Pedal Amputations In The Diabetic Population

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INTRODUCTION

The word amputation is derived from the Latin term "amputare", which means "to cut around." Amputations are generally performed for five main reasons: peripheral vascular disease (PVD), infection, trauma, tumors, and congenital deformities. Of these five, PVD is the most common.

Many state laws forbid podiatrists to perform amputations, although this has been interpreted to mean amputation of the foot *in toto*. One state law states that "surgical debridement with plastic repairs and/or reconstruction of diseased, traumatized and/or devitalized, nonviable or necrotic tissue has been and continues to be the standard of treatment for these disease processes."

Forty-five to seventy percent of all lower extremity amputations are the result of complications from diabetes mellitus. This involves complications from peripheral vascular disease, infection, and neuropathy. The five year survival rate after unilateral amputation is 50% for the first three years and 40% after five years. This is mainly attributed to end-stage diabetic disease in these individuals.

The previous belief of diabetic micro-angiopathy in peripheral vascular disease is being challenged. LoGerfo and Coffman in 1984 presented studies which refute the microvascular theory of diabetic angiopathy. Diabetics exhibit a clear macro-angiopathy which usually manifests within the tibial and peroneal vessels, yet these patients appear to possess adequate collateral circulation and small vessels within the foot. Due to this new perspective, it is now more common to bypass from proximal arteries (femoral, popliteal) into the foot and ankle in an attempt to prevent below-knee amputation.

LEVEL OF AMPUTATION

The potential for wound healing obviously increases with a more proximal amputation level. However, this is a trade-off for both function and energy expenditure, which should be highly regarded. Selection of the most distal level which is compatible with wound healing and tissue viability is preferred to maintain optimal function.

Studies have shown that the amount of energy expended for normal ambulation is directly proportional to the level of amputation. There is a much higher energy (oxygen consumption per meter travelled) expenditure for an above-knee amputee versus a below-knee amputee, and likewise with a Symes amputee. Other parameters such as stride length, cadence, and velocity are likewise affected.

A patient's previous ambulatory status must be considered before performing an amputation. For example, in the situation where the patient is bed-ridden, function is not a major factor.

Bleeding skin edges is probably the best and most consistent indicator of healing potential, and should be evaluated in amputations performed for peripheral vascular disease. Doppler and segmental pressure measurements should be performed on any patient about to undergo an amputation. Assessment of the ankle/brachial index should always be determined in patients with non-palpable pulses. Wagner described healing in 90% of patients when the ABI was greater than 0.45. Elevated pressure readings may occur in patients with calcified vessels, thus giving falsely high indices.

Measuring a patient's transcutaneous oxygen level is a helpful exam in situations where calcified vessels provide an unreliable compression value. This reflects the balance between oxygen delivery to the skin and cutaneous oxygen consumption. In general, values of less than 20-25 mm Hg are not compatible with satisfactory wound healing.

MEDICAL CONSIDERATIONS

Proper assessment of a patient's nutritional status is a very important factor in predicting wound healing, in addition to the ABI and segmental pressures. Studies have shown that the albumin level and lymphocyte count are also valuable in determining healing potential. Albumin is the major protein-binding transport system within the body, and should be ≥ 3.5 g/dl. One important molecule which albumin binds is zinc, which plays an important role in collagen production and wound strength. The total lymphocyte count gives information with regards to the host's ability to combat infection. This value should be ≥ 1500 cells/ml. Oral and/or parenteral hyperalimentation is recommended to supplement patients who are nutritionally deficient. Once hyperalimentation is initiated, the nutritional status can best be assessed by measuring the serum transferrin levels. This level increases along with albumin, but is a more sensitive indicator of acute nutritional changes due to its shorter half-life.

Another important factor to facilitate wound healing and combat infection is stabilization of the diabetic's blood glucose level. Within the hospital, tight glycemic control with routine accuchecks and sliding scale insulin coverage should be instituted.

SURGICAL CONSIDERATIONS

If general anesthesia can be avoided, then this is preferable. Usually a local block (without epinephrine) is adequate for any foot amputation distal to the trans-metatarsal level, and spinal anesthesia can be attempted for more proximal levels of amputation. Intra-operatively, all vessels and nerves encountered should be securely ligated, and nerves should be buried into muscle to minimize potential problems with regeneration.

Amputations resulting from peripheral vascular disease may be handled differently than infections, depending on the clinical situation.

Infection

It is sometimes necessary to stage an amputation resulting from infection, i.e., one stage vs. two stage. The important point is to avoid primarily closing a wound prematurely over infected tissue (soft tissue or bone). Severe infections can be left open for several days to assess the viability of remaining tissue.

Bone biopsy with a cleanly resected bone margin, is necessary when performing amputations resulting from osteomyelitis. After resecting all diseased bone, a thin, proximal clean section should also be sent for histological examination to be sure that all of the devitalized bone is surgically resected. Of all the diagnostic modalities for osteomyelitis, the most definitive is still a bone biopsy. All other modalities (MRI, bone scans, CT, etc.) still have their share of false positives and false negatives.

Whether surgery is performed or not, six weeks of IV antibiotics is recommended for osteomyelitis if diseased bone is left within the foot or ankle. If all osteomyelitic bone is removed, then two weeks should be adequate to treat the soft tissues. It is good practice to place a surgical drain within the wound to prevent hematoma formation. Besides impeding wound healing, a hematoma also serves as a nidus for infection. If the drain is staying in place for several days, then it should exit the foot away from the incision to prevent maceration along the incision line.

Ischemic

Selection of an appropriate level of amputation should correlate with tissue viability. The presence of bleeding with the skin incision is one of the more predictable signs. These amputations should be primarily closed to facilitate collateralization and neovascularization of the wound. If an appropriate level has been selected, then there is no need to leave the wound open. This is different from treating amputations associated with infection.

If a tourniquet is used for the initial dissection, then it should be released prior to closure to assess the circulation to the wound edges. Wagner states that within three minutes of releasing a tourniquet, healthy bleeding should be noted along the skin edges. If the soft tissues look dusky or necrotic without active bleeding, then a higher level of amputation should be attempted.

SURGICAL TECHNIQUE

Digital

A fishmouth approach or a plantar or dorsal flap may be used in a digital amputation. As a general rule, plantar skin should be utilized to flap dorsally whenever possible. The plantar skin is thicker and

more durable for withstanding future forces, as well as maintaining a richer blood supply. If possible, the insertion of the intrinsic musculature into the base of the proximal phalanx should be maintained for a functional metatarsophalangeal joint. Nevertheless, even if the whole digit is removed, there is minimal to no functional loss.

Metatarsal

Beware of complete or partial metatarsal amputations and their effect on the ultimate weight-bearing parabola. If a partial resection at one level dramatically increases pressure at another level, then future ulcerations may ensue. It is easier to accommodate a lesser metatarsal head resection than one at the first metatarsal level. There may be situations where a pan-metatarsal head resection is a viable option if the digits are still present. This effectively removes the weight-bearing forces from the ulcer level and evenly re-distributes it across the forefoot. Giurini et al. reported good success with 30 cases. When two or more metatarsals have been resected fairly aggressively, then a trans-metatarsal amputation is indicated for long-term success.

Trans-metatarsal

An attempt must be made to establish a fairly normal metatarsal parabola even when performing a trans-metatarsal resection. One must take care to avoid leaving any prominent bony edges which may be a problem in the future. Careful consideration should also be given to performing an Achilles tendon lengthening, to prevent an equinus contracture postoperatively. Also consider the potential deforming forces that the anterior tibial tendon may have on frontal plane position of the foot and ankle. This tendon may be transferred to the dorsum of the foot to assist in straight dorsi-flexion motion and balance the posterior musculature.

LisFranc/Chopart's

These levels of amputations are less commonly performed than the trans-metatarsal amputation, as they are less amenable to weight-bearing and prothesis fitting. Also keep in mind the Achilles and the Anterior Tibial tendons, which again may need to be addressed.

Symes

This level of amputation gives the patient the ability to ambulate without a prothesis at home. Initially, these were performed as a one stage procedure, yet now the preferred approach is often two-staged. A common failure of the operation is shifting of the plantar fat pad of the calcaneus off the central weight-bearing aspect for the leg. If the malleoli are preserved after the first stage, then they aid in stabilizing the position of the fat pad during initial healing. They can be removed during the second stage, when adequate fibrosis and stabilization of the fat pad has occurred.

Calcaneal

Partial or total resection of the calcaneus is often a viable alternative for decubitus ulcers on the posterior heel. Osteomyelitis of the calcaneus can be treated with this approach, in lieu of a below-knee amputation. Studies have shown up to 90% success of healing when the ABI is > 0.45, and the nutritional status was adequate. The achilles tendon may be left to tenodeses to the remaining body of the calcaneus in a partial resection, or to the talus in a complete calcaneal resection. Patients need to be accommodated postoperatively with an appropriate orthosis to minimize complete tarsal subluxation in weight-bearing.

Below-Knee/Above-Knee

Incision placement for a below-the-knee amputation is often selected by the quality of circulation to the leg. Because the major vessels in the leg are supplied from the posterior side, a longer posterior flap is usually utilized in cases of peripheral vascular disease. In other situations where vascularity is not a concern, a fishmouth approach (equal dorsal and plantar flaps) is adequate.

In patients who are bed-ridden, an above-knee amputation is often chosen especially if the patient exhibits flexion contractures at the knee. This will help prevent future breakdown of the stump from pressure necrosis.

Aggressive necrotizing fascitis can necessitate a higher level of amputation. If gas is noticed within the initial foot and ankle radiographs, then higher leg films are necessary to rule out more proximal involvement. When this disease process is present, infection can travel from the foot to the knee or even higher within 24-48 hours. An open

guillotine-type of amputation (straight dorsal-plantar) is warranted with these aggressive infections. Subsequent revision and closure is based on resolution of the infectious process.

POSTOPERATIVE MANAGEMENT

Many patients experience the phenomenon of "phantom pain" after an amputation. This begins immediately postoperative, and is either characterized by symptoms of intense burning or a cramped posture. This is a persistent type of pain which is more severe if pre-amputation pain was present.

A very important part of rehabilitation for any amputation proximal to the trans-metatarsal level is the proper fitting of an orthoses or prosthesis. In this capacity, a well-trained prosthetist is an invaluable part of the diabetic team.

OTHER CONSIDERATIONS

Consistent with diabetic macro-angiopathy, the tibial and peroneal vessels are often involved in diabetic vascular disease. Due to this fact, there is renewed interest in bypass surgery from proximal popliteal/femoral vessels into the foot. Some techniques include the *in situ* Saphenous Vein Graft, Reverse Saphenous Graft, and Synthetic Vein Grafts. These are all performed with microvascular anastomosis techniques.

While almost all chronic diabetic Charcot deformities were previously amputated, there are now attempts to save these limbs. This process has involved extensive research into the disease process, understanding the intricate stages of the deformity, and applying sound surgical principles at the appropriate time. Long-term results are slowly starting to enter the literature, and will provide important documentation on the actual success of these reconstructions.

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