Prosthetic Implications With The Diabetic Patient

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INTRODUCTION

Diabetes mellitus, though a common disorder in man, is seldom understood in its surgical as well as prosthetic implications. In this paper there will be presented a prosthetic view of the impact of the disease. Various surgical as well as nonsurgical procedures will be discussed and this will be followed by their respective prosthetic appliances and complications.

Diabetes mellitus affects five percent of the world's population. An additional twenty five percent are carriers of the disease. It is, in addition, the third leading cause of blindness and the seventh leading cause of death.

There are three main types of diabetes and their names relate to the period of onset. Growth-onset or juvenile type is charaterized by its development in childhood, but may appear anytime. Onset is abrupt and leaves its victim very dependent on insulin to survive. This type of diabetes is usually difficult to control and is referred to sometimes as "brittle." The second type of diabetes is mature-onset and usually develops, as the name implies, later in life. It frequently occurs after the age of forty and affects more women than men. The patient still produces insulin, but there is either less produced or the need for insulin becomes too great. The patient is not ketosis prone and is usually very stable. There may or may not be a need to take insulin and most cases are well controlled by a diet low in carbohydrates and sugars. The last major classification is the nonhereditary diabetic. This patient is diabetic due to a decrease or absence of insulin production because of damaged or obliterated cells that produce the insulin. It may be due to disease or trauma. Diseases affecting the thyroid, adrenal, or pituitary glands may also effect the production of insulin and indirectly cause diabetes.

Complications of the disease are numerous, and include: hyperglycemia, insulin allergy, or resistance, insulin edema, susceptibility to infection, diabetic retinopathy (for which there is no prevention), vascular complications, and neuropathy. The last complication listed is of major concern to the prosthetist and needs further discussion.

The neuropathic diabetic usually exhibits one or more of the following disorders: parasthesias, pain, weakness, paralysis, and there is some evidence of autonomic pathology.[10,1] The evidence shows that the autonomic disorders may cause vasoconstriction and decreased blood flow to the extremities. If the blood sugar levels are maintained at or near normal levels, any neuron damage or axonal degeneration can be diverted, but once the process has begun, there is no removal of the damage done.[1] For there to be any correction or halting of the disease process, there must first be a diagnosis.

DIAGNOSIS

The diagnosis of diabetes mellitus is achieved by evaluating the clinical signs. The most easily recognized is the high blood sugar concentration and glycosuria, sugar in the urine. This along with the patient's complaints of constant thirst, hunger and polyuria complete the clinical picture. Breakdown of the body's fat stores produces a high level of circulating ketone bodies. Excretion of ketones in the urine leads to an unfavorable acid-base ratio and further dehydration. (Fig. 1) From this background information it is now possible to look at some of the more intricate workings of the pancreas and its product, insulin.

ETIOLOGY

The pancreas is a large lobulated gland resembling the salivary glands in structure. It is situated in the abdominal cavity just distal to the stomach and runs the length of the large intestine. The pancreas is the sit of both exocrine and endocrine functions. Pancreatic juice, excreted by the Acinar cells, is inactive until mixed in the

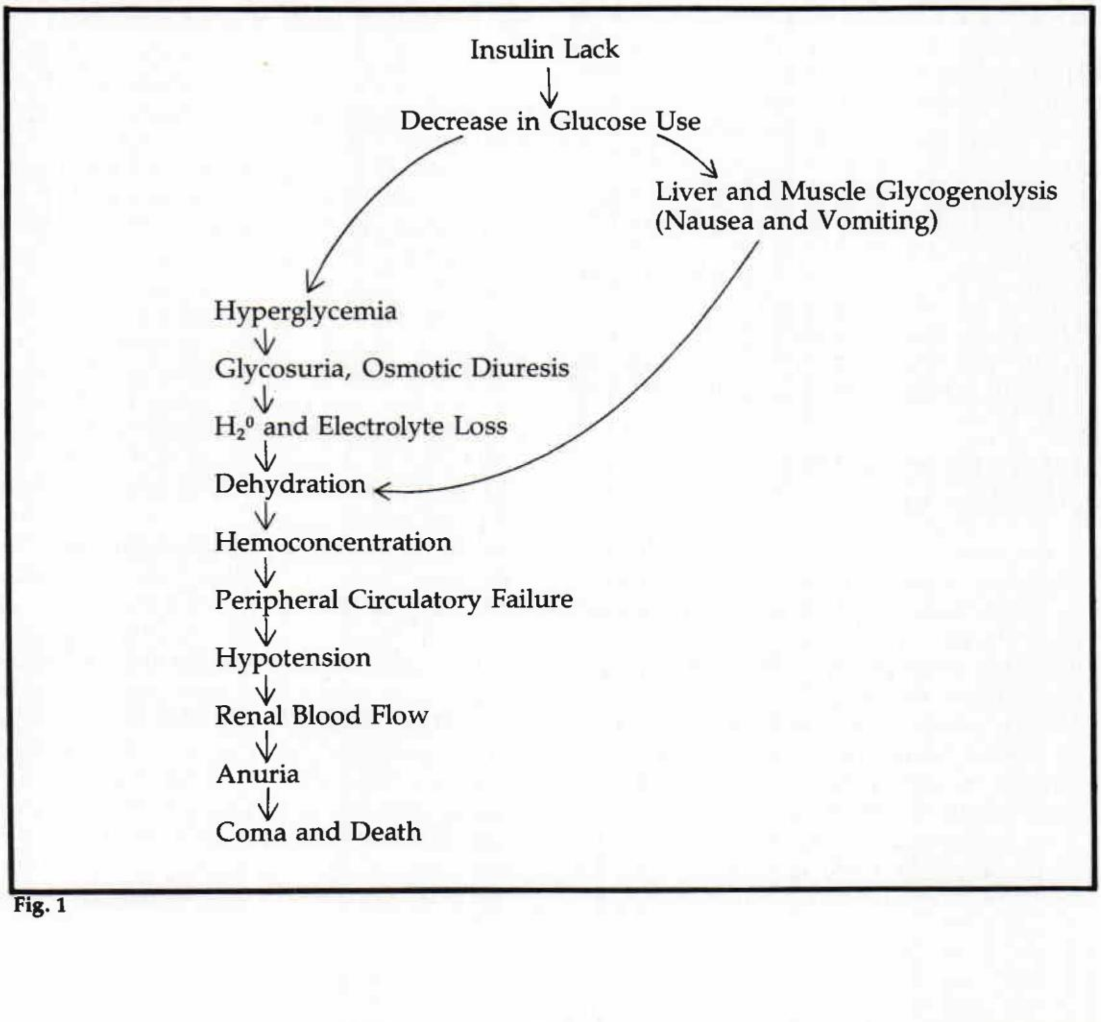

Fig. 1

digestive system and is the exocrine half of the products derived from the pancreas. The endocrine part is composed of two hormones, glucagon and insulin. Glucagon, an antagonist of insulin, is produced in the alpha cells of the pancreas, whereas insulin is produced in the beta cells. Both alpha and beta cells are located within the Islets of Langerhans. Tumor, trauma, or other diseases of the pancreas could lead to an insulin deficient state in the patient. This would be classified under the nonhereditary type of diabetes as mentioned previously.

Insulin, a fifty one amino acid protein was isolated in 1921 by doctors Best and Banting. By 1922 the hormone was available to the diabetic and allowed the well controlled patient a seventy five percent to full normal life span. It is secreted by the beta cells of the pancreas in response to a high glucose concentration in the circulating blood stream. Insulin acts on the blood sugar level by traveling through the bloodstream to its target cells, muscle and adipose. Here it attaches to a receptor structure on the plasma membrane and facilitates entry of the glucose into the cell. Insulin indirectly promotes the anabolic processes, glycogen, fatty acid, and protein synthesis, within the target cells. Glucagon and epinephrine, which act as antagonists to insulin by signalling that the blood sugar is low, support catabolic processes such as gloconeogenesis and gycogen breakdown.

DIABETIC FOOT PROBLEMS

The most conservative treatment for the diabetic with foot problems, such as ulcers or other pressure problems, is the use of special shoes. These shoes are designed to make the neuropathic diabetic bear weight properly on the sole of his foot. It is the diabetic's lack of sensitivity in the plantar surface of the foot that prevents him from bearing weight properly and eventually leads to ulceration and/or gangrene.

According to one study,[6] patients presenting a foot with no sensation and pressure sores on the sole of their feet show absent sural nerve action potentials in ninety five percent of the cases. Inexcitability of small foot muscles secondary to neuropathy leads to foot deformity and poor weight distribution with resultant pressure necrosis of the anesthetic skin. When damage to the foot is more extensive and can not be treated conservatively, an amputation with or without reconstructive vascular surgery may be indicated. These cases will be treated in order of severity.

AMPUTATION SURGERY

The diabetic in need of surgery undergoes special surgical risks due to the early arteriosclerotic state, vascular and neuropathic complications, low resistance to infection and slow healing rate. Surgical, as well as anesthetic, stress on the system may lead to hyperglycemia. The diabetic patient is also prone to the development of cholecystitis, cholelithiasis, and cancer of the pancreas. Assuming that the neuropathy is the major cause for the need for surgery, the coexistence of arterial disease could cause the development and persistence of an ulceration, and, in this way, the two processes are synergistic in their action.[3] The longer the two processes are allowed to operate unchecked, the more severe the damage. Twenty five to fifty percent of patients receiving amputations are diabetics with peripheral vascular disease.[14] The use of a Doppler ultrasound device or mercury in a silastic blood pressure cuff is effective in determining the level of amputation to be performed.

The least severe of the amputations for localized gangrene of the toes is amputation of the affected toe without use of a prosthesis. In a study of fifty three patients with vascular complications, more than fifty percent of the patients were diabetic. It was determined that if there was a palpable pedal pulse or functioning vascular reconstruction that there was a good chance for successful healing following the amputation. However, by a median time of thirteen months, a major amputation was necessary for fifty percent of the patients. By three and one half years almost seventy five percent came to a major amputation. It was concluded that the long range outlook for the toe amputee was poor and would remain so until a more effective method of distal vascular reconstruction could be found.[11]

Transmetatarsal amputation is the next level proximally. The theory behind this amputation is that, with the diabetic patient, arteriosclerosis affects small vessels more than it does large vessels, and that the gangrene will respond more favorably to this conservative level. This site, as with the toe amputation, allows the amputee to walk without the use of a prosthesis and must be considered one factor in selecting this level of amputation. Localized gangrene of the toes along with controlled infection and good collateral circulation are other reasons for the selection of this site. The study used in this paper reported a range of success from 44 to 83 percent. Of the 433 patients studied, five died within days post-operatively, 69 died within two years and, of 336 survivors, only 63 percent had a well healed amputation. The failures in healing related to factors including: length of time the patient had been diabetic, and the level of palpable pulse. Fifty percent of the patients without a pulse palpable distal to the femoral artery failed to heal. Only four percent, however, with a palpable pedal pulse failed to heal.

The preceeding amputations are all considered conservative. The major surgical amputations should now be considered. Until 1942 the mortality rate for major limb amputations approached that recorded for open heart surgery, about 44 percent. Fifty-one to 66 percent mortality rates were not uncommon in those cases where spreading gangrene or cellulitis were present.[16] Gangrene was almost always the major cause of amputations amongst diabetics. Post operative deaths among diabetics were more than twice those of non-diabetics. Midthigh amputations had a two times higher mortality rate than that for midleg amputations. Sepsis was the major mortality factor in postoperative diabetics. Mortality rates were lowered only when surgical procedures were modified to adapt to the very infection prone diabetic patient. Adequate control of diabetes must be maintained, insulin reactions must be avoided, and procrastination must not occur. If sepsis is controlled, the diabetic patient need not have a lower success rate than that for the nondiabetic.

The Symes amputation affords a lower level of amputation as well as providing the patient with both a better psychological outlook and an increased energy efficient gait over amputations more proximal. With the use of the Doppler ultrasound flow meter, the circulation can be mapped out and a resulting ninety three to ninety eight percent success rate has been achieved by William Wagner, M.D. at Rancho Los Amigos Hospital. The use of a two stage amputation and a drainage pump to remove pooled blood and fluids from the wound also increase his success rate.

The below-the-knee amputation is performed more often for the diabetic vascular patient than for the ischemic nondiabetic. The reasons for this are that the area of the midleg is very well vascularized and is much more viable in the diabetic vascular patient than in the nondiabetic patient. This is demonstrated by a much higher success rate with the diabetic as opposed to the nondiabetic. The below-knee level is selected by the surgeon if he believes the leg will heal, the patient has a good chance of walking again, and the proximal two thirds of the skin are viable. A good popliteal pulse is associated with a high success rate, and in one study, 77 percent of the diabetic patients received and walked with a prosthesis.[2] All the diabetic deaths postoperatively showed cardiovascular or renal complications with an average survival time of 30 months.

The above-the-knee amputation is one of the most radical amputations performed for diabetes. The reasons for using this level are varied and include: failed lower level amputation, rapidly spreading gangrene, procrastinating on either the part of the surgeon or the patient. With the above-the-knee amputation there was recorded in one study a 76 percent primary healing rate and a nine percent morbidity rate. Seventy five percent of these amputees received and walked with the ischial weight bearing prosthesis with or without some soft tissue bearing. Neither tourniquet nor antibiotics were used either during surgery or postoperatively. This appeared to have no significance in the success of failure rates. Four failures in diabetic patients were resolved with a hip disarticulation amputation. Diabetics showed a 53 percent primary healing rate and 18 percent morbidity. Ischemic lesion of the remainig limb developed in 66 of 283 patients, usually due to the bilaterality of the disease. Many of these had walked with a prosthesis and all 66 required an amputation of the second limb.

POSTSURGICAL MANAGEMENT

Postsurgically, wound healing depends on many factors including: the restoration of local circulation, formation and deposition of collagen, which involved protein as a building block. Both of these processes are diminished in the diabetic due to the patients early arteriosclerosis and their decreased protein production. Insulin appears to have an effect on the collagen phase of healing, in that the well controlled diabetic produces much more protein than the uncontrolled or poorly controlled diabetic. It is therefore most important to have the diabetic well under control both prior to and after surgery. The protein requirement for normal healing is one gram per kilogram body weight.[18] Though this is a small ratio, to the diabetic who is poorly controlled it is virtually unobtainable. Hemoglobin content of the blood needs to be maintained at or near 12 grams per 100 milliliters of blood for proper healing to be initiated.[18] Respiratory, nervous system, musculoskeletal system, or mental disease also act to retard the healing rate. The healing of the residual limb must be already in process in order for prosthetic intervention to be successful. Preprosthetic care is essential and, if undertaken correctly, can assure the patient of an optimal chance of ambulating again.

It is most important that care be taken to prevent contractures. In the above-knee amputee, hip flexion, abduction, or external rotation contractures are the most common. Development of these are enhanced by fibrous tissue development commonly found in the ischemic. Contractures may also be preoperative in nature. These may be the result of conservative treatment to unload the affected limb in the surgeon's desire to postpone the amputation (eg. sitting in a wheelchair to relieve the site of ulceration on the plantar surface of the foot). Contractures require the skills of a therapist and may improve somewhat with the use of a prosthesis.[9]

SKIN PRESSURE PROBLEMS

Mild chronic trauma may be tolerated by an insensitive diabetic without concern until actual skin breakdown occurs. High shear forces or excess pressure, positive or negative, are bad for the amputee and especially so for the diabetic. Coupled with decreased subcutaneous tissue, these forces may result in a major problem for the amputee. Body positioning, local tissue environment, and activity levels may also contribute to the problem and should be distinguished from breakdown related to direct pressure from a poorly contoured socket.

Diabetics usually remain active and ulceration usually comes from repetitive loading of short duration and of skin pressure levels from 30 to 300 pounds per square inch or more.[15] A very tight socket may lead to continuous pressure problems and will create edema as will a popliteal pressure in the below-knee amputee of 25 millimeters mercury. The insensitive diabetic patient at the start of the day can tolerate loading as can a normal person, but when tissues reach their threshold, the insensitive patient has no way of knowing and does not change his gait to reduce the loading. There is a need to make the patient aware when threshold pressures have been reached, and pressure transducers are under research to find an answer to this problem. Tests have also been done to show the effects of pressure on sites of infection as might occur over an ulcer in a diabetic patient.[15] Results showed that an infection site was more likely to remain localized if pressure was absent that it was if pressure was applied. Pressure over an infected site was also more often the cause of ulceration or abcess than was either pressure or infection alone. Finally, severe pressure applied to an area before infection resulted in pus formation whereas pressure applied after infection did not result in pus formation. It was concluded from these tests that pressure applied continuously over the freshly infected site eliminating access of blood and leukocytes, white blood cells, meant delayed localization and inflammation. A total contact cast or socket with correctly applied tension was actually found to be beneficial for diabetic ulceration healing in another survey and demonstrates that there is a boundary.[15]

PROSTHETIC TREATMENT

The prosthetic implications for the major amputation levels and complications to prosthetic fitting can now be discussed. At the Symes level, there are usually no contrary implications to a prosthesis. (This site is only chosen if the physician believes the patient is going to walk again, as the below knee level is more functional if the patient will always be wheelchair bound.) A permanent prosthesis is usually prescribed of either the bladder or Canadian Symes variety.

The considerations are similar with the below-knee amputee. The knee joint is maintained for a more energy efficient gait. The patient is also expected to walk with a prosthesis in most of these cases. A temporary, or preparatory, prosthesis may be provided for many reasons; the patient may desire to walk as soon as possible or the second limb may be threatened and the physician desires to have the patient gain some prosthetic experience before the loss of the second limb. In these cases, a rigid dressing may be fit immediately after surgery. The doctor may desire to have the patient in an ischial weight bearing prosthesis if healing has not occurred after two months and there is no thought of reamputation at a more proximal level. The residual limb also may not have atrophied enough for a definitive prosthesis to be fitted. In these cased the fitting is not as urgent as the previous situations. In all these cases though, some fit and alignment is sacrificed for early ambulation. A definitive prosthesis may or may not be considered depending on a number of factors including the patient's ability to manage himself on the prosthesis.

With the above-knee amputee, a temporary prosthesis is often encouraged but there are more problems at this level than at more distal levels. It is basically a non-energy efficient gait and, if the patient is debilitated in any way, could be an even greater hinderance to mobility than crutch walking. In no case, and at no level was ischemia in the second limb considered a contraindication to prescription of a prosthesis.

In the geriatric patient, of which many are diabetic, changes in functional ability were more due to increased disease processes than prosthesis use.[8] Eighty-eight percent of patients in one study were successful prosthesis wearers with 15½ percent needing a second amputation within six to 31 months following the first amputation. Sixty six percent of the patients requiring a second amputation were diabetics and functional loss was determined not to be due to prosthesis wearing. In fact a prosthesis was thought to be beneficial in a majority of the cases, even when vascular changes were noted in the second leg. Special care must be taken with the geriatric diabetic, as he may develop cardiovascular problems due to his disease process and an increased energy load on his system (eg. above-knee or hip disarticulation prostheses) may prohibit use of or decreased use of a prosthesis for mobility.

CONCLUSION

A look at the fate of the second limb in the diabetic is in order. The outlook is not positive in any respect and must present the prosthetist with a challenge to provide the diabetic amputee with the best possible service.

Of 67 diabetics studied, only twenty survived.[19] Only five of the 47 deceased had lost their second limb and all of these five died within five years of their second amputation. Within two years after their first amputation, 49 percent were deceased and within five years, 67 percent. The authors stated, "Arteriosclerosis complications will probably kill the patient before he loses his second leg."

SUMMARY

This report presented a look at the types, causes, and complications associated with diabetes as well as the prosthetic outlook for patients following amputation. While most of the material is not new, it does focus the subject and provide background that should be considered by the prosthestist who is confronted with the end result of the disease on a daily basis. An understanding of the disease process is encouraged and hopefully will assist in providing a better service to the patient.

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