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Dental Considerations for Patients with Diabetes Mellitus

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Abstract: *As per International Diabetes Federation (2017), 8.8% of total Indian population are diabetic. Sometimes Diabetes is accidentally diagnosed before extraction during routine laboratory investigations. The stress of extraction in these patients may result in altered glucose homeostasis, hyperglycaemia, endothelial dysfunction, postoperative sepsis, impaired wound healing and cerebral ischemia. It may precipitate perioperative complications like diabetic ketoacidosis, hyperglycaemic hyperosmolar syndrome as well as hypoglycaemia. Hence metabolic control is imperative. This paper deals with proper guidelines for routine dental extractions in diabetic patients.*

Keywords: *Diabetes mellitus, dental surgery, Sliding scale insulin, pre-operative management, peri-operative management, post-operative management.*

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I. Introduction

Managing diabetes in people undergoing oral surgery is a common problem. Diabetic patients occupy9% [1,2] or more of general hospital beds, and several oral & maxillofacial complications require surgical intervention. The purpose of this article is to demystify this topic by providing simple, safe and effective guidelines for diabetic management that can be easily used on a busy oral & maxillofacial surgical ward.

Patients with diabetes undergo surgical procedures at a higher rate than do nondiabetic people.[3] The stress of surgery itself results in metabolic perturbations that alter glucose homeostasis, and persistenthyperglycaemia is a risk factor for endothelial dysfunction[4],postoperative sepsis[5],impaired wound healing,[6,7] and cerebral ischemia.[8] The stress response itself may precipitate diabetic crises (diabetic ketoacidosis , hyperglycaemic, hyperosmolar syndrome) during surgery or postoperatively. [9,10.] Furthermore, gastrointestinal instability provoked by anaesthesia, medications, and stress-related vagal overlay can lead to nausea, vomiting, and dehydration. These compounds the volume contraction that may already be present from the osmotic diuresis induced by hyperglycaemia, thereby increasing the risk for ischemic events and acute renal failure. It is therefore imperative that careful attention be paid to the metabolic status of people with diabetes undergoing surgical procedures.

DIAGNOSIS & CRITERIA FOR THE DIAGNOSIS OF DIABETES MELLITUS[11,12]

FASTING BLOOD SUGAR TEST-	• **< 100 mg/dL (5.6 mmol/L) : Normal** • **100 to 125 mg/dL (5.6 to 6.9 mmol/L): Borderline** • **126 mg/dL (7 mmol/L) or higher on two separate tests: Diabetic**
POST PRANDIAL BLOOD SUGAR TEST	• **<200mg/dl: Normal** • **>200 mg/dl: Diabetic**
GLYCATED HEMOGLOBIN (A1C) TEST	• **A1C < 5.7% : Normal** • **A1C 5.7% to 6.4%:Prediabetes** • **A1C >6.4% :Diabetic**

II. Discussion

Diabetes itself is playing a huge role in the field of any surgical procedures. As the field of maxillofacial surgery is comprising of elective and emergency procedures as well as minor and major surgeries so that an adequate knowledge of perioperative management of diabetes mellitus is required to practice the speciality.

Type 1 Diabetes Mellitus

It was previously called insulin-dependent diabetes mellitus (IDDM) or juvenile-onset diabetes.

- Type 1 diabetes develops when the body's immune system destroys pancreatic beta cells- the only cells in the body that make the hormone insulin that regulates blood glucose.
- This form of diabetes usually strikes children and young adults, although disease onset can occur at any age.
- Type 1 diabetes may account for 5% to 10% of all diagnosed cases of diabetes.
- Risk factors for type 1 diabetes may include autoimmune, genetic, and environmental factors. [16]

Type 2 Diabetes Mellitus

It was previously called non-insulin-dependent diabetes mellitus (NIDDM) or adult-onset diabetes. Type 2 diabetes may account for about 90% to 95% of all diagnosed cases of diabetes.

- It usually begins as insulin resistance, a disorder in which the cells do not use insulin properly. As the need for insulin rises, the pancreas gradually loses its ability to produce insulin.
- Type 2 diabetes is associated with older age, obesity, family history of diabetes, history of gestational diabetes, impaired glucose metabolism, physical inactivity, and race/ethnicity.
- African Americans, Hispanic/Latino Americans, American Indians, and some Asian Americans and Native Hawaiians or Other Pacific Islanders are at particularly high risk for type 2 diabetes.
- Type 2 diabetes is increasingly being diagnosed in children and adolescents.

PREOPERATIVE ASSESSMENT[13,14]

Preoperative assessment begins with a physical examination and complete diabetic history.

- FBS, PPBS and HBA_{1C} (Blood glucose should be maintained at 4-10 mmol/L and it is very important to avoid hypoglycaemia. If blood sugar cannot be maintained below 13 mmol/L, surgery should be deferred (risk of ketoacidosis or hyperosmolar state.) The surgeon should also determine the patient's medication regimen, including the name of the medication, dosage, and time when the medication is taken. The patient's compliance with the medication regimen should also be investigated.
- Cardiac evaluation should include an ECG because patients who have diabetes frequently have hypercholesterolemia, hypertension, macrovascular disease, and neuropathy and therefore have a higher risk for silent ischemia. If any ischemic changes are evident on the ECG, or the patients' history suggests coronary artery disease, a stress test should be performed. Evidence of angina, intermittent claudication should be sought. Examine for postural hypotension (systolic fall of >30 mm Hg on standing).
- Chest radiograph is usually not necessary in patients who are otherwise healthy, but if they have any known underlying risk factors, such as smoking, then a chest radiograph must be performed before surgery involving general anaesthesia.
- Chest X-ray should be done to add for pulmonary infections including tuberculosis.
- Renal function should also be evaluated because patients who have diabetes are susceptible to renal failure. Renal workup should include serum urea nitrogen and creatinine levels, and screening for the presence of microalbuminuria and proteinuria. Symptoms of polyuria may reflect glycosuria or renal failure. Anaemia and hypertension should be detected as possible associated conditions.
- Hypertension should be identified and treated. If the patient is already taking antihypertensive medication, the medication should be continued throughout the perioperative period.
- The skin should be examined for sepsis.Pressure areas (heels, buttocks, etc) should be examined for sores.
- The autonomic nervous system (ANS) dysfunction may be seen in patients who have diabetes. Any or all of the components of the ANS can be affected, leading to a wide range of disorders. Diabetic autonomic neuropathy is linked to silent myocardial infarction, cardiac dysrhythmias, ulcerations, gangrene, and neuropathy. It is also associated with an increased risk for sudden death. Diabetic autonomic neuropathy may manifest clinically with postural hypotension, resting tachycardia, and lack of heart-rate variability with deep respiration or exercise.
- Some patients may experience diabetic gastroparesis. History of heartburn or acid reflux when lying supine may indicate delayed emptying of the gastric contents, causing these patients to have an increased risk for vomiting and aspiration during a surgical procedure involving general anaesthesia.

- Preoperative laboratory studies should include a complete blood count and chemistry panel.

PRE-OPERATIVE AND PER-OPERATIVE MANAGEMENT[15]

Management of patients suffering from Type 1 Diabetes Mellitus

It is usually best to admit patients 2-3 days before elective surgery, particularly if outpatient adjustments are difficult. There are different recommended routines but it is important that ward staff and those responsible for postoperative care have clear instructions. Complicated regimens can cause confusion amongst staff.
• Ensure good pre-operative control usually with short-acting insulin (or a mixture of short- and intermediateacting insulin) twice daily. Extra short-acting insulin can be added if necessary.
• Monitor blood glucose throughout the day.
• On the day of surgery starve from midnight and do not give the first dose of insulin.
• Operation should be as early as possible (i.e. put the patient with diabetes first on the list).
• Check glucose and electrolytes early on the day of surgery (defer if glucose >13 mmol/L or if there is significant electrolyte disturbance).
• Start intravenous (IV) infusions of dextrose (500 ml10% dextrose plus 10 units soluble insulin plus 10 mol KCl at 125 mlper hour). Check blood glucose and electrolytes at the end of the operation or at 1- to 2-hourly intervals.
• Monitor blood glucose during surgery at least every 30 minutes. Continue this as long as blood glucose is between 5-10 mmol/L. Reduce insulin to 5 units if less than 5 mmol/L and increase to 15 units if blood glucose is 10-20 mmol/L (new infusion needed of course).
• After surgery, check glucose every 2 hours and electrolytes every 6-12 hours, adjusting infusions as necessary.
• Continue infusions but, when eating normally, restart subcutaneous insulin (as before surgery).

Management of patients suffering from Type 2 Diabetes Mellitus[16]
• Pre-operatively, control should be assessed.
• Patients controlled by diet alone do not usually need any special measures, providing control on diet is adequate.
• It is better to use short-acting drugs (for example, glipizide).
• Remember that the hypoglycaemic effect of sulphonylureas is enhanced by some drugs (for example, aspirin, sulphonamides, anticoagulants).
• Metformin should be discontinued 48 hours prior to and subsequent to surgery in order to reduce the risk of lactic acidosis.
• If control is inadequate, insulin may be needed.
• Insulin can be required in the postoperative phase temporarily.
• On the day of surgery keep 'nil by mouth' as usual and omit short- acting sulphonyl urea.
• Monitor blood glucose as for type 1 diabetes above. If blood glucose is >13 mmol/L, use insulin to control (small doses of soluble insulin).

Patients Managed With Diet Alone[16]

People whose diabetes is well controlled by a regimen of dietary modification and physical activity may require no special preoperative intervention for diabetes. Fasting blood glucose should be measured on the morning of surgery, and intraoperative blood glucose monitoring is desirable if the surgical procedure is lengthy (>1 h). If surgery is minor, no specific therapy is required. If surgery is major or if diabetes is poorly controlled (blood glucose >200 mg/dl), an intravenous infusion of insulin and dextrose should be considered , and hourly intraoperative glucose monitoring is recommended.

Patients Treated With Oral Antidiabetic Agents[16]

Second-generation sulfonylureas should be discontinued 1 day before surgery, with the exception of chlorpropamide, which should be stopped 2–3 days before surgery. Other oral agents can be continued until the operative day. Although metformin has a short half-life of ~6 h, it is prudent to temporarily withhold therapy 1–2 days before surgery, especially in sick patients and those undergoing procedures that increase the risks for renal hypoperfusion, tissue hypoxia, and lactate accumulation. At a minimum, blood glucose should be monitored before and immediately after surgery in all patients. Those undergoing extensive procedures should have hourly glucose monitoring during and immediately following surgery. Bedside capillary blood glucose meters are adequate for these monitoring requirements. However, extremely high or low values should

immediately be repeated before instituting remedial action, and a simultaneous blood specimen should be sent for laboratory corroboration.

Insulin-Treated Patients[16]

Minor Surgery

Patients treated with long-acting insulin (e.g., ultra-Lente, glargine, protamine zinc insulin) should be switched to intermediate-acting forms 1–2 days before elective surgery. Close perioperative blood glucose monitoring is crucial to avoid extremes of glycemia. Intravenous insulin/glucose/potassium should be commenced before surgery. Blood glucose levels should be monitored hourly intraoperatively and immediately after surgery. The infusion should be stopped and usual insulin treatment resumed once oral intake is established. There should be a 1-h overlap between stopping intravenous insulin and re-instituting subcutaneous insulin.

Major Surgery

Insulin-treated patients undergoing major elective surgery should preferably be admitted 2–3 days before surgery, if glycaemic control is suboptimal (haemoglobin A1c >8%). If admission is not feasible, a physician or diabetes nurse practitioner should work with the patient to optimize self-monitoring of blood glucose (SMBG) values in the days preceding the planned surgery. In such circumstances, SMBG should be performed at least before each meal and at bedtime, with target pre-prandial values of 80–120 mg/dl and bedtime values of 100–140 mg/dl.23 The preoperative evaluation should include a thorough physical examination (with particular focus on autonomic neuropathy and cardiac status), measurement of serum electrolytes and creatinine, and urine ketones. The presence of autonomic neuropathy mandates increased surveillance for hypotension, respiratory arrest, and hemodynamic instability during surgery.Gross metabolic and electrolyte abnormalities (e.g., hyponatremia, dyskalemia, acidosis) should be corrected before surgery.

Intravenous infusion of insulin, glucose, and potassium is now standard therapy and has replaced subcutaneous insulin therapy for the perioperative management of diabetes, especially in type 1 diabetic patients and patients with type 2 diabetes undergoing major procedures. Several reports have emphasized the advantages of the insulin infusion regimen over subcutaneous delivery.It is not necessary to add albumin to the insulin infusion to prevent nonspecific adsorption of insulin to the infusion apparatus; flushing ~50 ml of the insulin infusion mixture through the tubing will accomplish the same purpose. Adequate fluids must be administered to maintain intravascular volume. Fluid deficits from osmotic diuresis in poorly controlled diabetes can be considerable. The preferred fluids are normal saline and dextrose in water. Fluids containing lactate (i.e., Ringer's lactate, Hartmann's solution) cause exacerbation of hyperglycaemia.[17]

Insulin[16]

Two main methods of insulin delivery have been used:

- Either combining insulin with glucose and potassium in the same bag (the GIK regimen) or
- Giving insulin separately with an infusion pump.

The combined GIK infusion is efficient, safe, and effective in many patients but does not permit selective adjustment of insulin delivery without changing the bag. The glucose component can be either 5 or 10% dextrose. The latter provides more calories. Regardless of whether separate or combined infusions are given, close monitoring is required to avoid catastrophe during these infusion regimens.

Regimen for Separate Intravenous Insulin Infusion for Perioperative Diabetes Management

- Prepare a 0.1 unit/ml solution by adding 25 units regular insulin to 250 ml normal saline.
- Flush 50 ml of insulin solution through infusion tubing to saturate nonspecific binding sites.
- Set initial infusion rate (generally, 0.5 unit/h [5 ml/h] for thin women; 1.0 unit/h [10 ml/h] for others
- Adjust infusion rate according to bedside blood glucose measurement as follows:

Blood Glucose (mg/dl)	**Insulin Infusion Rate**
<80	Check glucose after 15 min*
80–140	Decrease infusion by 0.4 unit/h (4 ml/h) No change
141–180	No change
181–220	Increase infusion by 0.4 unit/h (4 ml/h)
221–250	Increase infusion by 0.6 unit/h (6 ml/h)
251–300	Increase infusion by 0.8 unit/h (8 ml/h)
>300	Increase infusion by 1 unit/h (10 ml/h)

Glucose[16]

Adequate glucose should be provided to prevent catabolism, starvation ketosis, and insulin-induced hypoglycaemia. The physiological amountof glucose required to prevent catabolism in an average nondiabetic adult is ~120 g/day (or 5 g/h).

Regimen for Glucose-Insulin-Potassium (GIK) Combined Infusion[18]

	Glucose-Insulin-Potassium Infusion Rate	
Blood Glucose(mg/dl)	**5% Dextrose**	**10% Dextrose**
<80	↓ 5 units	↓ 10 units
<120	↓ 3 units	↓ 5 units
120–180	No change	No change
181–270	↑ 3 units	↑ 5 units
>270	↑ 5 units	↑ 10 units

5% dextrose: 1,000 ml containing 20 mEq KCl + 15 units regular insulin
10% dextrose: 1,000 ml containing 20 mEq KCl + 30 units regular insulin
Arrows indicate amount by which insulin in each 1,000-ml bag of infusate is to be decreased or increased.

Potassium[16]

The infusion of insulin and glucose induces an intracellular translocation of potassium, resulting in a risk for hypokalaemia. In patients with initially normal serum potassium, potassium chloride, 10 mEq, should be added routinely to each 500 ml of dextrose to maintain normokalaemia if renal function is normal. Hyperkalaemia (confirmed with repeat measurement and electrocardiogram) and renal insufficiency are contraindications to potassium infusion.

Sliding Scale Regular Humulin Insulin[19]

Check Blood Sugars

- AC and HS (6:30 AM, 11:30 AM, 4:30 PM and 9:30 PM)
- BID (6:30 AM and 4:30 PM)
- q 6 hours (recommended for patients receiving continuous nutrition over 24 hours)
- q 4 hours (recommended for patients requiring close monitoring)

REGULAR INSULIN SLIDING SCALE -STANDARD ORDERS-

Recommended Indications:

- As a supplement to a patient's usual diabetes medications (long- acting insulin or oral agents) to treat uncontrolled high blood sugars .
- For short term use (24-48 hours) in a patient admitted with an unknown insulin requirement .

Regimens:

Low Dose Scale :	Suggested starting point for thin and elderly, or those being initiated on TPN (total parenteral nutrition).
Moderate Dose Scale :	Suggested starting point for average Patient .
High Dose Scale :	Suggested for patients with infections Or those receiving therapy with high dose corticosteroids .

Blood Sugar (mg/dL)	**Low Dose Scale (unit)**	**Moderate Dose Scale (unit)**	**High Dose Scale (unit)**	**Patient-Specific Scale (unit)**
< 70	Initiate Hypoglycaemia Protocol	Initiate Hypoglycaemia Protocol	Initiate Hypoglycaemia Protocol	Initiate Hypoglycaemia Protocol
70-130	0	0	0	-
131-180	2	4	8	-
181-240	4	8	12	-
241-300	6	10	16	-
		12	20	-

301-350	8			
351-400	10	16	24	-
> 400	12 & call physician	20 & call physician	28 & call physician	-

POSTOPERATIVE MANAGEMENT [21]

If patient are well controlled preoperatively, Oral Hypoglycaemic Agents can be readministered at half the usual dose on the day diet resumed . Advancement to the patient's full regular medicine schedule can coincide with patient's return to regular diabetic diet ,assuming blood glucose is within acceptable level . patient taking metformin should withhold this medication for 3 days after surgery . Patient who have developed postoperative renal failure should not resume metformin until normal renal function is assured .

Patient who have started therapy on insulin coverage and have undergone major surgery or will be hospitalized , transition back to oral therapy must be approached differently . Once the patient begins to eating normally , the oral agents are resumed assuming that blood glucose is well controlled . However addition of a sliding scale dose of insulin may be needed during the transition period . Patient who have undergone major surgery & have developed complications such as infection are unlikely to return to their same preoperative diabetes status; thus , their insulin therapy regimen may need to be reconsidered and modified .

Post-Operative "Sliding Scale Insulin"[22]

"Sliding scale insulin" is NOT recommended for the post-operative management of diabetes when used as sole therapy.A "supplemental insulin protocol", which is given in addition to the patient's usual diabetes medication regimen, is more appropriate. In many institutions, a "sliding scale insulin" regimen has traditionally been used to manage hyperglycaemia, often in the post- operative setting. This involves the administration of prescribed doses of insulin when the BGL is within specified ranges, with insulin often being withheld when the BGL is within the normal range. The main problem with this approach is that, when given as sole therapy, it is retrospective and aimed at correcting rather than preventing hyperglycaemia. It usually results in under-insulinisation (and therefore hyperglycaemia), especially if opportunities to administer insulin are missed or insulin is not given when the blood glucose level is 'normal' (or low). In addition, the frequency of insulin administration is often not specified. Attention is not paid to the timing of insulin in relation to meals, nor is there any consideration of the pharmacokinetics of the injected insulin or of the individual patient's insulin sensitivity. The frequency of insulin administration is also dependent on the timing of BGL monitoring by the nursing staff. The "sliding scale insulin" approach is often a "set and forget" process and is usually not reviewed or adjusted by the medical team. "Sliding scale insulin", when used as sole therapy, can lead to inadequate, inappropriate or indiscriminate insulin administration, resulting in large swings in blood glucose levels without contributing to any understanding of the patient's true daily insulin requirement [Quale et al. 1997]. "Sliding scale insulin" is not recommended for the management of post-operative hyperglycaemia.

On the other hand, given the changing insulin requirements in the post-operative setting, there may be a place for a "supplemental insulin regimen". This is based on the patient's usual (or recently prescribed) insulin / oral AHG regimen, with provisions for supplemental or additional insulin if the BGL exceeds a certain threshold. This supplemental insulin is always in the short- or rapid- acting form and given before meals and supper. It is additional to any insulin already prescribed at that time, and it is reliant on BGL monitoring being performed at pre-determined time points. It is essential that daily medical review of the patient's BGLs and insulin requirements is undertaken, thereby enabling appropriate adjustment of the patient's insulin doses for the subsequent day.

HYPOGLYCEMIA[20]

Glucose is an obligatory metabolic fuel for the brain. Hypoglycaemia should be considered in any patient with confusion, altered level of consciousness or seizures. Counterregulatory responses to hypoglycaemia include insulin suppression and the release of catecholamines, glucagon, growth hormone and cortisol.Laboratory diagnosis is Plasma glucose level <2.5-2.8 mmol/L although the absolute glucose level at which symptoms occur varies among individuals.

It is essential that BGLs be monitored more frequently during this period and treatment requirements be reviewed on a daily basis. Should oral intake not be adequate and hypoglycaemia occur, the next dose of insulin should not be omitted (otherwise hyperglycaemia and possible ketosis may occur). Rather, the dose of insulin could be reduced by ~10% and the whole insulin treatment regimen reviewed. When oral intake is variable or unreliable, a basal- bolus insulin regimen is more appropriate, as the basal insulin can be continued, and the timing and doses of quick-acting insulin adapted according to the patients carbohydrate intake.

Many patients with diabetes not previously treated with insulin that require insulin in the post-operative period will also require insulin after discharge from hospital. Thus it is important to commence self-injection education for the patient as early as possible, in order to avoid delaying the patient's discharge unnecessarily.
Patients with diabetes that was poorly controlled (HbA1c ≥8%) prior to admission should have their treatment reviewed and adjusted as appropriate either during their admission (major surgery) or following discharge (minor surgery).
Patients not previously known to have diabetes who are found to be hyperglycaemic post-operatively, should have their HbA1c measured and be managed as if they had diabetes until they have recovered from their surgery and resumed their usual diet and activity. If their HbA1c is ≥7%, then it is likely that diabetes was present, but undiagnosed, prior to admission. It should not be assumed that post-operative hyperglycaemia in someone not previously known to have diabetes is a stress response that does not require treatment and that does not require further evaluation after discharge from hospital.

DIABETIC KETOACIDOSIS[20]

DKA is initiated by inadequate levels of plasma insulin . Most commonly, DKA is precipitated by increased insulin requirements, as might occur duringa concurrent illness. Failure to augment insulin therapy often compounds the problem. Occasionally, complete omission of insulin by the patient or health care team (in a hospitalized patient with type 1 DM) precipitates DKA. Patients using insulin in- fusion devices with short-acting insulin are at increased risk of DKA, since even a brief interruption in insulin delivery (e.g. mechanical malfunction) quickly leads to insulin deficiency.
After confirmingthe diagnosis (plasma glucose, positive serum ketones, metabolic acidosis), treatment should be as administered.
1.Replace fluids: 2–3 L of 0.9% saline over first 1–3 h (10–15 mL/kg per hour); subsequently, 0.45% saline at 150– 300 mL/h; change to 5% glucose and 0.45% saline at 100–200 mL/h when plasma glucose reaches 250 mg/dL (14 mmol/L).
2. Administer short-acting insulin: IV (0.1 units/kg) or IM (0.3 units/kg), then 0.1 units/kg per hour by continuous IV infusion; increase 2- to 3- fold if no response by 2–4 h. If initial serum potassium is < 3.3 mmol/L (3.3 meq/L), do not administer insulin until the potassium is corrected to > 3.3 mmol/L .
4. Measure capillary glucose every 1–2 h; measure electrolytes (especially K+, bicarbonate, phosphate) and anion gap every 4 h for first 24 h.
5. Monitor blood pressure, pulse, respirations, mental status, fluid intake and output every 1–4 h.
6. Replace K+: 10 meq/h when plasma K+ < 5.5 meq/L, ECG normal, urine flow and normal creatinine documented; administer 40–80 meq/h when plasma K+ < 3.5 meq/L or if bicarbonate is given.
7. Continue above until patient is stable, glucose goal is 150–250 mg/dL, and acidosis is resolved. Insulin infusion may be decreased to 0.05–0.1 units/kg per hour.
8. Administer intermediate or long-acting insulin as soon as patient is eating. Allow for overlap in insulin infusion and subcutaneous insulin injection.

HYPERGLYCEMIC HYPEROSMOLAR STATE[20]

Volume depletion and hyperglycaemia are prominent features of both HHS and DKA. Consequently, therapy of these disorders shares several elements . In both disorders, careful monitoring of the patient's fluid status, laboratory valuesand insulin infusion rate is crucial. Underlying or precipitating problems should be aggressively sought and treated. In HHS, fluid losses and dehydration are usually more pronounced than in DKA due to the longer duration of the illness. The patient with HHS is usually older, more likely to have mental status changes, and more likely to have a life-threatening precipitating event with accompanying comorbidities. Even with proper treatment, HHS has a substantially higher mortality than DKA (upto 15% in some clinical series). Fluid replacement should initially stabilize the hemodynamic status of the patient (1–3 L of 0.9% normal saline over the first 2–3 h). Because the fluid deficit in HHS is accumulated over a period of days to weeks, the rapidity of reversal of the hyperosmolar state must balance the need for free water repletion with the risk that too rapid a reversal may worsen neurologic function. If the serum sodium > 150 mmol/L (150 meq/L), 0.45% saline should be used. After hemodynamic stability is achieved, the IV fluid administration is directed at reversing the free water deficit using hypotonic fluids (0.45% saline initially then 5% dextrose in water, D5W). Thecalculated free water deficit (which averages 9–10 L) should be reversed over the next 1–2 days (infusion rates of 200–300 mL/h of hypotonic solution). Potassium repletion is usually necessary and should be dictated by repeated measurements of the serum potassium. In patients taking diuretics, the potassium deficit can be quite large and may be accompanied by magnesium deficiency. Hypophosphatemia may occur during therapy and can be improved by using KPO4 and beginning nutrition.

As in DKA, rehydration and volume expansion lower the plasma glucose initially, but insulin is also required. A reasonable regimen for HHS begins with an IV insulin bolus of 0.1 units/kg followed by IV insulin

at a constant infusion rate of 0.1 units/kg per hour. If the serum glucose does not fall, increase the insulin infusion rate by twofold. As in DKA, glucose should be added to IV fluid when the plasma glucose falls to 13.9 mmol/L (250 mg/dL), and the insulin infusion rate should be decreased to 0.05–0.1 units/kg per hour. The insulin infusion should be continued until the patient has resumed eating and can be transferred to a SC insulin regimen. The patient should be discharged from the hospital on insulin, though some patients can later switch to oral glucose- lowering agents.

III. Conclusion

Therapeutic surgery is a frequent requirement for diabetic patients and in the past has been associated with increased morbidity and mortality. Clinicians are encouraged to continue to give careful attention to metabolic control in surgical patients with diabetes. Maintaining good glycaemic control during the peri-operative period results in improved outcomes following surgery. In order to keep blood glucose levels within the target range, diabetes medications often need to be altered immediately before and following surgical procedures. There may be great individual variation in the impact of surgery and the adjustments to therapy required, depending on the pre-existing diabetes status of the patient, the nature of the surgery and the presence of post-operative complications. Therefore, management of patients with diabetes in the pre-operative, peri-operative and post-operative periodis complex, and requires a close working relationship and effective communication between surgeons, physicians and anaesthetists.

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