

# Management of Diabetic Patients during and after Surgery \*

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## INTRODUCTION

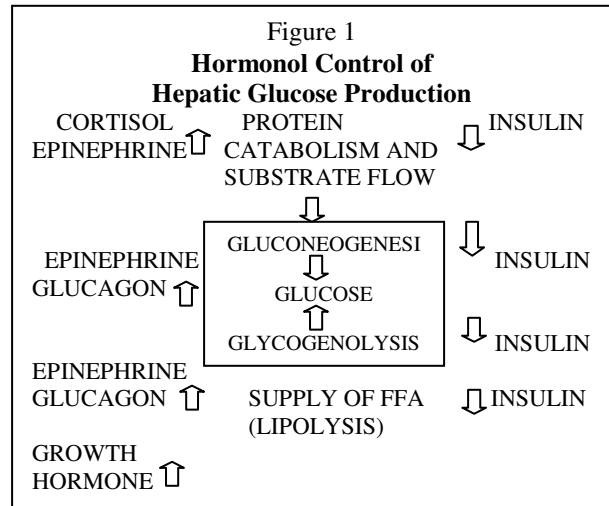
There is a high probability that a diabetic patient will encounter surgical disease during his or her lifetime [1,2,3]. The advent of insulin and antibiotic therapy has increased the life expectancy of diabetic patients. With this prolongation of life expectancy and an overall increased incidence of diabetes, surgeons will see more diabetic patients with surgical illness. It is well known that a diabetic patient undergoing surgery carries increased morbidity and mortality. Even in good surgical operations in reported mortality rate for surgical operations in diabetic patients range from 3.6 to 13.2% [3,4,5]. An increased incidence of cardiac and peripheral vascular disease and infection are the major causes for increased surgical mortality in diabetic patients. However, metabolic derangement with electrolyte imbalance are important additional factors which are responsible for the catastrophic events in diabetic patients during and after surgery [3,9]. Therefore, understanding of physiological alteration of body metabolism in response to anaesthesia and stress of surgery is essential in proper management of diabetic patients undergoing surgery.

## PATHOPHYSIOLOGY

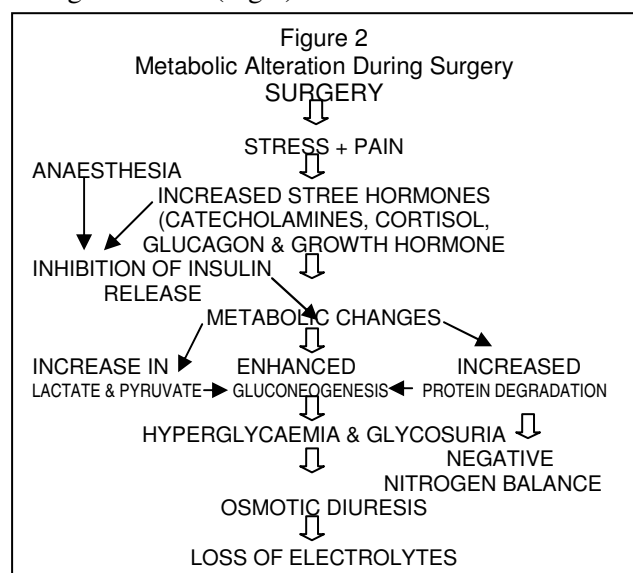
### Metabolic and Hormonal Alterative

Surgery and tissue injury in a nondiabetic patient causes a catabolic response which is characterized by increased metabolic rate, increased protein degradation and glucose intolerance [3,10-13]. This catabolic response occurs as a consequence of a rise in circulation of various stress hormones such as catecholamines, cortisol, glucagons and growth hormone, as well as decrease in circulating concentrations of insulin [14-20]. Increased catecholamine promotes gluconeogenesis and lipolysis. Increased cortisol levels are responsible for net protein breakdown in the extrahepatic tissue and increasing flow of gluconeogenic precursors. A rise in glucagons has its main effect on the liver promoting gluconeogenesis, glycogenolysis and ketosis; whereas increase in growth hormone causes increased lipolysis. These stress hormones in combination can cause a catabolic effect by opposing the action of insulin. However, none of these hormones individually can

cause a major catabolic effect and oppose the anabolic effect so characteristic of insulin alone (Fig 1).



Therefore insulin deficiency plays a major role along with a rise in stress hormones in the catabolic events of surgical stress. The decrease in the insulin release during the surgical stress is caused by (i) the direct inhibitory effect of anaesthetic agents, especially ether and chloroform, on endocrine pancreas, and (ii) the inhibitory effect of adrenomedullary stimulation caused by pain and stress [19,21]. This decrease in insulin and excess of stress hormones cause metabolic derangements which are characterized by enhanced gluconeogenesis, hyperglycaemia, glycosuria, osmotic diuresis, loss of electrolytes, increased protein degradation and negative nitrogen balance (Fig 2).



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The loss of electrolytes, due to osmotic diuresis further exacerbates the electrolyte loss occurring as a result of the operative procedure itself. Obviously relative or absolute insulin deficiency in a diabetic patient will compound this metabolic imbalance and potentiate catabolism and electrolyte disturbance. The catabolic response to surgery in the diabetic patient is also related to the severity of operation, the extent of tissue injury and complicating effects of shock and infection [1,3,6,8,22].

### Factors influencing postoperative course

Several factors play an important role in postoperative recovery and complications in the diabetic patient (Table 1).

<b>Table 1</b> <b>Factors influencing Postoperative Course in the Diabetic Patient</b>
<b>INFECTION</b> Altered leucocyte function Impaired wound healing
<b>CARDIOVASCULAR</b> Acute myocardial infarction Gangrene
<b>RENAL DISEASE</b> Hypertension Toxicity of drugs Fluid & electrolyte imbalance
<b>AUTONOMIC NEUROPATHY</b> Urinary retention Orthostatic hypotension Respiratory & cardiac arrest
<b>USE OF DRUGS</b> Insulin resistance Inhibition of insulin release

It is well known that the infection rate are increased in diabetic patients. Impaired wound healing and decreased leucocyte function contributes to increased incidence of infections in these patients[8,23]. Cardiovascular complication such as acute myocardial infarction, gangrene, and cerebrovascular accidents may also play a significant role in the postoperative outcome of the diabetic patients [6,7]. It is not unusual for a diabetic patient undergoing surgery to have significant impairment of renal functions. Therefore these patients should be routinely examined for hypertension, oedema and proteinuria prior to surgery [3-6]. The presence of renal disease in a of therapeutic drugs and can cause special problems for fluid administration because of comautonomic neuropathy in a diabetic patient may cause sudden respiratory and cardiac

arrest during or after surgery and therefore contribute to the increased morbidity and mortality of diabetic patients during surgery [24]. Furthermore, urinary retention and orthostatic hypotnesion due to autonomic neuropathy may cause confusion in the postoperative assessment for fluid replacement therapy in these patients. In a diabetic patient postoperative administration of drugs such as glucocorticoids, dilantin, propranolol or adrenergic agents may precipitate ketoacidosis or hyperosmolar state [25-28].

### MANAGEMENT

The aims of the management of the diabetic patient during and after surgery are to prevent the effect of (a) insulin deficiency, (b) increased catabolism, and (c) electrolyte changes. The aims of management should also include prevention of postoperative complications specific to the diabetic patient as outlined above.

#### General Aspect of the Management of Surgical Diabetic Patient

In order to provide optimal care and prevent hypoglycaemia or extreme hyperglycaemia and ketosis in a diabetic patient undergoing surgery the following information should be considered:

##### A. Basal carbohydrate requirements, hyperglycaemia and hypoglycaemia

1. It is imperative that under the fasting conditions, a diabetic patient should receive approximately 200 grams of glucose intravenously per twenty-four hours (approximately same amount of glucose produced endogenously during fasting conditions) to prevent significant gluconeogenesis and ketosis. Needless to say an adequate amount of insulin should also be continuously available to promote utilization of intravenously administered glucose. Therefore in a diabetic patient, caloric intake and insulin availability must always be considered together.
2. Hypoglycaemia is more hazardous than mild to-moderate hyperglycaemia of a short duration. Hyperglycaemia in the range of 150-200 mg/dl without ketonaemia is expected during a early ostoperative period. However, severe hyperglycaemia during the postoperative period may be responsible for altered fibroblast and leucocyte function which

may lead to poor wound healing infections, respectively [8,9,234]. Therefore, plasma glucose level should optimally be maintained between 100-200 mg/dl range, as long as this does not lead to severe hypoglycaemic periods.

### *B. Increased requirement for insulin*

1. Some diabetic patients are specifically prone to develop marked hyperglycaemia and hyperosmolar coma. These include (a) patients receiving hyperalimentation, (b) those who undergo neurosurgical procedures while receiving glucocorticoid and dilantin treatment or (c) those who are receiving steroid and immunosuppressive therapy for renal transplant surgery [26-28]. These conditions should be anticipated and treated with appropriate intravenous fluids and increased amount of insulin.
2. A diabetic patient undergoing cardiac surgical procedure on a cardiopulmonary bypass machine may require more insulin [29] in comparison with a diabetic patient undergoing general surgery because : (a) The "dead space" in the bypass machine may sequester as much as 500 grams of glucose . (b) Hypothermia is known to cause insulin resistance. (c) The frequent requirement of adrenergic agents in these patients postoperatively can aggravate an insulin resistance which already exists because of the stress of the surgery.
3. Presence of infection can also cause an increase in insulin requirement. In a diabetic patient the usual bacterial defense mechanisms are insufficient due to leucocyte dysfunction [8]. The usual contamination which may not cause any significant wound infection in a nondiabetic patient may cause gross wound infection in a diabetic patient. Therefore any apparent wound infection should be cultured for the identification of the organism and should be vigorously treated with the appropriate antibiotics.

### *C. Decreased requirement for insulin*

Insulin requirements are significantly decreased after stressful (physiological or pathological ) situations are terminated. For example, the patient

who delivers a baby or has a pregnancy terminated or one with an abscess which is drained, will require less insulin when these type of stresses are relieved . These should be anticipated by decreasing the insulin dose by 50% . Supplemental insulin may be given later if the reduction in the insulin dose was too great.

### *D. Elective versus Emergency Surgical Procedure*

The diabetic patient should be under an optimal metabolic and nutritional state at the time of surgery. Therefore all elective surgery should be delayed until hyperglycaemia, electrolyte imbalance, dehydration and poor nutritional status have been corrected. If the patient presents in ketoacidosis and an operative procedure is urgent, even then, sincere efforts should be made for a few hours to correct ketoacidosis prior to surgery. Intensive treatment with fluids electrolytes and insulin with even partial correction of ketoacidosis may significantly decrease the perioperative mortality ignored. Furthermore, ketoacidosis be corrected prior to laparotomy [30]. It is important to realize that prolonged postponement of surgical procedure until each and every metabolic parameter are perfectly normalized may lead to a serious and at times lethal complication of surgical condition. Therefore an experienced and judicious medical and surgical judgment should mandate the surgical treatment in these patients.

### *E. Monitoring Insulin Therapy*

Insulin therapy during surgery and early postoperative period should be monitored by determining plasma glucose and ketones. Urine glucose determination in the preoperative period are unreliable because of individual variation of renal threshold for glucose as well as the possibility of urinary retention with incomplete emptying of the bladder. It is important to emphasize that "sliding scale" method for insulin administration based on urine glucose determination should be completely avoided. This method of insulin treatment does not only treat numbers in a retrospective manner but is also based on false logic. Because, during and after surgery, (a) plasma glucose concentration can change abruptly, (b) urine volumes and renal threshold for glucose may alter rapidly, and (c) urine samples may not be available at desired time due to urinary retention, the "sliding scale" method of treating a patient during postoperative period will cause marked fluctuation of glucose levels and instability in diabetic control [3].

## F. Avoidance of Lactate and fructose Containing Solution

Lactate containing solutions cause a sharp increase in plasma glucose concentration in diabetic patients [31]. Therefore lactate containing solutions such as Ringer's lactate, are best avoided in the surgical diabetic patients needing electrolyte replacement therapy. Similarly, fructose containing solution, in the treatment of diabetic patients during surgery should also be avoided, since fructose is readily metabolized to glucose and lactate [32]. In addition, the presence of lactic acidosis due to hypovolaemia and abnormal liver function in these patients can be further aggravated by fructose administration.

## Specific Management of Surgical Diabetic Patients

The specific management of surgical diabetic patient will depend on whether:

(a) The patient has insulin dependent (Type I) or noninsulin dependent (Type II) diabetes, (b) the patients' hyperglycaemia has been controlled by insulin or by sulphonylurea agents, (c) the patient is undergoing major or minor surgery, and (d) the surgical procedure is planned under general or local anaesthesia.

There is a general consensus that if a patient's diabetes has been well controlled by diet alone and a minor surgery is planned, then no specific therapy is necessary [2,3]. Similarly, a specific treatment is also not needed in a patient with Type II diabetes taking sulphonylurea agents to control hyperglycaemia, provided that the diabetes is well controlled before minor surgery under local anaesthesia. In these type of patients, plasma glucose should be monitored after surgery and persistent hyperglycaemia should be treated with insulin. Specific management plans are necessary for insulin dependent and non-insulin dependent diabetic patients undergoing major surgery under general anaesthesia.

### A. Management of Insulin-Dependent (Type I) Diabetic Patient

The Type I diabetic patient undergoing surgery will require insulin and glucose supplementation and close monitoring of plasma glucose and ketone, urinary urea excretion and ketone, and plasma electrolytes [3]. Although, various methods of insulin treatment regimens have been proposed for Type I diabetic patients, methods

using insulin and glucose infusions during and immediately after an operative period have been shown to be most beneficial [3,33-35]. Methods using subcutaneous fractional insulin have been shown to be less successful in this type of diabetic patients [3,34]. A glucose controlled insulin infusion system (artificial pancreas) have been reported to be useful in controlling hyperglycaemia in a diabetic patient during surgery [36]. By using this system, normal glycaemia could easily be maintained, regardless of duration and type of surgery and anaesthesia, and variation of fluid replacement therapy.

The following guidelines of the treatment are recommended for insulin-dependent diabetic patients and undergoing major surgery.

### 1. Management with subcutaneous insulin injections during and after surgery.

- a) For the convenience of management the surgery should be planned early in the morning, if possible.
- b) On the day of operation:
  - 1) The patient should be fasting.
  - 2) Early in the morning, start IV infusion with 1000 ml of 10% glucose in water or saline, to be infused over six to eight hours.
  - 3) At the time of starting the IV solutions, give one half the daily dose of intermediate acting insulin (NPH or Lente) subcutaneously.
  - 4) Monitor plasma glucose prior to and on completion of surgery. If surgery is prolonged for more than two hours, measure plasma glucose at least once during the surgery.

### c) During and immediate postoperative period:

- 1) Continue IV infusion with 5% glucose in water or saline so that the patient receives 200 grams of glucose over twenty-four hours. This IV supplementation of carbohydrate calories should be continued until the patient is able to eat. Modification of fluid therapy may be done to adjust any electrolyte imbalance, but the patient must receive 200 grams of IV glucose per day.

- 2) Give regular insulin every four to six hours subcutaneously or intramuscularly to maintain plasma glucose in the range of 150-200 mg/dl. As a start, give 10-15 units of regular insulin for plasma glucose between 250-350 mg/dl and 15-20 units of insulin for plasma glucose above 350 mg/dl. It is important that the patient must receive some regular insulin every six hours as to maintain the plasma glucose levels below 200 mg/dl.

(d) On the days following surgery:

- 1) Give oral fluids and solid foods as soon as patient's condition permits.
- 2) If the patient is unable to tolerate fluids or solid food orally, continue IV infusion with 5% or 10% glucose in water or saline to a total of 200 gram of glucose per twenty-four hours. Continue to monitor plasma glucose every four to six hours and continue to give regular insulin subcutaneously every four to six hours to maintain plasma glucose between 150-200 mg/dl.
- 3) If the patient is able to eat then resume preoperative insulin treatment regimen. Obviously IV supplementation of glucose should be discontinued at this time.
- 4) Adjustment in insulin dose should be done if previous infection is cured or postoperative course is complicated by a new wound infection.

## 2. Management with Continuous Glucose and Insulin Infusion During and After Surgery.

An alternative therapy with continuous glucose and insulin infusion during and after surgery is equally or even more effective. Early in the morning of surgery, start an infusion of two to three units of regular insulin and 100 ml of 10% glucose and insulin infusion to maintain plasma glucose between 100-200 mg/dl. Before starting the infusion, flush the IV tubing of the infusion set with 50 ml of insulin containing solution to prevent further binding of insulin to the IV tubing and infusion set [37]. Similarly to prevent insulin binding, the using of in-line filters should be avoided, should be replaced via a separate IV infusion site. The glucose and insulin infusion may be continued during postoperative period until oral feeding could be resumed.

The advantage of this type of therapy is (a) insulin is available constantly to exert its anabolic effect and (b) the possibility of hypoglycaemia is avoided because insulin and glucose are given simultaneously through the same IV infusion set.

### B. Management of Noninsulin-Dependent (Type II) Diabetic Patients

The noninsulin dependent diabetic patient may temporarily require insulin treatment to control hyperglycaemia during major surgery. Patients who are taking long acting sulphonylurea agents such as chlorpropamide should be switched to shorter acting agents such as glyburide or glipizide, at least three days but preferably one week prior to surgery. If diabetes is poorly controlled on oral agents, then it is advised to discontinue oral agents and start intermediate acting insulin treatment as a preparation for surgery. This approach may take three to four days to control hyperglycaemia. The rest of the therapy is similarly to that outlined above for the insulin-dependent diabetic patient undergoing surgery. Remember that if the patient has been well controlled on oral agent prior to surgery, then (a) oral agents are not given on the day of surgery and (b) the morning dose of insulin on the day of operation is not required. However regular insulin, subcutaneously, may be required postoperatively to maintain plasma glucose between 150-200 mg/dl. If the patient's condition and the degree of postoperative hyperglycaemia are satisfactorily controlled then the treatment with sulphonylurea agent can be resumed on the second or the third postoperative day.

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