CLINICAL RESEARCH STUDIES

From the New England Society for Vascular Surgery

Durability of open repair of juxtarenal abdominal aortic aneurysms

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Objective: **As branched/fenestrated endografts expand endovascular options for juxtarenal abdominal aortic aneurysms (JAAAs), long-term durability will be compared to that of open JAAA repair, which has not been documented in large contemporary series. The goal of this study was to assess the late clinical and anatomic outcomes after open JAAA repair.**
Methods: **From July 2001 to December 2007, 199 patients underwent open elective JAAA repair, as defined by a need for suprarenal clamping. End points included perioperative and late survival, long-term follow-up of renal function, and freedom from graft-related complications. Factors predictive of survival were determined by multivariate analysis.**
Results: **The mean patient age was 74 years, 71% were men, and 20% had baseline renal insufficiency (Cr >1.5). Thirty-seven renal artery bypasses, for anatomic necessity or ostial stenosis, were performed in 36 patients. Overall 30-day mortality was 2.5%. Four patients (2.0%) required early dialysis; one patient recovered by discharge. Two additional patients progressed to dialysis over long-term follow-up. There was one graft infection involving one limb of a bifurcated graft. Surveillance imaging was obtained in 101 patients (72% of survivors) at a mean follow-up of 41 ± 28 months. Renal artery occlusion occurred in four patients (3% of imaged renal arteries; one native/three grafts). Two patients (2.0%) had aneurysmal degeneration of the aorta either proximal or distal to the repaired segment, but there were no anastomotic pseudoaneurysms. Remote aneurysms were found in 29 patients (29% of imaged patients), 14 of whom had descending thoracic aneurysm or TAAA. Four patients underwent subsequent thoracic endovascular aneurysm repair (TEVAR). Actuarial survival was 74 ± 3.3% at 5 years. Negative predictors of survival included increasing age at the time of operation (relative risk [RR], 1.05; $P = .01$), steroid use (RR, 2.20; $P = .001$), and elevated preoperative creatinine (RR, 1.73; $P = .02$).**
Conclusions: **Open JAAA repair yields excellent long-term anatomic durability and preserves renal function. Perioperative renal insufficiency occurs in 8.5% of patients, but few of them progress to dialysis. Graft-related complications are rare (2% at 40 months); however, axial imaging revealed descending thoracic aneurysms in 14% of imaged patients, making continued surveillance for remote aneurysms prudent. These data provide a benchmark against which fenestrated/branched endovascular aneurysm repair (EVAR) outcomes can be compared. (J Vasc Surg 2012;56:2-7.)**

Since its introduction nearly 20 years ago,[1] endovascular aortic aneurysm repair (EVAR) has gradually supplanted open abdominal aortic aneurysm (AAA) repair, to the extent that in large contemporary series, over 70% of AAAs are repaired via an endovascular approach.[2,3] Open repair, therefore, is now largely reserved for patients with complex aortic anatomy, including those with aneurysms in close proximity to or involving the renal arteries. Subsequently, contemporary studies have focused on the perioperative mortality and preservation of renal function after open juxtarenal abdominal aortic aneurysm (JAAA) repair.[4,5] A recent review, including 1256 patients undergoing open JAAA repair, reported a mean perioperative mortality of 2.9%, a mean incidence of new onset dialysis of 3.3%, and a median incidence of perioperative renal insufficiency of 18%.[6] Although focus on early complications has been both evident and appropriate, few contemporary series report late outcomes after open repair, such as long-term anatomic surveillance and renal function. The alternatives to open JAAA repair – fenestrated and branched endografts – have only limited availability in the United States. Initial studies of fenestrated grafts, both in the United States and in Europe, have demonstrated very high technical success rates (99% target vessel patency in the French multicenter study) and low rates of renal dysfunction.[7,8] Both fenestrated studies, however, are currently limited to 2-year follow-up. While awaiting approval of the branched and fenestrated devices, reports of small series of patients undergoing "snorkel" or "chimney" stent configurations to preserve visceral artery perfusion have demonstrated initial success, but the long-term durability is unclear.[9,10] The goal of this study,

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Author conflict of interest: none.
Presented at the Thirty-eighth Annual Meeting of the New England Society for Vascular Surgery, Westin Providence, Providence, RI, September 16-18, 2011.
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The editors and reviewers of this article have no relevant financial relationships to disclose per the JVS policy that requires reviewers to decline review of any manuscript for which they may have a conflict of interest.
0741-5214/$36.00

http://dx.doi.org/10.1016/j.jvs.2011.12.085

therefore, was to assess the long-term outcomes and durability of open JAAA repair in contemporary practice. These data should ultimately serve as a standard by which branched and fenestrated EVAR results can be compared.

METHODS

From July 2001 to December 2007 (chosen to ensure long-term follow-up), 199 consecutive patients underwent open elective JAAA repair at a single institution. Patients were included if they required a suprarenal or higher aortic clamp to repair the aneurysm. The study population included patients with true juxtarenal aneurysms (n = 145), and also those with suprarenal aneurysms (n = 54); patients with ruptured aneurysms or type IV TAAAs, wherein the graft reconstruction itself extends to or is proximal to the celiac axis, were excluded from the cohort. The study protocol was approved by the Institutional Review Board of the Massachusetts General Hospital.

Demographic, preoperative, intraoperative, and postoperative data, including clinical presentation, aneurysm extent, operative conduct, complications, follow-up radiographic imaging, and renal function, were collected from a review of the electronic medical records. Baseline renal insufficiency was defined as a serum creatinine >1.5 mg/dL. New onset renal insufficiency (either in the perioperative period or over long-term follow-up) was defined by an increase in creatinine of >0.5 mg/dL over baseline and serum creatinine >1.5 mg/dL. Although the majority of patients underwent cardiac risk stratification before elective open repair, for the purposes of this study, the designation of coronary artery disease was limited to a positive history of myocardial infarction, regardless of the status of coronary revascularization.

Surgical considerations. Ninety-two percent of patients were repaired via a left flank incision; the rest were approached with a midline transabdominal incision. The proximal anastomosis was end-to-end to either a normal infrarenal cuff, or incorporated one or both of the renal artery origins. In cases where the aneurysm involved the renal artery origins or where there was significant renal artery stenosis, intraoperative renal artery stenting under direct visualization, as previously described,[11] or renal artery bypass with a prosthetic conduit was performed. In cases involving renal artery bypass, renal cold perfusion was administered (normal saline with 18 grams Mannitol and 500 mg methylprednisolone per liter at 4°C).

Postoperative follow-up. Perioperative mortality was defined as any death within 30 days of the procedure or any death occurring within the initial admission. Early (within 30 days) and long-term events (>30 days postoperative and after the initial admission) were identified through a review of office charts and the hospital electronic medical records. Additional data concerning long-term survival was obtained from the Social Security Death Index. Assessment of renal function was based on serum creatinine and also medical records indicating whether the patient was dialysis dependent. In the 140 surviving patients, those who did not have follow-up axial imaging were contacted by telephone and scheduled for computed tomography or computed tomographic angiography (CTA). All CTAs were performed with fine cuts and included at least the abdomen and pelvis; the chest was included when possible. Patients with known renal insufficiency or contrast allergy were imaged without contrast. All CTAs were reviewed by a staff radiologist blinded to the study. The designation of an aneurysm involving a remote arterial segment was based upon the following criteria: thoracic/visceral aorta (≥4 cm), visceral vessels (≥2 cm), or iliac/femoral arteries (≥2 cm). Primary study end points included overall survival and 30-day mortality, freedom from aneurysm-related mortality (death from any cause within 30 days of the primary aneurysm repair, death from any cause within 30 days of any secondary intervention related to the aneurysm repair, or any death due to aneurysm rupture), preservation of renal function, and detection of remote aneurysmal disease.

Table I. Patient demographics

Variable	*Data*
No. of patients	199
Male	142 (71%)
Mean age (range)	74 (51-93)
Hypertension	176 (88%)
COPD	39 (20%)
Renal insufficiency (Cr >1.5 mg/dL)	39 (20%)
Diabetes	17 (8.5%)
History of smoking	159 (80%)
Steroids	10 (5%)
Previous MI	77 (39%)

COPD, Chronic obstructive pulmonary disease; *Cr,* creatinine; *MI,* myocardial infarction.

Statistical analysis. Actuarial survival analysis was performed using Kaplan-Meier life table analysis. Relative risk (RR) and confidence intervals were determined using a multivariate Cox proportional hazards model for data with variable follow-up. A logistic regression model was used for multivariate analysis of perioperative outcomes. Variables included in the regression analysis were age, gender, hypertension, history of myocardial infarction, history of chronic obstructive pulmonary disease, diabetes, any history of smoking, steroid use, and preoperative creatinine (analyzed as a continuous variable).

RESULTS

Over the 6-year study period, 199 consecutive patients underwent open elective repair of JAAA with a suprarenal clamp. The mean age at operation was 74 years (range, 51-93 years). Thirty-nine patients (20%) had baseline renal insufficiency. Demographic and clinical data are summarized in Table I. One hundred eighty-four patients (92%) had a left flank approach; 25 patients (13%) had a supraceliac clamp and 29 additional patients (15%) had a clamp placed between the superior mesenteric artery and celiac artery. The majority of proximal anastomoses were sewn to an infrarenal cuff or beveled to include the right renal artery, with renal bypass grafting when necessary. Operative details are summarized in Table II.

One-quarter of the patients underwent adjunctive renal intervention at the time of aneurysm repair. Thirty-seven

Table II. Operative details

Operative data	*No. of patients (%)*
Operative approach	
Left flank	184 (92)
Midline	15 (7.9)
Graft material	
Dacron	197 (99)
Other	2 (1)
Graft construction	
Tube	165 (83)
Bifurcated	33 (17)
Proximal clamp	
Suprarenal	145 (72)
Supramesenteric	29 (15)
Supraceliac	25 (13)
Renal reconstruction	49 (25)
Aortorenal bypass	37 (19)
Renal artery stent (intraoperative)	13 (6.5)
Renal orifice endarterectomy	6 (3.0)
Renal artery reimplantation	2 (1.0)
Distal anastomosis	
Bifurcation	165 (82)
Iliac arteries	27 (14)
Femoral arteries	6 (3)
Previous graft	1 (1)

Table III. Thirty-day outcomes

Postoperative complications	*Patients (n = 199)*
Hospital LOS (mean ± SD)	9.7 ± 4.6 days
ICU LOS (mean ± SD)	2.1 ± 3.2 days
Renal insufficiency (increase >0.5)	17 (8.5%)
Renal failure requiring HD	4 (2%)
Respiratory failure (vent >48 hrs)	11 (5.5%)
Re-intubation	7 (3.5%)
Pneumonia	10 (5%)
Pulmonary embolism	0
Postoperative DVT	0
Myocardial infarction	4 (2%)
Arrhythmia	20 (10%)
Atrial fibrillation	12
Postoperative CVA	0
Return to OR	7 (3.5%)
Death	5 (2.5%)

CVA, Cardiovascular accident; *DVT,* deep venous thrombosis; *HD,* hemodialysis; *ICU,* intensive care unit; *LOS,* length of stay; *OR,* operating room.

Table IV. Univariate analysis of variables affecting 30-day mortality

Variable	*P value*
Male gender	.81
Hypertension	.38
Previous MI	.15
History of COPD	.86
Diabetes	.47
Any history of smoking	.23
Steroids	.0012
Creatinine (continuous variable)	.91
Age (continuous variable)	.66

COPD, Chronic obstructive pulmonary disease; *MI,* myocardial infarction.

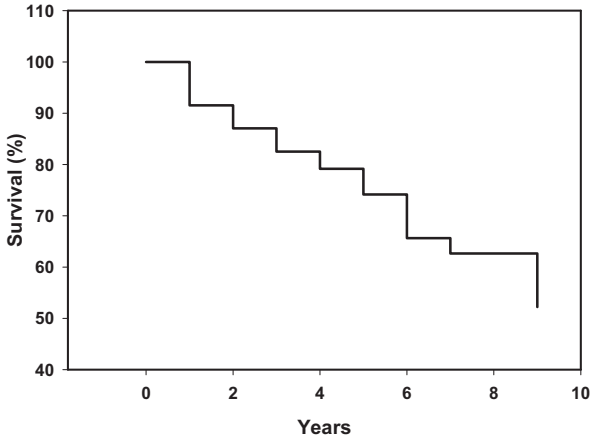
renal artery bypasses were performed in 36 patients. Thirteen patients had pre-existing severe left renal artery stenosis and eight patients had aneurysmal degeneration of the left renal artery origin or proximal renal artery. Thirteen patients underwent intraoperative placement of a renal artery stent: 12 on the right and one on the left. Of the right renal artery stents, 67% were placed for stenosis and the rest were placed because of encroachment of the suture line on the right renal artery orifice. In six patients, a renal orificial endarterectomy without other renal intervention was sufficient. Two renal arteries were reimplanted into the graft.

Overall 30-day mortality was 2.5%. Seventeen patients (8.5%) developed new renal insufficiency in the perioperative period. Four patients (2.0%) required dialysis in the immediate postoperative period and one patient recovered by the time of hospital discharge. Other perioperative outcomes are detailed in Table III. On univariate analysis, the only preoperative predictor of death at 30 days was steroids; among patients being treated with steroids, 30-day mortality was 20%, compared to 2% in patients not treated with steroids ($P = .0012$; Table IV).

The mean follow-up period was 56 months (range, 0-108 months). Fifty-nine patients died during follow-up. Actuarial survival was 74% ± 3.3% at 5 years (Fig). On multivariate analysis, negative predictors of survival included age at the time of surgery (RR, 1.05; $P = .01$), steroid use (RR, 2.20; $P = .001$), and creatinine (RR, 1.73; $P = .02$). There was one known aneurysm-related death in a patient who underwent successful JAAA repair, but was diagnosed with an enlarging and symptomatic extent type III TAAA 5 years later. He underwent open TAAA repair and died after a complicated postoperative course.

Over long-term follow-up, serum creatinine levels were obtained in 105 patients at an average of 46.6 months (range, 2-105 months) postoperatively. Two of 17 patients with perioperative renal insufficiency recovered to normal renal function. However, an additional five patients developed new renal insufficiency after the perioperative period, resulting in a total of 20 patients (10%) with renal insufficiency at last follow-up of their creatinine when compared to their preoperative baseline. Two patients with perioperative renal insufficiency progressed to dialysis over long-term follow-up. On multivariate analysis using a Cox proportional hazards model, the only preoperative predictors of renal insufficiency were increasing age (RR, 1.10; $P < .01$) and preoperative creatinine (RR, 2.61; $P < .01$).

Surveillance imaging was obtained in 101 of 140 patients (72% of survivors) at a mean follow-up of 41 ± 28 months. Twenty-two percent of patients with follow-up imaging underwent noncontrast computed tomography because of renal insufficiency or contrast allergy. In terms of renal artery/reconstruction patency, 153 renal arteries were evaluated with contrast-enhanced imaging. Of the native renal arteries imaged (136 total), 135 were patent (98%) and 1 was thrombosed at last follow-up. This patient thrombosed the right renal artery and developed mild renal insufficiency (creatinine 2.0 from baseline of 1.1) after 84-month follow-up.



Years	*Survival (%)*	*SE*
1	91.54	1.96
2	87.06	2.37
3	82.52	2.69
4	79.15	2.91
5	74.15	3.29
6	65.64	3.97
7	62.66	4.31
8	62.66	4.31
9	52.21	10.19

Fig. Actuarial survival curve of 199 patients undergoing elective juxtarenal abdominal aortic aneurysm (JAAA) repair. The 5-year actuarial survival rate was 74% ± 3.3%.

Of the 37 renal artery bypasses performed, 12 were evaluated with follow-up imaging. Nine were patent (75%) and three were thrombosed (25%) at last imaging follow-up. One patient with a thrombosed bypass graft suffered perioperative acute renal failure with a rise in serum creatinine from 1.0 to 3.7. In long-term follow-up over 103 months, his creatinine stabilized around 3.0; he never required dialysis. One patient, who underwent aortorenal bypass to a diminutive left renal artery at the time of aneurysm repair, maintained a normal serum creatinine of 1.1 through 66 months of follow-up, despite the thrombosed graft. The third patient had imaging follow-up at 1 month showing a thrombosed left aortorenal bypass graft. This patient is alive, but was lost to follow-up at our institution. Of 13 renal artery stents placed, five were imaged with contrast, and all were patent after 11 to 61 months of follow-up. All of these patients maintained normal renal function.

There were no anastomotic pseudoaneurysms identified on follow-up imaging; however, two patients (2.0%) had contiguous aneurysmal degeneration. In one patient, the infrarenal neck at the time of operation was noted to be ectatic but not aneurysmal and the aorta was replaced with a 20-mm Dacron graft. Follow-up imaging after 55 months revealed a 4-cm aneurysm just above the proximal suture line extending to the level of the renal arteries. The other patient had a known right common iliac artery aneurysm at the time of JAAA repair. The aorta was replaced with an 18- × 9-mm bifurcated graft with an anastomosis to the distal right common iliac artery beyond the aneurysmal segment. Follow-up imaging after 73 months showed a 3.2-cm aneurysm just distal to the right iliac anastomotic line. Neither of these aneurysms have required repair to date.

Remote aneurysms were detected in 29 patients (29% of imaged patients). There were 11 iliac artery aneurysms and 14 descending thoracic aortic aneurysms (dTAAs). Four patients underwent subsequent thoracic endovascular aneurysm repair (TEVAR) and one patient underwent open thoracic aortic aneurysm (TAA) repair.

There was one graft infection in a patient who underwent emergent right colon resection for ischemic colitis 5 days before open repair of a symptomatic 8.5-cm JAAA with a Dacron tube graft and left aortofemoral bypass for left iliac occlusive disease. One month later, she developed an infection of the left aortofemoral bypass requiring graft resection and subsequent right femoral to left popliteal bypass. She recovered from her JAAA repair and ultimately died 2 years later from metastatic non-small cell lung cancer.

DISCUSSION

Herein we report on 199 consecutive patients undergoing open elective JAAA repair. With 25% of patients requiring adjunctive renal intervention, the majority of which consisted of renal artery bypass, 8.5% of 199 patients had postoperative renal insufficiency (as defined by rather stringent criteria), and 2.0% of patients required postoperative dialysis. These outcomes compare favorably with previous studies of open JAAA repair.[4,5] Unique to this current series, however, is the long-term follow-up of renal function and axial imaging for anatomic surveillance.

As summarized in a recent comprehensive review of open JAAA repair,[6] the perioperative mortality ranges from 0.8%[4] to 6.3%.[12] When compared to open infrarenal AAA repair, open JAAA repair has been shown to have comparable perioperative mortality, both in single center series[13] and in a multicenter series based on the National Surgical Quality Improvement Program (NSQIP) database.[14] The 30-day mortality in patients undergoing elective aneurysm repair in this current series was 2.5%, which is comparable to the perioperative mortality of 3% in a larger series of 540 patients undergoing open AAA repair (the majority of which were infrarenal) from our institution.[15]

In the long-term, the percentage of patients with renal insufficiency as compared to their preoperative baseline was 10% and only an additional two patients progressed to dialysis. The risk of delayed renal insufficiency after aneurysm repair is not limited to open repair. In an analysis of patients undergoing EVAR with suprarenal fixation, Greenberg et al[16] reported that there was a significant rise in mean serum creatinine from a baseline of 1.13 to 1.26 over 12 months in patients undergoing EVAR with suprarenal stent fixation. Over the next 12 months, the mean serum creatinine stabilized. They propose that the etiology of this pattern of renal insufficiency is multifactorial – ranging from the amount of nephrotoxic contrast reagent used (in the initial EVAR and in follow-up CTAs), late manifestations of atheroembolic dis-

ease, and/or hemodynamic effects of the suprarenal stent that traverses the renal artery origin.

The significance of chronic renal insufficiency rests in the broader implications thereof. Whereas dialysis-dependent renal failure is well recognized as a predictor of mortality, chronic renal insufficiency, as defined by decreasing glomerular filtration rate (GFR) below 60 mL/minute, has also been associated with increasing risk of death over the short-term (<3 years) from any cause.[17] In the current series, the only preoperative predictors of late renal insufficiency were age and preoperative creatinine. The relationship between preoperative creatinine and postoperative renal insufficiency has been documented in the complex aortic reconstruction literature. West et al,[18] in the 2006 series from Mayo Clinic studying 30-day outcomes after open pararenal aneurysm repair, reported that preoperative renal insufficiency (Cr >1.5) was predictive of postoperative myocardial infarction, postoperative renal failure requiring dialysis, and in-hospital mortality. In the TAA literature, an elevated preoperative creatinine has also been shown to be an independent predictor of increased postoperative morbidity and mortality.[19,20] In light of these associations between preoperative renal function and postoperative renal insufficiency and associated morbidity thereof, baseline renal function should figure prominently in the clinical determination of whether a patient is a good candidate for open JAAA repair.

Contemporary studies of open JAAA repair are hindered by an inconsistent definition of renal insufficiency or acute renal failure, and essentially no large studies have used the standardized definition based on GFR.[6] In the JAAA literature, definitions of renal insufficiency have ranged from absolute measurements (creatinine >1.8,[5] or 2.0[21]) to measurements of change in creatinine (increase of >0.5[4,22] or 1.2 × baseline[23]). On the other hand, the French fenestrated trial, for example, defined a significant decrease in renal function as a decrease of 30% or more in GFR. In this study, data required to calculate GFR were not available in all patients; therefore, changes in serum creatinine were used as a measurement of renal function. The stringent definition for renal insufficiency used in this study is similar to that used in the initial fenestrated trials and, therefore, the data may be more comparable to that from the fenestrated endograft trials.

Over 90% of our cases were performed via a left flank incision. This varies from the experience of others[4,5,22] in which the midline transperitoneal approach was used in the majority of cases. Multiple studies have suggested that patients recover faster after a left flank incision: in the randomized control study reported by Sicard et al[24] comparing retroperitoneal vs transabdominal incision, it was found that patients with a retroperitoneal incision had a significantly lower complication rate and decreased intensive care unit and hospital lengths of stay. In our view, the left flank approach affords optimal exposure of the visceral aortic segment and facilitates a flexible approach to placement of the proximal clamp, should that be necessary. A potential limitation of the left flank approach is access to the right renal artery. However, orificial stenosis of the right renal artery can be readily managed by transaortic placement of a balloon-expandable stent under direct vision, or endarterectomy, just before completion of the proximal aortic anastomosis.[11] Others contend that bypass to the right renal artery via a left flank approach is feasible with acceptable rates of postoperative morbidity and mortality.[25]

The current study is the only contemporary series to our knowledge with long-term imaging follow-up after open JAAA repair. The relatively low graft-related complication rate after open JAAA repair has led some authors to conclude that postoperative surveillance is unnecessary.[26] However, several small studies and a larger study based on a cohort of 680 patients in the Canadian Society of Vascular Surgery registry undergoing open nonruptured AAA repair have recommended regular follow-up imaging.[27-29] In the current series, continued follow-up imaging after JAAA repair identified remote aneurysms in 29 patients (29%), and dTAA in 14 of these patients, based on the size criteria of >4 cm. One-third of these patients with dTAA ultimately had indications for aneurysm repair and underwent successful TEVAR or open thoracic aortic repair. These data underscore the importance of imaging the entire aorta, including the thoracic aorta, in the initial evaluation of patients with JAAA and also the importance of continued surveillance with axial imaging after open JAAA repair. In our current practice, the initial workup for many patients includes a CTA of the chest, abdomen, and pelvis. Patients with axial imaging of only the abdomen and pelvis will always have a preoperative chest X-ray, on which a large thoracic aneurysm could be detected. Postoperatively, follow-up imaging is recommended every 5 years, unless there are other clinical reasons for imaging, such as known iliac or visceral aortic segment ectasia.

In the current series, there were no anastomotic pseudoaneurysms; however, there was contiguous aneurysmal degeneration in 2 of 101 (2.0%) patients with follow-up imaging. The small number of patients with contiguous aneurysmal disease reflects our general approach to resect all aneurysmal tissue during the initial open JAAA repair and to sew the proximal anastomosis to normal aorta. Indeed, the use of a suprarenal clamp and aggressive approach to renal artery bypass decreased the practice of sewing to ectatic or aneurysmal proximal aorta.

To our knowledge, the only aneurysm-related or renal reintervention occurred in a patient who underwent right renal artery stenting subsequent to open JAAA repair with left aortorenal bypass. This patient had a peak serum creatinine of 2.8 (baseline 1.4) in the initial postoperative period, but fully recovered to her baseline renal function by the time of discharge to home 2 weeks later. However, a renal artery duplex 3 months later revealed a right renal artery stenosis. A subsequent aortogram showed a widely patent left renal artery bypass, but a severely stenosed right renal artery. She underwent successful right renal artery stenting and has maintained a creatinine of 1.0 after 66 months of follow-up.

Limitations to this study are inherent in the retrospective nature of the study design. In cases where determination of survival was based on the Social Security Death Index, the cause of death was unknown. Based on institu-

tional chart review and telephone follow-up with primary care providers, the cause of death was determined in only 15% of deceased patients. It is possible that other aneurysm-related deaths or graft infections recorded at referring institutions were not captured by our protocol. Because of the retrospective nature of this study, follow-up imaging was obtained in 101 patients and follow-up creatinine in 105 patients of 199 patients enrolled in the study. At the time of the analysis, only 140 patients were still alive, and as reflected in our data, nearly one-third were lost to follow-up. Similarly, follow-up imaging was obtained in only one-third of patients undergoing renal artery reconstruction because the remaining patients had either died or were lost to follow-up. This limitation could only be avoided if the data were collected as a prospective database.

In conclusion, open JAAA repair can be performed safely and with durable long-term results, in terms of both graft integrity and preservation of renal function. Both age at treatment and baseline renal function are predictors of long-term survival and renal insufficiency. Although nearly 9% of patients had early renal insufficiency, few progressed to dialysis over long-term follow-up. Graft-related complications are rare (2% at 40 months); however, axial imaging revealed TAAs in 14% of patients, one-third of whom met criteria for either TEVAR or open repair. Therefore, we recommend continued surveillance with axial imaging after open JAAA for remote aneurysms.

AUTHOR CONTRIBUTIONS

Conception and design: MC, RC
Analysis and interpretation: ST, MC
Data collection: ST, MC, VP, CK, GL, DB, RC
Writing the article: ST, MC, RC
Critical revision of the article: ST, MC, VP, CK, GL, DB, RC
Final approval of the article: ST, MC, VP, CK, GL, DB, RC
Statistical analysis: ST, MC
Obtained funding: MC, RC
Overall responsibility: RC

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Submitted Oct 17, 2011; accepted Dec 30, 2011.