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Inpatient diabetes care: evaluation and intervention.

Thesis

In fulfilment of requirements for the degree Philosophiae Doctor

By

Daniel Gerhardus van Zyl

Supervisor: **Prof Paul Rheeder**

University of Pretoria

Declaration

I, **Daniel Gerhardus van Zyl** hereby declare that the work on which this thesis is based is original and my own work (except where acknowledgements indicate otherwise), and that neither the whole work or any part of it has been, is being or shall be submitted for another degree at this or any other university or institution.

Abstract

This thesis consists of 3 components. The first consisted of an audit of inpatient glycaemic control; this was followed by an intervention which attempted to improve the inpatient glucose control, followed by a second audit to assess how well the intervention succeeded in improving glycaemic control. The second component assessed the knowledge and attitudes of hospital staff regarding inpatient management of diabetes. The third component consisted of a randomized controlled trial evaluating whether Ringer's lactate or 0.9% Sodium chloride solution is superior in the resuscitation of patients with diabetic ketoacidosis.

The intervention to improve the quality of inpatient diabetes management consisted of a physician and nurse training programme as well as the introduction of a structured inpatient management protocol for diabetic inpatients. The mean blood glucose on day one of the second audit was significantly higher than that of the first audit (1.72 mmol/L higher, $p < 0.001$). A significant improvement from day 1 to day 7 was seen in audit 2 (-1.88 mmol/L, $p < 0.001$), which was not significant in audit 1 (- 0.88 mmol/L, $p = 0.33$). The proportion of patients achieving glycaemic control did not significantly differ between the two audits (43.0% versus 43.7%, $p = 0.97$). Even after adjustment for baseline differences between the two audits no difference in glycaemic control could be demonstrated.

The second component evaluated the perceptions, knowledge and attitudes of health care providers at Kalafong hospital regarding care of diabetic inpatients. A survey of 54 doctors and 61 nurses taking care of inpatients (response rate of 82%), using the DAS3 scale and the diabetes knowledge questionnaire of O'Brien, indicated that 80.9% felt that special training for management of diabetic patients is needed, 90.5% realised that diabetes is a serious condition and 92.2% valued the importance of tight glycaemic control. Despite this perception of importance, the knowledge of doctors and nurses caring for diabetic inpatients were suboptimal.

The third component reports on a double blind randomised controlled trial to assess if Ringer's lactate solution is superior to 0.9% Sodium chloride solution in the normalisation of pH in patients with diabetic ketoacidosis. The study analysed 27 patients allocated to each arm of the study. The time to normalisation of venous pH (pH > 7.32) was not significantly different between the two arms of the study (HR: 1.863, CI: 0.937 to 3.705). The time to reach a blood glucose of 14 mmol/L was significantly longer in the Ringer's lactate group (410 minutes) compared to the 0.9% Sodium chloride group (300 minutes) (p = 0.044). Patients treated with Ringers lactate needed significantly more insulin during the first six hours of treatment (44 units versus 36 units, p = 0.02). No difference between the two groups could be demonstrated in time to resolution of DKA (p = 0.758). The overall conclusion of this study is that there is no significant benefit in using Ringer's lactate solution as initial resuscitation fluid compared to the currently advised 0.9% Sodium chloride solution.

Keywords: Diabetes, Inpatient, Glycaemic control, Knowledge, Attitudes, Inpatient diabetes management protocol, Audit, Diabetic Ketoacidosis, Ringer's lactate solution, 0.9% sodium chloride solution.

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List of Abbreviations

0.9% NaCl - 0.9% Sodium Chloride solution
AACE - American Association of Clinical Endocrinologists
ACE - American College of Endocrinology
ADA - American Diabetes Association
Anti-GAD antibodies - Anti-Glutaminic AcideDecarboxylase antibodies
CI - Confidence interval
CO_2 - Carbondioxide
DAS - Diabetes Attidude Scale
DIGAMI - Diabetes mellitus Insulin-glucose infusion in Acute Myocardial Infarction
DKA - Diabetic Ketoacidosis
EURODIAB study - European Diabetes Study
HbA1C - Glycated Haemoglobin
HIV - Human Immunodeficiency Virus
hly - hourly
HR - Hazard Ratio
ICU - Intensive Care Unit
IQR - Inter Quartile Range
IV - Intravenous
JEMDSA - Journal of Endocrinology Diabetes and Metabolism of South Africa
K^+ - Potasium ion
Na^+ - Sodium ion
NaCl - Sodium Chloride
$NaHCO_3$ - Sodium bicarbonate
NPH - Neutral Protein Hagedörn
PCO_2 - Partial carbondioxide pressure
PO_4 - Phosphate
RR - Relative Risk
SA Fam Pract - South African Journal of Family Practice
SD - Standard Deviation
SPSS - Statistical Package For Social Sciences
ß-OHB - Beta-hydroxybuterate
TEN - Total Enteral Nutrition
TPN - Total Parenteral Nutrition

Contributors and acknowledgements

Chapter	Contributor	Contribution
Chapter 1:	DG van Zyl	Planning of chapter Literature search Writing of chapter
	Prof Paul Rheeder	Supervisor
Chapter 2:	DG van Zyl	Research idea Writing of protocol Data analysis Writing of chapter and paper Submission of paper for publication
	Prof Paul Rheeder	Supervisor
	Zelda van der Merwe Lorette Venter (Paid research assistants)	Review of patient hospital records Data capturing
Chapter 3	DG van Zyl	Research idea Writing of protocol Data collection Data analysis Writing of chapter and paper Submission of paper for publication
	Prof Paul Rheeder	Supervisor
Chapter 4	DG van Zyl	Research idea Writing of protocol Writing of diabetes inpatient management protocol for use in hospital wards Training of medical staff in diabetes inpatient managemen Data analysis Writing of chapter
	Prof Paul Rheeder	Supervisor Analysis of serial data
	Ane Lombaard (Paid research assistant)	Training of nursing staff in inpatient diabetes management in the wards at Kalafong hospital Data collection for the second audit

Chapter 5	DG van Zyl	Writing of chapter and paper Submission of paper for publication
Chapter 6	DG van Zyl	Research idea Writing of protocol Coordinating execution of study at Kalafong hospital Preparation of trial materials Data analysis Writing of chapter and paper Submission of paper for publication
	Prof Paul Rheeder	Supervisor Research idea
	E Delport	Coordinating execution of study at Steve Biko Academic hospital
	Debbie Schmidt (Paid data capturer)	Data capturing
	Registrars and medical officers of Department of Internal Medicine	Management of patients with DKA and following the prescribed patient management protocol

This thesis is based on a number of studies done in the department of internal medicine at Kalafong and Steve Biko Academic hospitals. I firstly would like to acknowledge all medical officers and registrars who diligently see diabetic inpatients every day and record notes, which formed an integral part of the studies reported. Secondly, to nursing staff who are caring for patients and are often not sufficiently recognized for the role the play. Thirdly, to the dieticians at Kalafong hospital who are so dedicated to the nutritional care and diabetes education of diabetic inpatients.

Two people need to be specifically recognised for their contribution:

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CHAPTER 1

Importance of inpatient hyperglycaemia

Introduction

The management of diabetes over the last 60 years has changed from focussing on the management and prevention of coma, to the prevention of long term micro- and macro-vascular complications. This shift in focus has changed the aim of glycaemic control from sufficient control to keep patients out of hospital, to intensive control aimed at preventing late diabetes complications.[1]

Epidemiology of diabetes

Type 2 diabetes is globally the predominant form of diabetes and accounts for 90% of all cases of diabetes. In both developed and developing countries diabetes has become an epidemic and it seems that the burden of this disorder occurs disproportionately in non-European populations: Hispanic, Native American, Pacific and Indian Ocean island populations, with Indian and Australian Aboriginal communities on top of the list. Certain populations where diabetes was practically non-existent 50 years ago now have diabetic populations that constitute 40% of the population, e.g. the Pacific island of Nauru.[2]

The 2010 global burden of diabetes is estimated to be 285 million people or a prevalence of 6.6% for the age groups 20 to 79 years. This number is expected to rise by 50% over the next 20 years, to 438 million people by 2030 (prevalence of 7.8%).[2 3]

In South Africa the prevalence of diabetes varies from 3% to 28% depending on the population studied, the age range and whether the population is rural or urban (table 1). With the International Diabetes Foundation estimating the prevalence of diabetes in South Africa in the adult population to be between 4.5% and 5%.[3]

Table I: Prevalence of type 2 diabetes in different populations in South Africa.[4]

Population	Region (number of participants)	Prevalence (%)	Age range (years)	Reference
African	Cape Town, urban (729)	8.0	30 +	Diabetes Care 1993;16:601
African	QwaQwa, rural (853)	4.8	25 +	S Afr Med J 1995;85:90
African	Mangaung, urban (758)	6.0	25 +	S Afr Med J1995;85:90
African	Durban, urban (479)	5.3	15 +	S Afr Med J 1993;83:641
Coloured	Cape Town, urban (200)	28.7	65 +	S Afr Med J 1997;87 (suppl 3):364
Coloured	Cape Town, peri-urban (974)	10.8	15 - 86	Diabet Med 1999;16:946
European	Durban, urban (396)	3.0	15 - 69	S Afr Med J 1994;84:257
Indian	Durban, urban (2479)	13.0	15 +	Diabetes Care 1994;17:70

Diabetes in hospitalized patients

Hospitalized patients frequently have diabetes as a co-morbid condition. Because of the nature of diabetes and its related complications, diabetic patients, are more prone to be admitted to hospital. For the non-internist diabetes is frequently a problem that complicates the care of the primary problem for which the patient is admitted.

Three groups of patients can be recognized with inpatient hyperglycaemia. Firstly, patients with known diabetes, admitted for diabetes related or unrelated reasons. Secondly, the group of patients with hyperglycaemia discovered for the first time while in hospital that persists after discharge, and thus constitutes newly diagnosed diabetic patients. The third group of patients are patients who have hyperglycaemia whilst in hospital, which resolves before or after discharge. This third group of patients are often referred to as “hospital related” or “stress” or “transient” hyperglycaemia. The inpatient risk related to the second and third groups of patients seems to be increased (see below). However, up to now no prospective study specifically investigated transient stress related hyperglycaemia as an entity separate from patients with hyperglycaemia in general.[5]

Frequency of admission of diabetic patients

Diabetic patients are more prone to be admitted to hospital and it is a frequent co-morbid condition in hospitalized patients. The relative risk for hospital

admission for people with diabetes is 2.97 and for people with diabetes and hypertension are 3.44 in comparison with patients without these risk factors.[6 7] .In the United States of America diabetes is the fourth most common co-morbid condition complicating all hospital discharges. For example: diabetes was present in 9.5% of all hospital discharges and 29% of all patients undergoing cardiac surgery in 1997.[6]

Diabetes also contributed significantly to prolonged hospital stay, as well as inpatient mortality. The median length of hospital stay was 22 days (2 to 300 days), which is significantly longer than the median stay for all patients in the district (less than 10 days).[8]
Masson et.al.[8] assessed the outcome of a cohort of diabetic inpatients in an urban health district in the United Kingdom. They found that 8.4% of all hospitalized patients were suffering from diabetes; of these 55% were medical, 16% general surgery patients and the remaining 29% from all other departments. Of all the diabetic patients, 14.5% died during that admission and 10.1% died of macro-vascular disease.

In the study by Robins and Webb[9] diabetes contributed 32.8% excess odds of rehospitalisation in comparison to patients who did not have diabetes. In 2006 data from the California state inpatient dataset 26.3% of diabetic patients admitted was readmitted within three months of the index admission.[10]

Reasons for admission of diabetic patients

Patients with diabetes frequently need admission to hospital for a variety of reasons, which can be related to diabetes or not:[11]

- Life threatening acute metabolic complications
- Newly diagnosed type 1 diabetes
- Substantial and chronic poor metabolic control that necessitates close monitoring
- Severe chronic complications of diabetes
- Uncontrolled or newly discovered diabetes in pregnancy requiring insulin

- Introduction of insulin pump therapy or other intensive insulin regimens

Jiang [12] stated that 6.1% of all admissions were for acute diabetic complications, 25.1% had chronic diabetes complications and 91.7% had major cardiovascular diseases including hypertension, in 76.6% of patients.
Diabetic patients are liable to suffer from all other conditions similar to the non-diabetic population and are frequently admitted to hospital for reasons not related to diabetes. In the study by Hongsoo et al.[10] 56.7% of all patients with unscheduled admissions and 57.1% of scheduled admissions were for diabetes complications or for conditions other than the diabetes itself.

Cost of management of diabetic inpatients

Diabetic patients' hospital admissions are costly, and this cost is usually related to complications of the disease.
Jiang et.al.[7] used the healthcare cost and utilization project data of 1999 of five states of the USA to assess the extent of hospitalizations and costs in patients with diabetes. She concluded that 70% of patients with diabetes were admitted once, 18.1% twice and 11.9% thrice. The average cost of hospital stay was $ 8 508 for patients admitted once, and $ 23 119 for patients admitted repeatedly. The average length of stay was 6.8 days for patients admitted once and 7.4 days per stay for those admitted more than once.
Health care cost of people with diabetes is at least 2.5 times more expensive than that of the non-diabetic control populations (matched for age and gender), and about 5 times as expensive as the average for the entire population.[7]
From the Helsinki study[13] excess cost caused by diabetes inpatients was $ 25 506 000. This amounts to 55.6% of the total cost of management of inpatients with diabetes. Hospital care contributed 49.5% to the total cost of diabetes care.
The percentage excess cost for hospital care of macro-vascular complications was 17.9%, micro-vascular complications was 4.9% and for illness unrelated to diabetes 28.7%.

From a recently published study assessing the cost of hospital care for patients with diabetes; the mean cost per admission for patients with diabetes is £ 2 103.90 in comparison to that for non-diabetic patients of £ 1 487.00.[14]

Glycaemic control and outcome

Strong evidence of improved hospital outcomes exist for patients in intensive care and coronary care settings using intravenous infusions of insulin, but data for general medical and surgical inpatients similar outcome data is sparce. There is a lack of randomized clinical trials in settings outside intensive care and coronary care units.[15]

Physiological mechanisms explaining hyperglycaemia in patients, experiencing stress due to disease, which require hospital admission, are well described. These conditions promote a decrease in insulin secretion and induce an increase in insulin resistance. Protection against adverse outcomes may be influenced by numerous metabolic and non-metabolic mechanisms related to control of hyperglycaemia.[15]

Sufficient evidence is available to confirm that blood glucose control is extremely important in the management of diabetes, whether as an in- or out-patient. Complications are seen more often in diabetic patients who are seriously ill, have wounds or are undergoing surgery. This applies to patients who are known to have diabetes as well as undiagnosed patients presenting with hyperglycaemia for the first time on admission.

Inpatients admitted to general hospital wards

Umpierrez et.al.[16] reviewed 1886 admissions for the presence of hyperglycaemia (fasting glucose ≥7 mmol/l or random ≥11.1 mmol/l on two or more occasions) in surgery and general medicine patients in a community teaching hospital. Of the patients admitted to hospital 26% were known to have diabetes and an additional 12% previously undiagnosed with diabetes had hyperglycaemia first detected in hospital.

After adjusting for confounders the group with newly diagnosed hyperglycaemia had an 18-fold increase in in-hospital mortality. Patients with

known diabetes had a 2.7-fold increase in comparison with normoglycaemic patients. The length of hospital stay was higher for the new hyperglycaemia and known diabetic patients (9 ± 0.7, 4.5 ± 0.1 and 5.5 ± 0.2 days). New hyperglycaemic and diabetic patients were more likely to need ICU care in comparison to normoglycaemic patients (29% vs. 14% vs. 9%, $p < 0.01$). From this study it can be concluded that in both medical and surgical patients an elevated blood glucose contribute significantly to the length of hospital stay, mortality and morbidity.

In a recently published meta-analysis of studies on glycaemic control in non-critically ill hospitalized patients, intensive glycaemic control was not associated with an increased risk of death, myocardial infarction or stroke. However, a non-significantly increased risk of hypoglycaemia (RR: 1.58, CI: 0.97 to 2.57) was demonstrated. In surgical settings a decrease in the risk of infection was detected (RR: 0.41 CI: 0.21 to 0.77).[17]

Davidson et.al.[18] states that two methods are currently used to manage inpatients with diabetes in general wards namely sliding scales and mixed/split insulin regimens.

It is generally accepted that the sliding scale is not very effective, though it is frequently used for its simplicity. The major drawback of the sliding scale is that the physicians wait for the blood glucose to elevate to a certain level before action is taken. Although never proven with a randomized controlled trial, it is assumed that the mixed/split regimen with addition of supplemental or correction dosages of short acting insulin is superior to a sliding scale. This regimen is an attempt to prevent hyperglycaemia before it occurs. Davidson et al.[18] compared two six-month periods; in the first six months patients were treated with sliding scale regimens and in the second six months with a mixed/split regimen with supplemental insulin related to meals. The outcome was as follows: there was a trend towards fewer days in hospital with the mixed/split regimen period although it was non-significant ($p = 0.556$). No significant difference could be demonstrated in glucose control between the two treatment regimens ($p = 0.534$). This inability of the study to show superiority of the mixed/split regimen was ascribed to the short period of patient hospital stay.

In a study by McAlister et.al.[19] hyperglycaemia on admission was independently associated with adverse outcomes in patients with community acquired pneumonia. A cohort of 2471 patients with community acquired pneumonia was observed for hyperglycaemia. Patients with an admission glucose of > 11 mmol/l showed an increased mortality compared to patients with blood glucose ≤11 mmol/l (13% vs. 9%, p = 0.03). For each 1 mmol/l blood glucose increase the risk of in-hospital complications increased by 3% (0.2 - 6%).

Critically ill patients admitted to Intensive Care Units

Van den Berghe et.al.[20] did a prospective randomized controlled study of 1548 adult patients who were admitted to a surgical ICU and were receiving mechanical ventilation. The spectrum of patients included cardiac surgery, cerebral trauma or brain surgery, other thoracic surgery, abdominal surgery, vascular surgery, extensive trauma, burns and transplant surgery patients. All included patients had hyperglycaemia irrespective of whether it was stress related, newly diagnosed diabetes or known diabetic patients. Patients were randomized to receive intensive insulin therapy where blood glucose was maintained between 4.4 and 6.1 mmol/l or conventional therapy with target blood glucose of 10 to 11.1 mmol/l.

Intensive insulin therapy reduced the mortality during ICU care from 8.0% in the conventionally treated patient group to 4.6% (p < 0.04). This study indicated that the risk of death in ICU increased by 30% for every 1.1 mmol/l the blood glucose was above 5.5 mmol/l. The highest survival rates were achieved in patients where the average blood glucose was below 6.1 mmol/l. However, since the van Berghe study other prospective randomised controlled trials attempting to obtain optimal glycaemic control shows conflicting results for critically ill patients. In a meta-analysis (which included the NICE SUGAR study) where all ICU patients (medical and surgical) are included the Relative risk (RR) for mortality between patients on intensive insulin treatment and conventional insulin treatment is 0.93 (CI 0.83 to 1.04). For purely medical ICUs the RR is 1 (CI 0.78 to 1.28), for mixed medical and surgical ICUs the RR for mortality is 0.99 (CI 0.87 to 1.12). However, for

purely surgical ICU the RR for mortality is 0.63 (CI 0.44 to 0.91). In this group one study contributed overwhelmingly to this beneficial effect (van den Berghe), and all the other studies were small and not significant.[21]

Patients with Myocardial Infarctions

In the DIGAMI [22] study 620 patients with an acute myocardial infarction and hyperglycaemia were randomized to receive intensive therapy, which consisted of insulin infusions, and followed by a 3 month multiple injection regimen. This group achieved mean blood glucose of 9.6 mmol/l. The conventional treatment arm had a mean blood glucose of 11.7 mmol/l. Mortality at one year in the intensive treated group was 18.6% and in the conventionally treated group 26.1% (p = 0.027). This benefit extended to at least 3.4 years.

The DIGAMI 2 [23] study was designed to answer the question if in addition to the strict peri-infarction period, a longer term glycaemic control would improve the outcome further. The DIGAMI 2 study randomized 1253 type 2 diabetic patients post myocardial infarction to one of three groups of care after the initial intensive insulin based glycaemic management in hospital. The three groups were: Insulin based long-term glucose control, standard glucose control and routine metabolic management according to local practice. At baseline the group characteristics were the same. The median study duration was 2.1 years (Interquartile range: 1.03 to 3.00 years). The results: 42% of patients in the insulin based long term glucose control group received multidose insulin daily compared to 15% and 13% of patients in the other two groups respectively. At the end of follow up the HbA1c did not differ significantly between the 3 groups. The mortality between the groups also did not differ significantly; 23.4%, 22.6% and 19.3% respectively for the three groups. The target blood glucose of 5 to 7 mmol/l for the insulin based treatment group was never achieved.

Patients peri-surgery

In a study by Furnay et.al.[24] it was demonstrated that a continuous insulin infusion reduced the mortality of patients with diabetes undergoing coronary bypass surgery

Pomposelli et.al.[25] studied 97 patients undergoing general surgery. Blood glucose was monitored every 6 hours. It was found that a single blood glucose measurement >12.2 mmol/l on the first post-operative day was a sensitive (85%) but relatively nonspecific (35%) predictor of nosocomial infections. Patients with a blood glucose of >12.2 mmol/l had infection rates 2.7 times higher than those with blood glucose lower than 12.2 mmol/l. When minor infections were excluded the relative risk (RR) for serious infections post operatively was 5.7.

Zerr et.al.[26] conducted a study in cardiac surgery patients from 1991 to 2001 with management of blood glucose to a target: 8.3 to 11.1 mmol/l. An optimal blood glucose in the first 2 days post surgery resulted in a reduction of deep wound infections from 2.4% down to 1.5% ($p \leq 0.02$). Within the same study in Portland the risk of death was decreased by 60% (RR = 0.04), this was due to a reduction in heart failure and arrhythmias.[27]

Diabetic patient management in hospital

Management of inpatients suffering from diabetes should be matched to the patient's specific circumstances and disease severity. Patients with hyperglycaemia can be categorized according to the inpatient situation, which will determine what type of treatment regimen should be followed (table II). At present guidelines do not differentiate between the management of hyperglycaemia in diabetic patients and patients with transient stress induced hyperglycaemia. The glycaemic targets for both these groups are the same and the means to achieve these do not differ.[28]

Diabetes is frequently not diagnosed before admission. Even after admission an alarming proportion of patients will not have been recognized as having hyperglycaemia. Levetan et.al.[29] report a prevalence of laboratory documented hyperglycaemia in 13% of hospitalized patients; of these 64%

had pre-existing hyperglycaemia or new onset diabetes. Thirty six percent of these remained unrecognized as having diabetes in an audit of discharge summaries.

All doctors caring for patients irrespective of the discipline in which they work should be familiar with the management of diabetes, and need to be able to fit the correct treatment protocol to his/her patients. All nursing staff irrespective of the nursing unit where they work should know how patients with diabetes should be managed.[30 31]

The AACE and ADA[32] recommend the following:

In critically ill patients:

- Insulin therapy should be started for persistent hyperglycaemia, starting at a threshold of 10 mmol/L.
- Glycaemic target should be 7.8 to 10 mmol/L.
- Intravenous insulin infusion is preferred and should preferably be administered using a validated protocol with a low rate of hypoglycaemia.
- Frequent blood glucose monitoring is essential.

Non critically ill patients:

- Pre-meal glycaemic target should be less than 7.8 mmol/L and random blood glucose values should be less than 10 mmol/L, provided that it can be achieved safely.
- More strict control may be appropriate in stable patients with previously tight control.
- Less strict targets may be appropriate in patients with terminal illness or severe co-morbidities.
- Scheduled subcutaneous insulin should be administered to supply basal and prandial requirements as well as supplemental (adjustment or correcting) dosages of insulin.
- The use of sliding scales only is strongly discouraged.

Additional issues in inpatient diabetes management

Inpatient glucose monitoring

Blood glucose monitoring for inpatients with diabetes is analogous to an additional vital sign. This can be achieved today by rapid capillary blood glucose determinations; these blood glucose determinations can and should be performed by adequately trained personnel. The use of bedside glucose monitoring requires:[33]

- a clear administrative responsibility for the procedure
- a well defined policy and procedure manual
- a training program for personnel doing the testing
- quality control procedures
- regular and scheduled equipment maintenance.

The American Diabetes Association advises bedside glucose monitoring using capillary blood due to the rapidity of the result, which allows for point of care decisions on therapy. For patients that are eating, it is recommended to test before meals and at bedtime. For non-eating patients testing at 4 to 6 hour intervals is recommended. For patients controlled with intra-venous insulin, it is advised that testing be done hourly until the blood glucose is stable, thereafter every 2 hours. [34]

Table II: Guideline for in-hospital management of diabetes and hyperglycaemia.[5 21 35 36]

		Scheduled insulin		
Clinical setting	Comments	Basal	Prandial / nutritional	Supplemental / correctional
Eating patients well controlled on home regimen	Type 2 patients only on oral agents should continue with home treatment unless contraindicated (if contraindicated manage same as type 1 patients)			Regular or Rapid acting insulin before meals according to scale
	Type 1 diabetic patients should continue with home insulin schedule but consider reducing the total daily dose if caloric intake will be more restrictive			Regular or Rapid acting insulin before meals according to scale
Eating patients poorly controlled on home regimen	Type 2 patients should continue with insulin sensitizers unless contraindicated	0.2 to 0.3 U/kg/day NPH insulin or Detemir 12 hly or Glargine daily. Adjust daily to pre-breakfast glucose value	Regular or Rapid acting insulin. Start with 0.05 to 0.1 U/kg/meal or 1 U/15g carbohydrate. Adjust daily according the need for supplemental insulin	Regular or Rapid acting insulin before meals according to scale
Peri-operative or peri-procedural but will eat afterwards	If in doubt start patient with insulin infusion	Give usual basal insulin	Commence with prandial insulin as above as soon as patient starts to eat	Regular insulin 4 to 6 hly or Rapid acting insulin 4 hly according to scale
Peri-operative or peri-procedural but will not eat afterwards	Insulin infusion preferable during procedure but can be continued afterwards	Give usual basal insulin	N/A	Regular insulin 4 to 6 hly or Rapid acting insulin 4 hly according to scale
Continuous enteral feeding (TEN)	Consider insulin infusion, adjust infusion rate until control is achieved	Give 40% of daily requirement. NPH insulin or Detemir 12 hly or Glargine daily.	N/A	Regular insulin 4 to 6 hly or Rapid acting insulin 4 hly according to scale
Bolus enteral feeeding		Give 40% of daily requirement. NPH insulin or Detemir 12 hly or Glargine daily.	Regular or Rapid acting insulin. Start with 0.05 to 0.1 U/kg/bolus or 1 U/15g carbohydrate.	Regular insulin 4 to 6 hly or Rapid acting insulin 4 hly according to scale during bolus period
Continuous parenteral feeding (TPN)	Insulin infusion, adjust infusion rate until control is achieved			
Critically ill patient	Insulin infusion, adjust infusion rate until control is achieved then maintain			

Patient diabetes education

Patients admitted to hospital for whatever reason opens a unique opportunity to educate patients to improve patient knowledge of diabetes and to improve patient self-management skills.[36 37]

Roman and Chassin [38] conducted a study to assess the knowledge of inpatients with diabetes as well as glycaemic control post discharge. They noted that glycaemic control significantly improved after education. They however also found that 40% of patients still had important diabetes knowledge deficits post discharge.

Nutritional care

A registered dietician is a crucial team member in the in- and outpatient management of patients with diabetes. Two important aspects can be addressed specifically while patients are admitted to hospital: nutritional assessment and nutritional intervention. Once again the opportunity of educating patients with diabetes on nutritional issues during admission is an optimal situation in which the patient can be exposed to nutritional caregivers repeatedly.[39 40]

Discharge planning

All diabetic patients should have a post discharge plan. This includes follow up with an appropriate caregiver who is capable of taking care of diabetes and diabetes related problems. It should also be confirmed that the patient and preferably their families should be familiar with outpatient glucose targets. Attempts should be made to introduce the home diabetes management regimen to the patient whilst still in hospital.[15 36]

Workup opportunity and risk factor assessment

Hospitalization creates the perfect opportunity for the evaluation of patients with diabetes with specific reference to assessment of micro- and macro-vascular complications namely nephropathy, retinopathy, neuropathies, and

cardiovascular disease. The assessment of risk factors and the control thereof is ideal since fasting bloods can easily be taken, and a profile of blood pressure over a 24-hour period can be obtained. This opportunity should be structured to obtain the most information related to the prevention and care of complications in these patients during admission.[36]

Education of caregivers

Bernard et.al.[41] stated that a significant barrier to improvement of diabetes care, is that most trainee physicians do not think additional training in diabetes care is necessary. Resident physicians felt that a lack of time is a greater barrier to the quality of patient care than a deficiency of training. It was hypothesized that the difficulty with residents' diabetes practices could be the result of a lack of knowledge and experience of supervising physicians.

Baldwin et.al.[42] demonstrated that a systematic approach to education of residents in inpatient diabetes management could improve the care of hospitalized diabetic patients.

A number of studies assessing nurses' knowledge and behaviour after an education program concluded that a discrepancy exists between the knowledge and behaviour of nurses caring for diabetic patients. It seems that nurses primarily change their clinical practice from new knowledge obtained from unit-based resources. It is recommended that nurse training should focus on unit-based training. [43 44]

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CHAPTER 2

Inpatient blood glucose management of diabetic patients in a large secondary hospital

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Abstract

Background: Diabetes has become a major health problem worldwide, as well as in South Africa. This, coupled with the chronicity of the disease, relate to an increasing burden on health care facilities and an increasing number of hospital admissions of patients suffering from diabetes. Admissions are mostly related to diabetes itself, but the frequency of admissions for problems not related to diabetes is increasing as the prevalence of diabetes increases in the population. Proper inpatient glycaemic management is important for improving patient outcome and for reducing the risk of inpatient complications.

Objectives: The objective of this study was to evaluate current practices in the care of diabetic inpatients as well as to assess the glycaemic control that is achieved during hospitalisation.

Methods: An audit was done of clinical hospital records of adult diabetic patients admitted to Kalafong Hospital, a large secondary hospital in South Africa. All patients admitted who had type 1 or type 2 diabetes before admission, or who were newly diagnosed on admission or in hospital were included, irrespective of the discipline to which the patient was admitted. All patient admissions in the eight-month period preceding the initiation of the audit were included.

Results: The hospital records of 164 diabetic patients were audited. With regard to glucose monitoring, 60.8% of patients had irregular and erratic glucose monitoring, 37.2% had regular (either four- or six-hourly) monitoring and only 2% were monitored in relation to meals. Of the 164 patients, 160 were not fasting, 27 were treated with an insulin sliding scale at some stage during their admission, and in 14 (52%) of the patients who were on sliding scales the scale was used inappropriately. Most hospital inpatients with diabetes, i.e. 48 (30.4%), were treated with oral agents only; 29 (18.4%) were treated with oral agents plus a daily dose of NPH insulin and 17 (10.8%) with mixed insulin twice

daily. Only three patients (1.9%) received insulin supplemental to their regimen. The glycaemic control treatment schedule was appropriate in only 19.5% of cases.

Conclusions: Based on our findings, the monitoring and management of blood glucose in patients with diabetes during hospitalisation in a large secondary hospital in South Africa is currently inadequate. This calls for an educational intervention for doctors and nurses working with diabetic inpatients as well as the introduction of a blood glucose management protocol.

Introduction

Diabetes has reached epidemic proportions worldwide,[1] resulting in increased hospital admissions for patients with diabetes. In one United Kingdom hospital, the proportion of hospitalisations of patients with diabetes increased from 7.0% in 1991 to 11.1% in 2003.[2] Health insurance data in the United States indicates that diabetic patients also tend to be admitted 2.4 times more frequently and that their hospital stay is 30% longer than for non-diabetic patients.[3]

Numerous studies have been published on the advantages of good glycaemic control and associated improved outcomes. This relates mostly to more rapid recovery from infections,[4] shorter intensive care stays with reduced mortality,[5] improved prognosis after myocardial infarction,[6,7] less deep wound sepsis[8] and fewer nosocomial infections.[9,10] According to the American College of Endocrinology,[9] one way of achieving improved glycaemic control is to implement a standardised inpatient management protocol. Information on inpatient glycaemic control and methods of achieving control in diabetic patients admitted to South African hospitals are currently not available in the literature.

The aim of this study was to assess the status of glycaemic control and methods utilised in the inpatient management of diabetes in a large secondary hospital. The need for the introduction of a standardised inpatient diabetes management protocol was also assessed.

Methods

Setting

This study was done at Kalafong hospital, a secondary hospital in the West of Tswane district. It is an 800 bed hospital with general specialist units including: Internal Medicine, Surgery, Orthopaedics, Ophthalmology, Otorhinolaringology, Paediatrics, Obstetrics and Gynaecology and Family Medicine. The hospital

delivers in- and outpatient services to the surrounding areas which includes Atteridgeville, Laudium, Lotus gardens, Pretoria West and Centurion. Kalafong hospital form part of the University of Pretoria academic hospital complex, where pre- and postgraduate students are trained. All patients seen or admitted to Kalafong hospital are uninsured patients who cannot afford private medical care.

Study population

A cross-sectional audit was done of hospital records of diabetic inpatients. All patients were older than 13 years of age and were non-fasting at some stage during hospitalisation. All hospitalisations occurred during the eight months preceding the audit. A list was kept of all patients admitted who required a diabetic diet by the dietetics department, hospital records of all patients on this list was perused for diabetic patients to be included in the study. It was estimatd that about 150 patient admissions was needed to properly assess diabetes inpatient care. Specific attention was paid to the methods of inpatient glycaemic monitoring and glucose control. Hospital records were audited independent of the reason for admission or the severity of the disease.

Data collection

Only information relating to the last hospitalisation was evaluated. Evaluation focused on the appropriateness of the method of glycaemic control for individual patients, the level of control of blood glucose and hypertension, evaluation of diabetes-related complications, and risk factors. The frequency of blood glucose and blood pressure measurements as well as the duration of hospital stay were noted. Diabetes follow-up arrangements upon discharge from hospital were also evaluated. The audit was done in a structured way after patient discharge, addressing the specific aspects mentioned above. Two independent observers, trained in diabetes care, audited all the selected patient records.

Outcome measures

Outcome measures that were evaluated were: glycaemic control during hospitalisation as well as at time of discharge, time until glycaemic control after admission, hypertension control in hospital and at time of discharge, duration of hospital stay and patient outcome, and the frequency of in-hospital disease and treatment-related complications.

Appropriateness of inpatient management of diabetes was based on the inpatient management guidelines of the American Diabetes Association.[11] The criteria included three aspects for patients on insulin who were non-fasting: basal insulin, prandial insulin and supplemental or adjustment insulin. The appropriateness for inpatients on oral agents is unclear due to the scarcity of studies investigating the roles of various oral agents.[12] For the study on which this article is based, use of oral agents was considered appropriate if non-fasting patients' glycaemic control was good.

Data management

Data were captured electronically on Microsoft Access. Statistical analysis was done by using SPSS 14 for Windows (SPSS Inc, 1989–2005) statistical software. All descriptive data and proportions are reported as percentages and continuous variables are reported as means with standard deviations (SD) or, in the case of ordinal and skew data, as medians with inter-quartile ranges. Comparisons were done by using appropriate parametric or non-parametric tests dependent on the type and distribution of data.

Ethical issues

This study was done after ethics approval was obtained from the Ethics committee of the Faculty of Health Sciences of the University of Pretoria. All patient and treating physician identification information was removed from the data after the audit of clinical records was completed.

Results

Patient and hospitalisation characteristics (Table I)

During the eight-month period, 164 patients with diabetes were admitted to Kalafong Hospital (a large secondary hospital in Gauteng, South Africa). The median duration of admission was 7.5 days with a range of 1 to 87 days, and an inter-quartile range of 3 to 13 days. Only patients admitted to the adult units of the hospital (patients older than 13 years) were included in this audit. The mean age of patients at the time of admission was 58.5 years with a SD of 15.3 years (a range of 13 to 86 years). Predominantly females (n = 119, 72.6%) were hospitalised. The mean age of females was higher than that of males although this was not statistically significant, 60.2 vs 54 years (p = 0.21). No significant difference was demonstrated in the duration of diabetes between the two gender categories, 6.2 vs. 5.4 years (p = 0.59). Of the 164 patient records audited, 103 mentioned the duration that patients had diabetes. The median duration of diabetes in hospitalised patients was 3.7 years with an inter-quartile range of 1.1 to 9.25 years. A major contributor to the skewness of the distribution of the duration of diabetes is the fact that 19 patients were newly diagnosed during the audited admission. Of note is that 3.9% of patients had had diabetes for more than 20 years. Most patients were admitted to Internal Medicine (medical) units (97 patients, i.e. 59.1%). Two patients were admitted to the ICU first and then transferred to Internal Medicine. The admission to the ICU in both cases was for medical reasons.

Inpatient deaths

Most patients improved (76.8%), but a significant proportion of patients died during hospitalisation (7.3%): two males and 10 females. Of the 12 patients who died, three died of chronic renal failure, three of end- stage heart failure, two had acute coronary syndromes of which one was complicated by diabetic ketoacidosis (DKA), one died of pulmonary tuberculosis, one of hypoglycaemic brain injury, one patient died after a femur fracture and one patient had a diabetic foot with sepsis. The mean age of patients who died was higher,

although non-significant, namely 66 years in comparison to 57.9 years in the case of those who left the hospital alive ($p = 0.73$). No statistically significant difference in the duration of diabetes could be demonstrated between patients who died (5.8 years) and those who were discharged alive (5.94 years) ($p = 0.96$).

Table I: Patient demographics

Audit of diabetic inpatients	n = 164	Mean/ Median	Standard deviation /Range
Patient age (mean years)		58.5	SD 15.3
Duration of hospitalisation (median days)		7.5	Range: 1–87 IQR*: 3–13
Duration of diabetes in patients with diabetes diagnosed before hospitalisation (median years)†		3.7	IQR*:1.1–9.25
		Number	Percentage
Newly diagnosed		19	11.6%
Gender	Females Males	119 45	72.6% 27.4%
Diabetes treatment before hospitalisation ‡	None Diet only Oral agents Combination (oral and insulin) Insulin twice daily Insulin basal bolus	19 12 82 12 21 2	11.6% 7.3% 50.0% 7.3% 12.8% 1.2%
Department hospitalised to	Internal medicine Surgery Orthopaedics Ophthalmology Gynaecology, but excluding obstetric patients	99 40 11 11 3	60.4% 24.4% 6.7% 6.7% 1.8%
Primary reason for hospitalisation§	Diabetes control Cardiovascular disease including stroke Renal disease Respiratory disease Gastro-intestinal diseas Leg and foot problems Orthopaedic problems Eye disease Malignancies Other	48 32 9 18 14 12 14 18 3 14	29.3% 19.5% 5.5% 11.0% 8.5% 7.3% 8.5% 11.0% 1.8% 8.5%
Patient outcomes	Improved and discharged Died Unchanged Transferred for tertiary care Self-discharge	126 12 17 2 6	76.8% 7.3% 10.4% 1.2% 3.7%
Complications in hospital		15	9.1%

* IQR: inter-quartile range
† Mentioned in 103 of audited hospital records
‡ No data available in 16 patient records audited
§ Note that more than one primary admission diagnosis were present in some patients

Newly diagnosed patients

Nineteen of the 164 patients admitted were diagnosed with diabetes for the first time during hospitalisation. Of these, three patients presented with DKA, three were admitted with symptoms of diabetes, one patient had a stroke, three had foot ulcers, three presented with infections and one patient each with bowel obstruction, miscarriage and femur fracture.

Inpatient treatment (Figure 1)

Only four patients (2.4%) were kept nil per mouth at some stage during hospitalisation, and two patients (1.2%) received tube feeding. Of the four patients who were nil per mouth, three were treated with an insulin sliding scale and one received oral agents. Of the two patients who received tube feeding, one was on twice-daily insulin, and one did not receive any anti-diabetic treatment. The latter patient was however only controlled on diet before admission.

Most non-fasting patients were treated with oral agents (48 patients, 30.4%). Twenty-nine patients (18.4%) were treated with oral agents and once-a-day NPH-insulin. Thirteen per cent of patients, who were non-fasting, were on a regular insulin sliding scale only (20 patients). Twice- daily mixed insulin was prescribed to 17 patients (10.8%). Only three patients (1.9%) received meal-related supplemental insulin in addition to their treatment regimen. Fifteen patients (9.1%) were documented to have received an insulin infusion at some stage during admission. Twelve of them had DKA and received insulin infusions as part of the DKA treatment regimen. One patient was admitted with a stroke, one with renal failure and one patient received cancer chemotherapy.

Twenty-seven patients (16.5%) were on an insulin sliding scale only, at some stage during hospitalisation. Insulin sliding scales were utilised as follows in the various departments: Internal Medicine 15 patients (15.5%), surgery nine patients (22.5%) and orthopaedics three patients (27.3%). Fifty-two per cent (14 of 27) of patients on insulin sliding scales received it inappropriately because

they were non-fasting. Of these, eight were from Internal Medicine and six from surgical disciplines.

Appropriateness of treatment to control blood glucose

The inpatient diabetes treatment schedule was considered appropriate in 32 (19.5%) and inappropriate in 110 (67.1%) of the 164 patients. In 22 (13.4%) of the patient hospital records audited, insufficient information was available, making it impossible to decide if treatment was appropriate or not.

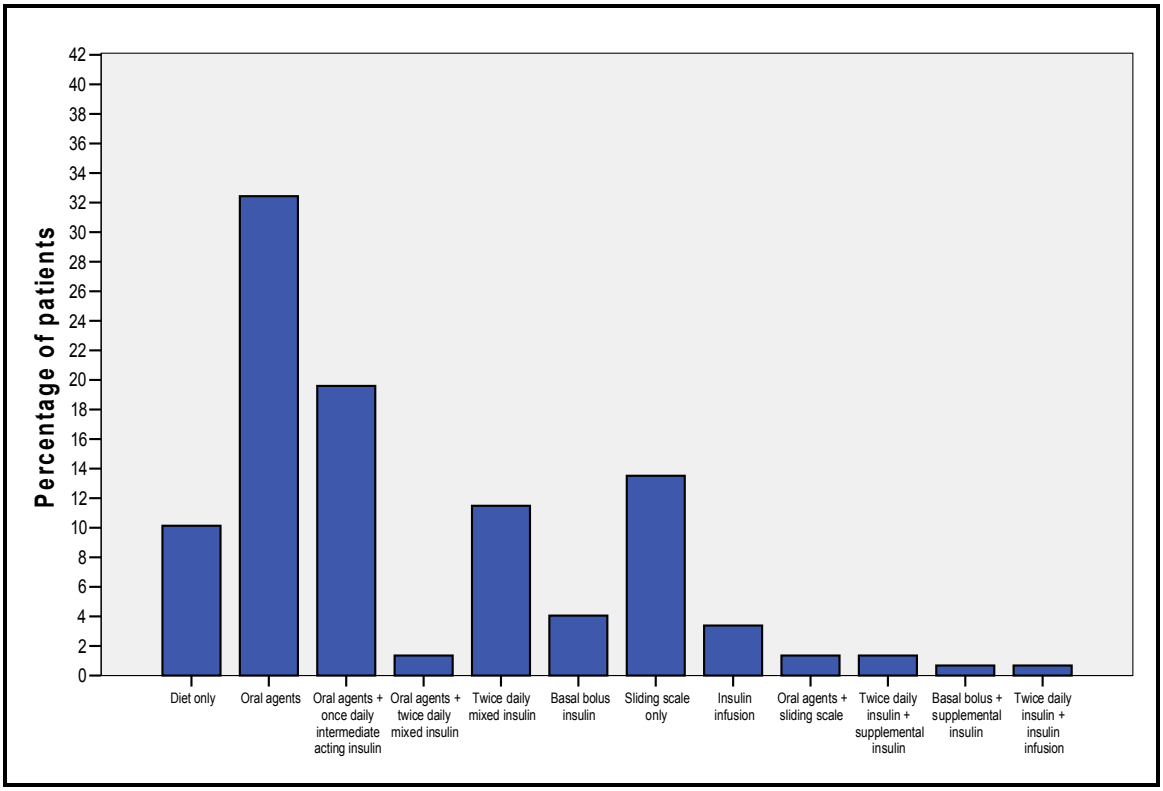

Figure 1: In-hospital treatment regimens among non-fasting diabetic patients

Inpatient glycaemic monitoring

Most inpatients (60.8%) had their blood glucose checked irregularly and haphazardly by ward staff. This could have been due to the lack of a ward schedule for testing blood glucose, or failure on the part of doctors to prescribe appropriate orders. About one-third had their blood glucose tested regularly according to a timed schedule, either four hourly or six hourly. Only three (2%) patients had their blood glucose tested in relation to meal consumption.

Hypoglycaemic events

Of the 164 patients admitted to hospital, ten were admitted with hypoglycaemia. In six cases, hypoglycaemia was corrected before the patients left the emergency unit. No hypoglycaemic events were recorded in patients admitted for hypoglycaemia after the third day of hospitalisation. Of the 154 patients not hospitalised for hypoglycaemia, 45 (29.2%) had at least one hypoglycaemic episode while in hospital. Of these, 20 patients (13%) had one episode, four had two hypoglycaemic episodes and 21 patients had three or more hypoglycaemic events during their hospital stay. No differences in the number of hypoglycaemic events could be demonstrated between patients on different treatment regimens.

Inpatient glycaemic control

The mean blood glucose on the first day of admission was 10.4 mmol/l (SD 4.2) with a range of 3.8 to 25.6 mmol/l. This improved to 8.53 mmol/l (SD 3.4) on the last day of hospitalisation. This improvement is statistically significant ($p = < 0.001$, paired sample t-test). This relates to a mean difference in blood glucose from the first to the last day of hospitalisation of 2.37 mmol/l (95% CI: 1.78 to 2.95). An HbA1c (glycated haemoglobin) was done on 71 (43.3%) patients at the time of admission. The mean HbA1c value for these patients was 11.3% (SD 4.3). In 67 (40.9%) patients hospitalised with diabetes, glycaemic control was achieved. For this purpose, control was defined as all blood glucose measurements for 24 hours monitored to be between 3.5 and 10 mmol/l.

Inpatient blood pressure control

Thirty-nine per cent of patients were hypertensive on admission and received antihypertensive therapy in hospital. The mean systolic blood pressure improved from 131 mmHg on the first day of hospitalisation to 125.4 mmHg on the last day of hospitalisation ($p = <0.001$). This relates to a mean reduction in systolic blood pressure of 5.61 mmHg (95% CI: 2.37 to 8.85). Diastolic blood pressure improved from a mean of 78.1 to 76.6 mmHg ($p = 0.004$), which represents a mean improvement of 1.47 mmHg (95% CI: -0.84 to -3.78).

Patient follow up and readmissions

From the audit of patient records, 70.7% referred to follow-up arrangements made for patients. It is uncertain for which proportion of these patients arrangements were made for follow up of diabetes or the primary presenting problem.

Of the 164 patients, 31 (18.9%) were readmitted to hospital within six months after discharge. This was due to various reasons; only four (12.9%) were readmitted for glycaemic control, three (9.6%) for foot problems, seven (22.6%) for eye problems, of which four readmissions were for cataract surgery on a second eye, four patients were readmitted for cancer chemotherapy, four for follow-up surgical procedures and five for other chronic medical problems.

Discussion

This study shows that glycaemic control in a significant proportion of diabetic inpatients is still sub-optimal, with only 40.9% achieving control. Hypoglycaemic events occurred frequently, as 29.2% of inpatients had at least one hypoglycaemic event in hospital. The mean blood glucose improved significantly during admission: from more than 10 mmol/l on the first day of hospitalisation to 8.53 mmol/l on the last day of hospitalisation.

The monitoring of blood glucose in diabetic inpatients was not optimal due to the erratic and irregular monitoring schedule in 60.8% of patients. Time-based monitoring, that is four or six hourly, is appropriate for patients who are fasting or who receive continuous tube feeds or total parenteral feeding, but not for patients who receive meals. Only six of the 164 patients (3.6%) were fasting or received tube feeding, in which case time-based monitoring would be appropriate, but time-based monitoring was utilised in 37.2% of the patients. The optimal monitoring schedule in at least 158 of the 164 diabetic inpatients should have been meal-related. Thus, at the time of this study only three patients (2%) were monitored optimally.[11 13]

The optimal way of treating hospitalised non-fasting diabetic patients would be to administer the patients' usual treatment, with adjustment to compensate for a more fixed and regulated hospital diet. In addition, patients should receive meal-related supplemental insulin according to blood glucose levels. The administration of insulin according to a four- to six-hourly sliding scale in patients who are receiving meals in hospital is inappropriate.[14] This audit indicated that sliding scales were still used inappropriately in 14 of the 164 patients.

Several limitations hampered this study. Firstly, this audit did not include any admission of paediatric patients, thus the findings are only applicable to patients older than 13 years of age who are admitted to adult hospital units. Secondly, the audit was done in only one large secondary hospital with limited resources. The assumption was made that it is typical of circumstances in similar hospitals in South Africa. This hospital serves a large community of mostly medically uninsured patients of lower socio- economic status.

The findings of this audit are congruent with other studies from other parts of the world. An audit done at the Mayo clinic15 indicated that 11% of patients had at least one hypoglycaemic event during admission, and 71% of patients had at least one blood glucose measurement higher than 11.1 mmol/l. A study done at

a tertiary care facility in India[16] showed that glycaemic control was achieved in 48%, was sub-optimal in 15%, and poor in 37% of hospitalised diabetic patients. In a study by Cook et al,[17] the mean duration of hospital stay for diabetic patients was 5.7 days and most admissions to hospital were for cardiovascular (33%), endocrine and metabolic (13%), as well as for infective conditions (14%). The average duration of hospital stay for diabetic patients in the study by Jiang et al.[18] was 6.8 days for patients who had a single hospitalisation in comparison to 7.4 days in patients with multiple admissions. This study also reported that 30% of diabetic patients had two or more admissions over a period of one year. In a Spanish study, the mean duration of hospital admission was 11.4 days for diabetic patients.[1] In a UK study, the mean duration of hospital stay was 19 days (range 1 to 300+) compared to the median length of stay of all hospital patients of 10 days.[1] The management of diabetes in this UK study was considered inappropriate in 29% of patients who were not referred to a diabetes management team. The same study also indicated that 28% of patients were treated with diet alone, 52% with oral hypoglycaemic agents, 15% with insulin only and 5% with a combination of insulin and oral agents.

The American College of Endocrinology advises that the upper limit for glycaemic control in hospitalised diabetic patients should be 6.1 mmol/l pre-prandial and 10.0 mmol/l maximal.[13] This target is currently not achieved in most patients in this audit as well as in numerous patients reported in other studies. The guideline is clear and methods to achieve this target should be developed and implemented. Probably the most important way to achieve glycaemic control is through proper education and training of physicians and nurses, implementation of adequate blood glucose monitoring schedules and protocols for management of hyperglycaemia.

The overall finding of this audit is that the inpatient management of diabetes by means of glucose monitoring and glycaemic control is currently inadequate. Doctors and nurses caring for diabetic inpatients should be educated in the

management of diabetes, and proper protocols for inpatient management should be implemented.

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CHAPTER 3

Survey of knowledge and attitudes regarding diabetic inpatient management by medical and nursing staff at Kalafong Hospital

Adapted from: JEMDSA 2008; 13(3):90-97

Abstract

Objective: The objective of this study was to evaluate perceptions regarding current practices in the care of diabetic inpatients as well as the knowledge and attitudes of nursing and medical caregivers at a large secondary hospital.

Design and methods: Doctors and nurses taking care of diabetic inpatients were surveyed to assess their knowledge of diabetes inpatient management and their attitudes towards diabetic patients. The survey made use of the diabetes knowledge questionnaire (O'Brien) and the DAS3 scale.

Results: The survey group comprised 115 health care providers, of whom 54 were doctors and 61 were nurses. The response rate was 82%. The doctors achieved a mean score of 68.3% (standard deviation (SD) 11.5%) and the nurses 53.9% (SD 16.3%) for the diabetes knowledge questionnaire. The DAS3 questionnaire indicated that 80.9% of health care personnel strongly agree that special training for managing diabetic patients is necessary, 90.5% agree or strongly agree that type 2 diabetes is a serious condition, 92.2% agree or strongly agree that tight glycaemic control is valuable, 85.2% agree or strongly agree that diabetes has a significant psychosocial impact on patients, and 88.7% agree or strongly agree that patients should have autonomy regarding their treatment.

Conclusions: Health care workers (doctors and nurses) in a large secondary hospital have average to poor knowledge about the care of diabetic inpatients. The DAS3 questionnaire, however, indicates that health care workers have a good attitude towards diabetic patients and realise that special training is necessary.

Introduction

Developed and developing countries are currently encountering an upsurge in the prevalence of diabetes. The burden of this disorder seems to be disproportionately large in non-European populations, with Hispanic, Native American, Pacific and Indian Ocean island populations, and Indian and Australian Aboriginal communities heading the list.[1]

The 2003 global burden of diabetes has been estimated to be 150 million people, and is expected to rise to 220 million by 2010 and to 300 million by 2025.[1] In South Africa, the prevalence of diabetes varies from 3% to 28%, depending on the population studied, the age range, and whether the population is rural or urban.[2]

Diabetic patients are more likely to be admitted to hospital, and diabetes is a frequent co-morbidity in hospitalised patients. Diabetes also contributes significantly to prolonged hospital stays and inpatient mortality.[3, 4] Patients with diabetes need admission to hospital for the usual variety of reasons, which may or may not be related to diabetes.[5] Diabetes, however, frequently complicates the condition for which they were admitted.[6] For this reason, health care providers, irrespective of the discipline in which they work, need to have knowledge of inpatient diabetes management. Moreover, hospitalisation of diabetic patients is costly, and this cost is usually related to complications of diabetes.[6 7]

Improving in-hospital diabetes care requires a multilevel and multidisciplinary approach, mediated by the personnel who interact with patients during hospitalisation, i.e. doctors and nurses.[8] Most trainee physicians did not think that additional training in diabetes care was necessary; this constitutes a significant obstacle in improving diabetes care.[9] Resident physicians, on the other hand, felt that lack of time was a greater obstacle to quality of patient care than a lack of training.[9] It is possible that inadequate diabetes management

practices on the part of resident doctors could be the result of lack of knowledge and experience. A systematic approach to educating residents in inpatient diabetes management could improve the care of hospitalised diabetic patients.[10]

A number of studies assessing nurses after education programmes concluded that a discrepancy exists between the knowledge and behaviour of nurses caring for diabetic patients. It seems that nurses primarily change their clinical practice as a result of new knowledge obtained via unit-based training resources. It therefore follows that training of nurses should be done on a unit-based basis.[11 12]

In a survey of 27 junior doctors and 143 nurses on their knowledge of management of diabetic inpatients, the average doctors' score was 48 out of 66 and that for nurses was 51 out of 66. Doctors scored better in the physiology and complications sections, and nurses fared better in the questions related to practical management of diabetes.[13]

Owing to the increasing prevalence of diabetic inpatients, a survey was conducted to assess knowledge and attitudes of doctors and nurses caring for patients with diabetes at Kalafong, a large secondary hospital.

Methods

The survey targeted the knowledge and attitudes of medical and nursing staff about service delivery to diabetic inpatients. All doctors and nursing staff caring for adult patients with diabetes were approached to take part in the survey, irrespective of the hospital unit or discipline in which they worked. Doctors were approached for participation regardless of seniority. Questionnaires as well as a covering letter explaining the importance of the study were given to all doctors attending departmental morbidity and mortality meetings, and they were requested to complete the questionnaires immediately. Questionnaires and covering letters were also distributed to all nursing units with adult diabetic patients, requesting nurses at all levels to complete the questionnaire. This was

done once during the day shift and once during the night shift. All forms were completed anonymously.

The questionnaires distributed to medical staff included the DAS3 questionnaire (to assess attitude towards diabetic patients), a diabetes inpatient knowledge questionnaire, and a questionnaire to assess the perceptions of care, issues related to referral systems and the availability of diabetes educators, and current prescription habits of physicians; this included demographic data of the health care professional.

The Diabetes Knowledge Questionnaire SVO version 7/1/06 compiled by O'Brien[13] was used, with minor adaptations for local circumstances. The questionnaire was developed and standardised for junior doctors and general nurses who take care of diabetic inpatients; it comprises 11 sections, each section containing 6 items. The sections cover the following aspects of diabetes care knowledge: physiology, blood glucose monitoring, medications, hypoglycaemia, insulin use, hyperglycaemia, complications, diet, screening/ prevention, surgery and a general section. All 66 questions require a 'yes', 'no' or 'don't know' answer. The questionnaire has good internal reliability, with a Cronbach's alpha coefficient for nurses of 0.81 and for junior doctors of 0.72. The Kappa coefficient for the questionnaire was 0.689, indicating good stability over time. The questionnaire takes 15 to 20 minutes to complete. Permission to use the questionnaire was obtained from the compiler.

The DAS3 measures diabetes-related attitudes. It consists of 33 items, and assesses attitudes towards diabetes in 5 categories, namely: seriousness of diabetes type 2, the need for special training of health care workers, the value of tight glucose control, the socio-economic impact of diabetes, and the need for patient autonomy. The DAS3 scale was standardised for use by (among others) physicians and nurses.[14] Permission to use this questionnaire was obtained from the Michigan Diabetes Research and Training Center.

Results

The total number of health care professionals participating was 115, of whom 54 (47%) were doctors and 61 (53%) were nurses. The overall response rate was 83%; 90% for doctors and 76% for nursing staff.

Of the 54 doctors, 36 (66%) felt that the registrar, 9 (17%) that the medical officer, 7 (13%) that the intern, and 2 (4%) that the consultant were primarily responsible for taking care of diabetic patients' blood glucose control.

Seventeen (31.5%) of the doctors felt that they frequently, 10 (18.5%) that they seldom, and 26 (48.1%) that they sometimes had problems controlling blood glucose in diabetic patients. Most doctors (31 (57%)) considered that obtaining glycaemic control in diabetic patients was difficult or problematic; the reasons were related to glycaemic control (16.7%), system and logistical issues of management (11.1%), coinciding complications (11.1%), and personal lack of knowledge and experience (7.4%).

Of all the doctors, 4 (7.4%) always, 9 (16.7%) frequently, 23 (42.6%) sometimes, 16 (30%) seldom, and 2 (3.7%) never consulted someone else about blood glucose control in their patients.

The reasons for admission of diabetic patients to hospital, as perceived by the doctors, were: hyperglycaemia – 24 (45%), sepsis – 23 (43%), chronic diabetes complications – 12 (23%), diabetic metabolic emergencies – 9 (17%), elective surgery – 7 (13%), trauma – 6 (11%), and other medical problems – 2 (4%). (Doctors were requested to mention the two to three most common reasons for admission of diabetic patients.)

The majority of doctors (48 (89%)) stated that patients with diabetes tended to have longer hospital stays than non-diabetic patients. They also reported that diabetic patients were more prone to have complications while hospitalised (50 (92.6%)).

Table I: Participant information

		Nursing staff N = 61 N (%)	Doctors N = 54 N (%)
Department	Internal medicine Obstetrics and Gynaecology Orthopaedics Surgery Missing / unknown	19 (31.1) 11 (18) 12 (19.7) 18 (29.1) 1 (1.6)	16 (29.6) 13 (24.1) 9 (16.7) 16 (29.6)
Doctor level	Consultant Registrar Medical officer Intern		15 (27.8) 21 (38.9) 12 (22.2) 6 (11.1)
Nurse level	Senior registered nurse Registered nurse Staff nurse Student nurse	17 (27.9) 8 (13.1) 20 (32.8) 15 (24.6)	
Patient load	Estimated number of patients at any moment with diabetes in hospital.	Median: 3 Range: 0 to 10	Median: 3 Range: 0 to 7

About a third of all nurses (17 (28%)) considered the management of diabetic inpatients troublesome, 40 (65%) did not, and 4 (7%) were uncertain or did not know.

Additional, more problem-based questions were put to the doctors to assess their practical knowledge of diabetes.

Regarding inpatient monitoring of blood glucose, the majority (44%) of doctors prescribed 4-hourly monitoring, and only 15% proposed meal-related monitoring.

Concerning target blood glucose in inpatients, answers varied from 3 to 11 mmol/l; 11 (20.4%) respondents stated 4 mmol/l; 9 (16%) said 7 mmol/l; 8 (15%) said 10 mmol/l; and 7 (13%) each said 5 and 8 mmol/l.

On the question of the insulin dose for a patient not usually treated with insulin, but who now needs insulin in hospital, 19 (35%) of doctors would calculate the dose according to the patient's weight, while 32 (59%) would put the patient on an insulin sliding scale to see how much insulin was needed.

Regarding what would be prescribed for a type 2 diabetic patient admitted for an unrelated problem who does not need to be starved and was well controlled at home on oral medication, only 38 (70%) of respondents would continue home

medication, 8 (15%) would continue home medication and start a sliding scale, and 6 (11%) would stop oral medication and continue with a sliding scale only.

Table II: Diabetes knowledge questionnaire

	Diabetes knowledge category	Nurses score Median (IQR)	Doctors score Median (IQR)	All Median (IQR)	Maximum score
1.	Physiology	3 (3 – 4)	5 (5 – 6)	4 (3 – 5)	6
2.	Blood glucose monitoring	4 (3 – 5)	4.5 (4 – 5)	4 (4 – 5)	6
3.	Diabetes medications	1 (0.5 – 2)	2 (1.5 – 4)	2 (1 – 3)	5
4.	Insulin use	2 (1 – 2.5)	2 (1 – 3)	2 (1 – 3)	6
5.	Hypoglycaemia	3 (2 – 4)	4 (3 – 5)	4 (3 – 4)	6
6.	Hyperglycaemia	5 (3 – 5)	6 (5 – 6)	5 (4 – 6)	6
7.	Diabetes complications	5 (4 – 5)	5 (4 – 5)	5 (4 – 5)	6
8.	Diabetes screening and prevention	4 (3 – 5)	3 (2.75 – 4)	5 (3 – 5)	6
9.	Diet in diabetes	4 (3 – 5)	3 (2.75 – 4)	4 (3 – 5)	6
10.	Surgery and fasting in diabetes	4 (2 – 4)	4 (4 – 5)	4 (3 – 5)	6
11.	General diabetes	2 (2 – 3)	3 (2 – 4)	2 (2 – 3)	4
	Total	36 (30 – 40.5) Mean 33.9 SD 10.3 Mean % 53.9 SD 16.3	43 (40 – 47) Mean 43.1 SD 7.26 Mean % 68.3 SD 11.5	40 (34 – 44.75) Mean 38.1 SD 10.1 Mean % 60.4 SD 16.0	63 100%

On being asked what would be prescribed for a type 1 diabetic patient admitted for a unrelated problem who can eat in hospital and was well controlled at home on twice-daily mixed insulin, 39 (72%) of respondents would continue home treatment, 5 (9%) would continue with home treatment but add a sliding scale, and 7 (13%) would stop the usual home regimen and start on a sliding scale only.

On the question of what would be prescribed for a type 2 diabetic patient admitted to hospital, on oral agents only before admission, and not allowed to eat, 34 (63%) of doctors would stop oral agents and start on a 4-hourly sliding scale and a continuous dextrose infusion, 7 (13%) would start an insulin infusion, and 9 (17%) would continue with oral agents and start a dextrose infusion.

On what would be prescribed for a type 2 diabetic patient, on oral agents and twice-daily mixed insulin, admitted to hospital and who needs to be starved, 10 (18.5%) would stop all usual treatment and initiate an insulin sliding scale and a dextrose infusion; 30 (56%) would start with a sliding scale only; 6 (11.1%) would start an insulin infusion as well as a dextrose infusion; and 4 (7.4%) admitted that they did not know.

Table III: Ten patient management scenario questions with true/false answers

	Question	True (%)	False (%)
1.	If a type 2 diabetic patient on oral therapy who is eating is admitted to hospital, the most correct way to treat the patient is to continue with the oral treatment with the addition of additional insulin boluses according to blood glucose values at mealtime.	*30 (55.6)	20 (37)
2.	If a patient with type 2 diabetes on oral therapy is admitted and unable to eat, the most suitable method of treatment is an insulin sliding scale to treat hyperglycaemia.	47 (87)	*6 (11.1)
3.	A type 1 diabetic patient admitted for surgery is best managed with a sliding scale if not eating	47 (87)	*7 (13)
4.	Peri-surgically a patient with diabetes type 1 or 2 should be treated with intravenous insulin	*29 (53.7)	19 (35.2)
5.	Type 1diabetic patients who are eating should have their blood glucose monitored 6 hourly	23 (42.6)	*29 (53.7)
6.	A sliding scale is the best way of deciding how much insulin a patient with diabetes need	32 (59.3)	*21 (38.9)
7.	Insulin adjustments should be made according to an adjustment scale for all eating patients on insulin in hospital	*29 (53.7)	16 (29.6)
8.	Long acting insulin is contra-indicated in all patients admitted to hospital who are eating	3 (5.6)	*42 (77.8)
9.	Patients with type 1 diabetes always need some insulin irrespective of whether they are eating or not	*36 (66.7)	17 (31.5)
10.	Combination insulins e.g. Actraphane and Humulin 30/70 are not suitable for use in any patient with diabetes who is admitted to hospital.	6 (11.1)	*38 (70.4)

For the true/false section, the mean score was 4.94 (SD 1.59), median 5 (IQR 4 - 6) out of a potential 10. The highest score was 9, achieved by only 1 doctor. The results of the above true/false section based on more practical applications correlates with the 3 equivalent (therapy-related) sections of the O'Brien questionnaire (Diabetes medications, Insulin use, and Surgery and fasting in diabetes) (r=0.384, p=0.005).

Additional, more problem-based, questions were put to all nurses to assess their practical knowledge of diabetes.

Table IV: Nurses practical knowledge questions

	Question	True (%)	False (%)
1.	Do you consider a patient to be hypoglycaemic if the blood glucose is 2.9 mmol/l?	*51 (83)	6 (9.8)
2.	The best schedule to monitor blood glucose is a day profile (before and two hours after each meal and at 22:00)?	*35 (57.4)	14 (23)
3.	Is a blood glucose level of 8.3 mmol/l acceptable for a diabetic patient?	*39 (63)	19 (31.1)
4.	Do you think that diabetic patients are more prone to develop complications than non-diabetic patients while in hospital?	*39 (63.9)	18 (29.5)
5.	The forearm is the best place to inject insulin.	17 (27.9)	*42 (68.9)
6.	An insulin adjustment scale is the dose of insulin to be given in addition to the usual insulin dose and is determined by the pre-meal blood glucose.	*43 (70.5)	6 (9.8)
7.	Protaphane can be injected intravenously.	1 (1.6)	*40 (65.6)
8.	To test capillary blood glucose the side of the finger is the best place to do the finger prick.	*53 (88.5)	3 (4.9)
9.	Patients that are not eating should not receive boluses of insulin, but rather insulin infusions.	*38 (62.3)	6 (9.8)

When the same aspects were probed for in open questions, responses were as follows:

On asking what would be the ideal frequency of blood glucose testing in the ward, only 17 (27%) indicated that it should be done in relation to meals; this is in keeping with the doctors' responses.

Regarding which are the best body sites to inject insulin, 22 (36%) thought it was the forearm, 50 (82%) the thigh, 53 (87%) the abdomen, and 4 (7%) the upper arm.

About the symptoms of hypoglycaemia, 12 (20%) mentioned sweaty cold skin, 3 (5%) dizziness, 9 (15%) confusion or delirium, 11 (18%) coma or loss of consciousness, 3 (5%) restlessness, and 7 (11%) wrongly stated thirst. Thirty-five (57%) considered that a blood glucose less than 3 mmol/l is hypoglycaemic. In response to hypoglycaemia, 34 (56%) stated an appropriate action.

Concerning the difference between a sliding scale and a supplementation scale, 50 (82%) did not know that supplementation scale should be related to meals.

On asking which insulins can be given intravenously, 37 (61%) responded correctly – regular insulin.

From the DAS 3 questionnaire, it appears that nearly all medical and nursing staff are aware of and realise the need for special training in the management of diabetic patients (median score 4.6, mode 5). No difference could be indicated in their attitude towards the need for diabetes training between doctors and nurses. Regarding the four other parameters, the attitude towards diabetic patients was less strong (medians: 3.86, 3.86, 3.83 and 3.62). It seems that doctors are more aware than nurses of the seriousness of type 2 diabetes, the value of tight glycaemic control, and the psychosocial impact of diabetes on patients. This was indicated by the significant difference in mean DAS3 scores for the mentioned parameters ($p=0.001$, <0.001 and <0.001 respectively). Regarding patient autonomy in the management of their disease, both nurses and doctors felt equally strongly.

Discussion

The survey group comprised doctors and nurses working in a large secondary hospital in the government sector. It was found that these doctors, who care for mostly uninsured patients, have insufficient knowledge especially in three aspects of diabetes care for inpatients:

Firstly, knowledge of the use of diabetic medication seems to be inadequate, with a median score of 2 out of 5.

Secondly, knowledge of insulin use is lacking, with a median score of 2 out of 6. This deficit in knowledge was also apparent in the questionnaire on diabetes management, in which the median score was 5 out of a possible 10. The same can be concluded from the open practical diabetes management questions.

Thirdly, doctors have poor knowledge on dietary management of diabetes, with a median score of 3 out of 6. In comparison with the nurses, doctors tended to have better knowledge of the physiology of diabetes but, for all the other aspects of inpatient diabetes care, were no better than the nursing staff. The

mean total score was, however, significantly higher in doctors than in nurses – 68.3% v. 53.9%, with a difference of 14.4% (95% CI, 9.12 - 19.68, p<0.001).

Poor knowledge of diabetes management is not an unusual finding in health care providers, especially in the mostly surgical disciplines. This finding was also demonstrated in the study by Piaggesi et al.[15] who tested 60 non-diabetological health care providers for knowledge of diabetes care. Prominent in the Piaggesi study was the lack of knowledge regarding hypoglycaemia, the use and storage of insulin, and the correct utilisation of glucose test strips; these same aspects were identified in this study as requiring attention.

In comparison with the study by Oosthuizen[16] , the median DAS3 scores are comparable with those of doctors in this study. Both studies indicate that a need for special training exists; furthermore, the poor perception of patient autonomy needs to be addressed.

In comparison with the results of the O'Brien study,[13] this study seems to have had the same results, showing poor performance in aspects related to treatment and insulin administration.

This study surveyed only doctors and nurses who were prepared to take part, although an attempt to approach all medical and nursing staff was made. Since participation was voluntary, this study's results may overestimate the knowledge and attitudes of doctors and nurses, owing to volunteer bias. The generalisability of the findings is limited to hospitals with similar physician and nurse profiles. The generalisability of the study would have been better if the survey was done in more than one hospital, and included district and tertiary care hospitals.

The major problem identified in this survey is the lack of knowledge of doctors regarding to treatment of diabetic inpatients; this could be addressed by introducing training sessions on diabetes management to all doctors.

Alternatively, a specialised diabetes management team could take care of the management of diabetic inpatients concerning diabetes-related problems. A third option is the introduction of standardised diabetic inpatient management protocols that are specific enough to accommodate all the various diabetes inpatient circumstances and that incorporate potential therapies simple enough to be clearly understandable and easy to use.

Conclusion

Diabetes is becoming a very common disease, and increasing numbers of patients suffering from it will be hospitalised, for reasons not always related to diabetes per se. All health care providers, irrespective of the discipline they work in, should have a basic knowledge of how to manage diabetic patients when they are admitted, as a diabetologist or internist will by no means invariably be available to take care of the diabetic aspects of patients. Hospitals should consider appointing dedicated diabetes caregivers for inpatients or the introduction of clear and user-friendly inpatient diabetes management protocols.

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CHAPTER 4

Management of inpatients with diabetes who are able to eat meals: An audit before and after the implementation of a standardised inpatient management protocol.

Abstract

Background: Globally the prevalence of diabetes is increasing, which results in more patients with diabetes being admitted to hospital for diabetes related and diabetes unrelated causes. There are good reason for blood glucose to be controlled in hospital because of an increased risk of mortality and morbidity associated with hyperglycaemia. Current guidelines exist, detailing management of blood glucose in hospitalised patients. The implementation of these guidelines are often problematic and the guidelines are often not followed.

Objectives: This study attempted to implement a structured inpatient management protocol to assess if glucose control in hospital would be improved.

Methods: This was a quasi-experimental study with a before and after design. An audit of glycaemic control was done before and after physicians' and nurse training program as well as the introduction of a standardised inpatient management protocol. A second audit was done to assess the impact of the intervention on glycaemic control.

Results: The first audit included records of 164 patients and the second audit 199 patients. Of these, 150 records from audit one, and 183 records from audit two were eligible for inclusion in the study. On the first full day of hospitalisation the mean blood glucose was significantly higher in the second audit (1.72 mmol/L higher) ($p < 0.001$). This could be attributed mostly to patients admitted to internal medicine in whom the average blood glucose was 2.07 mmol/L higher ($p < 0.001$). A significant improvement in mean blood glucose was seen from day one to day seven within audit two (-1.88 mmol/L, $p < 0.001$), within audit one this change was not significant (-0.88 mmol/L, $p = 0.33$). Despite the higher mean blood glucose at day one, the proportion of patients that achieved a mean daily blood glucose of less than 10 mmol/L during hospital admission was very similar (43.0% versus 43.7%, $p = 0.97$). The number of hypoglycaemic events (blood glucose less than 4 mmol/L) per day of

hospitalisation increased significantly during audit two (19.6 versus 17.2 events per 100 patient days, p = 0.048). After adjustment for age, diabetes related admission or not and known with diabetes before admission or not mean blood glucose values was still higher in audit 2 than in audit 1 over time.

Conclusion: This study found no evidence that implementation of a standardised management protocol reduces hyperglycaemia and achieves earlier target blood glucose levels, in comparison to a free unstructured approach in inpatient glycaemic management.

Introduction

The global prevalence of diabetes is estimated to be 6.6% of the population, amounting to a staggering 285 million people. It is estimated that the prevalence will increase to 7.8% by the year 2030 (438 million people). The prevalence in Southern Africa is estimated at 4.5 to 5% and is expected to increase to 5 to 7% by 2030.[1] The increased prevalence of diabetes results in an increase in hospital admissions of patients with diabetes for diabetes related or unrelated problems.

Umpierrez et al.[2] studied admissions (medical and surgical) in a community hospital in the USA and found 26% of inpatients were known to have diabetes and 12% were newly diagnosed with diabetes in hospital. From the mentioned study patients with newly diagnosed hyperglycaemia were at higher risk of being admitted to ICU compared to patients with known diabetes and non-diabetic patients (29%, 14%, and 9% respectively). Inpatients with newly diagnosed hyperglycaemia were also at significantly higher risk of death (16%) in comparison to patients with known diabetes (3%) and non diabetic patients (1.7%). The reason for the excessively high mortality and morbidity rate in the newly diagnosed patients was that the hyperglycaemia was often left untreated (only 13% of these patients had a diabetic diet prescribed, 2% were prescribed oral hypoglycaemic agents, 6% received scheduled insulin dosages, and 35% were prescribed a sliding scale). However no randomised trial has been published examining the effect of intensive glycaemic control on outcomes in hospitalised patients outside ICU.

A number of observational studies have demonstrated a correlation between hyperglycaemia in peri-operative inpatients and adverse outcomes. Pomposelli et al.[3] found that a single blood glucose measurement in the first post-operative day of more than 12.2 mmol/L amounted to a 2.7 times higher risk of nosocomial infections. Similar findings were reported after trauma independent of the injury characteristics.[4] In patients with pneumonia the risk of

death also increased with an increase of blood glucose on admission; it seemed that the risk of in-hospital death increased by 8% for every one mmol/L increase in blood glucose after adjustment for the pneumonia severity.[5]
Zerr et.al.[6] conducted a study in cardiac surgery patients from 1991 to 2001 with management of blood glucose to a target range of: 8.3 - 11.1 mmol/l. An optimal blood glucose in the first 2 days post surgery resulted in a reduction of deep wound infections from 2.4% to 1.5% ($p \leq 0.02$).

In contrast, prospective randomised controlled trials attempting to obtain good glycaemic control show conflicting results for critically ill patients. If all ICU patients are included the RR for mortality between patients on intensive insulin treatment and conventional insulin treatment is 0.93 (CI 0.83 to 1.04). For purely medical ICUs the RR is 1 (CI 0.78 to 1.28), for mixed medical and surgical ICUs the RR for mortality is 0.99 (CI 0.87 to 1.12), and, for purely surgical ICU's the RR for mortality is 0.63 (CI 0.44 to 0.91). In this latter group one study by van den Berghe [7] explains this beneficial effect - all other studies were small and non-significant.[8]

Olson et. al.[9] analysed the impact of a hospital-wide diabetes management program on quality of care, length of stay and cost. They concluded that when more patients with diabetes were identified earlier during hospital stay, care was better as measured by lower mean blood glucose concentration (from 13.5 mmol/L to 8.21 mmol/L) and length of stay was reduced (8 days to 4.3 days).

We conducted this study to evaluate the effectiveness of the implementation of a structured protocol for management of blood glucose in inpatients with diabetes who are not critically ill.

Methods

Setting and participants

The study was conducted on patients admitted to Kalafong hospital, a large secondary hospital in the west of Tshwane district. A cross sectional audit of hospital records was done on two occasions. The first audit was done on records of patients admitted from May 2005 to December 2005 (reported in Chapter 2 of this thesis). The second audit was done on records of patients admitted from November 2006 to October 2007. Between the two audits a physician and nurse training programme was implemented.

The physician training programme consisted of formal lectures on how to manage non-fasting diabetic patients in the general wards. These lectures were presented at each department's regular meetings where all doctors of the department were present. The nurses were trained in the wards by a nurse educator who went from ward to ward offering nurses in-service training. All wards were issued with a poster with the diabetes management protocol; the protocol was put up against the wall at a conspicuous place in each ward. A new glucose monitoring sheet was introduced on which glucose monitoring in the wards was captured as well as record was kept of basal, prandial and supplemental insulin administered (see attached appendix).

All diabetic patients qualified for inclusion in the study provided they were eating and not on an insulin infusion. Patients who were admitted to the high care and intensive care units were included only after discharge to the wards. All records of diabetic patients were audited irrespective of the severity of the underlying disease and the reason for admission. Patients were prospectively identified for inclusion in the second audit on admission to the hospital. However, the researcher made no attempt to interfere or intervene in the management of the treating physician or caring nurses.

Measurements and data collection

Data was extracted from patient records for each of the patients included in the study. The data sources utilised were nursing notes and record sheets, medication administration sheets, vital sign and glucose monitoring sheets as well as physicians' clinical notes. All capillary blood glucose measurements and blood pressure measurements were recorded from patients' records for day one, three, seven and the last day of admission.

The outcome measures were: The mean blood glucose of patients on the first, third and seventh full day of hospitalisation and the time to glycaemic control. Glycaemic control was defined as the mean of all capillary glucose measured in 24 hours less than 10 mmol/L. The number of hospital days until glycaemic control was achieved was recorded. The proportion of patients who achieved glycaemic control according to the above mentioned criteria at discharge were determined. The number of inpatient hypoglycaemic events was counted for each patient. Hypoglycaemia was defined as finger prick blood glucose of less than 4 mmol/L.[10] Other patient information that was collected included: age, gender, reasons for admission, treatment before admission, unit and discipline admitted to, duration of diabetes since diagnosis, length of hospital stay, and patient outcome.

Statistical analysis

Data was captured electronically in a Microsoft Access database. Statistical analysis was done utilising SPSS 17 for Windows (SPSS Inc, 2008) and STATA 12 statistical software (StataCorp. 2011. *Stata Statistical Software: Release 12*. College Station, TX: StataCorp LP). All proportions are reported as percentages and continuous variables are reported as means and standard deviations (SD) except where data is ordinal or skew in which case it is reported as medians and inter-quartile ranges (IQR).

The analysis within each audit was done comparing. blood glucose change (delta) of day 1 to day 3 and day 3 to day 7 with a paired t-test.

Comparison between audit one and two were done as follows:

The repeated mean daily glucose profiles over time (day1, day 3 and day 7) were analysed using a covariance pattern model in STATA. Firstly, a saturated model including all the clinically important variables and the audit*time interaction was compiled. Based on Wald tests the fixed effects with highest p values were dropped from the model. An exchangeable covariance structure was used utilising maximum likelihood estimation. The model with and without the interaction term was assessed with a likelihood ratio test. Least square means contrasts between the two audits at different times were tested using the contrast option after the mixed model.

Secondly, the difference in time from admission to glycaemic control between the two audits was determined using survival analysis with Cox-proportional hazards modelling. For this analysis glycaemic control was defined as a mean blood glucose of all glucose measurements done per day, less than 10 mmol/L.

Results

Patient characteristics (Table I)

The records of 150 patients were evaluated in the first audit, with 11 patients from the department of Ophthalmology and 3 from the department of Gynaecology excluded in the analysis because of the lack of patients of similar departments in audit two. The second audit evaluated 184 patient records, with 15 pregnant patients from the Obstetrics unit and 1 patient from the department of Gynaecology excluded because the first audit did not include any obstetric patients and very few gynaecology patients. Figure 1 indicates the numbers of patients included and excluded to the study as well as the distribution between departments for both the first and second audits.

Baseline characteristics of all patients, reasons for admission and co-morbidities are given in table I.

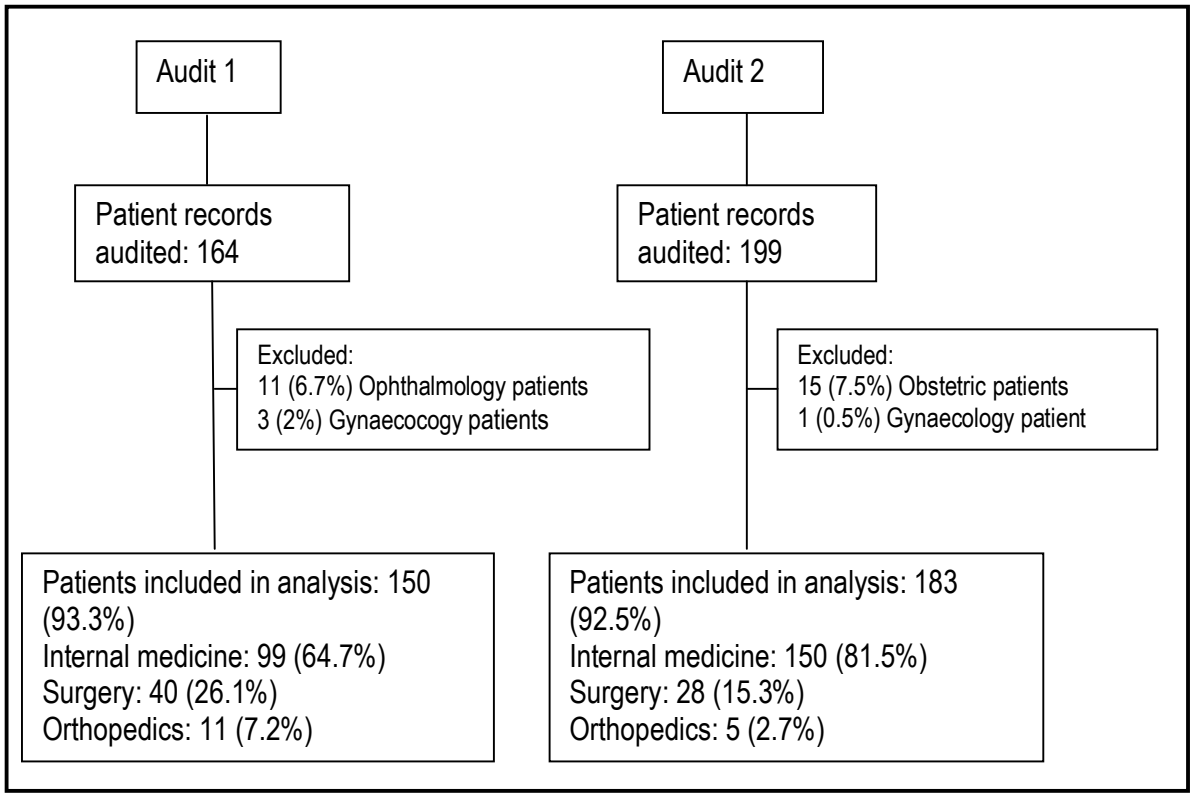

Figure 1: Flow of patients for analysis

Blood glucose

The mean blood glucose on the first full day of admission was significantly higher for audit two in comparison to audit one (delta: 1.7 mmol/L, $p < 0.001$). For patients admitted to the internal medicine units the difference between audit one and two were 2.1 mmol/L ($p = 0.001$) (Table II). The difference in baseline blood glucose between audit one and two was significantly different for the internal medicine units in comparison to that of the surgery and orthopaedic units together (2.0 mmol/L, $p < 0.001$).

For both audits the blood glucose change within the audit from day one to day three was not statistically significant ($p = 0.227$ for audit one and $p = 0.163$ for audit two). However the decrease in mean blood glucose from day one to day seven and from day one to the last day was significant for audit two (Delta: -1.9 $p < 0.001$ and delta: -2.2 $p < 0.001$ respectively). For Audit one the change in mean blood glucose from day one to day three increased non- significantly (Delta: 0.1 $p = 0.227$).

Table I: Patient characteristics in audit 1 and 2

Audit of diabetic inpatients	Audit 1 All N=150	Audit 2 All N = 183	P
Patient age (years)		N = 177	0.012
mean (SD)	58.1 (15.1)	53.6 (16.7)	
Duration of hospitalisation (days) median (IQR)	8 (4 – 14) range 1 - 87	8 (6 – 12) range 2 – 40	0.185
Duration of Diabetes (years) diagnosed before admission median (IQR)	N = 76/132 6 (2.25 – 12)	N = 120/142 5 (1 – 11)	0.253
Newly diagnosed	19 (12.6%)	42 (23%)	0.016
Gender Male	41 (27.3%)	75 (41%)	
Female	109 (72.7%)	108 (59%)	0.013
Diabetes treatment before admission (newly diagnosed cases excluded)	N = 138	N = 136	
No treatment	20 (14.5%)	4 (2.9%)	<0.001
Diet only	12 (8.7%)	0	
Oral treatment only	74 (53.6%)	69 (50.7%)	
Insulin only	20 (14.5%)	37 (27.2%)	
Combination oral and insulin	12 (8.7%)	26 (19.1%)	
Department hospitalised to			
Internal Medicine	99 (64.7%)	150 (82%)	0.001
Surgery	40 (26.1%)	28 (15.3%)	0.015
Orthopaedics	11 (7.2%)	5 (2.7%)	0.09
Primary reason for admission:			
Hyperglycaemia (excluding DKA and ketosis)	34 (22.7%)	92 (50.3%)	<0.001
Hypoglycaemia	10 (6.7%)	14 (7.6%)	0.718
DKA or ketosis	12 (8%)	38 (20.7%)	0.002
Leg and foot problems	17 (11.3%)	23 (12.57%)	0.861
Uncontrolled hypertension	13 (8.6%)	14 (7.6%)	0.892
Cardiovascular disease and stroke	22 (14.6%)	11 (6.01%)	0.015
Renal disease	7 (4.6%)	5 (2.73%)	0.518
Respiratory disease including pneumonia	13 (8.6%)	9 (4.92%)	0.251
Tuberculosis	4 (2.6%)	3 (1.64%)	0.79
Infections excluding respiratory and tuberculosis	3 (2%)	5 (2.73%)	0.941
Malignancy	4 (2.6%)	2 (1.1%)	0.51
Gastro-intestinal problems	12 (8%)	6 (3.3%)	0.098
Retroviral disease (HIV)	1 (0.67%)	4 (2.2%)	0.496
Orthopaedic related excluding leg and foot problems	16 (10.6%)	5 (2.73%)	0.006
Other	10 (6.7%)	8 (4.4%)	0.498
Patient outcomes	N = 144	N = 183	
Discharged	126 (87.5%)	169 (92.3%)	0.201
Died	12 (8.3%)	8 (4.4%)	0.44
Self discharged*	6 (4.1%)	6 (3.3%)	0.85
HbA1c on admission (%)	N = 71	N = 115	
Mean (SD)	11.3 (4.3)	13.3 (3.6)	0.139

*patients who refuse further hospital treatment

However, a significant decrease in mean blood glucose was evident from day one to the last day of hospitalisation (Delta: −2.0, $p < 0.001$). (See Figure 2) The change in mean blood glucose from day one to day seven in audit one (−0.88

mmol/L, p = 0.33) was significantly less than that of audit two (−1.9 mmol/L) (p = 0.031).

The improvement in mean blood glucose from day one to day seven was not consistent for all four departments. In audit one for internal medicine the mean blood glucose increased first (Delta: 0.1 p = 0.277) to day three and then decreased (delta: -1.0 p = 0.358), however the decrease from day one to the last day before discharge was significant (Delta: -2.0, p < 0.001). Audit two showed an initial slow decline in blood glucose from day one to day three (delta: -0.5, p = 0.163), the decline steepened to day seven (Delta: -1.9, p < 0.001) and a significant decline was observed from the first day to the last day of admission (Delta: -2.2, p = < 0.001) (Figure 2 and Table II).

Table II: Median duration of hospitalisation and comparison of unadjusted mean blood glucose for day 1, day 3, day 7 and the last day hospitalised for disciplines separately and together

	Audit 1		Audit 2		p
Internal Medicine	N		N		
Length of hospital stay median (IQR) (days)	99	8 (5 to 13)	150	8 (6 to 11)	0.494
Mean (SD) glucose day 1 (mmol/L)	91	10.7 (4.7)	150	12.8 (4.7)	0.001
Mean (SD) glucose day 3 (mmol/L)	78	10.9 (4.6)	139	12.1 (4.5)	0.056
Mean (SD) glucose day 7 (mmol/L)	49	9.9 (4.4)	76	10.5 (3.9)	0.44
Mean (SD) glucose last day (mmol/L)	81	9.0(3.6)	150	10.2 (3.2)	0.006
Surgery					
Length of hospital stay median (IQR) (days)	40	5 (2 to 17)	28	11 (6. to 15)	0.034
Mean (SD) glucose day 1 (mmol/L)	34	10.7 (3.3)	28	10.3 (4.0)	0.671
Mean (SD) glucose day 3 (mmol/L)	19	11.1 (4.9)	27	10.9 (3.7)	0.839
Mean (SD) glucose day 7 (mmol/L)	12	9.4 (3.3)	19	10.6 (4.1)	0.376
Mean (SD) glucose last day (mmol/L)	33	7.9 (0.3)	28	9.9 (4.3)	0.047
Orthopaedics					
Length of hospital stay median (IQR) (days)	11	5 (4 to 12)	5	18 (11 to 26)	0.031
Mean (SD) glucose day 1 (mmol/L)	9	9.3 (2.7)	5	11.5 (4.0)	0.261
Mean (SD) glucose day 3 (mmol/L)	6	8.2 (1.4)	5	11.7 (3.3)	0.043
Mean (SD) glucose day 7 (mmol/L)	4	9.4 (4.7)	5	10.1 (2.0)	0.754
Mean (SD) glucose last day (mmol/L)	8	7.9 (3.3)	5	10.3 (2.6)	0.0204
All disciplines					
Length of hospital stay median (IQR) (days)	150	8 (4 to 14)	183	8 (6 to 12)	0.185
Mean (SD) glucose day 1 (mmol/L)	134	10.7 (4.0)	183	12.3 (4.6)	<0.001
Mean (SD) glucose day 3 (mmol/L)	103	10.8 (4.5)	171	11.9 (4.4)	0.042
Mean (SD) glucose day 7 (mmol/L)	65	9.8 (4.2)	100	10.5 (3.9)	0.255
Mean (SD) glucose last day (mmol/L)	122	8.6 (5.5)	183	10.2 (3.4)	<0.001

For patients admitted to the surgery department in audit one a non-significant increase in mean blood glucose was seen from day one to day three (Delta: 0.42, p = 0.328). This increase was not maintained and the mean blood glucose

to day seven decreased (Delta from day one: -1.4, p = 0.55). The mean blood glucose on the last day before discharge was significantly lower compared to day one (Delta: -2.8, p <0.001). At the second audit the mean blood glucose increased from day one to day three (Delta: 0.5, p = 0.484), from day 3 to day seven (Delta: 0.2, p = 0.983). The mean glucose however decreased non-significantly by 0.4 mmol/L (p = 0.68), from day one to the day before discharge. The trends for orthopaedics can be seen in figure 3 but is not reliable because of small numbers.

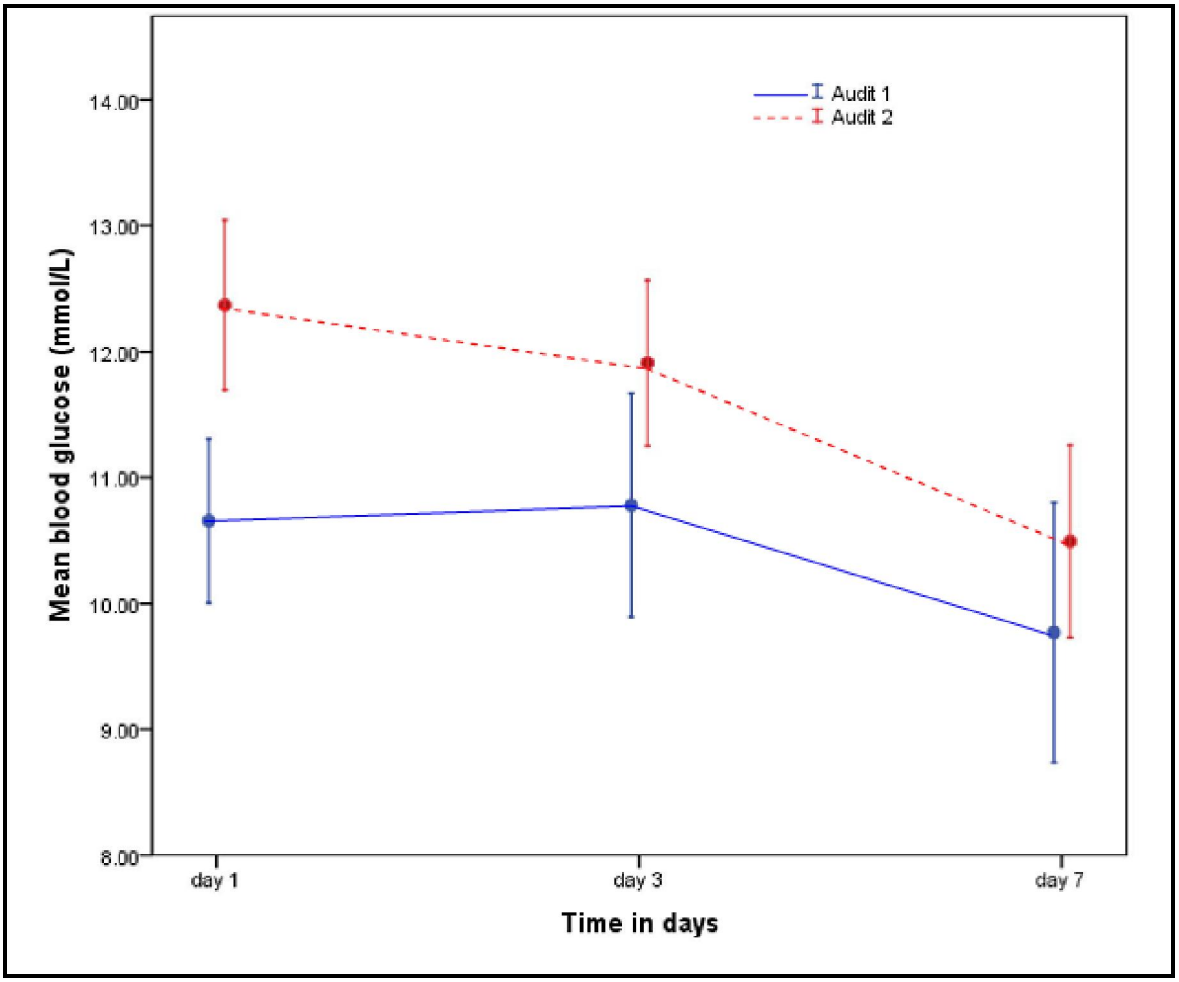

Figure 2: Unadjusted change in mean blood glucose from day one to day seven of hospital admission

Hypoglycaemia

The number of hypoglycaemic events per hospital day in audit two (19.6 events per 100 patient days) was significantly more than in audit one (17.2 events per 100 patient days) (p = 0.048). Hypoglycaemic events during the day of admission were not included in the analysis to prevent bias introduced by patients admitted for hypoglycaemia.

Adjusted between audit analysis of glycaemic control

Audit one and two was done more than a year apart and from the audits it seems that a significant change occurred in patient demographics and severity of disease (Tables I, II). Baseline (day 1) blood glucose in audit two were significantly higher than in audit one. Therefore an adjusted analysis was done. The final model was adjusted for age, diabetes related admission or not and, known diabetes before admission or not. Hyperglycaemia as primary reason for admission was not adjusted for because it was probably under reported in audit one, and therefore not comparable to that of audit two. The model with the interaction term (audit*time) included is shown below.

Table III: Saturated model with interaction term

Variables included in the model	Coefficient	P	95% Conficence interval
Age	-0.05	<0.001	-0.1 to -0.0
Diabetes related admission	1.3	0.001	0.5 to 2.1
Audit (Reference audit is audit 1)	0.8	0.083	-0.1 to 1.8
Time with reference time day 1			
Day 3	0.2	0.689	-0.7 to 1.0
Day 7	-0.7	0.138	-2.6 to -0.0
Interaction (audit*time) reference audit 1 and time day 1			
At day 3	-0.6	0.266	-1.7 to 0.5
At day 7	-1.3	0.049	-2.6 to -0.0
Diabetes known before admission	-1.7	<0.001	-2.6 to -0.7
Constant	14.7	<0.001	13.0 to 16.5

The coefficient for audit can now be seen as the unweighted average of the audit effect obtained from each time point (0.8 mmol/l higher in audit 2 versus

audit 1). However as the 95% CI indicates this was just not statistically significant (-0.1 to 1.8)

Based on the model the predicted values for each audit at day 1, day 3 and day 7 are presented in table IV and graphically in figure 4

Table IV: Predicted mean glucose values for day 1, day 3 and day 7 based on model in table III

Time	Audit	Predicted mean blood glucose	95% confidence interval
Day 1	1	11.2	10.5 to 11.9
Day 1	2	12.0	11.4 to 12.6
Day 2	1	11.4	10.6 to 12.2
Day 2	2	11.6	11.0 to 12.2
Day3	1	10.5	9.5 to 11.4
Day 3	2	10.0	9.2 to 10.8

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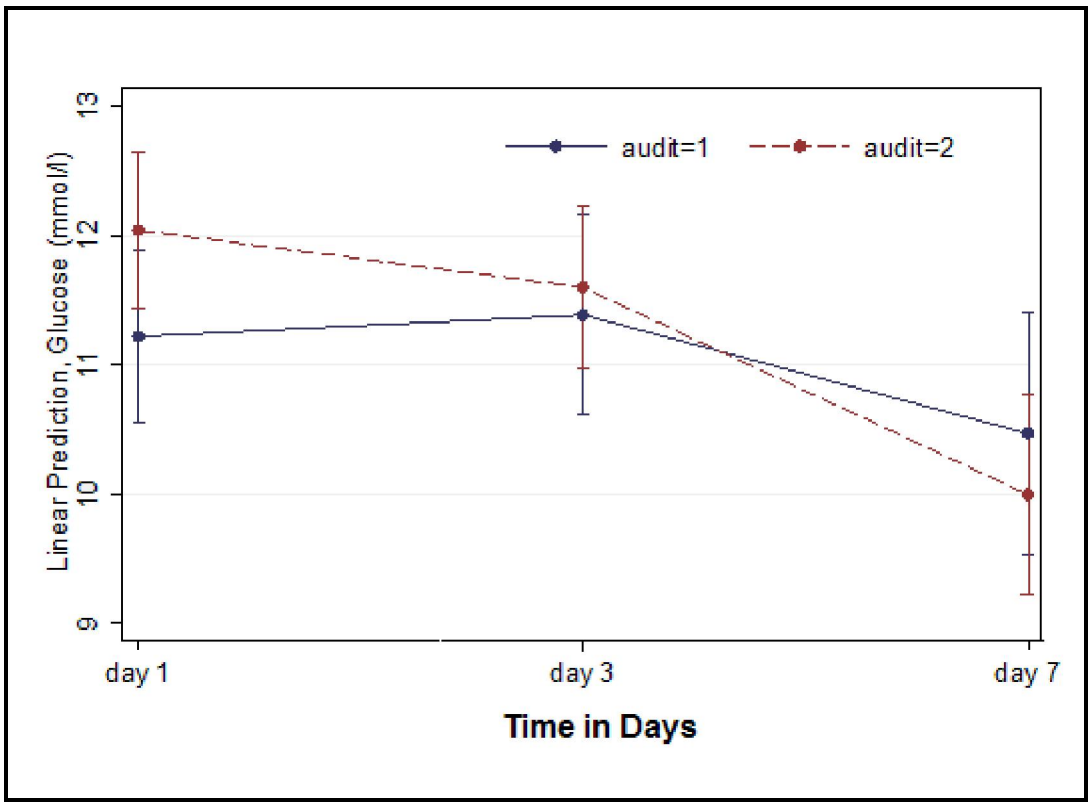

Figure 3: Predicted mean blood glucose for Audit 1 and 2 at day 1,3 and 7

For the model described in table III the contrasts over time are reflected in table V.

Table V: Contrasts between audits for mean glucose predicted for Day 1, 2 and 3

Time	Contrast between Audit 1 and 2	Standard error	95% Confidence interval	p
Day 1	0.8	0.5	-0.1 to 1.8	0.083
Day 3	0.2	0.5	-0.8 to 1.2	0.685
Day 7	-0.5	0.6	-1.7 to 0.8	0.453

Since none of the contrasts were statistically significant no corrections for multiple testing were done. The likelihood ratio P value for the interaction term was 0.13. If the interaction term was dropped from the model the results were as follows

Table VI: Revised model without the interaction term

Variables included in the model	Coefficient	P	95% Conficence interval
Age	-0.1	<0.001	-0.1 to -0.0
Diabetes related admission	1.4	0.001	0.6 to 2.2
Audit (Reference audit is audit 1)	0.4	0.350	-0.4 to 1.1
Time with reference time day 1			
Day 3	-0.2	0.493	-0.7 to 0.3
Day 7	-1.5	<0.001	-2.1 to -0.9
Diabetes known before admission	-1.7	<0.001	-2.6 to -0.7
Constant	15.0	<0.001	13.3 to 16.7

With the interaction term removed the coefficient for audit represents a weighted average of the audit effect for each time point (0.4, 95% CI -0.4 to 1.1 mmol/l). The predicted mean blood glucose values for the two audits at day 1, 2 and 3 for the revised model are reflected in table VII and figure 6.

Table VII: Predicted mean glucose values for day 1, day 3 and day 7 based on the revised model in table VI

Time	Audit	Predicted mean blood glucose	95% confidence interval
Day 1	1	11.5	10.9 to 12.1
Day 1	2	11.8	11.3 to 12.4
Day 2	1	11.3	10.6 to 11.9
Day 2	2	11.6	11.1 to 12.2
Day3	1	10.0	9.2 to 10.7
Day 3	2	10.3	9.7 to 11.0

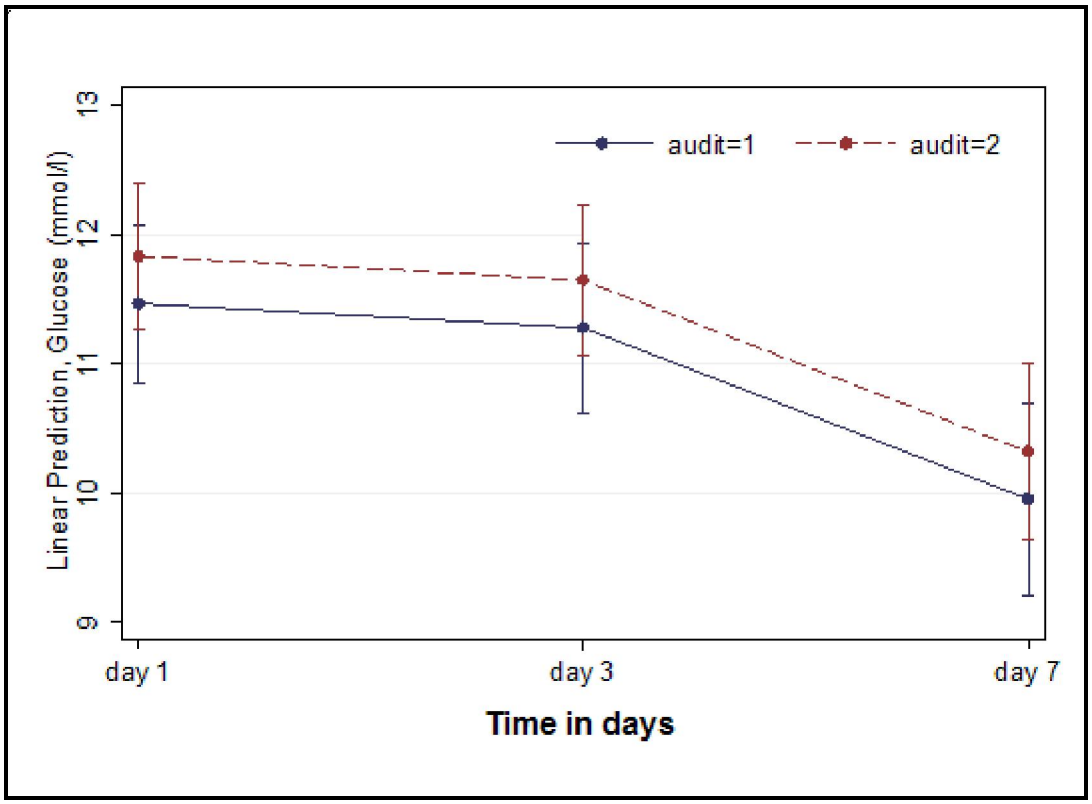

Figure 4: Predicted mean blood glucose from the revised model (without interaction term) for Audit 1 and 2 at day 1, 3 and 7

These results thus show that the audit did not have an effect over days of measurement and neither was the mean difference over time significant between the 2 audits.

Time to glycaemic control

There was no significant difference in the proportion of patients between the two audits who achieved control (audit one: 43%, audit two: 43.7%, p = 0.97)

The median time to achieve glycaemic control in an unadjusted Kaplan Meyer analysis, for the patients that achieved control was 14 days (95% CI: 6.8 to 21.2) for audit 1 and 15 days (95%CI: 9.8 to 20.2) for audit 2. The median time to glycaemic control if unadjusted was non-significantly longer in audit 2 than in audit 1 (p = 0.189). A Cox proportional hazards model was compiled to compare the time in hospital to achieve glycaemic control (a mean blood glucose of less than 10 mmol/L) between the two audits, adjusted for the significant difference in baseline mean blood glucose (HR: 0.77, p = 0.124). The difference in time to glycaemic control between audit one and two was completely explained by the

difference in baseline blood glucose (-Log Likelihood: 1443.018, Chi-square: 26.159. p <0.001). Thus, after adjustment for the difference in baseline glucose no difference in time to glycaemic control between audit one and two could be demonstrated.

Discussion

The results of this study failed to show that the implementation of an inpatient diabetes management protocol and a physician and nurse education programme improved blood glucose control as measured by the change in mean blood glucose from admission to day seven after admission. It could also not indicate any improvement in the time to achieve glycaemic control before and after the implementation of the intervention.

On admission patients in audit two had poorer pre-admission glycaemic control (baseline HbA1c) (although not statistically significant), as well as higher mean blood glucose values on the first full day in hospital.

In audit one there was an initial slight increase in blood glucose to day three where after the blood glucose decreased. In audit two there was an initial slight decrease in blood glucose to day three, which accelerated to day seven. In both audits the most improvement in mean blood glucose seemed to occur after day three.

For both audits, the patients with the highest blood glucose on admission were admitted to the Internal Medicine department, because most patients were specifically admitted for poor glycaemic control. All the other departments admitted patients for reasons other than diabetes control but with diabetes related or diabetes unrelated diseases. This different spectrum of patients may also explain the difference seen in blood glucose improvement between patients admitted to Internal Medicine and the other departments. This discrepancy between patients admitted to internal medicine versus surgical departments is

not unique to this study; it was also seen in a Swiss study.[11] The admission blood glucose in the Swiss study was also significantly higher in patients admitted to medical units. The increase in blood glucose from the first to the second audits for the first day of hospitalisation may indicate an increase in the glycaemic threshold for admission by clinicians. The increase was also seen in the Swiss study[11] where the baseline glucose increased from 11.3 mmol/L in 2002, to 13.5 mmol/L in 2005.

This was a quasi-experimental study with a before and after design. This design is not the ideal study design, but because of limitations in the study setting this was the only design to prevent cross contamination of the intervention. The reason for this is that the doctors' work in more than one of the hospital units, and it would be unethical to give training to one group of doctors and nurses working in the same clinical departments and not to others.

Part of the intervention was to implement a meal related blood glucose monitoring system instead of the previously used four or six hourly system. The implication of this change is that ascertainment bias may have been introduced due to the difference in timing of blood glucose monitoring between audit one and two. However this would introduce a random rather than a systematic error.

For this study, glucose control was defined as the mean of all blood glucose measurements in 24 hours of less than 10 mmol/L. At present there are no clear criteria for what would constitute good glycaemic control in diabetic patients in hospital. The reason for this uncertainty is that patients in hospital usually have multiple blood glucose measurements, some of these measurements are fasting, some post prandial and some random. Because of this a number of performance measures are proposed, of which one is the mean daily blood glucose. The mean daily blood glucose was used in this study is because it gives a good reflection of the glycaemic exposure.[12]

In the study reported here nurses and physicians were trained and protocols for treatment were made available in all units, but doctors and nurses were free to adjust treatment as they deemed appropriate. A limitation of this study was that the appropriateness of treatment decisions regarding glycaemic control made by clinicians and nurses were not evaluated. The suspicion is that as in other studies there was a lack of treatment intensification despite the availability of treatment protocols.[13]
During the second audit, nurses and doctors may have been aware of the audit taking place and therefore could have changed there behaviour (Hawthorn effect), however in the light of the results of this study it unlikely played a significant role.

In a similar study which used a retrospective observational design to compare blood glucose control pre and post implementation of a diabetes management protocol the hyperglycaemic control was poorer (Mean blood glucose 9.6 mmol/L before versus 10.4 mmol/L afterwards), but less hypoglycaemia episodes occurred.[14] In our study there was also a decline in glycaemic control, but blood glucose on admission was significantly higher at the onset of the second audit. In a cluster randomised controlled trial published by Schnipper et. al.[15] who used a computer based patient order set as intervention compared to usual care, the improvement of the patient-day weighted mean blood glucose control was significant (8.2 mmol/L versus 8.7 mmol/L in the control group). In our study no measurement of compliance to the implemented protocol by medical and nursing staff was made, furthermore the effect of staff turnover was not assessed. These factors might explain the lack of an improvement in mean blood glucose.

From the literature glycaemic control and the risk of errors occurring in patient management can be improved with the use of a structured protocol or order set for the management of inpatients with diabetes. A protocol can also reduce the risk of hypoglycaemia and it can result in increased patient, nurse and doctor satisfaction in diabetes management.[16 17]

Conclusion: From this study no improvement in mean blood glucose could be demonstrated by the introduction of a standardised inpatient diabetes management protocol. There was also no evidence for achieving glycaemic control more often and earlier in patients treated with a standardised inpatient management protocol.

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CHAPTER 5

Diagnosis and treatment of diabetic ketoacidosis

Adapted from: SA Fam Pract 2008;50(1):35-39

Abstract

Diabetic ketoacidosis (DKA) is the most frequent hyperglycaemic acute diabetic complication. Furthermore it carries a significant risk of death, which can be prevented by early and effective management. All physicians, irrespective of the discipline they are working in and whether in primary, secondary or tertiary care institutions, should be able to recognise DKA early and initiate management immediately.

Introduction

Diabetic ketoacidosis (DKA) is a common complication of diabetes with an annual occurrence rate of 46 to 50 per 10 000 diabetic patients. The severity of this acute diabetic complication can be appreciated from the high death-to-case ratio of 5 to 10%.[1] In Africa the mortality of DKA is unacceptably high with a reported death rate of 26 to 29% in studies from Kenya, Tanzania and Ghana.2 It is a complication of both type 1 and type 2 diabetes mellitus, although more commonly seen in type 1 diabetic patients. Of known diabetic patients presenting with DKA about one-quarter will be patients with type 2 diabetes. In patients presenting with a DKA as first manifestation of diabetes about 15% will be type [2.3]

This correlates well with data from South Africa suggesting that one- quarter of patients with DKA will be type 2 with adequate C-peptide levels and the absence of anti-GAD antibodies.[4]

This review will focus on the principles of diagnosis, monitoring and treatment of DKA, with special mention of new developments and controversial issues.

Clinical features

DKA evolves over hours to days in both type 1 and type 2 diabetic patients, but the symptoms of poor control of blood glucose are usually present for several days before the onset or presentation of ketoacidosis.[5] The clinical features of DKA are non-specific and patients may present with complaints of nausea, vomiting and weakness, polyuria, polydipsia, abdominal pain and weight loss. In a study by Newton and Raskin[6] the frequency of symptoms in patients were as follows: nausea 83.4%, vomiting 78.5%, polyuria 75.2%, polydipsia 74.4%, abdominal pain 51.2%, weight loss 42.1% and polyphagia 33.1%. Abdominal pain is a misleading manifestation, which can result in the late or misdiagnosis of DKA. Abdominal pain appears to be related to the presence of metabolic

acidosis, but the exact mechanism is poorly understood.[7] Often in children the abdominal pain may clinically mimic the findings of an acute abdomen.

Physical examination may also show evidence of dehydration: loss of skin turgor, dry mucus membranes, tachycardia and hypotension.[5] In the study by Newton and Raskin,[6] patients had an average heart rate of 117 beats per minute, but most patients had a slightly elevated systolic and diastolic blood pressure (mean 135 ± 23 and 85 ±15). Most patients were normothermic or hypothermic despite the high frequency of infection present and it seems that severe hypothermia carries a poor prognosis.[5] patients with DKA can present with varying levels of consciousness with the majority of patients being alert and less than 20% present comatose.[8] Abnormalities detected in mental status examination seem to correlate best with an increase in osmolality. Furthermore, patients with severe metabolic acidosis will usually have distinctively rapid and deep breathing (Kussmaul's breathing).

Diagnostic criteria

In 2003 the American Diabetes Association (ADA)[9] modified the diagnostic criteria of DKA with the introduction of severity categories of mild, moderate and severe (see Table I).

The diagnosis of DKA consists of a triad of hyperglycaemia, ketonaemia and metabolic acidosis.[10]

Most DKA guidelines indicate that hyperglycaemia of more than 13.9 mmol/l is necessary for the diagnosis of DKA, however this is not an absolute requirement, as DKA without hyperglycaemia has been reported. DKA without hyperglycaemia is mostly reported during pregnancy, and in patients with prolonged vomiting or starvation. It can also occur in patients with liver failure or in alcohol abusers.[11]

Table III: Diagnostic criteria and severity of DKA

	Mild	Moderate	Severe
Plasma glucose (mmol/L)	> 13.9	> 13.9	> 13.9
Arterial pH	7.25–7.30	7.00–7.24	< 7.00
Serum bicarbonate (mmol/L)	15–18	10–14.9	< 10
Urine ketones	Positive	Positive	Positive
Serum ketones	Positive	Positive	Positive
Anion gap	> 10	> 12	> 12
Sensorium	Alert	Alert/drowsy	Stupor/coma

Adapted from ADA position statement [9]

Ketone bodies are produced in the liver from acetyl-CoA liberated during lipolysis from fatty acids. For DKA to develop, an absolute or relative insulin deficiency must be present. Three ketone bodies are produced: acetone (resulting in the fruity odour of DKA patients), aceto-acetate and ß-hydroxybuterate (ß-OHB). ß-OHB is the most prominent contributor to metabolic acidosis in patients with DKA. Acetone does not contribute to acidosis and is not usually measured as such. Aceto-acetate can be measured in the urine with a urine dipstick utilising the nitroprusside reaction. As DKA resolves, ß-OHBare oxidised to acetoacetate. Therefore, if only a urine ketone dipstick procedure is done it might give the impression that the condition is not improving. Currently blood ketones can be measured with a point of care (bedside) meter utilising capillary finger prick blood.[12] This measures ß-OHB directly and accurately.[13 14] A capillary ß-OHB value of 3 mmol/l and above has a positive likelihood ratio of 15 for the presence of DKA.[15] It is recommended by the ADA that the blood ketone measurement of ß-OHB is preferable to urine measurement for the diagnosis and monitoring of DKA.[9]

An arterial pH of less than 7.3 should be present in the diagnosis of DKA. The measurement of pH and/or serum bicarbonate is essential for the diagnosis and estimation of severity of DKA. The pH is also an important measure to assess improvement and for adjustment of treatment. A venous pH determination would probably be sufficient, unless respiratory function needs to be assessed as well. The venous pH is on average 0.03 lower than the arterial pH.[16]

Precipitating events that can trigger DKA

The most common precipitating event for the development of DKA is infection, which accounts for 28% to 45% of cases. Pneumonia or any lung disease that can influence oxygenation, and can lead to respiratory failure, should always be considered as extremely serious because it may impair respiratory compensation of metabolic acidosis.[17] The second most common precipitating event worldwide is the omission of insulin.[18] The third most common cause is the first manifestation of new onset diabetes. Other common precipitating events include cardiovascular events such as a stroke, myocardial infarction and peripheral vascular disease with gangrene.[19 20] In a Kenyan study,[21] 34% of DKA events were due to missed insulin injections, 23.4% to overt infection and only 6.4% had both infection and missed insulin injections. Infection sites included respiratory, genito-urinary and septicaemia. DKA is about 10 times more common in patients with schizophrenia. This may be due to the use of the newer antipsychotic agents clozapine and olanzapine.[22 23]

The physician caring for diabetic patients should enquire and be aware of the high risk related to psychological and socioeconomic factors. A study of urban African Americans[24] states that 50% of patients presenting with DKA as a result of non-compliance of insulin did so because of lack a of money to buy insulin or to pay for transport to the hospital. Another 14% failed to comply with the prescribed insulin injections due to behavioural or psychological reasons. All diabetic patients should be educated and trained about what to do when they become ill, until they are able to see a health care professional.[25]

Monitoring to recovery of DKA

Due to the seriousness and high risk of relapse or deterioration in patients with DKA, it is important to monitor progress frequently. Monitoring should include clinical parameters such as blood pressure, pulse rate, hydration status and mental status. Laboratory and bedside biochemical measurements should be assessed regularly. These include capillary blood glucose, urine or blood ketones, serum potassium, sodium, phosphate and, very importantly, venous pH.[26] For a suggested monitoring schedule please see Table II.

DKA is considered resolved when the blood glucose is less than 11.1 mmol/l and the serum bicarbonate above 18 mmol/l or the venous pH is greater than 7.3. Note that the clearance of serum or urine ketones takes longer to resolve than the blood glucose and the pH.[26 27]

The indicators of recovery in most institutions are a pH greater than 7.3 and urine ketone-free. Evidence is accumulating to utilise point-of- care ß-OHB determinations less than 1 mmol/l, on two occasions, as indicator of recovery, which seems to occur significantly earlier than urine ketone clearance.[28]

Novel ways to monitor patients with DKA include continuous non- invasive measurement of end-tidal CO_2. This was used in two paediatric studies , which seemed to give an accurate estimate of the PCO_2 and correlated well with venous pH. Capnometry therefore allows the clinician to have continuous, indirect indication of the acidic state of patients with DKA.[31 32] The CO_2 can also be continuously measured transcutaneously.[33]

Table II: Suggested frequencies of monitoring of laboratory and bedside parameters

Monitoring parameter	Suggested frequency
Blood glucose	Hourly until blood glucose less than 14 mmol/l. Thereafter two- to four-hourly. Once the patient is off an insulin infusion and eating: meal-related monitoring (before each meal and two hours afterwards)[26 29 30]
Electrolytes and venous pH or bicarbonate	Two- to four-hourly[26 29 30]
Urine or blood ketones	Two- to four-hourly[29 30]
Blood urea and creatinine	Six- to eight-hourly[29 30]
Serum magnesium and phosphate	Two- to four-hourly[29 30]

A frequently encountered problem is to decide where to manage a patient with DKA. The ADA hospital admission guidelines for diabetes advise admission to hospital when the plasma glucose concentration is 14 mmol/l or more, the pH is less than 7.3 or the serum bicarbonate less than 15 mmol/l in the presence of moderate amounts of ketones in the blood or urine.[34] These guidelines also suggest ICU admission in cases of severe DKA. In a survey on treatment of DKA in Denmark, it was found that in one-third of institutions DKA is routinely managed in ICU.[35] This is also the case in the United States, where hospital policy dictates that insulin may only be administered intravenously in an ICU.[2 36] In a setting with limited resources, ICU or high-care admission is frequently not an option, but a higher level of care is needed for patients with DKA due to the need for frequent monitoring and the complexity of treatment regimens. This requires a team approach of dedicated nursing and medical ward staff.

Treatment of DKA

The management of DKA is multifaceted and therefore requires a structured approach by clinicians and nurses. Numerous treatment guidelines are available in the medical literature; however, these are not always rigorously followed. In a Scottish study in an academic institution, delays in the initiation of intravenous (IV) fluid replacement and administration of insulin were seen in up to 70% of cases. Under- replacement of IV fluids and inadequate potassium replacement during the first 24 hours were seen in 70% of cases. These inadequacies occurred despite the availability of treatment guidelines.[37] Every hospital managing patients with DKA should have a structured way or a so-called integrated care pathway for managing patients with DKA. This is a detailed management plan that should dictate the sequence and timing of actions, and specify by whom it should be done, in order to fulfil the goals of treatment. A recent study showed that an integrated care pathway improves key areas in the management of DKA significantly.[38]

Fluid replacement

The fluid deficit is typically about 100 ml/kg body weight, which amounts to five to seven litres in the average adult patient.[26 27] The deficit can be calculated using the following formulas:

Fluid deficit = (0.6 x body weight in kg) x (corrected Na^+/140)

Where: Corrected Na^+ = sNa^+ + (sGlucose - 5)/3.5

Administration of fluids alone results in a significant fall in blood glucose levels. This is mediated by recovery of the glomerular filtration rate, which declines with severe dehydration caused by the DKA.[39] All the guidelines recently published and accessed by the author recommend the use of 0.9% NaCl solution as initial resuscitation fluid or the use of 0.45% NaCl solution if the serum sodium concentration is high.[4 19 26 27 40 41] No randomised controlled trials are currently available to support the superiority of any specific fluid regimen.[40] The use of

Ringer's lactate solution is advocated in some units based on the strong-ion theory for acidosis (Stewart's hypothesis).[42] The proponents of the use of Ringer's lactate are concerned about the development of hyperchloraemic metabolic acidosis with the use of 0.9% sodium chloride solution, which may delay recovery of metabolic acidosis if the pH or base deficit is used as indicator of resolution of DKA. The pH and base deficit cannot distinguish between resolution of ketosis or hyperchloraemia as cause of acidosis, the anion gap may be useful distinguishing between the two causes.[43] The proponents of the use of 0.9% sodium chloride are concerned about the lactate in Ringer's lactate because patients with DKA already has a high lactate to pyruvate ratio, and the additional lactate may lead to an initial worsening of acidosis.. A second concern is the potassium content of Ringer's lactate which can potentially lead to worsening of hyperkalaemia often present early in patients with DKA.[44]
Currently no definitive proof based on randomised controlled trials are available to assume that there is any benefit in using Ringer's lactate solution instead of a saline-based regimen. No information is available for potential benefits of use of Ringer's lactate after initial resuscitation.[40]

Fluid resuscitation should be aggressive with the administration of 1 to 1.5 l of fluid within the first hour and thereafter 250 to 500 ml/hour.[5 45] The aim is to replace 50% of the fluid deficit within the first 8 to 12 hours and the rest within the next 12 to 16 hours.[26] Once the blood glucose drops below 14 mmol/l, it is generally advised to change the fluid administration to a dextrose-containing solution (either 5% dextrose water or 5% dextrose in 0.9% NaCl solution or 5% dextrose in 0.45% NaCl solution).[5 26 27 41] In elderly patients or patients with cardiovascular, renal or liver disease, be careful for overhydration and volume overload. It is usually beneficial in these patients to monitor fluid administration invasively with a central venous line.[46]

Insulin therapy

Low dose (0.1 U/kg/hour) IV administration of soluble insulin is currently the standard of care in patients with DKA.[47 48] Soluble insulin (regular, lispro or aspart) should be used, but it should be noted that the synthetic insulins do not work faster than regular insulin when administered intravenously.[19] Before commencing insulin therapy, hypokalaemia (sK^+ < 3.3 mmol/l) should be excluded. Insulin should be initiated with an IV bolus of 0.1 to 0.15 U/kg followed by a continuous infusion of 0.1 U/kg/hour. Children should not receive an insulin bolus since it may increase the risk of cerebral edema.[49] Adjust the insulin infusion rate to maintain a steady decrease in blood glucose of 3 to 5 mmol/l/hour.[5 19] Once blood glucose is lower than 9 mmol/l, the infusion rate can be decreased.[5 26]

After resolution of DKA, the patient can be started on a multidose insulin regimen with regular or rapid-acting insulin for prandial requirements and intermediate or long-acting insulin for basal requirements. The insulin infusion should be stopped one to two hours after the first subcutaneous insulin injection. Patients who were on insulin therapy before the onset of the DKA can be restarted on their usual insulin regimen. The usual starting dose for patients who were not on insulin before is 0.5 to 0.6 U/kg/day.[5 19 30 40]

Two clinical trials have been done to assess the use of rapid acting insulin analogues subcutaneously in patients with DKA.[50 51] Although these were small studies, no statistical difference in outcomes could be demonstrated between patients receiving subcutaneous rapid-acting insulin analogues and those receiving regular insulin infusions. The analogues were administered as an initial bolus of 0.3 U/kg, which was followed by 0.1 U/kg every hour until the blood glucose was less than 14 mmol/l, when the dosage was halved to 0.05 U/kg/h.

Potassium replacement

Total body potassium is depleted in DKA. This occurs in spite of a normal, high or a low serum potassium concentration. Volume increase during rehydration, insulin therapy and recovery of acidosis all mediate a drop in potassium concentration, which may lead to severe hypokalaemia with cardiac arrhythmias or respiratory muscle weakness. Therefore potassium needs to be replaced even if the concentration is still normal. Initiate potassium supplementation if the serum potassium is 3.3 to 5.3 mmol/l, and monitor it regularly.[5 26]

Table III: Summary of management of DKA in adults

Timing	IV fluids	Insulin	Electrolytes
Admission	0.9% NaC1: 1 to 1.5 litre in the first hour (infusion rate: 15–20 ml/kg)	IV bolus: Regular insulin 0.1–0.15 IU/kg followed by a continuous infusion at a rate of 0.1 IU/kg per hour Usually prepared as follows: 20 IU in 200 ml 0.9% saline (0.1 IU/ml) Thus for an 80 kg person: 8 IU/h = 80 ml/h or 80 microdrops/min	**Bicarbonate** (Controversial) If the pH < 7.0: 50 mmol/l NaHCO3 in 200 ml 0.45% saline over one hour If the pH < 6.9: 100 mmol/l NaHCO3 in 400 ml 0.45% saline over one hour This can be repeated two-hourly
After 1 hour	Reassess: Hydration status hourly sNa^+ concentration Continue with 0.9% NaCl if sNa is normal or low: 250–500 ml/h (4–14 ml/kg depending on the hydration status) If sNa^+ is elevated change to 0.45% NaCl Replace half the fluid deficit in the first 12 hours (serum osmolality should not change > 0.3 Osmol/kg)	Reassess blood glucose Increase the insulin infusion rate if the blood glucose concentration does not decrease by 3 to 4 mmol/l/h Adjust infusion rate two-hourly based on blood glucose as follows: • s Glucose: < 5.6 mmol/l decrease by 10 ml/h and give 25 ml of 50% dextrose IV • s Glucose: 5.6–8.9 mmol/l decrease by 10 ml/h (1 IU/h) • s Glucose: 9–12.2 mmol/l no change • s Glucose: 12.3–15.6 mmol/l increase by 10 ml/h (1 IU/h) • s Glucose > 15.6 mmol/l increase by 10 ml/h and give a bolus of regular insulin of 8 U IV	**Potassium** Always check K^+ concentration before commencing with insulin administration. • If sK^+ > 5.0 mmol/l no K+ supplement but check q two-hourly • If sK^+ 3.0 – 5.0 mmol/l add 20 mmol in each litre of IV fluid in order to maintain the sK^+ concentration between 4.0–5.0 mmol/l • If sK^+ < 3.0 mmol/l add 40 mmol to the initial IV fluid (withhold insulin until K^+ > 3.0 mmol/l)
Blood glucose < 14 mmol/l	Change to 5% dextrose or 5% dextrose in 0.45% NaCl solution	When the patient is able to eat, give meal-related boluses of regular insulin (usually 1 IU per 15 g carbohydrate in meal), in addition to the continuous IV insulin infusion	**Phosphate** Replacement only necessary if PO4 concentration is < 0.33 mmol/l. Replace with potassium phosphate solution IV 14 mmol (10 ml) in 1l hydration fluid

Bicarbonate

The administration of bicarbonate in patients with DKA is controversial. Prospective trials have indicated that no benefit or harm is associated with the administration of bicarbonate in patients with DKA who have a pH of 6.9 to 7.1.[52] No information is available for potential benefits of bicarbonate administration in patients with a pH less than 6.9. Some published DKA guidelines recommend the use of bicarbonate if the pH is less than 7.[5 10] Others do not recommend the use of bicarbonate at all, unless cardiogenic shock or other lactate-generating conditions are present.[41]

Phosphate replacement

The total body phosphate is depleted in patients with DKA, but as in the case of potassium the serum concentration is frequently normal or high at presentation. With treatment of DKA and especially insulin administration the phosphate concentration may drop significantly. Studies evaluating the routine administration of phosphate in DKA patients did not show any benefit.[53] However, a very low phosphate concentration may result in muscle weakness and respiratory depression and for this reason phosphate should be replaced if the serum phosphate is less than 0.33 mmol/l.

DKA in special populations

Although the pathophysiology of DKA is essentially the same in children, adolescents, and the elderly as well as during pregnancy, each of these special populations have their specific nuances.

Children

Due to the inability of infants and small children to give a history of the symptoms of diabetes, DKA is often misdiagnosed at first presentation as pneumonia or bronchiolitis. The diagnosis is often made late. At diagnosis patients are frequently severely dehydrated, have severe acidosis and are often unconscious. Children require a more precise calculation and replacement of fluid losses because of changes in body surface area in relationship to mass as

the child grows older.[54] The cerebral autoregulatory mechanism in younger children is less well developed which, in conjunction with greater severity of DKA, results in a much higher frequency of cerebral oedema in up to 1% of all DKA cases.[30 49]

Adolescents

The major problem in this patient group is neglect on the part of patients to take insulin with serious lapses in patient adherence to treatment. These patients need to be seen in conjunction with their families, and long-term psychological support may be needed to prevent repeated DKA episodes. In this patient group, 5% of patients are responsible for more than 25% of DKA admissions.[30 55]

The elderly

Comorbid conditions play an important role in elderly patients. It predisposes them to DKA and a poorer outcome of DKA. Important precipitating conditions that need to be considered in elderly patients with DKA are myocardial infarctions, stroke and infections.[56] In a UK study females older than 59 years of age were identified as a high-risk group for recurrent DKA due to other chronic diseases complicating the diabetes.[57]

During pregnancy

During pregnancy not only the mother is significantly affected by the development of DKA. The perinatal mortality related to DKA is between 9 and 35%.[58 59] DKA during pregnancy results in reduced oxygenation of the feto-placental unit due to reduced uterine blood flow and a left shift in the haemoglobin dissociation curve (increased affinity of haemoglobin for oxygen).[60] During DKA foetal distress is frequently observed, but intervention for foetal compromise should be delayed until the mother is properly resuscitated, because this frequently reverses foetal distress.[61]

Complications of DKA

DKA and the management thereof occur frequently and can to a large extent be prevented if management and monitoring is optimal. The most common complications are hypoglycaemia,[8] hypokalaemia,[5] relapses of DKA and, in children, cerebral oedema.[50]

Conclusion

DKA is a common and severe complication of diabetes mellitus that occurs in both type 1 and type 2 diabetic patients. It is to a large extent preventable if the proper patient education, training on how to manage sick days and when to contact a health care provider is introduced. Patients should know the importance of using insulin and the significant dangers if use is neglected. Patients' families should be educated to identify acute diabetes complications so that immediate measures can be instituted. Physicians and other health care professionals should be vigilant to identify high-risk patients and timely institute measures to prevent the development of severe hyperglycaemic complications.

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CHAPTER 6

Fluid Management in diabetic-acidosis: Ringer's lactate versus normal saline: A randomised controlled trial

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Abstract

Objective: To determine if Ringers lactate is superior to 0.9% Sodium Chloride solution for resolution of acidosis in the management of diabetic ketoacidosis.

Design: Parallel double blind randomised controlled trial

Methods: Patients presenting with diabetic ketoacidosis at Kalafong and Steve Biko Academic hospitals were recruited for inclusion in this study if they were older than 18 years of age, had a venous pH >6.9 and ≤7.2, a blood glucose of >13 mmol/L and had urine ketones of ≥2+. All patients had to be alert enough to give informed consent and should have received less than one litre of resuscitation fluid prior to enrolment.

Results: Fifty-seven patients were randomly allocated, 29 were allocated to receive 0.9% Sodium Chloride solution and 28 to receive Ringer's lactate (of which 27 were included in the analysis in each group). An adjusted Cox proportional hazards analysis was done to compare the time to normalisation of pH between the 0.9% Sodium Chloride solution and Ringer's lactate groups. The hazard ratio (Ringer's compared with 0.9% Sodium Chloride solution) for time to venous pH normalisation (pH = 7.32) was 1.863 (CI: 0.937 to 3.705, p = 0.076. The median time to reach a pH of 7.32 for the 0.9% Sodium Chloride solution group was 683 minutes (CI: 378 to 988) (IQR: 435 to 1095 minutes) and for Ringer's lactate solution 540 minutes (CI: 184 to 896) (p = 0.251). The unadjusted time to lower blood glucose to 14 mmol/L was significantly longer in the Ringer's lactate solution group (410 minutes, IQR: 240 to 540) than the 0.9% Sodium chloride solution group (300 minutes, IQR: 235 to 420) (p = 0.044). No difference could be demonstrated between the Ringer's lactate and 0.9% Sodium Chloride solution groups in the time to resolution of DKA (based on the ADA criteria) (unadjusted: p = 0.934, adjusted: p = 0.758)

Conclusion: This study failed to indicate benefit from using Ringer's lactate solution compared to 0.9% Sodium chloride solution regarding time to normalisation of pH in patients with diabetic ketoacidosis. The time to decrease blood glucose to 14 mmol/L took significantly longer with the Ringer's lactate solution..

Introduction

Diabetic ketoacidosis (DKA) is an acute complication of diabetes with potential life threatening metabolic and homeostatic derangement. DKA is common in diabetic patients and occurs most frequently in children and adolescents. Fifteen to 20% of adults with new onset diabetes mellitus type 1 will present with a DKA.[1-3] In the United States DKA is reported to be responsible for more than 100 000 hospital admission per year and it accounts for 4% to 9% of all hospital discharge diagnoses among patients with diabetes.[4] The EURODIAB[5] study reported that 8.6% of 3250 diabetic patients were admitted for DKA in the preceding year. In a Danish study the annual incidence of DKA in the general population was 12.9 per 100 000, with a mortality rate of 4%.[6] The mortality associated with DKA is less than 5%, with the prerequisite that standardised written guidelines are used.[7 8] In Africa the mortality is unacceptably high, with a death rate of 26 to 29%.[9] Most patients with DKA are type 1 diabetic patients, but it can occur in type 2 patients as well during episodes of acute stress such as infections or trauma. [2 10]

Current management of DKA includes: replacement of fluid losses, correction of hyperglycaemia with appropriate administration of insulin, correction of electrolyte losses, detection and correction of precipitating causes and maintenance insulin to prevent recurrence of DKA.[11] Normal saline (0.9% NaCl) has traditionally been used as replacement fluid in DKA and this is also reflected in recent guidelines.[11-13.] However recent evidence suggests that the administration of large volumes of saline (0.9% NaCl) contributes to the development of metabolic acidosis.[14] The acidifying effect of saline is explained by the un-physiological excessive administration of Cl^- ions contained in saline. This hyperchloraemic metabolic acidosis is described in endotoxemia,[15] and in patients undergoing surgery.[16 17] In diabetic ketoacidosis, the incidence of hyperchloraemia increases over time during treatment, with the most rapid rise coinciding with the period of most rapid fluid (saline) administration. Resolution

of ketoacidosis is masked by the acidifying effect of chloride, with ketones the major contributor to acidosis early and chloride late in the treatment of DKA.[18] The aim of this study was to ascertain if the use of Ringer's lactate solution is superior to normal saline infusion if used as primary resuscitation fluid in patients with diabetic ketoacidosis regarding time to resolution of acidosis.

Methods

Participants

Patients were recruited from two sites in Pretoria namely Kalafong (secondary) hospital and Steve Biko Academic (tertiary) hospital. Recruitment for this study took place from February 2008 to November 2009. Patients were eligible for inclusion if they fulfilled the following criteria: newly diagnosed or previously known to have diabetes mellitus, type 1 or type 2 diabetes, age 18 years or older, a venous blood pH at presentation 6.9 to 7.2, presence of at least two plus ketones on urine dipstick test at presentation, a capillary blood glucose of more than 13 mmol/L at baseline and able to give verbal informed consent. Patients were excluded from participation if another cause for acidosis was present e.g. end-stage renal failure or lactic acidosis, if severely ill and in need of inotropic or ventilatory support, and if more than one litre of resuscitation fluid was administered before enrolment. Informed consent was obtained from all patients before enrolment to the study. The study protocol was approved by the ethics committee of the Faculty of Health Sciences of the University of Pretoria. The study was registered at the South African National Clinical trials register, registration number: DOH-27-0607-1612.

Patient management and procedures

The study was a double blind randomised controlled trial with a parallel design and an allocation ratio of one to one. Stratified randomisation per centre was done by centre in blocks of ten using a sequential numbered opaque box system. Sequentially numbered boxes contained study material and resuscitation solution Blinding was achieved by using unlabeled coded one litre

resuscitation fluid bags (prepared by Dismed CritiCare (Lty) Ltd. Midrand, South Africa). All clinicians, patients and investigators were blinded for the coding of resuscitation fluid. Unblinding of the code was only done after analysis of the primary outcome was completed.

All patients were treated according to the same diabetic ketoacidosis protocol implemented at the two hospitals. Patients received study fluid as initial resuscitation fluid until blood glucose was less than 14 mmol/L. Subsequently the attending clinician could continue with any dextrose or glucose containing fluid according to preference. Blood samples were taken (as per DKA management protocol implemented at the hospitals) for electrolytes, urea and creatinine measurement at baseline, one hour later and once pH was normal. Calcium, magnesium, phosphate, albumin and total protein measurement was done at baseline and once pH was normal. All blood tests were analysed at the local NHLS laboratory of each of the hospitals. Venous blood gas and blood ketones and blood glucose were determined at baseline, one hour later and then according to a schedule becoming more frequent as the pH approached normal. All blood gas determinations were done utilising a Copenhagen Radiometer ABL 700 blood gas analyser (Kalafong hospital) and a Copenhagen Radiometer ABL 700 or Cobas B221 blood gas analyser (Steve Biko Academic hospital). Ketones were measured with a Medisense Optium Exceed ketone meter (Abbott Laboratories) and glucose was measured with an Accu-chek active glucometer (Roche diagnostics). Urine was assessed for ketone content using Combur 9 urine dipsticks (Roche diagnostics). Urine ketones were tested by urine dipstick at baseline and periodically until pH normalised. All patients were initially managed in the emergency department and transferred to the high care unit if beds were available otherwise they were managed in the medical wards until pH normalised. Insulin dose was adjusted for each patient hourly according to the DKA management protocol.

Endpoints were: time to reach a venous pH of 7.32, to achieve serum glucose of 14 mmol/L and time to resolution of DKA. Time to achieve a serum glucose less

than 14 mmol/L was selected because according the DKA management protocol 14 mmol/L was the threshold for changing patients from glucose free resuscitation fluid to glucose or dextrose containing intravenous fluids. Time to resolution of DKA was defined as fulfillment of the following three criteria: venous pH >7.3, serum bicarbonate ≥18 mmol/L and blood glucose >11.1 mmol/L.[11]

Statistical analysis

A pilot study consisting of ten patients was done with normal saline as resuscitation fluid only to obtain an estimate of the time to recovery of pH as well as a SD. The result of the pilot study was used to calculate the sample size. The sample size calculation assumed the following: alpha value of 0.05, power of 0.9, and difference between the two arms of the study 0.8 SD, equal SD in both arms and equal number of patients allocated to each arm. The calculated sample size was 37 patients per arm with a total sample size of 74 patients, and to compensate for potential losses, 40 patients per arm were targeted.

The primary endpoint was time to normalisation of pH; therefore comparison between the two arms of the study was done by Log-rank and Cox proportional hazards methods for time to event outcomes. Unadjusted as well as an adjusted analysis for baseline covariates was done. An adjusted analysis was planned a priori, irrespective of baseline imbalances, to compensate for minor differences between the Ringer's and 0.9% Sodium Chloride groups as well as to increase the power of the study. Repeated measures ANOVA analysis was done to assess within group and between group changes in blood parameters measured.

Results

This study was stopped before the planned sample size was obtained due to slower than expected enrollment and expiry of consumables obtained for the study. At the time of termination 57 patients were enrolled with diabetic ketoacidosis (DKA), 52 patients had a ph ≤ 7.2 and 5 patient had a pH of 7.2 to 7.29. All patients fulfilled all the other inclusion criteria. All the enrolled patients

were followed up until clinical resolution of the DKA. Three patients were excluded from the analysis due to missing data: one patient had baseline information absent, one the insulin infusion rate was not recorded, and one patient fluid administration was not recorded (Fig 1). Of the 54 analyzable patients 32 were enrolled at Kalafong hospital and 22 at Steve Biko Academic Hospital. Of the analyzed patients 28 were managed only in casualties department, 21 in a high care unit and 5 in a general ward. In both groups 15 patients had an identifiable precipitating event, of which non-compliance was the most common (14/30) followed by infections (11/30).

Baseline and descriptive

Table 1 presents baseline and pre-treatment characteristics of the patients included in the analysis. Differences between the groups were not statistically significant.

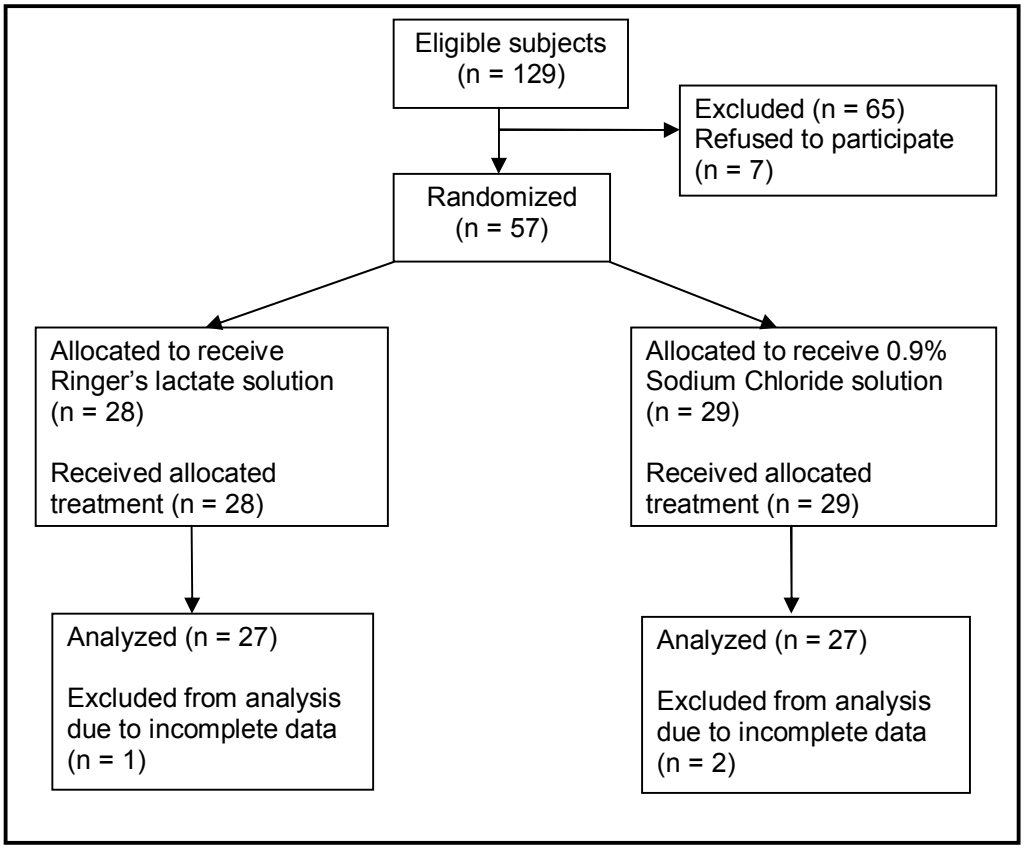

Figure 1: Trial profile

Table I: Baseline characteristics (Numbers and mean (standard deviation))

Variables	Ringers Lactate Solution	0.9% Sodium chloride Solution
Total number of patients	27	27
Gender (M/F)	18/9	13/14
Age (years) median (IQR)	36.1 (24.1 to 46.6)	36.6 (25.5 to 42.2)
Newly diagnosed	12	10
Type of diabetes		
Uncertain	13	9
Type 1	12	15
Type 2	1	3
Secondary	1	0
Identifiable precipitant	15	15
Hospital enrolled		
Kalafong /SBAH	17/10	15/12
Baseline pH	7.10 (0.105)	7.12 (0.099)
Baseline HCO3 (mmol/L)	6.74 (3.36)	7.66 (3.71)
Baseline Potassium (mmol/L)	4.87 (1.01)	4.93 (1.09)
Baseline capillary glucose (mmol/L)	25.01 (5.9)	27.66 (10.02)
Baseline capillary ketones (mmol/L)	4.47 (1.41)	4.27 (1.40)

Normalization of pH

An unadjusted Kaplan Meyer plot and Log Rank analysis was done for duration to recovery of pH (venous pH 7.32). The median time to reach a venous pH of 7.32 for the 0.9% Sodium chloride solution was 683 minutes (CI: 378 to 988) (IQR: 435 to 1095 minutes) and for Ringer's lactate solution 540 minutes (CI: 184 to 896) (IQR: 300 to 940). The log rank analysis did not indicate a significant difference between the two treatment groups (p = 0.251).

A Cox proportional hazards analysis was done to adjust for differences between the two treatment groups (Figure 2). The difference between the two groups was adjusted for the following: baseline bicarbonate concentration, baseline capillary glucose concentration, baseline capillary Beta-hydroxy-buterate concentration, amount of study fluid administered (liters), mean hourly insulin administered and the hospital to which patients were enrolled. After adjustment the difference between time to pH normalization was non-significant (p = 0.076). Resolution of pH in patients resuscitated with Ringers lactate solution occurred non-significantly earlier than those treated with 0.9% Sodium chloride solution (HR: 1.863, CI: 0.937 to 3.705).

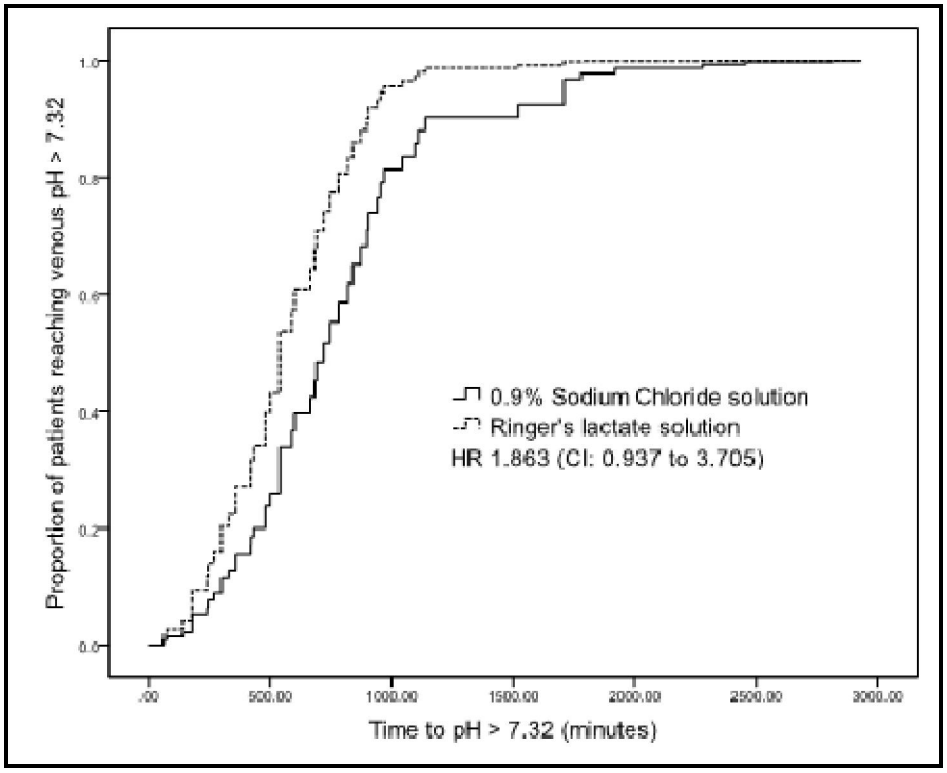

Figure 2: Cox proportional hazards model for time to venous pH more than 7.32

Normalisation of bicarbonate to 18 mmol/L was non-significantly longer in the 0.9% Sodium chloride group (743 minutes, IQR: 552 to 934) than the Ringer's lactate group (540 minutes, IQR: 261 to 819) (unadjusted Log Rank: p = 0.902). After adjustment for the same factors as for pH above, the hazard for bicarbonate to reached 18 mmol/L was non-significantly increased in the Ringer's lactate group (HR: 2.042, CI: 0.621 to 6.715, p = 0.24).

Glycaemic endpoints

The time to lower blood glucose to 14 mmol/L in the Ringer's lactate group was 410 minutes (median) (IQR: 240 to 540), which was significantly longer in comparison to that of 0.9% Sodium chloride 300 minutes (median) (IQR: 235 to 420) (unadjusted Log Rank: p = 0.044). When adjusted for blood glucose at baseline, liters study fluid administered, mean insulin administered per hour, hospital enrolled to and unit where managed, the time taken to obtain a blood glucose concentration of 14 mmol/L or less was significantly longer in the Ringer's lactate group than in the 0.9% Sodium chloride group (HR: 0.38, CI: 0.175 to 0.826, p = 0.014) (figure 3).

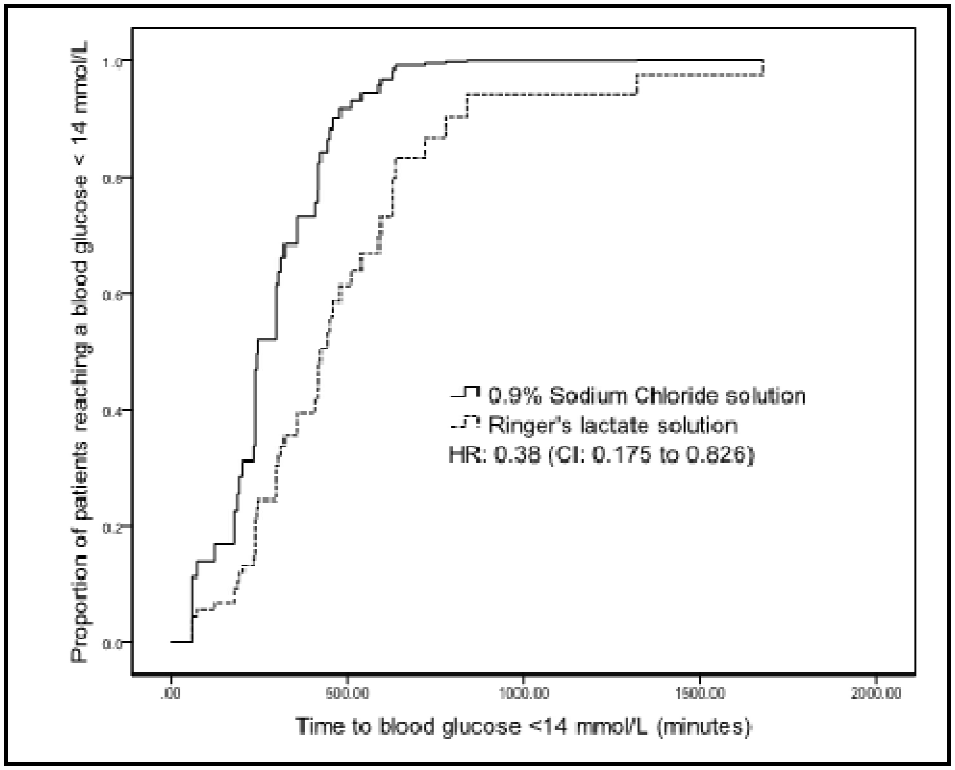

Figure3: Cox proportional hazards model for time to glucose less than 14 mmol/L

The number of hypoglycaemic events (blood glucose less than 3.5 mmol/L) during the study was non-significantly more in the 0.9% Sodium chloride group (6 events, 2 events in 2 patients and 1 in two patients) versus no events in the Ringer's lactate group (p = 0.111). The group receiving Ringer's lactate required non-significantly more insulin per hour (Median: 5.6 units, IQR: 4.63 to 7.54) in comparison to the 0.9% Sodium chloride group (Median: 5.05 units, IQR: 4.1 to 6.13) (p = 0.414). The total units insulin used per patient was significantly more during the first six hours for the Ringer's lactate group (Median: 44 units, IQR: 36 to 48) in comparison to the 0.9% Sodium chloride group (Median: 36 units, IQR: 30 to 44) (p = 0.02). This difference in total insulin utilization between the two groups was not significant after 8 hours of treatment.

Other endpoints

No deaths occurred in any of the two groups. The median duration of hospital stay for both groups was 7 days (p = 0.547).

Significant changes in the blood parameters from baseline to the end occurred for all the parameters over time ($p < 0.001$). However no significant different changes could be demonstrated between the 0.9% Sodium Chloride and Ringer's lactate solution groups (Table 2). After one hour of fluid resuscitation one patient in the 0.9% Sodium Chloride group had a serum potassium of more than 5.2 mmol/L as did five patients in the Ringer's group. After the first hour of administration of resuscitation fluid and insulin the mean serum potassium decreased more in the 0.9% Sodium Chloride group than the Ringers Lactate group ($p > 0.05$), thereafter the potassium levels were equal. The serum Chloride increased non-significantly in the 0.9% Sodium Chloride group after 1 hour of fluid administration, but the difference was not evident at the time the ketoacidosis resolved.

Combined endpoint

Resolution of diabetic ketoacidosis according to the 2006 ADA is based on three criteria: venous pH >7.3, serum bicarbonate ≥18 mmol/L and blood glucose <11.1 mmol/L. According to these criteria only 21 of the 54 (39%) DKA episodes have achieved resolution by the time follow up was stopped. Follow up was continued in an attempt to ensure fulfillment of the serum bicarbonate criteria for resolution of the 2006 ADA criteria. By the time the venous pH has reached 7.36, which was achieved in 46 DKA episodes only 22 episodes (47.8%) had a bicarbonate of ≥18 mmol/L. Of this 46 episodes 11 of 22 were receiving 0.9% Sodium chloride solution and 11 of 24 received Ringer's lactates solution ($p = 0.777$). The time to resolution between the 0.9% Sodium chloride solution (1621 minutes) and the Ringers lactate solution (1710 minutes) groups were not significantly different (Log Rank: $p = 0.934$). After adjustment there was no difference in the time to resolution (HR 1.78, CI: 0.415 to 30342, $p = 0.758$).

The ADA (2009) reduced the bicarbonate criterion to 15 mmol/L and added an anion gap criterion to the criteria for resolution of DKA. In this study the electrolytes was not routinely measured to allow calculation of the anion gap. If

the 2009 criteria are implemented for resolution of DKA, excluding the anion gap: 39 of the 54 (72%) of the DKA episodes would have reached resolution. Of the patients achieving resolution according to this criteria 19 (48.7%) were receiving 0.9% Sodium chloride solution and 20 (51.3%) Ringer's lactate solution. By the time the venous pH has reached 7.36, 5 of 46 (10.9%) of the DKA episodes had not yet reached a serum bicarbonate of 15 mmol/L. A Kaplan-Meier analysis to assess the time to resolution of DKA between Ringers lactate (median: 870 minutes, IQR: 421 to 1650) and 0.9% Sodium Chloride solution (median: 845 minutes, IQR: 563 to 1380) indicated a non-significant difference (Log rank: p = 0.923). After adjustment for baseline bicarbonate concentration, baseline capillary glucose concentration, baseline capillary Beta-hydroxy-buterate concentration, amount of study fluid administered (liters), mean hourly insulin administered and the hospital to which patients were enrolled in a Cox-proportional hazards model, no difference could be demonstrated between the Ringer's and 0.9% Sodium Chloride groups in the time to resolution of DKA (HR: 0.886, CI: 0.417 to 1.88, p = 0.752)

Table II: Biochemical parameters at baseline and over time in the 0.9% Sodium chloride and Ringer's lactate groups

Parameter	Group	Baseline	1 hour	End	Between groups P-value
sAlbumin mg/dL	Saline Ringer's	36.15 34.70		26.65 26.05	0.566
sProtein mg/dL	Saline Ringer's	76.37 74.70		58.67 60.57	0.618
sCalsium mmol/L	Saline Ringer's	2.213 2.213	2.11 2.14	1.98 2.113	0.372
sMagnesium mmol/L	Saline Ringer's	1.004 0.96	0.89 0.85	0.716 0.731	0.981
sPhosphate mmol/L	Saline Ringer's	1.48 1.453	0.86 1.02	0.505 0.537	0.576
sSodium mmol/L	Saline Ringer's	133.83 134.13	134.93 136.94	137.24 137.35	0.504
sPotasium mmol/L	Saline Ringer's	5.056 5.081	4.41 4.52	3.8 3.88	0.722
sChloride mmol/L	Saline Ringer's	101.65 101.37	111.36 104.95	108.83 109.02	0.421
sCO2 mmol/L	Saline Ringer's	8.86 7.71	8.21 8.83	16.38 17.00	0.605
sUrea mmol/L	Saline Ringer's	8.9 9.34	6.69 8.58	4.25 4.85	0.314
sCreatinine mmol/L	Saline Ringer's	136.96 139.65	111.79 127.11	80.14 89.09	0.716

Discussion

The results of this study indicate that normalization of pH occurs non-significantly faster if the primary resuscitation solution in patients with diabetic ketoacidosis is Ringer's lactate solution instead of 0.9% Sodium Chloride solution. Glycaemic recovery to the 14 mmol/L and 11.1 mmol/L levels is significantly delayed with Ringer's lactate solution.

This result makes sense pathophysiologically, because the Lactate in Ringer's lactate solution is metabolized via two routes. Firstly, lactate undergoes gluconeogenesis predominantly in the liver but also in the kidneys. This mechanism accounts for about 70% of the clearance of lactate. Gluconeogenesis of lactate occurs via the production of pyrovate and results in a transient increase in blood glucose in normal individuals who has an

appropriate insulin response, which is not the case in patients with diabetic ketoacidosis.[19] [20]

The second mechanism of lactate clearance is via oxidation, which accounts for about 30% of the metabolism of lactate. The oxidation of lactate occurs predominantly in the liver but also to a lesser extent in the kidneys, heart and skeletal muscle cells. During the oxidation of lactate CO_2 and H_2O is formed and Hydrogen ions is consumed. Hydrogen is also consumed during the gluconeogenesis process; therefore both reactions play a role in limiting acidosis. The consumption of H^+ leaves OH^- to bind to CO_2 to form HCO_3^-. The production of bicarbonate from lactate has a half-life of 10 to 15 minutes. Thus in patients with acidosis the use of Ringer's lactate is of benefit in acidotic patients as in patients with DKA, however the current study failed to show significance of this effect.[21]

The decrease in potassium was not (as expected) significantly less in the Ringer's group (Ringer's contains 4 mmol Potassium per liter compared to zero in 0.9% Sodium Chloride solution) The opposite is also true for chloride which did increase in the 0.9% Sodium Chloride solution (containing 150 mmol/L Chloride) group but not statistically significantly more than in the Ringer's (containing 110 mmol/L chloride) group.

This study had a time to event design with progressively shortening of the intervals of sequential blood sampling in an attempt to obtain the time of resolution of DKA as accurately as possible. This design however limits the comparability and assessment of sequential measurements much more than if blood would have been drawn at fixed intervals. No clear harm in the use of any one of the two resuscitation fluids could be demonstrated.

The major limitation of this study was the inability to obtain the sample size as calculated. This could have led to less precise comparisons between the two arms of the study.

The time to resolution of DKA according to ADA criteria of 2006 was not significantly influenced by whether 0.9% Sodium chloride or Ringer's lactate solution was used. The same accounts for the 2009 ADA resolution criteria, although it could not be fully assessed due to unavailability of the anion gap.

Conclusion

This study failed to demonstrate that the normalisation (venous pH > 7.32) of acidosis when using Ringer's lactate as initial resuscitation fluid occur more rapidly than when 0.9% Sodium Chloride solution is used. Blood glucose threshold values, for changing to glucose containing intravenous fluids, occurs faster with administration of 0.9% Sodium Chloride solution than with Ringer's lactate solution. For resolution of DKA according to the ADA criteria no difference could be demonstrated between the use of Sodium chloride and Ringers lactate solutions.

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Summary

As a prevalent disease diabetes is relevant to both medical and surgical disciplines in the inpatient environment. It has therefore become imperative that all medical and nursing staff should know the implications of diabetes and glycaemic control on the outcome of patients they see. The staff should also be equipped to manage diabetic inpatients appropriately. This thesis attempts to answer a number of questions related to the management of diabetic inpatients and the management of diabetic ketoacidosis.

Chapter 1 Covers the current knowledge of inpatient management of patients with diabetes. The fact that diabetic patients are more prone to be admitted to hospital and the disease related increase in cost of inpatient management is highlighted. The important issue of which glycaemic targets to aim for in diabetic inpatients is discussed. Current evidence regarding inpatients in specific situations is explored. A number of additional issues related to inpatient management are discussed such as glucose monitoring, nutritional care and discharge planning.

Chapter 2 reports on an inpatient audit exploring the situation in Kalafong hospital prior to the institution of an inpatient diabetes management plan. The major finding of this audit of 164 diabetic patient admissions was that glycaemic monitoring in hospitalised patients was irregular and erratic in 60.8% of patients, 37.2% of patients had regular four or six hourly blood glucose monitoring and that only 2% of patients had meal related glucose monitoring. What was striking was that only 1.9% of patients received supplemental insulin to their usual insulin regimen. The glycaemic control treatment schedule was appropriate in only 19.5% of cases. From the results of this study we conclude that the management and monitoring of blood glucose in diabetic inpatients at Kalafong hospital was inadequate and an intervention was needed to improve the quality of care.

Chapter 3 evaluated the perceptions, knowledge and attitudes of health care providers at Kalafong hospital regarding care of diabetic inpatients. A survey of 54 doctors and 61 nurses taking care of inpatients (response rate of 82%). using the DAS3 scale and the diabetes knowledge questionnaire of O'Brien, indicated that 80.9% felt that special training for management of diabetic patients is needed, 90.5% realised that diabetes is a serious condition and 92.2% valued the importance of tight glycaemic control. Despite this perception of importance,, the knowledge of doctors and nurses caring for diabetic inpatients were suboptimal.

Chapter 4 reports on the results of an intervention to improve the quality of inpatient diabetes management. This intervention consisted of a physician and nurse training programme as well as the introduction of a structured inpatient management protocol for all diabetic inpatients. The results of this intervention were assessed by a second audit. From the first audit 150 patient admissions and from the second audit 183 patient admissions were included. The mean blood glucose on day one of the second audit was significantly higher than that of the first audit (1.72 mmol/L higher, $p < 0.001$). A significant improvement from day 1 to day 7 was seen in audit 2 (-1.88 mmol/L, $p < 0.001$), which was not significant in audit 1 (-0.88 mmol/L, $p = 0.33$). The proportion of patients that achieved glycaemic control, defined as a mean daily blood glucose of less than 10 mmol/L did not significantly differ between the two audits (43.0% versus 43.7%, $p = 0.97$). Even after adjustment for baseline differences between the two audits no difference in glycaemic control was evident after the introduction of the education programme and structured management protocol. The number of hypoglycaemic events were more after implementation of the structured management protocol (19.6 versus 17.2 events per 100 patient days, $p = 0.048$).

Chapter 5 reviews the most frequent hyperglycaemic complication of diabetes namely ketoacidosis. It discusses the diagnosis, grading of severity and precipitating events. The current view on the management is discussed with

special mention of fluid replacement, insulin therapy and replacement of associated electrolyte deficiencies. Lastly this chapter address DKA in special populations: Children, Adolescents, Elderly and during pregnant women.

Chapter 6 reports on a double blind randomised controlled trial to assess if Ringer's lactate solution is superior to 0.9% Sodium chloride solution in the normalisation of pH in patients with diabetic ketoacidosis. The study enrolled 57 patients with mild to moderate diabetic ketoacidosis of which 27 patients could be analysed in each arm. The time to normalisation of venous pH (pH > 7.32) was not significantly different between the two arms of the study (HR: 1.863, CI: 0.937 to 3.705). The median time for the 0.9% Sodium chloride solution group to reach a pH of 7.32 was 683 minutes and for the Ringer's lactate group 540 minutes. The time to reach a blood glucose of 14 mmol/L was significantly longer in the Ringer's lactate group (410 minutes) in comparison to the 0.9% Sodium chloride group (300 minutes) ($p = 0.044$). Patients treated with the Ringers lactate group needed significantly more insulin during the first six hours of treatment (44 units versus 36 units, $p = 0.02$). No difference between the two groups could be demonstrated in time to resolution of DKA based on the ADA criteria for resolution of DKA) ($p = 0.758$). The overall conclusion of this study is that there is no significant benefit in using Ringer's lactate solution as initial resuscitation fluid when compared to the currently advised 0.9% Sodium chloride solution.

Concluding remarks

Currently inpatient management of diabetes is severely neglected in South Africa. Firstly, there is a significant paucity of data on information on the prevalence of hospital admissions of diabetic patients. Secondly, no information is available regarding problems in inpatient diabetes management. Thirdly, no information is available regarding knowledge and skills of medical and nursing staff caring for diabetic inpatients. And lastly, there is no knowledge of processes implemented in local South African hospitals to improve inpatient diabetes management.

This thesis was based on research to answer four questions, which was to a large extent successfully answered.

The first question: What are the current practices in diabetes inpatient glycaemic management in Kalafong hospital and how well are glucose levels controlled during hospitalisation?
The study answered conclusively that the glycaemic management was inadequate with regards to inpatient monitoring as well as the methods used to control blood glucose.

The second question: What are the attitude and perceptions of medical and nursing staff towards diabetic inpatients and their management, and how well are they equipped to face this challenging task?
Medical and Nursing staff realised that diabetes is a serious condition and that training in diabetes care are needed, they also realised that diabetes has a significant psychosocial impact on the lives of diabetic patients. The knowledge of health care providers, however, was suboptimal and thus they were poorly equipped to manage diabetic inpatients.

The third question: Will the implementation of a structured inpatient management protocol improve the glycaemic control of inpatients with diabetes?
No conclusive evidence could be found to demonstrate that the implementation of a structured inpatient diabetes management protocol will improve glycaemic control. A structured management plan did result in a small but significant reduction in hypoglycaemic events.

The researcher has gained insight in the complexity of not just inpatient diabetes management, but also in the problems related to the logistics and effort needed by medical and nursing staff to make a difference in improving glycaemic control. The methods currently utilised in Kalafong hospital are not working, and the researcher is certain that similar problems exist in nearly all hospitals in South Africa. We need to consider novel methods to get staff motivated in an attempt to make a difference in caring for diabetic patients and to improve the quality of the care. The researcher believes that one such a solution is to ensure that all staff is trained in the management of diabetic inpatients. Each hospital should have a properly designed and well followed inpatient management protocol. However, each hospital should preferably have a diabetes management team who are equipped to give advice and help in the treatment of difficult cases. An important challenge in the management of diabetic inpatients is the additional time burden placed on already thinly stretched staff; to monitor blood glucose, inject insulin whilst also attempting to train patients to manage their own disease. All diabetic patients admitted to hospital gives an ideal opportunity for patient diabetes education, this opportunity is often missed due to excessive work load on staff and educators (seldom available for inpatients).

Thus, how can the current situation be improved? A few possibilities are mentioned, although further research on each of these is required:

- Staff should know how to treat and manage diabetic patients; they should have access to inpatient management protocols and should follow it.

- All patients should have a follow up plan before discharge.
- All patients should know who to contact if they encounter problems with disease management.
- Patients who are healthy enough should be allowed to make diabetes treatment decisions themselves whilst under supervision of ward staff. This includes testing blood glucose and administering insulin treatment themselves.
- Having diabetes group training sessions for all diabetic patients in a ward or unit.
- Often inhospital insulin regimens could be simplified, if the availability of insulin analogues could be improved.
- The support of a dietician is invaluable in diabetic inpatients.
- Diabetes should be seen as a disease that needs a team approach with the doctor, nurse, and dietician and if available a psychologist and diabetes educator as members. Each team member should know what to expect of the other members. Messages regarding diabetes, given to patients by all the team members, should be similar.
- A model that should be considered in management of inpatients with diabetes is a diabetes expert team. Such a team can see all diabetic inpatients, give advice on management and train patients to manage themselves. The team can also ensure that all patients have follow up arrangements made before discharge for the long term care of their diabetes.
- Regular monitoring and evaluation of the quality of diabetes inpatient management should be done. It would probably be best if a formal monitoring and evaluation programme could be implemented in each hospital.

The greatest stumbling block in the improvement of inpatient diabetes care is the inertia of staff to change old habits. Staff will often say they want to be trained, but new knowledge is meaningless if it does not lead to improvement of actions and better habits.

The fourth question relates to the acute management of patients with diabetic ketoacidosis (DKA): Does it make a difference if 0.9% Sodium chloride solution or Ringer's lactate solution is used as primary resuscitation fluid in the time to normalisation of pH, blood glucose and resolution of DKA? This question was answered in chapter 6 of this thesis.

With regards to time to normalisation of pH, no conclusive evidence to prove any benefit of using Ringer's lactate solution in comparison to 0.9% Sodium chloride solution could be found. For time to reach blood glucose of 14 mmol/L 0.9% Sodium chloride solution was superior to Ringer's lactate solution. However, for resolution of DKA there was no benefit demonstrated in using either of the two resuscitation solutions.

This study indicated that there are advantages and disadvantages in using each of the two resuscitation fluids. Perhaps it should be investigated which patients will benefit more from Ringer's lactate solution and which patients from 0.9% sodium chloride solution eg. patients with less severe hyperglycaemia and normo- or hypokalaemia may benefit more from Ringer's lactate solution.

Appendix 1

Questionnaires

Staff diabetes attitudes questionnaire

Michigan Diabetes Research and Training Center Survey Instruments (DAS – 3). Permission to use survey instrument is attached.

Below are some statements about diabetes. Each numbered statement finishes the sentence "In general, I believe that..." You may believe that a statement is true for one person but not for another person, or may be true one time but not be true another time. Mark the answer that you believe is true most of the time or is true for most people. Place a check mark in the box below the word or phrase that is closest to your opinion about each statement. It is important that you answer every statement.

Note: The term "health care professionals" in this survey refers to doctors, nurses, and dieticians.

		Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
	In general, I believe that:					
1	...health care professionals who treat people with diabetes should be trained to communicate well with their patients	1	2	3	4	5
2	...people who do not need to take insulin to treat their diabetes have a pretty mild disease.	1	2	3	4	5
3	...there is not much use in trying to have good blood sugar control because the complications of diabetes will happen anyway.	1	2	3	4	5
4	...diabetes affects almost every part of a diabetic person's life.	1	2	3	4	5
5	...the important decisions regarding daily diabetes care should be made by the person with diabetes.	1	2	3	4	5
6	...health care professionals should be taught how daily diabetes care affects patients' lives.	1	2	3	4	5
7	...older people with Type 2* diabetes do not usually get complications.	1	2	3	4	5
8	...keeping the blood sugar close to normal can help to prevent the complications of diabetes.	1	2	3	4	5
9	...health care professionals should help patients make informed choices about their care plans.	1	2	3	4	5
10	...it is important for the nurses and dietitians who teach people with diabetes to learn counseling skills.	1	2	3	4	5
11	...people whose diabetes is treated by just a diet do not have to worry about getting many long-term	1	2	3	4	5

	complications.					
12	...almost everyone with diabetes should do whatever it takes to keep their blood sugar close to normal.	1	2	3	4	5
13	...the emotional effects of diabetes are pretty small.	1	2	3	4	5
14	...people with diabetes should have the final say in setting their blood glucose goals.	1	2	3	4	5
15	...blood sugar testing is not needed for people with Type 2* diabetes.	1	2	3	4	5
16	...low blood sugar reactions make tight control too risky for most people.	1	2	3	4	5
17	...health care professionals should learn how to set goals with patients, not just tell them what to do.	1	2	3	4	5
18	...diabetes is hard because you never get a break from it.	1	2	3	4	5
19	...the person with diabetes is the most important member of the diabetes care team.	1	2	3	4	5
20	...to do a good job, diabetes educators should learn a lot about being teachers	1	2	3	4	5
21	...Type 2* diabetes is a very serious disease.	1	2	3	4	5
22	...having diabetes changes a person's outlook on life.	1	2	3	4	5
23	...people who have Type 2* diabetes will probably not get much payoff from tight control of their blood sugars.	1	2	3	4	5
24	...people with diabetes should learn a lot about the disease so that they can be in charge of their own diabetes care.	1	2	3	4	5
25	...Type 2* is as serious as Type 1† diabetes.	1	2	3	4	5
26	...tight control is too much work.	1	2	3	4	5
27	...what the patient does has more effect on the outcome of diabetes care than anything a health professional does.	1	2	3	4	5
28	...tight control of blood sugar makes sense only for people with Type 1† diabetes.	1	2	3	4	5
29	...it is frustrating for people with diabetes to take care of their disease.	1	2	3	4	5

30	...people with diabetes have a right to decide how hard they will work to control their blood sugar.	1	2	3	4	5
31	...people who take diabetes pills should be as concerned about their blood sugar as people who take insulin.	1	2	3	4	5
32	...people with diabetes have the right not to take good care of their diabetes	1	2	3	4	5
33	...support from family and friends are important in dealing with diabetes.	1	2	3	4	5

Revised 12/18/98

Physicians Questionnaire

Please answer the following questions as good as possible. This is not an examination. It will however give an indication of the knowledge of doctors on diabetes inpatient management.

1. Department: _____

2. Level:

Consultant	Registrar Year:_____	MO	Intern

3. On average how many patients with diabetes do you have in your ward / unit at any given time? _____

4. Who is primarily responsible for the management of diabetic patients' blood glucose control in your ward / unit?

Consultant	Registrar	MO	Intern

5. How often do you have difficulty to control your diabetic patients' blood glucose?

Always	frequently	sometimes	seldom	never

6. How often do you consult someone to help you manage your diabetic patients' blood glucose?

Always	frequently	sometimes	seldom	never

7. Who do you consult to help?

_____

8. The diabetic patients admitted to your ward / unit are mostly admitted for what reasons (mention the 2 or three most common reasons for admission)?

_____
_____

9. Do you consider the management of hyperglycaemia in diabetic patients as difficult or problematic?

Yes	No

Why?

_____
_____
_____

10. Do you think that diabetic patients are admitted to hospital for longer compared to non-diabetic patients?

Yes	No	Don't know

11. Do you think that diabetic patients are more prone to develop complications than non-diabetic patients while in hospital?

Yes	No	Don't know

12. How do you request that your diabetic patients' blood glucose be monitored in the ward in general?

_____
_____

13. What is the target blood glucose you are aiming for in inpatients admitted to your wards (not ICU) with diabetes?

_____
_____

14. Describe how you will decide how much insulin a diabetic patient will need when they were not on insulin before and now need to receive insulin in hospital?

_____
_____
_____
_____

15. In a type 2 diabetic patient admitted to your ward for an unrelated problem how will you prescription look if the patient is eating, and not for surgery within the next 3 days. The patient's blood glucose was well controlled with Metformin (Glucophage) 850 mg 3 times per day and gliclazide (Diamicron) 2 tabs (160 mg) 2 times per day?

_____
_____
_____
_____
_____

16. In a type 1 diabetic patient admitted to your ward for an unrelated problem how will you prescription look if the patient is eating, and not for surgery within the next 3 days. The patients blood glucose was well controlled with Actraphane insulin 30 units mane and 16 units nocte?

_____
_____
_____
_____

17. If your patient with type 2 diabetes was well controlled with Metformin 850 mg 3 times per day and gliclazide 2 tabs (160 mg) 2 times per day at home, is unable to eat in hospital. Please write a prescription for this patient?

_____
_____
_____
_____

18. If you have a type 2 diabetic patient treated at home with Metformin 850 mg 3 times daily and Actraphane insulin 40 U in the morning and 20 U in the evening. Your patient is unable to eat. Please write a prescription for this patient in hospital?

_____
_____
_____
_____

19. You have a patient with type 1 diabetes on insulin, Basal bolus regimen: Protaphane 26 u nocte, Rapid acting insulin 12 u before each meal. The patient is going for surgery tomorrow. Please write a prescription for your patient?

_____
_____
_____
_____

20. The target blood glucose for a diabetic inpatient is 5.5 to 8.3 mmol/l

True	False	Don't know

21. If a type 2 diabetic patient on oral therapy who is eating is admitted to hospital, the most correct way to treat the patient is to continue with the oral treatment with the addition of additional insulin boluses according to blood glucose values at mealtime.

True	False	Don't know

22. If a patient with type 2 diabetes on oral therapy is admitted and unable to eat, the most suitable method of treatment is an insulin sliding scale to treat hyperglycaemia.

True	False	Don't know

23. A type 1 diabetic patient admitted for surgery is best managed with a sliding scale if not eating

True	False	Don't know

24. Peri-surgically a patient with diabetes type 1 or 2 should be treated with intravenous insulin

True	False	Don't know

25. Type 1diabetic patients who are eating should have their blood glucose monitored 6 hourly

True	False	Don't know

26. A sliding scale is the best way of deciding how much insulin a patient with diabetes need

True	False	Don't know

27. Insulin adjustments should be made according to an adjustment scale for all patients on insulin in hospital

True	False	Don't know

28. Long acting insulin is contra-indicated in all patients admitted to hospital who are eating

True	False	Don't know

29. Patients with type I diabetes always need some insulin irrespective of whether they are eating or not

True	False	Don't know

30. Combination insulins e.g. Actraphane and Humulin 30/70 are not suitable for use in any patient with diabetes who is admitted to hospital.

True	False	Don't know

Nurses' questionnaire

Please answer the following questions as good as possible. This is not an examination. It will however give an indication of the knowledge of doctors on diabetes inpatient management.

1. Level

Senior Registered nurse	Registered nurse	Staff nurse	Student nurse

2. Unit

Medical	Surgical	Orthopedic/ Ophthalmology /ENT	Gynecology

3. On average how many patients with diabetes are present in your unit / ward at any given time?

_____
_

4. Do you consider a patient to be hypoglycaemic if the blood glucose is 2.9 mmol/l?

Yes	No	Don't know

5. The best schedule to monitor blood glucose is a day profile?

Yes	No	Don't know

6. Is a blood glucose level of 8,3 mmol/l acceptable for a diabetic patient?

Yes	No	Don't know

7. Do you think that diabetic patients are more prone to develop complications than non-diabetic patients while in hospital?

Yes	No	Don't know

8. Do you consider the management of blood glucose in diabetic patients troublesome?

Yes	No	Don't know

9. The forearm is the best place to inject insulin.

Yes	No	Don't know

10. An insulin adjustment scale is the dose of insulin to be given in addition to the usual insulin dose and is determined by the pre-meal blood glucose.

Yes	No	Don't know

11. Protaphane can be injected intravenously.

Yes	No	Don't know

12. To test capillary blood glucose the side of the finger is the best place to do the finger prick.

Yes	No	Don't know

13. Patients that are not eating should not receive boluses of insulin, but rather insulin infusions.

Yes	No	Don't know

14. Please describe how often should blood glucose ideally be tested in diabetic patients when they are admitted to hospital, and at what times.

_____

15. List the best body sites to inject insulin in a diabetic patient?

16. When will you consider a patient to be hypoglycaemic, and how will you respond?

17. Explain what is the difference in an insulin supplementation scale and an insulin sliding scale?

18. What insulins can be given intravenously?

19. Explain how you go about measuring capillary blood glucose? And what blood glucose machine is available in your ward?

20. Under what circumstances should you withhold insulin injections?

21. What are poorly controlled diabetic patients at risk of developing in the hospital?

22. What is the normal blood glucose that we aim for in patients with diabetes?

Diabetes inpatient knowledge questionnaire

Please complete the following questionnaire by circling Yes, No or Don't Know for each answer.				
Knowledge Questionnaire SVO/ver 7/1/06				
	PHYSIOLOGY			
1	Type 1 diabetes is caused by an absolute lack of insulin production.	Y	DK	N
2	Type 2 diabetes is usually associated with insulin resistance.	Y	DK	N
3	Insulin increases blood glucose.	Y	DK	N
4	Type 1 diabetes is more serious than Type 2 diabetes.	Y	DK	N
5	All patients treated with insulin have Type 1 diabetes.	Y	DK	N
6	Obesity is a risk factor for Type 2 Diabetes.	Y	DK	N
	BLOOD GLUCOSE (BG) MONITORING			
7	When the BG meter on the ward is in use Quality Assurance checks should be carried out once a day.	Y	DK	N
8	Whilst in hospital patients with Type 1 diabetes always need 4 tests a day, pre-meal & pre-bed.	Y	DK	N
9	When in hospital patients with Type 2 Diabetes always need to do one BM per day.	Y	DK	N
10	A BG greater than 12 mmol/l should always be reviewed by a doctor.	Y	DK	N
11	It is important to have a pattern of BG measurements over a few days before changing treatment.	Y	DK	N
12	BG measurements in hospital may differ from those recorded by the patient at home.	Y	DK	N
	MEDICATIONS			
13	Metformin typically causes hypoglycaemia.	Y	DK	N
14	Glibenclamide is the drug of choice in Type 2 diabetes.	Y	DK	N
15	Metformin is the drug of choice in patients with Type 2 diabetes who are overweight.	Y	DK	N
16	Gliclazide should be taken after meals.	Y	DK	N
17	Metformin is safe in kidney impairment.	Y	DK	N
	INSULIN			
19	Actraphane or Humulin 30/70 contains 70% cloudy NPH & 30% soluble insulin.	Y	DK	N
20	If you had to mix Actrapid with Protaphane the best technique is to draw up the Protaphane first.	Y	DK	N
21	Pre-mixed insulins are typically taken twice a day.	Y	DK	N
22	Only soluble insulin can be given IV.	Y	DK	N
23	Actrapid should be given 5 min. before food.	Y	DK	N
24	Insulin pen devices must be stored in a fridge.	Y	DK	N
	HYPOGLYCAEMIA			
25	Aggression is a symptom of hypoglycaemia.	Y	DK	N
26	Shaking is a symptom of hypoglycaemia.	Y	DK	N
27	Diabetics may go hypo many hours after exercise.	Y	DK	N
28	Poor intake of carbohydrate is a cause of hypoglycaemia in patients on insulin.	Y	DK	N
29	A cheese sandwich is an appropriate initial treatment for hypoglycaemia.	Y	DK	N

30	When a BM is less than 4 mmol/l you should omit giving insulin.	Y	DK	N
	HYPERGLYCAEMIA			
31	Hyperglycaemia is high blood sugars.	Y	DK	N
32	Lethargy is a symptom of hyperglycaemia.	Y	DK	N
33	Impotence can be caused by longstanding hyperglycaemia.	Y	DK	N
34	Acute illness is a typical cause of Hyperglycaemia.	Y	DK	N
35	Thirst is a symptom of hyperglycaemia.	Y	DK	N
36	If a patient with Type 1 diabetes is ill and has hyperglycaemia, you should check for ketones.	Y	DK	N
	COMPLICATIONS			
37	Retinopathy is the leading cause of blindness in young adults in developed countries.	Y	DK	N
38	Most Type 2 patients with Nephropathy are dead within 5 years of diagnosis.	Y	DK	N
39	Loss of sensation is an indication that the patient is at risk of diabetic foot disease.	Y	DK	N
40	Tight BP control is important in patients with Nepropathy.	Y	DK	N
41	Good glycaemic control can prevent complications of diabetes.	Y	DK	N
42	Patients with diabetes are more at risk of coronary heart disease than patient without diabetes.	Y	DK	N
	SCREENING / PREVENTION			
43	Patients with diabetes should have their eyes checked only if they have problems.	Y	DK	N
44	Patients with diabetes should have their feet checked by a podiatrist or doctor at least every 5 years.	Y	DK	N
45	Proteinuria can signify diabetic kidney disease.	Y	DK	N
46	Patients with diabetes should never cut their own toe nails.	Y	DK	N
47	Patients should only have their eyes checked in the hospital diabetes clinic.	Y	DK	N
48	The Annual Review is a yearly check of eyes, feet, kidneys, cholesterol and BG control.	Y	DK	N
	DIET			
49	Patients with diabetes should have a diet with no sugar, restricted protein, low fat, restricted carbohydrates.	Y	DK	N
50	Patients with diabetes must never eat cakes or sweets.	Y	DK	N
51	Special Diabetic Foods are a good choice for patients with diabetes.	Y	DK	N
52	Peas, beans & lentils can help control BG levels.	Y	DK	N
53	Patients with Type 1 diabetes need a late night snack.	Y	DK	N
54	Patients with diabetes must not drink alcohol.	Y	DK	N
	SURGERY / FASTING			
55	The most appropriate way to manage a patient on insulin going to theatre is to use an insulin infusion & adjustment scale.	Y	DK	N
56	When changing from a glucose constant infusion back to the patients normal insulin you should stop the GKI the night before you start the normal insulin.	Y	DK	N

57	Patients with diabetes often need to stay in hospital longer after surgery than patients without diabetes.	Y	DK	N
58	Patients with diabetes must never be fasted for a hospital procedure.	Y	DK	N
59	When possible patients with diabetes should be on the morning list for surgery.	Y	DK	N
60	Patients with Type 1 diabetes who are unable to eat should be on a insulin.	Y	DK	N
	GENERAL			
61	HbA1c is a test to measure average BG over 6 – 12 weeks	Y	DK	N
62	Patients on insulin cannot drive public service vehicles.	Y	DK	N
63	Patients with diabetes are not excluded from any forms of employment.	Y	DK	N
65	There are national guidelines for the management of type 2 diabetes.	Y	DK	N

Appendix 2

Inpatient diabetes management protocol for patients eating meals

Diabetes Insulin Prescription for Patients Eating

A. *Scheduled Insulin – given subcutaneously*

Regular insulin should be given 20 to 30 minutes before meals and 30/70 insulin should be given 20 to 30 minutes before breakfast and dinner.
Bedtime (22h00) insulin should be given with the evening snack, more or less 22h00
Patients on oral agent should continue with treatment as usual unless a contraindication for the use of oral agents is present.
All patients should continue their home insulin regimen.
Patients newly started on insulin should be initiated as follows:

- Type 2 diabetic patients: 0.2 – 0.3 u per kg per day. This can be started as once daily NPH insulin at bedtime, as long as less than 20 u are needed per day. If more than 20 u are needed either twice daily 30/70 premixed insulin or a basal bolus regimen can be started. Metformin should be continued; Sulphonylureas can be stopped or continued.
- Type 1 diabetic patients: 0.5 to 0.7 u per kg per day. This should be given either as a basal bolus regimen or twice daily 30/70 premixed insulin.
- NPH or evening 30/70 premixed insulin should be adjusted according to the morning pre-breakfast glucose.

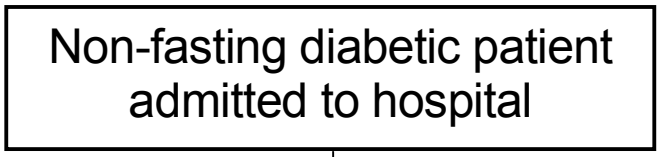
B. *Adjustment / Supplemental / Correctional insulin*

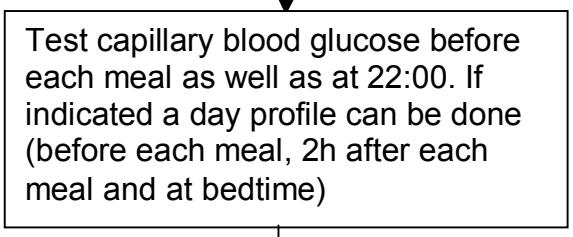
- This should be administered in addition to the SHEDULED insulin or oral agents.
- Supplemental / Adjustment insulin should always be given 20 to 30 min before meals as regular insulin.
- Patients on oral agent only can receive only supplemental insulin in addition to the oral medication.
- Patients on Regular insulin before meals, supplemental insulin can be added to the scheduled insulin and given simultaneously.
- Patients on only NPH or 30/70 insulin should receive the Supplemental insulin as an additional injection.
- Known type 1 diabetic patients and type 2 diabetic patients on insulin – initiate additional insulin according to the column corresponding to the total daily insulin dose that the patient receives.
- Type 2 diabetic patients on oral treatment should be started in column A.
- If pre-meal blood glucose measurements are higher than 8 mmol/L on 2 occasions move one column to the right. If it is lower than 4 mmol/L on two occasions move one column to the left.

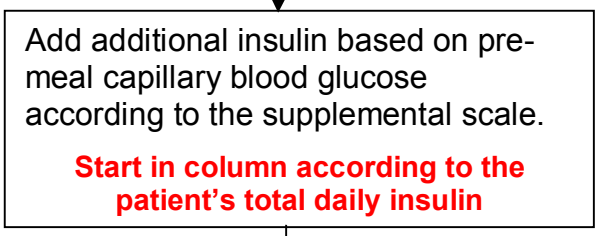
Insulin Supplementation (Always Regular insulin)

Capillary blood Glucose level mmol/L	**Total daily insulin**				
	A 0 – 20U	**B 21 – 46U**	**C 47 – 72U**	**D >72U**	**E individualised**
< 4	Initiate hypoglycaemia regimen				
6 – 8	+ 0	+ 2	+ 4	+ 6	
8.1 – 10	+ 2	+ 4	+ 6	+ 8	
10.1 - 13	+ 4	+ 6	+ 8	+ 10	
13.1 – 17	+ 6	+ 8	+ 10	+ 12	
17.1 - 20	+ 8	+ 10	+ 12	+ 14	
> 20	+10	+12	+14	+16	

Regular: Actrapid or Humulin R NPH: Protaphane or Humulin N 70/30: Actraphane or Humulin 70/30

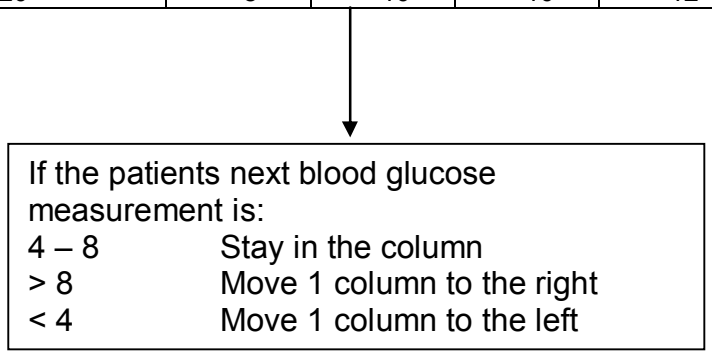


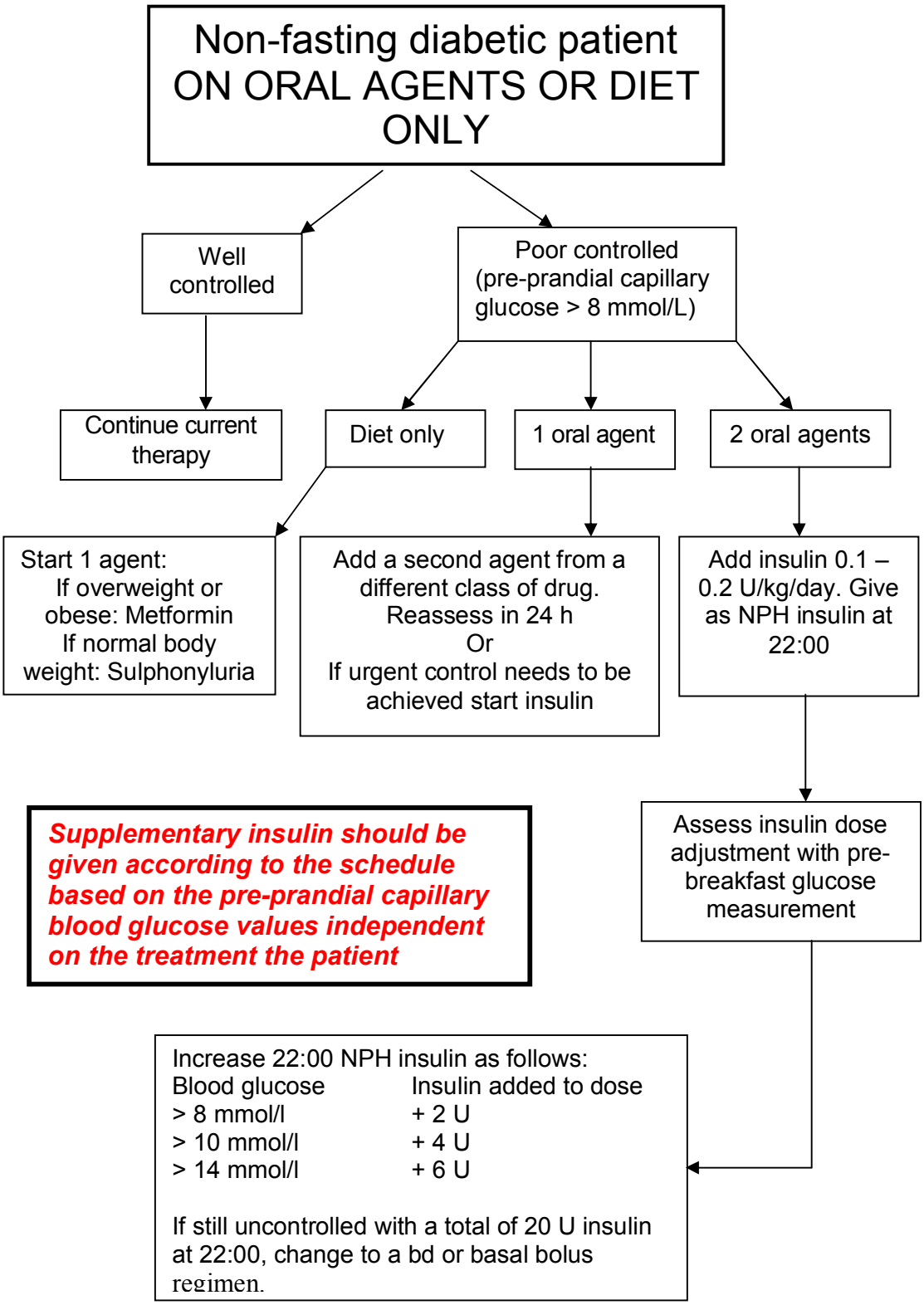




Insulin Supplementation

Capillary blood Glucose level	Total daily insulin			
	0 – 20U	***21 – 46U***	***47 – 72U***	***>72U***
< 4	- 2	- 2	- 4	- 6
4 – 8	0	0	0	0
8.1 – 13	+ 2	+ 2	+ 4	+ 6
13.1 – 17	+ 4	+ 6	+ 8	+ 8
17.1 - 20	+ 6	+ 8	+ 10	+ 10
> 20	+ 8	+ 10	+ 10	+ 12




Non-fasting diabetic patient ON ORAL AGENTS OR DIET ONLY
Well controlled
Poor controlled (pre-prandial capillary glucose > 8 mmol/L)
Continue current therapy
Diet only
1 oral agent
2 oral agents
Start 1 agent: If overweight or obese: Metformin If normal body weight: Sulphonyluria
Add a second agent from a different class of drug. Reassess in 24 h Or If urgent control needs to be achieved start insulin
Add insulin 0.1 – 0.2 U/kg/day. Give as NPH insulin at 22:00
Supplementary insulin should be given according to the schedule based on the pre-prandial capillary blood glucose values independent on the treatment the patient
Assess insulin dose adjustment with pre-breakfast glucose measurement
Increase 22:00 NPH insulin as follows:
Blood glucose Insulin added to dose
> 8 mmol/l + 2 U
> 10 mmol/l + 4 U
> 14 mmol/l + 6 U
If still uncontrolled with a total of 20 U insulin at 22:00, change to a bd or basal bolus regimen.

Non-fasting diabetic patient USUALLY ON INSULIN.

Patient usually on basal bolus regimen

Continue regular insulin boluses (usually Actrapid or Humulin R before meals).
Continue with basal insulin (usually NPH in evenings) at 22:00
Since in-hospital diet is more strictly regulated the dosage might need to be reduced by ± 80% of the usual home insulin.
The usual hospital diet contains more or less equal amounts of carbohydrates for breakfast, lunch and dinner. Thus the regular insulin boluses should be of equal size.
Give additional regular insulin according to the pre-meal blood glucose according to the supplementation insulin scale.
If the pre breakfast blood glucose is high on two consecutive mornings increase the evening NPH with 2 to 4 units.
If a new patient needs to be started on basal bolus insulin: Total daily dose of combination insulin: 0.5 to 0.7 x body weight (kg). Give 40% as NPH at 22:00 and 20% before each meal.

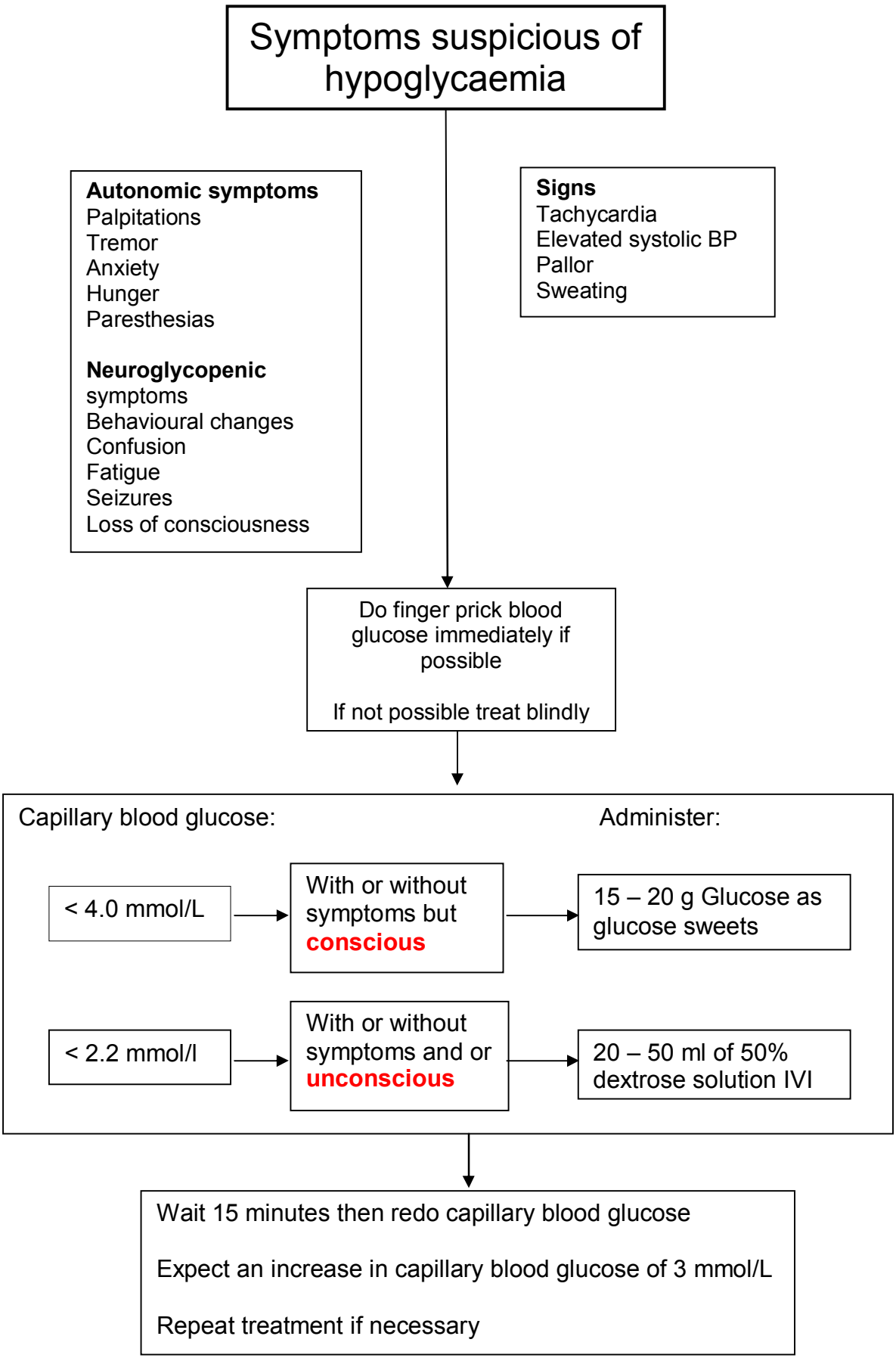
Patient usually on bd combined insulin

Continue with home regimen. Give additional regular insulin, according to the pre-meal blood glucose according to the supplementation insulin scale.
If a new patient need to be started on bd insulin:
Calculate the dose as follows:
Total daily dose of combination insulin: 0.5 to 0.7 x body weight (kg). Give 66% of this before breakfast and 33% before dinner.

Note that any patient on NPH insulin can develop hypoglycaemia during the night. This can manifest as either hypoglycaemia or hyperglycaemia in the morning before breakfast. Thus all patients with before breakfast hyper- or hypoglycaemia should have a blood glucose done between 2:00 and 4:00 at night

Insulin Supplementation

Capillary blood Glucose level	Total daily insulin			
	0 – 20U	***21 – 46U***	***47 – 72U***	***>72U***
< 4	- 2	- 2	- 4	- 6
4 – 8	0	0	0	0
8.1 – 13	+ 2	+ 2	+ 4	+ 6
13.1 – 17	+ 4	+ 6	+ 8	+ 8
17.1 - 20	+ 6	+ 8	+ 10	+ 10
> 20	+ 8	+ 10	+ 10	+ 12


Symptoms suspicious of hypoglycaemia
Autonomic symptoms
Palpitations
Tremor
Anxiety
Hunger
Paresthesias
Neuroglycopenic symptoms
Behavioural changes
Confusion
Fatigue
Seizures
Loss of consciousness
Signs
Tachycardia
Elevated systolic BP
Pallor
Sweating
Do finger prick blood glucose immediately if possible
If not possible treat blindly
Capillary blood glucose:
Administer:
< 4.0 mmol/L
With or without symptoms but conscious
15 – 20 g Glucose as glucose sweets
< 2.2 mmol/l
With or without symptoms and or unconscious
20 – 50 ml of 50% dextrose solution IVI
Wait 15 minutes then redo capillary blood glucose
Expect an increase in capillary blood glucose of 3 mmol/L
Repeat treatment if necessary

ONE WEEK BLOOD GLUCOSE CHART

WEEK: 1 2 3 4 5

A – actrapid/humulin R
AP – actraphane/ humulin 30/70
P – protaphane/ humulin N

For patients eating and not on Actrapid infusion

Do blood glucose 4x/day
*Before meals + bedtime (22:00)
If prescribed do 7x/day (Day profile)
*Before meals, 2h after meals and at bedtime
If requested do at 02h00

Patient name:

Hospital number:

			Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
		DATE							
Breakfast	Before	Time							
		Value							
		Insulin AP							
		Insulin A							
	After	Time							
		Value							
Lunch	Before	Time							
		Value							
		Insulin							
	After	Time							
		Value							
Dinner	Before	Time							
		Value							
		Insulin AP							
		Insulin A							
	After	Time							
		Value							
Bedtime	22H00	Time							
		Value							
		Insulin P							
Night	02H00	Time							
		Value							