# Peri-operative Management of Diabetes

**Hemraj B Chandalia*, Shaival H Chandalia****

***Director, ****Fellow,**
**Diabetes Endocrine Nutrition Management and Research Centre;**
**Endocrinologist & Diabetologist, Jaslok, Lilavati, Breach Candy Hospital, Mumbai.**

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The diabetic patient faces additional hazards when undergoing surgery as compared to the non-diabetic population. These are as follows:

1. Hyperglycemia and possible ketoacidosis caused by the body's stress response to surgery
2. Hypoglycemia due to peri-operative fasting worsened by the prolonged action of certain long acting insulins or oral hypoglycemic agents.
3. Peri-operative complications that are increased by diabetes, e.g. incidence of wound infections and myocardial infarctions.

## THE STRESS RESPONSE TO SURGERY

Surgery induces a series of changes in the human body commensurate with the magnitude of stress. Typically, the secretion of stress hormones like cortisol and epinephrine is increased and insulin secretion is decreased. Also insulin resistance as measured by the euglycemic hyperinsulinemic clamp method is increased.[1] These responses are maladaptive in the diabetic subject and result in a persistence of the catabolic state induced by surgery.

## PRINCIPLES OF MANAGEMENT[2,3]

1. The half-life of intravenous insulin is about 4 minutes. Hence stopping the insulin infusion for a short period of time can rapidly result in the development of DKA in an insulin-dependent diabetic. Therefore, it is a good idea to supplement the intravenous insulin infusion in type 1 diabetics with subcutaneous insulin 30 minutes before interrupting the infusion or changing the drip.
2. Insulin is adsorbed to the glassware and plasticware during infusion. As much as 60% of insulin (usually about 30%) can be lost by this process. This can be counteracted by running about 50 ml of the infusate rapidly through the tubing to saturate the adsorption sites or by adding a small amount of protein to the infusate. We add 2 ml of the patient's serum to the IV fluids before starting the insulin infusion and we have found that this works well.
3. We do not recommend the use of a sliding scale for adjusting the insulin dosage, as changes made with this method are often retrospective and confounding rather than prospective.
4. The IV insulin infusion can be set up by two methods:-
   a. The GKI drip or the glucose potassium insulin drip which is the simpler of the two methods. The method involves the addition of a fixed dose of insulin to the bag of IV fluids. Since both insulin and glucose are being delivered simultaneously, a precise drip counter is not essential for this process. Thus the GKI drip is easily set up and used even in remote areas. On the other hand, the GKI system assumes that the patient's metabolism is in steady state; hence it should not be used in severely hyperglycemic, unstable or brittle patients. In any case, the amount of insulin added should not be fixed (e.g. 1 unit for 2 g of glucose), but linked with the patient's usual insulin requirement.
   b. The separate line approach uses two separate lines for insulin and glucose infusions. This facilitates the ability to make changes in the insulin or glucose infusion separately and thus offers greater flexibility. Hence it is better used in severely uncontrolled, brittle patients or in special circumstances like CABG surgery or pregnancy during labor. However, this system needs closer monitoring and supervision because of the intrinsic dangers involved in uncoupling the delivery of insulin from the delivery of glucose i.e. if one of the lines gets blocked it could result in dangerous hypo or hyperglycemia. Overall, glycemic control, number of hypoglycemic episodes, infection rate and duration of hospitalization are equivalent between the two methods.
5. Data about the association between glycemic control and peri-operative wound infection rates in the form of prospective clinical trials does not exist. However we do know from basic & animal studies that wound healing may be impaired in the presence of persistent hyperglycemia (> 240 mg/dl), this being manifested by impaired fibroblast function. Hence it is prudent to target a blood glucose level of 100-200 mg/dl in the peri-operative period, rather than a more stringent control with its attendant risk of a more dangerous hypoglycemia.
6. Most importantly, in deciding the dose of intravenous insulin that will be administered to the patient per day, it is useful to link this decision to the patient's previous insulin requirements. The degree of insulin needed to utilize a fixed amount of glucose varies form person to person depending on the individual's insulin resistance. Hence the best guess as to

how much insulin the patient would require peri-operatively is made by looking at how much insulin the patient was on previously (to maintain euglycemia) and modifying this figure for the stress of surgery. This method is probably the best clinical method for judging an individual's insulin resistance.

## PRE-OPERATIVE MANAGEMENT

With appropriate peri operative management, the excess morbidity and mortality associated with diabetics undergoing surgery as compared to non-diabetics can be normalized. This process should begin at the pre-operative stage. A good pre-operative evaluation and consultation between the anesthetist, physician and surgeon is essential to reducing risk for the diabetic patient. The following factors should be assessed: -

1. Type of diabetes mellitus: Type 1 or Type 2 as well as the amount of insulin required in the past.
2. Previous glycemic control: self-monitoring of blood glucose and $HbA_1C$.
3. Diabetes related complications:
   a. Nephropathy which might alter fluid and electrolyte balance and drug therapy.
   b. Neuropathy can affect the cardiovascular system making it more prone to arrhythmias and postural hypotension; the gastrointestinal system making it more prone to gastroparesis, vomiting and or aspiration and the bladder making it more prone to urinary retention.
   c. Proliferative retinopathy with the possibility of vitreous hemorrhage with anticoagulation.
4. Cardiovascular system with the possibility of coronary artery disease and congestive heart failure and hypertension is responsible for 30% of the surgical mortality in diabetic patients.

### Indications for insulin therapy

1. All type 1 patients must be on insulin drip peri-operatively
2. Type 2 diabetics on insulin therapy should be continued on an insulin drip peri-operatively.
3. Type 2 diabetics with poor glycemic control ($HbA_1c$ > 9% or FPG > 180 mg/dl) and / or under going major surgery should be started on insulin therapy.
4. Type 2 diabetics with good glycemic control and / or undergoing minor surgery can be managed without insulin therapy.

The route of administration in the above cases is always intravenous. Subcutaneous administration of insulin is fraught with dangers of variable absorption specially in conditions of stress. However type 1 diabetics may be supplemented by subcutaneous insulin before stopping and / or changing the insulin drip.

### Estimating insulin requirements[4]

As alluded to earlier, the best method to assess a diabetic's peri-operative insulin requirements is to link it to his or her previous requirements and then adjust for the stress imparted by surgery. Table 1 can be used, however, as a rough guide

**Table 1 : Guidelines for Estimation of Insulin Dosage**

- For insulin treated diabetics (type 1 or 2) on > 50 U/day suggested dose is 36 U/day (1.5 U/hour – Blood glucose 141 – 180 mg/dl)
- For patients on diet, OHA or insulin < 50/day, suggested dose is 24 U/day (1.0 U/hour – Blood glucose 141 – 180 mg/dl)
- Further dose adjustments as follows:

* Conditions associated with insulin resistance

- Poor glycemic control, HbA1c > 9.0%: Selected dose x 1.5
- Obesity (BMI > 30): hepatic disease: Selected dose x 1.5
- Severe infection: Steroid therapy: Selected dose x 2

* Type of Surgery

- General surgery: Selected dose
- Renal Transplant: Selected dose x 2
- CABG: Selected dose x 3-5

### PERI-OPERATIVE MANAGEMENT[5]

In a fraction of patients, preoperative glycemic control can be achieved without intravenous insulin therapy. These are type 2 diabetics treated with diet or oral hypoglycemic agents with good control. This is specially true for situations where surgery duration is < 2 hours, a body cavity is not invaded and or spiral / epidural anesthesia is being used.

### Type of anesthesia and / or surgery

General anesthesia results in gearing up of the body towards a stressful catabolic state, that is augmented by poor diabetic (glycemic) control. Local and / or spinal / epidural anesthesia does not result in this stressful metabolic response. Key hole or laparoscopic surgery is responsible for a general metabolic stress response that is equivalent to that produced by open general surgery.

In all other cases, peri operative glycemic control is best achieved by intravenous insulin therapy. The two regimens alluded to earlier that are commonly used are the GKI infusion method and the separate line technique.

The GKI infusion involves the addition of a fixed amount of insulin and potassium chloride to each bag of IV fluids. Precision in delivery of insulin and glucose in not paramount in this method because both insulin and glucose are being infused simultaneously via the same line. A good starting point is to add 15 units of insulin to a pint of dextrose or dextrose saline. Blood glucose is checked hourly; if low, the bag is changed to another bag with 10 units of insulin per pint of dextrose / dextrose saline. If high, a bag of dextrose / dextrose saline with 20 units of insulin is hung. An alternative approach which is perhaps more rational is to use two-third of a patient's daily requirement of insulin (e.g. if a patient has a daily requirement of 48 units: 2/3 of 48 = 32 units) as a starting point. Then distribute these 32 units over 24 hours, thus adding approximately 6 - 7 units per pint of dextrose or dextrose saline. This is perhaps a more physiological way of estimating an individual's insulin sensitivity. Two-third of the total dose of insulin is used to scrupulously avoid hypoglycemia which is even more dangerous than hyperglycemia in the peri operative period.

The second approach to insulin management in the peri operative setting involves the separate line approach where the two infusions of insulin and glucose are dissociated in space and infused

**Table 2 : Insulin Scale**

| Blood Glucose (mg/dl) | IV insulin (u/hr) |
|---|---|
| 61 – 100 | 0.5 |
| 101 – 140 | 1 |
| 141 – 180 | 1.5 |
| 181 – 220 | 2 |
| 221 – 260 | 2.5 |
| 261 – 300 | 3 |
| 301 – 340 | 3.5 |
| 341 – 380 | 4 |
| > 380 | 5 |

**Table 3 : Modified Insulin Scale**

| Blood Glucose (mg/dl) | IV insulin (U/hr) |
|---|---|
| 61 – 100 | 1.0 |
| 101 – 140 | 1.66 or ~ 1.5 u/hr |
| 141 - 180 | 2.0 |
| 181 - 220 | 2.5 |
| 221 – 260 | 3.0 |
| 261 - 300 | 3.5 |
| 301 – 340 | 4 |
| 341 – 380 | 5 |
| > 380 | 6 |

through two separate lines. In such a setting, the timing and precision of simultaneous delivery of the two infusions becomes paramount. Hence this approach requires closer supervision and if one of the lines gets blocked is more prone to dangerous hypo or hyperglycemia. Table 2 shows the scale that can be used as a starting point for most patients.

An alternative approach (as described in the GKI section) is to utilize two-thirds of an individual's insulin dosage as the dose required to maintain euglycemia.

For example: If an individual utilizes 60 units of insulin per day, 2/3 of 60 units is equal to 40 units / day which is approximately equal to 1.66 units / hour. Hence the above scale would be modified as in Table 3:

Hence in either approach, i.e. the GKI infusion or the separate line approach we find it very useful to link the rates of insulin delivery to the patient's previous insulin dosage and use this as a surrogate marker of the patient's insulin resistance or sensitivity.

## POST-OPERATIVE MANAGEMENT

Management during this stage is almost as important as management during surgery, yet it remains a neglected area. The IV insulin infusion should be continued till the patient is able to eat per mouth. This might be soon after surgery or in the case of abdominal surgery a few days later. Insulin given subcutaneously is almost as bioavailable as insulin given intravenously. Hence, when changing over from IV to SC insulin (when the patient starts feeding) the total IV dose is added up for the past 24 hours and this dose is then divided into 3-4 parts given subcutaneously (the multiple insulin injection regimen). The patient's insulin sensitivity over the last 24 hours (total IV insulin dose) is again being linked to the current dose (total subcutaneous insulin dose). Post-operatively, as the patient's insulin resistance decreases, the insulin requirements will change but the best bet is always to link the total required dose to the previous day's dose.

## CASE HISTORY

We would like to reinforce this article with an example, in order to illustrate the dynamic nature of insulin adjustments that are required in the peri-operative period.

A 55 years old male with a ten years h/o of diabetes, on insulin therapy for the last 5 years is admitted pre operatively for a cholecystectomy. His pre-operative routine insulin dose is 18 units (am) and 16 units (pm) of Mixtard 50/50 respectively. The following regimen was prepared for him:

1. On the evening before surgery he was given his usual dose of Mixtard 50/50 i.e. 16 units.
2. On the morning of surgery, Dextrose / Dextrose saline infusion was started at 100 cc/hour. A separate line for IV insulin infusion was used at the rate of 2/3 of (18 + 16) units = 2/3 of 34 which is approximately equal to 24 units/day or 1 unit/hour to maintain euglycemia i.e. if blood glucose is between 100 – 141 mg/dl, then drip insulin at 1 unit/hr.
3. During surgery, the dextrose infusion was continued and the insulin infusion was stopped (to avoid the risk of hypoglycemia). Blood glucose was checked hourly.
4. Immediately post-operatively, if blood glucose was > 200 mg/dl then an IV bolus of 6 units was given
5. For the next 24 hours, while the patient was NPO, insulin infusion was continued at the rate of 1 unit/hr to maintain euglycemia.
6. When the patient started eating post-operatively on day 2, a dose of 12 units and 10 units of Mixtard 50/50 was given. (Remember that hypoglycemia is riskier than hyperglycemia). Insulin infusion was stopped 30 minutes after giving the first dose of subcutaneous insulin.

The above principles of management can be applied to any emergency in the diabetic or glucose intolerant patient i.e. the GKI infusion or insulin drip can and should be used in the setting of an acute myocardial infarction as well.

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