. The number of actual endovascular repairs divided by the number considered for such repair: 138/324 = 43%
3. One could argue that those considered for endovascular repair were preselected and had a higher likelihood of having the desirable anatomy. Therefore, the denominator should also include all open AAA repairs performed at Stanford during the same period: (324 patients considered for endografting + 277 patients who underwent open repair after 1996 - 75 patients who were considered and found unsuitable for endovascular grafting and who underwent open repair = 526). 176/526 = 33%
4. The number of actual endovascular repairs divid-

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**Table III.** Eventual treatment of the aneurysm

<table>
<thead>
<tr>
<th></th>
<th>EV repair</th>
<th>Open repair</th>
<th>No treatment</th>
<th>AU1</th>
<th>Pending</th>
<th>Unknown</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Candidates</td>
<td>138 (78%)</td>
<td>10 (6%)</td>
<td>20 (11%)</td>
<td>4 (2%)</td>
<td>4 (2%)</td>
<td></td>
<td>176</td>
</tr>
<tr>
<td>Noncandidates</td>
<td>75 (54%)</td>
<td>26 (19%)</td>
<td>3 (2%)</td>
<td>3 (2%)</td>
<td>31 (22%)</td>
<td></td>
<td>138</td>
</tr>
<tr>
<td>Incomplete eval</td>
<td>4</td>
<td>2</td>
<td></td>
<td>2</td>
<td></td>
<td></td>
<td>10</td>
</tr>
<tr>
<td>Total</td>
<td>138 (43%)</td>
<td>85 (26%)</td>
<td>50 (15%)</td>
<td>3 (1%)</td>
<td>9 (3%)</td>
<td>39 (12%)</td>
<td>314</td>
</tr>
</tbody>
</table>

AU1, Aortouniiliac; EV, endovascular.

**Table IV.** Open abdominal aneurysm repair

<table>
<thead>
<tr>
<th></th>
<th>Period</th>
<th>Simple</th>
<th>Complex</th>
<th>Rupture</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-EV program</td>
<td>213 (80%)</td>
<td>43 (16%)</td>
<td>9 (3%)</td>
<td></td>
<td>265</td>
</tr>
<tr>
<td>Post-EV program</td>
<td>216 (78%)</td>
<td>43 (16%)</td>
<td>18 (6%)</td>
<td></td>
<td>277</td>
</tr>
<tr>
<td>Overall</td>
<td>429 (79%)</td>
<td>86 (16%)</td>
<td>27 (5%)</td>
<td></td>
<td>542</td>
</tr>
</tbody>
</table>

EV, Endovascular.
ed by those considered and those who underwent open repair during the same period: 138/526 = 26%.

The first rate is probably the best reflection of the population-based eligibility rate because those who presented for consideration were not selected for appropriate anatomy and a large spectrum of aortic pathology including clearly inappropriate cases was reviewed. The latter two rates (no. 3 and no. 4), which include concomitant open repairs in the denominator, are probably gross underestimates. Many patients who underwent open repairs were never considered for endovascular repair, and many may have indeed qualified. The reason for this was surgeon and/or patient preference, and this factor clearly depends on the experience accumulated with this new technology and its general acceptance. However, even these inordinately low rates are higher than the rate of 20% suggested by Treiman et al. and the rate of 25% found by Sarkar et al. We did not count patients suitable for aortouniliac grafts and femorofemoral bypass grafting as candidates because the criteria for this procedure are different and we were interested in defining eligibility for bifurcated stent graft repair. This procedure accounted for only three cases in our series, but aggressive use of this approach would result in still higher rates of endovascular repair.

We have found an overall eligibility rate of 54%. This is higher than the rate of 30% to 43% anticipated by reviewing dimension of aneurysm on CT and the rates of 47% and 50% found by Blum et al. and Brewster et al. in clinical studies. Furthermore, with accumulating experience during the later phase of our endovascular program, the eligibility rate has increased to 63% Although the numerical criteria have not changed, our impression was that more difficult cases were accepted. The overall high eligibility rate compared with other reports may be related to the shorter proximal neck length of 10 mm required for implantation of the AneuRx stent graft compared with 15 mm for some of the other devices.

Our findings are in agreement with others that the most common factor for disqualification is involvement of the proximal neck with the aneurysmal process. In an attempt to increase applicability to short and wide necks, stent grafts that anchor above the renal arteries with an uncovered stent portion have been designed. Whether this type of fixation will increase the eligibility rate and will prove to be durable and safe remains to be determined.

In addition, aneurysm size is inversely correlated with eligibility for endovascular repair. We have also found that advanced age is associated with a lesser rate of eligibility, although we have placed stent grafts successfully in patients older than 90 years.

The number of open aneurysm repairs at Stanford has remained stable throughout the period of evolution of the endovascular program so that the entire volume of endovascular aneurysm repair represents additional activity. A significant proportion of patients evaluated for endovascular repair and of those who eventually underwent it would not have been referred for open aneurysm repair because of severe comorbidities. Whether this trend of endovascular repair representing additional rather than alternative patient volume will be sustained over time or will be true for other centers remains to be seen.

We conclude that the rate of eligibility of patients with AAA for endovascular repair is higher than previously reported and is around 54%. The presence of an active endovascular program has not decreased the number or shifted the distribution of open AAA repair.

REFERENCES


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