
CLINICAL MANAGEMENT OF DIABETES MELLITUS DURING ANAESTHESIA AND SURGERY

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INTRODUCTION

Diabetes is a condition where the cells of the body cannot metabolise sugar properly, due to a total or relative lack of insulin. The body then breaks down its own fat, proteins and glycogen to produce sugar, resulting in high sugar levels in the blood (hyperglycaemia) with excess by-products called ketones being produced by the liver.

There are two main types of diabetes (table 1) which classically affect different age groups. In reality there is a huge overlap between age groups.

Diabetes causes disease in many organ systems, the severity of which may be related to how long the disease has been present and how well it has been controlled. Damage to small blood vessels (diabetic microangiopathy) and nerves (neuropathy) throughout the body results in many pitfalls for the unwary anaesthetist. The following

guidelines should help to identify these problems and cope with them.

Preoperative assessment. The general preoperative assessment has been reviewed in a previous article. Update in Anaesthesia in 1997;7.

Specific problems arise:

Cardiovascular- diabetics are more prone to hypertension, ischaemic heart disease, cerebrovascular disease, myocardial infarction which may be silent and cardiomyopathy. Damage to the nerves controlling the heart and blood vessels (autonomic neuropathy) may result in sudden tachycardia, bradycardia or a tendency to postural hypotension. A history of shortness of breath, palpitations, ankle swelling, tiredness and of course chest pain should therefore be sought and a careful examination

Table 1.	Classification of diabetes mellitus *	
	Insulin Dependent (Type I)	Non Insulin Dependent (Type II)
Age of onset	Infancy to twenties	Sixties onwards, occasionally younger
Pathology	Pancreas unable to produce insulin (autoimmune disorder)	Body unable to use insulin properly
Treatment	Insulin	Diet and oral hypoglycaemics.

* Note. This is a general classification and there is considerable overlap. Obesity is a common cause of Type II- the pancreas cannot make enough insulin for the body size. Diet /oral hypoglycaemics may initially be enough but eventually insulin may be required.

for heart failure (distended neck veins, ankle swelling, tender swollen liver, crackles heard on listening to the chest) made. A preoperative ECG should be performed. Heart failure is a very serious risk factor and must be improved before surgery with diuretics. Table 2 describes how to test clinically for autonomic neuropathy.

Renal - kidney damage may already be present, often indicated by the presence of protein (albumin) in the urine. Urine infections are common and should be treated aggressively with antibiotics. The diabetic is at risk of acute renal failure and retention postoperatively. Blood electrolyte measurement (if possible) may reveal a raised urea and creatinine. If the potassium is high (> 5 mmol/l) then specific measures should be taken to lower it before surgery.

Respiratory - diabetics, especially if obese and smokers, are particularly prone to chest infections. Chest physiotherapy pre and postoperatively are indicated, with nebulised oxygen and regular bronchodilators (salbutamol 2.5-5mg in 5ml saline) if wheeze is heard. A chest X-ray, blood gases and spirometry are the gold standard investigations, but careful repeated clinical assessment will

usually reveal when a patient is as good as they are going to get. Non-emergency surgery should be delayed until this point.

Airway - thickening of soft tissues occurs eg ligaments around joints. If the neck is affected there may be difficulty extending the neck, making intubation difficult. To test if the patient is at risk, ask them to bring their hands together as in praying. If they cannot have the fingers of each hand flat against the other hand, then they probably have ligament thickening of the finger joints, and difficult intubation should also be anticipated.

Gastrointestinal - the nerves to the gut wall and sphincters can be damaged. Delayed gastric emptying and increased reflux of acid make them more prone to regurgitation and at risk of aspiration on induction of anaesthesia. A history should be sought of heartburn and acid reflux when lying flat; if present they should have a rapid sequence induction with cricoid pressure, even for elective procedures. If available, prescribe an H₂ antagonist and metoclopramide as a premedication. Ranitidine 150mg or cimetidine 400mg plus metoclopramide 10mg orally 2 hours preoperatively to reduce the volume of stomach acid.

Table 2: Detecting autonomic neuropathy

	Tests for autonomic neuropathy	Normal response	Abnormal response
Sympathetic System	Measure systolic blood pressure lying down then standing.	Decrease < 10 mm Hg	Decrease > 30 mm Hg
Parasympathetic system	Measure heart rate response to deep breathing	Increase rate > 15 beats /min	Increase < 10 beats /min

Note: if above detected, patient at risk of unstable BP, myocardial ischaemia, arrhythmias, gastric reflux and aspiration, inability to maintain body temperature under anaesthesia.

Eyes - cataracts are common, as is an abnormal growth of blood vessels inside the eye (retinopathy). The anaesthetist should try to prevent sudden rises in blood pressure that might rupture them, further damaging the eyesight. Ensure an adequate depth of anaesthesia, especially at induction.

Infection - diabetics are prone to getting infections that can upset their sugar control. If possible, delay surgery until these are treated. Wound infections are common. Great care should be paid to aseptic techniques when any procedure is undertaken.

Miscellaneous - diabetes may be caused or worsened by treatment with corticosteroids, thiazide diuretics and the contraceptive pill. Thyroid disease, obesity, pregnancy and even stress can affect diabetic control.

Blood and urine glucose monitoring - meter analysis (most accurate) or reagent strips (which employ a visual colour comparison with a pre-printed chart) are commonly available. It is vital that the instructions are properly followed for whatever method is used. Out-of-date strips will give an inaccurate reading. If strips are cut in half for economy (not recommended), then the unused portion must be carefully stored in a dry place. When using meters, ensure that the testing strips are properly matched for the meter. Remember, false readings could lead to the wrong, even life threatening treatment being given. Strips or tablets can also be used to test the urine for glucose or ketones. The same precautions apply.

Anaesthetic management:

Many of the operations diabetic patients face are a direct result of their disease. Skin ulcers, amputations and abscesses are amongst the commonest.

Preoperative assessment-

Timing - diabetic patients should be placed first on the operating list. This shortens their preoperative fast. Badly controlled diabetics need to be admitted to hospital one or two days before surgery if possible to allow their treatment to be stabilised.

Hydration - Glucose in the urine (glycosuria) causes a diuresis which makes the patient dehydrated and even more susceptible to hypotension. Check for dehydration (Table 3) and start an intravenous infusion.

Medication - all medications should be continued up until surgery. Surgery causes a stress response which will change the patient's insulin requirements. Treatment will need to be adjusted according to:

- the extent of the anticipated surgery
- whether the patient is insulin dependant (IDDM) or non-insulin dependant (NIDDM)
- the quality of their blood sugar control.

In general, if the patient can be expected to eat and drink within 4 hours of surgery, then it is classified as MINOR. All surgery other than minor is classified as MAJOR. Figures 1-4 give regimes for major and minor surgery and for NIDDM and IDDM.

The aim is to keep the blood glucose level within the range 6 -10 mmol/l at all times.

Special problems.

Low Blood Sugar (hypoglycaemia)-

The main danger to diabetics is low blood sugar levels (blood glucose < 4mmol/l). Fasting, alcohol, liver failure, septicaemia and malaria can cause this. The characteristic signs and symptoms of early hypoglycaemia are tachycardia, light-headedness, sweating and pallor. If hypoglycaemia persists or gets worse then confusion, restlessness, incomprehensible speech, double vision, convulsions and coma will ensue. If untreated, permanent brain damage will occur, made worse by hypotension and hypoxia.

Anaesthetised patients may not show any of these signs. The anaesthetist must therefore monitor the blood sugar regularly if possible, and be very suspicious of any unexplained changes in the patient's condition. If in doubt, regard them as indicating hypoglycaemia and treat.

Treatment - diabetic patients learn to recognise the early signs and often carry glucose with them to take orally. If unconscious, 50ml of 50% glucose (or any glucose solution available) given intravenously and repeated as necessary is the treatment of choice. If no sugar is available, 1mg of glucagon intramuscularly will help.

High Blood Sugar (hyperglycaemia)-

This is defined as a fasting blood sugar level > 6 mmol/l. It is a common problem found in many conditions other than diabetes eg - pancreatitis, sepsis, thiazide diuretic therapy, ether administration, glucose infusions, parenteral nutrition administration and most importantly, any cause of stress such as surgery, burns or trauma. Slightly elevated levels are thus commonly found after routine major surgery. It is usual to treat this only if the level is above 10 mmol/l. At this level, sugar is present in the urine and causes a diuresis which may result in dehydration, loss of potassium

(hypokalaemia) and sodium (hyponatraemia) ions. The blood thickens and this may cause clotting problems such as thrombosis, and could precipitate a crisis in a patient with sickle cell disease.

Assess the patient, rehydrate them and delay surgery if necessary. Remember the aim is a sugar level of 6-10 mmol/l. If the sugar is below 10 mmol/l, observe and recheck it hourly throughout the operation. Should it be above 10 mmol/l, then follow the regimes in figures 1 - 4, according to the extent of the surgery planned.

After surgery, the insulin requirements fall as the stress response subsides. Newly diagnosed diabetics need further investigation to establish whether they will need insulin therapy, oral hypoglycaemics or indeed just diet control.

Sometimes when the blood sugar has become very high, the patient becomes comatose (diabetic coma). It is vital to correct this by adhering to the general guidelines and regimes already mentioned. Aim to reduce the sugar levels to below 10 mmol/l. When this has happened over a few days, the body uses its own fat to produce energy, and this results in high levels of waste products (ketones) in the blood and urine - this is called **diabetic ketoacidosis** and is a medical emergency with a significant mortality.

Diabetic ketoacidosis

This may be triggered by infections or other illnesses such as bowel perforations and myocardial infarction. The patient will be drowsy or even unconscious with fast, deep breathing due to acid in the blood. The ketones make their breath smell sweetly, like acetone. Ketones can also be detected by the use of urine and blood testing strips.

Diarrhoea, vomiting, gastric dilatation (insert a nasogastric tube) or even severe abdominal pain may be present which can be misinterpreted as an acute surgical problem! As severe dehydration is usually present, surgery must be delayed until fluid resuscitation has commenced in order to avoid disastrous hypotension with induction agents. A urinary catheter will help monitor fluid balance, and an ECG and CVP line (to estimate the fluid deficit) are helpful. The aim is to slowly return the body chemistry to normal.

Give high flow oxygen therapy.

Although the blood potassium level is usually high, the body has actually lost large amounts in the urine, and extra potassium is required intravenously. It is important to lower the blood sugar level slowly, as reducing it too fast can result in further complications such as brain oedema and convulsions. Search for infections (chest X-ray, blood and

urine cultures) and treat with antibiotics. Blood gases and electrolyte measurements may also help management. figure 5 gives a regime for treatment.

Anaesthetic technique.

Intraoperative monitoring - record blood pressure and pulse every 5 minutes during the operation, and watch skin colour and temperature. If the patient is cold and sweaty, then suspect hypoglycaemia, check the blood glucose and treat with intravenous glucose

General anaesthesia - if gastric stasis is suspected then a rapid sequence induction should be used. A nasogastric tube can be used to empty the stomach and allow a safer awakening. There are no contraindications to standard anaesthetic induction or inhalational agents, but if the patient is dehydrated then hypotension will occur and should be treated promptly with intravenous fluids. Hartmanns solution (Ringers lactate) **should not** be used in diabetic patients as the lactate it contains may be converted to glucose by the liver and cause hyperglycaemia.

Sudden bradycardias should respond to atropine 0.3mg iv, repeated as necessary (maximum 2 mg). Tachycardias, if not due to light anaesthesia or pain, may respond to gentle massage on one side of the neck over the carotid artery. If not then consider a beta-blocker (propranolol 1mg increments: max 10mg total or labetalol 5mg increments: max 200mg in total).

IV induction agents normally cause hypotension on injection due to vasodilatation. If a patient has a damaged autonomic nervous system (and many diabetics do), then they cannot compensate by vasoconstricting, and the hypotension is worsened. Reducing the dose of drug and giving it slowly helps to minimise this effect.

Regional techniques - are useful because they get over the problem of regurgitation, possible aspiration and of course difficult intubation. However, the same attention should be paid to avoiding hypotension by ensuring adequate hydration. It is a wise precaution to chart any pre-existing nerve damage **before** your block is inserted.

With spinals and epidurals, autonomic nerve damage means the patient may not be able to keep their blood pressure in a normal range. Intervene early with ephedrine (6mg boluses) when the systolic pressure falls to 25% below normal.

Postoperative therapy regimes are also given in figures 1 - 4. It is not unusual to find that insulin requirements are reduced once the patient begins to recover from surgery.

Figure 1. Which regime for my patient ?	
1.	Decide on the type of surgery Minor - patients expected to eat and drink within 4 hours of operation Major - all other patients
2.	Then, is the patient Insulin or Non-insulin dependent ?
3.	Finally, are they - poorly controlled : delay surgery and change to soluble insulin three times daily <i>but</i> if surgery urgent, use Major surgery regime - well controlled : use the appropriate regime from the Major or Minor
<p>General Measures for all diabetics: Measure random sugar preoperatively - 4 hourly for IDDM - 8 hourly for NIDDM Test urine 8 hourly for ketones and sugar Place first on operating list Aim for a blood glucose of 6 - 10mmol/l</p>	

Figure 2. Minor Surgery	
<p>Non insulin Dependent Diabetics</p>	<p>Preoperatively - random blood sugar on admission < 10 mmol/l Normal medication until day of op > 10 mmol/l Follow as for MAJOR SURGERY</p> <p>Day of operation Omit oral hypoglycaemics Blood glucose- 1 hour preop and at least once during op (hourly if op > 1 hour long) postop - 2 hourly until eating then 8 hourly</p> <p>Postoperatively Restart oral hypoglycaemics with first meal</p>
<p>Insulin dependent Diabetics</p> <p>This regime only suitable for patients whose random sugar is < 10 mmol/l on admission, will only miss one meal preop & are first on the list for very minor surgery eg cystoscopy</p>	<p>Preoperatively Normal medication</p> <p>Day of operation No breakfast, no insulin, place first on list. Blood glucose- 1 hour preop and at least once during op (hourly if op > 1 hour long) postop - 2 hourly until eating then 4 hourly</p> <p>Postoperatively Restart normal S/C insulin regime with first meal</p>

Figure 3.

Major surgery

- All insulin dependent and non-insulin dependent who are poorly controlled (blood glucose >10mmol/l) (many NIDDM become insulin dependent during major surgery and will need managing as such. Regular glucose measurements will detect this).
- Normal medication until day of operation

Day of operation - Omit oral hypoglycaemics and normal subcutaneous (S/C) insulin

Blood glucose - check blood sugar (and potassium) 1 hour preop
then 2 hourly from start of infusion
at least once during operation
(hourly if op > 1 hour long)
at least once in recovery area
2 hourly post operatively

Regime 1 - no infusion pump available.

Start intravenous infusion of 5 or 10 % dextrose (500 ml bags) over 4 - 6 hours and add Insulin and Potassium Chloride (KCl) to each 500 ml bag as below. Change bag according to blood sugar level readings:-

Blood glucose (mmol/l)	Soluble insulin (units) to be added to bag	Blood potassium (mmol/l)	KCl (mmol) to be added to bag
< 4	No insulin		
4 - 6	5	<3	20
6 - 10	10	3 - 5	10
10 - 20	15	> 5	None
> 20	20		

* If blood potassium level not available, add 10 mmol KCl

Postoperatively

- *Non-insulin dependent* - stop infusion and restart oral hypoglycaemics when eating and drinking
- *Insulin dependent* - stop infusion when eating and drinking
 - calculate the total daily dose (units) of insulin the patient was taking preoperatively
 - give this as S/C Soluble insulin (Actrapid), divided into 3 - 4 doses in 24 hours
 - this may need to be adjusted up or down until blood sugar levels stable.
 - once stable restart normal regime

Remember that the patient may need additional fluids depending on surgery, blood loss etc.

Figure 4:

Major surgery - alternative regime**Regime 2 - for use with infusion pumps**

The insulin and dextrose infusions are given via separate infusion pumps. This allows better control than regime 1, but care is needed to ensure the separate lines do not become blocked, or that one infusion runs out leaving the other infusing alone.

Insulin infusion - 50 units insulin made up to 50 ml with saline (i.e. concentration is 1 unit per ml)

Blood glucose (mmol / l)	Insulin infused at (units / hour)
< 5	0
5.1 - 10	1
10.1 - 15	2
15.1 - 20	3
> 20	6 & review *

- If it is proving difficult to reduce the blood sugar level, then consider increasing the rate of insulin for each glucose level or also giving a bolus of Actrapid of 3 - 5 units.
- Patients normally on higher doses of insulin will need higher rates of insulin infusion.
- Dextrose infusion - 5 or 10 % dextrose infused at 100 ml per hour. Add 10 mmol KCl to each 500 ml of solution.
- Post op - follow instructions as in figure 3.

Summary

The diabetic patient presents the anaesthetist with many challenges. Careful attention to clinical signs and rapid action to prevent even suspected hypoglycaemia preoperatively should see them safely through their surgery. The goal is to keep things as normal as possible. Regional techniques are often safer than general anaesthesia, but require the same vigilance.

References:

1. Hirsch IB, McGill JB, Cryer PE, White PF. Perioperative management of surgical patients with diabetes mellitus. *Anesthesiology* 1991; 74: 346 - 59.
2. Alberti KGMM. Diabetes and surgery. *Anesthesiology* 1991; 74: 209 - 11.

Figure 5.

Treatment of Diabetic Ketoacidosis

Aims -

- rehydration (water and salt)
- lower blood sugar
- correction of potassium depletion

Start an intravenous infusion of 0.9 % saline as follows-

- 1 litre over 30 minutes
- then 1 litre over 1 hour
- then 1 litre over 2 hours.
- Continue 2 - 4 hourly until the blood glucose is below 15 mmol / l,
- then change to 5% glucose, 1 litre 2 - 4 hrly

Up to 6 -8 litres of fluid may be required or more. Use clinical signs BP, heart rate, CVP, conscious level to judge the amount.

Give soluble insulin (Actrapid) intramuscularly (IM) as follows-

- 20 units IM first dose then 6 units IM hourly
- measure the blood glucose hourly
- when the blood glucose is below 15 mmol/l, change to 6 units IM every 2 hours.

Once the patient has recovered and is eating/drinking, change to S/C insulin.

Potassium (K⁺) supplementation will be required-

There may be a high blood potassium initially, but this will fall as the sugar level comes down.

Measure the potassium hourly. Put 10 mmol K⁺ in the first litre of saline then 10 - 40 mmol in subsequent litres of fluid, depending on the plasma level (normal 3.5 - 5.0 mmol/l).

If potassium measurements are unavailable then put 10 mmol KCl in each litre of fluid.

Other measures- 100 % O₂. Blood gas estimation-if pH < 7.10, give 50 mmol of 8.4% bicarbonate. Usually acidosis will correct itself slowly as the sugar comes down. Emergency surgery can start once the rehydration and lowering of blood sugar is underway.

Table 3

Clinical signs of dehydration

Sign	Water loss (% body weight)
Thirst	< 5 %
Dry mouth	
Capillary refill > 2 seconds *	5 - 10 %
Decreased skin turgor *	
Orthostatic hypotension *	
Low intraocular pressure (soft eyes)	
Reduced urine output	
Low CVP/JVP	
Shock	> 10 %
Unconscious	

* Capillary refill - lift limb above level of heart, press on skin for 5 seconds, release and observe colour returning to area. Normal is < 2 seconds. Skin turgor - pinch skin on back of hand and release. Normally the fold of skin quickly falls back flat but if dehydrated stays folded or returns slowly. Orthostatic hypotension - a severe fall in BP when patient stands up causing fainting.