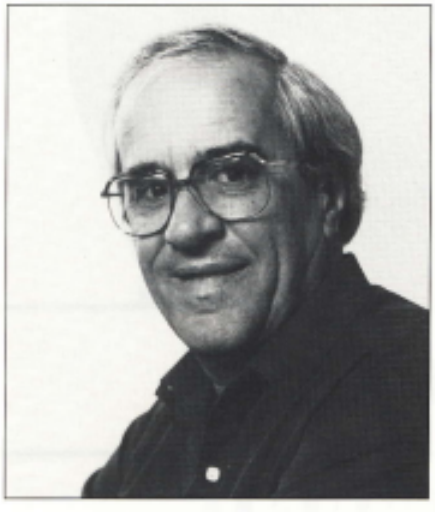
# Problems in Diabetes Management Part I. The Diabetic needing Surgery and the Addington Protocol — LI Robertson



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## Curriculum vitae

Dr LI Robertson studied at Cape Town University where he received the MB ChB in 1954. He did some post-graduate training at Mc Cord Zulu Hospital (Durban) and St Monica's Home (Cape Town), received the MFGP (SA) in 1975 and has been in Private Family Practice in Durban since 1957. He has a wide interest in different fields of medicine, and at the moment still holds the following posts: Senior Medical Officer - Diabetes Dept (Addington Hospital), Medical Director - Child Guidance & Research Centre (Durban/Westville), Medical Director - Institute of Human Sexuality. He also makes time to serve on several committees. He is Vice-chairman of the council of SA Academy of Family Practice/Primary Care; he is an elected member of the SA Medical and Dental Council and gives time to many other committees serving the community. Dr Robertson has presented many papers at Medical Conferences, has published several scientific papers and contributed to two medical textbooks. He is married to Barbara and have 4 children.

*Summary*

*This is Part I of the Diabetes Management, and describes why the Addington Protocol was developed and what it is. Of the 1,2 million diabetics in the RSA, half of them will require surgery at least once in their lifetime, and there is no standard method which has been successful in regulating all the surgical diabetic-patients because both surgical procedures and patients' physical states, vary too much. Even the indispensible "sliding scale", which junior consultants carry with them as part of their survival-kit, is doomed to fail. This need for a more predictable, logical and scientific method of maintaining glycaemic control in surgical patients (and in other diabetic complications) was identified, and met by the author, who developed this Addington Protocol to be used in the Addington Hospital in Durban. The protocol is explained, giving clear step-wise guidelines to the nursing staff, and looking at emergency surgery in diabetics. It concludes with the finding that, with adequate management during surgery, the mortality rate for patients with diabetes approximates that of the non-diabetic population.*

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KEYWORDS:
Surgery; Diabetes Mellitus; Management Teams, Institutional

Whilst there is no recent epidemiological evidence to verify the prevalence of the two main primary types of diabetes mellitus in the RSA a "guesstimate", based on known data, would indicate that there are about 1,2 million known and/or undiagnosed diabetics in South Africa. The majority of these are Type 2 diabetics but the number of Type

## A guesstimate of 1,2 million diabetics in the RSA

1 patients is certainly on the increase, and, interestingly, as well as ominously, this increase is also being noted in Blacks, and Indian South Africans, in which population groups this auto-immune, ketosis-prone form of the disease was hitherto seldom seen. On any given day, every ward in most hospitals, with the possible exception of the paediatric unit, will house two or three diabetics. This will apply particularly to the surgical wards.

Diabetes mellitus reaches its peak incidence in the fifth decade of life, the time when the need for surgery is also greatest in the general population. Diabetics are also more likely to develop disorders requiring surgery, such as occlusive vascular disease, severe tissue infection, eye problems, cholelithiasis,[1] as well as not infrequently requiring major procedures which combine major trauma with the use of diabetogenic drugs. 50% of diabetics will require surgery at least once in their lifetimes.[2] Undergoing surgery is the

## ... Problems in Diabetes Management: I

most frequent major stress to which diabetic patients are subjected, and even well-controlled, relatively mild diabetes may be disrupted by the multiple challenges of anaesthesia, surgical trauma, fluid and nutritional imbalance and altered physical activity.[3,4]

Because both surgical procedures and patients' physical states vary, there is no standard method for regulating all surgical candidates with diabetes. My observations would indicate that most interns and registrars bring with them, from their medical schools and previous training institutions, the so-called "*sliding scale*", despite the fact that this device has long been discarded by diabetologists worldwide. Briefly, the sliding scale, that indispensible part

Diabetics are more likely to develop serious disorders

of the Junior Consultant's survival-kit, based as it is on subcutaneous (and therefore unpredictably absorbed) insulin, and relying on historical data, is always doomed not to succeed. Add to this the fact that no two practitioners employ the same algorithm (and some individuals employ more than one algorithm even on the same patient on different days), and it is clear that there is a need for a more predictable, logical and scientific method of maintaining glycaemic control in surgical patients, and indeed in all diabetic patients hospitalised with diabetic complications or intercurrent disease. Except in the mildest NIDDM patients well-controlled on diet with minimal problems, this will involve the use of insulin. 98% of diabetics can be controlled on a total dose of insulin ranging from 0,4 to 1,2u per

## ... Problems in Diabetes Management: I

kg per day and one should aim at ultimately employing either a bd or basal/bolus regimen once the patient has recovered from the surgery or infection. In the acutely stressful period however there is NO substitute for intravenous insulin, which acts immediately and is inherently SAFE due to the fact that

### Every second diabetic will require surgery at least once

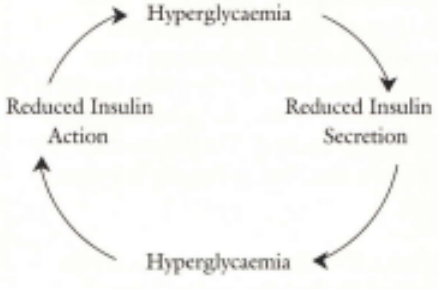
the half-life of intravenously administered insulin is 2 to 3 minutes. This protocol (which I shall from now on refer to as the *Addington Protocol*, as I orginally developed it for use in our surgical and medical obstetrics wards at the Addington Hospital in Durban) has been designed to have as few "moving parts" as possible in order not to impose unnecessarily on an already overburdened nursing and junior medical staff. Note that the only changes made are to the *rate* of infusion and that these are made on the basis of *capillary* blood-glucose estimations done in the wards. While this means that the path lab is not unduly strained, it does mean that the quality of capillary blood glucose estimations must be of the highest standard, that the ward reflectance meters must be checked and calibrated (by the suppliers, who will do this as a service, and *not* by the untrained hospital maintenance engineers) and that constant quality control venous blood comparisons must be sent to the lab to be performed on their Beckman or Yellow-Springs auto-analyser.

Further, it is in the interests of all of us, staff and patients alike, that the nurses doing the capillary blood checks are trained by one of our diabetes educators or by the representatives of the suppliers of the equipment, so that common mistakes are not perpetuated in teaching.

### The Addington Protocol

This is a regimen for all seasons. It may be used in all save the very severest cases of diabetic ketoacidosis, in all diabetics with sepsis or foot ulcers requiring hospitalisation, in diabetics with intercurrent medical disorders, and in Type 2 diabetics who are severely hyperglycaemic and no longer responding to conventional management with diet, exercise and oral hypoglycaemic agents (ie "secondary oral failure") and in whom the use of insulin is contemplated. Due to the well-known vicious cycle of

Figure 1




these patients with secondary oral failure require huge doses of subcutaneous insulin during the change-over. It has been our experience that after a few days of relative or absolute euglycaemia as can be achieved with the *Addington Protocol* these patients can often be controlled on low doses of subcutaneous insulin. We have also found that many of these patients can go back onto oral agents with improved control after this period of intravenous-insulin-induced normoglycaemia. This fact was confirmed in a few papers at the June 1991 International Diabetes Federation Meeting in Washington,

### Surgery is most stressful for a diabetic

at which it was recommended that ALL diabetics have a week a year spent on a glucose normalising infusion.

It would be ideal if we had infusion pumps in which case large volumes of fluid are avoided, but we have not found this a problem, nor has adsorption to the polythene of the drips bags or infusion line been an obstacle to good control. The insulin is added to the drip bag by suspending the drip from its loop and injecting *through* the polythene *not through the rubber stoppered valves.* These are suitable for injections employing syringes with long needles but insulin syringes have short needles and cannot pass the valve mechanism so that there is a danger of some of the insulin not getting into the fluid in the vacolitre, Leakage through the hole made in the polythene does not occur as insulin syringes have needles with a fine bore.

Forty (40) units of *soluble* insulin ("Actrapid HM ge" or "Humulin R") are added to 1000cc of either normal saline or 0,45% saline and run via a flow rate controller such as an IVAC.

## ... Problems in Diabetes Management: I

The rate to commence with is *100ml/hour which, using a 15 drop per ml drip set means a flow rate of 25 drops per minute.* As most of the nursing staff find it easier to deal with drops per minute and as all the infusion sets are 15 drops per ml, I shall confine the changes to increments or decrements of drops per minute.

A capillary (finger-prick) blood glucose is done at the commencement of the infusion, and this is repeated initially every 2 hours, and based on these estimations, the *flow rate* is changed in order to maintain a capillary blood glucose of between 4 and 7 mmols/ℓ. If the 2 hourly blood test is below 4 mmol/ℓ the *flow rate* is *decreased* by 5 drops per minute. If the 2 hourly blood glucose is above 7 mmol/ℓ the *flow rate* is *increased* by 5 drops per minute. In practice this range of blood glucose is achieved within 3 to 5 hours of commencing the infusion. Note that when the blood glucose drops to below 3 mmol/ℓ, the patient may experience mild hypoglycaemic symptoms which are easily relieved by giving half a glass of fruit-juice such

No standard method available for regulating surgical candidates with diabetes

as Liqui fruit. If the patient has hypoglycaemic symptoms at a time when a 2 hourly blood glucose test is not yet due, a finger prick test should be done immediately and, if found to be lower than 4 mmol/ℓ the rate should be reduced by 5 dpm and fruit-juice given.

Due to the reduced insulin requirements after midnight, it will be found that the drip rate usually is lower from midnight to 05h00 and that it needs to rise after this. *However, the same principles as indicated above, apply equally to the night staff and they should not allow their own personal anxiety to influence them to alter this management.* One has observed that the classic response of the night staff

Even mild, well-controlled diabetes could be disrupted by the multiple challenges of anaesthesia, fluid and nutritional imbalances

is to turn the flow rate down to the slowest possible rate the moment they find a lower than normal blood sugar. This results in elevated blood-glucose levels at "hand-over" time and hours are wasted trying to recover control. If antibiotics or other drugs have to be given by the intravenous route they should never be "piggy-backed" via the insulin infusion line, but given via another vein.

After a few days of tight glycaemic control in the case of the Type 2 diabetic with secondary oral failure, or when the infection or other acute process necessitating the infusion has been controlled, the patient has to be put back onto a conventional insulin regime, either a bd regime with a pre-mixed combination of soluble and intermediate-acting insulin such as Humulin 20-80, or Humulin 30-70, or Humulin 40-60 or Actraphane or, in the C-peptide negative Type 1 diabetic, onto a basal/bolus regime, for which we use Humulin L as our basal-delivery insulin at bedtime, and soluble insulin boluses pre-mealtimes. In the case of the bd regimen decide on the total dose based on the aforementioned range of 0,5 to 1,2 units per kg per day, and divide this into $^{2}/_{3}$ rds to be given before breakfast and $^{1}/_{3}$ rd before supper. However, my recent practice has been to divide the morning and evening doses equally.

In the case of a basal/bolus regimen, again decide on the total daily dose, preferably choosing a dose in the higher part of the range (again to avoid getting into the "hyper-glycaemia-begets-hyperglycaemia"-situation), and, in any case, an awareness of what a hypoglycaemic episode is, constitutes a very useful learning experience for the novice diabetic on insulin. And what better place to get it than in the ward?

The "sliding scale" which junior consultants rely on, is doomed to fail

The proportions of the total dose to be given are distributed as follows:

40% as bedtime basal Humulin L

25% as pre-breakfast soluble
15% as pre-lunch soluble
20% as pre-supper soluble

} Actrapid or Humulin R

### Very important

Particularly in the case of the totally Beta-cell depleted diabetic, this insulin infusion represents the *only* source of insulin and some 3 minutes after ceasing the infusion the patient

## ... Problems in Diabetes Management: I

has no insulin supply. *Therefore, whatever insulin regimen is chosen to follow the infusion, you should have a sufficiently long overlap to ensure that the subcutaneous insulin is having its effect before removing the insulin-containing drip.* In practice I would recommend an overlap of 24 hours, as the only effect would be that the

Night staff needs to be trained strictly and carefully, otherwise they can waste many hours trying to recover control

intravenous drip rate will be correspondingly slower due to the additional subcutaneous insulin.

In the case of previously well-controlled Type 2 diabetics who have only required insulin infusion because of infection or surgery, it may be possible to get them back on to oral hypoglycaemic agents once the acute need has passed.

### Patients undergoing surgery

For Type 1 patients who are in good control on basal/bolus regimens who are having minor procedures requiring only a short period of anaesthesia, it is sufficient to give the previous night's basal dose, book the patient to be done first thing in the morning, omit both breakfast as well as the pre-breakfast bolus insulin, and, provided the nature of the procedure allows the patient to have lunch, there is no need to put up a glucose-containing drip and the patient gets back on to his routine with the usual pre-lunch soluble bolus followed by lunch. If there is a degree of nausea and uncertainty as to whether lunch will be retained, simply give lunch, and if it is tolerated, follow with the lunch time insulin.

During minor surgery of short duration the Type 2 diabetic controlled on diet or low-dose sulphonylureas will probably not require exogenous insulin, but for all other elective or emergency surgery, the management principles below apply to both Type 1 and Type 2 diabetics.

1. Schedule the operation as early as possible.
2. Obtain fasting blood glucose and electrolyte values. (Note: If the patient has been on the Addington Protocol prior to surgery, the chances are that surgery will commence with an euglycaemic patient with normal potassium and other electrolyte values).

Emergency surgery is more common with diabetics than in non-diabetics

3. Start an infusion with 1000cc *Maintelyte* (with 10% glucose) with added soluble insulin (Actrapid or Humulin R):-

   20u if the blood glucose is 6 mmol/L or less.

   32u if the blood glucose is 10 mmol/L or more.

   26u if the blood glucose is 6,1 to 9,9 mmol/L.

This "GKI" or "PIG" (glucose, insulin, potassium) mixture is run via an ivac or similar rate-minder at 100ml/hour (ie 25 drops per minute) throughout the surgery and post-operatively and until the patient is taking feeds and should *not* be disturbed at any stage, *particularly not for introducing anaesthetic agents or "piggy-backing".* Blood glucose estimations are performed hourly during the operation and if the result is OUTSIDE the range, which

Mortality rate for surgery patients with diabetes is the same as for non-diabetic patients

determined the original amount of insulin added to the maintelyte, change to a fresh vacolitre of maintelyte containing the indicated amount of insulin. The removed vacolitre is not discarded but clamped, as it may be required later in the procedure.

After full recovery, the patient may return to the original treatment, either oral agents and diet or one of the insulin regimes, or, if there is still sepsis or other complications but the patient is on full diet, the Addington Protocol may be reverted to.

### Emergency Surgery

Emergency surgery is more common in patients with diabetes than in non-diabetic individuals, probably due to their greater susceptibility to acute vascular catastrophes and especially to infection such as gangrenous cholecystitis, necrotising fasciitis and other conditions which induce rapid decompensation. Physicians usually

## ... Problems in Diabetes Management: I

prefer to attempt, for two to four hours, to improve metabolic control and rehydrate the patient. However, in some cases of sepsis such as abscess formation, delay in operating merely increases the risks, and, in any case, insulin resistance and the metabolic decompensation associated with infection, will respond only after the source of infection has been treated properly with antibiotics incision and drainage, or excision. Conventional treatment as for diabetic keto-acidosis is instituted immediately with rapid administration of saline (1000cc in one hour and 500cc hourly thereafter). Soluble insulin 10u to 20u is given as a stat intravenous bolus injection along with 10u of insulin hourly via an infusion pump if available or by hourly boluses via the drip tubing. Potassium is replaced by giving the chloride and phosphate salts alternatively in doses sufficient to prevent hypokalaemia but not produce hypocalcaemia. Severe metabolic acidosis (pH less than 7,1) is treated with sodium bicarbonate, 100mEq. Suspect lactic acidosis if the anion gap cannot be attributed entirely to the serum ketone-body concentration. If the lactic acid concentration is elevated (more than 6,0 mmol/L) additional bicarbonate will be required.

A central venous pressure line is advisable.

Nasogastric suction is required for patients with gastric distension or vomiting.

Note that patients with hyperosmolar non-ketotic states require *less* insulin, whilst obese patients or ones with severe sepsis require *more*.

As in diabetic keto-acidosis, once blood glucose levels drop to 13,9mmol/L or less, 5% dextrose in saline, or half normal saline is substituted for the saline.

### Mortality and Morbidity

With adequate management the mortality rate amongst patients with diabetes during surgery approximates that of the non-diabetic population, regardless of the type of surgery.[5] Cardiovascular diseases associated with atherosclerosis and hypertension are the leading morbidity causes of deaths, followed by infection.[6] Increased morbidity and length of hospitalisation apply to at least 20% of patients with diabetes following surgery however, due to vascular complications, infection and delayed wound healing.[3]

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