ELECTIVE SURGERY IN THE DIABETIC PATIENT

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INTRODUCTION

Elective surgery for the diabetic patient has often been arbitrarily labeled as risky. But with better understanding of diabetes and careful evaluation of the patient elective surgery can be entertained with confidence. Complete preoperative evaluation and careful perioperative attention can significantly reduce the danger associated with the diabetic patient. This chapter will present some guidelines for preoperative assessment and perioperative management in the diabetic patient.

Elective surgery can be divided into three categories: prophylactic, reconstructive, and traumatic. Prophylactic surgery in the diabetic foot has been proposed by many authors for the prevention or treatment of neurotrophic ulceration (1-4). These ulcers are usually the result of pressure or friction applied by a bony prominence. Unfortunately, the irritating cause of neurotrophic ulcers can not always be effectively controlled with conservative measures (Fig.1). In those cases surgical correction may be warranted. Common prophylactic procedures include excision of ingrown toenails, hammered digit repair, metatarsal osteotomies or even partial amputation (Fig.2).

The diabetic foot may require reconstructive surgery following infection or Charcot joint deformity. The destructive nature of such deformities may leave the foot severely unbalanced leading to a multitude of complications. Previously these patients required amputation to prevent continuing problems with ulceration and infection. Today these feet can be reconstructed with procedures such as pan metatarsal head resection or LisFranc arthrodesis to create a more functional foot (2,5) (Fig. 3).

Diabetics incur trauma which may necessitate surgical reduction. If possible the injury should be stabilized or close reduced until the medical status can be assessed and stabilized. Once the patient has been thoroughly evaluated and medically prepared the surgeon can proceed with the proposed surgery.

CRITERIA

In general, the morbidity and mortality following surgery in the diabetic patient is considerably higher than that in the non diabetic population (6,7). Therefore special preoperative criteria should be satisfied in an effort to reduce possible complications. Of foremost concern the patient should be in good medical control of the diabetes. Patients with erratic glucose levels should not be considered a candidate for elective surgery until better glucose control is obtained. The patient should possess adequate circulation to the area of proposed surgery. The vascular status should be carefully evaluated prior to any surgical procedure. If a neurotrophic ulceration is present at the surgical site the surgeon should be certain that there is no infection present in either the soft tissue or bone.

The most common complication following elective diabetic surgery is infection. The incidence of post surgical infection rises sharply when infection is present within the ulceration (4).

PREOPERATIVE EVALUATION

Preoperatively the diabetic patient should be thoroughly evaluated in the following areas: medical, vascular, neurologic, nutritional, bacteriologic, and radiologic status.

Medical Evaluation

The medical status of the diabetic patient should be assessed by an endocrinologist or an internist with an interest in diabetes. The diabetic should be evaluated for the effectiveness of their glucose control. Glucose levels greater then 200 mg/dl has been shown to impair wound healing (8,9). Uncontrolled glucose levels can cause metabolic disturbances which can lead to a greater incidence of intraoperative and postoperative complications (7).

The diabetic patient should be evaluated for operative risk factors such as cardiac and renal dysfunctions. Cardiac problems include coronary artery disease, congestive heart failure, supra ventricular and ventricular disease (3,7).

Renal dysfunction is a common sequela of diabetes which can lead to many intra operative disturbances (7). After careful evaluation of the patient any abnormalities that provide for increased risk should be addressed.

Fig. 1. A. 66 year old insulin dependent diabetic with chronic neurotrophic ulceration plantar to interphalangeal joint of hallux.

Fig. 1. B. Preoperative x-rays show significant deviation of interphalangeal joint of hallux.

Fig. 1. C. Postoperative x-rays following hallux interphalangeal joint arthrodesis with internal fixation.

Vascular Evaluation

Vascular disease is common sequela of diabetes. Pathologic lesions of lower extremity vessels tend to occur more frequently, at an earlier age and with more complications than in the non diabetic population. Peripheral vascular disease can be 20 times more common in diabetics than non diabetics (10). No surgery should be considered until the vascularity to the surgical site has been evaluated. The vascular examination should include evaluation of the local circulation,in conjunction with non-invasive studies. Invasive vascular examination may be used if further evaluation is necessary.

Local circulation can be evaluated by distal pulses, skin turgor, hair and nail growth, skin temperature, dependent rubor, blanch test, and venous filling time. Distal pulses may also be evaluated with the doppler. Non-invasive testing is an adjunct but can not be a substitute for accurate clinical examination.

Segmental systolic pressures, pulse volume recordings and photoplethysmography are three common non-invasive vascular studies. Segmental systolic pressures are found with a doppler just distal to the level of an occluding cuff. Segmental readings are obtained at the midthigh, midcalf, and ankle. As the occluded cuffs are released the first sound by the doppler is the systolic pressure (Fig. 4). Normal ankle pressures are equal or greater than brachial pressures. Ankle-arm indexes can be charted by this technique. Wagner used these values as predictive for wound healing (11). His findings suggest that with a ratio greater then 0.45, more then 90 percent of operative wounds will heal. Some institutions suggest the minimum index to be 0.75 (4). Diabetics tend to have calcified uncollapsible vessels which will limit the reliability of the study. Inflated values secondary to deceptive high ankle readings are not uncommon in the diabetic patient. The ankle arm index does not take into account the local circulation in the foot.

D

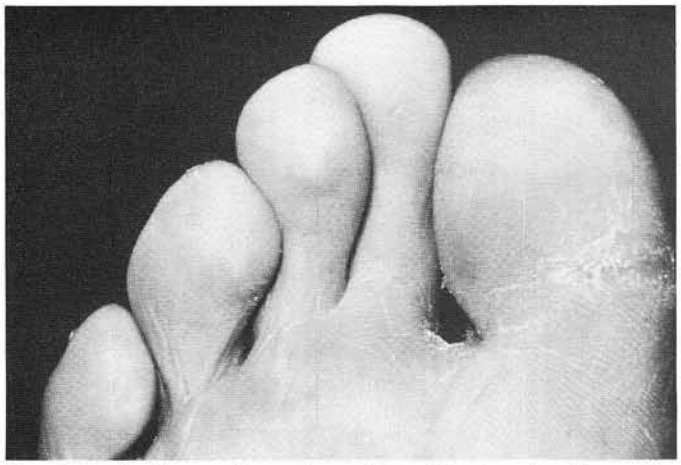


Fig. 1. D, E. Six months postoperative clinical and radiographic appearance showing resolution of neurotrophic ulceration.

E

Fig. 2. Patient is 58 year old insulin dependent diabetic male with significant hammertoe contracture resulting in intermittent ulcerations of digits.

A

Fig. 2. A, B. Clinical and radiographic appearance of digital deformities. Note bowstring appearance of long extensor tendons.

C

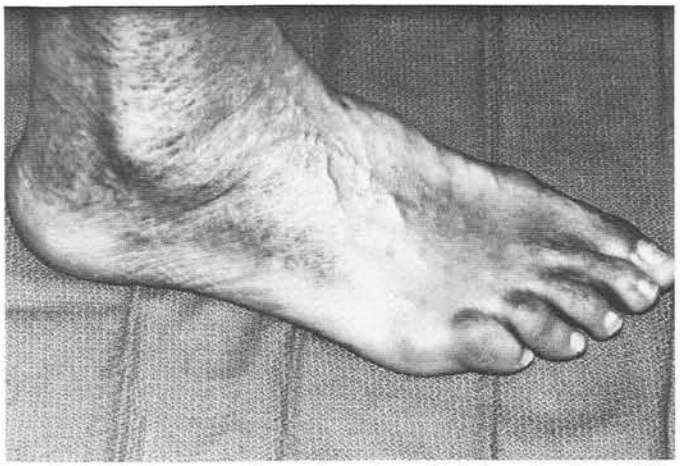


Fig. 2. C, D. Three month postoperative clinical and radiographic appearance.

B

D

Fig. 3. A, B. Patient is 52 year old female insulin dependent diabetic of long standing duration. Clinical and radiographic appearance of foot after Charcot deformity of LisFranc's joint.

Digital systolic pressures can be obtained by photoplethysmography. A photoplethysmograph transducer is placed on the tip of the digit which contains a near infrared light-emitting diode. Changes in the reflected light due to variations in blood content are detected by a phototransducer. A digital cuff which is placed on the base of the digit is then released. The pressure is recorded when blood flow returns to the digit. Holstein and Lassen noted successful healing whenever toe pressures exceeded 30mm Hg (12).

The pulse volume recorder quantitatively measures the arterial waveform during each cardiac cycle. The wave form shape and amplitude are a reflection of vessel occlusion or stenosis (13). The wave form can also determine possible collateralization and local perfusion. The monophasic waveform is usually suggestive of decreased arterial blood flow. Biphasic and triphasic wave pattern is consistent with favorable blood flow. Non-invasive studies tend to be falsely positive in the diabetic patient. If there is any question with the results of these studies an arteriogram should be obtained prior to elective foot surgery.

Several other blood flow studies have been described in the literature such as xenon-133 washout, cutaneous

Fig. 3. C, D. Clinical and radiographic appearance one and one-half years following LisFranc arthrodesis on right foot.

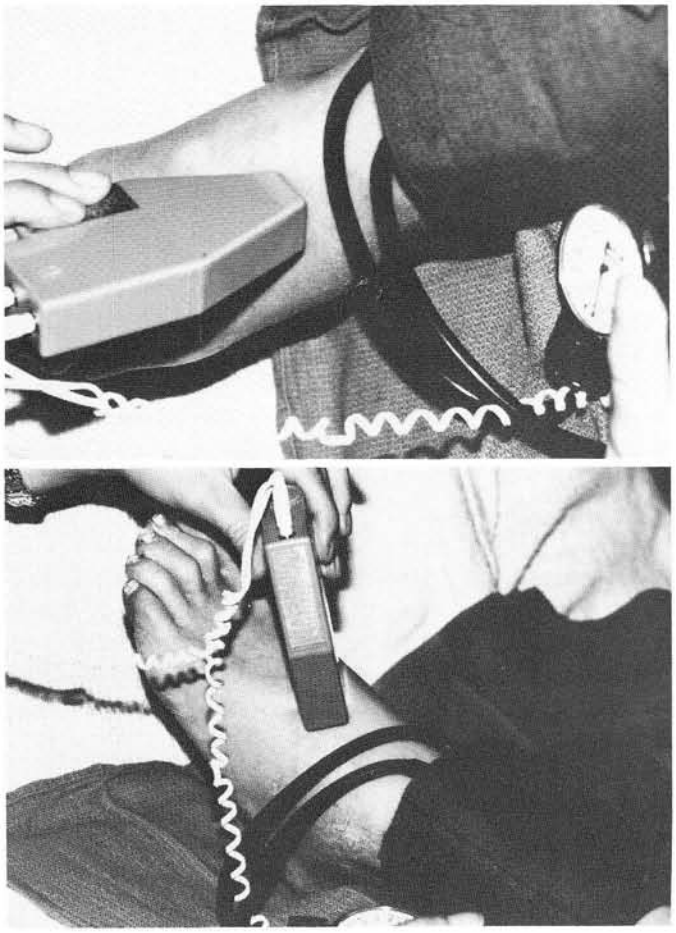


Fig. 4. Ankle-arm indices can be obtained by recording systolic blood pressures of brachial artery and dorsalis pedis artery using Doppler and pneumatic blood pressure cuff.

pressure plethysmography, laser Doppler fluorometry, and segmental transcutaneous oxygen tension. Of these transcutaneous oxygenation has recently become the most popular technique. Transcutaneous oxygen tension reflects a balance between oxygen delivery to the skin and cutaneous oxygen consumption. Oxygen tension of at least 26 mm Hg will result in successful healing (14). Unfortunately oxygen delivery to the cutaneous tissue is not always a good predictor of efficient wound healing. Transcutaneous oxygen tension does not evaluate local tissue metabolism or nutritional status which are major factors in wound healing (15).

Neurologic Evaluation

Since the late 1700s it has become well recognized that neuropathy is a frequent sequela of diabetes (16). Diabetic neuropathy can be divided into three groups, sensory, motor, and autonomic. A symmetric sensory polyneuropathy is the most common of the diabetic neuropathies. The symptoms can vary from the mild stocking glove numbness and dysesthesia to disabling burning, sharp pain, and hypersensitivity. This sensory loss does allows the patient to ignore noxious stimuli that may lead to skin ulcerations and possible infection.

Motor neuropathy usually accompanies the sensory neuropathy to some degree. The motor component causes distal muscle weakness leading to muscular imbalances. The foot then functions abnormally causing digital, forefoot, midfoot and rearfoot deformities to develop. The pedal deformities are then a potential site for irritation and ulceration.

Autonomic neuropathy can present from relatively asymptomatic to disabling. Multiple systems are affected including gastrointestinal, cardiovascular, thermoregulatory, genito-urinary and integumentary. This can lead to significant perioperative challenges and complications. Patients with significant autonomic neuropathy have only a 50 percent five year survival rate (17). Dry skin caused by the autonomic neuropathy can cause wound healing problems leading to dehiscence.

The neurologic examination should attempt to document the extent and severity of the sensory, motor, and autonomic neuropathy. The exam should evaluate vibratory, pain, temperature and proprioception senses. The boundaries of the sensory neuropathy should be clearly delineated and documented. Complete muscle testing and grading should be performed. Autonomic neuropathy should be assessed by the surgeon and the internist. Only after assessment can the risk and gains of a proposed surgical procedure be weighed.

Nutritional Evaluation

The nutritional status of the patient has a direct effect on wound healing. Dickhaut and Delee have demonstrated that wound healing of lower extremity amputations is significantly affected by the nutritional condition of the patient (18). They found that healing may not occur if the serum albumen is below 3.5 gm/dl and the total lymphocyte count is less then 1500 cells per ml. Hypoalbuminemia is detected in patients involved in weight loss diets in an attempt to reduce blood glucose. Albumen is necessary to control colloid osmotic pressure during wound healing as well as to transport essential amino acids and ions to expedite wound healing. Preoperative evaluation of serum albumen and total lymphocytes may be helpful in predicting the nutritional status of the patient and potential problems with wound healing.

Bacteriologic Evaluation

Current or previously ulcerated areas should be thoroughly evaluated for the possibility of infection. Before any elective surgery is contemplated a complete

ulcer history must be obtained. The duration of ulceration and the infection history are needed to predict the relative bacteriologic state of the area at the present time. Elective surgical procedures have a higher incidence of infection when previous infection is documented (4). Aerobic and anaerobic cultures should be obtained from any current ulceration. Cultures from superficial ulcers are not too helpful since colonization by normal flora is common. Quantitative wound analysis is helpful in determining the bacterial count. Counts of greater then 10^6 are consistent with wound infection. Some authors believe that if tendon, bone, joint or ligament are exposed and there has been infection present over the last year ablative procedures should be performed (4). Prior to elective foot surgery the wound should be cleared of infection and the ulcer should be healed to increase the chance of good results (Fig. 5). In cases where this is not possible the patient should receive appropriate preoperative antibiotics.

Radiologic Evaluation

Radiologic evaluation is an important preoperative study. Routine films should be surveyed to determine the osseous deformity causing the irritation leading to breakdown of the skin. Lesion markers may be placed over the lesion to assist in this process. If there is suspicion of osteomyelitis, especially in an area of chronic ulceration, a bone scan should be performed. Technetium-99 and gallium-67 citrate are helpful imaging techniques to determine if osteomyelitis or cellulitis is present. Technetium-99 can be useful in determining the extent that bone is affected and amount of resection that may be necessary to eradicate the infection. Careful radiologic assessment should be performed on all diabetic patients prior to elective foot surgery.

PERIOPERATIVE MANAGEMENT

Diabetics have special needs during the perioperative period. Stress initiated by the surgical procedure or infection is associated with elevated blood glucose levels and increases the insulin requirement. As stated previously well controlled blood glucose levels are of prime importance. Good control places the patient in a favorable metabolic state for surgery. An isolated blood glucose level during preoperative testing is not indicative of the patient's current metabolic state.

The patient should have good glucose control for as far prior to the surgical procedure as possible. This can be monitored by the patient by daily use of finger sticks with a glucose reflectance device (Accucheck) or chemical oxidation strips. Blood glucose levels in the range of 70 to 130 mg per dl in the fasting state and 150 to 190 mg per dl post prandial are considered optimum (19). This level will normally be elevated following the stress of surgery.

The measurement of Hemoglobin A1c(HbA1c) may be of assistance in determining the metabolic state of the patient. The HbA1c will reflect the overall glucose control from the past three months. If the HbA1c is normal (3.4-6.1 percent) the patient is in a favorable metabolic state. An HbA1c value of 6.0 percent correlates to a 2 month glucose level average of 100 mg/dl. Proportionally a patient with a 2 month average blood glucose of 220 mg/dl will have a 9 percent HbA1c (20). Surgery should be delayed in patients with a significant elevation in the HbA1c until glucose can be controlled for 1 to 3 weeks. The goal is to have HgA1c below 7.5 percent (150 mg/dl) in the preoperative diabetic patient.

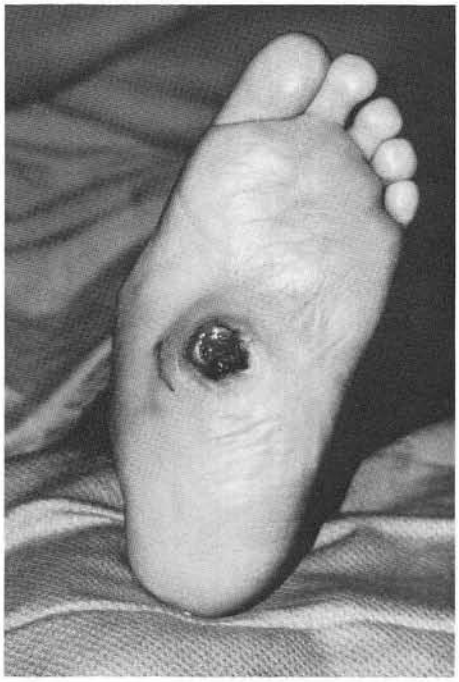
Management of blood glucose levels on the day of surgery can be a challenge in any diabetic patient. In addition to the stress of surgery certain anesthetic agents may cause significant elevations in blood glucose. The type of diabetes will determine the mechanism to safely maintain the glucose levels.

The type 1 (insulin dependent) diabetes mellitus has an absolute deficiency of insulin and requires insulin to maintain life. The type 2 (non insulin dependent) does produce some insulin but has inadequate amounts to prevent hyperglycemia. These patients may be controlled by diet, oral hypoglycemic agents or a combination of both. However, there are some type 2 diabetics that may require insulin to remain normoglycemic and are termed insulin requiring. The type of diabetes should be identified prior to surgery because each patient is managed differently during the perioperative period.

Type 1 and type 2 insulin requiring diabetics can be regulated in the same manner. These patients should be scheduled as early as possible in the morning. A fasting blood glucose should be obtained on the morning of surgery. If the glucose level is less than or equal to 250 mg/dl, a solution of dextrose 5 percent in water should be infused at approximately 100 cc per hour. The patient would then receive one-half to two-thirds of their usual intermediate acting (NPH/Lente) insulin dosage according to the method advocated by Podolsky (21). Glucose levels are monitored by finger stick every 3-4 hours if the procedure is greater than two hours in duration.

In procedures less then two hours the glucose levels are obtained immediately postoperatively in the recovery room. Patients having local anesthesia who are awake and alert and can eat may receive the remainder of the intermediate insulin. If these patients also require regular insulin in the morning they may take it at this time. In-

Fig. 5. Patient is 52 year old female insulin dependent diabetic with Charcot deformity of LisFranc's joint and chronic plantar ulceration. Since ulceration had been intermittently infected it was decided to excise and remodel plantar skin and allow for healing prior to surgical repair of Charcot joint.



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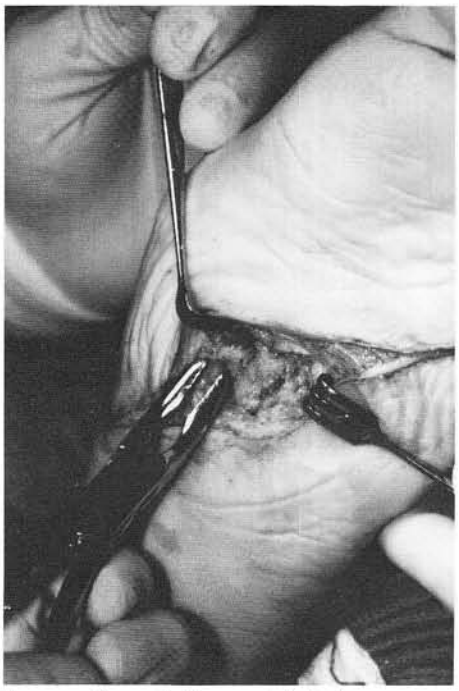
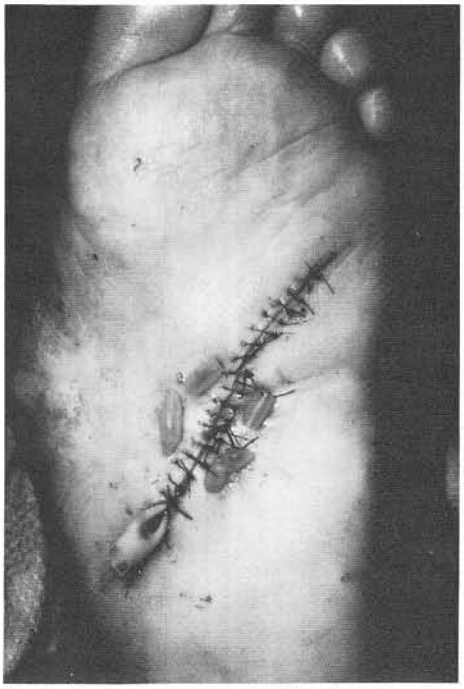


C

Fig. 5. C. Intraoperative resection of ulcer and irritating osseous structures.

B

Fig. 5. A, B. Preoperative clinical and radiographic appearance of ulcerated area.



D

Fig. 5. D, E. Postoperative clinical and radiographic appearance of operative site. Wound was allowed to remain open until negative cultures were obtained.

E

sulin must be given prior to eating if blood glucose levels are greater the 100 mg/dl. The intravenous solution may be discontinued when normal eating and drinking has resumed.

Those patients who do not resume intake for more than 2 hours following the procedure must be maintained on intravenous solutions of dextrose 5 percent. Blood glucose levels should be obtained at least every six hours and regular insulin should be given to control glucose by the formula:

$$\text{Units of Regular Insulin} = \frac{\textit{Blood Glucose-100}}{30}$$

The goal of therapy is to maintain the diabetic in a steady state and avoid extremes of hyperglycemia or hypoglycemia (7).

Patients who have poor control of their diabetes should be maintained on dextrose and insulin infusions. Controversy exists on the different methods of delivering the insulin infusions (7,22). Potassium can be added to this solution to increase the glucose utilization by the cell. Patients requiring more aggressive control of their blood glucose levels should be place on a protocol that the internist and anesthesiologist are comfortable administering.

Patients who have not been insulin requiring prior to surgery can be managed in one of two ways. The patient who is controlled by diet and oral hypoglycemic agents can have their medication held the morning of surgery if the procedure is less than two hours and under local anesthesia. Patients on longer acting oral hypoglycemic agents such as chlorpropamide (Diabinase) may be required to cease medication the day prior to surgery (21). The morning of surgery an infusion of 5 percent dextrose in water at 100 cc/hour is begun if the blood glucose level is less then 250 mg/dl. Following surgery the patient may eat and take their medication if the blood glucose is greater then 100 mg/dl. Patients not well controlled by diet and oral hypoglycemic agents may be placed on regular insulin during the surgical period. The insulin dose can be adjusted as per the above formula.

Perioperative management of the diabetic patient undergoing elective surgery must be tailored to meet the individual needs of the patient. The approach will vary depending on the control of blood glucose levels and whether the patient is insulin requiring. Proper perioperative management is essential in reducing the morbidity and mortality associated with diabetic surgery.

COMPLICATIONS

The most devastating complication following elective foot surgery in the diabetic patient is infection. One study showed a complication rate of 31.2% following prophylactic surgery even after a thorough evaluation was performed (4). The high complication rate was related to areas with weight-bearing ulcerations which were present for greater then one year duration. Soft tissue infections following surgery in the diabetic patient have a tendency to progress to osteomyelitis (4). However, if certain risk factors are identified early a higher success rate can be anticipated. Clinical experience has shown that when diabetic patients are handled in a proper manner the infection rate approaches that of the non-diabetic population.

Delayed healing is a common complication in the diabetic patient. Wound complications occur in from 5-10 percent of the patients undergoing surgery (23). Delayed healing is a multifactorial problem stemming from improper control of blood glucose levels. It has been shown that appropriate maintenance of diabetes results in proper wound healing. Therefore, patients undergoing elective surgery should have good control of their diabetes to reduce potential problems with wound healing. Vitamins and zinc have been linked with improved wound healing in the deficient patient. If the nutritional status of the patient is in question, vitamin and zinc supplementation should be initiated well before the surgical procedure is attempted. When there is a delay in healing, improper control of diabetes or infection should be suspected.

SUMMARY

Elective surgery in the diabetic patient is more precarious than in the non diabetic population. Obtaining a thorough preoperative evaluation and establishing careful perioperative control is essential to successful results. The cornerstone of preoperative preparation is maintenance of blood glucose control. Perioperative and postoperative complications can be significantly reduced when the patient is adequately controlled. Diabetics often require surgery in order to prevent future devastating complications. The opportunity to safely perform prophylactic and reconstructive procedures has reduced the necessity for primary amputation.

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