Emily Briggs

Improving the Perioperative Management of Diabetes Mellitus in Tonga

Background

One in eight Tongan adults suffer from Diabetes Mellitus. Despite an effective universal-access national healthcare system, this statistic is increasing disproportionately to the global trend. This cohort of patients carries increased peri-operative and surgical risk. Guidance was published in 2015 detailing the peri-operative management of diabetic patients. This study investigated the compliance of practice in the major tertiary referral centre in Tonga with this guidance.

Methods

Data was collected in an observational, retrospective manner with supervision from the centre's Medical Superintendent. The audit included all adult diabetic cases undergoing surgical procedures during the study period. Patient, procedural data and aspects of perioperative care were recorded for each case in a data collection sheet created in the study protocol. Data was compared to audit criteria based on national guidance.

Results

12 surgical diabetic cases were identified. Intra-operative blood glucose levels deviated from the target range (6-10 mmol/l) in 63.6% of patients. There were 4 cases of recorded hyperglycaemia (range 10.7-16.8 mmol/l) and 3 cases of recorded hypoglycaemia (5-5.5 mmol/l). The use of intra-operative infusions to correct blood glucose levels when indicated was not observed. The use of variable-rate insulin infusions was also not observed when indicated. None of the patients in this study were listed first on the theatre list. The mean fasting time in the study was 11:15h, with 58% of patients missing >1 meal. Metformin was unnecessarily omitted on the day of surgery in 16% of patients. Glucose-lowering agents were still administered on the day of surgery in 8% of patients.

Conclusion

The peri-operative management of diabetic patients in Tonga does not adhere to internationally-accepted guidelines. Practice would therefore benefit from further investigation and improvement.

Background

Tonga is an archipelago of 169 islands in the South Pacific Ocean, with 70% of the population residing on the main island of Tongatapu. Tonga is an upper-middle income nation, with 22.5% of its inhabitants living below the poverty line and a heavy dependence on remittances sent from nationals living and working abroad in Australia and New Zealand. Despite this, the county has high levels of sanitation and a universal access National Healthcare System which has decreased the rates of infectious diseases to the level of Western communities (1).

Recent epidemiological studies of the global distribution of Diabetes Mellitus and metabolic syndrome has drawn attention to the South Pacific, and in particular the Kingdom of Tonga (2). Reports from the Global Burden of Disease study group have demonstrated that there is a

disproportionately increasing prevalence of hyperglycaemia in Oceania; fasting plasma glucose levels rose by 0.32 mmol/L per decade on average for men in the region, compared to 0.07 mmol/L globally. Diabetes Mellitus affects 1 in 8 Tongan adults, in comparison, this is double the rate of nearby Australia (3,4). These concerning statistics are predicted to become a growing burden to the Tongan National Healthcare System and in 2003 it became the first pacific state to develop a strategy for the prevention of 'Non-Communicable Diseases', which was later updated in 2010 in line with the WHO Stepwise Framework for Action (5).

There is an abundance of evidence to demonstrate higher risk in diabetic patients undergoing surgery with poor glucose control. Complications such as postoperative myocardial infarction, stroke, wound infection, prolonged intensive care are all seen more frequently in diabetic patients (6–9). Furthermore, peri-operative blood glucose monitoring is crucial to prevent life-threatening conditions such as diabetic ketoacidosis and hyperosmolar non-ketotic diabetic coma (10).

Although glycaemic control has such significant implications for surgery, there are no internationally-accepted evidence-based standards for the clinical management of diabetic cases in the peri-operative period. However, in 2015, the Association of Anaesthetists published guidance that focussed on reducing disruption to the patient's glycaemic control peri-operatively. They recommend prioritising diabetic cases on morning theatre lists to avoid prolonged starvation (defined as missing >1 meal), a practice that is well-recognised in many centres (11–13). Furthermore, the group recommend that intra-operative maintenance of blood glucose in these patients should be achieved through a minimum of hourly blood glucose monitoring with a target of 6-10 mmol/l. To eliminate risk of hypoglycaemia, they advise that glucose-lowering agents such as sulphonylureas should be omitted on the day of surgery, whilst metformin is considered safe to continue. In high risk patients, those with poor glycaemic control and emergency cases, a variable rate insulin infusion protocol is preferred to maintain blood glucose levels.

Clinical guidelines have also been published in Tonga detailing the peri-operative management of a diabetic patient (14). This states that patients should be monitored for their blood glucose levels serially and an intravenous infusion of 5% dextrose with insulin used to correct abnormalities during surgery (Table 1).

Blood Glucose mmol/L	Variable Rate IV Insulin Infusions (VRIII)
<6.5 mmol/L	5% dextrose 100 ml/hour + insulin 0.5 units/hour
6.5-10 mmol/L	5% dextrose 100 ml/hour + insulin 1 unit/hour
>10 mmol/L	5% dextrose 100 ml/hour + insulin 1.5 units/hour

Table 1: Recommended Tongan guidelines for administering Variable Rate IV Insulin Infusion (VRIII) in the surgical diabetic patient. *Start infusion of 1 litre 5% dextrose water at 100ml/hr plus insulin infusion at 1 unit/hour. The blood glucose should be monitored at 2 to 4-hourly pre and post operatively and hourly during surgery. The infusion rate should not be changed if the blood glucose is between 6.5-10mmol/L. The rate should be increased to 1.5 units/hr if glucose is >10mmol/L, and decreased to 0.5 units/hour if glucose is <6.5 mmol/L.*

The significance of such guidance in Tonga was illustrated by the Minister of Health's Report in 2010, which stated that diabetic complications were second only to cancer mortality as the largest cause of death on surgical wards (1). Without attention to this, a deterioration in national post-operative outcomes is to be expected alongside the exponentially rising prevalence of diabetes mellitus. Our study aimed to address this crisis, by investigating the peri-operative management of diabetic patients in the country's main referral centre, Vaiola Hospital. Vaiola, located on the main island of Tongatapu, is the largest healthcare centre in Tonga with approximately 200 patient beds. The centre receives patients from the nation's three community hospitals, 14 health centres and 34

clinics which are spread over the 36 inhabited islands within the archipelago (15). The centre sees a high annual hospitalisation rate in the Tongan population of 10% and frequently receives visiting specialist teams from overseas. The management of diabetic surgical cases at this centre was investigated through auditing compliance of practice with the local guidance and international guidance published by the Association of Anaesthetists, with the aim of generating recommendations to improve surgical outcomes and management of this growing cohort of patients within Tonga (12).

Methods

This retrospective observational study was performed at Vaiola hospital, the major tertiary referral centre for the Kingdom of Tonga. The protocol and data collection was registered by the Medical Superintendent at the centre prior to the study. All adult diabetic cases undergoing surgical procedures at the Vaiola during the month period from May to June 2017 were included in the analysis. For each case data relevant to peri-operative diabetic management was recorded in a data collection table through a combination of direct observation and the use of patient notes (Appendix 1).

The data was subsequently analysed and compared to guidelines on completion of the study using Microsoft Excel 2015. Four of the recommendations set out by the Association of Anaesthetists in 2015 were used as standards for the audit, *Figure 2* (12). The recommendations were chosen as they were accessible and relevant to individual patient care during the immediate perioperative period. In addition, the study aimed to audit compliance with the Tongan protocols published by the Ministry of Health in 2007 detailing the use of variable rate insulin infusions *Table 1* (14). As well as recording compliance with the recommendations, the data collection sheet included patient demographics, the type of procedure and anaesthesia used (Appendix 1). From the raw data the time fasted for was calculated (time fasting since minus time of anaesthesia) and data presented as a percentage of the total cohort or mean with range where appropriate.

Association of Anaesthetists, 2015

1. *Intra-operative blood glucose target: 6-10 mmol/l*
2. *Patients do not miss >1 meal*
3. *Metformin may be continued on day of surgery*
4. *Glucose-lowering agents should be discontinued on the day of surgery*

Figure 1. *The peri-operative management of diabetes mellitus. Recommendations from the Association of Anaesthetists, 2015* (12)

Results

Results have been compared to standards set by the Association of Anaesthetists, 2015 (12). 12 cases of diabetic patients undergoing surgical procedures at Vaiola hospital were recorded during the study period. The patient demographics have been recorded in Table 2 and the characteristics of the procedures in Table 3.

	Number of patients (mean or %)
n	12
Age	58.6 (37-73)
Gender	
Male	5 (41.6%)
Female	7 (58.3%)

Diabetes mellitus	
Type 1	0
Type 2	12 (100%)
Type of anaesthesia	
General	2 (1.67%)
Regional +/- sedation	10 (83.3%)

Table 2. Characteristics of patients included in the audit. *Values are mean or n (%).*

Procedures by surgical specialty	**n**
Orthopaedics	**3**
Above knee amputation	1
Below knee amputation	1
Forefoot amputation	1
Plastics	**6**
Wound debridement/washout/change of dressing	6
General	**1**
Hernia repair	1
Obstetrics and gynaecology	**2**
Elective caesarean section	1
Dilatation and curettage	1

Table 3. Procedures organised by specialty

Maintenance of peri-operative blood glucose

Pre-operative blood glucose was recorded in all patients. The mean length of procedure was 33 minutes with 16.7% of procedures performed under general anaesthesia and 83.3% of procedures performed with local anaesthesia with or without sedation. During the procedure 63.6% of patients had an intra-operative blood glucose outside of the target range recommended by the Association of Anaesthetists (6-10 mmol/l). There were 4 cases of recorded hyperglycaemia (range 10.7-16.8 mmol/l) and 3 cases of recorded hypoglycaemia (range 5-5.5 mmol/l). Despite these measurements, there were no attempts to correct blood glucose intra-operatively in any of the cases observed. The use of variable-rate insulin infusions was also not observed during the study period.

Fasting times

There was no prioritisation of diabetic patients in the order of theatre lists at Vaiola with no patients in the study listed at the beginning of the morning theatre. The mean fasting time was 11:15h. This led to 58% of patients missing >1 meal and fasting for longer than is recommended.

Alterations to diabetic regime on day of surgery

Metformin was unnecessarily omitted on the day of surgery in 16% of patients. Glucose-lowering agents (sulfonylureas) were still administered on the day of surgery in 8% of patients.

Discussion

This clinical audit investigated several aspects of peri-operative care relating to the management of diabetic patients in Tonga. The measurement of compliance with internationally-recognised guidelines published by the Association of Anaesthetists has illustrated that there is significant room for improvement in the peri-operative care of this cohort of patients (12).

Derangement of blood glucose levels peri-operatively has been frequently demonstrated in the literature to negatively impact postoperative outcomes (16–22). In general, the pre-operative assessment of diabetic patients was well-coordinated with every patient in the study undergoing at least a single measurement of capillary blood glucose (CBG). However, it is concerning that 63.6% of patients in the study were identified to have an intraoperative CBG that deviated from the recommended range and was left uncorrected. One explanation for the lack of intra-operative glycaemic control is the costs of using corrective insulin or glucose infusions intraoperatively for short procedures. The majority of cases were performed with regional anaesthesia and sedation rather than general anaesthesia. Sedative agents and co-administration of catecholamines have been shown to exert an effect on blood glucose levels alongside the natural stress response to surgery (23–25). Further investigation comparing different anaesthetic agents and their metabolic effects would be worth pursuing to address this.

We were not able to observe the consequences of poor intra-operative glycaemic control as the time-frame of this study did not allow the measurement of surgical outcomes. Studies have shown that acute derangement to blood glucose can impact on endothelial and immune functioning (26). This mechanism may explain the increased risk of surgical site infection (SSI) and delayed healing in these patients (27,28). Although we did not measure surgical outcomes directly, it was interesting to observe that a number of procedures (25%) were concerned with the treatment of infections following a primary procedure. It was noted also that surgeons often use antibiotics prophylactically in diabetic patients to decrease the risk of SSI. Improved glycaemic control could further decrease this risk and reduce the requirement for and cost of pre-operative antibiotics. We would recommend a further study to address the impact of glycaemic control on post-operative outcomes, with a long term follow up of surgical diabetic patients and complications they encounter.

Guidelines published by the Royal College of Nursing and the European Society of Anaesthesiology recommend that solid food is prohibited for 6 hours before surgery with clear fluids allowed up to 2 hours before (29,30). This is the standard peri-operative protocol adopted in many countries to reduce the risk of gastric aspiration during anaesthesia. It is of concern that the mean fasting time in our study was over 11 hours with more than two meals missed in the majority of cases (58.3%). In the last decade there has been a move to adopt more liberal fasting times with periods shorter than 6 hours deemed safe by several groups for certain procedures (31,32). Benefits cited include a reduction in patient discomfort as well as improved haemodynamic stability and a decreased risk of post-operative complications. On the other hand, an excessive starvation period leads to increased catabolism and release of ketone bodies which heightens surgical stress (13). Fasted animals models have been shown to have a reduced capacity to cope with disruption to fluid status and trauma and hence increased peri-operative risk (33). The debate is further complicated by the diabetic status of our patients. Excessive fasting times correspond to more modification of the normal insulin regime and increased risk of hypoglycaemia. This is likely to have contributed to the large proportion of patients in the study with an intra-operative blood glucose outside of the target range. It is recommended by many institutions that diabetic patients are listed first for surgical procedures to reduce the likelihood of this occurring (12). This practice would be easily implemented, even in a resource-poor environment, and is worth considering to improve peri-operative management of diabetic patients in Tonga.

Modification of diabetic medication in preparation for surgery is essential to avoid catastrophic dips in blood glucose levels alongside pre-operative fasting. Agents which act by lowering blood glucose (sulfonylureas, meglitinides, insulin, thiazolidinediones) may lead to hypoglycaemia during periods of starvation and must be stopped or doses lowered peri-operatively. However, drugs that prevent glucose levels rising (metformin, glucagon-like-peptide-1 analogues, dipeptidyl peptidase-4 inhibitors) may be safely continued on the day of surgery (12). There is no standard protocol for

alteration of diabetic medication in Tonga which mostly relies on correcting pre-operative hyperglycaemia with insulin boluses. In a number of our patients there was inappropriate administration of glucose-lowering medication which may have resulted in peri-operative hypoglycaemia and risk intra-operatively. Conversely, patients receiving metformin were prohibited from taking it on the day of surgery. Guidance in many countries now declares metformin safe to continue on the day of surgery unless there is intra-operative use of contrast dyes due to the risk of contrast material-associated nephropathy (34). This study has shown the need for a standard protocol in Tonga for the peri-operative management of diabetic medications to eliminate unnecessary pharmacological modification and reduce patient risk.

A significant barrier to implementing our recommendations to improve the peri-operative care of diabetic patients in Tonga is a lack of funding. Glucostrips, used in the monitoring of capillary blood glucose, were quoted by clinicians to be relatively costly and their use is rationed to align with the healthcare budget. To provide a system which is free-of-charge care in a country where poverty still exists in 22.5% of the population is a challenge (15). It would be interesting, therefore, to observe the effect of improved peri-operative management of diabetic patients on post-operative outcomes and measure any correlations. The potential reduction in surgical site infection and prolonged in-patient stays as a result of diabetic complications after surgery may outweigh the cost of implementing the recommendations quoted in this study.

The recommendations audited in this study were authored by members of the Association of Anaesthetists of Great Britain and Ireland (AAGBI), and approved by the AAGBI board of directors in 2015 (12). The publication was based on 2011 guidelines produced by NHS Diabetes, with attempts to provide a working document for anaesthetists, summarising the previous guidance and focussing solely on peri-operative care (11). This study has identified that there is a number of areas that do not comply with the guidance. Future work should establish which guidelines can be reasonably implemented into peri-operative practice in Tonga and how these may be adhered to successfully. This is of importance to address the increasing burden of diabetes in the nation, as well as the significant costs of diabetic complications to the Tongan healthcare system.

This investigation was designed to be carried out in an environment with limited resources that may have impacted the content of the audit. The chosen guidelines could be directly audited through observation and reference to in-patient notes. Factors that could not be measured, such as long term outcomes, were impossible to record in the design of the study and future work would benefit from investigating these. Furthermore, clinicians and auditors were not blinded to data collection, as it was not deemed feasible to perform with the study design. Due to the observational nature of the study, it is possible that some relevant cases were neglected in data collection which could provide some bias to our results. This investigation is not a closed audit loop and would profit from further endeavours. We would recommend amendments to future protocols to include the measurement of further outcomes and audited guidance, resources and time-permitting.

To conclude, this study has illustrated that the management of diabetic patients during the peri-operative period in the nation of Tonga does not adhere to internationally-accepted guidelines and would benefit from further investigation and improvement.

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Appendix

Appendix 1. Data collection form used during the audit.

Field	Explanation
Date of procedure	*e.g. 01/05/17*
Case number	*e.g. 01* The identifiable number
Procedure	*e.g. Below knee amputation* The procedure the patient is undergoing as stated on the theatre list
Age	*e.g. 45*
Sex	Male/Female
Anaesthetic technique	*e.g. sedation and regional block* The anaesthesia administered to the patient
Type of diabetes	
Normal diabetic regime	*e.g. insulin/oral medications/diet-controlled*

Pre-op CBG (day of surgery)	
Use of a VRII	
Anaesthesia start time	To closest 15 mins
First on list	*e.g. Yes/No*
Fasting time	To closest 15 mins
Intraoperative CBG	
Length of procedure	
Additional information notes	*e.g. Extra relevant data outside of protocol.*