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Perioperative management of diabetes in elective patients: a region-wide audit†

M. J. Jackson[1,*], C. Patvardhan[1], F. Wallace[2], A. Martin[2], H. Yusuff[3], G. Briggs[4] and R. A. Malik[5,6] On Behalf of the NWRAG Peri-Op Diabetes Audit Group (www.NWRAG.com)

[1]Department of Anaesthesia and Intensive Care, Manchester Royal Infirmary, Oxford Road, Manchester M13 9WL, UK, [2]Department of Anaesthesia and Intensive Care, Royal Preston Hospital, Sharoe Green Lane, Preston PR2 9HT, UK, [3]Department of Anaesthesia and Intensive Care, Salford Royal NHS Foundation Trust, Stott Lane, Salford M6 8HD, [4]Department of Anaesthesia, University Hospital South Manchester, Southmoor Road, Manchester M23 9LT, UK, [5]Centre for Endocrinology and Diabetes, Institute of Human Development, Manchester Royal Infirmary and University of Manchester, Oxford Road, Manchester M13 9WL, UK, and [6]Weill Cornell Medical College, Education City, Qatar Foundation, Qatar

*Corresponding author. E-mail: m.j.jackson@doctors.org.uk

Abstract

Background: Ten percent of elective surgical patients have diabetes. These patients demonstrate excess perioperative morbidity and mortality. National guidance on the management of adults with diabetes undergoing surgery was published in 2011. We present a region-wide audit of adherence to this guidance across the North Western Deanery.

Methods: Local teams prospectively collected data according to a locally approved protocol. Pregnant, paediatric and non-elective patients were excluded from this audit. Patient characteristics, type of surgery and aspects of perioperative management were collated and centrally analysed against audit criteria based upon national recommendations.

Results: 247 patients with diabetes were identified. HbA1c was recorded in 71% of patients preoperatively; 9% of patients with an abnormal HbA1c were not known by, or referred to, the diabetes team. 17% of patients were admitted the evening preceding surgery. The mean fasting time was 12:20(4) h. Variable rate i.v. insulin infusions (VRIII) were not used when indicated in 11%. Only 8% of patients received the recommended substrate fluid, along with the VRIII (5% glucose in 0.45% saline). Intra-operative capillary blood glucose (CBG) was measured hourly in 56% of patients. Intra-operative CBG was within the acceptable range (4–12 mmol.L^{-1}) in 85% of patients. 73% of patients had a CBG measurement performed in recovery. The WHO checklist was used in 95% of patients.

Conclusions: National perioperative guidelines were not adhered to in a substantial proportion of patients with diabetes undergoing elective surgery. This study represents a template for future trainee networks.

Key words: anaesthesia; clinical audit; diabetes mellitus; perioperative care; surgical procedures, elective

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Editor's key points

- Diabetes is a common problem among surgical patients.
- Optimal perioperative management probably limits the increased perioperative morbidity and mortality associated with diabetes.
- The authors, part of a regional trainee network, audited compliance with current UK guidelines in 17 hospitals.
- Compliance with the guidelines was poor.

At least ten percent of patients undergoing elective surgery have diabetes.[1 2] These patients have complex medical needs and experience increased morbidity and mortality.[1] In a retrospective cohort study of 11 633 patients undergoing elective colorectal and bariatric surgery, perioperative hyperglycaemia was associated with a significantly increased risk of postoperative infection, re-operative interventions and death, whilst patients with preoperative hyperglycaemia who were commenced on insulin, had no significant increase in these complications.[3] In a meta-analysis of observational studies in patients with diabetes undergoing total hip replacement, there was an approximately two fold increase in the risk of established surgical site infection, urinary infection and lower respiratory tract infections.[4] National guidance, commissioned by NHS Diabetes and authored by the Joint British Diabetes Societies Inpatient Group, was published in 2011.[2] It adopts a comprehensive, multi-disciplinary approach, with the aim of improving management and outcomes in this high-risk cohort.

While many aspects of diabetes care are nationally audited each year, perioperative care has received less attention. In one study of 69 patients with diabetes undergoing both emergency and elective surgery, conducted before publication of the national guidelines, only 56.5% of patients were managed according to the local protocol for perioperative glycaemic control.[5] A recent retrospective review of 50 patients with diabetes undergoing knee arthroplasty, showed a lack of optimization of blood glucose control in relation to preoperative glycated haemoglobin (HbA1c) and perioperative blood glucose monitoring.[6]

We therefore undertook a prospective region-wide audit of the perioperative management of patients with diabetes undergoing elective surgery in the North West of England, over a two-week period. We believe the results of this audit will allow hospital trusts to benchmark local against regional practice and identify both deficiencies in current practice and lack of adherence to national guidance. This is the first region-wide project conducted by our group, North West Research and Audit Group (NWRAG); a secondary outcome is to validate the concept of trainee-led, region-wide projects in anaesthesia across our region.

Methods

The protocol and data collection sheets were registered with and approved by the local audit department at each participating hospital. Each anaesthetic department provided verbal consent to allow an assessment of their practice. The audit was advertised through local and regional e-mail lists, social media and posters in order to recruit local investigators (LI) and raise awareness amongst all anaesthetists in the region. Audit protocol and criteria were provided by e-mail on request.

All patients undergoing elective surgery at participating hospitals during the weekdays from 7th to 18th October 2013 were eligible for inclusion. Pregnant, paediatric and non-elective patients were excluded, as the national guidance is primarily intended for non-pregnant adults undergoing elective surgery.

The writing group reviewed the 22 principal recommendations in the national guidance. Recommendations that were measurable and related to individual patient care during the immediate perioperative period were chosen (Table 1). Additionally the following sub-recommendations were chosen: all patients should undergo preoperative assessment, a capillary blood glucose (CBG) should be checked before induction of anaesthesia and patients should be encouraged to return to normal eating and drinking at the earliest opportunity. The data collection sheet (Supplementary material, Appendix S1) was designed to include patient characteristics (age, sex, ASA status, surgical specialty, principal mode of anaesthesia, type of diabetes and disposal) and fields to assess the implementation of the chosen recommendations.

All theatre lists with potentially eligible patients were screened and discussed with the anaesthetizing anaesthetist. Theatres dedicated to trauma, emergency, paediatric and obstetric surgery were not screened. The LI made an initial visit at the beginning of each operation and collected patient characteristics and information regarding perioperative diabetes care on an anonymized paper form. The form was left with the anaesthetizing anaesthetist, who was asked to complete the form. The LI then re-visited the patient in the recovery area and completed

Table 1 Audited recommendations and data collected. VRIII, variable rate i.v. insulin infusion; AA, anaesthetizing anaesthetist; KCl, potassium chloride; CBG, Capillary blood glucose; WHO, world health organization

Recommendation
K4 - High-risk patients (poor glycaemic control/complications of diabetes) should be identified in surgical outpatients or at preoperative assessment and plans should be put in place to manage their risk
K6 - Routine overnight admission for preoperative management of diabetes should not be necessary.
K7 - Starvation time should be minimized by prioritizing patients on the operating list.
K16 - Patients with a planned short starvation period (no more than one missed meal in total) should be managed by modification of their usual diabetes medication, avoiding a VRIII wherever possible.
K17 - Patients expected to miss more than one meal should have a VRIII.
K18 - The recommended first choice substrate solution for a VRIII is 0.45% sodium chloride with 5% glucose and either 0.15% KCl or 0.3% KCl.
K20 - CBG concentrations should be monitored and recorded at least hourly during the procedure and in the immediate postoperative period.
K23 - The WHO surgical safety checklist bundle should be implemented. The target blood glucose should be 6–10 mmol.L^{-1} (acceptable range 4–12 mmol.L^{-1}).

any remaining data fields. All data was stored and transported securely. Each hospital team developed and piloted a local data collection plan to optimize capture.

Our data collection method was anticipated to produce incomplete data sets. Where the information for a specific data point was unavailable to the investigator because it had not been performed (such as a preoperative capillary blood glucose), the data collection sheet included a 'data unavailable field'. Where a data field was completely blank, it was assumed that the LI did not fill in the form completely. For each data type, means were derived using the total number of patients where complete data for that field was available.

From the raw data, the following calculations were made: BMI (weight divided by height squared); fasting time (anaesthesia start time minus time of last meal); whether the patient had at least one CBG measurement per h (procedure length minus one divided by number of CBG readings undertaken intra-operatively). Data are presented as percentage of total cohort or mean, standard deviation or median alongside interquartile range, where appropriate.

Results

Over the study period, 247 patients with diabetes were identified and included. The patients' clinical characteristics are summarized in Table 2 and the operative procedures undertaken are detailed in Table 3. Over a two-week period 85 doctors and two audit clerks in 17 hospitals were involved in the audit. As detailed in the methods section, some data fields were incomplete and therefore the denominators are the total number of patients for whom data were available.

87% (214/245) of patients were seen in the preoperative assessment clinic. A preoperative HbA1c was recorded in 71% (168/238) of patients. The mean HbA1c was 58.0(16.9) mmol. mol^{-1} [7.5 (3.7%)]. 20% (34/168) of patients who had had their

Table 2 Characteristics of study subjects. Values are given as mean (sd) or *n* (%)

	All Patients
n	247 (100%)
Age (yr)	64.4 (20–91)
BMI (Kg M^{-2})	31.1 (6.6)
Gender	
Male	134 (54%)
Female	113 (46%)
ASA class	
I	0 (0%)
II	125 (51%)
III	117 (47%)
IV	5 (2%)
Diabetes mellitus	
Type 1	32 (13%)
Type 2	215 (87%)
Primary mode of anaesthesia	
Sedation	8 (3%)
General	169 (68%)
Regional	30 (12%)
Neuraxial	40 (16%)
Discharge from recovery to	
Day case unit	104 (42%)
Ward	130 (53%)
Level 1–3	13 (5%)

Table 3 Operations by surgical specialty

Operations by surgical specialty	Number
Orthopaedic surgery	**76**
Total knee replacement	18
Total hip replacement	8
Arthroscopic shoulder surgery	8
Arthroscopic knee surgery	7
Cubital tunnel decompression	6
Revision total hip replacement	4
Shoulder arthroplasty	2
Dupytren's contracture surgery	2
Carpal tunnel decompression	2
Other	19
General surgery	**53**
Laparoscopic cholecystectomy	13
Hernia repair, inguinal	6
Hernia repair, other	8
Bowel resection, laparoscopic or open	7
EUA rectum / with or without other procedure	4
Reversal of ileostomy	3
Mastectomy and sentinel lymph node biopsy	3
Other breast procedure	4
Hepatic resection, laparoscopic or open	2
Other	3
Urology	**40**
Cystoscopy/ with or without biopsy	14
Transurethral resection of bladder tumour	6
Nephrectomy, laparoscopic or open	5
Transurethral resection of the prostate	5
Circumcision	3
Ureteroscopy and treatment of renal calculi	3
Other	4
Gynaecology	**20**
Hysteroscopy / with or without other procedure	10
Gynaecological laparotomy	4
Repair anterior vaginal prolapse	2
Vulval biopsy and excision lesion	2
Other	2
ENT	**16**
Endoscopy/with or without biopsy	**6**
Septoplasty	**2**
Resection of thyroid gland	**2**
Other	**6**
Ophthalmology	**12**
Phacoemulsification and intraocular lens implantation	9
Other	3
Vascular	**11**
Amputation toe	4
Carotid endarterectomy	3
Other	4
Maxillofacial	**7**
Dental extractions	4
Other	3
Other	**12**
Pain	**3**
Neurosurgery	**2**
Cardiology	**2**
Cardiothoracic surgery	**2**
Plastic surgery	**2**
Transplant and endocrine surgery	**1**

HbA1c recorded had an HbA1c greater than 69 mmol.mol^{-1} (8.5%); these operations continued as planned. 23% (52/230) of patients were already under the care of a diabetes specialist team, a further nine patients were referred as part of the pre-operative assessment process. 9% (14/164) of patients had an HbA1c greater than 69 mmol.mol^{-1} (8.5%) and were not under specialist diabetes care.

17% (42/243) of patients were admitted the evening preceding surgery. In the opinion of the anaesthetizing anaesthetist, 12/42 patients were admitted solely for optimizing glycaemic control. This small group of patients tended towards a higher preoperative HbA1c, than the study population as a whole [71.6(13.7)] mmol.mol^{-1} [8.7(3.4%)] compared with 58.0(16.9) mmol.mol^{-1} [7.5(3.7%)]. Pre-anaesthesia CBG was within the acceptable range in 75% of these patients. The mean age and range was 56.8(00.00) yr and distribution of ASA grades (41% ASA II, 58% ASA III) were similar to the study population as a whole. The reason for overnight admission before surgery was not recorded in the remaining 30 patients.

Data for the time of the last meal and start of anaesthesia was available in 222 patients and the mean fasting time was 12:20(4:00) h. 51% (124/244) of patients were undergoing surgery first on the operating list. Variable rate i.v. insulin infusion (VRIII) (previously 'sliding scale insulin') is intended to achieve and maintain normoglycaemia. It is recommended for patients missing at least two meals and in those with decompensated diabetes. In our study, VRIII was used in 39 patients; 27 of whom had a short starvation time. A VRIII was not used in 25 patients missing two or more meals; four, 13, and eight of these patients routinely use insulin, tablets or diet only to control their blood sugars, respectively. 0.45% sodium chloride and 5% glucose with either 0.15% or 0.3% potassium chloride is the substrate recommended by the national guidance to be used alongside a VRIII. The recommended substrate was used in only 3/39 patients prescribed a VRIII.

The WHO checklist was omitted in 5% (12/246) of patients. A CBG measurement was performed before induction of anaesthesia in 93% (226/243) of patients. CBG was in the acceptable range (4 to 12 mmol.L^{-1}) and ideal range (6 to 10 mmol.L^{-1}) in 89% (201) and 61% (137), respectively. Three patients had CBG less than 4 mmol.L^{-1} (range 3.4–3.9 mmol.L^{-1}) and 22 patients had CBG greater than 12 mmol.L^{-1} (mean 13.7 mmol.L^{-1}, range 12.1–16.9 mmol.L^{-1}).

The median length of operation was 1:15 h (interquartile range 0:40 to 2:15 h, n=225). Intra-operative CBG measurements were only available for 105/247 (43%) patients. During the operation, 50% of patients (53/105) were in the ideal range, 85% (89/105) were in the acceptable range. The lowest recorded intraoperative CBG was 2.7 mmol.L^{-1} and the highest was 20.1 mmol.L^{-1}.

In recovery 73% (165/226) of patients had CBG recorded. Postoperative values were within the acceptable range in 91% (150/165) and in the ideal range for 55% (91/165) of patients. Recorded CBG values in recovery ranged from 2.4 to 21.3 mmol.L^{-1}.

The majority of patients returned to normal food and diet in a timely manner, with 57% (135/238) eating within one h of the end of surgery and a further 36% (86/238) planning to eat the next meal. Only 7% (17/238) of patients did not eat the next meal, either because of a surgical decision or postoperative nausea or vomiting.

Discussion

To our knowledge, this is the largest published prospective audit of perioperative diabetes management. We have demonstrated that national perioperative recommendations for the management of patients with diabetes have been poorly implemented across the North West of England, which is in keeping with other published work.[5 6]

High preoperative HbA1c concentrations have been shown in several studies to be associated with increased postoperative complications.[7–11] However a recent systematic review found no definitive relationship between preoperative HbA1c and postoperative outcomes.[12] The authors of that review raised concerns regarding the quality of available studies; these were often retrospective, of small sample size and included patients from a wide range of surgical specialties. The concentration at which preoperative HbA1c was considered 'high' varied; many studies utilized the American Diabetes Association cut-off of 53 mmol.mol^{-1} (7%), which is derived from a non-surgical population.[13] One large retrospective study of 1775 patients undergoing major non-cardiac surgery found that an HbA1c greater than 64 mmol.mol^{-1} (8%) was associated with increased hospital length of stay.[14] The target of 69 mmol.mol^{-1} (8.5%) in current UK guidelines is pragmatic; it reflects the lack of evidence to support more aggressive preoperative glycaemic control and should be safely achievable in the majority of patients. A well-conducted large prospective study examining the association between preoperative HbA1c and postoperative outcome is required.

Despite the uncertainty it is nonetheless concerning that 28% of patients in our study did not have a preoperative HbA1c recorded. Most of the 'high-risk patients', as identified by a high HbA1c, were already under specialist care. Delaying elective surgery to optimize glycaemic control may reduce postoperative complications and is recommended by guidelines. There are a number of potential barriers to delaying surgery; these include the urgency of surgery, organizational factors, such as a lack of local protocols for referring patients from preoperative assessment clinic, and lack of awareness and understanding of current recommendations.

The Royal College of Nursing perioperative fasting guidelines recommend fasting times of six h for solids and two h for clear fluids in healthy adults.[15] The national guidance for perioperative management of adults with diabetes recommends minimizing starvation by organizing operative lists and avoiding modification of usual diabetes medication, when no more than one meal is missed. In our cohort, mean fasting time for solids was 12 h. Worryingly, many patients routinely fasted 10 to 16 h, resulting in more than one missed meal and the use of VRIII. There was also clearly considerable room to improve prioritization of patients with diabetes on operating lists; only 51% of patients were listed first. Minimizing interruptions to food and medication routines reduces the need for VRIII, improves perioperative glycaemic control and improves patient satisfaction.[16] Our data suggest management of fasting could be improved. While airway management mandates an awareness of absolute fasting time, optimal diabetes management and patient satisfaction requires a paradigm shift towards assessing and predicting the number of missed meals.

Some studies suggest that acute changes in blood glucose lead to oxidative stress, which contributes to macrovascular disease.[17 18] Other theoretical benefits of normoglycaemia include reduced endothelial dysfunction and improved immune function. The treatment of in-patient hyperglycaemia (defined as blood glucose greater than 12 mmol.L^{-1}) has been questioned recently, predominantly because of a lack of proven benefit, potential for significant hypoglycaemia and poor junior medical staff confidence in managing glycaemic control.[19] Nonetheless, studies have shown that even mild hyperglycaemia is associated with poor postoperative outcomes.[1] Our results demonstrate that most patients remained within the acceptable, though not the ideal, CBG range intra-operatively. We cannot comment on the

consequences of poor perioperative glycaemic control, as we did not collect outcome data.

The national guidance aims to reduce the use of VRIII where and when possible as a result of the frequent complications associated with this intervention. However, VRIII is sometimes necessary when other attempts to achieve glycaemic control have not been successful. Reduction in VRIII use can be achieved by identifying patients with good glycaemic control, minimizing fast times and adjusting usual anti-hyperglycaemic medication; this requires planning. In spite of a short predicted fasting time, 11% of patients receive a VRIII; it is unclear whether there were other indications for VRIII, such as poor long-term glycaemic control, or failure of alternative strategies to achieve glycaemic control. Nonetheless, given the long fasting time in our cohort, it is likely that a significant number of patients who were predicted to have a short fasting time, actually missed more than one meal. This might have contributed to the large proportion of patients with an intra-operative CBG outside the ideal range.

The national guidance is authored by diabetologists, anaesthetists and a diabetic specialist nurse, with input from surgical and patient safety representatives.[2] It has been endorsed by a number of medical and nursing groups including the Royal College of Anaesthetists and the Association of Surgeons of Great Britain and Ireland. The recommendations are based on the best available evidence, summarized in a non-systematic review by the guideline authors. Some recommendations are not measurable; this impacted upon which recommendations we chose to audit. Future editions must give greater consideration as to how well the guidelines are implemented to effect a change in practice; our findings highlight major deficiencies in adhering to these guidelines. This is particularly important given the increasing prevalence of diabetes, driven largely by the worldwide epidemic of type 2 diabetes, and the fact that patients with diabetes are more likely to undergo surgery than patients without diabetes.[1 20]

Regional trainee-led networks offer the opportunity to collect large data sets and to characterize the care given to specific patient sub-groups. Within surgical sub-specialties randomized controlled trials and national surveys of practice have been successfully published in high profile journals.[21 22] This project represents one of the first attempts by a group of anaesthetists in training to transfer this approach to perioperative medicine. Through this project, we provide a proof of concept within our own region. Future projects following this model would benefit from working in partnership with the guideline authors. Because our network covers approximately 10% of the acute NHS footprint, a successful project would be of considerable national interest.

Our audit was designed to be pragmatic and clinicians were not blinded to the presence of auditors; they assisted with data collection. This approach was chosen, as we wished to ensure all relevant patients were identified and all forms completed. Nonetheless, not all data forms were complete and it is likely we missed some eligible patients during the data collection period. This is a potential source of bias for our results and indeed it is possible that implementation of the recommendations is better or worse than we report. We did not collect reliable denominator data to calculate the incidence of diabetes in our elective surgical population.

Our audit differs from the traditional audit cycle and might be better described as a clinical survey. We do not make explicit recommendations and have not 'closed the audit loop'. Instead, each trust submitting data to this project have had the opportunity to review their results against the aggregate average of the region and consider local changes to practice. We chose this approach because we felt, as a group of trainees, it was unrealistic to implement a set of recommendations across a large region.

In conclusion, we have demonstrated that the national guidance for the management of patients with diabetes during the perioperative period, has been poorly implemented in adult patients undergoing elective surgery in our region. Our audit approach was pragmatic, providing a useful characterization of current practice from which future guidance might be developed. Trainee-led collaborative studies across multiple sites are an evolving concept in British anaesthesia and this study provides an early proof of concept for other groups to build upon.

Authors' contributions

Study design/planning: M.J.J., H.Y., R.M.
Study conduct: M.J.J., C.P., F.W., G.B., A.M.
Data analysis: M.J.J.
Writing paper: M.J.J., C.P., F.W., G.B., A.M., F.W.
Revising paper: all authors

Supplementary material

Supplementary material is available at *British Journal of Anaesthesia* online.

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Declaration of interest

M.J.J. and C.P. are the Vice-chair and Chair of NWRAG, respectively. F.W. and A.M. sit on the NWRAG executive committee. G.B. is acts as link person between NWRAG and the North West School of Anaesthesia.

References

1. Frisch A, Chandra P, Smiley D, *et al*. Prevalence and clinical outcome of hyperglycemia in the perioperative period in noncardiac surgery. *Diabetes Care* 2010; **33**: 1783–8

2. Dhatariya K, Levy N, Kilvert A, *et al*. *NHS Diabetes Guideline for the Perioperative Management of the Adult Patient with Diabetes*. Diabet. Med. London: Blackwell Publishing Ltd; 2012. pp. 420–33
3. Kwon S, Thompson R, Dellinger P, Yanez D, Farrohki E, Flum D. Importance of perioperative glycemic control in general surgery: a report from the Surgical Care and Outcomes Assessment Program. *Ann Surg* 2013; **257**: 8–14
4. Tsang S-TJ, Gaston P. Adverse peri-operative outcomes following elective total hip replacement in diabetes mellitus: a systematic review and meta-analysis of cohort studies. *Bone Joint J* 2013; **95-B**: 1474–9
5. McCavert M, Mone F, Dooher M, Brown R, O'Donnell ME. Peri-operative blood glucose management in general surgery - a potential element for improved diabetic patient outcomes - an observational cohort study. *Int J Surg* 2010; **8**: 494–8
6. Howieson AJ, Brunswicker A, Dhatariya K. A retrospective review of the assessment of current perioperative management of diabetes in patients undergoing knee replacement surgery. *JRSM Open* 2014; **5**: 2042533313515864
7. Walid MS, Newman BF, Yelverton JC, Nutter JP, Ajjan M, Robinson JS. Prevalence of previously unknown elevation of glycosylated hemoglobin in spine surgery patients and impact on length of stay and total cost. *J Hosp Med* 2010; **5**: E10–4
8. Gustafsson UO, Thorell A, Soop M, Ljungqvist O, Nygren J. Haemoglobin A1c as a predictor of postoperative hyperglycaemia and complications after major colorectal surgery. *Br J Surg* 2009; **96**: 1358–64
9. Weykamp C. HbA1c: a review of analytical and clinical aspects. *Ann Lab Med* 2013; **33**: 393–400
10. Marchant MH, Viens NA, Cook C, Vail TP, Bolognesi MP. The impact of glycemic control and diabetes mellitus on perioperative outcomes after total joint arthroplasty. *J Bone Joint Surg Am* 2009; **91**: 1621–9
11. Halkos ME, Lattouf OM, Puskas JD, *et al*. Elevated preoperative hemoglobin A1c level is associated with reduced long-term survival after coronary artery bypass surgery. *Ann Thorac Surg* 2008; **86**: 1431–7
12. Rollins KE, Varadhan KK, Dhatariya K, Lobo DN. Systematic review of the impact of HbA1c on outcomes following surgery in patients with diabetes mellitus. *Clin Nutr*. Advance Access published on March 17, 2015, doi: 10.1016/j.clnu.2015.03.007
13. American Diabetes Association. Standards of medical care in diabetes–2013. *Diabetes Care* 2013; **36**(Suppl 1): S11–66
14. Underwood P, Askari R, Hurwitz S, Chamarthi B, Garg R. Preoperative A1C and clinical outcomes in patients with diabetes undergoing major noncardiac surgical procedures. *Diabetes Care* 2014; **37**: 611–6
15. Royal College of Nursing. Perioperative fasting in adults and children: an RCN guideline for the multidisciplinary team. London: Royal College of Nursing; 2005.
16. Furrer L, Ganter MT, Klaghofer R, Zollinger A, Hofer CK. [Preoperative fasting times: patients' perspective]. *Anaesthesist* 2006; **55**: 643–9
17. Egi M, Bellomo R, Stachowski E, French CJ, Hart G. Variability of blood glucose concentration and short-term mortality in critically ill patients. *Anesthesiology* 2006; **105**: 244–52
18. Monnier L, Mas E, Ginet C, *et al*. Activation of oxidative stress by acute glucose fluctuations compared with sustained chronic hyperglycemia in patients with type 2 diabetes. *JAMA* 2006; **295**: 1681–7
19. Dhatariya K. Should inpatient hyperglycaemia be treated? *Br Med J* 2013; **346**: f134
20. Moghissi ES, Korytkowski MT, DiNardo M, *et al*. American Association of Clinical Endocrinologists and American Diabetes Association consensus statement on inpatient glycemic control. *Diabetes Care* 2009; **32**: 1119–31
21. National Surgical Research Collaborative. Multicentre observational study of performance variation in provision and outcome of emergency appendicectomy. *Br J Surg* 2013; **100**: 1240–52
22. Pinkney TD, Calvert M, Bartlett DC, *et al*. Impact of wound edge protection devices on surgical site infection after laparotomy: multicentre randomised controlled trial (ROSSINI Trial). *Br Med J* 2013; **347**: f4305

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