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ORIGINAL RESEARCH

Achieving a Preoperative Target HbA_{1c} of < 69 mmol/mol in Elective Vascular and Orthopedic Surgery: A Retrospective Single Center Observational Study

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ABSTRACT

Introduction: Diabetes mellitus (DM) is present in 10–15% of the surgical population. It is a known risk factor for adverse postoperative outcomes. UK perioperative guidance recommends optimizing glycemic control preoperatively, aiming for a target glycated hemoglobin (HbA_{1c}) of < 69 mmol/mol. However, real-world compliance with this guidance remains unknown. The aim of our study was to determine how many patients with DM undergoing elective orthopedic and vascular surgery had a preoperative HbA_{1c} of < 69 mmol/mol. We also reviewed the surgical reasons for non-

concordance with the recommended preoperative HbA_{1c} target.

Methods: This was a retrospective observational study of 1000 consecutive patients who had been referred for elective vascular and orthopedic surgery at a large tertiary center. Data were collected on these patients, both those with and without DM, between January 2016 and February 2017. Electronic databases were used to collect information on the patients' preoperative HbA_{1c} concentration and to determine whether there was a resulting delay in surgery when the preoperative HbA_{1c} target of < 69 mmol/mol was exceeded.

Results: Of the 1000 patients referred for surgery (500 orthopedic and 500 vascular patients) included in the study, 201 (20%) had diabetes. Among these 201 people with DM, 155 (77%) had a preoperative HbA_{1c} < 69 mmol/mol. Among the 46 people with DM whose HbA_{1c} exceeded the recommended target, 41 were operated on despite the high HbA_{1c} level, and only five had their surgery deferred or canceled due to suboptimal preoperative glycemic control.

Conclusions: Our data shows that the majority (77%) of people undergoing elective vascular and orthopedic surgery were able to achieve a target HbA_{1c} of < 69 mmol/mol. The current preoperative guidance is therefore achievable in a real-life setting. However, as is stated in the national guidance, this target should only be used where it is safe to do so and a degree of clinical discretion is necessary.

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INTRODUCTION

The prevalence of diabetes mellitus (DM) is increasing in the UK, where it has been estimated that there are currently 3.8 million adults with DM, equivalent to 8.6% of the adult population [1]. This is an increase from the estimate of 2.7 million (6% of the adult population) in 2013 [2]. Recent studies have shown that 8.8% of surgical referrals to all specialities are for persons with diabetes, and that 10–15% of those who ultimately undergo surgery have DM [3, 4]. This figure is expected to increase alongside increases in the prevalence of DM.

Poor perioperative diabetes control has been shown to be associated with adverse outcomes in almost every surgical speciality [5–18], although it is acknowledged that these data show an association and not causation. However, given the strength of the association, national guidelines recommend that glycemic control be optimized prior to elective surgery—i.e. the patient should achieve a glycated hemoglobin (HbA_{1c}) of ≤ 69 mmol/mol (8.5%), where it is safe to do so [4, 19]. To date there are few data on how closely clinicians adhere to this standard at the preoperative assessment, or whether this target is achievable.

The aim of this single-center study was to determine how many orthopedic and vascular surgery patients with DM in a convenience sample had a preoperative HbA_{1c} above the recommended target of 69 mmol/mol (8.5%), and how many ultimately underwent surgery despite having an HbA_{1c} which exceeded the target.

METHODS

We carried out a retrospective review of a convenience sample of 1000 consecutive vascular and orthopedic patients who had a preoperative

assessment between 15 January 2016 and 20 February 2017 at the Norfolk and Norwich University Hospital (NNUH), a 1000-bed teaching hospital in the East of England.

All patients who require an elective vascular or orthopedic procedure are seen in a preoperative assessment clinic in the 2 weeks preceding their surgery. This clinic is run by experienced nursing staff with anaesthetic medical support. For those with significant co-morbidities, the assessments are undertaken by the anaesthetists themselves.

Patients attending their assessment were identified using the hospital's patient administration system (PAS). Details of patients' preoperative assessment were found using internal electronic databases (Orsos Web Periop [Allscripts, Manchester UK] and Bluespier [Droitwich, UK]). Sunquest ICE (Integrated Clinical Environment, an online pathology requesting and reporting system [Tucson, AZ]) and online outpatient clinic letters were then used to collect data on the patients' HbA_{1c} and any resulting delay in their elective surgery. Patients with and without DM were included in the study.

The study was registered as a local clinical audit (registration code DIAB-17-18-08) and as such ethical approval was not required. The study was registered with Researchregistry.com, registration number 4756. Reporting of this work followed the STROCSS (Strengthening the Reporting of Cohort Studies in Surgery) criteria. [20].

RESULTS

Demographics and Type of Surgery

Of the 1000 consecutive patients reviewed, the median age was 69 (range 16–92) years, 42% were female and 20% had diabetes (Table 1). There was an even split between vascular and orthopedic surgery patients. The type of surgery performed is summarized in Table 2.

Table 1 Glycemic status and type of diabetes for all 1000 patients in the study

Type of diabetes	Frequency (<i>n</i>)	Percentage (%)	Gender (male:female)	Age (\pm SD)
No diabetes	796	79.6	344:452	64.3 (16.3)
Type 1	10	1.0	5:5	59.7 (14.8)
Type 2	181	18.1	64:117	69.7 (10.5)
Type unknown	10	1.0	4:6	69.2 (7.4)
Borderline ^a	2	0.2	2:0	82.0 (0.0)
Prediabetes ^a	1	0.1	0:1	76.0 (0.0)
Total	1000	100.0	418:582	65.4 (15.5)

SD Standard deviation

^a Those recorded as 'borderline' or 'prediabetes' had a glycated hemoglobin (HbA_{1c}) concentration of between 43 and 47 mmol/mol, a fasting glucose concentration of 6.0–6.9 mmol/l or a random plasma glucose level of 7.8–11.0 mmol/l

HbA_{1c} Concentration

Overall there were 201 patients with DM, among whom 155 (77%) achieved an HbA_{1c} below the target of 69 mmol/mol (8.5%) prior to their surgery. A total of 46 patients (23%) with DM did not meet the recommended preoperative HbA_{1c} target.

Of the 46 individuals with DM who had a preoperative HbA_{1c} \geq 69 mmol/mol (8.5%), 41 underwent surgery irrespective of their preoperative glycemic control. The procedures carried out for these individuals are listed in Table 3. The remaining five individuals had their surgery deferred or canceled as a result of suboptimal preoperative glycemic control.

Deferred Surgeries

The details of the five individuals who had their surgery delayed or canceled due to a high HbA_{1c} concentration are summarized in Table 4.

The surgery of one individual who was scheduled to have a vascular procedure for an occluded superior femoral artery stent, for

which a femoro-distal bypass was indicated, was canceled due to high HbA_{1c}. However, because the patient had continued poor glycemic control but the symptoms showed an improvement, surgery was no longer deemed urgent, and the decision was made to continue conservative treatment. This individual had the highest HbA_{1c} readings of all the patients included in this study (134 and 140 mmol/mol [14.4 and 15%, respectively]).

Of the seven orthopedic patients with an HbA_{1c} of \geq 69 mmol/mol, only three ultimately had their respective surgery without delay. The HbA_{1c} values of these three patients were 74, 72, and 69 mmol/mol (8.9, 8.7 and 8.5%), respectively. The patient with the HbA_{1c} of 74 mmol/mol (8.9%) underwent an urgent foot amputation following a diagnosis of osteomyelitis.

No further preoperative assessments or admission details were found for the two patients with high HbA_{1c} concentrations awaiting total hip replacements. These patients may have had their surgery elsewhere or had their surgery canceled altogether, thereby opting for conservative management.

Table 2 Type of surgery performed

Type of surgery	Frequency (n)	Percentage (%)
Amputation	14	1.3
Aneurysm repair	4	0.4
Angiography	8	0.8
Angioplasty	86	8.6
Ankle surgery	11	1.1
Anterior cruciate ligament repair	13	1.3
Aortic aneurysm open repair	47	4.7
Arthroscopy	34	3.4
Aspiration	1	0.1
Biopsy	1	0.1
Bypass	21	2.1
Elbow replacement	1	0.1
Endarterectomy	45	4.5
Endovascular aneurysm repair	73	7.3
Excision clavicle	1	0.1
Femoro-popliteal bypass	17	1.7
Fenestrated endovascular aneurysm repair	11	1.1
Aorto-venous fistula	71	7.1
Foot surgery	13	1.3
Hand surgery	9	0.9
Hardware removal	18	1.8
Hip replacement	130	13.0
Iliac stent	16	1.6
Knee replacement	121	12.1
Manipulation under anaesthesia	3	0.3
Other	35	3.5
Profundoplasty	2	0.2
Rotator cuff repair	3	0.3
Scan under general anaesthetic	3	0.3

Table 2 continued

Type of surgery	Frequency (n)	Percentage (%)
Shoulder replacement	19	1.9
Soft tissue removal	8	0.8
Spinal procedure	76	7.6
Thoracic endovascular aneurysm repair	1	0.1
Unknown	3	0.3
Varicose veins	73	7.3
Wrist surgery	3	0.3
Total	1000	100

Table 3 Type of surgery performed without deferment on those with glycated hemoglobin concentrations that exceeded 69 mmol/mol

Type of surgery	Frequency (n)	Percentage (%)
Amputation	3	7.3
Angiogram	2	4.9
Angioplasty	15	36.6
Endarterectomy	7	17.1
Endovascular aneurysm repair	2	4.9
Femoro-popliteal bypass	1	2.4
Fistula	3	7.3
Hip replacement	1	2.4
Iliac stent	2	4.9
Open aortic aneurysm repair	2	4.9
Spinal procedure	1	2.4
Varicose veins	2	4.9
Total	41	100.0

Table 4 Details of patients whose surgery was delayed/canceled due to high glycated hemoglobin concentration

Specialty	Procedure	Age (years)	Gender	Type of diabetes mellitus	Pre-clinic HbA _{1c} (mmol/mol)	Repeat HbA _{1c} (mmol/mol)	Surgical outcome
Vascular	Femoro-popliteal bypass	47	Female	2	134	140	Cancelled
Orthopedics	Removal of hardware from femur	73	Female	2	79	59	Delayed
Orthopedics	Wrist fusion	55	Male	1	84	63	Delayed
Orthopedics	Total hip replacement	65	Male	2	87	–	Cancelled
Orthopedics	Total knee replacement	70	Male	2	81	71	Cancelled

DISCUSSION

Our study shows that of 201 vascular and orthopedic patients with DM, only 46 (23%) had a pre-operative HbA_{1c} \geq 69 mmol/mol (8.5%). Of these latter 46 patients, only five individuals had their surgery deferred or canceled due to exceeding the target HbA_{1c} concentration, while the majority (41/46) underwent surgery as planned.

Our institution is a 1000-bed tertiary teaching hospital that primarily serves the population of Norfolk, UK as well as neighboring counties. The prevalence of DM (diagnosed and undiagnosed) in Norfolk alone was estimated at 68,098 in 2015 [1]. At the time of the 2017 National Diabetes Inpatient Audit there were 140 inpatients with DM at the NNUH, accounting for 15.9% of the total number of beds included in the audit [21].

It is clear that if poor glycemic control was not picked up by the diabetes caregiver prior to the patient attending the preoperative assessment clinic, then 2 weeks would be insufficient time to optimize glycemic control and the decision on whether to defer surgery would depend on the outcome of a discussion between the anaesthetist and the surgeon. The predominant factor in this discussion would be the urgency of the surgery. In line with UK

national guidelines, the preoperative assessment clinic staff does not manage the diabetes care of individuals other than giving out instructions on how to manage their diabetes medications on the day prior to and on the day of surgery [19]. Among the patients reviewed here, those whose surgery could be safely deferred were asked to return to their primary diabetes caregiver who would then apply the current standard of care to improve glycemic control. These patients were sent to their diabetes caregiver with the information that the delay in surgery was due to poor glycemic control, and they were given additional information on the glycemic target. The vast majority of patients with type 1 diabetes (> 98%) in our study were looked after by secondary care services, while > 80% of those with type 2 diabetes were looked after by primary care services.

We believe that the sample size was large enough to allow for the primary analysis—i.e. to determine how many patients with DM had a pre-operative HbA_{1c} below the target of 69 mmol/mol (8.5%) for elective orthopedic and vascular surgery. We were also able to review any patients who had a delay in their surgery due to high HbA_{1c}. A strength of our study is that it was a single-center study which enabled us to comprehensively collect the data

on HbA_{1c} and on whether surgery went ahead or not.

A limitation in our data was that we did not collect information on interventions implemented to optimize glycemic control before the preoperative assessment, a task which may have been performed by primary or secondary care teams [4, 19]. Such data would have demonstrated whether patients with high HbA_{1c} concentrations were being targeted for optimization of glycemic control before being referred for surgery. In addition, the aim of this study was not to look at any excess morbidity and mortality following surgery in patients with an HbA_{1c} \geq 69 mmol/mol. We are aware that the sample size was too small for such a study, and other work is ongoing to address this question. Further limitations to our study include not collecting data on the use of continuous glucose monitoring or insulin pump use nor on who was at high risk of developing hypoglycemia.

Data are available which show that post-operative outcomes worsen with worsening of preoperative glycemic control [5–18]. This increased postoperative complication rate is also associated with increased costs [22]. However, little data are currently available on whether various preoperative HbA_{1c} targets are achievable for those undergoing elective surgery or whether clinicians adhere to these guidelines before proceeding with surgery. The data from the present study show that the orthopedic department adhered relatively closely to the target HbA_{1c} of 69 mmol/mol. A previous study by Giori et al. focused on whether people with diabetes requiring total joint arthroplasty at a single center in the USA could achieve a preoperative HbA_{1c} goal of 53 mmol/mol [23]. These authors found that 94% of their patients ultimately did achieve the target HbA_{1c}, but that 15% had their surgery delayed due to poor glycemic control, similar to our findings. These results led them to conclude that a goal designed to reduce perioperative risk should be achievable but also that it may not be possible for some patients with DM to achieve this target HbA_{1c} of $<$ 53 mmol/mol. However, Giori et al. [23] aimed for much tighter glycemic control than the UK current guidelines, which

recommend an HbA_{1c} of $<$ 69 mmol/mol [19]. Furthermore, many individuals requiring joint arthroplasty are elderly, and such ‘tight’ glycemic control may be inappropriate and indeed harmful in this patient population [24, 25]. Some authors from the USA have shown that risks of excess postoperative complications first occur when the HbA_{1c} rises to $>$ 58 mmol/mol [26], and thus a target of $<$ 58 mmol/mol may be inappropriate.

The recommended threshold for preoperative HbA_{1c} differs between studies, ranging between 53 and 75 mmol/mol [6, 26–30]. When investigating joint infections following total knee arthroplasty [31] and hip arthroplasty [29], Cancienne et al. calculated that a target HbA_{1c} of 64 or 58 mmol/mol, respectively, could be used. However, for both studies the authors suggested that HbA_{1c} had poor sensitivity as an independent predictor of infection.

There are data to suggest that those people who are hyperglycemic, but not previously known to have diabetes preoperatively, have poorer postoperative outcomes than those known to have diabetes [32–34]. These data suggest that for those who are at risk of developing hyperglycemia, pre-operative HbA_{1c} testing may be beneficial [35]. Those people who may benefit from preoperative testing of HbA_{1c} are listed in Table 5.

Table 5 People without diabetes who may benefit from having their pre-operative glycosylated hemoglobin concentration measured

Aged $>$ 40 years old ($>$ 30 years in people of South Asian origin)
Family history of diabetes
Personal history of gestational diabetes
Personal history of hypertension
Personal history of dyslipidemia
Personal history of prediabetes
Body mass index $>$ 25 kg m ² (23 kg m ² in those of South Asian origin)
Those on long-term glucocorticoid treatment

CONCLUSIONS

In summary, our data show that the majority (77%) of patients in our convenience sample of 1000 consecutive patients undergoing elective vascular and orthopedic surgery were able to achieve a target HbA_{1c} of < 69 mmol/mol. The current preoperative guidance is therefore achievable in a real-life setting. However, as is stated in the national guidance, this target should only be used where it is safe to do so and that a degree of clinical discretion is necessary.

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Compliance with Ethics Guidelines. The study was registered as a local clinical audit (registration code DIAB-17-18-08) and as such ethical approval was not required. The study was registered with Researchregistry.com, registration number 4756. This work has been reported in line with the STROCSS criteria [20].

Data Availability. The datasets during and/or analyzed during the current study are available from the corresponding author on reasonable request.

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