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Management of Diabetes Patients across the Peri-Operative Pathway: A Systematic Review

Jennifer Wallace, Shahwar Jiwani, Philemon Gyasi-Antwi, Andrew Meal, Gary G. Adams*

The University of Nottingham, Faculty of Medicine and Health Sciences, South Block Link, Queen's Medical Centre, Nottingham, NG7 2HA UK

***Corresponding Author:** Gary G. Adams, The University of Nottingham, Faculty of Medicine and Health Sciences, South Block Link, Queen's Medical Centre, Nottingham, NG7 2HA UK; **E-mail:** Gary.Adams@nottingham.ac.uk

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Abstract

Peri-operative environments are a hazardous setting for diabetes patients. A systematic review of literature regarding the management of diabetes patients across the peri-operative pathway has been undertaken to assess if the management of patients within this pathway is suitable and effective for patients.

Methods

A database search of Google Scholar, CINAHAL, Embase, OVID, Cochrane Library, Joanna Briggs institute and PUBMED was undertaken from 15th of March 2019 to 30th of March 2019. A total of 57 papers were found and reduced down to 11 final papers that answered the review question and met the inclusion and exclusion criteria. Inclusion criteria were: Full text, English language, human subjects, adult patients only and studies that focused on diabetes care in a section of the peri-operative pathway. Exclusion criteria: children or adults and children, studies that looked a one particular intervention or type of surgery. No date limit was set. PICO tool was used to frame the study question.

Results

Three main themes emerged from the literature. 1. Poor patient outcomes; 2. Longer length of stay (LOS); 3. Lack of adherence to guidance and or protocols and glycaemic control. Elective patients had advantageous outcomes compared to emergency surgical patients. Hyperglycaemia still remained a problem with an increase in other medical complications for diabetes patients. LOS in hospital was found to have increased due to medical complications. Adherence to protocols and guidance was found to be beneficial in monitoring and managing hyperglycaemia. However, this review found that best practice guidance and hospital protocol is not always adhered to. A liberal approach to glycaemic control is beneficial.

Conclusion

This systematic review investigated the management of diabetes patients across the peri-operative pathway. Three main themes emerged from the literature: poor patient outcomes; length of stay; and lack of adherence to guidance and or protocols and glycaemic control. We concluded the peri-operative environment is a hazardous setting for a diabetes patients. Elective patients had slightly more advantageous outcomes than emergency patients. Hyperglycaemia still remains a problem which leads to poor patient outcomes and longer LOS. Adherence to protocols and guidance was found to be beneficial in monitoring and managing hyperglycaemia.

Introduction

The Department of Health and Social Care (DOH) (2001) state that diabetes patients undergoing surgery carry a greater clinical risk than non-diabetes patients. This is due a number of complex factors such as reduced food intake due to a starvation period, and cessation of normal diabetes medications [1]. In addition, the body's stress response and inhibition of insulin secretion increases the potential for hyperglycaemia [2]. The Association of Anaesthetists of Great Britain and Ireland [3] state that diabetes affects 10–15% of the surgical population, with these patients carrying a greater risk of complication rates, mortality rates and Length of stay (LOS).

Despite these findings, there is very little guidance and research surrounding diabetes management across the peri-operative pathway. There are currently no standardised worldwide guidelines for use by theatre or PACU practitioners [4] and globally, diabetes management during the peri-operative period is widely debated [5]. The aim of this systematic review was to investigate the management of diabetes patients across the peri-operative pathway.

Methodology

A systematic and comprehensive search of databases was carried out between the 15th of March 2019 and the 30th of July 2019. The search involved Google Scholar, CINAHAL, Embase, OVID, Cochrane Library, Joanna Briggs institute and PUBMED. Combinations of key words were inputted into each database. Further restrictions were then applied to reduce the number of papers, such as; English language, full text and used adult human patients as the participants.

Studies which examined the care and management of diabetes patients across the peri-operative pathway were included. Studies into specific interventions or surgeries were excluded due to the broadness of the review question. Exclusion criteria: children participants and studies that looked a one particular intervention or type of surgery. No date limit was set.

This review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines to ensure systematic transparency of report [6]. After duplications were removed, 57 papers were read to determine their relevance to the review question.

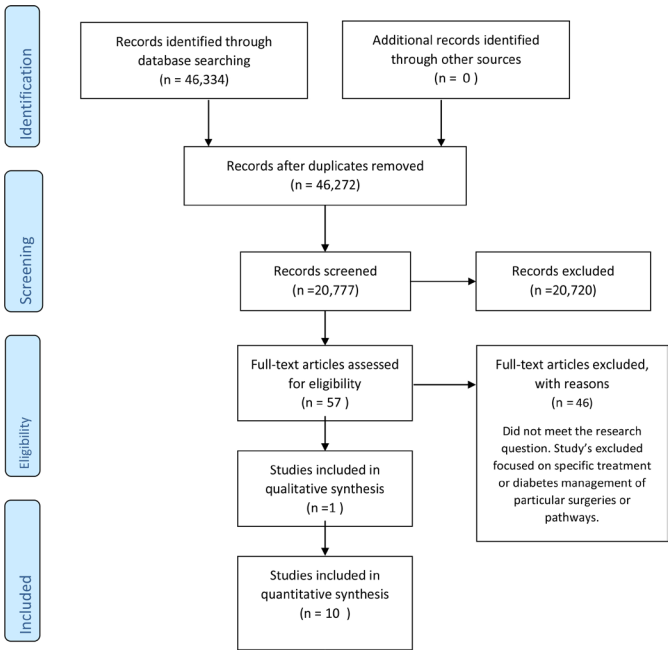

Figure 1. PRISMA flow diagram of Studies included in quantitative synthesis

The Cauldwell, Henshaw and Taylor (2011) framework was utilised for assessing the meaningfulness or generalisability of qualitative and quantitative research in contemporary nursing practice, which enabled a structured approach to the assessment of each study's quality, validity and reliability (Clarke, 2011). The final 11 papers were RAG (red amber green) rated [7] to reflect the answer to each of the questions from the tool. Dates ranged from 1983- 2019 and included studies from various countries. 9 of the 11 studies focused on the peri-operative period. 1 study focused on intra-operative and post-operative diabetes management. 1 study looks at diabetes management in the pre-operative period. Full text was then read to extract the results from each paper for the formation of themes.

Results and discussion

A systematic review as undertaken to establish the management of diabetes patients across the peri-operative pathway. Three key themes emerged from the review: poor patient outcomes, length of stay (LOS) which were commonly reported jointly and adherence to guidance and or protocols and standards for glycaemic control.

Poor patient outcomes

8 out of 11 studies reported on the outcomes of patients with diabetes. Studies 2, 3,5,6,8,9,10 and 11 discussed surgical outcomes directly related to diabetes management. McCavert, Monem and Dooher, et al [8] found that best practice of glycaemic control, in-line with hospital protocols, saw a 25.4% reduction of peri-operative complications. Overall complications being 29% (out of 69 patients). Elective patients with T2DM were more prone to complications. 5 out of 17 (29.4%) of T2DM elective patients experienced complications; in contrast, only 4 out of 21 (19.0%) of elective patients with T1DM developed a complication such as wound infection or peritonitis. For emergency patients, the rate of complications was slightly higher for those with T1DM (5 out of 14; 35.7%) versus 6 out of 17 patients (35.3%) with T2DM. Complications such as; Wound dehiscence, septicaemia, wound infection, wound infection, confusion, deep vein thrombosis and lower respiratory tract infection were reported as a complication. Frisch, Chandra, Smiley, et al [9] similarly analysed outcomes of mobility contrasting both diabetes and non-diabetes patients. Outcomes such as pneumonia (12.1 vs 5.4%; p=0.001), wound and skin infections (5 vs 2.3%; p<0.001), systematic blood infection (3.6 vs 1.1%; p<0.001), urinary tract infections (4.5vs 1.4%, p<0.001) acute myocardial infarction (2.6 vs 1.2 %; p< 0.001) were reported. Patients who experienced complications had a strong affiliation with high blood glucose levels pre and post-operatively.

"Haemoglobin A1c, often abbreviated as A1C, is a form of haemoglobin (a blood pigment that carries oxygen) that is bound to glucose" [10]. Underwood, Askari, Hurwitz et al [11] linked to various A1C categories to patient outcomes. It showed that, like McCavert et al and Frisch et al, [8, 9] diabetes patients (specifically group A1C ≤6.5%) had a higher incidence of LOS, acute renal failure death within 30 days and wound class (dirty). Groups ≤6.5%, A1C> 8-10% and A1C > 10% was significantly longer compared with the control subjects (p<0.001,p<0.008, and p=0.002, respectively).

Wang, Chen, Li, et al (2019) found that patients over 65-years old, male, high mean post-operative blood glucose (BG), diabetes complications, abnormal kidney function and have underwent general surgery were the highest risk category for poor patient outcomes. The study compared surgery type and patient outcomes. Of the 301 (19.8%) of all patients with diabetes complications, 295, (98.0%) had major vascular complications, 8 (27. %) had diabetes nephropathy, 3 (0.7%) had diabetes retinopathy, 5 (1.7%) had diabetes foot post-operatively. Post-operative adverse events occurred in 118 (7.7%) including 43 (36.4%) delayed extubation caused by surgery-related respiratory failure or muscle weakness. 15 (12.7%) patients had circulatory disorders, 23 (19.5%) had respiratory and circulatory abnormalities. 11 (9.3%) had non-healing of the incision. 15 (12.7%) had infections at other sites. 8 (6.8%) patients with other complications. 3 (2.5%) patients died due to pulmonary embolism and two cases of septic shock. Kotgal, Symods, Hirsch, lrl, et al [12] did not correlate BG management with patient outcomes, but results showed that patients had a greater chance of poorer outcomes with any level of hyperglycaemia versus those who had better diabetes control.

In contrast, Sathya, Davis, Taveria, et al [13] found that stroke, atrial fibrillation and wound infection were the most significant complications from pooled results of 6 studies. Mixed results were noted; 2 pooled results found that the incidence of post-operative stroke was reduced by liberal glycaemic regimes, but pooled results from a further 3 studies suggested that there was no significant difference between the effect of moderate vs strict control on stroke outcomes (odds ratio, 18.5, 95% CI 0.72-4.74, p=0.020). Sathya et al [13] also examined the relationship between atrial fibrillation as a patient outcome and diabetes control. Again, pooled estimates from 2 pooled studies found that moderate versus liberal control had no direct effect on atrial fibrillation as an outcome (Odds ratio 0.54, 95% CI 0.17-1.76, p =0.31). In addition, pooled results from 3 other studies found that there was no significant difference between strict versus moderate control in relation to atrial fibrillation (odds ratio: 0.71, 95% CI0.39-1.30, p=0.27). Wound infection was also not found to have a significant link to the effects of moderate versus glycaemic control from the results of 2 pooled studies.

Length of stay

LOS was a significant finding in studies 2, 3, 6 and 8. Although not a complication in itself, LOS was linked to or reported alongside poor patient outcomes.

McCavert et al [8] found that Emergency patients had a significantly longer LOS in hospital than the elective groups. Frisch et al (2010) [9] also reports that diabetes patients had a higher rate of complications than non-diabetes counterparts (p=0.105). Patients with diabetes were found to have a greater LOS (and LOS in ICU) than non- diabetes patients. It was also noted that African American patients were not at an increased risk of mortality than other races. No other study compared likelihood of surgical outcomes and race.

Patients with diabetes were also more likely to have greater complications including LOS. Underwood et al, 2014 [11] however, reported that patients with A1C levels >6.5-8% had a similar LOS to the control group. Patients with higher A1C ≤6.5 up to greater than 10% had a significantly longer LOS compared to control subjects. This was the most significant difference of the various A1C groups compared in the study. Higher A1C level was more significant than any other variable such as a diabetes patient's race, gender or type of surgery in relation to LOS. Longer LOS in the hospital was found by Hommel et al [14] to be associated with higher dissatisfaction of patients regarding patient centred-ness in their assessment of results.

Lack of adherence to guidance and or protocols and glycaemic control

The third key theme that emerged from the literature was adherence to guidance, such as hospital protocols and national guidelines and glycaemic control. This theme was disused in studies 1,2,5,7 and 10.

McCavert et al [8] studied both elective and emergency surgical patients. 60% of elective patients with T1DM were not treated according to hospital protocol. Elective patients who were treated according to protocol had a complication rate of 6.3 %. For emergency surgical patients, 7.3% of T1DM patients who were treated as per protocol developed a complication. 12.3% of scheduled blood glucose measurement were not completed. 11.1% of T1DM elective patients did not have their blood glucose checked, and 6.8% of emergency T1DM patients. For T2DM, blood glucose was not checked in 17.4% of elective patients and 12.7% in emergency cases.

Similarly, Coan, Schlinkert, Brandon et al [15] note that capillary BG was taken in 89% of cases in the pre-operative area, and only52% of patients had a HBA1C. Intra-operatively, 33% of patients had a BG check, and the post- operative figure was 87%. 90% of pre-operative BG was point of care (POC), and 4% was venous sampling. Intraoperatively, 10% of patients had POC BG values, 16% had POC blood gas sampling. In the PACU, 86% of BG were obtained by POC and 1% was venous. Similarly, Jackson, Patvardhan et al (2015) reported that only 71% of patients had a HBA1C recorded pre-operatively and 56% intra-operatively via CBG. 73% of patients had a CBG performed in recovery (PACU) contrary to national guidance. Hommel, Van Gurp, Tack et al's [16] quality indicators suggest that best-practice involved measuring BG 4 hours pre-operatively, every 2 hours intra-operatively, and 1 hour post-operatively. Hommel et al [14] reported that in relation to patient satisfaction and person centeredness, 20% of 362 patients were not informed about intra-operative BG level and its effect. 15% were also not informed that insulin was administered during surgery. This correlated to overall low score from patients' involvement in the survey. Sathya et al [13] report that patients undergoing a liberal target for glycaemic control had significantly better post-operative outcomes (less or no complications) than other groups. No difference with wound infection or atrial fibrillation were found. Bibble (1983) commented from the 3 case studies that protocols for glycaemic control were directed towards managing 'average' diabetes patients rather than complex ones, making guidance non-beneficial.

Future recommendations would be to undertake extensive quantitative and qualitative research across the peri-operative pathway with staff who have direct responsibility for diabetes patients undergoing surgery. The views and attitudes of staff members regarding diabetes management may shed light on the barriers as to why this is still a problem despite being highlighted by several studies seen in this review since 1983. Any further research conducted needs to be influential on practice in order to drive change.

Conclusion

This systematic review examined the management of diabetes patients across the peri-operative pathway. Three main themes emerged: poor patient outcomes; longer length of stay; and lack of adherence to guidance and or protocols and glycaemic control. We concluded the peri-operative environment can be a hazardous setting for diabetes patients. Elective patients had slightly more advantageous outcomes than emergency patients. Hyperglycaemia still remains a problem which leads to poor patient outcomes and longer LOS. Adherence to protocols and guidance was found to be beneficial in monitoring and managing hyperglycaemia.

Table 1. Characteristics of studies

Study No	Title	Author/s	Year	Type of study	Participants	Location/ setting	Findings/results/statistics
1.	Perioperative control of diabetes mellitus – revisited	Bibble C.J Hernandez, S	1983	Case reports	3 case studies of diabetes patients undergoing surgery. Adult patients.	America theatre setting - Maryland	Case 1 arrived to the operating room confused distressed and complaining of a headache. The morning of surgery she was given 5 units of regular insulin and 5 % dextrose in physiolic saline. Blood glucose of the patient was 66mg/ dl. The patient experienced 'wide swings' in blood glucose levels intraoperative and postoperatively. Case 2 have 75-year-old male with Multisystem disease such as heart failure. His normal regime was 15 units in the morning and 15 units in the evening. 10 units was given subcutaneously to the patient on the morning of surgery. Blood glucose was 58mg/dl. Intervention raise the blood glucose to 211mg/dl. The patient experienced wide ranges of blood glucose for the next 8 days. Case was a 39-year-old male with juvenile onset diabetes of 19 years. The patient had a strict diet and 15-25 units of lente insulin every morning. The morning of surgery 10 units of insulin was given subcutaneously and intravenous dextrose 5% in lactated ringers solution was started at 155 cc per hour. The patient didn't arrive to the operating room until 4 hours later with a blood glucose level of 420mg/dl. All patients experienced wide swings in glucose levels which could have been avoided.
2.	Peri-operative blood glucose management in general surgery – a potential element for improved diabetes patient outcomes- an observational cohort study	McCavert , M., Monem, F., Dooher, M ., Brown, R and O'Donnell, M.E.	2010	Observational cohort study. Data collected was regarding blood glucose measurements, adherence to the protocol and complications following surgery.	69 patients. Males=44. Females=25. Median ages 61. 35= type 1. 34=type 2. 38 underwent elective surgery, 31 underwent emergency surgery. Elective males =29, females, 9, emergencies, males=15 and females =16.	Daisy hill hospital 271 bed DGH located in Newry City Northern Ireland.	10.3% of CBG capillary blood glucose readings. were less than 6.1mmol\l, 32.8% were between 6.1mmol and 10.0mmol/l, 44.6% were greater than 10.0mmol/l . 12.3% of scheduled blood glucose measurements were not completed. Insulin dextrose infusion was indicated in 30 patients. Of which 24 (46.7%) were treated according to protocol. In 16 protocol deviated cases, insulin was administered as a sliding scale, 6 patients. 14 35.9% were inappropriately given insulin. Only 39 (56.5% of patients) were treated as per protocol. Overall complication rate was 29.4% which included 7 out of 39% 17.6% and 13 out of the 30 43.3% protocol based and protocol deviation patients retrospectively. P=0.45. Comparisions of blood glucose level at different time points. 6 am day 0= 93%, 6pm day 0 88.3%, 6am day 1 85.7%, 6am day 2 80.6%. At each time point the proportion of total admitted patients that had blood glucose BG, 6.0 mmol/l was 6am day 0=12.3% 6pm day 0= 10%, 6am day 1 =10.7% , 6am day 2 6.4% between 6 and 10 mmol/l was 6am day 0 =33.3% , 6pm day 0= 30% 6am day 1 = 30.4%, 6am day 2 =41.9% and >10mmol/l was; 6am day=0 47.4% , 6pm day 0 =48.3% 6am day 1 =44.6% 6am D2=32.3%.

Study No	Title	Author/s	Year	Type of study	Participants	Location/ setting	Findings/results/statistics
							A GILK infusion was indicated in 30 patients (43.5%) according to hospital – based protocol (elective T1DM = 14, elective T2DM=3, emergency T1DM=6, emergency T2DM =7). 14 (46.7%) of these patients had a GIK infusion erected during the peri-operative period (elective T1DM =3, emergency T2DM =0). 6 of the 16 patients who did not receive GIK infusion according to protocol were managed with an insulin sliding scale. one of the remaining patients was treated with a peri-operative bolus of insulin. No specific stagey followed up the other 9 patients. 25.4% reduction of peri-operative complications overall complications being 29% (out of 69 patients). Elective patients with T2DM were more prone to complications. 5 out of 17 (29.4%) of T2DM elective patients experienced complications; in contrast, only 4 out of 21 (19.0%) of elective patients with T1DM developed a complication such as wound infection or peritonitis. For emergency patients, the rate of complications was slightly higher for those with T1DM (5 out of 14; 35.7%) versus 6 out of 17 patients (35.3%) with T2DM.
3.	Prevalence and clinical outcome of hyperglycaemia in the perioperative period in non-cardiac surgery	Frisch, A., Chandra, P., Smiley , D., Peng, L., Rizzo, M.,Gatcliffe,C., Hudson,M., Mendoza, J., Johnson,R., Lin,E and Umpierrez, G.E.	2010	Observational study regarding pre and post glucose levels and the hospital length of stay, complications and mortality in 3,184 noncardiac surgery patients.	3,184. 53.8% female and 46.2%. Mean age ±SD age 56.5±16nyears and BMI 27.6 ±7.3kg/m^2	Emory University Hospital Atlanta Georgia.	Data collected from 1st of Jan 2007 to the 30th of June 2007. Patients were split into diabetess and non-diabetess. 643 (20.2%) patients has a known history of diabetes. Patients with diabetes compared to patients without diabetes (61.2±13.2 vs 55.4 ±15.9 years <0.001), had had higher BMI (29.6 ±7.8 vs. 26.8± 6.9 kg/m^2 p<0.001), were more likely to be male, (52.1 vs 44.8%; p<0.001), were of minority ethnic groups (African Americans 28.8 vs 21.4%;p<0.001), and were more likely to undergo high-risk surgical procedures (8.9 vs 6%; p<0.012). Blood glucose BG for the cohort was 120 ±38 mg/dl. Non diabetes patients had a lower pre-surgery blood glucose BG levels (113±28mg/l) than patients with diabetes (145 ± 51 mg/l; p<0.001). BG level on the first day after surgery was 155±42 mg/l in diabetes patients and 132± 28mg/dl) both results were higher that reported during subsequent hospital stays; (139±34 and 115± 21mg/dl p<0.001). Post-surgery 40% of patients had mean blood glucose >140mg/dl. Three fourths of these had mean BG between 141 and 180mg/dl, the other had >180 mg/dl. The study defined clinically significant hyperglycaemia as >180mg/dl. 7.9% had this before surgery, 17.2% had this on the day of surgery and in 9.9% during the post-operative period.

Study No	Title	Author/s	Year	Type of study	Participants	Location/ setting	Findings/results/statistics
							For non-diabetes's mortality rate was 2.3% (72 of 3112). 3.1% for diabetess and 2.1% for non-diabetess. Did not reach statistical significance (p=0.0105). Diabetes patients had higher rate of complications including pneumonia (12.1 vs 5.4%; p=0.001). Wound and skin infections, (5 vs 2.3%; p=0.001), systematic blood infections (3.6 vs 1.1%;p=0.001), urinary tract infections (4.5 vs1.4% ;p<0.001), acute myocardial infarction (2.6 vs 1.2%;p=0.008) and ARF (9.6 vs 4.8%; p=0.001). Diabetess had a higher length of stay and ITU length of stay than non-diabetes subjects (8.8± 10.6 vs 7±10.8 days; p=0.001 and 2.3± 6.2 vs 1.8 ±6.5 days; p<0.01). Multi variant adjustment was made for age, sex, race and surgery severity showed that preoperative glucose can be a predictor of mortality with marginal significance (p=0.063) and likewise post-operative blood concentration (p=0.087). African American patients did not have an increased risk of morbidity (p=0.96) but they were more likely to develop pneumonia (p=0.0075) and ARF (p=0.0158) than non- African-Americans. No significant different between racial groups after surgery. Patients who died had a significantly higher blood glucose before surgery (133.4± 40.9 vs 119.9 ±37.7mg/dl;p=0.002) and after surgery (126.6± 23.7vs 119.7±26.6 mg/dl; p<0.001). Majority were men (p<0.001) they had longer hospital day (18±24vs 7±10 days; p<0.001) and had higher rates of ARF (30.6 vs 5.2%; p<0.001) and bacteraemia/ sepsis (16.7 vs 2.2%; p<0.01).
4.	Intensity of peri-operative glycaemic control and postoperative outcomes in patients with diabetes: a meta-analysis.	Sathya, B., Davis, R., Taveria, T., Whitlach,H and Wu, W.C.	2013	Meta – Analysis relating to the role of specific glycaemic targets of diabetes patients relating postoperative outcomes. A systematic review was performed by two authors.	0 participants.	Not stated. USA stated as the authors places of work.	Literature searches yielded 754 citations. 681 were excluded based on a review of their abstracts and 3 studies were added from screening of reference lists of papers. 76 underwent full text review with 42 being excluded due to absence of a control group. 15 were excluded due to lack of outcome data. 9 excluded due to absence of post-operative adverse event data. 6 studies were included in the meta-analysis. One was a non-randomized prospective study of 200 patients, three were randomized trials of 423 patients. Five out of six studies included exclusively patients with diabetes. One study had patients with diagnosed diabetes and undiagnosed diabetes who mainly met criteria for having diabetes. Glycaemic targets varied between trials. Four trails compared liberal vs moderate glycaemic control.

Study No	Title	Author/s	Year	Type of study	Participants	Location/ setting	Findings/results/statistics
							150 deaths occurred. 74 in the liberal control group and 69 in the moderate control group. 7 in the strict control group. Pooled results suggested that a moderate glycaemic control strategy was linked with significant reduction in mortality vs a liberal control. (odds ratio =0.48, 95% CI 0.24-0.76, p=0.004). Heterogeneity found in the pooled estimates (I^2=20.7%, p=0.29). Beggs test publication bias (p=0.01). Pooled results did not show significant difference between moderate vs strict glycaemic control (odds ratio =0.94, 95% CI: 0. 40-2.19, p=0.88)2 studies compared moderate vs liberal with significant reduction in the incidence of stroke (odd ratio 0.61, 95% CI 0.38-0.98, p=0.04). Without significant heterogeneity (I^2=0% p=0.68). Pooled results from 3 studies showed no significant difference between the effect of moderate vs strict glycaemic control (odds ratio 1.85, 95% CI 0.72-4.74, p=0.20). Poole estimates from two studies moderate vs liberal control did no show a relationship between atrial fibrillation, glycaemic control was not significant (odds ratio 0.54 95%CI 0.17-1.76, p=0.31). 3 studies that compared strict vs moderate glycaemic control also did not find a significant difference on incidence on atrial fibrillation (odds ratio 0.71, 95% CI 0.39-1.30, p=0.27). Relationship between glycaemic control wound infection was not a significant throughout, odds ratio was 0.25 (95% CI 0.01-5.20, p=0.37) for the moderate vs liberal control from 2 studies and 0.52 (95% CI 0.01-31.1, p=0.75) for the strict vs moderate from three studies.
5.	Peri operative management of patients with diabetes undergoing ambulatory elective surgery	Coan, KE., Schlinkert A.B., Brandon .R.B., Haakinson D.J Castro J.C Schlinkert , R.T and Cook, C.B	2013	Retrospective study. A review of medical records.	268 patients who had type 2 diabetes. Mean ages were 67. Most were obese. Had been diagnosed with diabetes. Used different regimes for glycaemic control pre-op. Adult patients.	USA? American hospital – not well described	268 patients who underwent 287 elective procedures 17 patients had two procedures? what for. 1 patient had 3. Pre-op evaluations were conducted in 192/68%. Hba1c was obtained in only 52% n=149 36%of values were 7.0%. and 21 (14%) were 8.0%. patients taking oral medication plus insulin had a significantly higher HbA1C versus patients on diet therapy alone, oral agents or insulin, alone. No differences in HbA1c among the latter mentioned patients. Most cases had an American societies of anaesthesiologist's physical status of 3. After 219 of 217 / 76% surgical procedures patients required admission. Mean pre-operative HbA1c was 7.0%however this was only obtained in 52% of the 287 cases with the average interval 18 days prior to surgery.

Study No	Title	Author/s	Year	Type of study	Participants	Location/ setting	Findings/results/statistics
6.	Preoperative A1C and clinical outcomes in patients with diabetes undergoing major non cardiac procedures.	Underwood, P., Askari,R.,Hurwitz, S., Chamarthi, B and Garg, R.	2014	Retrospective study. Data was obtained from the national surgical quality improvement group NSQIP. Which included preoperative, intraoperative and postoperative variables in randomly selected same of patients (20% of all surgery in the institute). compared outcomes in five categories: heathy individuals, diabetes with A1C >6.5-8%, diabetes with A1C> 8-10% and diabetes with A1C >10%.	2,395 surgeries performed on 1775 patients with diabetes. Adult patients undergoing general, gastrointestinal, endocrine, thoracic, oncologic and vascular surgery. Diabetes patients with an A1C 90 days before surgery were included. A non-diabetes control group admitted to the hospital during the same time period and matched for age (± years in the following groups; 18-24, 25-34, 35-44, 45-54,55-64,65-74 and 7, sex, BMI (<18, ≥18 and <25, ≥25-30, and >30kg/m^2.	Brigham women's institute Boston Massachusetts, USA.	LOS was a primary outcome. 622 (35%) of patients had a A1C available 90days before surgery. Distribution of patients with missing A1C was equal across the racial groups. Among Caucasians 73% had missing A1C values. 449 were included in the final analysis. Patients with diabetes were more likely to be non-white smokers who underwent vascular surgery more often than subjects in the control group. Patients with diabetes has significantly higher surgical complications such as death, infections and LOS. Patients with diabetes had a significantly higher hospital stay ($p<0.0001$) even after adjustments for age, sex, BMI, race, smoking status, type of surgery (vascular vs general). CCI and glucose level on the day of surgery. A1c levels >6.5-8% had LOS similar to the control group ($p=0.5$). however LOS in patients with A1C levels ≤6.5%, A1C> 8-10% and A1C > 10% was significantly longer compared with the control subjects ($p<0.001$,$p<0.008$, and $p=0.002$, respectively).compared with individuals with A1C levels ≤6.5 and > 8% (combined group of A1C >8-10% and A1C > 10%) were associated with significantly longer LOS compared with control subjects in the A1C group > 6.5-8 % after accounting or multiple testing. There were no significant different among other surgical outcomes- 5 previously mentioned criteria. After removing high risk individuals with A1C levels ≤6.5%, univariate regression analysis demonstrates that higher A1C values in patients with diabetes are associated with increased LOS. This relationship remained significant even after removing adjustments for other previously mentions patient characteristics, which remained significant even after removing patients who died during the hospitalisation period.

Study No	Title	Author/s	Year	Type of study	Participants	Location/ setting	Findings/results/statistics
7.	Perioperative diabetes care: development and validation of quality indicators throughout the entire hospital pathway	Hommel , I ., Van Gurp, P.J., Tack, C.J., Wollersheim, H and Hulscher, M E.J.L .	2015	Literature-based modified Delphi method . A set of quality indicators were created to assess peri-operative diabetes care.	A practice test took place in 6 Dutch hospitals using a sample of 389 major surgery patients with diabetes who had undergone abdominal (32%), cardiac (29%) or large joint orthopaedic surgery (39%). 62% of these patients were women, 38% men. The panel creating the quality indictors were 35 experts on peri-operative diabetes care 6 anaesthesiologists/ internists with an interest in diabetes care, 5 ITU specialists, and 4 surgeons.	6 Dutch hospitals Netherlands between may 2009 and November 2009.	Likert rating scale ranging from 1- 9, not relevant - relevant. An answer of cannot assess was made available. An indicator was considered unmeasurable if > 25% of patents individual l indicators score could not be computed because of missing data. Quality indicators were selected according to their relevance , median scores of 7,8 and 9 if there was no disagreement 30%or more ratings in both the 1-3 and 7-9 tertiles. 1100 patients with diabetes who underwent major surgery were identified. Practice test was under taken with the finial 36 quality indicators on a sample of 389 patients. Clinometric properties for the outcome's indicators Please see table 1 and 2 in study. Measurability - >25% of scores were missing at he time of data extraction. Applicability As hypoglycaemia rarely occurred, the indicator intravenous glucose ordered for pasting patients was inapplicable. Reliability The indicators blood glucose measurement every 4-6 ours ordered for fasting patients had a kappa of 5.1, which indicted moderate interobserver reliability. In other indicators kappa scores of >0.6 considered. Improvement potential the potential for improvement as low for four process indicators and one outcome indicator. Case-mix stability was assess for 12 indicators that had good climetric properties (1, 4, 8, 9, 11, 15, 16, 18, 21-23, 26) . All these needed correction for case-mix. The indicators blood glucose every 2 hours during surgery was influenced by gender.

Study No	Title	Author/s	Year	Type of study	Participants	Location/ setting	Findings/results/statistics
8.	Peri-operative diabetes care: room for improving person centredness.	Hommel, I., Van Gurp, P.J., tack, C.J., Liefers, J. .,Mulder , J., Wollersheim, H. and Hulscher , M.E.J.L.	2014	Survey. Survey related to 7 dimensions of person centeredness in diabetes care Information, patient involvement, communication and education, coordination, access to care, transition, physical comfort and continuity.	298 out of 690 participants with diabetes who underwent major abdominal, cardiac or large –joint orthopaedic surgery. Adult patients. Male female split not stated. Ethnicity of participants not mentioned.	6 Dutch hospitals, Netherlands	Complete data was 298 of 690 participants. 362 returned a completed questionnaire. 24 did not completed an informed consent form and were therefore excluded. 17 medical records showed that criteria were not met and were excluded. 23 were excluded because full data was not available. 65% of participants had reported care as described for each item. The scores form the dimensions 'access to care' varied from 52% to 92%. 52% of participants had the opportunity to contact his/her internist. Overall scores for 'information' were low- 13 of 16 items had scores of below 65%. Preoperatively few patients received information 31% and information about target BG. Post operatively few patients were told about their intraoperative BG and insulin administered 20% and 15%. Patient involvement was also low. 7 of 11 scores were less than 65%. Scores for communication and education were higher than 85%. Physical comfort had scores under and over 65%. Overall scores for co-ordination and integration of care were low. 5 out of 8 items had scores below 65%. 13% did not know who their caregiver was in charge of their diabetes treatment. Or who to contact during their stay 17%. Transition and continuity varied from 42% to 92%. 49% indicated their G.P knew about their diabetes treatment when they were discharged. Variation between hospitals was not significant a range of less than 20% was noted. Insulin treatment prior to hospital admission was associated with higher mean scores for the dimensions of patient's involvement ($p<0.001$) and co-ordination ($p<0.005$). Older participants had lower mean scores for the dimensions of information ($p=0.002$) and co-ordination ($p=0.012$). these patients who were also treated with oral hypoglycaemic agents or diet prior to hospital admission had the lowest scores for information ($p=0.023$). Longer hospital stay was associated with higher scores for coordination ($p=0.003$).

Study No	Title	Author/s	Year	Type of study	Participants	Location/ setting	Findings/results/statistics
9.	Peri-operative hyper glycemia and risk of adverse events among patients with and without diabetes	Kotgal, M ., Symods, RG , Hirsch, lrl, B , Guillermo.E., Umpierrez.,Patchen Dellinger , E., Farrokhi, E.t., Flum. D.R.	2015	Cohort study 2010-2012	40,836 patients with a mean age of 54 years. 53.6% females. 19% had diabetes. Adult patients.	53 hospitals in Washington state USA	19% of the cohort had diabetes :47% underwent peri-operative blood glucose test. Of those with diabetes melitus (DM)18% had perioperative hyperglycaemia 40% of DM patients and 6% of NDM. 18% had a BG of 180mgdl and above. Diabetes patients had a higher rate of events 12% compared to those non diabetes melitus patients (NDM). NDM those with hyperglycaemia had an increased risk of adverse events compared with those who has a normal BG. There was a dose response relationship found with B.G and adverse events. NDM were less likely to receive insulin at each level p<0.001. All patients who had peri-operative hyperglycaemia and received insulin, those who had persistent hyperglycaemia had significantly higher adverse event rates than those whose BG was corrected 40.3%vs 25.6% for NDM 17.5% vs 8.3% for DM patients. DM patients had a higher composite adverse event rate than NDM. 12.0%vs 8.9%, p<0.0001. Patients who underwent BG testing had no difference in the rate of adverse events between DM and NDM 12.6%VS 12.1% p+0.26. Those with adverse events of hyperglycaemia DM Patients did not have increased odd of adverse vents odds ratio OR =0.76% (95% confidence interval, CI) 0.57-1.0,p+0.06) for BG 125mg/dl and or =0.94(95% CI 0.72-1.2 ;=0.65) FOR BG >_ 180mg/dL in an unadjusted analysis . DM patients with BG between 125 and 180 mg/dL were found to have decreased odds of adverse event (OR =0.66 (95% CI = 49-0.91) when compared with the reference group. BG <_BG<125mg/dl. Patients with a BG level more than 180mg/dL, had no significant difference in odds of adverse event (OR =0.78(95%CI =0.58-104) whence compared with the reference group. NDM patients with hyperglycaemia had significant higher odds of a composite adverse event (OR =2.4(95% CI, 1,9-3.0) for BG 125-180 mg/dL OR = 5.1 (95% CI, 3.8-6.9) for BG >_180mg/dL; p<0.001 for both. If hyperglycaemia persisted, with a. dose response relationship between the level of hyperglycaemia and the odds o a composite adverse event (OR =1.26(95%CI. 1.08-1.47 for BG 125- 180mg/dL.

Study No	Title	Author/s	Year	Type of study	Participants	Location/ setting	Findings/results/statistics
10.	Perioperative management of diabetes in elective patients: a region-wide audit.	Jackson, M.J ., Patvardhan, C., Wallace, F., Martin, A., Yusuff, H., Briggs, G and Mailk , R.A.	2015	Region wide audit of adherence guidance across the north west of England.	247 patients with diabetes. Adult patients. Elective surgery patients only. No Pregnant patients. Mean ages was 56.8 (00.00) yrs. ASA grades (41%ASA II, 5.8% ASA III).	North West of England.	HbA1c was recorded in 71% of patients preoperatively 168/238. 87% (214/247) were seen in a preoperative assessment clinic. The mean HbA1c was 50.8 (16.9) mmol. 7.5 (3.7%). 20% (34/168) of patients who had their HbA1c greater than 69mmol (8.5%) these operations continued as planned.23% (52/230) were under the care of the diabetes specialist team. 14/164 had a HbA1c > 69mmol/l. 8.5% were not under specialist diabetes care. 9% of patients with abnormal HbA1c were not known by or referred to by the diabetes team. 17% (42/243) of patients were admitted the evening prior to surgery for glycaemic control. They tended to have higher pre-operative HbA1c. [71.6 (13.7)]mmol.mol . [8.7(3.4%)] compared with 58.0 (16.9)mmol. mol 7.5 (3.7%). Pre anaesthesia CBG was in an acceptable range for 75% of those patients. CBG measurement was performed before induction in 93% (22/243) patients. CBG was in the acceptable range of (4 to 12 mmol) in 89% (201) and 61% (137). 3 patients had a CB > 4mmol. 22 had a CB <12mmol (mean 13.7 mmol, range 12.1mmol -16.9mmol). Mean fasting time for patients was 12:20(4) h. data was only available in 222 of these patients. 51% (124/244) were first on the list. Variable rate I.V insulin infusions (VRIII) were not indicated in 11%. 8% of patients received the recommend substrate fluid along with VR (5% glucose and 0.45% saline) Intraoperative CBG was measured hourly in 56%. Intraoperative CBG was within an acceptable range (4-12mmol/l) in 85% of patients. A VRIII was used in 39 patients; 27 who had short starvation period. A VRIII was not used in 25 patients missing two or more meals.; 4 ,13, and 8 of these patients routinely use insulin. Only the recommended VRIII was used in 3/39. Median operation length was 1:15 h intra-operative CBG was only available in 105/247 (43%). During operation 50% of patients 53?105 where within the ideal range. 85% (89/105) were in acceptable range. Lowest record CBG was 2.7mmol. highest was 20.1mmol. 73%of patients had CBG performed in the recovery room WHO checklist was used in 95% of patients. 91% 150\165 were in the acceptable range, 55% in the ideal range (91/165) values ranged from 2.4mmol-213mmol/l. 57% (135/238) eating one-hour post-surgery and 36% planning the next meal (86/238). &% did not exact the next meal due to surgical decision or POMV.

Study No	Title	Author/s	Year	Type of study	Participants	Location/ setting	Findings/results/statistics
11.	Postoperative adverse events in patients with diabetes undergoing orthopaedic and general surgery	Wang, J., Chen, K., Li, X., Jin, X., An, P., Fang, Y and Mu, Y.	2019	Single centre retrospective study of adverse events using patient medical records. Analysed using multivariable logistic regression.	1525 Patients diagnosed with type 1 or type 2 diabetes prior to surgery. Patient underwent general and orthopaedic surgery 8.8 ±6.6 years. Mean BMI of 25.8 ±3.9kg/$m^{2.}$ Males 779 (51.1%) and 746 (48.9%). Mean ages was 63.5 ± 10.8 years.	Bejing – the general hospital of people liberation Army.	Patient's baseline was obtained from the hospital medical records such as age, sex, BMI dieses course, diabetes complications, diabetes co-morbidities. Pre- and post-nutritional support, biochemical indices, venous blood glucose levels and peripheral blood glucose levels. Of the 301 (19.8%) of all patients with diabetes complications, 295, (98.0%) had major vascular complications, 8 (27. %) had diabetes nephropathy, 3 (0.7%) had diabetes retinopathy, 5 (1.7%) had diabetes foot. Of the 1019 (66.8%) patients with diabetes comorbidities 758 (49.7%) had hypertension, 183, (12.0%) had coronary heart disease. 94 (6.2%) had cerebrovascular disease. 761 (49.9%) and 764 (50.1%) underwent general surgery. mean hospital stay was 14.7±12.1 days. Post-operative adverse events occurred in 118 (7.7%) including 43 (36.4%) delayed estuation cause by surgery-related respiratory failure and or respiratory muscle weakness. 15 (12.7%) patients with circulatory disorders, 23 (19.5%) had respiratory and circulatory abnormalities. 11 (9.3%) had nonhealing of the incision. 15 (12.7%) had infections at other sites. 8 (6.8%) patients with other complications (1 case); adhesive intestinal obstruction, renal failure, case, disturbance of consciousness, persistent anatomical bleeding, metabolic acidosis, digestive tract haemorrhage, multiple compound injury. 3 (2.5%) patients who died, including pulmonary embolism, and two cases of septic shock. Seven factors were significantly different between groups with and without adverse events. age > 65 years [OR = 2.03, 95% confidence interval (CI): 1.76-3.77, p<00.1], sex (OR=20.3, 95% CI 1.39-2.97, p<00.01), systolic blood pressure, >140 mmHg (OR =1.64, 95% CI 1.14-2.35, p=.007), smoking (OR =1.68, 95%CI: 1.11-2.55, p+.015), postoperative mean peripheral blood glucose (OR1.13 per 1mmol/L, 95% CI:1.03-1.24, p=.009), diabetes comorbidities (OR =2.32, 95% CI: 1.44-37.3, p<.001), abnormal kidney function (OR=27.3, 95% CI:1.66-6.69, p=.001) and general surgery (OR = 1.69, 95%CI:1.32-5.67, p=.013). Multivariable analysis, in various tables, table 3 and figure 2. Ages >65 years (OR=2.2395% CI: 1.25-3.98, p=.002), postoperative mean peripheral blood glucose, (OR =1.13 per 1mmol/L, 95% CI:1.13-1.82, p=.029), diabetes complications (OR=2.41, 95% CI:1.36-4.28, p=0.003), abnormal kidney function, (OR =2.73, 95%CI: 1.13-6.58, p=.003), general surgery (OR =1.48, 95% CI: 1.11-5.26, P=.023) in relation to post op adverse events.

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