Prosthetic patch remnants to treat infected arterial grafts

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Purpose: Our previous experience with the traditional management of infected prosthetic arterial grafts, which included graft excision and vein patch repair of the involved artery, was complicated by a high incidence of vein patch rupture. This study assessed the treatment of infected prosthetic grafts with subtotal graft excision and oversewing of small graft remnants.

Methods: During the last 20 years, we treated 53 wounds involving 45 infected prosthetic grafts in 42 patients by means of subtotal graft excision and oversewing of a residual 2- to 3-mm graft remnant (patch) at an intact arterial anastomosis. This technique was selectively used to maintain patency of small-diameter arteries (41 common femoral, five deep femoral, three axillary, two iliac, and two popliteal), which were critical for limb salvage or amputation healing. This strategy avoided difficult dissection of the underlying artery in scarred wounds and obviated the placement of a new patch in an infected field. Graft remnants were polytetrafluoroethylene in 51 cases and Dacron in two cases. Of the 45 grafts, 31 were occluded and 14 were patent. All infected tissue was widely debrided, wet-to-dry dressing changes were performed three times daily, and appropriate intravenous antibiotics were administered for at least 1 week. Secondary bypass grafting procedures were performed as needed to achieve limb salvage. The follow-up period in surviving patients averaged 32 months (range, 1 to 218 months).

Results: No complications were directly attributable to prosthetic patch remnants in 92% of cases (49 of 53 cases). Six of 42 patients (14%) died during hospitalization (three of cardiac complications and three of sepsis with multiple organ failure). Two infected pseudoaneurysms developed 8 and 34 months after surgery, and two wounds failed to heal. Sixteen secondary bypass grafting procedures were necessary to achieve limb salvage. Patch oversewing led to limb salvage without the need for secondary revascularization in 26 other cases and to the successful healing of 10 amputated limbs when secondary revascularization was not possible.

Conclusion: Prosthetic patch remnants are a useful adjunct that simplify management of infected prosthetic grafts, are associated with a low incidence of wound complications, and help maintain patency of essential collaterals to achieve limb salvage or heal an amputation. (J Vasc Surg 2000;31:245-52.)

The traditional management of infected prosthetic arterial grafts includes total graft excision, oversewing or ligation of the involved arteries, debridement of infected tissue, and revascularization when

necessary to achieve limb salvage.[1] However, when maintaining patency of an involved artery is essential for limb salvage or to allow healing of an amputation, placement of an autologous tissue patch in the infected field has been advocated. We have observed a disturbingly high rate of autologous tissue patch rupture when we attempted this technique.[2] An alternative method of treatment includes subtotal excision of the infected prosthetic graft and oversewing a small remnant or "patch" of graft at the arterial anastomosis.[3] We present our updated results of infected prosthetic grafts treated by means of this method.

PATIENTS AND METHODS

Between January 1, 1978, and December 31, 1998, we treated 53 wounds involving 45 infected

Table I. Types of infected grafts

Type	Number
Femorodistal	30
Above-knee popliteal	6
Below-knee popliteal	5
Infrapopliteal	19
Axillofemoral	5
Femorofemoral	5
Aortobifemoral	3
Iliofemoral	2

Table II. Bacteriology

Gram-positive bacteria	
Staphylococcus aureus	14
Staphylococcus epidermidis	12
Streptococcus faecalis	7
Streptococcus viridans	6
Corynebacterium diptheroides	1
Corynebacteria	1
Gram-negative bacteria	
Pseudomonas aeruginosa	8
Escherichia coli	4
Proteus mirabilis	4
Enterobacter	4
Serratia marcescens	3
Acinetobacter	2
Bacteroides fragilis	2
Aerobacter	1
Klebsiella oxytoca	1
Morganella morganii	1

More than one bacterium were cultured from several wounds.

prosthetic grafts in 42 patients by means of subtotal graft excision and oversewing of a residual 2- to 3-mm graft remnant (patch) at an intact arterial anastomosis (Table I). The procedures were performed in 22 men and 20 women, ranging in age from 34 to 87 years (average age, 69 years). Indications for the bypass graft that ultimately became infected were limb salvage in 40 cases and disabling claudication in five cases. The vessels involved were 41 common femoral, five deep femoral, three axillary, two popliteal, one common iliac, and one external iliac artery. Graft remnants were polytetrafluoroethylene in 51 cases and Dacron in two cases. Of the 45 grafts, 31 were occluded and 14 were patent. All 42 patients had signs of local wound and graft infection, including purulent drainage, a sinus tract, or erythema involving a previous incision overlying a prosthetic arterial graft.

Subtotal graft excision and oversewing of a patch remnant was performed to treat an infected prosthetic graft only when these criteria were fulfilled: (1) maintaining patency of the underlying artery was critical to achieving limb salvage or healing an amputation; (2) the anastomosis was intact without pseudoaneurysm; and (3) the integrity of the underlying artery was satisfactory. Alternatively, the artery was oversewn or ligated when maintaining patency of the artery was not considered essential, the anastomosis was disrupted, or the infectious process significantly weakened the underlying artery.

When the underlying artery was encased in dense scar tissue and dissection was considered to be particularly hazardous, a Satinsky clamp was applied to the base of the graft near the intact anastomosis, the graft was transected 2 to 3 mm above the clamp, and the graft remnant was oversewn with a double-running layer of 5-0 or 6-0 polypropylene suture, leaving a small cuff or patch (Figs 1 and 2). In 37 of the 45 grafts, the entire graft was excised, except for an oversewn patch at one anastomosis. In the other eight cases, patch remnants were oversewn at both anastomoses, because maintaining patency of both

arteries was considered important, and the entire intervening graft was excised. When the infection was found by means of preoperative clinical and radiologic evaluation to be confined to one anastomotic segment of the graft, the other uninvolved anastomotic segment of graft was excised, and the wound was closed; then the next uninvolved segment of graft was excised, and so on until the infected segment of graft was reached.

All infected tissue in the involved wound was initially widely excised in the operating room, and repeated debridement of necrotic tissue was performed as necessary, until there was no further drainage from the wound and healthy granulation tissue was present. Antibiotic-soaked wet-to-dry dressings were changed at least three times daily. Appropriate intravenous antibiotics were administered for at least 1 week, until there was no further clinical evidence of infection. Wound cultures for aerobic and anaerobic bacteria and fungi were obtained in all patients (Table II).

Secondary bypass grafting procedures were performed as needed to achieve limb salvage. The follow-up period in surviving patients averaged 32 months (range, 1 to 218 months).

RESULTS

No complications directly attributable to prosthetic patch remnants were found in 92% of cases (49 of 53 cases). Two infected pseudoaneurysms developed 8 and 34 months after surgery. These patients were treated by means of excision of the oversewn prosthetic patch, oversewing of the involved artery, and extra-anatomic revasculariza-
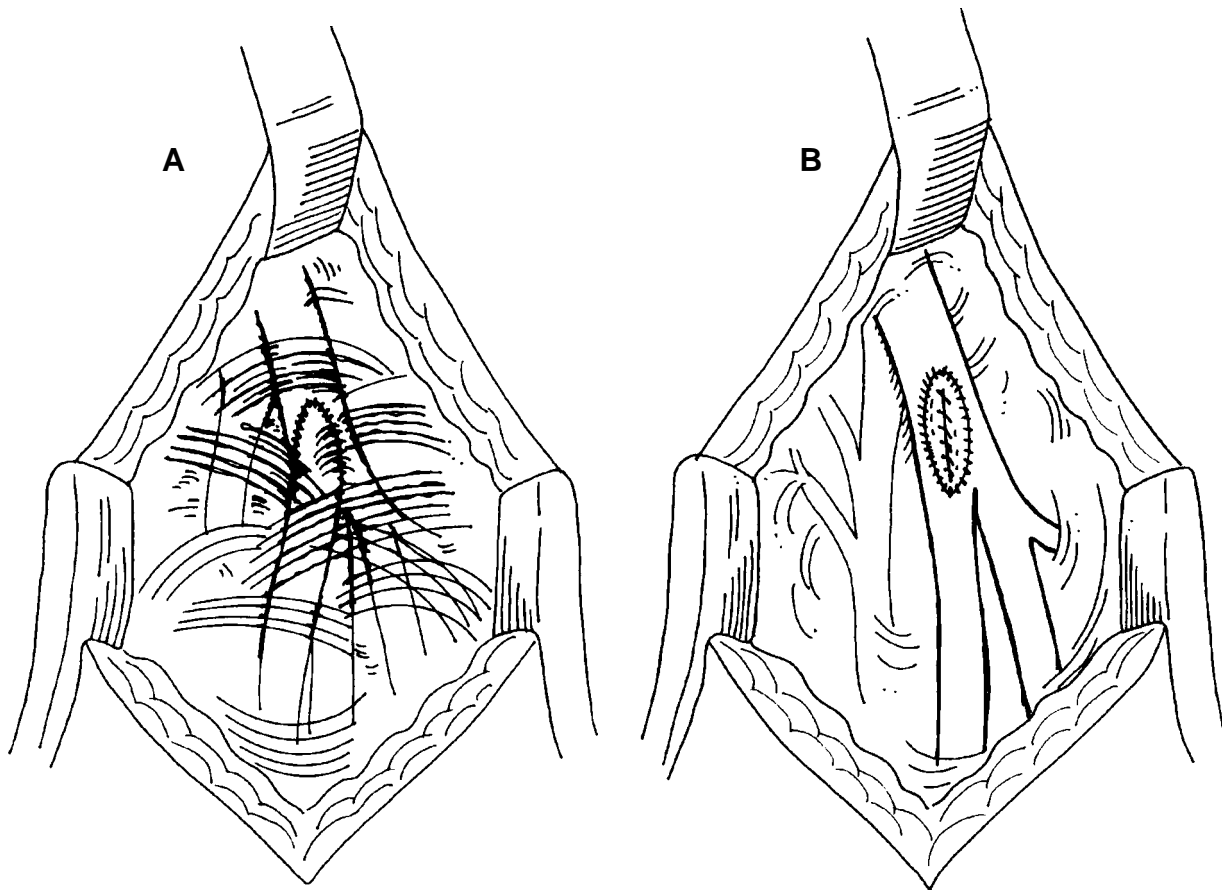
Fig 1. A, Schematic showing an infected groin wound with an intact prosthetic graft anastomosis to the common femoral artery. **B,** The same wound after aggressive operative debridement of all infected tissue, subtotal excision of the graft, and oversewing of a 2- to 3-mm prosthetic graft remnant or patch.

tion. These two patients died of cardiac causes 3 and 84 months after excision of the prosthetic patch. Two patients with non-healing wounds after 1 and 2 weeks of aggressive wound debridement and local wound care underwent excision of the prosthetic patch. One patient underwent placement of a vein patch, with apparent healing of the wound. This patient was lost to follow-up after hospital discharge. The other patient was treated by means of primary closure of the involved artery, which was complicated by arterial hemorrhage 3 weeks later. This patient required arterial ligation proximal and distal to the arteriotomy and an extra-anatomic vein bypass grafting procedure.

Six of 42 patients (14%) died during hospitalization (three of cardiac complications and three of sepsis with multiple organ failure). None of the deaths were necessarily attributable to patch remnant oversewing, because the wounds were healing well at the time of death, although the prosthetic remnant potentially may have led to persistent infection. Although we did not believe that the small remnant of prosthetic graft was contributing to the septic process, the complication rate of oversewn prosthetic patches was 13% (7 of 53 cases), when the three deaths caused by sepsis are included with the four wound complications.

In 26 of 52 threatened limbs, patch remnant oversewing led to limb salvage without the need for secondary revascularization. In 16 patients, secondary bypass grafting procedures were necessary to achieve limb salvage. Two patients who required amputation died during hospitalization, and the amputation wounds of eight patients successfully healed when prosthetic patch remnant closure had maintained flow through a key collateral vessel and no other secondary revascularization was deemed possible. Long-term limb-salvage rates were not calculated, because some patients were treated with
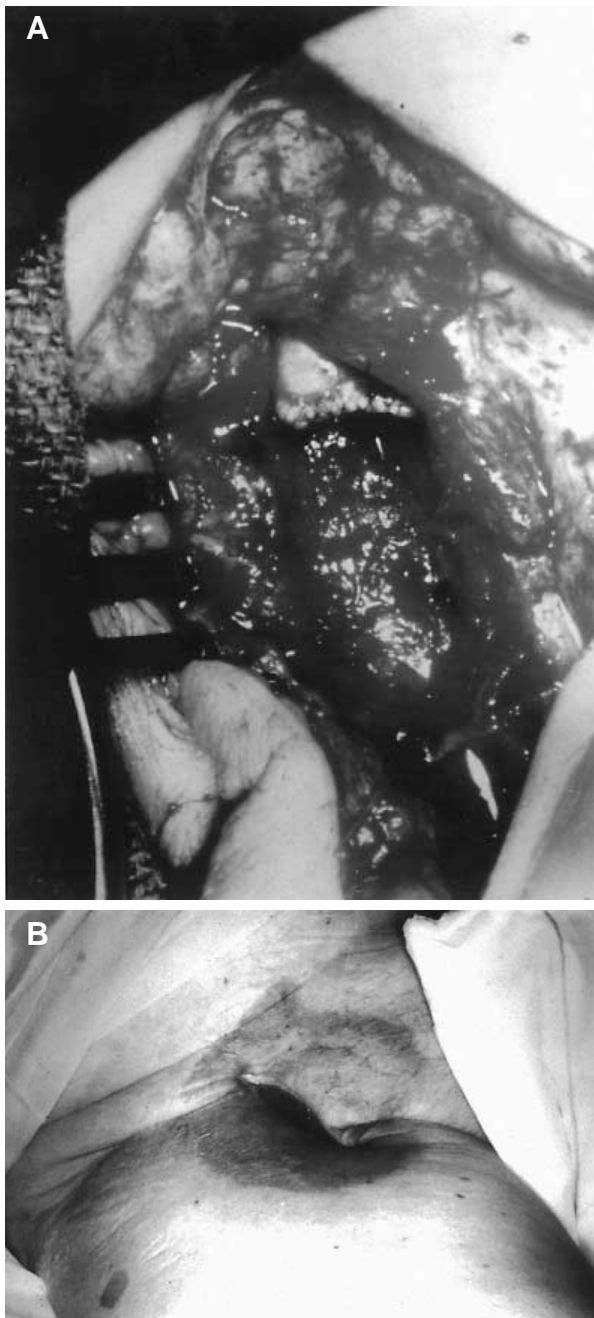
Fig 2. A, An operative photograph of an oversewn prosthetic patch remnant in a groin wound with surrounding granulation tissue. **B,** A follow-up photograph of the same wound after granulation tissue has covered the prosthetic patch remnant.

secondary bypass grafting procedures at the time of management of the infected grafts, whereas other patients were treated by means of patch remnant oversewing without secondary revascularization.

Staphylococcus aureus and *S epidermidis* were the most common gram-positive bacteria cultured, and *Pseudomonas aeruginosa* was the most common gram-negative bacteria cultured (Table II). In the two wounds that developed late pseudoaneurysms, one wound cultured *Proteus mirabilis,* and the other cultured *Serratia marcescens.* In the two wounds that failed to heal, one cultured *S aureus,* and the other cultured *S marcescens.*

DISCUSSION

Leaving oversewn prosthetic patch remnants to treat infected prosthetic arterial grafts is a controversial strategy for several reasons. There is universal agreement that the optimal strategy to ensure that recurrent or persistent infection does not occur is total excision of all infected prosthetic material. There is also general agreement that the safest method of managing the involved artery in an infected field after graft excision is ligation or oversewing of the artery proximal and distal to the previous anastomosis.

However, there is a high limb-loss rate associated with routine total graft excision and arterial ligation or oversewing.[4] In many patients with infected arterial grafts, maintaining patency of the artery at the infected site is essential for limb salvage or healing an amputation. In a patient with an infected common femoral-to-distal arterial bypass graft, originally placed to heal a small area of ischemic ulceration or gangrene, maintaining patency of the common and deep femoral artery may be sufficient to achieve limb salvage, without the need for a secondary revascularization procedure. In cases in which a secondary bypass graft would be necessary to achieve limb salvage but is not possible because of the lack of a suitable outflow artery or appropriate conduit, preservation of the deep femoral artery may be critical to healing the amputation. Therefore, the patch remnant technique may improve limb-salvage rates or allow for more distal amputations than methods that involve arterial interruption.

A more commonly accepted method to preserve the underlying artery in prosthetic graft infections is total graft excision with the placement of an autologous tissue patch by using vein or an endarterectomized arterial segment.[5] However, when we have used this strategy, rupture of the autologous tissue patch has occurred.[2] We have a much smaller experience with the use of vein patches, compared with oversewn prosthetic patch remnants, to treat infected arterial grafts. When vein patches were placed in an infected field, three of seven patches eventually rup-

tured. In one instance, the vein patch was placed to treat a disrupted anastomosis. We have rarely used endarterectomized segments of occluded superficial femoral artery as patches in infected fields. Although we believe that the complication rate associated with oversewn prosthetic patch remnants is acceptable and possibly represents improved results compared with autologous patches, the use of oversewn prosthetic remnants is a simpler and less time-consuming treatment in these frequently critically ill patients with densely scarred wounds. These ruptures occurred at both the anastomosis and the center of the autologous patch. We believe that total excision of the prosthetic graft, taking down the anastomosis, and suturing in a new autologous patch at the previous anastomotic site that is exposed to bacteria may lead to more significant arterial wall weakening than leaving the original anastomosis and artery intact. In addition, virulent bacteria, such as *Pseudomonas*, can degrade autologous tissue through the action of elastase and collagenase and lead to autologous patch weakening and rupture.[6,7] The same problem with placing an autologous patch holds for placing a new prosthetic patch, namely that a new arterial anastomosis will need to be performed.

A second advantage of leaving an oversewn prosthetic patch remnant is that the difficult and time-consuming dissection of the underlying artery in densely scarred wounds can usually be avoided. Placing a new patch usually requires complete dissection of the artery with proximal and distal control, although balloon control may, in some cases, obviate the need for such dissection or full arterial mobilization in these infected wounds.[8] These maneuvers can be associated with nerve, venous, or arterial injury and can result in permanent neuropathy or major arterial or venous bleeding. Patients with infected arterial grafts are often elderly and have multiple medical problems. A quicker, less-morbid procedure is advantageous. The placement of a new prosthetic patch has the same disadvantages as an autologous patch.

We and other authors have previously reported success with a controversial strategy to treat focal infections of prosthetic arterial grafts, complete graft preservation.[3,7,9,10] This treatment should only be considered when the patient is not septic because of the graft infection, the anastomosis is intact, only a small segment of the graft is infected, and the graft is patent. In the 14 patent grafts in this series, the presence of at least one of these other criteria prevented the attempted complete graft preservation, and the patients were instead treated by means of subtotal graft

excision with an oversewn prosthetic patch. In addition, when *Pseudomonas* is cultured from the wound, complete graft preservation should probably not be attempted because of the virulent nature of this organism, although we have made exceptions when the only alternative was certain amputation.[7] A somewhat different set of criteria must be kept in mind when considering subtotal graft excision and leaving an oversewn prosthetic patch remnant. The only absolute contraindication to this latter strategy is a disrupted anastomosis. In these cases, the only option is total excision of the infected graft and oversewing or ligation of the underlying artery with or without revascularization. Closing a disrupted infected anastomosis and leaving a patch or all of the graft will routinely result in recurrent bleeding and is a poor strategy. Subtotal graft excision and leaving an oversewn prosthetic patch remnant is most appropriate when trying to maintain patency of arteries that may be critical to limb salvage or amputation healing. *Pseudomonas* was cultured from eight wounds treated by means of oversewn prosthetic patch remnants. Although the results when leaving an oversewn prosthetic patch in wounds that cultured *Pseudomonas* were good, our earlier poor results with complete graft preservation in the setting of this bacteria makes us very cautious in attempting to leave even a prosthetic patch in wounds in which *Pseudomonas* is cultured. Currently, we would only leave a prosthetic remnant in an infected wound that cultured *Pseudomonas* when amputation would be the certain outcome if the artery was ligated or oversewn. Although the placement of an autologous patch in a wound infected by *Pseudomonas* may be more likely to heal than the leaving of a prosthetic patch, we are concerned that autologous patches may be more likely to rupture in the presence of such a virulent organism.[6,7]

Although they were not used in this series, muscle flaps are frequently used to achieve successful wound healing when attempting complete preservation of infected grafts. Muscle flaps were not used to help preserve oversewn prosthetic patch remnants because many patients were debilitated or too critically ill to return to the operating room for another major operation, the wounds were still draining or did not have enough healthy granulation tissue to accept a flap, or the wounds were granulating well a few days after wound debridement with the prosthetic patch remnant almost covered. Patients were frequently discharged after granulation tissue covered the graft, but before the entire wound had completely healed. Visiting nurses provided wound care and daily dressing changes, and patients were examined during frequent office visits.

Prosthetic patch remnants are a useful adjunct that simplify the management of selected prosthetic graft infections. Our long-term results suggest that this technique is associated with a low incidence of wound complications and late recurrent infection.

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DISCUSSION

Dr Patrick J. O'Hara (Cleveland, Ohio). Dr Zarins, Dr Green, Dr Cronenwett, members, and guests.

Dr Calligaro and his colleagues are to be congratulated on achieving impressive results in a group of patients who, most of us would agree, are difficult to treat. They retrospectively examined a group of 42 patients with 45 infected prosthetic grafts, accumulated in a 20-year period, whom they were able to treat with partial graft excision, leaving a small remnant of prosthetic cuff to act as a patch angioplasty to preserve arterial continuity. These patients were carefully selected, by using criteria that seems designed to exclude anastomotic involvement, thus yielding infections involving the shaft of the graft. Despite this selection, however, hospital mortality was still 14%, and, notably, half the early deaths were caused by multisystem failure and sepsis. Four other patients, another 10%, had recurrent graft sepsis that required reoperation for complete graft excision. This yields a combined sepsis-related early mortality and morbidity rate of approximately 17%.

Although I would agree with the authors that it is sometimes possible to leave some uninfected synthetic material in place, in practice, I've often found it difficult to choose appropriate patients for this procedure, because often the infection begins in the groin and involves the anastomosis. In our own experience with infrainguinal synthetic graft infections at the Cleveland Clinic, we found that 82% of patients were treated with incomplete graft excision and required subsequent operation for the control of sepsis, whereas only 13% of complete graft excisions required subsequent operation for the control of sepsis—a difference that was significant. Furthermore, we observed an 18% early postoperative mortality rate, and 58% of these deaths were related to uncontrolled sepsis, all occurring among the group in which limb salvage was still being attempted.

These considerations lead to three questions.

First, on the surface, your results with incomplete graft excision seem much more optimistic than ours. However, our report includes all graft infections that we treated. According to your manuscript, during the study period you did treat some other patients with complete graft excision. Therefore, what proportion of your overall experience does the selected subset of patients in this report represent?

Second, I think that some patients may live in symbiosis with bacterial colonization of their synthetic material. Do you think that your patients with retained graft segments require long-term suppressive antibiotic coverage, perhaps for life?

Finally, my main concern is how the authors can be certain that the deaths of the three patients who died of sepsis and multisystem organ failure, representing fully 50% of the early mortality in this series, were not related to persisting infection in the graft remnant, although the wounds looked good?

Even with the authors' acknowledged expertise in this area, they arguably failed to control sepsis in one of six patients in this series. Consequently, I would advise caution in the application of this method, and, when it is used, careful and close late follow-up in an extended period is required.

I would like to thank the authors for providing me with a copy of the manuscript, and I'd like to thank the Society for the privilege of the floor.

Dr Keith D. Calligaro. Thank you, Dr O'Hara.

First, I'd like to point out that, in most of these cases, purulent fluid came very close or actually involved the anastomosis. These were not cases that involved just the body of the graft. Granted, in some cases, the infectious process seemed to stop just short of the anastomosis, but in most the anastomosis was exposed. In all cases, the anastomosis was intact, but there was still pus near the anastomosis.

We are aware of your results at the Cleveland Clinic with incomplete graft excision. Quite frankly, I'm just not sure whether the way those patients were handled would have been the way we would have handled them at our institution. Maybe some of your patients who had occluded grafts were treated with an incomplete graft excision, and rather long segments of occluded, infected graft were left in place. We would never do that.

In answer to your questions, this experience probably represents approximately one third of all of the infected prosthetic grafts managed at both institutions, maybe less. The reason it's not more is that when the arteries were not deemed critical, they were either ligated or handled in other ways. Also, the other criteria had to be fulfilled. When a patient came in with an infected pseudoaneurysm, they were not treated this way.

In answer to your second question about the duration of intravenous antibiotic administration, we suggest that it be given for at least 1 week. Most patients were given intravenous antibiotics for at least 6 weeks. As far as lifelong intravenous, or even oral, antibiotics are concerned, we do not feel that they are necessary.

In answer to the third question about whether this 2-mm patch of the prosthetic graft accounted for persistent sepsis, I find that somewhat hard to believe, to be frank. When there is healthy granulation tissue in the wound and in the next week or so you see healthy granulation tissue close over this small patch of graft and no drainage at all, it's hard for me to accept that the patch is the cause of persistent sepsis. The reason I think these patients died of sepsis is they came in septic. They mainly died of multiple organ failure, meaning pneumonia or renal failure or other problems, and it's hard to attribute that to a small segment of patch.

Dr Michael T. Watkins (Boston, Mass). Dr Calligaro, I enjoyed your talk. I have a question.

How did you get the granulation tissue to develop in the wounds? That is, did you use any adjunct procedures, such as a rectus or a sartorius flap?

Dr Calligaro. Regarding granulation tissue, I can't emphasize enough the aggressive nature of wound debridement that you must use to satisfactorily heal these wounds.

Muscle flaps were only used in two patients, and they weren't really muscle flaps. They were sartorius myoplasties, in which the muscle is just moved over to cover the patch a little bit.

Dr Linda M. Reilly (San Francisco, Calif). I just have a couple of questions from the traditionalist group.

You emphasize that it's important to widely resect all the involved infected tissue. How can you do that if you don't know the location of the anastomosis and don't have that perianastomotic region dissected out to protect it?

Second, how do you determine specifically that the anastomosis is not involved if you have not exposed it thoroughly at the time of surgery?

Third, did you mention the interval between the placement of the graft and the appearance of infection in your patient group? If you did, I missed it. Could you tell us what the rate of patch disruption was in the patients who prompted you to move to this alternate technique? And if so, was it a long time ago, before the recognition of the importance of wide resection of the infected tissue and the use of other adjunctive techniques?

Fourth, could you comment about the possibility that having a little short stump of graft with thrombus in it actually is a disadvantage for eradicating infection locally?

Finally, I think that you would probably be wiser to just accept the fact that if you have patients dying of sepsis in the perioperative period when you've treated them for infection, they should be considered as perioperative deaths related to your technique.

Dr Calligaro. Thank you, Dr Reilly.

Again, I want to clarify something you may have missed. We knew exactly where the level of the anastomosis was in every single case. This graft was clamped, literally, a millimeter or two above the anastomosis. So, clearly, we saw the level of the anastomosis in every single case.

The onset of infection has ranged from days to months and years later.

Third, the vein patch disruption rate that we've previously noted was a very limited series. But, nonetheless, that's why we stopped it. There were three vein patch ruptures in the seven cases on which we've tried it. I would welcome others to report their data.

Fourth, I still do not accept that oversewing this very small prosthetic patch was the cause of persistent sepsis. We've all seen patients who have severe infection. It's clear that they're dying of multiple organ failure, because they've come in extremely sick. I can't imagine that leaving a 2-mm patch of prosthetic graft is causing consistent bacteremia.

There is minimal thrombus in there, because the graft is essentially oversewn as a patch, not as a segment of graft.

Dr William D. Turnipseed (Madison, Wis). Approximately three quarters of your patients were pretty easy to treat because they had occluded grafts. Basically, you removed the grafts and preserved collaterals. I totally agree with this concept.

The problem that I have is that 14 patients in your group apparently had intact anastomoses, functional grafts, and perigraft infection. These grafts frequently can be salvaged by alternative techniques, either direct graft preservation or graft replacement and coverage with myocutaneous or other biological flaps. I wonder if you would comment on why graft salvage was not attempted in these patients.

Dr Calligaro. Yes, Dr Turnipseed, in answer to your first question about the occluded grafts, you're right.

Those were relatively easier to treat. But again, the point was that the grafts were occluded. And as you alluded, we still needed to maintain patency of the artery to achieve limb salvage; that's why the remnants acted as a patch.

Second, we have published a study on graft preservation for patients with infected prosthetic grafts. In these 42 patients, we did not attempt that strategy, because the entire graft was either bathed with pus or because of other reasons, such as the patients were septic.

Dr Peter Gloviczki (Rochester, Minn). Keith, it looks like you only used a few polyester grafts, so I'm wondering whether you preferentially used this technique for the treatment of infected polytetrafluoroethylene grafts?

My second question concerns the graft material that we should use in an infected field. I presume most of your infrainguinal revascularization patients did not have autologous vein. So, what do you recommend that we use? Should we use a rifampin-soaked polyester graft or maybe a cryopreserved artery or cryopreserved vein graft?

Dr Calligaro. Yes, the numbers were very small for oversewing a Dacron graft. Those were aortobifemoral grafts. We believe it still would work for that type of graft, but the numbers are admittedly small.

For revascularization, obviously, if we can harvest arm vein or any other vein, we would prefer to use that, but still place it through an extra-anatomic bypass graft. If vein is not available, then placing another prosthetic graft through an extra-anatomic bypass graft is our choice. And when concerned about bacteremia, we favor a rifampin-coated graft.

Thank you.