Original Article

Quality of diabetes treatment in four orthopaedic departments in the Capital Region of Denmark

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ABSTRACT

INTRODUCTION. Hyperglycaemia during hospitalisation is associated with a longer and more complicated admission and with increased mortality. Therefore, guidelines suggest that blood glucose should be less than 10 mmol/l. In this audit, we aimed to describe the prevalence of diabetes patients at four orthopaedic departments in the Capital Region of Denmark and to measure the quality of in-hospital diabetes management.

METHODS. We conducted audits of medical records in the electronic health record system for two months in 2019. All patients admitted were included in the audit. We gathered information on diabetes status, orthopaedic diagnosis, glycosylated haemoglobin and diabetes management.

RESULTS. Among 2,463 included patients, 10% had diabetes. The three most frequent diagnosis groups were infection, fracture of lower extremity and hospitalised for alloplastic surgery. The number of blood glucose measurements during 24-hour perioperative care was 6.5. Among patients analysed, 10-20% did not have their blood glucose measured in the days following surgery. Among patients, 64% received insulin 1-50% of the required times.

CONCLUSION. We demonstrated that 10% of hospitalised patients suffer from diabetes. The audit also showed that blood glucose is generally measured according to guidelines, whereas the treatment of an elevated blood glucose is far from being given according to guidelines. This may potentially delay recovery and prolong hospitalisation.

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People with diabetes carry a higher risk of hospitalisation than do people without diabetes. Hyperglycaemia at or during hospitalisation is associated with a longer and more complicated admission and with increased mortality [1, 2].

Epidemiological studies and a few randomised trials suggest that a normal glucose level during hospitalisation in a non-intensive care unit may be associated with a more favourable outcome, especially with fewer infections [3]. Therefore, guidelines suggest that the blood glucose level should be less than approximately 10 mmol/l as a higher glucose level is considered harmful to the patient [4]. To achieve this, close monitoring of blood glucose is

necessary, and updating hospital staff's diabetes skills is a prerequisite. In the Capital Region of Denmark, it is recommended that blood glucose is measured five times per day in hospitalised diabetes patients, and it is also recommended to measure the level of glycosylated haemoglobin (HbA_{1c}), unless a recent measurement is available. For correction of hyperglycaemia, insulin aspart is recommended up to five times a day (sliding-scale insulin (SSI)), with a standardised dose depending on blood glucose level and patient weight. It is also recommended that in patients with diabetes and intercurrent illness, need for surgery, lack of food intake, fasting or expected surgery, level of plasma (p)-potassium, p-sodium and p-creatinine are measured daily during hospitalisation to prevent dehydration and electrolyte disorders (according to the guideline "Diabetes - fastende og/eller dysregulerede voksne diabetespatienter" [5]).

No Danish estimates exist of the prevalence of diabetes among hospitalised patients. In Non-Danish reports, the prevalence of hospitalised diabetes patients is approximately 20% [6, 7]. Moreover, only limited knowledge exists about the quality of in-hospital diabetes care in Denmark. In this study, we aimed to describe the prevalence of diabetes patients at four orthopaedic departments in the Capital Region of Denmark. We reported on hospital length of stay (LOS), diabetes management and other variables that we believe are important for the treatment of hospitalised patients with diabetes. The purpose was to provide an overview of diabetes-related conditions during hospitalisation, which may form the basis for future monitoring and improvements of the quality of diabetes management during hospitalisation.

METHODS

Before initiation of a diabetes educational initiative targeting staff at orthopaedic departments, we conducted audits of medical records in the electronic health record system coined Sundhedsplatformen (Epic, Wisconsin, USA) from orthopaedic departments at Bispebjerg-Frederiksberg Hospital (in the following termed Bispebjerg Hospital), Herlev-Gentofte Hospital (in the following termed Herlev Hospital), Nordsjællands Hospital and Rigshospitalet, all in the Capital Region of Denmark. All patient admissions from 1 February 2019 to 31 March 2019 were included whether the patient had known diabetes or not. The audit was conducted by the same person. The audited variables are presented in **Table S1** (https://ugeskriftet.dk/files/a05210449_-_supplementary.pdf).

Definition of endpoints:

Definition of diabetes: participants were identified as having diabetes if they met one of the four following criteria:

1) Had a diabetes diagnosis (E10.X, E11.X, E13.X) registered in Sundhedsplatformen, 2) Were being treated with blood glucose-lowering medicine, 3) Had an HbA_{1c} exceeding 47 mmol/mol (measured during admission or within the past three months), 4) Had a min. of two blood glucose values above 11.1 mmol/l measured during hospitalisation.

The primary orthopaedic diagnoses were divided into seven groups, see **Table 1**. Only patients admitted for more than 24 hours were included in the analysis and patients were only be included once (first time).

TABLE 1 Description of the 247 admitted persons by the seven diagnosis groups (defined by the authors), HbA$_{1c}$ at admission (or within the past three months) and length of stay at hospital.

Diagnosis group	n (%)	HbA$_{1c}$, mmol/mol (± SD) [n$_{sub}$]	Length of stay, days (min.-max)
Infection of soft tissues or bones	55 (22.3)	64 (± 17)	13.9 (1-56)
Fracture of upper extremity	19 (7.7)	53 (± 5.2)	2.3 (1-7)
Fracture of lower extremity	45 (18.2)	60 (± 14)	7.2 (2-39)
Fracture of the spine, ribs, pelvis, clavicula	19 (7.7)	39 [1]	5.7 (1-14)
Hospitalised for alloplastic surgery	65 (26.3)	52 (± 10)	2.1 (1-8)
Accident without fracture	17 (6.9)	44 [1]	2.7 (1-6)
Other diagnoses: cancer, benign tumours, head and eye damage, artery embolism, pneumonia, arthritis, other ulcers, kyphosis, Depuytren's contracture	27 (10.9)	56 (± 12)	5.7 (1-15)
Total	247 (100)	56 (± 14) [101]	6.4 (1-56)

HbA$_{1c}$ = glycosylated haemoglobin; SD = standard deviation.

Statistics

We primarily used standard descriptive statistics. Comparison of HbA$_{1c}$ between different groups was done using the t-test. Comparisons of fractions were performed with the χ^2-test. Comparisons of continuous variables between the four hospitals were done using one-way ANOVA. IBM SPSS Statistics (version 25) was used as statistics software. A $p < 0.05$ was considered statistically significant.

Trial registration: not relevant.

RESULTS

A total of 3,503 records of individual patients were reviewed. Among these, 1,040 (30%) were admitted for less than 24 hours and were therefore not included in the analyses. Among the remaining 2,463 patients, 247 (10%) were defined as having diabetes. The remaining group of patients was distributed with 778 (32%) patients at Herlev Hospital, 406 (17%) patients at Rigshospitalet, 613 (25%) patients at Nordsjællands Hospital and 666 (27%) patients at Bispebjerg Hospital. Among the 247 diabetes patients, 147 (60%) were hospitalised acutely and 100 (41%) were planned admissions. Among the 247 diabetes patients, 218 (88%) had a diabetes diagnosis registered in Sundhedsplatformen. The remaining 29 (12%) patients were diagnosed with diabetes based on elevated blood glucose and/or HbA$_{1c}$. A total of 177 diabetes patients (72%) underwent surgery (see **Figure S1**). The prevalence of diabetes in the four orthopaedic departments was not significantly different ($p = 0.075$, χ^2-test), see **Table 2**.

TABLE 2 Prevalence of diabetes, level of HbA$_{1c}$ (in 101 persons) and length of stay for the 247 persons with diabetes admitted to orthopaedic departments on four hospitals in the Capital Region of Denmark.

	Hospital						
	Nordsjællands Hospital	Herlev Hospital	Rigshospitalet	Bispebjerg Hospital	all	p-value[a]	Statistical test
Prevalence of DM, %	10.3	11.7	6.9	9.8	10.0	0.075	χ^2-test
HbA$_{1c}$, mmol/mol (± SD)	57 (± 14)	58 (± 13)	52 (± 11)	56 (± 16)	56 (± 14)	0.58	1-way ANOVA
Length of stay, days (± SD)	7.8 (± 11)	5.2 (± 7.3)	10 (± 9.0)	5.1 (± 5.1)	6.4 (± 8.3)	0.01	1-way ANOVA

ANOVA = analysis of variance; DM = diabetes mellitus; HbA$_{1c}$ = glycosylated haemoglobin; SD = standard deviation.
a) Comparison between the four hospitals.

Orthopaedic diagnosis

The patients were hospitalised due to very different diagnoses, as shown in Table 1. The three most frequent diagnosis groups were *infection of soft tissues or bones, fracture of lower extremity* and *hospitalised for alloplastic surgery*. The distribution of orthopaedic diagnostic groups at Nordsjællands, Bispebjerg and Herlev Hospital was the same, whereas the diagnosis spectrum at Rigshospitalet was different, see **Figure S2**.

Duration of admission

Patients with diabetes were hospitalised for an average of 6.4 days, but with great variation (see Table 1 and Table 2). The median LOS was four days. Maximum LOS was 56 days, and 10% of patients were hospitalised for more than 13 days. In acutely hospitalised patients with diabetes, a mean LOS of 8.3 days (median six days, min. one day, max 53 days) was recorded. In electively hospitalised patients with diabetes, the mean LOS was 3.6 days (median two days, min. one day, max 34 days). LOS at the four different hospitals differed, with Rigshospitalet having the longest mean LOS (p = 0.01, one-way ANOVA), see Table 2.

Before admission/surgery

In the 147 acutely hospitalised patients with diabetes, 80 underwent surgery. In this group, preoperative blood glucose was present in 55 patients (69%). In the 100 electively hospitalised, surgery was performed in 97 people, among whom preoperative blood glucose was available in 84 patients (87%). Preoperative haemoglobin was available for the acute hospitalised group in 76 (95%) and in planned hospitalised patients in 76 (76%). Electrolyte status and p-creatinine was available in 75 (94%) of the acutely hospitalised and in 74 (74%) of the planned hospitalised patients. HbA$_{1c}$ was available in 42 (53%) of the acutely hospitalised, and in 59 (59%) of the planned hospitalised patients and no difference was observed between HbA$_{1c}$ between hospitals (p = 0.58, one-way anova), Table 2. Among the 100 electively hospitalised diabetes patients, the referral letter stated that 34 patients (34%) had diabetes. Data on the acutely hospitalised patients were not obtained since they were typically not admitted with a referral letter before hospitalisation (e.g. in the case of accidents).

Blood glucose measurements during hospitalisation

The average number of measured blood glucose measurements during postoperative care and on the orthopaedic ward on the day of surgery (i.e. from the start of surgery and for the next 24 hours) was 6.5 with a median of 6.0. The number varied between no measurements and 13 measurements. On the day of surgery, in a total of 16 (9.0%) patients with diabetes out of a total of 177 operated patients, blood glucose was measured zero times in six (3.4%) patients, once in four (2.3%) patients and twice in six (3.4%) patients. In the following days, the number of daily measured blood glucose measurements decreased to an average of 3.7 on the second, 3.8 on the third, 3.3 on the fourth and 3.6 on the fifth post-surgery admission days, but with great variation. A total of 10%, 15%, 16% and 18% of the post-surgery patients had their blood glucose measured zero times in the second, third, fourth, and fifth post-surgery hospital days, respectively.

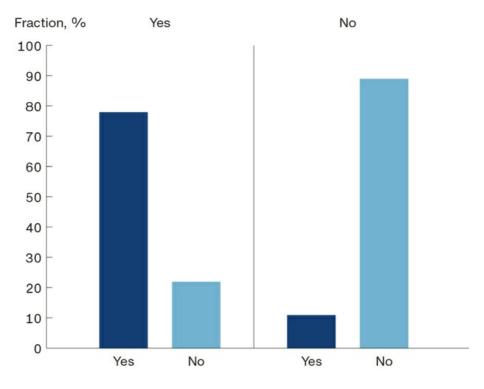## Electrolytes and p-creatinine during hospitalisation

Among the 247 diabetes patients, 83 (34%) had p-potassium, p-sodium and p-creatinine measured daily for the first five days of hospitalisation or until discharge. Among the 177 patients who had surgery, 70 patients (40%) had their p-potassium, p-sodium and p-creatinine measured daily for the first five days of hospitalisation or until discharge.

Diabetes treatment during hospitalisation

During hospitalisation, insulin aspart was prescribed up to five times a day (SSI) in 111 (45%) of the 247 patients with diabetes. Among these, 87 patients (78%) received insulin aspart at least once during hospitalisation as part of this prescription. Of the 135 patients who were *not* prescribed insulin aspart up to five times a day during their hospitalisation, 15 patients (11%) nevertheless received insulin aspart (see **Figure 1**). Among the 102 people who received insulin (whether prescribed at admission or not), 21 (20%) received insulin aspart 76-100% of the times when their blood glucose was so high that insulin was required. Sixteen patients (16%) received insulin 51-75% of the times it was required. Forty-five patients (45%) received insulin 26-50% of the required times and 20 (19%) patients were given insulin 0-25% of the times it should have been administered (see **Figure 2**).
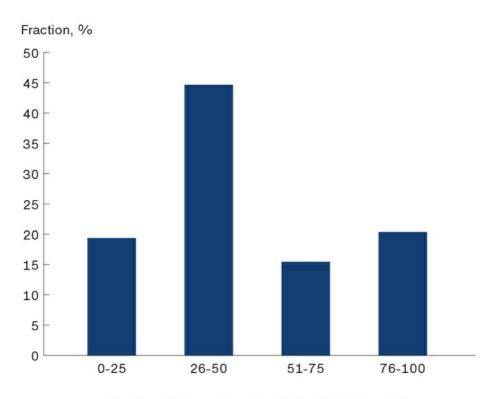

FIGURE 1 Fractions of patients with diabetes who are treated with insulin aspart up to five times a day (sliding-scale insulin) during admission. Data are split into two groups depending on whether insulin aspart up to five times a day (sliding scale insulin) was prescribed at admission.

FIGURE 2 Fraction of patients with diabetes who were treated with insulin when such treatment was indicated given their blood glucose level measurements.

The diabetes treatment was reviewed and optimised by the diabetes specialist nurse teams during hospitalisation in 25 patients (10%). The mean hospitalisation time for these patients was 18 days and mean HbA_{1c} was 66 mmol/mole (HbA_{1c} was available for 12 patients). HbA_{1c} was 55 mmol/mole (for 89 patients) in patients not seen by diabetes nurses ($p = 0.007$, t-test).

Discharge

Ordinary diabetes medication was prescribed in 208 (84%) of the 247 diabetes patients when they were discharged from hospital. Eight patients (3.2%) were discharged with SSI without this being justified in the discharge report.

DISCUSSION

This audit of patients with diabetes admitted to four large orthopaedic departments in the Capital Region of Denmark revealed three important points. Firstly, we now know that the prevalence of diabetes in these departments is about 10%; the prevalence of diabetes in the Danish population is approximately 5% [8]. Secondly, we know that the mean duration of hospitalisation is about six days (for patients who are hospitalised for more than 24 hours), although it was significantly longer for some patient groups. Thirdly, our audit shows that guidelines on blood glucose monitoring are generally followed, i.e. blood glucose is measured about four times a day, whereas the treatment of elevated blood glucose is treated insufficiently. Thus, about 65% of patients were treated with insulin less than half of the times they should have been treated according to

guidelines. This is unfortunate as hyperglycaemia in inpatients is associated with an increased risk of death and impaired postoperative wound healing [10]. From this audit, we may also conclude that the postoperative focus on hydration of the patient is probably deficient. The consequence of this may be prerenal acute kidney injury, possibly complicated by nephrotoxic medicine, which is associated with subsequent increased mortality [9]. The reasons for non-adherence to guidelines are probably complex and may include lack of time or knowledge about diabetes management, unclear or complicated guidelines, lack of focus on postoperative diabetes care or other reasons. Therefore, improvement of diabetes care during hospitalisation probably warrants multifaceted and tailormade solutions.

The strength of this audit is that the data were collected at four different orthopaedic departments within four of the five major hospitals in the Capital Region of Denmark. This increases generalisation to other orthopaedic departments in Denmark (and other countries). However, it seems that patients admitted to Rigshospitalet differed from the patients of the other three hospitals, which is probably because Rigshospitalet has a highly specialised function and treats rare orthopaedic conditions. Another strength is that data were collected systematically and following a predefined auditor guide with very limited room for interpretation. One weakness of the present audit is that it included very little clinical data (e.g. data on blood glucose-lowering drugs or treatment decisions), but was largely focused on process indicators. Process indicators do not necessarily provide a valid assessment of the quality of treatment. Furthermore, the incidence of diabetes at 10% is probably slightly underestimated. Our diagnosis was based on one of four variables: either a diabetes diagnosis in the patient record, an elevated HbA_{1c} or a measurement of an elevated blood glucose level or treatment with blood glucose-lowering medicine. A group of diabetes patients may exist that meets none of these criteria. Furthermore, the fact that we could not compare our data to those of people without diabetes is a weakness. The number of blood glucose measurements during hospitalisation may be higher, since blood glucose monitoring may have been done by the patient using his/her own blood glucose meter and therefore not being registered in the electronic patient record. Finally, the data collection, conducted in February and March, may potentially have biased our results due to seasonal variation in admission patterns.

In future studies, focusing on diabetes-related adverse events will be relevant. Such events may include in-hospital hypoglycaemia, diabetic ketoacidosis/hyperosmolar hyperglycaemic state, development of diabetic foot ulcers during hospitalisation, glycaemic control during hospitalisation, medication errors and use of diabetes specialist nurse teams. Consistent use of these teams is likely to benefit both patients and the healthcare system [11]. In our audit, about 10% of patients were seen by a diabetes specialist nurse team and it would likely be beneficial to employ diabetes teams more actively.

CONCLUSION

Approximately 10% of hospitalised patients in orthopaedic departments in the Capital Region of Denmark suffer from diabetes and the hospitalisation time of patients with soft tissue infections is long; two weeks on average. The audit also showed that blood glucose is generally measured according to guidelines, whereas treatment of an elevated blood glucose level is far from being given according to guidelines. This may potentially delay recovery and prolong hospitalisation periods.

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