Bovine pericardial patch repair in infected fields

William D. McMillan, MD, Christopher D. Leville, MD, and **Chantel N. Hile, MD,** *Plymouth, Minn*

Objective: **Bovine pericardial patches (BPP) are frequently used for arterial reconstruction, but little data exist regarding their ability to resist infection. We hypothesize that BPP would provide a reasonable alternative to autologous vein patches in infected fields.**

Methods: **We used BPP to repair 51 arteriotomies (25 brachial, 23 femoral, three popliteal) in 48 consecutive patients (mean age, 68 years; 65% men, 75% diabetic, 67% dialysis dependent) undergoing removal of infected (33 gram-positive, three gram-negative, eight mixed flora, and four culture-negative) polytetrafluoroethylene grafts (35 arteriovenous grafts, nine femoral-distal bypasses, and four femoral patch angioplasties) between January 2007 and January 2011. Patient records were retrospectively reviewed and outcomes, including death, rupture, secondary reconstruction, and infection, were recorded.**

Results: **Over a mean follow-up of 2.1 years (range, 3-48 months), 50 of 51 patches remained in place without evidence of recurrent infection, rupture, or revision. One patient had acute rupture of a popliteal arteriotomy 1 week postrepair and had subsequent ligation and above-knee amputation. Eight of the 48 patients died from unrelated causes during follow-up (three withdrew from dialysis, three myocardial infarction, and two unknown).**

Conclusions: **BPP provide a durable alternative to saphenous vein for arterial reconstruction following removal of infected arterial grafts. (J Vasc Surg 2012;55:1712-5.)**

Prosthetic graft infection remains a challenge for the practicing vascular surgeon. Major graft infection requiring excision occurs infrequently after lower extremity bypass, with an estimated frequency of 1% to 2%. Infections in arteriovenous (AV) dialysis access grafts are more common, occurring in 3% to 8% of patients.[1-7] Regardless of location, graft infection is associated with significant mortality and morbidity.

Nearly all such infections mandate removal of the infected graft. While multiple treatment algorithms exist, most involve resection of the infected graft and closure of the resulting arteriotomies. To accomplish this, some authors employ in situ replacement.[8,9] Others favor subtotal graft excision and leave a stump of graft remaining on the artery.[10,11] Most, however, choose total graft excision and closure of the arterial defect using autologous material.[3-5,12]

Bovine pericardial patches (BPP) are frequently used for arterial closure, and numerous publications detail acceptable long-term patency and durability when used as patch material for carotid endarterectomy.[13-18,21,22] The same material has also been used with some success during reconstruction of infected bronchial stumps and occasionally for intracardiac infection. However, data regarding the effectiveness of BPP in infected fields are limited to isolated case reports and no long-term data are available.[19,20,23,24]

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Reprint requests: William D. McMillan, MD, 20 Campus Dr, Plymouth, MN 55456 (e-mail: wmcmillan@mplsrad.com).

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We review our experience using BPP to repair arteriotomies in patients undergoing total graft excision for infection.

METHODS

Between January 1, 2007 and January 1, 2011, 48 consecutive patients presenting with prosthetic graft infection had total graft excision and BPP closure of 51 arteriotomies. During this same interval, we placed 730 AV fistulae, 590 AV grafts, 518 lower extremity bypasses, and did 430 femoral endarterectomies. Of the patients treated for infection, 32 of 48 (26 AV grafts, four lower extremity bypasses, and two femoral endarterectomies) had graft placement by our group, and the remaining patients were referred with infection for treatment.

All patients undergoing graft excision had arterial closure using a portion of a 0.8-cm × 8-cm BPP (Synovis Medical, St. Paul, Minn). No other type of patch material was used during the interval. During the same interval, many dialysis patients presented with localized graft infections secondary to access site infection, and these were handled by localized excision and replacement and are not part of the current study. However, no patient in the current series underwent subtotal graft excision using a small portion of polytetrafluoroethylene (PTFE) remaining as a stump closure of the arteriotomy.

All upper extremity graft excisions were done with tourniquet control. This technique provided adequate arterial exposure for closure and obviated the need for dissection around the inflamed brachial artery. Of the 25 cases, four had simultaneous construction of a new upper extremity AV fistula. Lower extremity graft excisions were accomplished using standard vascular surgical techniques. All femoral venotomies in the 10 lower extremity AV graft patients were repaired primarily. Of the nine patients undergoing removal of an arterial femoral distal arterial graft, five had removal with extra-atomic bypass (three of five had

Table I. Patch location and outcome

Infected graft	*Patients/patches*	*Outcome patch*	*Long-term follow-up*
Arteriovenous graft	35/35	35/35 no late rupture or local recurrence	6/35 died–none due to infection; 31/35 had new access placed
Lower extremity bypass	9/12	1/12 failed (rupture)	2/9 died–neither due to infection 4/9 had amputation
Femoral endarterectomy	4/4	4/4 no rupture or local recurrence	No deaths/amputations

closure of the femoral and popliteal artery, two of five had oversewing of the distal artery and closure of the femoral only), and four had removal with subsequent planned major amputation. All four of the patients presenting with infected femoral patches had complete excision of the old patch and replacement using BPP.

The majority (35 of 48) of patients undergoing BPP arterial closure had their skin left open and were allowed to heal by secondary intention. All patients undergoing removal of a femoral graft had a Sartorius muscle flap placed at the time of removal. In the patients with infected upper arm grafts, the skin was left open only if there was extensive purulence. Attempts were always made to place soft tissue across the artery to prevent late rupture. Thirteen of 25 patients undergoing upper extremity graft removal had primary skin closure.

All patients undergoing removal were treated with intravenous antibiotics postoperatively. Most (83%) were treated for 4 weeks or more, although 16% switched to oral antibiotics after 2 weeks of intravenous therapy.

All patients were followed retrospectively using a combination of medical record review and direct patient contact. Outcomes, including death, rupture, amputation, secondary infection, and/or reconstruction, were recorded.

RESULTS

The mean age of the 48 patients presenting with infection requiring total graft excision was 68 years (range, 48-81 years), and 75% of these patients were diabetic. Sixty-five percent were men, 73% had chronic renal failure, and 67% were dialysis dependent at the time of removal.

All patients in this series had total graft excision and were thought to have involvement of the entire graft and/or the arterial anastomosis. During the same interval, other patients, not included in the present series, presented with localized infections amenable to local resection/replacement or antibiotic therapy alone. The most common presentation of patients in the current series was that of erythema, pain, and fever occurring in 32 (67%) patients. The remaining patients presented with positive blood cultures and fever in 11 (23%), exposed graft with drainage in four (8%), and arterial pseudoaneurysm in one (2%). The vast majority (45 of 48) of patients were imaged with computed tomography or ultrasound prior to graft removal and were found to have changes consistent with infection.

Approximately half (25 of 48) of the patients had removal of infected PTFE upper extremity AV grafts with simultaneous closure of the brachial artery. Ten patients presented with infected femoral AV grafts and had femoral artery BPP closure. Nine patients presented with infected lower extremity PTFE arterial grafts, and four had removal and in situ replacement of infected Dacron femoral artery patch angioplasties (Table I).

Table II. Culture results

	No. patients (%)
Gram-positive	33/48 (69%)
Mixed flora	8/48 (17%)
Gram-negative	3/48 (6%)
No growth	4/48 (8%)

Table III. Organisms

Most frequently cultured organisms	*Percentage of all organisms cultured*
Staphylococcus aureus (MRSA)	22%
Staphylococcus aureus (MSSA)	16%
Streptococcus group B	14%
Pseudomonas aeruginosa	4%
E coli	4%
Salmonella	4%

Cultures were obtained in all patients undergoing graft removal. Gram-positive organisms were identified in 33 of 48 patients, mixed flora in eight of 48 patients, gram-negative in three of 48 patients, and no growth was found in the remaining four patients (Table II). The most common cultured organisms were *Staphylococcus aureus* (19 of 51; 37%) and *Streptococcus* group B (seven of 51; 14%). Among the gram-negative organisms identified, *Pseudomonas aeruginosa*, *E coli*, and *Salmonella* were each identified in two patients (Table III).

Patients were followed clinically until they had achieved complete wound healing. Subsequent follow-up consisted of retrospective chart review and direct patient phone calls. In addition, dialysis patients were followed by contacting their dialysis units and referring nephrologists. Follow-up was available for all 48 patients.

Mean follow-up was 2.1 years (range, 3-48 months). During follow-up of the 51 pericardial patches placed, only

one had to be removed or replaced for recurrent infection. This occurred in a patient undergoing removal of an infected femoral to below-the-knee popliteal bypass. One week after graft excision and BPP angioplasty of the femoral and popliteal arteries, the patient suffered disruption of the popliteal patch and hemorrhage. Cultures subsequently grew methicillin-resistant *Staphylococcus aureus*. He underwent ligation of the popliteal artery and subsequent above-the-knee amputation. His femoral patch remains in place and without evidence of infection 22 months postgraft excision.

During follow-up, eight patients died. Three of the patients withdrew from dialysis, two had cardiovascular events, and two died from an unknown cause. No patient developed recurrent infection at the site of arterial repair. No patient had subsequent reoperation, repair, or replacement of the patched arterial segment.

Of the 35 patients undergoing AV graft excision, 31 had a subsequent AV access placed. Four patients were dialized via catheters without subsequent AV access placement. None of the 31 patients who had a new AV access placed developed recurrent infections during follow-up. All 10 of the patients undergoing removal of a femoral arterial AV graft had a Sartorious flap placed at the time of graft excision.

Of the nine patients undergoing removal of a lower extremity bypass, five ultimately had ipsilateral major amputation during follow-up. Three of these patients were initially treated without bypass replacement and underwent staged major amputation. Two additional patients had extra-anatomic bypass with laterally tunneled spliced vein, which failed after 16 months and 19 months, respectively, and ultimately led to ipsilateral amputation. Four had successful extra-anatomic bypass and achieved long-term limb salvage. Three had a laterally tunneled PTFE graft placed from the profunda femoris artery to a tibial vessel, and one had a laterally tunneled cadaveric vein graft from the femoral patch to the anterior tibial artery. None of the nine had to have replacement or revision of the femoral pericardial patch.

Finally, all four of the patients presenting with infected femoral Dacron patches had successful in situ replacement with BPP and Sartorius flap closure.

DISCUSSION

Multiple strategies for the management of infected arterial bypass grafts exist. Total graft excision and autogenous arterial closure remains the benchmark against which other strategies are measured.[3-5,12] Bandyk and others have popularized the concept in selective in situ graft replacement when low-virulence organisms are encountered, saving total graft excision for high-virulence organisms or for failed in situ replacement.[8,9] Ryan et al and others have advocated the selective use of prosthetic graft stump arterial closure with subtotal graft excision in AV grafts and for selected infections of lower extremity arterial grafts.[10,11] However, the same authors advocate total graft excision when there is frank purulence and poor incorporation. More recently, some authors have employed stent grafts to deal with infected arterial anastomoses in larger arteries.[20,24] Appropriately applied, each of these strategies seems to achieve reasonable results in published reports.

When total graft excision is required, identifying and harvesting appropriate autogenous material for closure of the arteriotomy can be challenging. Many patients, especially those on hemodialysis, may have limited vein available. In addition, dissection in the infected reoperative field can be tedious and time consuming. Finally, if a portion of vein is identified, it is often thin or otherwise marginal in quality so that late failure or "blowout" is of concern.

While there are several case reports of bovine pericardium used for cardiac and pulmonary reconstruction in infected fields, there are no series or long-term follow-up data available.[19,20,23,24] Certainly, the patch material has proven durable in a number of arterial applications, most commonly as a patch material for carotid endarterectomy.[13-18,21,22] We have used BPP for all of our elective carotid and femoral endartectomies over the past decade.

Our adaptation of the BPP for arterial closure in infected fields grew out of necessity. Our initial experience involved a patient who ruptured an infected aortic stump following excision of the abdominal aorta for primary *Salmonella* aortic infection. Following reconstruction of the perivisceral aorta using a BPP, the patient survived and is alive today without evidence of recurrent infection. Given this initial success, we slowly adapted the use of BPP for arterial stump closure in difficult cases and switched completely in 2007.

The type and location of infections in our patients are typical for a busy vascular practice with AV access cases dominating the current series. We could identify no difference in the outcomes of the patients treated based on the infecting organism or type of bypass excised. This likely relates to the small numbers of patients involved and the variety of organisms identified. Our infection rates for AV grafts mirror those reported elsewhere, with 26 of 590 (4%) presenting with infection. Of the 26, 11 presented within 30 days of placement and the remaining patients presented months to years later. Similarly, our major infection rate for femoral-distal bypass (four of 518;1%) and femoral endarterectomy (two of 430; 1%) seems comparable with other contemporary experiences.

The routine use of pericardial patch closure of arteriotomies has facilitated the operation. We find that the handling characteristics of the patches are better than that of a vein patch, and that by using an off-the-shelf product, we avoid the additional time and dissection needed to identify autogenous material for closure. We chose the 0.8-mm-thickness patch simply because of our familiarity with it for closure of the carotid, but these patches are noticeably thicker than a typical vein and perhaps more resistant to late rupture. Finally, as opposed to other treatment strategies described earlier, we were able to use the pericardial patches without regard to the type of organism or extent of infection.

The current study has several notable limitations. Its retrospective nature makes comparison with other treatment strategies problematic. For instance, it is impossible to say whether in situ replacement with PTFE or PTFE stump closure of the arteriotomies might have fared as well as did the pericardial patch closure in the current series. Direct comparison of our results to series of PTFE stump closure[10,11] or in situ replacement[8] is difficult, as each of the former techniques limits application to certain subsets of patients. However, our freedom from infection or rupture in 50 of 51 patched arteries does compare favorably to historical reviews of autogenous patch closure, in which as many as 3% to 5% of patients developed recurrent infection or aneurysm.[3-5] Still, critics of the current study might justifiably point out that the majority of patients had dialysis graft infections with lower-virulence gram-positive organisms, a fact that might limit the widespread applicability of pericardial patch closure.

There is little doubt that any number of treatment strategies, when properly applied, allow for successful closure of an arteriotomy after excision of infected graft material. Our experience with BPP suggests that they too provide a useful tool in the treatment of infected grafts. Unlike other strategies, we have found them to be useful regardless of organism, extent of graft involvement, or location of the graft. While the retrospective nature of our study precludes any direct comparison to the "gold standard" of autogenous arterial closure, our results suggest that BPP closure is a viable option during total graft excision for infection.

AUTHOR CONTRIBUTIONS

Conception and design: WM, CH, CL
Analysis and interpretation: WM, CH
Data collection: WM, CH, CL
Writing the article: WM
Critical revision of the article: WM
Final approval of the article: WM, CH, CL
Statistical analysis: WM
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