

RESEARCH: CARE DELIVERY

The Pro-Diab Melbourne Perioperative Study: A structured pre-admission perioperative diabetes management plan to improve medication usage in elective surgery

Qi Yang Damien Qi^{1,2} | Mervyn Kyi^{1,2,3}  | Elizabeth Pemberton⁴ | Peter Grahame Colman^{1,2} | Spiros Furlanos^{1,2} 

¹Department of Diabetes and Endocrinology, Royal Melbourne Hospital, Parkville, Victoria, Australia

²Department of Medicine, Royal Melbourne Hospital, University of Melbourne, Parkville, Victoria, Australia

³Department of General Medicine, Royal Melbourne Hospital, Parkville, Victoria, Australia

⁴Department of Anaesthesia and Pain Management, Royal Melbourne Hospital, Parkville, Victoria, Australia

Correspondence

Qi Yang Damien Qi, Department Diabetes and Endocrinology, Royal Melbourne Hospital, 300 Grattan St, Parkville, VIC 3050, Australia.
Email: damien.qi@mh.org.au

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Abstract

Background: Perioperative diabetes management has become increasingly complex; management is often inconsistent resulting in dysglycaemia and associated morbidity.

Aim: To evaluate a structured pre-admission perioperative diabetes management plan (PDMP) for safe and appropriate recommendation, prescription and administration of diabetes medications in the perioperative period for people with diabetes undergoing elective, non-cardiac surgery.

Methods: A multidisciplinary team developed the intervention, a structured PDMP (including diabetes medication reconciliation, management guide, individualised plan) to standardise optimal perioperative diabetes management. A single centre prospective pre- and post-intervention pilot study was performed, including all individuals with diabetes medications attending the pre-admissions clinic during two 4-month periods (February to May) in 2016 (control period) and 2017 (intervention period). The primary outcome was appropriate recommendation, prescription and administration of diabetes medications (including insulin), according to the PDMP, in the perioperative period. Secondary outcomes measures were glycaemia. Analysis was by intention to treat.

Results: Control and intervention groups included 131 and 133 participants, respectively; they were well matched in clinical characteristics. The PDMP was completed correctly in 100 (75%) individuals in the intervention group. The appropriate use of diabetes medications increased from 30% in the control group to 71% in the intervention group ($p < 0.001$). Following the PDMP implementations, glycaemia improved in the overall perioperative period (8.7 ± 2.9 vs. 9.8 ± 3.3 mmol/L, $p = 0.005$) and at all time points (from admission and over entire hospital stay).

This study is registered with the Australian New Zealand Clinical Trials Registry, number ACTRN12617000827336.

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Conclusion: A structured pre-admission perioperative diabetes management plan for elective surgery improved safe and appropriate diabetes medication use and glycaemia in the perioperative period.

KEYWORDS

diabetes, glucose, perioperative, pre-admission, structured plan

1 | INTRODUCTION

Suboptimal glycaemia in hospital inpatients is associated with nosocomial infections, longer length of stay and increased mortality.¹ Illness, hospitalisation and surgery are well known to promote dysglycaemia by altering an individual's physiology due to activation of the sympathetic nervous system and counter-regulatory stress hormone secretion in addition to decreased physical activity levels and large variations in carbohydrate intake. Furthermore, the dynamic hospital environment is often characterised by inconsistent provision of diabetes care due to a lack of highly refined diabetes protocols and models of care, frequent shift changes in nursing and medical health professionals and a lack of diabetes expertise.² Widespread inconsistent and unsafe diabetes medication prescription and administration have been identified by many studies including the National Diabetes Inpatient Audits in the United Kingdom,³ where most recently almost one-third of inpatients with diabetes were found to have a medication error on their treatment chart, with these being more common on surgical wards.

Perioperative diabetes medication management is becoming increasingly complex due to the increasing number of new diabetes medications; hence management is often inconsistent resulting in perioperative dysglycaemia and associated morbidity.⁴ The use of a perioperative diabetes management plan is not mandated as part of the surgical checklist in Australian hospitals, thus the approach to perioperative diabetes management is highly inconsistent. Structured approaches to perioperative diabetes management plans, including intensive insulin administration, have been well described in the cardiac surgery setting,¹ however in non-cardiac surgery inpatients there have been fewer clinical trials.⁵⁻⁷ In the Pro-Diab Melbourne Perioperative Study, we sought to evaluate the effect of implementing a structured pre-admission perioperative diabetes management plan (PDMP) for safe and appropriate diabetes medication recommendation, prescription and administration for people with diabetes undergoing elective surgery. We hypothesised that the use of a PDMP would improve key measures of perioperative diabetes care including medication usage and glycaemia.

What's new?

- Perioperative diabetes medication management is becoming increasingly complex due to the availability of an increasing number of diabetes medications with relatively limited evidence for management approaches.
- This study demonstrates that a structured pre-admission perioperative diabetes management plan (incorporating medication reconciliation, guideline and individualised plan sections) can significantly improve perioperative medication management and perioperative glycaemia, without increasing the risk of hypoglycaemia.
- This study adds to the evidence base for optimising inpatient diabetes care in the perioperative period.

2 | METHODS

We conducted the 'Pro-Diab Melbourne Perioperative Study', a prospective pre-post interventional study with control (February-May 2016, standard care) and intervention (February-May 2017, PDMP care) periods, following implementation of the structured pre-admission 'Melbourne PDMP' (Melbourne Health Human Research and Ethics approval 2017.039) in February 2017. Developing the Melbourne PDMP involved multidisciplinary input from endocrinologists, anaesthetists, perioperative nurses and diabetes nurse educators. It was designed to create a structured individualised approach to perioperative diabetes medication recommendation, prescription and administration. The Melbourne PDMP included a diabetes medication reconciliation section, a perioperative diabetes medication management guide section, and a written, individualised diabetes management plan section (Appendix 1). Recommendations on insulin and non-insulin medication use were based on national Australian guidelines aligned with contemporary best practice.⁸

The Melbourne PDMP is an example of a structured but less insulin-intensive approach whereby non-insulin requiring participants pre-surgery were not automatically prescribed multi-dose (basal bolus) insulin, while

insulin-requiring participants were prescribed modified insulin treatment. The PDMP was performed in the Pre-admissions Clinic by either an anaesthetist or surgical hospital medical officer for all elective (non-cardiac) surgery participants with diabetes who attended the Pre-admissions Clinic, where recruitment occurred in a consecutive manner during each 4-month period in 2016 and 2017. The PDMP document was added to the pre-admission clinic paperwork, where medication reconciliation was performed by either an anaesthetist or surgical hospital medical officer (without the presence of a clinic pharmacist). The PDMP was implemented with multiple group education sessions for health professional staff. Individuals who were not on any diabetes medications were excluded, as were individuals treated with sodium glucose co-transporter inhibitors (as original contemporaneous guidelines recommended withholding on the day of surgery only,⁹ however, current practice now recommends withholding for at least 48 hours prior to the day of surgery).

Electronic health information systems, including electronically typed information and scanned handwritten clinical notes, were used to collect data for entry into a computerised database. The assessment of correct medication usage was performed by reviewing inpatient progress notes and medication charts during the admission. Blood glucose monitoring practices, and blood glucose measurements were recorded for the duration of the admission from the perioperative anaesthetic charts and glucose observation charts.

The primary study outcome was the appropriate perioperative diabetes medication usage, defined as fulfilling the triad of appropriate recommendation of a medication plan, along with documented prescription and administration in the written medication chart. Appropriate medication recommendation consisted of the following components: non-insulin medications to be withheld on the day of surgery; and for individuals on insulin treatment, prandial rapid-acting insulin to be withheld whilst fasting, while ensuring some form of basal insulin was still administered (at least 75% of the PDMP recommended dose). Appropriate medication prescription and administration consisted of diabetes medications prescribed (correct name and dose) and administered (correct dose and time) on the medication chart. Glycaemia was analysed as a secondary outcome, according to the models of glucometric reporting as previously described.¹⁰ Glucometrics pre-specified for assessment included: (i) patient-day mean glucose, defined as the mean of all glucose values taken for a patient on a calendar day, (ii) the proportion of patient-days where any blood glucose was above the threshold of 15 mmol/L (270 mg/dL) (iii) the proportion of patient days with any blood glucose <4.0 mmol/L (72 mg/dL).

2.1 | Statistical methods

For the primary outcome, individual participant scores were recorded [dichotomous variable 0 (no) or 1 (yes)] to indicate if there was documentation of a recommended PDMP, prescription and administration of diabetes medications according to the PDMP. Descriptive data of the study population are presented as mean \pm SD, median (quartiles) or n (%). We performed analyses with SPSS software (version 24). Outcomes were assessed on intention to treat (intention to receive PDMP care) basis, thus all individuals in the intervention group were analysed even if they did not receive use of the PDMP. Categorical variables were compared using the χ^2 test, which included the primary outcome. Continuous variables, including glycaemia, were analysed to determine normality, and compared using the non-parametric Mann-Whitney or t tests, and are reported as mean differences and 95% CIs.

3 | RESULTS

The study involved 264 participants with the control and intervention groups being well-matched in clinical characteristics (Table 1), and surgical characteristics (Appendix 2). Of the 133 intervention group cases, in 100 (75%) the PDMP was completed correctly, in 18 (14%) the PDMP was incomplete or incorrect and in 15 (11%) the PDMP was not used.

The appropriate recommendation, prescription and administration of diabetes medications in the perioperative period was significantly higher in the intervention group, 71% (95 of 133), than in the control group 30% (39 of 131) ($p < 0.001$) (Table 1). The appropriate diabetes medication usage in the non-insulin requiring diabetes subgroup was higher, 88% (71 of 81), than in the control group, 44% (36 of 81) ($p < 0.001$), where the most common improvement following PDMP implementation was appropriately withholding a glucose-lowering medication on the day of surgery alone. In the insulin-requiring diabetes subgroup, appropriate medication usage was again higher in the intervention group, 46% (24 of 52), than in the control group, 6% (3 of 50) ($p < 0.001$), with the most significant improvement noted in appropriately recommending basal insulin administration the night prior, as well as appropriately adjusting mixed insulin doses according to the planned timing of surgery. Of those with a correctly completed PDMP, 89% (89 of 100) received the appropriate prescription and administration of diabetes medications.

Glycaemia significantly improved following the implementation of the PDMP at all time periods analysed (Table 1). For the overall perioperative period following

TABLE 1 Participant characteristics and outcomes

	Control group (usual care) <i>n</i> = 131	Intervention group (PDMP care) <i>n</i> = 133	<i>P</i>
Age (years)	67 ± 11	69 ± 11	0.079
Men	79 (60)	75 (56)	0.519
BMI (kg/m ²)	31.4 ± 6.9	31.9 ± 6.2	0.528
Diabetes type			0.113
Type 1 diabetes	3 (2.0)	8 (6.0)	
Type 2 diabetes	128 (98)	125 (94)	
Diabetes treatment			0.877
Non-insulin medications only	81 (62)	81 (61)	
Insulin-requiring	50 (38)	52 (39)	
Admitted on day of surgery	126 (96)	129 (97)	0.717
Discharged on day of surgery	25 (19)	24 (18)	0.828
Intraoperative time (mins)	115 ± 84	105 ± 89	0.730
Length of stay (days)	1.4 (1.1, 4.1)	1.3 (1.0, 3.1)	0.301
No. of glucose measurements on day of surgery	4.2 ± 2.3	4.2 ± 2.0	0.644
No. of glucose measurements during hospital stay	11.2 ± 9.4	10.9 ± 10.2	0.788
Medication usage			
Had a recommended medication plan	61 (47)	106 (80)	<0.001
Medication plan, prescribed & administered	39 (30)	95 (71)	<0.001
Glycaemia in the perioperative period			
First admission glucose (mmol/L)	10.0 ± 4.4	8.8 ± 3.6	0.017
Overall perioperative period ^a (mmol/L)	9.8 ± 3.3	8.7 ± 2.9	0.005
Participants with glucose >15 mmol/L	20 (15)	10 (7.5)	0.074
Participants with glucose <4 mmol/L	4 (3.0)	8 (6.0)	0.258
Participants with glucose <3 mmol/L	0	1 (1.0)	0.258
Glycaemia following operation			
Postoperative day 1 glucose (mmol/L)	10.1 ± 2.9	9.2 ± 2.8	0.012
Postoperative day 2 glucose (mmol/L)	9.9 ± 2.8	8.6 ± 2.3	0.005
Postoperative day 3 glucose (mmol/L)	10.2 ± 3.3	8.1 ± 2.0	0.002
Glycaemia in the overall hospitalisation period			
Patient-stay mean glucose	10.2 ± 3.0	9.0 ± 2.4	<0.001
Patient-day ^b mean glucose	10.0 ± 3.0	8.8 ± 2.5	
Patient-days ^b with glucose >15 mmol/L	88 (22)	55 (13)	
Patient-days ^b with glucose <4 mmol/L	14 (3.4)	20 (4.8)	
Patient-days ^b with glucose <3 mmol/L	3 (0.7)	3 (0.7)	

Note: Data are shown as mean ± SD, median (quartiles) or *n* (%). Categorical variables were compared using the χ^2 test. Continuous variables were compared using *t*-test or non-parametric tests as appropriate.

^aPerioperative period includes from the time of admission to pre-operative area on the day of surgery until discharge from the post-anaesthesia care unit.

^bThere were 389 and 425 patient-days in the control and intervention groups respectively.

the implementation of the PDMP, the mean \pm standard deviation glucose improved from 9.8 ± 3.3 to 8.7 ± 2.9 mmol/L ($p = 0.005$). There was a similar decrease in the first admission glucose in the intervention group from 10.0 ± 4.4 to 8.8 ± 3.6 mmol/L ($p = 0.017$). Regarding the overall hospitalisation glycaemia, patient-stay glucose decreased from 10.2 ± 3.0 to 9.0 ± 2.4 mmol/L ($p < 0.001$). There was no difference in hypoglycaemia rates across all time periods, including the perioperative period ($p = 0.258$) and the overall hospital admission ($p = 0.304$).

4 | DISCUSSION

The use of a structured pre-admission perioperative PDMP resulted in significant improvements in perioperative diabetes medication recommendation, prescription and administration, as well as glycaemia. The improved medication usage was predominantly driven through improving appropriate diabetes medication recommendations prior to admission (via performing diabetes medication reconciliation, following a guide, and formulating a structured plan in pre-admission clinic) which then promoted improved prescription and administration upon admission for surgery. General increased knowledge and awareness of perioperative diabetes medication use is likely a concomitant mechanism for the PDMP's effect on improving perioperative diabetes medication use and glycaemia. First admission glucose improved due to more appropriate pre-admission medication recommendation, an important finding as hyperglycaemia at admission and pre-surgery is universally associated with poor outcomes.⁴ This significantly improved glycaemia perioperatively was sustained for several days postoperatively; suggesting optimal management on the day of procedure translates to improved glucose control for the entire hospital stay. The magnitude of glucose decrease is comparable to other published studies of perioperative interventions.^{1,5,6,11} Importantly, these improvements in glycaemia occurred without increasing the risk of hypoglycaemia, suggesting the intervention is safe.

Previous studies of perioperative diabetes interventions have occurred in the United States using structured electronic insulin order sets, where individuals undergoing surgery were treated with strict intensive insulin infusion regimens.^{1,6} Although improved glycaemia was demonstrated, these interventions demand greater staffing resources and insulin use; and thus, may not be suitable in some healthcare systems due to increased costs. Several studies have also reported varying combinations of guideline-based and dedicated team-based interventions to improve perioperative glycaemia.^{5,7,11-14} A recent

large prospective Dutch study of a multidisciplinary education perioperative diabetes intervention did not improve glycaemia.¹² Given research in this field is still relatively limited, we believe the Pro-Diab Melbourne Perioperative Study findings on the PDMP intervention provide important lessons for improving perioperative diabetes care. The Melbourne PDMP has the advantage of being relatively straightforward to implement as it does not rely on increasing technology or staffing resources. Multi-centre randomised studies are required to validate the effect of the PDMP interventions on glycaemia and clinical outcomes.

Some study limitations need to be considered. This was a single centre observational study which may have been subject to other hospital practice variations, although we were not aware of any improvement programs during the short study periods. We demonstrated that the efficacy of the PDMP is dependent on its uptake and accurate application of the guidelines. Utilisation rates could potentially decrease over time without intermittent surveillance and feedback. It may be of interest to examine the various diabetes medication regimen prescriptions divergent from the recommended PDMP guide, however, the small study size would limit its interpretation. Anecdotally, the consistent administration of appropriate basal insulin doses in people with pre-existing insulin-requiring diabetes is a cornerstone to optimising perioperative diabetes care. Finally, the proportion of participants with type 1 diabetes, at higher risk of significant perioperative glycaemic complications, including diabetic ketoacidosis, was relatively low, and the PDMP was not investigated in people with diabetes undergoing emergency surgery. Further clinical studies, including randomised clinical trials, are required, to validate the study findings and determine the generalisability for other healthcare settings.

5 | CONCLUSION

A structured pre-admission perioperative diabetes management plan, which was straightforward to implement, significantly improved perioperative diabetes care. It is our strong conviction that all individuals with diabetes undergoing surgery should receive a well-structured medication plan for safe diabetes management at the time of surgery.

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CONFLICT OF INTEREST

There are no relevant conflicts of interest to disclose.

AUTHORS' CONTRIBUTIONS

QYDQ contributed to PDMP implementation, recruited participants, performed data collection and data analysis and wrote the initial manuscript. MK contributed to developing the PDMP intervention and study design, performed analysis and revised the manuscript. EP contributed to the development of PDMP and its implementation, developed the study design and revised the manuscript. PC contributed to the development of the PDMP and revised the manuscript. SF conceived the study, developed the PDMP intervention and implementation, interpreted the results, wrote the initial manuscript and revised the manuscript.

ORCID

Mervyn Kyi  <https://orcid.org/0000-0002-4341-8250>

Spiros Furlanos  <https://orcid.org/0000-0002-5153-8324>

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SUPPORTING INFORMATION

Additional supporting information may be found in the online version of the article at the publisher's website.

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