Glycaemic control in diabetic patients during hospital admission is not optimal

Fanny Hellkvist[1], Line Budde[2], Bo Feldt-Rasmussen[1], Lisbeth Jørgensen[3] & Elisabeth R. Mathiesen[1]

ABSTRACT

INTRODUCTION: The aim of this pilot study was to evaluate glycaemic control in diabetic patients admitted to hospital.

MATERIAL AND METHODS: Patients were prospectively identified at 11 consecutive Wednesdays in one medical and one surgery department and information from the previous three days of admission was collected, including: bedside p-glucose readings, scheduled and supplemental insulin treatment.

RESULTS: In total, 111 observation days were included from 37 diabetic patients (27 medical and ten surgical). P-glucose was measured on average four and 2.5 times daily at the medical and the surgery department, respectively. The median p-glucose level was 8.6 mmol/l (range 4.0-22), with no obvious difference between the two departments and no trend towards improvement observed. Approximately one third of the patients had median p-glucose values > 10 mmol/l. 7% of the patients at the medical and none at the surgery department had a p-glucose < 3 mmol/l. Supplemental insulin was prescribed to the majority of patients at the medical department and to 30% at the surgery department with a median p-glucose threshold of 12 and 14 mmol/l at the two departments, respectively. Supplemental insulin was not given despite being indicated in 37% of the elevated glucose episodes. Increments in scheduled insulin dose were rarely observed despite being indicated.

CONCLUSION: Despite acceptable median p-glucose levels, hyperglycaemia was frequent. The number of glucose readings was low and clinical inertia was observed, both with regard to intensification the scheduled insulin and with regard to administration of supplemental insulin.

FUNDING: not relevant.

TRIAL REGISTRATION: not relevant.

Previous studies have reported a prevalence of diabetes mellitus in the range 15-36% among hospitalized patients, and hyperglycaemia during hospitalization has been found to be associated with various adverse clinical outcomes, including increased risk of postoperative complications, prolonged hospital stay and increased mortality, both in-hospital and in the long term [1-4]. Findings in randomized control trials (RCT) indicate that tight glycaemic control during admission improves these clinical outcomes and reduces both the number of admission days and mortality [5-7]. However, a more recent RCT [8] and a meta-analysis [9] have been unable to confirm these findings.

The American Diabetes Association (ADA) and the American Association of Clinical Endocrinologists (AACE) recommend that random blood glucose levels should be < 10 mmol/l in non-critically ill patients during hospitalization [10]. Previous studies have reported that hyperglycaemia among inpatients is common. In a non-intensive care unit (ICU) general medicine setting, approximately 75% of the patients were reported to have experienced a minimum of one episode of hyperglycaemia (> 10 mmol/l) and the mean percentage of hyperglycaemic glucose readings per patient remained relatively constant during a five day observation period [11]. In a mixed ICU/non-ICU study, 50% of all patients had a minimum of one hyperglycaemic measurement (≥ 10 mmol/l) [12].

The aim of this pilot study was to evaluate the level of glycaemic control achieved in diabetic patients at a medical and a surgery department at a large university hospital, and if needed, to identify areas where improvements were possible.

MATERIAL AND METHODS

Design and setting

This was an observational study on the management of hyperglycaemia in non-critically ill diabetic patients based on review of diabetes treatment schemes. The setting was two non-intensive departments, the Department of Nephrology (a medical department) with 40 beds and the Department of Vascular Surgery (a surgery department) with 26 beds, at Copenhagen University Hospital (Rigshospitalet), as these departments were expected to treat a considerable number of diabetic patients.

Data collection

Each Wednesday as from 31 March, 2010 and the following 10 weeks, the departments were visited by one of the investigators and diabetes treatment schemes of

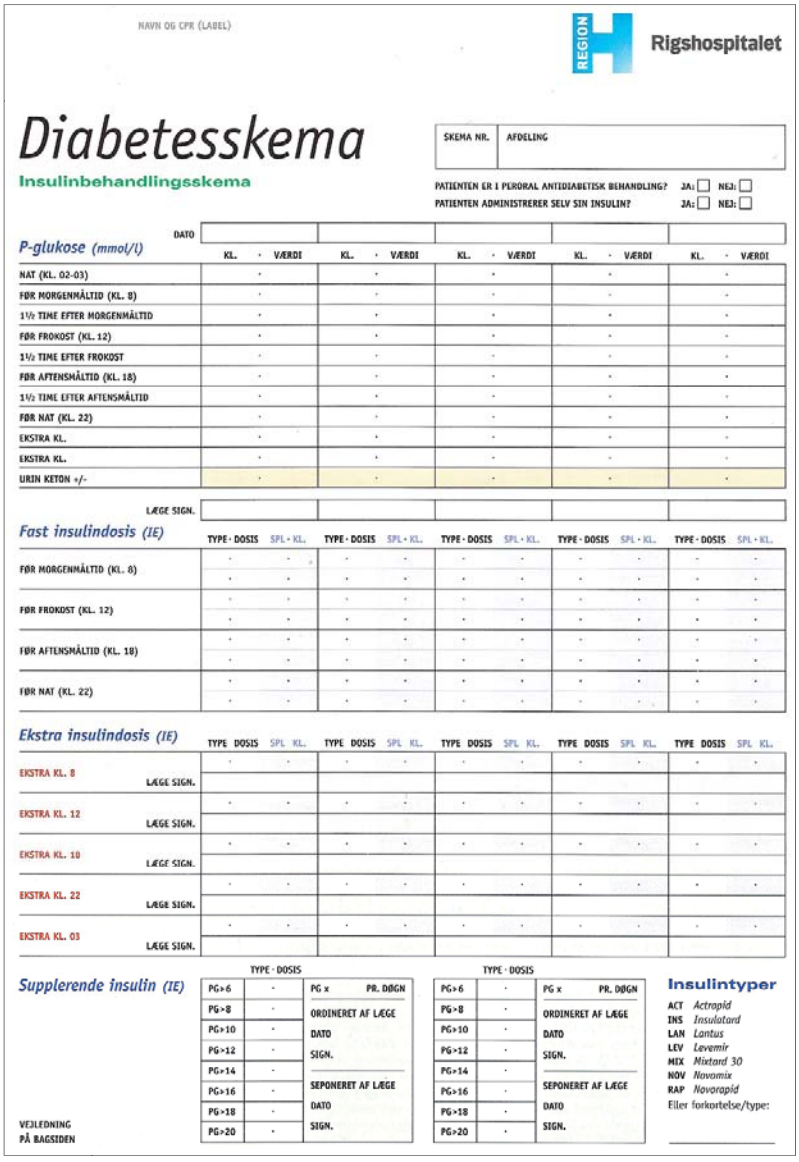
ORIGINAL ARTICLE

1) Department of Endocrinology, Rigshospitalet, 2) Department of Nephrology, Rigshospitalet, and 3) Department of Vascular Surgery, Rigshospitalet

Dan Med Bul 2011;58(8):A4306

FIGURE 1

The diabetes treatment scheme used at the two departments.



NAVN OG CPR (LABEL)

REGION H Rigshospitalet

Diabetesskema

Insulinbehandlingsskema

SKEMA NR. | AFDELING

PATIENTEN ER I PERORAL ANTIDIABETISK BEHANDLING? JA: NEJ:

PATIENTEN ADMINISTRERER SELV SIN INSULIN? JA: NEJ:

P-glukose *(mmol/l)*

DATO	KL. · VÆRDI	KL. · VÆRDI	KL. · VÆRDI	KL. · VÆRDI	KL. · VÆRDI
NAT (KL. 02-03)					
FØR MORGENMÅLTID (KL. 8)					
1½ TIME EFTER MORGENMÅLTID					
FØR FROKOST (KL. 12)					
1½ TIME EFTER FROKOST					
FØR AFTENSMÅLTID (KL. 18)					
1½ TIME EFTER AFTENSMÅLTID					
FØR NAT (KL. 22)					
EKSTRA KL.					
EKSTRA KL.					
URIN KETON +/-					
LÆGE SIGN.					

Fast insulindosis *(IE)*

	TYPE · DOSIS · SPL · KL.	TYPE · DOSIS · SPL · KL.	TYPE · DOSIS · SPL · KL.	TYPE · DOSIS · SPL · KL.	TYPE · DOSIS · SPL · KL.
FØR MORGENMÅLTID (KL. 8)					
FØR FROKOST (KL. 12)					
FØR AFTENSMÅLTID (KL. 18)					
FØR NAT (KL. 22)					

Ekstra insulindosis *(IE)*

	TYPE DOSIS SPL KL.	TYPE DOSIS SPL KL.	TYPE DOSIS SPL KL.	TYPE DOSIS SPL KL.	TYPE DOSIS SPL KL.
EKSTRA KL. 8					
LÆGE SIGN.					
EKSTRA KL. 12					
LÆGE SIGN.					
EKSTRA KL. 18					
LÆGE SIGN.					
EKSTRA KL. 22					
LÆGE SIGN.					
EKSTRA KL. 03					
LÆGE SIGN.					

Supplerende insulin *(IE)*

TYPE · DOSIS			TYPE · DOSIS		
PG>6		PG x PR. DØGN	PG>6		PG x PR. DØGN
PG>8		ORDINERET AF LÆGE	PG>8		ORDINERET AF LÆGE
PG>10		DATO	PG>10		DATO
PG>12		SIGN.	PG>12		SIGN.
PG>14		SEPONERET AF LÆGE	PG>14		SEPONERET AF LÆGE
PG>16		DATO	PG>16		DATO
PG>18		SIGN.	PG>18		SIGN.
PG>20			PG>20		

VEJLEDNING PÅ BAGSIDEN

Insulintyper

ACT *Actrapid*
INS *Insulatard*
LAN *Lantus*
LEV *Levemir*
MIX *Mixtard 30*
NOV *Novomix*
RAP *Novorapid*
Eller forkortelse/type:

the diabetic patients admitted to the departments during this period were collected. Diabetic patients with an admittance of three days or longer were identified via the whiteboards over currently admitted patients and by consulting the nurses on duty. Exclusion criteria were admission due to dysregulated diabetes mellitus. Also, days when intravenous insulin had been administered were not included in the study.

At Rigshospitalet, a diabetes treatment scheme was part of the patient record for all patients receiving insulin treatment. Each scheme enabled documentation of six days of glycaemic control and consisted of three parts. In the first part, plasma glucose (p-glucose) measurements were noted. The recommended times were preprandially and postprandially in connection with the three main meals and before nighttime. In the second part, scheduled insulin was prescribed by the responsible physician and signed off by the nurses when administered. The third part contained documentation on prescription and administration of supplemental insulin. The physician prescribed supplemental insulin according to an algorithm based on the actual p-glucose level. The nurses noted the time, type and number of units of supplemental insulin given (**Figure 1**).

The key clinical data were obtained from the patients' charts. Duration of hospitalization was calculated as the period from the day of admission to the first day of glucose data collection in this study. Data regarding all glucose measurements, insulin prescriptions and administration were collected for the three days preceding the given data collection day. All p-glucose measurements taken during the given days were included. These were mainly preprandial, but postprandial and nighttime values were also included. However, to avoid ascertainment bias, if two p-glucose values were noted within one hour, the second value was excluded from calculations.

Outcomes

The primary outcome was the degree of glycaemic control measured as the median p-glucose level during each observation day. We also registered the number of patients with daily median p-glucose > 10 mmol/l and > 14 mmol/l as well as the number of patients with a minimum of one glucose measurement > 10 mmol/l, > 14 mmol/l, < 4 mmol/l and < 3 mmol/l. These values represent the desired range of p-glucose during hospitalization (4-10 mmol/l), hypoglycaemia (< 3 mmol/l) and clinically significant hyperglycaemia at a level that indicated administration of supplemental insulin at both departments (14 mmol/l).

We registered patients to whom scheduled or supplemental insulin was prescribed. In each patient, the median threshold for giving supplemental insulin was identified. We calculated the percentage of occasions when supplemental insulin was not given despite being indicated and prescribed.

Statistics

The values were given as frequencies (percentage) for categorical data and medians (ranges) for continuous data. Due to the pilot nature of the study and the small number of patients included, no other statistics were applied.

Ethics

Patient consent was not deemed necessary for this

study given the relatively non-sensitive nature of the data and the non-invasive means of data collection.

Trial registration: not relevant.

RESULTS

In total, data from 111 observation days were included resulting in 399 p-glucose readings from 37 diabetic patients (27 from the medical and ten from the surgery department). On average, 2.5 (6%) of the 40 in-patients in the medical department and one (4%) out of 26 in-patients at the surgery department fulfilled the inclusion criteria each week (**Table 1**).

The most common admission diagnose was infection and uraemia in the medical department and infection and ischaemia in the lower extremities in the surgery department. The median length of hospitalization prior to the first day of glucose observation in this study was three days in both departments (Table 1).

Type 2 diabetes mellitus (T2DM) was the most common diabetes type. The remaining patients were equally distributed between Type 1 diabetes mellitus (T1DM) and glucocorticoid-induced diabetes mellitus that had developed during the hospital stay. The most commonly scheduled medication regimen was insulin at the medical department and oral medication at the surgery department (Table 1).

The median daily number of glucose measurements was four at the medical department and 2.5 at the surgery department (**Table 2**). The overall median patient glucose concentration obtained was 8.6 mmol/l, range 4.0-21.6 mmol/l (data not shown), with no obvious difference between the two departments and no trend towards improvement observed (Table 2). Approximately one third of the patients had median p-glucose values above 10 mmol/l and almost twice as many had a minimum of one reading > 10 mmol/l. 7% of the patients at the medical department and none of the patients at the surgery department had a minimum of one registered episode of hypoglycaemia with p-glucose < 3 mmol/l.

Generally, the administration of scheduled insulin in both departments remained unchanged during the observation period. Supplemental insulin was prescribed to the majority of patients at the medical department and to 30% at the surgery department. The median p-glucose threshold was 12 and 14 mmol/l at the two departments, respectively (Table 1). The prevalence of episodes where supplemental insulin was not given despite indicated was high (Table 2).

DISCUSSION

The main finding was a high prevalence of high p-glucose levels. Remarkably few glucose readings were performed, relevant treatment intensifications in scheduled insulin were rare and no tendencies toward improvement in glycaemic control over the observation period were documented. This is far from optimal according to the recommendations of the ADA and the AACE [10].

Hyperglycaemia in hospitalized patients has been found to be related to increased mortality rates and other adverse outcomes [1-4], and postoperative hyperglycaemia was a significant predictor of postoperative infection and prolonged hospitalization periods in patients who had undergone surgery [13].

Studies of patients with acute myocardial infarction or submitted to the ICU have demonstrated beneficial effect of intensive insulin treatment on time in mechanical ventilation, length of stay and mortality [5-7]. However, a more recent RCT in the ICU environment [8] and a meta-analysis [9] have been unable to confirm these findings. This is probably due to episodes of hypoglycaemia in vulnerable patients [8, 9]. It is therefore of uppermost importance to secure that intensification of glycaemic control does not induce hypoglycaemia. More frequent monitoring of the glucose level in insulin-treated in-patients than seen in this study is therefore neces-

TABLE 1

Patient characteristics.

	Medical department	Surgery department
Patients, n (% females)	27 (44)	10 (60)
Age, years, median (range)	62 (29-91)	68 (52-81)
BMI, kg/m^2, median (range)	29 (17-41)	26 (24-34)
Type of diabetes, n (%)		
T1DM	5 (19)	0 (0)
T2DM	17 (63)	9 (90)
New onset DM, induced by glucocorticoids	5 (19)	0 (0)
New onset DM, induced by somatostatin	0 (0)	1 (10)
Duration of diabetes, years[a], median (range)	14 (0-43)	6.5 (0-25)
HbA_{1c},%, median (range)	6.6 (4.4-8.9)[b]	7.6 (6.1-8.4)[c]
Preadmission diabetes treatment regimen, n (%)		
None	7 (26)	3 (30)
Oral medication only	3 (11)	5 (50)
Insulin	17 (63)	2 (20)
Known nephropathy at admission, n (%)	25 (93)	1 (10)
On dialysis treatment, n (%)	21 (78)	1 (10)
Admission diagnosis, n (%)		
Infection	15 (56)	4 (40)
Renal	11 (41)	0 (0)
Ischaemia in lower extremities	0 (0)	4 (40)
Other	1 (4)	2 (20)
Length of hospitalization, days, median (range)	3 (0-11)	3 (0-17)
Patients prescribed supplemental insulin, n (%)	21 (78)	3 (30)
Glucose threshold for supplemental insulin, mmol/l, median (range)	12 (8-16)	14 (12-16)

BMI = body mass index; DM = diabetes mellitus; HbA_{1c} = haemoglobin A_{1c}; T1DM = type 1 diabetes mellitus; T2DM = type 2 diabetes mellitus.

a) For three patients it was not possible to obtain information regarding diabetes duration.

b) n = 16.

c) n = 4.

Frequent blod glucose level monitoring is important in hospitalized patients with diabetes.

sary to detect and possibly prevent episodes of severe hypoglycaemia.

In the medical department, the majority of patients had supplemental insulin prescribed (78%), but at fairly high glucose concentrations (> 12 mmol/l). The instruction at the department in force at the time of the observation was, however, prescription and administration of supplemental insulin at glucose concentrations > 8 mmol/l. This discrepancy could in part explain the difficulty in reducing the percentage of hyperglycaemic glucose readings.

The number of p-glucose readings was fairly low at both departments and this did not facilitate correction of the insulin doses. Furthermore, supplemental insulin had not been administered in 37% of the cases even if it was indicated. This may be one of the reasons why the use of sliding scale insulin results in suboptimal glycaemic control. Sliding scale insulin as a sole regimen is no longer recommended [10]. Changes in scheduled insulin are therefore necessary to improve metabolic control. However, no substantial change in scheduled insulin was documented in this study.

There was clinical inertia with regard to intensification of the scheduled insulin and with regard to administration of supplemental insulin. This finding is not unique and previous studies have reported less than optimal treatment intensification despite persistent hyperglycaemia in settings comparable to ours [11, 14, 15]. Fear of hypoglycaemia may possibly explain this finding.

It has, however, been demonstrated that improvement of glycaemic control without increasing the rate of hypoglycaemia is possible in the non-ICU-setting with implementation of subcutaneous insulin protocols, intensified insulin regimens and clinical education resulting in a shortened length of stay [16,17]. More individualized patient-goals for p-glucose levels, individualized doses of supplemental insulin based on the previous day's insulin requirement and frequent revision of the supplemental insulin scheme may possibly be a way of improving glycaemic control during hospitalization. Whether this has the desired effect in the clinic remains speculative. On the other hand, simple instructions with

TABLE 2

Diabetes management and glycaemic control achieved during the observation period at the medical and the surgery department.

	Medical department (n = 27)			Surgery department (n = 10)		
	day 1	day 2	day 3	day 1	day 2	day 3
Glucose measurements per patient, n, median (range)	4 (1-7)	4 (2-7)	4 (1-7)	2.5 (1-5)	2.5 (1-6)	2.5 (2-5)
Patient p-glucose, mmol/l, median (range)	8.7 (4.4-19.1)	8.9 (4.0-19.8)	8.0 (4.6-17.6)	8.2 (5.1-18.4)	8.5 (6.7-21.6)	8.0 (5.3-19.6)
Patients with a median p-glucose > 10 mmol/l, n (%)	8 (30)	10 (37)	10 (37)	3 (30)	4 (40)	3 (30)
Patients with median a p-glucose > 14 mmol/l, n (%)	3 (11)	3 (11)	3 (11)	2 (20)	1 (10)	1 (10)
Patients with a minimum of one p-glucose > 10 mmol/l, n (%)	19 (70)	18 (67)	17 (63)	6 (60)	5 (50)	4 (40)
Patients with a minimum of one p-glucose > 14 mmol/l, n (%)	12 (44)	7 (26)	9 (33)	3 (30)	1 (10)	1 (10)
Patients with a minimum of one p-glucose < 4 mmol/l, n (%)	5 (19)	5 (19)	4 (15)	1 (10)	0	0
Patients with a minimum of one p-glucose < 3 mmol/l, n (%)	3 (11)	1 (4)	2(7)	0	0	0
Patients given scheduled insulin, n (%)	14 (52)	16 (59)	14 (52)	2 (20)	3 (30)	3 (30)
Units of scheduled insulin given – if any, IU, median (range)	34 (8-66)	29 (8-60)	29 (8-60)	17 (12-22)	18 (12-20)	16 (12-40)
Patients given supplemental insulin, n (%)	9 (33)	8 (30)	7 (26)	2 (20)	1 (10)	2 (20)
Units of supplemental insulin given – if any, IU, median (range)	10 (2-41)	13 (6-32)	10 (4-32)	16 (2-30)	28 (28-28)	11 (4-18)
Occasions where supplemental insulin was not given despite indication, % (n/N)	39 (11/28)	31 (8/26)	50 (12/24)	0 (0/3)	25 (1/4)	25 (1/4)

IU = international units; P-glucose = plasma glucose concentration.

easy rules of thumb are easier to implement at large clinics, especially when the main treatment focus of the admission is at odds with the patient's diabetes diagnosis.

Limitations and strength

The study has several strengths. It was performed in the clinical everyday setting reflecting routine care, and data were collected consecutively and in a structured manner. The prevalence of patients with diabetes at the two departments was expected to be between 15% and 36% [1-4]. However, only approximately 5% of the patients admitted to the departments at the time met our inclusion criteria. This reduced the number of patients in the present study which constitutes its main limitation. Data were collected once weekly on Wednesdays, and consequently patients had to be admitted at the end of the previous week to be included. The limited number of included patients may therefore be related to the way data were collected. Moreover, the length of stay at the medical and surgery department may have declined over recent years, with fewer patients staying in hospital for more than five days. Patients with diabetes may have been missed in the inclusion process; however, several patients without known diabetes but developing hyperglycaemia due to glucocorticoid therapy were also identified. Other limitations of this study were that the patients from the medical department were mainly on dialysis, which further complicates control of glucose, and they therefore do not quite represent a typical medical patient. Also, in order to detect possible hypoglycaemic episodes, all p-glucose values were included in the analysis resulting in the inclusion of both preprandial and postprandial values in the calculation of median p-glucose. However, the majority of the glucose values was preprandial or bedtime samples.

CONCLUSION

Hyperglycaemia was frequent among diabetic patients submitted to a medical or a surgery department with an admission diagnosis different from that of diabetes. Areas for improvement included focus on the daily number of glucose readings, administration of supplemental insulin when indicated and intensification of the scheduled insulin when necessary.

CORRESPONDENCE: *Fanny Hellkvist*, Endokrinologisk Afdeling, Rigshopitalet, 2132, 2100 Copenhagen, Denmark.
E-mail: fannyhellkvist@hotmail.com
ACCEPTED: 15 June 2011
CONFLICTS OF INTEREST: none

LITERATURE

1. Ainla T, Baburin A, Teesalu R et al. The association between hyperglycaemia on admission and 180-day mortality in acute myocardial infarction patients with and without diabetes. Diabet Med 2005;22:1321-5.
2. Jones KW, Cain AS, Mitchell JH et al. Hyperglycemia predicts mortality after CABG: postoperative hyperglycemia predicts dramatic increases in mortality after coronary artery bypass graft surgery. J Diabetes Complications 2008;22:365-70.
3. McAlister FA, Majumdar SR, Blitz S et al. The relation between hyperglycemia and outcomes in 2,471 patients admitted to the hospital with community-acquired pneumonia. Diab Care 2005;28:810-5.
4. Monteiro S, Monteiro P, Goncalves F et al. Hyperglycaemia at admission in acute coronary syndrome patients: prognostic value in diabetics and non-diabetics. Eur J Cardiovasc Prev Rehabil 2010;17:155-9.
5. Malmberg K. Prospective randomised study of intensive insulin treatment on long term survival after acute myocardial infarction in patients with diabetes mellitus. DIGAMI (Diabetes Mellitus, Insulin Glucose Infusion in Acute Myocardial Infarction) Study Group. BMJ 1997;314:1512-5.
6. Van den Berghe G, Wouters P, Weekers F et al. Intensive insulin therapy in the critically ill patients. N Engl J Med 2001;345:1359-67.
7. Van den Berghe G, Wilmer A, Hermans G et al. Intensive insulin therapy in the medical ICU. N Engl J Med 2006;354:449-61.
8. Finfer S, Chittock DR, Su SY et al. Intensive versus conventional glucose control in critically ill patients. N Engl J Med 2009;360:1283-97.
9. Wiener RS, Wiener DC, Larson RJ. Benefits and risks of tight glucose control in critically ill adults: a meta-analysis. JAMA 2008;300:933-44.
10. 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.
11. Schnipper JL, Barsky EE, Shaykevich S et al. Inpatient management of diabetes and hyperglycemia among general medicine patients at a large teaching hospital. J Hosp Med 2006;1:145-50.
12. Boord JB, Greevy RA, Braithwaite SS et al. Evaluation of hospital glycemic control at US academic medical centers. J Hosp Med 2009;4:35-44.
13. Ramos M, Khalpey Z, Lipsitz S et al. Relationship of perioperative hyperglycemia and postoperative infections in patients who undergo general and vascular surgery. Ann Surg 2008;248:585-91.
14. Knecht LA, Gauthier SM, Castro JC et al. Diabetes care in the hospital: is there clinical inertia? J Hosp Med 2006;1:151-60.
15. Cook CB, Castro JC, Schmidt RE et al. Diabetes care in hospitalized noncritically ill patients: More evidence for clinical inertia and negative therapeutic momentum. J Hosp Med 2007;2:203-11.
16. Elinav H, Wolf Z, Szalat A et al. In-hospital treatment of hyperglycemia: effects of intensified subcutaneous insulin treatment. Curr Med Res Opin 2007;23:757-65.
17. Schnipper JL, Ndumele CD, Liang CL et al. Effects of a subcutaneous insulin protocol, clinical education, and computerized order set on the quality of inpatient management of hyperglycemia: results of a clinical trial. J Hosp Med 2009;4:16-27.