Repeat Axillofemoral Grafting as Treatment for Axillofemoral Graft Occlusion

Christine J. Olson, MD, MPH; James M. Edwards, MD; Lloyd M. Taylor, MD; Gregory J. Landry, MD; Richard A. Yeager, MD; Gregory L. Moneta, MD

Background: Patency of failed axillofemoral (ax-fem) grafts following thrombectomy is so poor, aortofemoral grafts are recommended as treatment for ax-fem graft thrombosis. In patients who are not candidates for aortic grafting, repeat ax-fem grafting is an alternative to thrombectomy. This report compares our experience treating ax-fem graft thrombosis with replacement or revision vs thrombectomy.

Methods: Patients treated with ax-fem grafts from October 1985 to April 2001 were identified, and those who underwent reoperation for thrombosis were reviewed. Limb salvage and patency of revision procedures (thrombectomy vs repeat ax-fem grafting) were determined using Kaplan-Meier curves.

Results: Three hundred thirty-five patients underwent ax-fem grafting, and 39 (11.6%) of the 335 required reoperation for graft failure. Twenty-five of these 39 patients had 51 operations for graft thrombosis: 42 graft replacements and/or anastomotic revision(s), and 9 thrombectomies. At 18 months, mean ± SD patency following thrombectomy was 11% ± 10%, while that for graft replacement or anastomotic revision was 54% ± 8% (P<.001). Limb salvage at 18 months following revision for thrombosis was 88% ± 5%.

Conclusions: The large majority of ax-fem grafts do not require reoperation. For failure due to thrombosis, repeat ax-fem grafting provides excellent limb salvage. Axillofemoral graft replacement and/or anastomotic revision has superior patency to thrombectomy.

Arch Surg. 2002;137:1364-1368

THE USE of the axillary artery as the source of inflow to the lower extremities has been well described as an alternative to aortofemoral grafting. In general, patients receiving axillofemoral (ax-fem) grafts are typically older and have increased risk of significant morbidity and mortality, as well as a shorter life expectancy than those who receive an aortofemoral graft.1,2 While several centers have examined their experience with ax-fem grafting,3,4 few have looked specifically at the management of failed ax-fem grafts. One study by Marston et al5 compared the patency rates following treatment of ax-fem graft thrombosis with thrombectomy only vs revision with or without thrombectomy vs “secondary reconstruction.” The most commonly performed operation in the secondary reconstruction group was an aortic-based procedure. They found that patency rates following treatment of ax-fem graft thrombosis with thrombectomy only vs revision with or without thrombectomy vs “secondary reconstruction.” The most commonly performed operation in the secondary reconstruction group was an aortic-based procedure. They found that patency rates following treatment of ax-fem graft thrombosis with thrombectomy only vs revision with or without thrombectomy produced equivalent results, with 17% ± 7% (mean ± SD) patency at 12 months, which was significantly inferior to the 89% ± 11% patency at 24 months for the 6 patients who underwent thoracofemoral reconstructions. Given the poor patency rates following treatment of ax-fem graft thrombosis with thrombectomy and/or graft revision, the authors concluded that direct aortic reconstruction should be done whenever possible to treat ax-fem graft thrombosis. The authors acknowledged that some patients with thrombosed ax-fem grafts are not candidates for a direct aortic reconstruction, but they did not clearly identify the next best alternative. Only 1 patient in that series had a new ax-fem graft placed. In our practice, thrombosed ax-fem grafts are most commonly managed with subtotal or total graft replacement. The purpose of this report is to review our results of treatment of ax-fem graft thrombosis with subtotal or total graft replacement or anastomotic revision vs thrombectomy alone.

METHODS

Consecutive patients treated with ax-fem grafts from October 1985 to April 2001, at Oregon Health & Science University (OHSU; Portland) and the Portland Veterans Affairs Medical Center were identified from prospectively maintained registries. Patients were excluded if their original ax-fem grafts were performed at a re-
ferring hospital. All initial ax-fem grafts were constructed with 8-mm externally supported polytetrafluorethylene (PTFE) using the techniques previously described. For reoperations involving graft replacement or revision, proximal and distal anastomoses, along with inflow and outflow arteries, were dissected, and the need for operative revision of an anastomosis was determined by visual inspection.

Patients with ax-fem graft failures who underwent reoperation were identified, and those who failed secondary to thrombosis were reviewed in detail. Data abstracted included demographics, medical history, indication for operation, reason for failure, patency of superficial femoral and profundus femoral arteries, perioperative complications, limb salvage, duration of patency following reoperation, and survival. Failures were classified as occlusion, disruption, infection, and stenosis, and were repaired electively. In patients with bilateral ax-fem grafts, failure of one side was considered an independent event.

Survival data were obtained from patient medical records when available, and the Social Security Death Index (SSDI) Web site; only exact matches of the first and last name and/or the Social Security number were considered valid. The subgroup of patients who had at least one simple thrombectomy to manage ax-fem graft thrombosis was compared with the subgroup of patients whose ax-fem graft occlusions were managed exclusively with ax-fem graft replacement or revision using standard statistics (unpaired t test for continuous variables and χ² for categorical variables). Limb salvage and patency of revision procedures for ax-fem graft thrombosis were determined using Kaplan-Meier survival curves. The patency following thrombectomy alone was compared with the patency following subtotal or total graft replacement and/or anastomotic revision using the log-rank test. Anastomotic revisions were combined with the total or subtotal graft replacements for the purposes of analysis since the number of anastomotic revisions was small and often involved graft extension. Significance was measured at P<.05.

**RESULTS**

**PATIENT CHARACTERISTICS**

Three hundred thirty-five patients underwent ax-fem grafting during the study period. Thirty-nine patients (11.6%) were reoperated on for ax-fem graft failure. Twenty-nine of the patients (30 ax-fem grafts) were reoperated on for ax-fem graft thrombosis, and compose the study population. These patients had 51 operations to treat thrombosis: 37 total or subtotal graft replacements, 5 anastomotic revisions, and 9 simple thrombectomies. Eight of the 29 patients had at least one simple thrombectomy to manage ax-fem graft thrombosis (although 6 of these 8 had an ax-fem replacement and/or revision to treat a different episode of ax-fem graft occlusion). Axillofemoral graft thrombosis in the remaining 21 patients was managed exclusively with ax-fem graft replacement and/or revision.

The mean age at the time of initial ax-fem graft failure was 67 years (range, 26-86 years). Sixty-two percent of the patients were male. More than half (52%) of these patients had had a previous aortic inflow procedure. One patient had a confirmed hypercoagulable disorder (anticardiolipin antibody). All of the patients in this cohort had at least 1 documented comorbid condition. History of tobacco use was most common (97%), followed by coronary artery disease (66%), hypertension (69%), and chronic obstructive pulmonary disease (48%).

Twenty-three (77%) of the original ax-fem grafts were axilloiliacomeral grafts. The other 7 (23%) were axilloiliufemoral grafts. The indication for the original ax-fem graft was aortic graft infection in 9 cases (30%) and ischemia in 21 cases (70%). More than 80% of the patients operated on for ischemia had rest pain and/or ulcers. Fifteen (52%) of the 29 patients died during the follow-up period. The mean time to death after the first ax-fem graft failure was 36 months.

**ADDITIONAL PROCEDURES AND COMPLICATIONS**

Forty-seven percent (24.0) of the 51 reoperations done for ax-fem graft thrombosis included a concurrent procedure aimed at improving outflow (Table 1). Perioperative complications occurred following 24% of the reoperative procedures, and are presented here:

<table>
<thead>
<tr>
<th>Complication</th>
<th>Frequency (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wound infection</td>
<td>4 (8)</td>
</tr>
<tr>
<td>Lymphocele</td>
<td>1 (2)</td>
</tr>
<tr>
<td>Hematoma</td>
<td>2 (4)</td>
</tr>
<tr>
<td>Arm ischemia</td>
<td>1 (2)</td>
</tr>
<tr>
<td>Myocardial infarction</td>
<td>3 (6)</td>
</tr>
<tr>
<td>Death</td>
<td>1 (2)</td>
</tr>
</tbody>
</table>

There was 1 death within 30 days of operation in a patient with recurrent, nonoperable sarcoma, who had thrombectomy of an ax-fem graft alone.

**REASON FOR FAILURE FOLLOWING OPERATION FOR AX-FEM GRAFT THROMBOSIS**

Forty-three percent (13/30) of the grafts that thrombosed were revised a single time. In the remaining 17 grafts that failed more than once, the cause of subsequent ax-fem graft failure was reocclusion (69%), infection (19%), electively repaired stenosis (9%), and disruption (3%). Infection was more commonly associated with early (<30 days) ax-fem graft failure. Thrombosis was the most common cause of late (>30 days) ax-fem graft failure. Four patients were operated on 3 or more times for ax-fem graft thrombosis and received a total of 15 (29%) of the 51 reoperations.

**PATIENT CHARACTERISTICS BY TREATMENT SUBGROUP**

The 8 patients who had at least one simple thrombectomy to treat ax-fem graft thrombosis did not differ significantly (with regard to age or comorbid conditions including diabetes mellitus, end-stage renal disease, and

©2002 American Medical Association. All rights reserved.
tobacco abuse) from the 21 patients in whom ax-fem graft thrombosis was managed exclusively with replacement or revision. Similarly, there was no difference based on treatment subgroup in the percentage of patients who died during the follow-up period.

PATENCY AND LIMB SALVAGE AFTER REOPERATION FOR AX-FEM GRAFT THROMBOSIS

The average follow-up time after the first ax-fem graft failure was 36 months (range, 2-100 months). The patency rates are compared in Figure 1. Patency following subtotal or total graft replacement or anastomotic revision was significantly superior to patency following thrombectomy alone by log-rank test ($P < .004$). The corresponding data are presented in Table 2 and Table 3, respectively.

Superficial femoral artery patency at the time of initial operation was available for 27 of the 29 patients reoperated on for ax-fem graft thrombosis. There was no significant relationship between ax-fem graft patency and patency of the superficial femoral artery.

The mean ± SD limb salvage rate was 88% ± 5% at 18 months following reoperation for ax-fem graft thrombosis (Figure 2).

The principal finding of this retrospective review is that subtotal or total graft replacement, or anastomotic revision provides significantly superior patency rates compared with thrombectomy alone when performed to treat ax-fem graft thrombosis. In patients with ax-fem graft thrombosis who are not considered to be candidates for thoracofemoral or aortofemoral revascularization, replacement of the ax-fem graft is the next best alternative, providing mean ± SD patency rates of 54% ± 8% at 18 months. This approach provided excellent limb salvage rates (86% ± 5% at 20 months) and no deaths within 30 days of operation.

The second important finding is that the very large majority of ax-fem grafts placed during the study period did not require reoperation. In addition, among the ax-fem grafts that thrombosed and were revised, almost half required only 1 revision. Only 4 patients during the 15-year period required 3 or more operations for recurrent ax-fem graft thrombosis. This finding is consistent with the findings of Marston et al who identified a similar group of patients who required multiple reoperations for graft thrombosis. They hypothesized that this group of patients were hypercoagulable, although only 1 of the 4 patients had a confirmed cause. In our analysis, 29% of the procedures were performed on this small group of patients.

![Figure 1. Kaplan-Meier patency after axillofemoral (ax-fem) graft replacement or anastomotic revision (replacement) vs thrombectomy alone to treat ax-fem graft thrombosis. Log-rank, 16.13; $P < .004$](image1)

![Figure 2. Kaplan-Meier limb salvage rates in patients reoperated on for axillofemoral graft thrombosis.](image2)

| Table 2. Summary of Kaplan-Meier Estimates of Patency Following Treatment of Axillofemoral Graft Thrombosis With Axillofemoral Graft Replacement or Revision |
|---|---|---|---|---|
| Time, mo | % Patency (SE) | No. of Failures | No. Censored | No. at Risk |
| 1 | 90.5 (0.045) | 4 | 0 | 42 |
| 2 | 88.1 (0.050) | 2 | 1 | 38 |
| 3 | 83.3 (0.058) | 1 | 0 | 34 |
| 6 | 73.4 (0.069) | 4 | 1 | 31 |
| 9 | 65.5 (0.075) | 3 | 2 | 29 |
| 12 | 59.6 (0.079) | 2 | 2 | 24 |
| 18 | 53.6 (0.082) | 2 | 2 | 20 |
| 24 | 42.9 (0.094) | 2 | 0 | 16 |

| Table 3. Summary of Kaplan-Meier Estimates of Patency Following Treatment of Axillofemoral Thrombosis With Thrombectomy Alone |
|---|---|---|---|---|
| Time, mo | % Patency (SE) | No. of Failures | No. Censored | No. at Risk |
| 0.5 | 77.8 (0.14) | 2 | 0 | 9 |
| 1.0 | 55.6 (0.17) | 2 | 0 | 7 |
| 2.0 | 33.3 (0.16) | 2 | 0 | 5 |
| 3.0 | 22.2 (0.14) | 1 | 0 | 3 |
| 6.0 | 22.2 (0.14) | 0 | 0 | 2 |
| 12.0 | 11.1 (0.10) | 1 | 0 | 2 |
| 18.0 | 11.1 (0.10) | 0 | 0 | 1 |

©2002 American Medical Association. All rights reserved.
patients prone to recurrent graft thrombosis. Despite that fact, the mean ± SD patency following ax-fem graft replacement or anastomotic revision was 54% ± 8% at 18 months, which is far superior to the rate seen with thrombectomy alone.

Unlike other authors, we were not able to show a correlation between duration of graft patency and superficial femoral artery run-off. Forty-seven percent of the operations performed for ax-fem graft thrombosis included an additional procedure aimed at improving outflow, which may have obscured the relationship between superficial femoral artery patency and patency following revision.

There are limitations to the present study, based on the observational, retrospective design. The patients were not randomized to ax-fem graft revision vs thrombectomy alone. Our bias was to perform subtotal or total graft replacement to treat ax-fem graft thrombosis. Consequently, thrombectomy was performed infrequently to restore patency. Despite the potential selection bias, our primary patency rates following thrombectomy are comparable with those reported by Marston et al.

Overall, our complication rates for reoperation after ax-fem graft thrombosis were similar to those reported by Marston et al. We had fewer perioperative deaths (2% vs 13%); however, we did not include patients undergoing thoracoemoral or aortofemoral reconstructions, or patients with ax-fem graft failure who did not undergo reoperation.

Many of the reoperations for ax-fem graft thrombosis are performed on an urgent or emergent basis. This has been the argument made by some for performing a simple thrombectomy to restore perfusion quickly. At OHSU, we use a team approach to replace an ax-fem graft. With multiple operative teams working simultaneously, a new ax-fem graft can be placed relatively quickly, restoring perfusion without compromising limb salvage.

Our results with anastomotic revision with or without graft extension were superior to those reported by Marston et al. This may be due in part to their inclusion of patients undergoing ax-fem graft thrombectomy, plus outflow femoropopliteal bypass in the revision group. In their review, 31% of the patients in the revision group had an ax-fem graft thrombectomy plus femoropopliteal bypass. The 5 patients we included as revisions had a minimum of an anastomotic revision with thrombectomy. In some cases, both anastomoses were revised, and the graft was extended.

In conclusion, treatment of ax-fem graft thrombosis with graft replacement or anastomotic revision produces acceptable patency rates that appear superior to those that can be achieved with thrombectomy alone. Furthermore, ax-fem graft replacement can be performed with relatively minimal morbidity and mortality, and provides excellent limb salvage in this difficult group of patients with advanced lower-extremity arterial disease. In patients with ax-fem graft thrombosis who are not candidates for an aortic-based procedure, replacement and/or anastomotic revision of the graft should be performed whenever possible.

Accepted for publication June 1, 2002.

This study was presented at the 73rd Annual Meeting of the Pacific Coast Surgical Association, Las Vegas, Nev,

February 18, 2002, and is published after peer review and revision. The discussion is based on the originally submitted manuscript and not the revised manuscript.

Corresponding author: Gregory L. Moneta, MD, Division of Vascular Surgery, Oregon Health & Science University, 3181 SW Sam Jackson Park Rd, Mail Code OP11, Portland, OR 97201-3098 (e-mail: monetag@ohsu.edu).

REFERENCES


DISCUSSION

E. John Harris, Jr, MD, Stanford, Calif: The data led the Oregon group to use axilofemoral bypass grafting more widely, not just as a salvage procedure for infected aortic prostheses, but for an ever-increasing number of patients with aortic occlusive disease who were at increased risk for direct reconstruction.

When I left Oregon, I continued this practice of extended use of axilofemoral bypass grafting upon my arrival at Stanford, engendering never-ending lighthearted antagonism from my division chief every time he saw this procedure listed on the weekly case list. I remain convinced that axilofemoral bypass grafting is a safe and durable operation. Today, the Oregon group comes to the association with a report extending this series that I reviewed and confirming the durability of this procedure. For over 16 years, 333 axilofemoral grafts were performed, with only 11.6% requiring revision for graft failure. But the focus of this report is clearly on salvage of the axilofemoral grafts that do fail.

Thirty-nine patients of the 335 underwent revision, with this report focusing only on those graft failures related to thrombosis. Thirty grafts in 29 patients underwent 51 procedures to treat graft thrombosis. Anastomotic revision and total or subtotal graft replacement predominated with only 9 simple thrombectomies. As expected, those grafts undergoing extensive revision did better than those grafts undergoing simple thrombectomy.

This brings me to my first question: Did all patients with graft failure undergo preoperative angiography prior to their graft salvage procedure? If yes, were there missed lesions that led to failure of the simple thrombectomies that were subsequently addressed in the secondary salvage procedures? I know if I just thrombectomized a failed graft, I would be concerned that there would be some responsible lesion left behind. If no preoperative angiography was performed prior to revision, as these graft revisions may have been truly urgent revascularizations, did you consider a completion angiography, either in the operating room or prior to discharge?

Of the 30 thrombosed grafts, 42% were revised only once. In contrast, 4 patients accounted for 30% of the additional re-
vascularization procedures following the primary revascularization. Do you know the status of these 4 patients with regard to a hypercoagulable state? Do patients who fail one revision of ax-fem bypass grafting receive any coagulation? For that matter, do any of your ax-fem grafts routinely receive anticoagulation, and if so, what is your algorithm.

The long-term success of this ax-fem grafting series is admirable. It has been suggested initially by Dr Moore back in 1990 that such excellent results can only be achieved in favorable outflow situations. In the thrombosed graft revisions, there was no difference in the outcome related to superficial femoral arterial patency. Therefore, if superficial femoral arterial patency is not critical to a durable outcome, is frequent graft surveillance important to detect failing outflow, especially when the outflow is dependent on the profunda femoral artery? Do you perform duplex surveillance of ax-fem bypass grafts?

**Samuel Eric Wilson, MD, Orange, Calif:** Limb salvage rates generally exceed patency rates for femoral popliteal grafts (for example, by roughly 10%). In this report, the limb survival exceeded the patency rate by approximately 30%. How often do you perform ax-fem grafts for symptoms other than limb salvage, or redo them for symptoms other than limb salvage? Is it worthwhile, considering the relatively poor patency of secondary procedures, persisting in redo axillofemoral grafting if the patient has just claudication?

**Stephen N. Etheredge, MD, Oakland, Calif:** I am a little puzzled as to why you replace the grafts as opposed to using the graft that was present in place. Was it based on true failure of the long limb of the graft, the axillofemoral component, or was it the fear of going back into a redo subclavian artery anastomosis when you had problems with that? How many grafts do you feel failed as compared to anastomoses? How many proximal anastomoses did you have to redo to maintain the patency? Or was it basically, as we see in dialysis grafts, usually an outflow problem that caused your graft failure?

**F. William Blaisdell, MD, Sacramento, Calif:** I would like to compliment the authors on an excellent series clearly demonstrating the durability of this operation. One of the questions I have is what to do with the graft that you defunctionalized. Is that graft taken out? This can sometimes be a struggle. Is that graft taken out? This can sometimes be a struggle.

**Albert D. Hall, MD, Greenbrae, Calif:** First, I wish to recognize the 40-year anniversary of the axillofemoral bypass operation that Past President F. William Blaisdell conceived in 1962 at the VA [Veterans' Administration] Hospital in San Francisco. My question is to ask how many patients in your series who had thrombosis or some other form of intervention therapy to try to clear the graft? Was that because they were excluded from this analysis or is that form of management not favored at Oregon?

**G. Andrew Macbeth, MD, Stockton, Calif:** Was there a more common finding in their first-time graft failures, such as progression of disease in the femoral artery? Did the "revisions" primarily look at some procedure on the femoral artery in either groin? I also wanted to ask about their use of intraoperative angiography as a guide for their revisions.

**James J. Peck, MD, Portland, Ore:** The OHSU Oregon Health & Science University has excellent assisted primary patency for axillofemoral bypass and because of these good results has a large series of patients, 333. How many of the 335 are still alive? Many are very sick patients and not around long enough to need revision. The revision percentage looks very small, but how many patients are actually alive?

**Dr Moneta:** I had a small part in training Dr Harris, and I think all of us in academic surgery draw great satisfaction from seeing people that we have trained go on and do well and be successful.

With respect to Dr Harris’ questions, regarding graft failure and preoperative angiography for thrombosed ax-fem grafts, all but a few of them had preoperative angiograms. Of course, an angiogram in many cases where a graft is thrombosed doesn’t really help you very much regarding details of the anastomosis. It may help with determining outflow and the potential need for a secondary procedure to improve outflow, but the anastomosis is often not well revealed. The anastomosis therefore frequently requires direct inspection at the time of surgery.

In patients who underwent thrombectomy, a postdischarge angiogram was obtained if we considered an additional procedure in that patient. I don’t recall if any lesions were encountered. When thrombectomy alone is performed, and if an additional procedure is considered, a postoperative angiogram or intraoperative angiogram would be appropriate to see if there is a correctable lesion.

With regard to potential hypercoagulable states in patients requiring multiple procedures, only 1 of the 4 patients that had multiple procedures had an identified hypercoagulable state. I tend to anticoagulate troublesome ax-fem grafts. Even if they don’t have an identified hypercoagulable state, 2 years from now there may be a new test for a newly described hypercoagulable state. Whereas we do not routinely anticoagulate all ax-fem bypasses, we do tend to anticoagulate patients who have thrombosed ax-fem grafts without an obvious explanation.

With regard to the graft surveillance for axillofemoral bypass, we do examine the grafts in follow-up with duplex scanning. We have looked at this data, and it appears that what correlates best with patency of the graft is high flow velocity in the axillofemoral limb component. We have not had a graft fail where the velocity was over 135 cm per second in the axillofemoral component of the graft.

**Dr Wilson:** Dr Blaisdell asked about potential hypercoagulable states in patients requiring multiple procedures. Usually, the patients were never candidates for an angioplasty in the first place, and that’s why their axillofemoral bypass was performed initially.

**Stephen Etheredge:** Wanted to know why we replace the graft. It’s always been our philosophy that thrombectomy of the graft, and not revising the anastomosis, leaves the possibility that the graft thrombosed because of an anastomotic problem.

**Dr Blaisdell:** Asked what happens to the defunctionalized graft. We just leave it in. We don’t take them out, unless of course they are infected.

**Steve Etheredge:** We have not used thrombolysis in these patients. We treat them operatively. Again, Dr Macbeth asked about intraoperative angiograms. We have in the past not done the angiograms intraoperatively; we have done them pre- and postoperatively.

**Dr Hall:** Asked about angioplasty for aortoiliac disease. We do treat everybody, when we feel it is appropriate, with angioplasty. We haven’t used angioplasty (with 1 or 2 exceptions to salvage an axillofemoral bypass). Usually, the patients were never candidates for an angioplasty in the first place, and that’s why their axillofemoral bypass was performed initially.

Finally, Dr Jim Peck wanted to know how many people were still alive. The median survival is about 36 months after these procedures. There is no question that the death rate is high in these patients. I do not believe ax-fem grafting is a substitute for an aortofemoral procedure in a young healthy patient; but it does seem to be a very good procedure for older patients who have limited life expectancy.