

# Below-Knee Amputation for Gangrene\*

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*NOTE: Members of the American Orthotics and Prosthetics Association, who were active participants in the Amputee Census, will be especially interested in the second paragraph of Dr. Pedersen's article. The statistical information on new fitted cases that was collected in the Census is now being widely quoted in medical literature. Of special significance is the fact that these data have highlighted certain problem areas for future study and investigation.—Harold W. Glattly, M.D.*

**Concepts are changing with respect to the variability of arteriosclerotic vascular disease. It is being recognized increasingly that gangrene of a toe does not necessarily mean amputation at a high level. Thus, there is developing a much wider latitude within which amputations may be done.**

For many years it has been our impression that there is need for a more widespread, genuine interest in the subject of amputations for gangrene. In spite of the many worthwhile publications upon the subject, few surgeons have firm convictions concerning the criteria which determine the level of amputation, the proper treatment before operations, the important technical details of amputation, the postoperative care and, equally important, the problems of limb fitting and training for ambulation. Several papers recently published attest to the increasing general interest in the below-knee amputation for the treatment of gangrene, but simple criteria for the selection of the levels of amputation are not agreed upon.

The magnitude of the amputation problem has been emphasized recently in a statistical report published by Glattly.<sup>1</sup> An attempt is being made to determine a census of amputees in the United States as a joint project of the Committee on Prosthetics Education and Information of the Division of Medical Sciences, NAS-NRC, and the American Orthotics and Prosthetics Association. In a period of 16 months reports were filed on 8,640 new amputees. A review of these records reveals that most amputations in peace time are performed at the above-knee, or below-knee level in the lower extremities, of elderly patients suffering from peripheral vascular disease. Glattly emphasized that during the period in which there were recorded 1,798 below-knee and 2,520 above-knee amputations, there were only 12 instances in which below-knee amputations performed for disease were converted to above-knee. In a personal communication, Glattly revealed that statistics suggest markedly different policies upon amputation in our major cities. Thus, while there is no reason to suspect much variation in the disease process in neighboring cities, in

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Philadelphia 68.7% of the amputations reported were above-knee and 31.3% below-knee, whereas in Baltimore there were only 37.7% above-knee and 62.3% below-knee amputations. It is his belief that "a clinical study may be needed that is designed to define better the criteria that bear upon the decision as to the level of amputation in cases of lower extremity vascular disease."

Many of our concepts of treatment date back to as recently as 1948 when arteriosclerotic gangrene was looked upon as a surgical emergency. At that time Silbert<sup>2</sup> collected statistics from 22 large metropolitan hospitals and reported a mortality rate of 44 per cent. Mortality rates have gradually declined, however, and are now reported variously from five to ten per cent. It is generally agreed that declining mortality has come about primarily because of our ability to control infection, but also because of improved methods of anesthesia, and the improved management of diabetes, heart disease, and renal disease.

During the period of declining mortality there were many sporadic reports indicating that lower amputations could be successfully performed. Thus, Maes<sup>3</sup> and Smith<sup>4</sup> recommended open amputation through the leg in patients with diabetes and arteriosclerosis. Zierold<sup>5</sup> was among the first to emphasize that amputation was not an emergency procedure and that lower amputation could be performed after preparation by surgical control of infection. Bickel and Ghormley<sup>6</sup> recommended the use of a long posterior skin flap for below-knee amputations in patients with gangrene due to arteriosclerosis. In 1943, Silbert<sup>2</sup> advocated below-knee amputations, stressing that the only contraindication was gangrene following sudden femoral occlusion, where there was no opportunity to develop sufficient collateral blood supply. In 1949, McKittrick<sup>7</sup> published his record of transmetatarsal amputations performed for diabetic gangrene or infection limited to toes. In 1954, Silbert and Haimovici<sup>8</sup> discussed the indications and contraindications for amputations of the lower extremity at the several functional levels. One<sup>9</sup> of us (H.E.P.) published a similar discussion in 1958.

Thus, it has been demonstrated that low amputation can be successfully and safely performed with proper selection of candidates. It has likewise been demonstrated that low amputation is preferable in the rehabilitation process. In spite of marked improvement in the fabrication of prostheses fitting and training, experience in most prosthetic clinics confirms the fact that few elderly amputees walk well with the prosthesis for the above-knee amputation. Practically none walk with prostheses for bilateral above-knee amputations. On the other hand, at any age, the below-knee amputee with a suitable prosthesis should be able to walk without assistance, if he was able to walk prior to amputation. Many elderly bilateral below-knee amputees, with suitable prostheses, walk with little assistance.

Finally, it was once believed that arteriosclerosis is a generalized, relentlessly progressive disease. If so, once gangrene appears in toes, progressive gangrene should be imminent and a high thigh amputation indicated. There is excellent evidence now that there is usually patchy involvement of major vessels, and that if these vessels are gradually occluded a collateral blood supply does develop. Therefore the absence of palpable pulsation in the major vessels of an extremity does not necessarily indicate severe ischemia.

In this paper, it is our intention to report evidence supporting our conviction that for the treatment of arteriosclerotic gangrene, the below-knee amputation is the most useful of all lower extremity amputations. It is rarely necessary to amputate above the knee. The following discussion is

based on clinical experience obtained in the performance of 152 amputations for gangrene in the years 1950 to 1955 and reported in 1958. It is further supported by a follow-up study in 1959 of 106 below-knee amputations. Finally, it is supported by experience in two active prosthetic clinics.

In the selection of the level of amputation it was the policy to amputate, after gangrene had sharply demarcated and infection was controlled, at the next proximal level consistent with good function, provided skin at that level was warm and showed evidence of good nutrition. This was done regardless of the age of the patient or the presence or absence of palpable pulsation in the extremity, and without regard for rest pain or muscle atrophy. On admission, patients were usually evaluated by a peripheral vascular service with respect to the suitability for arterial surgery or lumbar sympathectomy.

Gangrene and infection were treated preoperatively according to principles laid down by Samuels. Patients were put at rest. The involved part was covered with a sterile dressing. Abscesses were drained early, in addition to the supportive therapy of daily lukewarm foot baths and antibiotics. At the time of operation the most delicate surgical technic was used. The stump was covered with a bulky dressing applying gentle pressure to the entire stump. The anesthesia of choice was spinal and a pneumatic cuff was used for all but six amputations.

### Surgical Results

Sixty below-knee amputations were performed on 55 patients. Twenty-eight healed primarily, 22 secondarily, and ten were reamputated at a higher level. There were no operative deaths. Ten patients had Buerger's disease, 16 arteriosclerosis, and 29 diabetes with arteriosclerosis.

In seven cases preparation for definitive amputation included an operative procedure, such as amputation of toes, incision and drainage of abscess, wedge resection of a toe and its corresponding metatarsal, and supramalleolar guillotine amputation. In six patients below-knee amputation was performed following failure of a more distal amputation. In these were included one toe, three transmetatarsals, one midtarsal and one Syme amputation.

Among the 22 cases of delayed healing there were eight wound infections, two hematomas, and five with localized areas of skin necrosis. The other seven patients had combined infection and skin necrosis. Delayed healing was treated by methods similar to those used to prepare the patient for operation. Infection was drained and localized areas of skin necrosis were allowed to separate spontaneously. For both necrosis and infection, sterile dressings and daily stump baths in lukewarm water and pHisoHex were used to promote drainage and spontaneous separation of necrotic tissue. In only two cases of delayed healing was further operation performed. Revision of those stumps after control of infection was followed by primary healing.

In the ten failures of below-knee amputation there was progressive gangrene postoperatively, for which reamputation above the knee was required. Study of those cases revealed no consistent cause for failure. Failure was not related to the use of a pneumatic cuff, the presence or absence of a palpable popliteal pulse, or preoperative lumbar sympathectomy.

In this series 22 patients had 26 lumbar sympathectomies. These patients were evaluated preoperatively by a peripheral vascular service. If any

response to sympathectomy seemed likely, lumbar paravertebral blocks were performed. Sympathectomy was then recommended when an increase in peripheral skin temperature followed the block.

### Experience with Prostheses

Of the original group of 60 below-knee amputations, 48 of 50 healed stumps were fitted with suitable prostheses. The so-called conventional prosthesis was used. It had a wooden socket, metal hinges and thigh corset. Skin abrasions frequently developed in the area of weight bearing. Weight bearing was then immediately discontinued until healing was complete and adjustments were made in fit and alignment to prevent such local irritation. It was frequently found that patients had less difficulty when the stump was allowed to sink into the bucket and weight was borne on the patellar tendon as well as the flare of the tibia and fibula. Only one patient in the group with a properly fitted limb had to have a second amputation because of recurrent ulceration.

With the development of the newer patellar tendon bearing prosthesis for the below-knee amputation, it was frequently prescribed. It was discovered that while it is an excellent prosthesis for the relatively young and vigorous patient, many difficulties were associated with its use among elderly amputees. The fitting of the total contact socket is critical. Too frequently there was serious evidence of abrasion and break down of the delicate skin on fresh below-knee amputation stumps. It was likewise thought that the elderly patient needed the stability of rigid hinges. The thigh corset added stability as well as an increased area for weight bearing. Finally, the necessary flexed position of the knee in the patellar tendon bearing prosthesis required additional strength and endurance not present in many of the elderly amputees.

Experience in the prosthetic clinic confirms the experience of others that the elderly patient learns to use the prosthesis for the below-knee amputation with relative ease and practically no special training. Most patients using the prosthesis were able to walk without canes, and for whatever distance their daily activities demanded. Many are at work and on their feet full time.

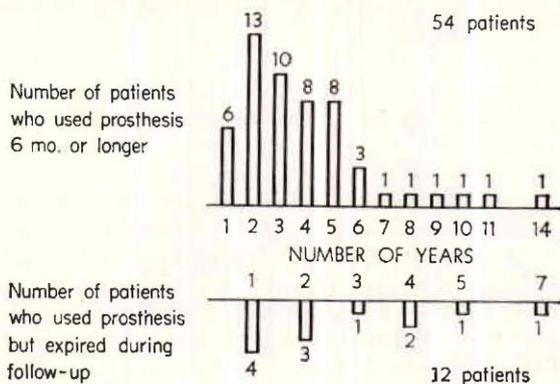
We would like to emphasize that recurrent ulceration is rare, after the initial period of fitting and ambulation. It is striking that the relative ischemia suggested by delayed secondary healing is not followed by repeated ulceration of the stump on weight bearing.

### Follow-Up

To get further information on the value to the patient of such care a follow-up study was conducted in 1959. At that time there were records of 106 below-knee amputations performed on 100 patients. Information was gained from charts, personal examination of patients, postcards from patients, and records of limb fitters. Concerning 106 amputations there was proof that 54 used a prosthesis for six months or longer. Seventeen others, after proper healing of the stump, fitting, and training used a prosthesis at least three months before being lost to follow-up. For nine, records were so poor that no information was available. There were 26 failures.

A review of the failures revealed that 13 were surgical failures requiring higher amputation. Nine patients died while still hospitalized, for reasons not necessarily related to operation, such as coronary occlusion, or cerebrovascular accident. Four with healed stumps were never fitted because of senility and general debility.

FIG. 1



The number of patients with the length of time they had successfully used a prosthesis as the time of follow-up.

The most instructive follow-up information is found in the analysis of the 54 patients who used the prosthesis six months or longer. Twelve of that group were dead at the time of follow-up but prior to death had used the prosthesis for periods ranging from 8 to 84 months (Fig. 1). The remaining 42, living at the time of follow-up, successfully used prostheses for periods of 6 months to 14 years, and most of them were still walking three to five years after successful fitting (Fig. 1). Only two patients, because of recurrent gangrene, had late conversion of a below-knee amputation to an above-knee amputation.

### Discussion

After this study it is our conviction that the below-knee amputation is the most useful of all for the treatment of gangrene. Some patients with limited disease are suitable for single toe amputation, transmetatarsal amputation, or the Syme amputation. Most of the remaining patients presenting with gangrene are suitable for the below-knee, and only rarely is the above-knee amputation required. The nature of arteriosclerosis, and its effect on total blood supply of the limb, is such that most patients with gangrene can and should be rehabilitated by conservative amputation. Mortality and morbidity no longer preclude such care. It has been demonstrated that these patients, once successfully fitted, use the prosthesis long enough to justify the required effort and time.

The criteria for the selection of suitable candidates are few. The patient's general health and vigor should suggest the possibility of ambulation and he should have a good knee without fixed contracture. Few patients whose gangrene follows sudden high thrombosis or embolism are satisfactory candidates. Almost all patients whose gangrene begins distally are good candidates. Distal disease is precipitated by such factors as trauma, excessive heat or cold, localized infection, or minor distal thromboses. When gangrene has demarcated and infection is controlled, below-knee amputation may be performed if the skin at the amputation site is warm and shows evidence of good nutrition. No distinction need be made between patients with and without diabetes since the basic blood vessel disease of atherosclerosis is similar. It should be recognized that results are generally conceded to be better among diabetics because for many diabetics the problem is not one of marked ischemia but their intolerance to infection.

For such an amputation program to be successful other facts must be known. Gangrene and infection do not present as surgical emergencies requiring early high amputation. McKittrick<sup>7</sup> predicted that when we could control infection mortality rates would reach the present low level. Rather than above-knee amputation we recommend early incision and drainage, clove-foot resection, or guillotine supramalleolar amputation as initial procedures to control infection. These are used in conjunction with suitable antibiotics during acute infection, sterile dressings to prevent secondary contamination, daily foot baths to promote drainage, and rest during demarcation to minimize the requirement for increased peripheral blood flow.

We would particularly stress the fact that icing the extremity, with or without a tourniquet proximal to gangrene, is practically never indicated. Once the extremity is cooled, above-knee amputation is mandatory. Cooling usually extends above the knee and results in an increased incidence of marginal skin necrosis and infection after formal above-knee amputation.

Pain *per se* is not an indication for high amputation. Among patients with peripheral vascular disease and gangrene we recognize three types of pain. Intermittent claudication is recognized as benign. Severe rest pain without an open lesion is evidence of at least temporary severe ischemia and is a poor prognostic sign. On the other hand, such rest pain associated with an open lesion and inflammatory change frequently precedes control of infection and successful conservative amputation. This is particularly true among patients with Buerger's disease where an extensive collateral circulation is known to develop.

The value of preoperative lumbar sympathectomy for patients presenting with gangrene is debatable. It is argued by some that some element of vasospasm exists and that lumbar sympathectomy relieves the vasospasm, particularly to vessels supplying the skin. We agree that vasospasm is a factor in the clinical picture of the patient presenting with gangrene, and that skin is the critical tissue in determining success or failure of amputation. For that reason, when below-knee amputation is selected on the basis of the skin condition, the finding of ischemic muscle at the time of operation is not considered a just cause for changing the level of amputation to the above-knee. In this group of patients, and in series presented by others, there is no evidence that in the presence of gangrene, lumbar sympathectomy limited the extent of gangrene or made possible a lower level of amputation. We do think that an accurate appraisal of skin circulation cannot be made until the process of spreading gangrene and infection is stabilized and proximal vasospasm is relieved. Not infrequently it has been noted that after complete wound healing proximal skin temperature, color and nutrition have markedly improved.

Since skin is the critical tissue and we are frequently dealing with a delicate balance between the available and the required local blood supply, the amputation should be planned to preserve skin vessels and to utilize that skin with the best blood supply. At the Dearborn Veterans Administration Hospital, the amputation producing the best stump for prosthetic fitting has been a plastic procedure utilizing equal anterior and posterior skin flaps. Unfortunately, with a limited blood supply there was a high incidence of ischemic necrosis of skin flaps, particularly in the lateral portion of the anterior flap. It has been frequently demonstrated that in the leg the blood supply in the anterior flap is not as good as in the posterior flap. We now recommend a simple, atraumatic amputation using a long posterior skin flap, with as little elevation of skin flap as possible. Muscle bundles are cut in one stroke, with the amputation knife. To do this safely, a pneumatic

cuff is usually used on the thigh. In this series of patients there is no evidence that the cuff used has contributed to complications in the wound.

In any conservative amputation program, wound complications are frequent, and the program cannot be successful unless both patient and physician are prepared to deal with these. Ischemic necrosis of wound margins, with or without infection, can usually be controlled by methods similarly used to prepare the patient for operation. Infection is drained, sterile dressings are used to prevent secondary contamination, and stump baths are used to promote drainage and spontaneous separation of necrotic from viable tissue. A strong plea is made to resist daily debridement of the wound. Any removal of necrotic tissue associated with bleeding results in an extension of necrosis and progressive gangrene which may require high amputation. Allowing spontaneous separation of necrotic from viable tissue, progressive granulation will usually result in satisfactory wound healing in three to four months, without secondary closure or skin grafting. On rare occasions secondary closure is indicated for wide open, clean, granulating wounds.

*Finally*, no amputation program can be successful unless the surgeon is concerned with the total rehabilitation of the patient. He must have a satisfactory knowledge of the available prostheses, their advantages and limitations, and the problems of fitting and training. While this is all the surgeon's responsibility the best results are usually found in prosthetic clinics utilizing the combined talents of surgeon, physiatrist, prosthetist, physiotherapist, occupational therapist, and social worker. The goal is not merely survival of a patient, but the return to society of a useful, independent citizen.

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