THE BELOW-KNEE AMPUTATION * b

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Throughout the United States and Canada an estimated 80 percent of all major elective civilian amputations result from ischemia. All but a relatively few involve the lower extremity. Significant improvements in below-knee prostheses and important advances in surgical and postsurgical management now allow amputation below the knee in a majority of patients. In a consecutive series of 96 unselected major lower-extremity amputations for peripheral vascular disease—1964 to 1967—we have been able to obtain primary healing at the below-knee level in 75 percent of the cases. Once healed, the stumps remain healed. With adequate prosthetic care, secondary breakdown will seldom occur. It is not possible to overestimate the great importance of the knee in amputee rehabilitation. This is true especially in the older, classical, ischemic patient. Debility, impaired vision and balance, neuropathy, compromised circulation and function in the remaining lower limb, together with chronic systemic illness, all emphasize the critical need to save the knee. The older bilateral leg amputee especially needs his knees to approach the rehabilitation goal permitting a reasonable degree of ambulation and self sufficiency. The below-knee amputation thus becomes statistically by far the most important major elective technique.

SELECTION OF PATIENTS

A. Peripheral Vascular Disease

When acute or chronic compromise of arterial blood supply reaches a level insufficient to support tissue viability and when reconstructive surgery and nonsurgical supportive measures fail, amputation will be required. The great achievements in surgical reconstruction of the peripheral

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vascular system represent a leading chapter in medical progress during the past two decades. Continuing basic and clinical research throughout the world supports the hope that an even higher percentage of limb salvage can be expected in the years ahead. As basic causes of degenerative arterial disease become better understood, prophylaxis will play an increasing role. Despite the practical effectiveness of modern vascular reconstructive surgery and the promise of preventative measures to forestall degenerative and occlusive arterial disease, statistics indicate that amputations for ischemia are increasing both relatively and absolutely in relation to population throughout the western world. Patients requiring amputation are entitled to comparable medical and surgical consideration, comparable team effort, and the same high-level rehabilitation management attending similar patients whose ischemic limbs are treated by vascular reconstruction. Too often, ablative surgery does not command this high estate.

Decision to amputate may be simple and evident. Gross necrosis of tissue with demarcation, uncontrollable infection, pain, irreversible neuropathy, alone or in combination with results of specific tests to assay circulation, will establish the need to amputate. When all available information poses a serious question as to the possibility of limb salvage by reconstructive surgery rather than amputation, it has been common practice to attempt such surgery, even though extensive. Before questionable extensive reconstructive arterial surgery is carried out, the surgeon should critically consider the overriding probability of its failure with mandatory subsequent amputation. Will the proposed surgery compromise the level of amputation? Will amputee rehabilitation be additionally complicated by further deterioration of general health incident to the extensive surgical attempt at limb salvage? We have, on a number of occasions, performed below-knee amputations in ischemic patients who were being considered for possible vascular surgical treatment but in whom, after review of all available information, such surgery might well have damaged existing blood supply to a degree that an above-knee amputation would then have been required. It is important that the responsible surgeon understand the great rehabilitation value of the knee and weigh all facts relevant to rehabilitation potential.

There is no single test or combination of tests now available that will specifically demonstrate the lowest effective amputation level. We have repeatedly obtained successful below-knee amputations in patients whose arteriograms indicated complete occlusion of the superficial femoral artery. A careful physical examination is then the first requisite in level determination. Tissue appearance, clinical assay of skin temperature, the presence or absence of edema after elevation, growth of hair, sensation level and acuity, together with palpation of pulses are all important and cannot be supplanted by laboratory data. Arteriography, plethysmography, thermography, and a number of other objective determinants are useful. These include skin map-
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ping with interarterial fluorescein, the use of radioactive Xenon \#133, and transcutaneous doppler recordings. Each adds to the available information and assists in level determination. Old established guidelines for determining amputation level are not valid when weighed against our recent experience. Unless it is clearly evident that a through-knee or above-knee amputation will be required, the surgeon should prepare the leg for both below-knee and above-knee amputation. Incisions through the skin and muscle preparatory to below-knee surgery can then be quickly carried out. Bleeding and tissue viability can then be visualized directly and the final decision now made as to the level of amputation. Only a few minutes are added to the operative time should one elect above-knee or through-knee level.

Technique for Below-Knee Amputation in Ischemia. No tourniquet is used. The leg is draped free with the patient supine. Open and infected areas are walled-off and shielded by sterile plastic drapes prior to skin preparation. The level of amputation is 3½ to 5 in. below the knee, i.e., a short below-knee stump. We routinely use a long-posterior and short-anterior skin flap. It has been recognized for many years that skin over the posterior leg has better blood supply than that anterior and anterolateral. A long anterior flap, even equal anterior and posterior flaps should be avoided. Using the long-posterior flap, the resulting anterior scar is no problem in limb fit. It is our policy in fact to place the scar wherever it will heal most advantageously. The modern total contact below-knee prosthetic socket can accept a stump with scar placement in any position, provided it is non-adherent, well-healed, and nontender.

The anterior skin flap is fashioned at approximately the level of anticipated tibial section. The posterior flap must then be 5 to 6 in. longer to provide proper skin coverage without undue tension.

After outlining the skin flaps, dissection is carried down through the deep fascia to the tibia. Periosteum is incised and stripped proximal 1 in. The anterolateral muscles are divided down to the intermuscular septum; blood vessels and nerves are appropriately ligated and severed, then the tibia and fibula are sectioned preferably with a power saw. The fibula is cut no more than 3/8 to 3/4 in. above the level of the tibia. Soft tissues are dissected from the posterior aspect of the tibia and fibula down to the level of the posterior transverse division of skin. The leg is then separated and removed. The tibia is very carefully rounded with a short bevel over its anterior and medial aspects. It is important that no rough bone areas or ridges remain. A long bevel is specifically avoided. Nerves are pulled down and sectioned high with a sharp knife. They are neither injected nor crushed nor cauterized. The major nerves are ligated with fine suture prior to and just above the site of division. Encircling suture controls oozing from blood supply accompanying the nerve. It also appears to localize neuroma formation and lessen overgrowth and adherence to adjacent structures. The posterior muscle mass.
consisting of the gastrocnemius-soleus and deep flexor group is now beveled
to permit the entire muscle flap to come forward and be sewn anteriorly
to the deep fascia of the anterolateral muscle group and to the reflected perios-
teum over the anterior tibia. Medial and lateral countouring and trimming of
gastrocnemius muscle gives a smooth musculofascial flap stabilized over the
end of the bones. The skin is then brought up and closed without sub-
cutaneous suture. Medial and lateral “dog ears” are contoured moderately.
They should not be taken back sufficiently to disturb skin circulation. The
immediate postsurgical socket rapidly shapes the stump including moderate
skin irregularity at the medial and lateral angles. The wound is drained deep
to the muscle flap, i.e., to bone. Through-and-through drain or suction
drainage may be used. An immediate postsurgical rigid dressing and prosth-
thesis is then applied.

Drains are removed 48 hours following surgery. If the patient’s general
condition permits, ambulation with guarded weight bearing is begun 24
to 48 hours following surgery. Touchdown weight bearing only is allowed
until the initial cast change. Weight in the initial prosthesis should not exceed
25 lb. until cast change. Personnel who ambulate the patient should be
carefully instructed as to their responsibility in preventing the patient from
bearing excessive weight or falling. However, the advantages of upright
activity with limited stance and gait are obvious.

Postoperative pain is generally of a diffuse aching type. The postsurgical
management with an immediate prosthesis has resulted in much less pain
than previously encountered. Localized complaints of pain would indicate
abnormal pressures and require stump inspection or possible socket change.
Unless complications develop—i.e., evidence of infection, excessive loosening
of the prosthetic cast, or severe pain—the initial rigid dressing should be
left intact until the time of anticipated suture removal, usually 2 to 2½
weeks following surgery. Without anesthesia, but with sedation, the cast is
removed, the wound inspected, sutures removed if indicated, and a new
temporary prosthesis applied. By this time the patient is usually ready for
unsupported crutch ambulation and discharge from the hospital. A tempo-
rary prosthesis is worn continuously until definitive limb fit. Ordinarily the
final limb can be fabricated, fitted, and worn 4 to 6 weeks following below-
knee amputation.

Necrosis of skin flaps can result either from inadequate blood supply or
undue pressure. If judgment as to level has been faulty at the time of surgery
and blood supply was insufficient to support a below-knee amputation, this
will be evident at the initial cast change. The decision then to amputate
at a higher level should be made promptly. The reamputation rate in our
series to through knee or above over the 3-year period has been 9.4 percent.
As experience and techniques have improved with the below-knee ampu-
tation for ischemia, our reamputation rate has continued to decrease. The
surgeon would, of course, like to avoid any reamputations. However, salvage of the knee is of such paramount importance that an occasional reamputation may be required on the basis of our present inadequate diagnostic means for level determination.

B. Non-Ischemic Below-Knee Amputation

The optimum level for a below-knee amputation in the presence of adequate blood supply is at the junction of the middle and lower third of the leg. This somewhat longer stump can be well fitted with a total contact prosthesis and provides excellent leverage for strong limb control. Often, the level of amputation will be determined by the causal pathology, including infection, the degree of scarring of the tissues, and related factors. The surgeon should save all effective length down to the optimum level that is consistent with providing a comfortable nontender stump.

The elective amputation must be considered plastic and reconstructive in nature. We have repeatedly emphasized need to create a dynamic and sensory motor end-organ. The below-knee stump no longer hangs suspended in an open-end socket. Total contact with variable degrees of pressure and weight bearing over the entire stump surface enhances the surgeon’s opportunity to fashion a functional terminal end-organ. Stump strength created by surgical muscle stabilization, pliable, sensitive, but nontender skin and scar, adequate soft tissue coverage of bone ends and other pressure sensitive areas, high ligation and division of nerves to remove neuromata from pressure zones, meticulous rounding and tailoring of bone surfaces all contribute to an ideal organ for substitute limb reception. As this stump matures, the profound shrinkage previously considered desirable is avoided. The atrophic, wasted, bony, below-knee stump so commonly encountered in years past is no longer acceptable.

In addition to established physical measures of rehabilitation the therapist must specifically stress exercise for stump musculature. Isometric exercises of the stump muscles sectioned at amputation level and surgically stabilized should be encouraged. A cylindrical stump shape is desired. For the purposes of teaching we direct the surgeon’s thinking in terms of producing a foot-like organ at below-knee level. The total contact socket is the “shoe on the foot.” Just as plastic surgical techniques are required in operating on the hand and foot, the same techniques of gentleness in skin and other tissue handling are applicable to amputation surgery. When viewed in this light, the amputation becomes a surgical challenge instead of a distressing surgical exercise. Immediate postsurgical prosthetic fitting not only supports and augments the dynamic approach to rehabilitation, it offers certain physical advantages, i.e., immobilization, appropriate continuous pressure relationships, and comfort. These benefits further justify its incorporation into the overall management of the below-knee amputee.
SUMMARY AND CONCLUSIONS

Below-knee amputation is statistically the most important major amputation used today. The vast majority of major lower-extremity amputations performed for ischemia will heal primarily and remain healed at below-knee level. The below-knee amputation for ischemia is short in length, the posterior skin and myofascial flaps are fashioned long, technique is precise. The resulting stump is cylindrical in shape, well-padded, comfortable, and easily fit with modern below-knee prostheses of the total contact type (Fig. 1 and 2). An immediate postsurgical prosthesis is an integral part of the overall below-knee amputee management in both the ischemic and non-ischemic patient. Restoration of function and rehabilitation of the below-knee amputee, both unilateral and bilateral, has improved in almost spectacular fashion when the guidelines and management which have been outlined are followed.