

Management of Diabetes Mellitus in Surgical Patients

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INTRODUCTION

Diabetes mellitus is a very common disease afflicting two percent of the general population. Therefore a practicing surgeon will inevitably, sooner or later, encounter one of these patients undergoing surgical procedures or having an infected wound treated. Extensive experience of surgeons of previous generations taught them not to take diabetic patients lightly because of the increased incidence of both the intra-operative and post-operative complications which may occur in these patients. In fact the fledgling new generation of surgeons are too cautious in dealing with diabetic patients, which results occasionally in inadequate treatment. In dealing with the diabetic patient it is not the control of the blood sugar per se that is the most important thing. It is also the thorough knowledge of the nature and possible complications which may occur among the diabetic patient and the exercise in prevention of these complications that are of the utmost importance. With modern anesthesia and antibiotics the diabetic patient can take on even the most difficult operation almost as well as the nondiabetic patient, if certain precautions for the diabetic patient is exercised. Most surgeons are concerned about the preparation of the diabetic patient for surgery and the best way to control blood sugar during intra-operative periods. There are many articles concerning these points both in review articles^{1,2} and in standard textbooks.^{3,4} This article has tried to select the method which the author found most practical and most effective for discussion. Most diabetologists now agree on the use of intermediate acting insulin such as NPH and lente insulin for the preparation of diabetic patients for surgery. The use of only short acting insulin (regular insulin) for urine coverage, a method used by many surgeons in the old days, is no longer acceptable as smooth control of the

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blood sugar cannot be achieved with such a method, especially in the insulin dependent diabetic patients. In addition to the preparation of diabetic patients for surgery this article will also attempt to answer many common questions which surgeons usually ask about diabetic patients and will also discuss the principle of treatment of diabetic wounds.

PREPARATION OF DIABETIC PATIENTS FOR ELECTIVE SURGERY

Diabetic patients under proper care should tolerate any elective surgery just as well as a non-diabetic patient. However, a careful evaluation of the diabetic status should be carried out prior to surgery. Therefore a diabetic patient undergoing elective surgery should be admitted to the hospital at least 2 days before operation.

EVALUATION OF THE PATIENTS

The evaluation should include

1. *Evaluation of blood sugar at various times of the day* : The most appropriate times are fasting blood sugar, prelunch or 11 AM blood sugar, 3 PM blood sugar and 9 PM blood sugar. Three PM is the time of the peak action of the intermediate acting insulin and the blood sugar at this time would be of great interest in these patients who receive such insulin. Nine PM blood sugar may be highest in some patients whose blood sugar rises up and down with dietary intake. These patients have more elevation of blood sugar with each meal resulting in the highest

blood sugar after dinner. The pattern of blood sugar throughout the day may tell the character of diabetics whether it is a stable or a brittle type. A patient with good diabetic control should have a blood sugar below 200 throughout the day and fasting blood sugar should be 130 or less. For practical purposes only fasting blood sugar and 3 PM blood sugar are usually taken, if they are satisfactory it is assumed that blood sugar is satisfactory throughout the day.

2. *Evaluation of vascular status.* This includes the cardiac status. Diabetics tends to have coronary artery disease at a younger age than non-diabetics. Electrocardiogram should be done even in young diabetic patients. Examination of the eyeground may reveal microvascular disease with microaneurysm, exudate and hemorrhage. If diabetic retinopathy is present the patient will most likely also have microvascular disease of the kidney and proteinuria will probably also be present. If surgery is to be done in the extremities, vascular status of the extremities must be evaluated carefully. Diabetes mellitus is a microvascular disease and ischemia of the tissue supplied by small arteries may be present without any abnormalities of the medium size vessels. For example a diabetic patient may have evidence of skin ischemia with smooth, shiny skin with hair dropping off the dorsum of the feet and yet dorsalis pedis and posterior tibial pulses are still strong. This skin ischemia is the cause of difficult wound healing in diabetic patients.

3. *Evaluation of bladder problems :* Diabetic patients very frequently have urinary tract infection. One frequent cause of urinary tract infection in diabetic patients is a large residual urine due to a neurogenic bladder. Urine examination in diabetics may reveal many things. Proteinuria most commonly indicates microvascular disease of the kidney. Fixed specific gravity of 1.010 and white blood cells in the urine may indicate chronic pyelonephritis. If only white blood cells are found it may indicate a bladder infection only and the residual urine should be checked for the possibility of a neurogenic bladder. Creatinine should be checked for evaluation of the status of the kidney.

4. *Chest roentgenography.* Should be checked for old or new evidence of tuberculosis since diabetics are compromised hosts and may contract tuberculosis more frequently than non-diabetics.

RESPONSE OF DIABETIC PATIENTS TO SURGERY

Surgery is a metabolic stress situation for diabetic patients both mentally and physically. During this stress situation glucocorticoid, growth hormone, catecholamines and glucagon secretion are increased. These hormones are all diabetogenic. In non-diabetic patients, insulin secretion also increases to counteract

the increased secretion of these hormones. Therefore hyperglycemia is not apparent in these patients. Diabetic patients however have limited capacity for insulin secretion and therefore hyperglycemia or even ketoacidosis may occur. This increased insulin requirement must be kept in mind in treating diabetic patients.

The following guidelines are not intended to keep diabetic patients euglycemic throughout the surgical period; but will keep the level of blood sugar within a reasonable range, calling for only small supplements of regular insulin during the postoperative period. Individual variations occur depending on the types of surgery, individual responses to stress and how long the patients have to be kept without oral intake after the operation. Therefore abdominal surgery would call for a different regime of treatments from orthopedic or neurosurgery during the postoperative period. The aim is to keep blood sugar in the range of 100-200 mg% throughout surgery and after the operation.

TREATMENT OF PATIENTS WHO HAVE BEEN MAINTAINED ON INSULIN

Normally maintenance insulin therapy for diabetic patients would be in the form of intermediate acting insulins (NPH, lente, Rapitard or Monotard). The dosage of insulin that can keep the blood sugar at a good level will be used as a guide for the preparation of diabetic patients for surgery.

Treatment on the day of the operation : if surgery is to be performed in the morning at before the lunch hour, the patient must be kept without oral intake until the time of operation. Infusion of 5% dextrose in water may be given at the rate of 125 milliliters per hour in place of breakfast. Half of the normal maintenance dosage of intermediate acting insulin may then be given subcutaneously at the time of the start of the infusion. Another half dosage of the intermediate acting insulin should be given immediately after the patient returns to the recovery room. Blood sugar determinations should be done in the midafternoon and at 9 or 10 PM to evaluate the diabetic status. If the blood sugar is higher than 250 mg% 5-10 units of regular insulin supplement should be given subcutaneously.

Example of the order for a diabetic patient, having surgery in the morning whose blood sugar has been maintained at a good level with 50 units of NPH insulin should appear like this.

1. NPO after midnight
2. At 7 AM start 1 L D₅W to run at 125 ml/h
3. At 7 AM give 25 units NPH insulin S.C.
4. Give 25 units of NPH insulin immediately postoperative.
5. Blood sugar at 3 PM and 9 PM

With this regimen of preparation a smooth con-

trol of blood sugar should be obtained. Although the patient may receive no food all day and still receive a full dosage of insulin, no hypoglycemia should occur because of the intravenous dextrose fluid and the hepatic glucose release by diabetogenic hormones which the patients secrete on the day of the operation.

The old method of frequent urinary determinations of sugar and supplementation with regular insulin according to the outcome urinary sugar (sliding scale urine coverage) is not needed if the patients are prepared with the method of splitting intermediate acting insulin. However in areas where blood sugar results cannot be obtained within 1 or 2 hours, urinary sugar determination with knowledge of the renal threshold for sugar in that particular patient (obtained during the evaluation period) may be used as a guide of intermittent regular insulin supplements.

If the operation is to take place at a different time, for example in the evening, and calls for no oral intake at lunch time, intravenous fluid of 5% dextrose may be started at noon and the half dose of intermediate acting insulin may be given in the morning.

Treatment of the day (s) following operation : The treatments on the day after operation depends on the amount of food the patient can take orally. If the operation is extraabdominal and the patient can eat normally, the normal dosage of insulin may be resumed. If the operative procedure is such that there can be no oral food intake the patient should be maintained on intravenous glucose of about 100-150 grams per day. The dosage of insulin may be reduced to two thirds of the normal dosage of intermediate acting insulin which the patient receives prior to the operation. Blood sugar in the morning, 3 PM and 9 PM should be determined and regular insulin 5-15 units may be supplemented subcutaneously depending on the level of the blood sugar. A satisfactory blood sugar range is between 100 to 200 mg percent. These levels of blood sugar and the amount of regular insulin supplement should be a guide for any adjustment of the dosage of intermediate acting insulin the next day provided that the same amount of glucose is to be given and still there is no oral intake of food. When the patient starts to take food orally the calories taken by this route must also be taken into consideration in the adjustment of the dosage of the intermediate acting insulin in the morning.

TREATMENT OF PATIENTS WHO HAVE BEEN ON ORAL HYPOGLYCEMIC AGENTS

The severity of diabetes mellitus of a given patient may be estimated from the type and dosage of oral agents which are required to keep his blood sugar in a good range (i.e. fasting blood sugar below 130 mg percent). As a guide to the severity of diabetes mellitus, diabetic patients on oral hypoglycemic agents may

be classified as follows :

1. *Minimal severity* This applies to the diabetic patients whose blood sugar can be controlled with diet alone or only 1 tablet (5 mg) of glibenclamide (Daonil and Euglucon)

2. *Moderate severity* This applies to the diabetic patients whose blood sugar can be controlled with 2 to 4 tablets of glibenclamide or with 1 to 2 tablets (250 mg) of chlorpropamide (Diabinese, Dumide)

3. *Relatively severe* This applies to the diabetic patients whose blood sugar can be controlled with the combination of sulfonylurea in high dosage (see 2. *Moderate severity*) and phenformin (for example diabinese 500 mg + DBI-TD 100 mg)

For operations which the patients can take food orally immediately afterwards, such as cataract extraction or orthopedic surgery the oral hypoglycemic agents may be withheld in the morning before operation. After operation the normal dosage of oral hypoglycemic agents may be given when the patient starts to take diet orally.

For the intraabdominal operations which the patient cannot take food orally for a few days insulin should be given as follows :

1. *Diabetes mellitus of minimal severity* : No insulin preparation is required for this group of patients. Blood sugar should be taken after operation and regular insulin supplement may be given as required. However normally there will not be severe elevation of blood sugar in this group of patients.

2. *Diabetes mellitus of moderate severity* : This group of patients should be prepared with 10 units of intermediate acting insulin (NPH or lente) before operation at the time when intravenous glucose is being started. Another 10 units of the same kind of insulin should be given immediately after the operation. Blood sugar determination should be done as with the patients on insulin therapy before operation as discussed above.

3. *Relatively severe diabetes mellitus* : This group of patients should be prepared as the patients in group two but an increase of the dosage of intermediate acting insulin to 15 units before and 15 units after the operation should be made.

Blood sugar determinations should be done on the patient in the late afternoon (3-4 PM) and once more at night (9 PM). Regular insulin supplement of 5-15 units subcutaneously may be given if the blood sugar is above 250 mg percent. Group one patients may not require any insulin at all on the day of operation or the day after operation. For group 2 and group 3 patients 10 to 30 units NPH insulin may be given in the morning daily while the patients cannot take medications orally and while still receiving intravenous dextrose solution. Insulin can be discontinued and oral hypoglycemic agents may be resumed when a regular diet can be taken.

EMERGENCY SURGERY

Diabetic patients may get involved in car accidents or develop an acute abdomen and these stress situations may cause the blood sugar to be elevated out of control. A surgeon is commonly in a dilemma to decide whether the elevated blood sugar should be treated first or to go ahead with operation despite a very high blood sugar. Generally if there is no acute and severe bleeding emergency operation of any kind may be delayed a few hours while the diabetic status is being evaluated and treated.

The most important thing to evaluate with these patients who require emergency surgery is whether or not they have ketoacidosis and electrolyte imbalance. If the patients have ketoacidosis surgery is definitely contraindicated. Moreover diabetic ketoacidosis may mimic an acute abdomen at the time of presentation. The signs and symptoms of acute abdomen may subside after the treatment of ketoacidosis. Generally it takes about eight hours to correct the metabolic abnormalities in ketoacidotic patients and if surgery is still indicated the surgeon may proceed with the operation.

If there is no ketoacidosis but only hyperglycemia at what level of blood glucose can the operation be done? If the glucose level is above 300 mg percent the patient usually will have severe polyuria, polydipsia and he may be dehydrated. Therefore the blood sugar should be treated first with regular insulin to the range of 200 to 250 mg percent. In an acute emergency when the blood sugar is below 300 mg percent the surgeon may proceed with the operation and the blood sugar may be treated both during the operation and after the operation.

When the diabetic patients are prepared as discussed above a smooth blood sugar level should be obtained with a minimal requirement for supplementary regular insulin. Because of the long action of NPH and lente insulin there should not be wide fluctuation of the level of blood sugar.

SURGICAL CARE OF THE DIABETIC WOUNDS

Diabetes mellitus is a small blood vessel disease and often causes ischemia of the skin without obstruction of the medium and large size arteries. The skin ischemia and high blood sugar make diabetic patients prone to poor wound healing and infection. The most common sites of diabetic wounds and infection are in the feet and the back.

DIABETIC FOOT ULCER

When a diabetic presents with a foot ulcer the most important thing to decide is whether amputation is required or not. The best policy is to try to conserve the limb if possible. The decision will depend on several factors.

1. *Vascular supply to the limb* : Examination of the good limb without the wound may be helpful. If the skin of the good limb is smooth, thin, shiny without hair the vascular supply to the skin is probably poor and wound healing would be difficult especially when there is superimposed infection. If the skin is dark and cool, the medium size and probably the large size arterial lumen may also be compromised. A careful palpation of the popliteal artery pulsation may be helpful in determination of the point of occlusion and therefore the level of amputation which is needed. Examination of the wound itself may show dry gangrene which indicates that amputation is necessary. If the wound looks fresh and bleeding is good with debridement and the tendons are not exposed the limb can probably be saved with careful and prolonged wound care and extensive drainage.

2. *Infection* : The extent of infection must be determined and appropriate antibiotics be given. A foul smelling wound would indicate anaerobic infection. Systemic fever indicates extensiveness of the infection. An extensive foul smelling wound with systemic fever (wet gangrene) indicates urgent amputation to prevent extension of the infection. The most common organism which infects a diabetic limb with a good vascular supply is *Staphylococcus aureus* coagulase positive and appropriate antibiotics such as dicloxacillin should be given. In wet gangrene the organisms are usually mixed, including *Staphylococcus aureus*, gram negative rods as well as anaerobic organisms. Antibiotics covering all these organisms (dicloxacillin + chloramphenicol + gentamicin) should be given and the antibiotics should be changed according to the results of culture and sensitivity tests.

3. *Bone involvement* : Roentgenography of the bone must be done to determine the extent of bone involvement. If the external wound is good and bone involvement is minimal, curettage of the bone together with good drainage and wound care can probably save the patient's limb. If bone involvement is extensive amputation is necessary.

4. *Sensory perception of the foot* : It is important to evaluate at the beginning the sensory perception and shape of the diabetic foot. A high arch with interosseous muscle atrophy are the consequence of prolonged neuropathic foot. Pinprick sensation and the achilles tendon reflex must be tested to determine the level of polyneuropathy. If diabetic polyneuropathy is present the wound could be due to loss of sensation, leading to trauma or a burn on the foot. This kind of wound usually heals well because the blood supply is still normal. Moreover extensive debridement and wound care is made easier by the patient's loss of pain sensation.

The most important role of a physician in treating diabetic wounds of the foot is to make the decision whether amputation should be done or to try to save

the foot and prolong hospitalization. This is a very important decision to make. If a wrong decision is made prolonged hospitalization as well as a loss of the limb may be the consequence. Once a decision to save the foot is made, extensive and adequate drainage must be done, otherwise infection will not be eliminated and wound healing will not be accomplished. Try to avoid using strong agents such as Dakin's solution or hydrogen peroxide on a diabetic wound because these may cause skin gangrene in diabetic patients whose skin circulation is already compromised. A good sign of wound healing is the appearance of granulation tissue on the wound. Frequent cleaning and debridement is necessary. Fresh honey is a good solution to help prevent infection and promote granulation tissue growth.

CARBUNCLES IN THE BACK

Diabetic patients frequently present with carbuncles in the back. The carbuncle usually starts with small folliculitis which rapidly expands due to virulence of the offending organism which is almost always *Staphylococcus aureus* coagulase positive. Many times these carbuncles had been treated by physicians outside the hospital and antibiotics have been given before. However, usually the antibiotics given were tetracycline or ampicillin which were not effective against *Staphylococcus aureus*. The most important thing in the treatment of these carbuncles are adequate drainage and the right antibiotics, namely dicloxacillin. Debridement must be done three to four times daily after the first extensive drainage and debridement in the opera-

ting room under general anesthesia. Dressing with honey is as good or better than any fancy or expensive dressing medications on the market. After good granulation tissue growth the skin normally can grow in and cover completely without a need of skin graft. Many of these patients have diabetes mellitus diagnosed for the first time at the time of presentation. While infection is still not well controlled, insulin in the form of NPH or lente should be given. After infection is controlled these patients usually can be controlled on oral hypoglycemic agents.

The best treatment for the diabetic wound anywhere is to have close cooperation between the internists and the surgeons. A joint evaluation of the patients must be done to obtain the greatest benefit for the patients.

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