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Brief communication

Episodes of hypoglycemia and hyperglycemia during the use of sliding scale insulin in hospitalized diabetes patients

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Background: Sliding scale insulin is frequently utilized in hospitalized diabetes patients. However, most of the studies done concluded that sliding scale insulin causes hyperglycemia and hypoglycemia episodes in patients receiving it.
Objective: To assess the rate of hyperglycemia and hypoglycemia in diabetes patients receiving sliding scale insulin.
Method: Data was collected prospectively for 3 months and a total number of 52 patients were included. Rates of hypoglycemia and hyperglycemia episodes during the use of the sliding scale insulin were evaluated.
***Results*:** The rates of hyperglycemia and hypoglycemia episodes were 19.7 and 0.7 per 100 glucose measurements respectively. There were an equal number of patients with uncontrolled diabetes and acute hyperglycemia receiving sliding scale insulin.
Conclusion: Hyperglycemia episodes were more prominent than hypoglycemia episodes in diabetes patients receiving sliding scale insulin. The rate of hyperglycemia was much higher than the previous studies.

Keywords: Episodes, hyperglycemia, hypoglycemia, sliding scale insulin.

Diabetes mellitus is a common diagnosis in hospitalized patients. The number of diabetics is increasing due to population growth, aging, urbanization and increase prevalence of obesity and lack of exercise [1]. In Malaysia, the prevalence was 9.4 % in 2003 and it is estimated to be 12.4 % in 2025 [2].

Diabetes patients are often hospitalized due to acute hyperglycemia secondary to serious infection, diabetic ketoacidosis (DKA) or hyperglycemia hyperosmolar syndrome (HHS), previously known as hyperosmolar non-ketotic coma (HONK). Poor glycemic control in these patients increases their susceptibility to complications and lengthens their hospital stays [3]. As a result, optimal control of blood glucose level in hospitalized diabetic patients is of paramount importance. Improvement of glucose control during hospitalization is able to reduce mortality, requirement for extended care, length of stay and overall cost of care for antibiotic [4].

The most common regimen used in treatment of acute hyperglycemia during hospitalization is the sliding scale insulin. Typically, sliding scale insulin may be warranted when a diabetic patient develops acute hyperglycemia episode secondary to infection, DKA, HHS or other precipitating factors that may lead to acute hyperglycemia.

Several studies have reported no benefit or no difference between the addition of an SSI regimen to routine medications. However, sliding scale insulin is frequently used for inpatient management of hyperglycemia and is associated with a large number of medication errors and adverse events including hypoglycemia and hyperglycemia [5].

A study on the use of sliding scale insulin at University of Malaya Medical Centre (UMMC) was carried out to assess patient's blood glucose control while they were on sliding scale insulin. The objective of this study is to study the patient's rate of hypoglycemia and hyperglycemia episodes during the use of sliding scale insulin.

Methods

A cross-sectional study was carried out after the approval from the Ethical Committee of UMMC. Data were collected prospectively from December 2005 to February 2006.

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The study participants for this study were all patients admitted to the endocrine ward of the UMMC who fulfilled the following criteria. The inclusion criteria were: i) all diabetes patients who were on the sliding scale insulin; ii) adult patients who were equal or more than 18 years old. The exclusion criteria were: i) patients with diabetic pregnancies; ii) patients who were not on the sliding scale insulin; iii) patients who were less than 18 years old.

The following data were collected from the patient's case note: i) patient's registration number (RN); ii) patient's demographic data; iii) main diagnosis for hospital admission; iv) date of initiation and termination of sliding scale insulin; v) blood glucose levels before and after initiation of sliding scale insulin; vi) regimen of sliding scale insulin.

Glycemic controls of the patients were assessed through rates of hypoglycemia and hyperglycemia episodes. Hypoglycemia was defined as blood glucose level lower than 3.3 mmol/L (60 mg/dL), while hyperglycemia was defined as blood glucose level greater than 16.5 mmol/L (300 mg/dL). These cut-off limits were based on a previous study [6].

Episode rate was derived by dividing the episodes with the total number of glucose level measurements taken. Episode rate was used to assess the patient's glucose control while they were on sliding scale insulin as follows [6]:

Rate of hyperglycemia episode = (Number of hyperglycemia episodes)/(Total number of glucose level measurement). (1)

Rate of hypoglycemia episode = (Number of hypoglycemia episodes)/ (Total number of glucose level measurement). (2)

The mean and standard deviation of the blood glucose levels were also calculated to observe the control of blood glucose. The main hospital diagnosis for patients receiving sliding scale insulin was obtained and documented. Uncontrolled diabetes mellitus was defined as a blood glucose level greater than 9.9 mmol/L [7, 8] excluding cases of DKA and HHS. Acute hyperglycemia is defined as blood glucose level greater than 15 mmol/L [9, 10].

Statistics

Data was tested for normality using skewness and kurtosis. If the skewness and kurtosis values were between -2 and 2, the data were considered to be of a normal distribution. All data were processed using the Statistical Package of Social Science (SPSS).

Results

A total of 52 patients were included in this study from Dec 2005 - Feb 2006. The majority of patients (around 60 %) were more than 50 years old. The numbers of male and female patients in this study were equal. The Indian contributed to the highest race in male (50 %), whereas the Malay contributed to the highest race in female patients (38.4 %).

Figure 1 shows blood glucose levels before the initiation of sliding scale insulin.

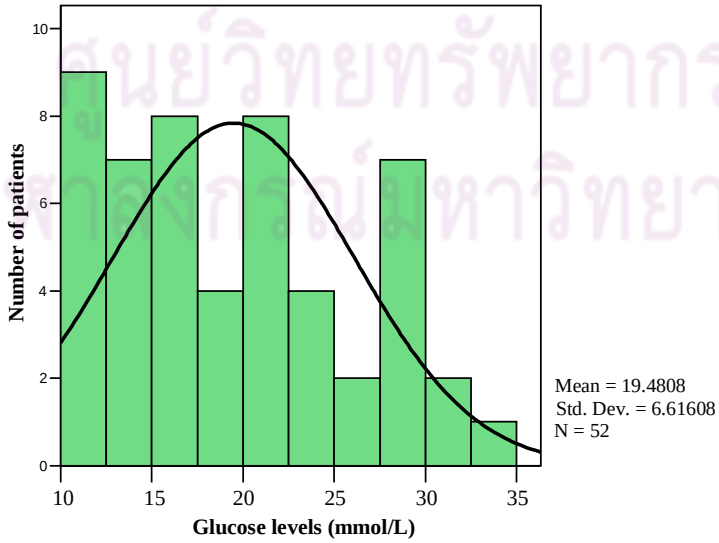

Fig. 1 Blood glucose levels measured before the initiation of sliding scale insulin. (Skewness = 0.383, standard error of skewness = 0.330, kurtosis = -0.907, standard error of kurtosis = 0.650.)

Data was tested for normality, using the skewness and kurtosis levels. **Figure 2** shows blood glucose levels, indicating that it was of a normal distribution. The mean blood glucose level before the initiation of sliding scale insulin was 19.48 mmol/L (range from 10.2 mmol/L to 33.3 mmol/L). Since the data was normal, 68 % of the data was within one standard deviation from the mean, which was from 12.9 mmol/L to 26.1 mmol/L. About 95 % of the data ranged between 6.3 mmol/L and 32.7 mmol/L (within 2 units of standard deviation).

A total of 970 glucose measurements were obtained in 52 patients, giving an average of 19 glucose measurements per patient. The lowest glucose level obtained was 2 mmol/L and the highest was 33.3 mmol/L. The mean SD blood glucose level during the use of sliding scale insulin was 12.3 5.5 mmol/L. (refer to Figure 2). The distribution of blood glucose levels during the use of sliding scale insulin was in a normal distribution. Around 68 % of the blood glucose levels fell in the range of 6.8 mmol/L to 17.8 mmol/L (within 1 unit of standard deviation). A total of 95 % of the blood glucose levels were ranged from 1.3 mmol/L to 23.3 mmol/L (within 2 units of standard deviation).

Out of all the 970 glucose measurements, 7 episodes of hypoglycemia and 191 episodes of hyperglycemia were found. The overall hypoglycemia and hyperglycemia rates were 0.7 and 19.7 per 100 glucose measurements respectively.

The overall rates of hypoglycemia and hyperglycemia episodes are summarized in **Table 1**. Out of 52 patients, 12 % of the patients had at least 1 episode of hypoglycemia while 83 % of the patients had at least 1 episode of hyperglycemia during the use of sliding scale insulin.

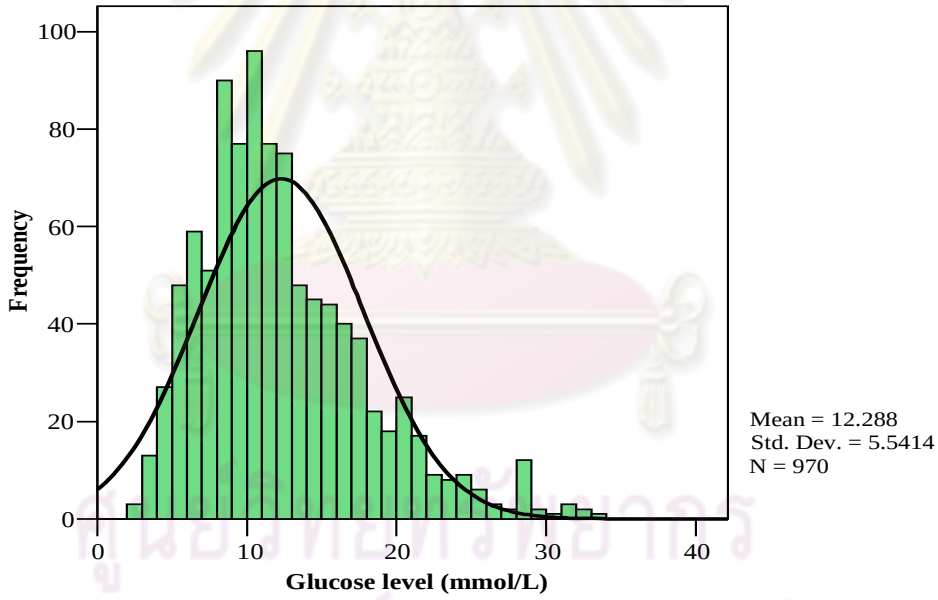

Fig. 2 Blood glucose levels measured during the use of sliding scale insulin. (Skewness = 0.383, standard error of skewness = 0.330, kurtosis = -0.907, standard error of kurtosis = 0.650.)

Table 1. Hypoglycemia and hyperglycemia episodes.

Number of episodes	Frequency (%)	
	Hypoglycemia episodes	Hyperglycemia episodes
0 episodes	46 (88.5)	9 (17.3)
1 episodese	5 (9.6)	8 (15.4)
≥ 2 episodes	1 (1.9)	35 (67.3)
Total	52 (100.0)	52 (100.0)

The main hospital diagnosis among patients receiving the sliding scale insulin was uncontrolled diabetes (50 %), followed by DKA (40.4 %) and HHS (9.6 %).

A total of 60 sliding scale insulin regimens were recorded in this study. A total of 36 types sliding scale regimens prescribed by the prescribers. The sliding scale insulin regimens may differ in terms of the starting dose of the insulin and the variation of glucose level range in which the dose of sliding scale insulin needs to be adjusted. In 86.5 % of the patients, only one type of sliding scale insulin regimen was used. The sliding scale was left unchanged throughout the duration of use. More than half of the patients (57.7 %) were put on sliding scale insulin for two days. The mean ± SD duration of sliding scale insulin usage was 2.6 ± 1.3 days.

Discussion

In our study, more than half of the patients were in the age range of 41-65 years old and were placed on sliding scale insulin. The mean blood glucose levels before the initiation of sliding scale insulin were 19.5 ± 6.6 mmol/L (range from 10.2 mmol/L to 33.3 mmol/L). This indicates that sliding scale insulin was initiated mainly in acute hyperglycemia episodes. However, sliding scale insulin was started at a lower blood glucose levels for Queale et al. study [6], which was 11.7 ± 5.9 mmol/L. This may be due to difference of practice in managing hospitalized diabetic patients. In our study, there were an equal number of patients with uncontrolled diabetes and acute hyperglycemia events such as DKA and HHS receiving the sliding scale insulin. As for their study, their participants were individuals with diabetes as a comorbid condition, where patients were excluded if they were admitted with a diagnosis of DKA or HHS. Hence, the sliding scale insulin was initiated at a lower blood glucose level.

This study also demonstrates that blood glucose controls were poor in patients using sliding scale insulin. There were fluctuations in the blood glucose levels. The hypoglycemia and hyperglycemia rates were remarkably high with a mean glucose level of 12.3 5.5 mmol/L. Around 68 % of the blood glucose levels were in the range of 6.8 mmol/L to 17.8 mmol/L. This indicates that hyperglycemia events were common. Compared with the study by Queale et al. [6], the hypoglycemia rate they obtained was 3.4 per 100 glucose measurements, while in this study this was slightly lower, 0.7 per 100 glucose measurements. This may be contributed by the different demographic characteristics of the patients. Their study participants were mainly African American. Different races may have slightly different pharmacokinetics properties, thus insulin absorption and excretion will not be the same. Genetic differences may also affect insulin efficacy [11]. Other than that, different regimen of sliding scale insulin may also contribute to the different in hypoglycemia rate. There is also a probability that sliding scale insulin regimen used in our study was more capable to prevent the hypoglycemia events. However further studies need to be done to conclude this findings.

The poor glycemic control during the use of sliding scale insulin can be explained in a few points. First, the regimens allow hyperglycemia to happen and tend to treat hyperglycemic episodes only after their occurrence [3]. Although blood glucose levels were monitored closely, glycemic events continue to happen. Therefore, in our study, more than 80% of the patients experienced at least one episode of hyperglycemia. Secondly, the sliding scale regimens were hardly individualized. Furthermore, the regimens were rarely modified and patients will be using the same regimen scale throughout the use. Usually, the prescribers will only be informed by the nurses if the glucose level exceeds 20 mmol/L. By the time they were being informed, the patients were already in acute hyperglycemia states, which will lead to multiple complications such as increase in mortality and length of hospitalization [4].

The present study also showed that sliding scale insulin was commonly warranted in DKA and HHS besides patients diagnosed with uncontrolled diabetes. This group of patients usually admitted with a blood glucose level of more than 15 mmol/L, which is considered as an acute hyperglycemia state [9, 10]. Insufficient of insulin and over secretion of regulatory hormones such as glucagons eventually lead to a fluctuation in blood glucose levels [12]. These patients are potential candidates for sliding scale insulin because it is believed that the acute hyperglycemia state can be effectively managed by this regimen. However, the present study reflected that hyperglycemic rate remained high with its use.

Sliding scale insulin regimens are often prescribed in patients with acute hyperglycemia although its effectiveness is unclear [13]. Our study showed that sliding scale insulin regimens differed from prescribers

to prescribers. In more than 85 % of the patients, their sliding scale insulin regimens were left unchanged throughout their use. Commonly, sliding scale insulin regimens were prescribed to the patients immediately after their admission to the hospital. More than half of the patients continued the regimens for two days, in which later on they switched to subcutaneous insulin or oral hypoglycemic agents. Sliding scale insulin regimen was used in the initial days of admission in believe that it is able to provide a better glycemic control. Our study showed that both hyperglycemia and hypoglycemia episodes did occur in patients receiving sliding scale insulin.

In conclusion, hyperglycemia episodes were more prominent in patients receiving sliding scale insulin therapy. The rate of hyperglycemia was much higher than the previous studies. Uncontrolled diabetes and acute hyperglycemia were common hospital diagnosis encountered in patients receiving sliding scale insulin.

The authors have no conflict of interest to report.

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