Follow-up costs increase the cost disparity between endovascular and open abdominal aortic aneurysm repair

Catherine L. Hayter, MBBS,[a] Stephen R. Bradshaw, FRACS,[b] Robert J. Allen, FRANZCR,[c] Murali Guduguntla, FRANZCR,[c] and David T. A. Hardman, FRACS,[b,d] *Canberra, Australia*

Objective: **This study compared the hospital and follow-up costs of patients who have undergone endovascular (EVAR) or open (OR) elective abdominal aortic aneurysm repair.**

Methods: **The records of 195 patients (EVAR, n = 55; OR, n = 140) who underwent elective aortic aneurysm repair between 1995 and 2004 were reviewed. Primary costing data were analyzed for 54 EVAR and 135 OR patients. Hospital costs were divided into preoperative, operative, and postoperative costs. Follow-up costs for EVAR patients were recorded, with a median follow-up time of 12 months.**

Results: **Mean preoperative costs were slightly higher in the EVAR group (AU $961/US $733 vs AU $869/US $663; not significant). Operative costs were significantly higher in the EVAR group (AU $16,124/US $12,297 vs AU $6077/US $4635; *P* < .001); this was entirely due to the increased cost of the endograft (AU $10,181/US $7,765 for EVAR vs AU $476/US $363 for OR). Postoperative costs were significantly reduced in the EVAR group (AU $4719/US $3599 vs AU $11,491/US $8,764; *P* < .001). Total hospital costs were significantly greater in the EVAR group (AU $21,804/US $16,631 vs AU $18,437/US $14,063; *P* < .001). The increase in total hospital costs was due to a significant difference in graft costs, which was not offset by reduced postoperative costs. The average follow-up cost per year after EVAR was AU $1316/US $999. At 1 year of follow-up, EVAR remained significantly more expensive than OR (AU $23,120/US $17,640 vs AU $18,510/US $14,122; *P* < .001); this cost discrepancy increased with a longer follow-up.**

Conclusions: **EVAR results in significantly greater hospital costs compared with OR, despite reduced hospital and intensive care unit stays. The inclusion of follow-up costs further increases the cost disparity between EVAR and OR. Because EVAR requires lifelong surveillance and has a high rate of reintervention, follow-up costs must be included in any cost comparison of EVAR and OR. The economic cost, as well as the efficacy, of new technologies such as EVAR must be addressed before their widespread use is advocated. (J Vasc Surg 2005;42:912-8.)**

Endovascular repair of abdominal aortic aneurysms (EVAR) has become an increasingly popular alternative to open repair (OR). Patients considered suitable candidates for EVAR have increased from initial rates of 20% of referred patients[1] to 68% in recent years.[2] Interested surgeons and manufacturers allege that patients are increasingly requesting this procedure because they are attracted to the concept of minimally invasive surgery. With increasing numbers of patients undergoing EVAR,[3] questions of cost are paramount to the clinician, hospital, and society.

Early studies reported that EVAR was less costly[4,5] or equivalent[6,7] in cost to OR because of reduced lengths of hospital stay and fewer intensive care unit (ICU) admissions. These studies, however, were performed within the context of clinical trials, and the costs of the endografts were significantly less than in the current commercial environment. Most later studies[8-13] have reported higher hospital costs for EVAR. Nonetheless, conflicting results remain. Studies that have used Markov decision modeling to evaluate cost-effectiveness[14,15] have found EVAR to be a cost-effective alternative to OR. Rosenberg et al[16] reported that EVAR was more profitable for a hospital than OR if indirect costs were excluded from analysis.

Many previous studies have used costing estimates,[13] have relied on clinical coding by medical records staff to obtain costs,[12] or have reported cost differences only.[6,11,13,17] To date, most studies have been conducted in American hospitals, where indirect costs are significantly higher than in Australian, Canadian, and European hospitals.[18]

Only two costing studies comparing EVAR and OR[8,9] have included follow-up costs in their analysis. This is a considerable oversight because follow-up costs contribute significantly to the overall cost of EVAR. In contrast to OR, which requires little or no long-term follow-up,[19] the durability of EVAR remains uncertain. Long-term surveillance is considered mandatory after EVAR[20]; thus, any meaningful costing analysis of EVAR vs OR must include follow-up costs.

METHODS

Between January 1, 1995, and December 31, 2004, 195 patients underwent elective infrarenal abdominal aortic aneurysm repair (all EVARs were performed after 1998). The treating surgeon, in consultation with an interventional radiologist, determined the selection of EVAR or OR. EVAR was performed on the basis of anatomic selec-

From the Canberra Hospital,[a] Departments of Vascular Surgery[b] and Radiology,[c] The Canberra Hospital, and Australian National University.[d]

Competition of interest: none.

Reprint requests: D. T. A. Hardman, FRACS, Department of Vascular Surgery, The Canberra Hospital, Woden, ACT 2606, Australia (e-mail: dtah@webone.com.au).

0741-5214/$30.00

doi:10.1016/j.jvs.2005.07.039

tion criteria and patient comorbidities. All ORs were performed by one of two vascular surgeons (D.T.A.H. or S.R.B.). EVARs were performed by one surgeon and one of two radiologists (R.J.A. or M.G.). All patient follow-up was performed by these two surgeons.

Patients were generally admitted 1 day before EVAR or OR. EVARs were performed by using a bifemoral approach with patients under general anesthesia. Zenith (Cook, Bloomington, Ind; n = 40), Excluder (W.L. Gore & Associates, Flagstaff, Ariz; n = 14), or Talent (Medtronic/AVE, Santa Rosa, Calif; n = 1) aortobi-iliac endografts were placed under fluoroscopic guidance. OR was performed by using a transperitoneal approach and a Dacron (DuPont, Wilmington, Del) straight (n = 93) or bifurcated (n = 47) graft was implanted.

Hospital and surgeon records were reviewed to obtain clinical characteristics, operative details, complications, outcome parameters, and the need for readmissions or additional procedures. Outcome parameters were defined according to the Ad Hoc Committee for Standardized Reporting Practices in Vascular Surgery.[21]

The cost for each patient was determined by reviewing the medical records, the pathology system, and the medical imaging system. For each patient, the total hospital cost was divided into preoperative costs, operative costs, and postoperative costs. Follow-up costs were obtained from discharge until December 31, 2004, by using hospital medical records, medical imaging department records, and surgeons' records.

The Canberra Hospital is a tertiary referral public hospital. Because of the system of federal government funding of public hospitals in Australia, hospital costs are not assigned to individual patients. Wherever possible, exact costs for individual patients were recorded. Other costs were derived by using a costing model or the best available estimate, described below. All costs were expressed in Australian dollars and were normalized to 2003/2004 prices to provide a picture of what is currently the real cost of performing EVAR and OR. Equivalent costs in US dollars (calculated at current exchange rates) are also reported.

Preoperative costs included pathology, standard cardiorespiratory investigations (chest radiograph, electrocardiogram, and spirometry), consultations (including physiotherapy), bed costs, and other investigations or interventions (such as internal iliac artery aneurysm embolization before EVAR) performed during the hospital admission. Operative costs included graft costs; additional guidewires, catheters, and sheaths required for EVAR; and operating room costs. Graft costs were obtained for each patient from the manufacturers. For patients undergoing EVAR, the cost of the guidewires, sheaths, catheters, and contrast used in a typical procedure were added. Operative room costs included allocations for operating room time, anesthetic and nursing time, recovery time, drugs, and surgical supplies. Operative costs for individual patients were available only from 2003. From an analysis of the 21 patients who underwent OR and 18 patients who underwent EVAR in the 2003 to 2004 financial year, a per-minute average operative cost was calculated. For each patient in the study, the operative time in minutes was multiplied by the per-minute cost; the surgeon's fee, according to the 2004 Medicare Benefits Schedule (MBS) rebate, was added to this to obtain the total operating room cost.

Postoperative costs included bed and nursing costs, pathology, medical imaging, cardiorespiratory investigations and interventions, specialist consultations, allied health costs, pharmacy costs, and additional costs, such as a return to the operating room. Bed and nursing costs were calculated by using details of expenditure from The Canberra Hospital Financial Services Department 2003 to 2004 budget. Employee expenses, operating expenses, and allocated indirect expenses were calculated to obtain an average cost per bed-day for an ICU bed, coronary care bed, and vascular ward bed. This was multiplied by the number of nights each patient spent in each location.

The number and type of pathology, radiology, and cardiorespiratory investigations performed, the number of specialist consultations, and the number of allied health visits were determined for each patient, and costs were calculated by using the 2004 MBS rate for hospital inpatients. To gain an estimate of pharmacy costs, 20 patients were randomly selected, and the cost of each drug administered during their admission was calculated. The total pharmacy cost was divided by the number of days of hospital stay to gain an average pharmacy cost per day, which was used to derive the pharmacy cost for each patient in the study. Costs associated with a return to the operating room or interventional radiology procedures were added to the postoperative costs for two EVAR and seven OR patients.

Follow-up costs were obtained for the 54 EVAR patients discharged from the hospital. The annual number of specialist visits, computed tomographic (CT) scans, angiograms, and interventional radiology procedures required to treat endoleaks were recorded for each patient. Costs were determined from the MBS and were discounted at a rate of 3% per year to reflect the greater value of the dollar currently compared with its future value.[22] Total follow-up time was calculated for each patient, and the mean follow-up cost per year was calculated.

Statistical outliers (EVAR, n = 1; OR, n = 3) of more than 3 SD from the mean for total hospital cost were excluded from the primary analysis. Two patients in the OR group who were transferred to a private hospital were also excluded from costing analysis because complete financial records were unavailable.

For normally distributed data, means are reported. Where the data did not fit a normal distribution (Kolmogorov-Smirnov test; $P < .05$), medians are reported with ranges. For the two groups, parametric data were compared by using the Student t test, and for non-normally distributed data, the Wilcoxon rank sum test was used. For proportions, the χ^2 test was used. A P value $<.05$ was considered statistically significant.

Table I. Clinical characteristics of patients undergoing EVAR and OR

Clinical characteristic	*Endovascular (n = 55)*	*Open (n = 140)*	P *value*
Age, y, mean ± SD (range)	74.5 ± 7.2 (58-89)	71.0 ± 7.5 (53-89)	.003*
Sex (M/F)	50/5 (91%/9%)	113/27 (81%/19%)	NS
Aneurysm diameter, mm (mean)	59	60	NS
Smoking history	46 (84%)	122 (87%)	NS
Diabetes mellitus	10 (18%)	18 (13%)	NS
Cardiac disease	27 (49%)	67 (48%)	NS
Chronic airway disease	24 (44%)	39 (28%)	.03
Hypertension	39 (71%)	97 (69%)	NS
Hypercholesterolemia	31 (56%)	71 (51%)	NS
Renal impairment	9 (16%)	22 (16%)	NS
Cerebrovascular disease	6 (11%)	12 (9%)	NS
Peripheral vascular disease	15 (27%)	28 (20%)	NS
Malignant disease	11 (20%)	15 (11%)	NS
ASA grade II	16 (29%)	50 (36%)	
ASA grade III	34 (62%)	86 (61%)	NS
ASA grade IV	5 (9%)	4 (3%)	

EVAR, Endovascular aneurysm repair; *OR*, open repair; *NS*, not significant; *ASA*, = American Society of Anesthesiology (anesthetic status classification).
*The 95% confidence interval of the difference was 5.81 to 1.17.

Table II. Outcome parameters for patients undergoing EVAR and OR

Outcome parameter	*Endovascular (n = 55)*	*Open (n = 140)*	P *value*
Length of hospital stay, d, median (range)	6 (4-24)	10 (6-46)	<.001
Need for ICU (No. of patients)	11 (20%)	140 (100%)	<.001
Length of ICU stay, d, median (range)	0 (0-3)	1 (1-19)	<.001
Length of operation, min (mean ± SD)	135 ± 56	150 ± 40	.045
30-d mortality	1 (1.8%)	2 (1.4%)	NS
Mortality/severe complications	6 (10.9%)	14 (10.0%)	NS

EVAR, Endovascular aneurysm repair; *OR*, open repair; *ICU*, intensive care unit; *NS*, not significant.

RESULTS

Clinical characteristics and outcome parameters. During the 10-year period, 55 patients underwent EVAR, and 140 patients underwent OR. The clinical characteristics of the patients in the two groups are shown in Table I. The mean age of the patients in the EVAR group was higher (74.5 vs 71.0 years; $P = .003$), and there was a higher incidence of chronic obstructive airway disease in the EVAR group (44% vs 28%; $P = .03$). There was no significant difference between the groups in the other characteristics examined.

EVAR resulted in a reduced hospital stay and a reduced need for ICU admission (Table II). The median length of hospital stay in the EVAR group was 6 days (range, 4-24 days) and in the OR group was 10 days (range, 6-46 days; $P < .001$). Only 11 (20%) of the EVAR patients were admitted to the ICU after surgery, with a median ICU stay of 0 days (range, 0-3 days) in the EVAR group compared with 1 day (range, 1-19 days; $P < .001$) in the OR group. There was a significant difference in the operation time between the groups (mean, 135 minutes for EVAR vs 150 minutes for OR; $P = 0.045$). There was no significant difference in 30-day mortality between the groups (1.8% for EVAR vs 1.4% for OR) or in the number of patients who died or experienced a severe complication (10.9% for EVAR vs 10.0% for OR).

Table III. Mean preoperative costs for patients undergoing EVAR and OR

Cost component	*Endovascular (n = 54)*	*Open (n = 135)*
Pathology	AU $140/US $107	AU $143/US $109
Cardiorespiratory investigations	AU $54/US $41	AU $54/US $41
Consultations	AU $4/US $3	AU $27/US $21
Other investigations/ interventions	AU $181/US $138	AU $39/US $30
Bed/nursing costs	AU $539/US $411	AU $603/US $460
Total	AU $961/US $733	AU $869/US $663

EVAR, Endovascular aneurysm repair; *OR*, open repair.

Two patients in the EVAR group were converted to OR—the first as a result of rupture of the external iliac artery during attempted graft placement and the second as a result of an inability to pass guidewires through the iliac arteries. These patients were analyzed in the EVAR group on an intention-to-treat basis.

Table IV. Mean operative costs for patients undergoing EVAR and OR

Cost component	*Endovascular (n = 54)*	*Open (n = 135)*
Graft cost	AU $10,181/US $7,765	AU $476/US $363
Guide wires, sheaths, etc	AU $497/US $399	N/A
Operating room cost	AU $5,447/US $4,154	AU $5,608/US $4,277
Total	AU $16,124/US $12,297	AU $6,077/US $4,635

EVAR, Endovascular aneurysm repair; *OR*, open repair; *N/A*, not applicable.

Table V. Mean postoperative costs for patients undergoing EVAR and OR

Cost component	*Endovascular (n = 54)*	*Open (n = 135)*
Bed/nursing	AU $3,892/US $2,968	AU $9,997/US $7,624
Pathology	AU $204/US $156	AU $483/US $368
Medical imaging	AU $181/US $138	AU $238/US $181
Cardiorespiratory interventions	AU $14/US $11	AU $71/US $54
Specialist consultations	AU $34/US $26	AU $46/US $35
Allied health consultations	AU $156/US $119	AU $274/US $209
Pharmacy	AU $130/US $99	AU $237/US $181
Return to operating room	AU $32/US $24	AU $13/US $10
Total	AU $4,719/US $3,599	AU $11,491/US $8,764

EVAR, Endovascular aneurysm repair; *OR*, open repair.

Hospital costs. Mean preoperative costs were slightly higher in the EVAR group (AU $961/US $733 vs AU $869/US $663; Table III). This was largely due to six patients who required embolization of an internal iliac artery aneurysm before EVAR (cost, AU $1635/US $1241). If these patients were excluded from analysis, the mean preoperative cost in the EVAR group was AU $774/US $587. Costs for pathology, cardiorespiratory investigations, consultations, and bed/nursing care were similar between groups.

Operative costs were substantially higher in the EVAR group (AU $16,124/US $12,297 vs AU $6077/US $4635; Table IV). This was entirely due to the high cost of the endograft, which was on average 21 times more expensive than the open graft (AU $10,181/US $7,765 vs AU $476/US $363). Endograft costs in this study ranged from AU $9,500 to $15,481 (US $7,211-$11,751). Operating room costs were similar between the two groups (AU $5447/US $4154 for EVAR vs AU $5608/US $4277 for OR).

The mean postoperative cost was reduced by a factor of 2.4 in the EVAR group (AU $4719/US $3599 for EVAR vs AU $11,491/US $8,764 for OR; Table V). There was a decrease in the cost of bed/nursing care (AU $3892/US $2968 for EVAR vs AU $9997/US $7624 for OR); this was due to both a reduced length of stay and a reduced ICU stay. Pathology costs, medical imaging costs, cardiorespiratory costs, allied health costs, and pharmacy costs were also less in the EVAR group. Two patients in the EVAR group and seven patients in the OR group required a return to the operating room. Return to operating room costs did not significantly alter the mean postoperative costs.

Total hospital costs were significantly greater in the EVAR group (AU $21,804/US $16,631 vs AU $18,437/US $14,063; $P < .001$; Table VI). The increase in total hospital costs was due to a significant difference in graft costs (and, hence, operative costs), which was not offset by reduced postoperative costs. The mean cost of the graft accounted for 47% of the total hospital cost in the EVAR group, compared with 3% in the OR group.

Total costs including follow-up. Patients in the EVAR group were routinely followed up by CT angiogram at 1, 6, and 12 months after surgery and then yearly thereafter. Two patients with impaired renal function were followed up by Doppler ultrasonography. With a median follow-up time of 12 months (range: 2-64 months), the endoleak rate was 27.8% (type I, n = 1; type II, n = 13; type III, n = 1). Ten patients with endoleaks were treated with interventional radiologic techniques. No patient has required conversion to OR, and there have been no cases of aneurysm rupture to date.

Yearly follow-up costs for the patients discharged after EVAR are shown in Table VII. Mean yearly costs were similar for the first 3 years after surgery. The total cost of follow-up for the 54 EVAR patients was AU $99,040/US $75,208 over a total of 903 months. Thus, the average follow-up cost per year after EVAR was AU $1316/US $999. The mean total follow-up cost for patients in the OR group was estimated at AU $73/US $55. At the 1-year follow-up, EVAR remained significantly more costly than

Table VI. Component costs contributing to the mean total hospital cost for EVAR and OR (Australian dollars/US dollars)

Cost component	*Endovascular (n = 54)*	*Open (n = 135)*	P *value*
Pre-operative costs	AUD $961/USD $733	AUD $869/USD $663	NS
Total operative costs	AUD $16,124/USD $12,297	AUD $6,077/USD $4,635	<.001
Post-operative costs	AUD $4,719/USD $3,599	AUD $11,491/USD $8,764	<.001
TOTAL HOSPITAL COSTS	AUD $21,804/USD $16,631	AUD $18,437/USD $14,063	<.001
Graft cost	AUD $10,181/USD $7,765	AUD $476/USD $363	<.001
% graft of total cost	47%	3%	

NS = not significant.

Table VII. Follow-up costs after EVAR expressed as years since operation

Year after EVAR	*No. Patients*	*Mean*	*Range* AU $	*Range* US $
Year 1	54	AU $1,127/US $860	36-5,545	27-4,230
Year 2	23	AU $1,226/US $935	530-5,442	404-4,151
Year 3	6	AU $1,175/US $896	34-3,836	26-2,927
Year 4	2	AU $499/US $381	381-381	499-499
Year 5	1	AU $484/US $369	484-484	369-369
Year 6	1	AU $469/US $358	469-469	358-358

EVAR, Endovascular aneurysm repair.

Table VIII. Hospital and follow-up costs of EVAR and OR

Cost	*Endovascular*	*Open*
Hospital cost	AU $21,804/US $16,631	AU $18,437/US $14,063
Total cost at 1 y	AU $23,120/US $17,640	AU $18,510/US $14,122
Total cost at 2 y	AU $24,436/US $18,644	AU $18,510/US $14,122

EVAR, Endovascular aneurysm repair; *OR*, open repair.

OR (AU $23,120/US $17,640 vs AU $18,510/US $14,122; $P < .001$; Table VIII). This cost discrepancy will further increase with longer follow-up.

DISCUSSION

As the number of patients undergoing EVAR increases, questions regarding cost are becoming more pertinent. In this study, we compared the hospital costs of EVAR and OR and the follow-up costs for patients undergoing EVAR to gain a picture of the total cost of this technology. Total hospital costs were significantly higher for EVAR (AU $21,804/US $16,631) than for OR (AU $18,437/US $14,063). Although there was a reduction in postoperative costs because of a reduced length of stay and reduced costs associated with pathology, medical imaging, pharmacy, and allied health costs, this difference did not recoup the large cost of the endovascular graft. The mean cost of the endovascular graft in this study was AU $10,181/US $7,765, which accounted for 47% of the total hospital cost. At 1 year of follow-up, EVAR cost AU $23,120/US $17,640, compared with AU $18,510/US $14,122 for OR. With longer follow-up, the cost disparity between EVAR and OR increased even further.

There are a number of limitations in this study, but we do not believe that these would significantly affect the overall results. We deliberately chose not to include prehospital costs in our analysis, because the investigations required to decide eligibility for EVAR (CT angiogram and aortogram) reflect the decision of whether to offer this procedure, rather than the cost of the procedure itself. Because the Australian public health system does not assign hospital costs to individual patients, a few costs in this study were necessarily derived from financial models or best available estimates by hospital accountants. We used the cost of a "typical" procedure when estimating the cost of guidewires, sheaths, and catheters used for EVAR; this is likely to underestimate the true operative cost of EVAR. In our hospital, no record is kept of discarded guidewires, sheaths, and catheters used in a particular procedure. The cost of the radiologists' time in performing EVAR was not included, reflecting the fact that in many institutions EVAR is performed by either a vascular surgeon or a radiologist, but not both. The addition of these costs would only further increase the cost disparity between EVAR and OR.

Endograft cost is the primary determinant of EVAR cost. It is clear that graft cost remains the largest determinant of overall hospital costs for EVAR. Initial studies in the late 1990s reported that EVAR was less costly[4,5] or equal in cost[6,7] to OR. Those studies, however, had small sample sizes and relatively low graft costs because they were conducted within the context of clinical trials, and grafts were provided to investigators at significantly reduced prices. The US Food and Drug Administration approved two endovascular devices in September 1999; since then, the price of grafts has increased substantially.[23] Almost all studies conducted since 1999 have shown EVAR to be more costly, with grafts accounting for 52% to 78% of the total hospital cost,[8,9,12,13,16] compared with 20% to 38% in the two earlier studies.

In our study, the endograft accounted for 47% of the total hospital cost, with a mean price of AU $10,181/US $7,765. Previous studies have shown that a graft cost of less than US $6000 is required for EVAR to be a on parity with cost for OR.[11,13] Our study agrees with these findings; with a graft cost of US $6000 (AU $7550), the total hospital cost for EVAR would have been equivalent to that of OR. As more endografts receive US Food and Drug Administration approval and as initial costs to companies associated with research and development are recouped, prices of endografts may be reduced. However, at the present time, the price of the endograft is the primary cause of the increased hospital cost of EVAR compared with OR.

Only one study since 1999 has found EVAR to be less costly than OR. Rosenberg et al[16] reported that EVAR was more profitable than OR when costs were expressed as "contribution margin per day." The authors excluded hospital overheads from their analysis, noting that overhead cost allocation is often arbitrary and does not reflect the true cost of the procedure. Nonetheless, hospital costs remained higher in the EVAR group ($15,049 EVAR vs $12,733 OR). It was only because EVAR attracted a higher rate of reimbursement and resulted in a reduced length of stay that EVAR resulted in an increased contribution margin per day. The authors asserted that "hospitals should seek to maximize the contribution margin per day of inpatient duration of stay," and from a hospital accounts perspective, this is certainly true; however, clinicians have a responsibility not just to their hospital, but to society as a whole. Similarly, studies that have analyzed costs relative to diagnosis-related group refunds[9,13,23] may be of interest to a particular hospital but are less relevant to making decisions about how widely EVAR should be implemented. With limited health care dollars, clinicians must be mindful of the overall cost of EVAR to the health care system.

Follow-up costs increase cost disparity after EVAR. Hospital costs account for only part of the total cost of EVAR. The possibility of endoleaks, graft migration, or graft kinking requires lifelong follow-up,[20] and secondary vascular procedures are often required, adding substantially to costs. However, few previous studies have included follow-up costs in their cost analysis.

Two studies have used Markov modeling to estimate the cost-effectiveness of EVAR compared with OR. Patel et al[15] demonstrated that the cost of the initial hospitalization was higher in the EVAR group compared with OR ($20,083 vs $16,016), with an estimated lifetime cost of $28,901 in the EVAR group. The study concluded that EVAR was a cost-effective alternative if the graft cost was $8,000 to $12,000 because of an increase in quality life-adjusted years and the potential for decreased costs associated with major long-term morbidities This study, however, assumed a mortality and major morbidity rate of just 1.1% for EVAR, compared with 8.8% for OR; no large trial to date has reported such a low complication rate after EVAR. Bosch et al[14] reported that although lifetime costs were higher for EVAR than OR ($39,785 vs $37,606), EVAR was a cost-effective alternative if the complication rate was less than 5% and the long-term failure rate was less than 13%. The long-term failure rate after EVAR remains unknown, but a reintervention for endoleak rate of approximately 7% per year is commonly reported.[24]

Two costing studies comparing EVAR and OR have included follow-up costs in their analysis. Birch et al[9] reported a lifetime follow-up cost of AU $4120 per patient in their group of 31 EVAR patients; however, it is uncertain how these costs were derived and whether they included the cost of treating endoleaks. Forbes et al[8] included 2 to 14 months of follow-up in their comparison of 7 EVAR and 31 OR patients. With an average of 5.4 CT scans per patient, postoperative follow-up scans accounted for 16.3% of the total cost of EVAR.

A further study[25] followed up 77 patients undergoing EVAR for a mean of 19.9 months. Estimated follow-up costs were $3631 at 1 year and $9729 at 5 years. However, the large number of procedures for endoleaks (27% of patients) and the high rate of conversion to OR (9%) would have markedly increased follow-up costs.

Our study estimated a mean follow-up cost after EVAR of AU $1316/US $999 per year, including specialist consultations, CT scans, and treatment of endoleaks by interventional techniques. Prinssen et al[25] noted that "shorter survival in [patients who died with a patent graft in place] eliminates the increased costs of long term follow-up—ie. cost-effectiveness appears to be greatest in this sub population." It is noteworthy that the youngest patient in our study group, at age 58 (selected for EVAR because of a horseshoe kidney), may incur lifetime follow-up costs of AU $30,000. It is doubtful whether EVAR should be offered routinely to patients of this age group, and EVAR may prove to be cost-effective only in very elderly patients or those with a reduced life expectancy. Further information is needed to determine the true lifetime follow-up costs after EVAR. It is clear, however, that follow-up costs after EVAR are substantial and must be included in any costing study.

CONCLUSIONS

Economics plays an increasingly important role in modern medical management, and clinicians should be mindful of not only the efficacy of new technology, but also its cost. Our study indicates that EVAR results in significantly greater hospital costs compared with OR, despite reduced hospital and ICU stays. The inclusion of follow-up costs further increases the disparity between EVAR and OR. Clinicians must be involved in assessing the cost-benefit analysis of new techniques on a patient-by-patient basis. If we fail to become involved in making such decisions, they will be made by others on our behalf.

Thanks to David Dowling, of the Financial Services Department at The Canberra Hospital, for his assistance in obtaining hospital costing data.

REFERENCES

1. Treiman GS, Lawrence PF, Edwards WH Jr, Galt SW, Kraiss LW, Bhirangi K. An assessment of the current applicability of the EVT endovascular graft for treatment of patients with an infrarenal abdominal aortic aneurysm. J Vasc Surg 1999;30:68-75.
2. Zarins CK, Wolf YG, Lee WA, et al. Will endovascular repair replace open surgery for abdominal aortic aneurysm repair? Ann Surg 2000; 232:501-7.
3. Health Statistics by MBS item number. Available at: http://www.medicareaustralia.gov.au/statistics/dyn_mbs/forms/mbs_tab4.shtml. Accessed Feb 12, 2005.
4. Holzenbein J, Kretschmer G, Glanzl R, et al. Endovascular AAA treatment: expensive prestige or economic alternative? Eur J Vasc Endovasc Surg 1997;14:265-72.
5. Ceelen W, Sonneville T, Randon C, De Roose J, Vermassen F. Cost-benefit analysis of endovascular versus open abdominal aortic aneurysm treatment. Acta Chir Belg 1999;99:64-7.
6. Quinones-Baldrich WJ, Garner C, Caswell D, et al. Endovascular, transperitoneal, and retroperitoneal abdominal aortic aneurysm repair: results and costs. J Vasc Surg 1999;30:59-67.
7. Seiwert AJ, Wolfe J, Whalen RC, Pigott JP, Kritpracha B, Beebe HG. Cost comparison of aortic aneurysm endograft exclusion versus open surgical repair. Am J Surg 1999;178:117-20.
8. Forbes TL, DeRose G, Kribs S, Harris KA. A cost-effectiveness analysis of standard versus endovascular abdominal aortic aneurysm repair. Can J Surg 2002;45:420-4.
9. Birch SE, Stary DR, Scott AR. Cost of endovascular versus open surgical repair of abdominal aortic aneurysms. Aust N Z J Surg 2000;70:660-6.
10. Bosch JL, Beinfeld MT, Halpern EF, Lester JS, Gazelle GS. Endovascular versus open surgical elective repair of infrarenal abdominal aortic aneurysm: predictors of patient discharge destination. Radiology 2001; 220:576-80.
11. Clair DG, Gray B, O'Hara PJ, Ouriel K. An evaluation of the costs to health care institutions of endovascular aortic aneurysm repair. J Vasc Surg 2000;32:148-52.
12. Dryjski M, O'Brien-Irr MS, Hassett J. Hospital costs for endovascular and open repair of abdominal aortic aneurysm. J Am Coll Surg 2003; 197:64-70.
13. Sternbergh WC III, Money SR. Hospital cost of endovascular versus open repair of abdominal aortic aneurysms: a multicenter study. J Vasc Surg 2000;31:237-44.
14. Bosch JL, Kaufman JA, Beinfeld MT, Adriaensen ME, Brewster DC, Gazelle GS. Abdominal aortic aneurysms: cost-effectiveness of elective endovascular and open surgical repair. Radiology 2002;225:337-44.
15. Patel ST, Haser PB, Bush HL Jr, Kent KC. The cost-effectiveness of endovascular repair versus open surgical repair of abdominal aortic aneurysms: a decision analysis model. J Vasc Surg 1999;29:958-72.
16. Rosenberg BL, Comstock MC, Butz DA, Taheri PA, Williams DM, Upchurch GR. Endovascular abdominal aortic aneurysm repair is more profitable than open repair based on contribution margin per day. Surgery 2005;137:285-92.
17. Moore WS, Kashyap VS, Vescera CL, Quinones-Baldrich WJ. Abdominal aortic aneurysm: a 6-year comparison of endovascular versus transabdominal repair. Ann Surg 1999;230:298-306; discussion 306-8.
18. Brox AC, Filion KB, Zhang X, et al. In-hospital cost of abdominal aortic aneurysm repair in Canada and the United States. Arch Intern Med 2003;163:2500-4.
19. Krupski WC. Con: endovascular stent repair for aortic aneurysm surgery is not associated with lower perioperative risk. J Cardiothorac Vasc Anesth 2003;17:659-67.
20. Bernhard VM, Mitchell RS, Matsumura JS, et al. Ruptured abdominal aortic aneurysm after endovascular repair. J Vasc Surg 2002;35:1155-62.
21. Chaikof EL, Blankensteijn JD, Harris PL, et al. Reporting standards for endovascular aortic aneurysm repair. J Vasc Surg 2002;35:1048-60.
22. Elliott SL, Harris AH. The methodology of cost-effectiveness analysis: avoiding common pitfalls. Med J Aust 1997;166:636-9.
23. Bertges DJ, Zwolak RM, Deaton DH, et al. Current hospital costs and Medicare reimbursement for endovascular abdominal aortic aneurysm repair. J Vasc Surg 2003;37:272-9.
24. Dattilo JB, Brewster DC, Fan CM, et al. Clinical failures of endovascular abdominal aortic aneurysm repair: incidence, causes, and management. J Vasc Surg 2002;35:1137-44.
25. Prinssen M, Wixon CL, Buskens E, Blankensteijn JD. Surveillance after endovascular aneurysm repair: diagnostics, complications, and associated costs. Ann Vasc Surg 2004;18:421-7.

Submitted Jun 13, 2005; accepted Jul 27, 2005.