Delayed open conversion following endovascular aortoiliac aneurysm repair: Partial (or complete) endograft preservation as a useful adjunct

Evan C. Lipsitz, MD, Takao Ohki, MD, PhD, Frank J. Veith, MD, William D. Suggs, MD, Reese A. Wain, MD, Soo J. Rhee, MD, Nicholas J. Gargiulo, MD, and Jamie McKay, RN, Bronx, NY

Objectives: The purpose of this study was to review our experience with delayed open conversion (>30 days) following endovascular aortoiliac aneurysm repair (EVAR) and to introduce the concept and advantages of endograft retention in this setting.

Methods: From January 1992 to January 2003, a total of 386 EVARs using a variety of endografts were successfully deployed. Eleven (2.8%) patients required delayed conversion to open repair at an average of 30 months (range, 10-64). Data from all patients undergoing both EVAR and open conversion were prospectively collected.

Results: EVARs were performed using grafts made by Talent (4), Vanguard (2), AneuRx (1), and Surgeon (4). Conversion to open repair (9 transabdominal, 1 retroperitoneal, 1 transabdominal plus thoracotomy) was performed for aneurysm rupture in 7 patients (4 type 1 endoleak, 2 type 2 endoleak, 1 aortoenteric fistula) and aneurysm enlargement in 4 patients (1 type 1 endoleak, 1 type 2 endoleak, 1 type 3 endoleak, 1 endotension). Patients with aneurysm rupture were treated on an emergent basis. Complete removal of the endograft with supraceliac cross-clamping was performed in two cases. One patient (rupture) did not survive the operation, and one patient (aortoenteric fistula) died 2 weeks postoperatively. In the remaining nine cases, the endograft was either completely (1) or partially (6) removed, or left in situ (2). Supraceliac balloon control (2), supraceliac clamping (1), suprarenal clamping (1), or infrarenal clamping (5) was used in these cases. All nine of these patients survived the operation. In one procedure in which the endograft was left intact (endotension), repair was accomplished by exposing the endograft and by placing a standard tube graft over it as a sleeve. In the second procedure in which the graft was left in situ (rupture), the graft was well incorporated, and bleeding lumbar arteries were oversewn and the sac was closed tightly over the endograft. In the remaining 7 cases, the endograft was transected and the proximal portion only (6) or the proximal and distal portions (1) were excised. All surviving patients continue to do well and remain without complications associated with the endograft remnant at a mean follow-up of 22 months (range, 3-56) from the time of open conversion and 46 months (range, 10-73) from the time of original EVAR.

Conclusions: Open repair in the setting of a long-standing endograft offers several unique technical challenges but can be successfully accomplished in most patients. Preservation of all or part of the endograft is possible in many patients. This technique simplifies the operative approach and is preferred over complete endograft removal if possible. (J Vasc Surg 2003;38:1191-8.)

Since the first endovascular repair of an abdominal aortic aneurysm (EVAR) was reported in 1991, thousands of endovascular grafts have been placed worldwide. The growing popularity of EVAR has proceeded at a dramatic pace, fueled by improvements in graft manufacture and design as well as graft availability, operator experience, and patient demand. Although EVAR can be performed with a high technical success rate, the midterm and long-term results are uncertain, and recipients of these grafts require close, ongoing, life-long follow-up. Although most endograft failures can be treated endovascularly, in some cases, the development of endoleak with aneurysm enlargement, aneurysm enlargement without demonstrable endoleak, aortoenteric fistula, graft migration, or rupture may necessitate conversion to an open repair on an elective or sometimes emergent basis. With the ever-increasing number of these grafts being placed, the need for a systematic approach to problems associated with them, including their removal and conversion to open repair when necessary, will become increasingly important.

Preservation of the proximal end of an endograft has been previously reported. In this setting preservation of the endograft was necessary because the surgeon was unable to remove the suprarenal and pararenal portions of the endograft. We propose that in many cases preservation of part of the endograft is a virtue in that it avoids damage in the native arteries as well as buttresses the suture lines for the new graft anastomosis, while avoiding the risk of type 1 endoleak beside the retained segment of the endograft.
Because of these concerns and the technical difficulties associated with the late removal of endografts, we reviewed our experience with delayed open conversion (>30 days) after endovascular aortoiliac aneurysm repair (EVAR) and introduce the concept and advantages of endograft retention in this setting.

METHODS

From January 1992 through January 2003, a total of 386 EVARs were successfully deployed for the treatment of aortoiliac aneurysms. The initial technical success rate for graft placement during this period was 97%, and the immediate conversion rate was 1% (3 of 386). Several different endografts were used in this experience, including 21 EVT or Ancure (EVT/Guidant, Menlo Park, Calif), 16 Vanguard (Boston Scientific, Natick, Mass), 49 Talent (Medtronic, Sunnyvale, Calif), 24 Excluders (WL Gore, Flagstaff, Ariz), 78 AneuRx (Medtronic, Sunnyvale, Calif), 3 Corvita (Schneider/Boston Scientific, Natick, Mass), 35 Zenith (Cook Inc., Bloomington, IN), 5 Quantum (Cordis, Warren, NJ), and 155 Montefiore Endovascular Graft System (MEGS) grafts. Bifurcated industry-made devices and surgeon-made aortouni-iliac or aortounifemoral grafts were placed by standard methods.4,5 Data from all patients undergoing both EVAR and open conversion were prospectively collected. Patients were followed with serial computerized tomography scans and routine physical examinations at 1, 6, and 12 months postoperatively and yearly thereafter. Indications for delayed conversion included rupture, aortoenteric fistula, and aneurysm enlargement of ≥2 cm with or without demonstrable endoleak. Those patients requiring conversion to open repair at greater than 30 days after EVAR were identified for further analysis.

RESULTS

There were 11 (2.8%) patients who required delayed conversion to open repair at an average of 30 months (range, 10-64) from the time of the original procedure (Table). Ten of the original EVARs were performed electively, and one was performed for aneurysm rupture. Nine delayed conversions were performed at our institution and two (patient nos. 1 and 2) were performed at other institutions. The mean age of the patients undergoing delayed conversion was 76 ± 8.4 years, and all were men. Associated comorbidities in this group included coronary artery disease (left ventricular ejection fraction <20%, recent congestive heart failure, unstable angina, areas of myocardium at risk on nuclear imaging studies, or nonreconstructible disease on coronary angiography) (82%), chronic obstructive pulmonary disease (forced expiratory volume at 1 second <50%, predicted, home oxygen requirement) (18%), diabetes mellitus (27%), hypertension (90%), and chronic renal insufficiency (creatinine >3, dialysis) (9%). Two (18%) of the patients were on warfarin for auricular fibrillation. There were 49 patients in the overall series with isolated iliac artery aneurysms and 2 patients (nos. 5 and 8, Table) in the treatment group with isolated iliac artery aneurysms. The mean aneurysm size at the time of EVAR was 6.9 cm (range, 6-10) for all patients and 7.0 cm (range, 6-10) when excluding patients with isolated iliac artery aneurysms. The mean aneurysm size at the time of delayed conversion was 8.2 cm (range, 6-12) for all patients and 8.4 cm (range, 6-12) excluding patients with isolated iliac artery aneurysms. Nine patients had an increase in aneurysm size, and two patients had stable aneurysm size. There were no significant differences in patient demographics or
follow-up between all patients undergoing EVAR and those patients who required delayed conversion other than the percentage of men which was 87% in the overall group. Of the seven patients presenting with rupture, all presented with pain and six with hypotension. Of the two patients who died, one patient (no. 1) had extensive blood loss both preoperatively and intraoperatively (because of extensive scarring and difficult graft removal), and the other patient (no. 2) died of multisystem organ failure several days after extra-anatomic bypass.

Four of the 11 patients (36%) underwent a total of six secondary procedures for the treatment of endoleaks before undergoing open conversion. One patient (no. 10) underwent translumbar decompression for an expanding aneurysm and endostent without demonstrable endoleak. By way of a translumbar approach a needle was placed into the aneurysm sac. Pressures were elevated without evidence of endoleak. A large amount of gelatinous material was withdrawn from the sac with resulting decrease in aneurysm size and intrasac pressure. This material subsequently re-accumulated, and aneurysm diameter increased, necessitating repair. Another patient (no. 6) required stent placement within the limb of a bifurcated graft that subsequently thrombosed, and a femorofemoral bypass was performed. This patient ultimately developed a type 1 endoleak and underwent delayed conversion when attempt at endovascular repair with a proximal AneuRx cuff failed, resulting in coverage of the renal arteries. Patient no. 3 underwent coil embolization of a patent iliac artery by way of a hypogastric artery approach for the treatment of type 2 endoleak. Patient no. 4 had a dislocation of the contralateral limb of a bifurcated graft (distal type 1 endoleak) treated with two Vanguard iliac extensions to re-seat the graft in the common iliac artery. He later developed a separation at the junction of these limbs, and a single bridging AneuRx graft was placed across the limbs. Completion angiography at that procedure suggested a small leak from the proximal ipsilateral limb, and a second AneuRx graft was placed across this area. None of these four patients undergoing secondary interventions presented with rupture.

EVARs in this group were performed using grafts made by Talent (4), Vanguard (2) AneuRx (1), and Surgeon (4). Conversion to open repair (9 transabdominal, 1 retroperitoneal, 1 transabdominal plus thoracotomy) was performed for aneurysm rupture in 7 patients (4 type 1 endoleak, 2 type 2 endoleak, 1 aortoenteric fistula) and aneurysm enlargement in 4 patients (1 type 1 endoleak, 1 type 2 endoleak, 1 type 3 endoleak, 1 endostent). All procedures were performed under general anesthesia. Patients with aneurysm rupture were treated on an emergent basis. Two of the four type 1 endoleaks (patient nos. 1 and 7) were diagnosed preoperatively, one patient refused intervention and one patient was scheduled for repair but ruptured prior. One of the two type 2 endoleaks (patient no. 11) was diagnosed preoperatively, and the patient was scheduled for surgery but ruptured prior. The aortoenteric fistula was not diagnosed before surgery. Whether this fistula was due to erosion by the graft or primary ulcer disease is not clear. Both patients whose endoleaks were diagnosed preoperatively were asymptomatic when diagnosed and were scheduled for repair within 2 weeks of diagnosis.

Complete removal of the endograft with suprarenal cross-clamping was performed in two cases. One of these patients (no. 1) had a known type 1 endoleak but refused intervention, went on to rupture, and did not survive the operation because of a massive myocardial infarction. The other patient (no. 2) had an aortoenteric fistula and died 2 weeks postoperatively after graft explant and axillofemoral bypass. In the remaining 9 cases, the endograft was either completely (1) or partially (6) removed or left in situ (2). Suprarenal balloon control (2), suprarenal clamping (1), infrarenal clamping (1), or infrarenal clamping (5) was used in these cases. All nine of these patients survived the operation. Distal arterial control was achieved by using clamps on the common iliac arteries, although Fogarty balloon control can also be used. In the setting of an unsupported graft (MEGS), the graft itself was clamped within the aneurysm sac.

In one procedure performed for endotension, repair was accomplished by dividing the surgeon-made aortounifemoral (MEGS) graft within the aneurysm sac. A standard tube graft was then placed over the endograft (as a sleeve). The endograft was then sutured back together, restoring continuity and flow. The standard graft was then sutured both proximally and distally, incorporating the endograft in the anastomosis proximally. Thus, flow was maintained through the endograft and buttressed by the standard graft. The second procedure in which the graft was left in situ was performed for rupture. At operation the graft was noted to be well incorporated both proximally and distally. Four bleeding lumbar arteries were oversewn, and the sac was closed tightly over the endograft. In the remaining 7 cases, the endograft was transected, and the proximal portion only (6) or the proximal and distal portions (1) were excised. Proximal graft was removed in those cases in which proximal stent migration was present. This migration facilitated extraction of the proximal stent from the neck. When the proximal graft was removed, a standard aortic graft was placed between the proximal neck and the remaining endograft (Fig 1, 2). To avoid future distal type I endoleaks, the distal end of the new graft (standard) was sewn to the residual endografts as well as to the iliac artery orifices.

All surviving patients continue to do well and remain without complications associated with the endograft remnant. One patient had a small myocardial infarction 1 month after the procedure (no. 7), and one patient developed a small bowel obstruction that necessitated lysis of adhesions 2 months postoperatively (no. 4). There were no episodes of renal failure excluding one patient who was already on dialysis. The perioperative morbidity and mortality rate for all patients was 27%. Patients with any or all graft left in situ had a perioperative morbidity of 13%,
whereas patients whose grafts were completely excised had a perioperative morbidity of 67%.

Mean length of follow-up from the time of delayed conversion was 22 months (range, 3-56) and from the time of the original EAVR was 46 months (range, 10-73). None of the 11 patients undergoing delayed conversion were lost to follow-up. Operation time for the delayed conversions was 6.4 ± 2.3 hours with an average blood loss of 3800 ± 2400 mL. The mean supraceliac and/or suprarenal ischemia time for the six patients requiring this approach was 15 minutes (range, 8-27). The mean length of stay for the nine patients undergoing successful delayed conversion was 9.9 days (range, 5-19).

**DISCUSSION**

The late removal of aortic endografts is technically challenging, especially when performed in the acute setting. The overall delayed conversion rate for patients undergoing EVAR has been estimated to be between 0.6% and 4.5%. The mortality rate seen in this series is comparable to that of other series and underscores the difficulty in performing these procedures. Despite the fact that there was good compliance with the follow-up regimen, the delayed conversion rates cited above and the number of patients presenting with rupture suggest that more frequent surveillance, especially in patients who have had EVAR more than 1 year ago, may be warranted. In
addition, the presence of certain cues, eg, failure to achieve aneurysm shrinkage, should indicate the need for more frequent imaging than indicated by the specific graft protocol.

The exact approach to the late removal of endografts depends on several factors, including the type and condition of the endograft originally placed as well as the presence of suprarenal stents and/or hooks or barbs; the presence of any additional grafts, cuffs, or coils placed as secondary interventions; the condition of proximal and distal fixation points and how intact they are; the current aneurysm morphology; the presence of periaortic scarring or inflammation; and, most importantly, the urgency of the repair. Additionally, several studies have documented peri-graft reaction with at least some incorporation of the endografts, especially at the proximal portion.\textsuperscript{16,17} Although not sufficient to provide secure long-term fixation,\textsuperscript{18} these changes contribute to the difficulties associated with late endograft removal. Simple traction or traction with compression of the graft might not be enough to permit graft retrieval. It could be necessary to cut either the proximal bare stents or the proximal graft itself, including stents, and wire cutters should be available for this purpose. Endografts with stents located on the outside of the graft material may also be more difficult to remove than those with stents located inside or contained within the graft.

![Image](image-url)

Fig 2. Standard graft being anastomosed to residual endograft (arrows) and iliac orifices (A) and complete repair (B) (patient no. 9). Proximal anastomosis (single wide arrow at left) and distal anastomoses (arrows at right) are shown.
material because of the inflammatory reaction incited by the stents. Additionally, when stents are positioned outside the graft, these stents may cause more damage to the native arteries during removal than would be the case if only the graft material were exposed to the native artery. We have found that the use of a compliant balloon placed in the suprarenal aorta by way of a brachial or femoral approach can decrease the time until proximal arterial control is achieved. It also reduces the need for what can be difficult dissection of the suprarenal and/or supraceliac aorta. It may also reduce the need for an extensive arteriotomy. Once the graft has been removed or infrarenal control has been obtained, the balloon can be deflated, reperfusing the visceral vessels.

In our series all patients but one were converted by using a midline transperitoneal approach. One patient (no. 2) required a left thoracotomy in addition to laparotomy for suprarenal control because of dense adhesions in the upper abdomen. The patient who was converted using a retroperitoneal approach (no. 6) had an occlusion of the right limb of the endograft with a functioning femorofemoral bypass. Although we prefer a midline transperitoneal incision for these cases, the retroperitoneal approach does facilitate exposure of the suprarenal and, if required, supraceliac aorta. The disadvantages of the retroperitoneal approach in this setting include limited exposure to the right iliac system. This limitation could, however, be easily overcome by making an incision in the right retroperitoneum. Additionally, should the orifice of the right renal artery be damaged during explant, control and exposure of the artery could be difficult by way of this approach.

Although excision of the proximal endograft has been the focus of most reports about delayed conversions, removal of the distal endograft may also be prohibitive. Removal of the distal limbs often requires significant traction and/or probing of the iliac arteries which can render these arteries unsuitable as target vessels for outflow.

Although complete removal of the endograft and replacement with a standard graft during delayed conversion is preferable, we believe that in many cases complete or even partial endograft removal might be unnecessary and might unduly complicate the procedure, adding to its morbidity. In only 1 of 9 patients who survived the perioperative period was the endograft completely excised. We can speculate as to whether partial or complete graft preservation could have improved the outcome in any of the three patients with complete endograft removal (67% morbidity and mortality) relative to the group with partial or complete endograft preservation (13% morbidity and mortality). But to answer the question adequately with meaningful statistical analysis would require a larger series. However, in this small series no significant differences were found between the two groups with regard to hypotension, free versus contained rupture, estimated blood loss, comorbidities, transfusions, operative time, number of days in the intensive care unit, or length of stay between the two groups of patients.

In cases in which the standard graft is anastomosed to the endograft, we recommend incorporating the native artery into the suture line (Fig 2). One potential concern is that suturing to an endograft might not provide as durable an anastomosis as suturing to standard grafts. An additional measure in cases in which a portion of the endograft is left in situ is to close the aneurysm sac tightly over the entire new graft complex to prevent any kinking, twisting, or buckling of the graft that could lead to limb dislodgement.

In the case of the patient with endotension (no. 10), the graft (MEGS) remained firmly seated both proximally (suprarenal balloon-expandable stent) and distally (endoluminal anastomosis). The repair was designed to further secure the proximal anastomosis, to protect against the development of type 1 endoleak, and to eliminate the effect of any fluid translocation from the graft material into the aneurysm sac. Patient no. 11 had a rupture because of a type 2 endoleak. Although currently we would recommend branch coil embolization or translumbar embolization as an initial therapy, this patient’s endoleak could not be adequately characterized preoperatively, and in the setting of an enlarging aneurysm he was scheduled for surgery. At operation the endograft was extremely well seated, and attempts to remove all or part of it would likely have resulted in significant trauma to the vessels involved as well as complicated the operation in this patient with multiple comorbidities.

Open repair in the setting of a long-standing endograft offers several unique technical challenges but can be successfully accomplished in most patients. With the large numbers of endografts being implanted worldwide the problem of delayed conversion to open repair will only increase in importance. The basic principles and techniques of endograft explantation should be familiar to all vascular surgeons. Although the approach to each patient requiring delayed conversion must be individualized, preservation of all or part of the endograft is possible in many patients. This technique simplifies the operative approach, reduces the amount of dissection required, and is often preferable to complete endograft removal.

REFERENCES

DISCUSSION

Dr Ronald M. Fairman (Philadelphia, Pa). This is a very interesting paper, and I commend your whole group for looking at this very carefully. I have a number of questions. My understanding of the manuscript is that you’ve presented 11 delayed conversions: 7 were ruptures and 4 were due to progressive enlargement. Two of the 11 patients died perioperatively. I would be interested to know what endograft types were in those two patients who died and whether that mattered. You commented in the paper that the mortality in the group where you completely excised the graft was 67%, so I’m interested to know whether perhaps they were suprarenal grafts versus infrarenal grafts?

I really like your approach that you have taken, which is a selective approach to managing these complications. I have been impressed with the explants that I have done that, in fact, there is very little incorporation, though, regardless of whatever the graft type is, whether it is an exoskeleton or an endoskeleton, they seem to slide right out of the sac when I open the sac. Have you seen much incorporation with any of these cases that you’ve done? How did the ruptures present? Are we protected? Do we have any premonition that something was going to happen?

If I sort out the numbers correctly, it looks as if 4 of the 49 Talent grafts that you implanted required conversion. That’s about an 8% or 9% incidence, and it seems to me to not bode very well for the Talent device. That certainly is very different from our experience.

It’s different from every other Talent report that I’ve heard. And I’m just curious whether you can shed any more light on that?

Dr Evan C. Lipsitz. Thank you Dr Fairman. Of the two patients who died, one had a surgeon-made graft (MEGS), and the other had a Talent graft. In both patients, although the grafts were suprarenal, it was more the severity of the presentation than the type of graft that contributed to the mortality. One of the patients had a known endoleak and refused intervention. His aneurysm increased in size from 7 to 12 cm, and he presented to the hospital hypotensive and with extensive blood loss. He did, in fact, have good incorporation of the proximal Palmaz stent of the MEGS graft and required a supracaecal clamp for what was a difficult graft extrication.

The other patient had an aortoenteric fistula and had more septic-related complications than anything else. Although in terms of those two patients, it is probably a case of sicker patients just doing worse, one could say that the presence of suprarenal stents that have not migrated added complexity.

Regarding your second question about the graft sliding out, in many cases we also did not find significant incorporation. In several cases we were able to clamp infrarenally because the grafts had slipped down. In several other cases, even within our required to a supracaecal balloon, the graft was relatively easy to remove. Whether this will be different as the industry increases and improves proximal fixation devices such as suprarenal stents, hooks, and barbs, these kinds of cases are going to become more difficult, although I hope that we will have to do them less often. One issue is that in the absence of graft migration, it is difficult to assess preoperatively how difficult it will be to remove the graft. The presence of an exoskeleton will likely not increase incorporation but may increase trauma to the vessel when removed.

As to whether or not we are protected, I think some early literature suggested that we might be. In our series several patients presented with “contained” rupture, which enabled them to return to our hospital for repair. That, in and of itself, may represent a somewhat selected group of patients. Overall, I do not think the presence of an endograft is protective nor that the time frame for repair should be any different than for de novo rupture, but again, the approach must be individualized.

Finally, regarding the relatively high delayed conversion rate for the Talent grafts (which was also seen in the Vanguard grafts), I did not do a graft-specific analysis because the length of follow-up for each of the grafts is really quite different.

Dr Dhiraj M. Shah (Albany, NY). Dr Lipsitz, I enjoyed your presentation. Were the seven patients who had ruptures lost to follow-up, or did you have any premonition that something was happening with any of these patients, like endoleak or slow migration? Could the ruptures have been prevented?

Dr Lipsitz. Thank you, Dr Shah. In the majority of these patients we did not have any indication of impending rupture on follow-up. One patient had a known type I endoleak and refused further intervention. Another patient with migration of the proximal graft had a CAT scan and angiogram and was being scheduled for explant, but had a rupture prior to his elective repair. A third patient had aneurysm enlargement with a type 2 endoleak and was being medically optimized in the hospital prior to repair when his rupture occurred. As an example of the remaining cases, I showed a 12-month CT without enlargement in a patient who suddenly, at


Submitted May 18, 2003; accepted Sep 3, 2003.