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Selective Preservation of Infected Prosthetic Arterial Grafts

Analysis of a 20-Year Experience with 120 Extracavitary-Infected Grafts

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Objective
The authors report on their 20-year experience with 120 patients with infected extracavitary prosthetic arterial grafts (95 polytetraflouroethylene, 25 Dacron). Throughout this experience, an effort was made, when appropriate, to salvage all or a portion of these infected grafts.

Methods
When patients had arterial bleeding (20 cases) or systemic sepsis (6 cases), immediate graft excision was performed. When the infected graft was occluded (43 cases), subtotal graft excision was performed, leaving an oversewn 2- to 3-mm graft remnant to maintain patency of the artery. Complete graft preservation was attempted in 51 cases in which the graft was patent, the patient was not septic, and the anastomoses were intact. Aggressive operative wound debridement was repeated, as necessary, to achieve wound healing. The preferred method of revascularization, when necessary, included secondary bypasses tunneled through uninfected (often lateral) routes. Follow-up averaged 3 years (range, 1 month–20 years).

Results
This strategy resulted in a hospital mortality of 12% (14/120) and a hospital amputation rate in survivors of 13% (14/106 threatened limbs). Of the surviving patients treated by complete graft preservation, the hospital amputation rate was only 4% (2/45) and long-term complete graft preservation was successful in 71% (32/45) of cases. Partial graft preservation also proved successful in 85% (35/41) of surviving patients who had occluded grafts. Successful complete graft preservation was as likely when gram-negative or gram-positive bacteria were cultured from the wound, with the exception of *Pseudomonas* (successful graft preservation in only 40% [4/10] of cases).

Conclusion
Based on this 20-year experience, the authors conclude that selective partial or complete graft preservation represents a simpler and better method of managing infected extracavitary prosthetic grafts than routine total graft excision.

Traditional management of infected arterial grafts has included total graft excision—to prevent persistent infection resulting in nonhealing wounds, systemic sepsis, and anastomotic hemorrhage.[1-3] Total graft excision often requires difficult dissections and complex revascularization procedures. For patients with infected peripheral arterial grafts, such management is associated with high mortality (9–36%) and limb loss (27–79%) rates.[4-8]

In 1963, Shaw and Baue first proposed that all infected arterial grafts be treated by total graft excision.[3] Veith was an early challenger of this traditional management and suggested that partial or complete graft preservation may be an easier and improved method of treating these complications.[9] In 1979, he reported an initial 7-year experience at Montefiore Medical Center in New York, applying this approach for infections confined to noncavitary prosthetic grafts and the distal limb of aortobifemoral grafts.[9] Selective graft preservation also was used to treat infected prosthetic arteriovenous fistulas at the same institution.[10] Based on Szylagyi's earlier classification system,[1] Samson, Veith, and their colleagues proposed a modified classification of infected peripheral (extracavitary) prosthetic grafts in 1988 and reported some continued success using selective graft preservation.[11] At Pennsylvania Hospital in Philadelphia, DeLaurentis and associates also have used a similar strategy and have noted better results than with routine graft excision.[12]

This report describes an updated and expanded series of 120 infected extracavitary prosthetic arterial grafts treated during the past 20 years at these two medical centers and evaluates the feasibility, advantages, and disadvantages of selective graft preservation when certain criteria are fulfilled.

METHODS

Patients

Between January 1972 and December 1993, we treated 120 patients with infected prosthetic grafts anastomosed to a peripheral or extracavitary artery (excluding the aorta and iliac arteries) at Montefiore Medical Center in New York (79 cases) and Pennsylvania Hospital in Philadelphia (41 cases) (Table 1). Twenty-four patients were referred from other hospitals. Fourteen infections involved femoral anastomoses of aortofemoral grafts (Table 2). The infections involved the anastomoses in 109 cases and were confined only to the bodies of the grafts in 11 cases. There were 63 men and 57 women, ranging in age from 34 to 91 years (mean, 66 years). Half of the patients had diabetes mellitus.

The infected grafts were polytetraflouroethylene in 95 cases and Dacron in 25 cases (Table 2). The bypasses were performed for limb salvage in 101 cases, for disabling claudication in 11 cases and for noninfected aneurysms or pseudoaneurysms in 8 cases. Eighty-two patients (68%) had undergone more than one vascular operation at the site of the infected wound (average, 2.5

Table 1. SITE OF INFECTION INVOLVING 120 EXTRACAVITARY PROSTHETIC ARTERIAL GRAFTS

Anastomotic infections (109)	
Femoral artery*	85
Tibial artery	13
Popliteal artery	10
Axillary artery	1
Infection confined to the body of the graft (11)	
Thigh	5
Flank	2
Chest	1
Knee	1
Calf	1
Ankle	1

* Femoral = common, superficial or deep femoral arteries in the groin in all cases.

Table 2. TYPE OF INFECTED EXTRACAVITARY PROSTHETIC ARTERIAL GRAFT*

		PTFE	Dacron
Femoropopliteal	50	44	6
Femorotibial	32	32	0
Aortofemoral†	14	0	14
Femorofemoral cross-over	10	10	0
Femoral interposition	8	4	4
Axillofemoral	6	5	1
Total	120	95	25

PTFE = polytetrafluoroethylene.

* Femoral = common, superficial, or deep femoral arteries.

† Patients who had aortofemoral graft infections were included in this series only if they had infection confined to the groin based on clinical, CT scan, sinogram, arteriographic, and initial operative findings.

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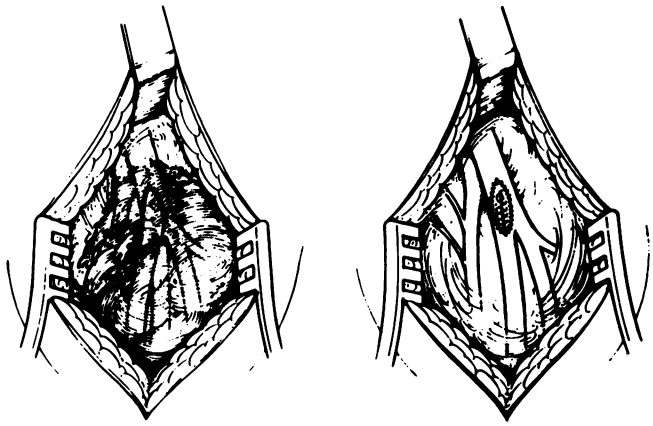

Figure 1. Schematic of an infected groin wound with an occluded prosthetic graft anastomosed to a patent common femoral artery (left). Schematic after aggressive operative wound debridement, excising all infected tissue, and subtotal excision of the graft leaving an oversewn 2- to 3-mm graft remnant on the underlying femoral artery (right).

prior dissections per patient). Follow-up averaged 3 years, with a range of 1 month to 20 years.

Presentation and Management

Patients who presented with systemic sepsis[6] or with infected disrupted anastomoses (20 cases) manifested by anastomotic hemorrhages or infected pseudoaneurysms were treated by immediate graft excisions. Entire grafts were removed in septic patients to eradicate any potential source of continuing infection. In patients who presented with disrupted anastomoses, the infected segments of graft were excised. The remainder of the grafts was left intact only if it was found to be well-incorporated and uninvolved with infection, based on preoperative radiologic studies (computed tomography scan, sinogram, arteriography), intraoperative gram stains, and operative explorations. This strategy proved especially useful when a patient presented with a disrupted distal anastomosis of an aortobifemoral graft. If there was no evidence of infection involving the proximal part of the graft, only the infected distal limb was excised. Through a separate flank incision, the proximal uninvolved limb of the graft was divided and oversewn or used as inflow for revascularization of the threatened limb via an uninfected (usually lateral) route.[9,13]

Patients who presented with infected thrombosed grafts and intact anastomoses (43 cases) were treated by subtotal graft excisions, except for 2- to 3-mm remnants in the wounds, to maintain patency of the underlying artery (partial graft preservation) (Fig. 1). This strategy proved particularly useful for infections involving an occluded graft in the groin, in which patency of the deep femoral artery was essential for limb salvage.[14] Subtotal graft excision to treat occluded infected grafts often obviated the need for additional revascularization proce-

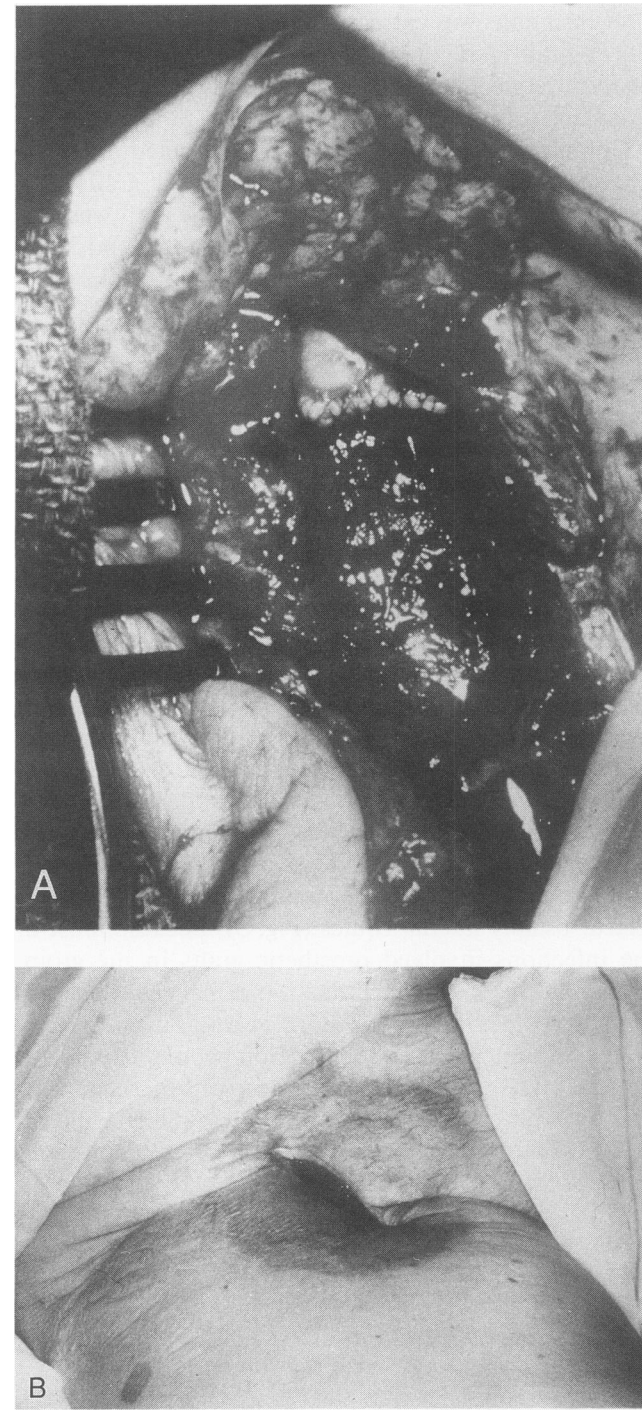

Figure 2. (A) Photograph after wound debridement with healthy granulation tissue and an oversewn polytetraflouroethylene stump on the underlying femoral artery. (B) Three weeks later, the wound has essentially healed completely by secondary intention.

dures. This technique allowed simple oversewing of the most proximal or distal cuff of graft without having to remove and dissect arteries in wounds, which results in extensive scarring. A clamp could be placed across the graft immediately above or below the intact anastomosis after thrombus was extracted. The remainder of the occluded graft then could be excised, and the cuff of graft on the artery could be oversewn, leaving a graft remnant as a patch (Fig. 2).

Complete graft preservation was attempted in 51 patients with infected extracavitary prosthetic grafts only when the following criteria existed: 1) the graft was patent; 2) the patient was not systemically septic; and 3) the infection had not resulted in anastomotic disruption.

Treatment Adjuncts

A critical adjunct to achieve successful wound healing included wound excision or aggressive operative debridement of all infected tissue in the wound, including exudate on the graft or artery. Debridement was repeated under anesthesia in the operating room as often as necessary to ensure a healing wound. Patients were observed in a special care unit where 1% povidone-iodine or antibiotic-soaked dressing changes were performed three times a day.[15] This protocol was carried out until healthy granulation tissue covered the anastomosis. Wound healing by secondary intention was attempted in conjunction with complete graft preservation in 42 cases; in 9 other cases, muscle flaps were used (3 sartorius, 2 gracilis, 2 rectus abdominis, 1 semimembranous, 1 soleus).[16]

When revascularization was necessary to salvage a threatened extremity after total or subtotal graft excision, we preferred ti tunnel a new graft through uninfected, usually lateral, routes (Fig. 3). Because most of the infections involved prosthetic grafts in the groin, proximal inflow sites included the axillary and iliac arteries and the infrarenal or thoracic aorta.[9,13,17] The new graft was tunneled lateral to the groin wound to a patent outflow artery, such as the distal deep or superficial femoral or popliteal arteries.[18,19] In a stable patient, the infected wound was isolated with adhesive dressings and the secondary bypass was performed before graft excision.

Aerobic and anaerobic cultures were obtained from all infected wounds. Appropriate intravenous antibiotics were administered through a central venous catheter for at least 6 weeks.

RESULTS

Patient Survival

Management of 120 infected extracavitary prosthetic grafts using the aforementioned protocol resulted in a

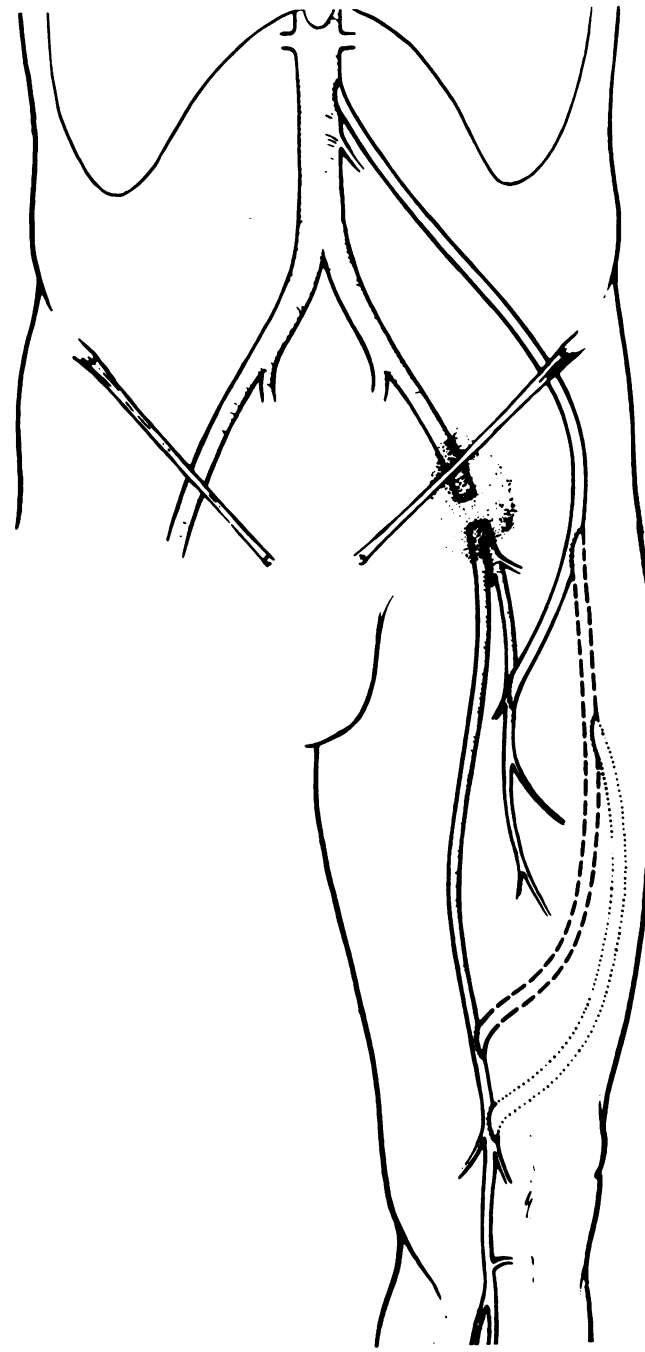

Figure 3. Schematic demonstrating possible routes of secondary bypasses after isolation of an infected groin wound. The aorta can serve as an inflow source, as shown here, or the iliac or axillary artery. The graft is tunneled lateral to the wound, preferentially medial to the anterior superior iliac spine under the inguinal ligament, if the infection in the soft tissue does not extend too far laterally. Possible outflow sites include the distal deep or superficial femoral artery or the popliteal artery. If these arteries are occluded, the infrapopliteal arteries also can be used as outflow arteries.

Table 3. RESULTS OF TREATMENT OF 120 INFECTED EXTRACAVITARY PROSTHETIC ARTERIAL GRAFTS

	Mortality*	Amputations†	Wound Healing‡
Graft excision for bleeding (20) or sepsis (6)	23% (6/26)	15% (3/20)	95% (19/20)
Partial graft salvage for occluded grafts	5% (2/43)	22% (9/41)	85% (35/41)
Total graft preservation	12% (6/51)	4% (2/45)	71% (32/45)
p value§	NS	$p < 0.05$	$p < 0.05$
Total	12% (14/120)	13% (14/106)	81% (86/106)

Patients who presented with patent grafts, intact anastomoses and were not septic (51) were treated by attempted complete graft preservation.

* Hospital mortality rate.

† Hospital amputation rate in survivors.

‡ Wound healing rate in survivors after long-term follow-up (mean = 3 yrs, range = 1 mo–20 yrs).

§ p values relate to statistically significant differences in results between any of the three treatment groups, i.e., no statistically significant differences in mortality existed between any treatment group compared to either of the other two treatment groups, but there were significant differences in amputations and wound healing between the treatment groups compared with either of the other treatment groups.

hospital mortality rate of 12% (14/120) (Table 3). Mortality rates were 23% (6/26) for patients who presented with bleeding or sepsis, 12% (6/51) for patients treated by complete graft preservation, and 5% (2/43) for patients with occluded grafts treated by partial graft preservation (p = NS). Deaths were attributed to sepsis in seven patients (four treated by total graft excision, three by complete graft preservation), myocardial infarction in four patients (two treated by partial graft preservation, two by complete graft preservation), pneumonia in one patient (treated by complete graft preservation), stroke in one patient, and recurrent hemorrhage in one patient (both treated by initial total graft excision).

Limb Loss

Major amputations (eight above-knee, six below-knee) were required in 13% (14/106) of the surviving patients (Table 3). Amputation rates were significantly higher in patients who had occluded grafts and had attempted partial graft salvage (22%, 9/41) than in patients who had sepsis or bleeding (15%, 3/20) or in patients treated by attempted complete graft preservation (4%, 2/45) ($p < 0.05$). Revascularization procedures were not attempted in any of the 14 patients who lost their limbs because the threatened extremities were not considered salvageable, their critical medical conditions prohibited prolonged operative procedures, or lack of adequate outflow arteries precluded distal bypasses.

Wound Healing

Of the surviving 106 patients, long-term wound healing was successfully accomplished in 86 (81%) of the patients (Table 3). Total excision of the graft resulted in higher wound healing rates (95%, 19/20) than partial graft preservation (85%, 35/41) or attempted complete graft preservation (71%, 32/45) ($p < 0.05$).

Complete Graft Excision

Nineteen of 20 grafts in surviving patients treated initially by total graft excision for sepsis or disrupted anastomoses remained healed during the period of long-term follow-up. Four years after complete graft excision, one patient suffered delayed arterial hemorrhage, which required further arterial interruption and an above-knee amputation. All 20 patients had been treated initially by oversewing or ligation of the involved arteries.

Of the 20 surviving patients who had sepsis or disrupted anastomoses and who were treated by graft excision, 11 maintained viable limbs without revascularization, 6 required a secondary bypass and 3 others required amputation.

Partial Graft Preservation

Thirty-five of 41 occluded grafts in survivors treated by subtotal graft excision with oversewing of 2- 3-mm graft remnants remained healed after long-term follow-up. Three wounds did not heal after 2 to 4 weeks of aggressive local wound care and required excision of the residual prosthetic patches and ligation or oversewing of the arteries. Three other patients suffered delayed anastomotic bleeding at the sites of the prosthetic patches after 1 week, 8 months, and 34 months of follow-up, and all were treated by excisions of the residual prosthetic patches and ligation or division and oversewing of the ends of the arteries.

Of the 41 surviving patients who initially presented with occluded grafts, 19 did not require secondary revascularization procedures because adequate collaterals were maintained, 13 needed secondary bypasses, and 9 others underwent major amputations during their hospital stays.

Complete Graft Preservation

Thirty-two of 45 grafts in the survivors treated initially by complete graft preservation remained healed after

long-term follow-up. Two patients hemorrhaged at the original infected sites 3 months and 12 months after initial presentation. Eleven other patients developed nonhealing wounds or recurrent infection after 2 weeks to 38 months of follow-up and required total graft excision.

None of the 32 patients treated successfully by complete graft preservation required secondary revascularization procedures. Of 13 patients in whom this approach failed, 6 required secondary bypasses, 5 did not need further revascularization procedures to maintain viable limbs, and 2 underwent above-knee amputations.

Muscle Flap Advancement

Only 9 of the 120 patients with infected prosthetic grafts were treated by placement of a muscle flap. One patient, who continued to drain purulent material from the wound after placement of the flap onto a patent graft, underwent graft excision, but later died of sepsis. One patient required excision of a necrotic flap and the arterial graft to achieve wound healing. Two sartorius flaps necrosed, and these patients were treated by placement of new muscle flaps to preserve the prosthetic grafts. Five patients treated with muscle flaps had their wounds heal without complications.

Bacteriology

Gram-positive bacteria only were cultured from 55 wounds, gram-negative bacteria only were cultured from 28 wounds, and both types of bacteria were cultured from 37 wounds (Table 4). *Staphylococcus aureus* was the most common gram-positive organism cultured, and *Pseudomonas aeruginosa* was the most common gram-negative organism cultured. This expanded, updated series confirms our previous finding that successful graft preservation was as likely when gram negatives were cultured from the wound as when gram positives were cultured, with the exception of *Pseudomonas*.[20] A successful outcome was less likely when this organism was cultured (40%, 4/10): 1 patient died of sepsis, 2 required graft excisions for nonhealing wounds, and 2 required above-knee amputations.

Table 4. BACTERIOLOGY OF 120 INFECTED EXTRACAVITARY PROSTHETIC ARTERIAL GRAFTS

Gram-positive bacteria	
Staphylococcus (69)	
Aureus	40
Epidermidis	29
Streptococcus (33)	
Faecalis	23
Viridans	6
Group D nonenterococcus	4
Diptheroides	5
Corynebacterium	4
Clostridia	1
Gram-negative bacteria	
Pseudomonas aeruginosa	25
Proteus mirabilis	12
Escherichia coli	10
Serratia marcescens	6
Bacteroides (6)	
Fragilis	5
Cloaca	1
Morganella morganii	4
Enterobacter	4
Acinetobacter	3
Klebsiella	1
Salmonella	1
Achrobacter	1

DISCUSSION

Compared with other series of infected extracavitary arterial grafts treated by routine graft excisions, this 20-year experience with management of 120 patients with infected extracavitary prosthetic grafts resulted in an improved amputation rate without increased mortality rates.[1,4–8] The 12% mortality rate in our current series is similar to the most favorable results of other reported series of infected peripheral grafts (9–36%).[1,4–8,21]

The high rate of limb salvage achieved in our patients occurred even though the original indication for revascularization was limb salvage or replacement of peripheral arteries for aneurysmal disease in 91% (109/120) of the cases. We believe that our low amputation rate primarily is because of the following three factors: 1) attempted complete graft preservation had been achieved successfully in approximately three quarters (32/45) of surviving patients; 2) patency of the underlying artery and important collaterals were maintained by leaving an oversewn prosthetic graft cuff on the artery when subtotal graft excision was necessary to treat occluded infected grafts; and 3) an aggressive approach to limb salvage was used by carrying out extra-anatomic bypass in clean fields throughout this 20-year period, when a secondary revascularization was required after infected graft excision or occlusion.[14,22]

Complete graft preservation under certain conditions, even when the graft-artery anastomosis is involved in the infectious process, represents the most important new aspect of our management scheme. By preserving arterial supply to the threatened limb, successful graft preservation often obviates the need to perform complex sec-

ondary bypasses. The highest amputation rates in surviving patients occurred in patients who required subtotal or total graft excision for occluded grafts (22%) or for sepsis and bleeding (15%), respectively (Table 3). In comparison, the amputation rate was only 4% for patients who could be treated by attempted complete graft preservation.

A key to successful graft preservation was wound excision or aggressive debridement. Excision of all infected tissue in the wound and all exudate or fibrin on the exposed graft initially must be performed in the operating room where adequate lighting, optimal anesthesia, and appropriate instruments are available. Even when the anastomosis was involved in the infectious process, as in the majority of grafts in this series, complete graft preservation usually could be accomplished.

In 1963, Carter et al. first suggested that preservation of a patent graft should be considered in selected cases.[23] However, this approach was never advocated widely and fell into disfavor[3] until it was again tried in selected cases.[9,24] Subsequently, other groups have used this approach with success.[25,26]

Based on our results to date and the confirmatory observations of others,[24–26] it appears that graft preserving techniques have already been established as a worthwhile option for managing infected arterial prosthetics in sick patients, under appropriate circumstances. However, we did not compare these techniques to more standard graft excision methods in a prospective or randomized fashion. Accordingly, our observations with the effectiveness of graft-preserving techniques need further confirmation. Moreover, better criteria for applying these techniques need to be developed to decrease the proportion of failures we encountered. In addition, it is appropriate to determine whether or not comparable methods can be used successfully when infection involves a prosthetic graft anastomosed to the aorta or the iliac arteries. Our limited experience with three such cases and the reports of others suggest that graft preserving methods for managing infection may sometimes be effective in these cases as well.[27–30]

Advancement of a muscle flap onto an exposed, infected graft has been reported as an important adjunct to achieve successful graft preservation.[16,26] A muscle flap provides well-perfused autologous tissue to deliver nutrients and blood cells necessary to combat infection in the wound.[26] However, the vast majority of our patients were successfully managed by repeated, operative wound debridement and antibiotic or povidine—iodine-soaked dressing changes until the wounds healed by delayed secondary intention. Thus, we believe that placement of a muscle flap is not essential to achieve a high rate of successful graft preservation. However, recently, we have been using this technique more frequently because it may shorten hospital stay. In our experience, however, this should only be done when healthy granulation tissue is present and the wound has minimal evidence of residual infection.[16]

Many of our patients with infected occluded prosthetic grafts did not require secondary revascularization procedures to achieve limb salvage because of another nonstandard aspect of our management scheme. Oversewing a small cuff of prosthetic graft on the underlying artery after excision of the thrombosed remainder of the graft maintained patency of the artery and often allowed adequate perfusion of the threatened extremity through important collaterals. We have demonstrated that the majority of wounds treated in this manner remained healed after long-term follow-up. Oversewing of a small graft patch is most applicable for infected occluded prosthetic grafts in the groin to maintain patency of the deep femoral artery.[14] Additionally, when an aortofemoral graft requires complete excision and an axillodistal superficial femoral bypass is performed, this technique allows arterial retrograde flow into a patent external iliac artery to perfuse the internal iliac artery and maintain pelvic and rectal circulation. Others have proposed placing an autologous tissue patch (vein or endarterectomized segment of occluded superficial femoral artery) on the involved arteriotomy or using *in situ* autologous conduits after prosthetic graft excision.[21,31–33] However, we have observed a high rate of rupture of autologous patches or grafts when they are placed in an infected field. We have therefore sought an alternative to this technique.[9,11,14]

Other recent observations support the concept that some infected grafts may be salvaged or may not require complete excision.[30,34] When coagulase-negative *Staphylococcus epidermidis* is the only organism cultured from the wound, Bandyk and his associates have reported excellent results by excising the infected extracavitary prosthetic graft segment and replacing it with a new *in situ* interposition polytetraflouroethylene graft.[34] In light of our results with complete graft preservation in this setting, one must question the necessity for replacing the graft. Moreover, because we were able to salvage grafts in wounds infected with organisms other than *S. epidermidis,* we believe the nature of the host-bacteria interaction is a more important determinant of successful prosthetic graft preservation than is the identity of the infecting organism.

In contrast to others who have recommended the use of obturator bypasses,[3,35] secondary revascularization procedures generally were accomplished by performing new bypasses tunneled laterally through sterile fields to avoid the infected wound. This approach has proven to

be simpler than and as effective as obturator bypasses. Often, it is necessary to tunnel the graft lateral to the anterior superior iliac spine if the groin wound extends far laterally. For groin infections involving a femorodistal graft, we preferentially have used the thoracic aorta, the abdominal aorta, or the iliac artery approached through a retroperitoneal incision as proximal inflow sources. We also have used the axillary artery in poor-risk patients or when the aortoiliac system is diseased. Preoperative arteriography of the aortic arch, aortoiliac system, and outflow tracts is recommended, if possible, before all secondary bypasses.[9,36]

Complete graft preservation was attempted in less than half (51) of the infected grafts because the other patients had contraindications to graft preservation—a disrupted anastomosis, sepsis, or an occluded graft. Patients with infected grafts with hemorrhage, pseudoaneurysms, or systemic sepsis represent extremely virulent manifestations of infection. We believe that this virulence is related more to individual host-bacterial interaction than to the identities of the causative organisms per se. In this series, aprroximately one quarter of the patients who had one of these virulent manifestations died, despite immediate graft excision. Although there have been occasional reports of successful graft preservation in the setting of anastomotic disruption,[26] we believe that the safest method to prevent recurrent hemorrhage in these cases is graft excision.[2,9] Similarly, patients with infected extracavitary prosthetic grafts with severe systemic sepsis are best managed by immediate total graft excisions.[2,3,9] To rid these critically ill patients of infection as quickly as possible, all infected prosthetic material must be removed. In addition, an occluded graft mandates at least subtotal graft excision because organized thrombus in the graft cannot be sterilized and will continue to be a focus of infection.[1]

Although gram-negative bacteria have been reported to be more virulent than gram-positive bacteria,[37,38] we found similar rates of successful graft preservation whether gram-negative or gram-positive bacteria were cultured from the wound, with one notable exception.[20] *Pseudomonas* was the only bacteria identified that correlated with a low rate of successful graft preservation. *Pseudomonas* was cultured in 25 wounds in the current series, but complete graft preservation was attempted in only 10 patients who fulfilled our previously mentioned criteria. A successful outcome was accomplished in only 40%[4] of these cases. *Pseudomonas aeruginosa* is relatively resistant to antibiotics, has a high adaptability to a wide variety of physical conditions, and produces elastase and alkaline protease, which lead to arterial wall disruption by inhibiting phagocytosis and degrading elastin, collagen, and fibrin.[38] These considerations may explain the poor results of attempted graft preservation when *Pseudomonas* is cultured, and for these reasons, we generally favor graft excision in these cases, unless no other alternative for revascularization exists.

Although our management scheme continues to evolve and several questions remain unanswered, we believe that our current strategy to treat extracavitary prosthetic graft infections represents an important alternative method to treat these often devastating complications. Using this method, improved amputation rates have been achieved without sacrificing patient survival. When used selectively, this graft-preserving management approach can be effective, particularly for severely ill patients or those with major risk factors who require treatment of an infected peripheral prosthetic graft.

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Discussion

DR. LAZAR J. GREENFIELD (Ann Arbor, Michigan): I'd like to congratulate Dr. Calligaro on an excellent presentation and express my gratitude for an opportunity to review the manuscript prior to the meeting. This extensive experience with infected peripheral prosthetic arterial grafts is not likely to be envied by other surgeons since graft infection is the nemesis of the vascular surgeon.

It is important to emphasize, as the authors did, that the effort to salvage the graft was considered appropriate in less than half of their cases since their exclusion criteria eliminated occluded grafts, a bleeding episode, or evidence of sepsis. These problems still require graft excision and it was clear from the authors' experience that in all patients there was better wound healing when the graft was excised.

In 35 of 41 occluded grafts, a remnant was left at the anastomosis to preserve patency of the underlying artery, although 6 of these patients later required excision. Since autologous tissue is usually preferred for this type of closure and since not all patients were treated this way, it would be helpful to know how the decision was made to preserve the remnant and whether the closure was reinforced by other healthy tissue.

All of these patients received intravenous antibiotics for approximately 6 weeks and it's presumed that they were then converted to oral antibiotics. The planned duration of antibiotic therapy would be of interest, particularly in those patients who still have a graft remnant.

It's a little surprising that only 9 of the 120 patients were treated with a muscle flap and of these, only 5 healed completely. The manuscript mentions two sartorius flaps that became necrotic, and this is certainly discouraging.

Dr. David Smith in our department has pointed out that the blood supply of the sartorius is segmental and that mobilizing it to fold it over can make it ischemic. A further limitation is the fact that the blood supply is from the superficial femoral artery, which is often obstructed in these patients. His experience has been more favorable with the use of the rectus abdominis, which has a blood supply on a pedicle allowing it to be positioned to cover a graft. He's also been able to demonstrate that healthy muscle can compete very effectively with bacteria to promote healing. I wonder if the authors have had any experience with the use of this particular approach.

Finally, antibiotic therapy and our ability to support the nutritional needs of the patient have improved significantly over the past 20 years. These may also have influenced the authors' results in addition to their superb technique for taking care of the infected wound.

When we reviewed the published literature in 1977, there were reports on only 55 cases of infected femoropopliteal bypass grafts, 21 of which had been treated by leaving the graft in place with an 81% recovery rate. But considering the expected amputation rate of 36% with infected grafts, the authors' suc-