

ORIGINAL ARTICLE

**Prevalence of Hyperglycemia and Hypoglycemia among
Adult Inpatients at a University Hospital
in Saudi Arabia**

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Abstract. The objective of the study is to estimate the prevalence of hyperglycemia and hypoglycemia in adult inpatients and to evaluate the use of insulin sliding scale in preventing hyperglycemia and hypoglycemia. A cross-sectional study was performed between May 1-7, 2012 on adult inpatients at King Abdulaziz University Hospital, Jeddah, Saudi Arabia, documenting the patients' blood glucose values and the method of blood glucose management. Data were collected and analyzed using the Statistical Package for Social Sciences and Excel. Of the 280 included inpatients, the overall prevalence of diabetes and hyperglycemia was 39.3%. For patients with type 1 diabetes, the prevalence of severe hyperglycemia was 38.5% versus 17.6% in those with type 2 diabetes (P-value = 0.0001). Hypoglycemia was more prevalent among patients with type 1 diabetes (38.5%) compared to patients with type 2 diabetes (14.1%) (P-value = 0.0001). The type of insulin regimen used did not significantly affect the prevalence of hyperglycemia or hypoglycemia. The high prevalence of hyperglycemia and hypoglycemia among adult inpatients with diabetes and hyperglycemia indicates poor control of blood glucose levels, suggesting an urgent need to review the methods used in controlling blood glucose levels in inpatients at King Abdulaziz University Hospital.

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Introduction

Diabetes mellitus (DM) is one of the most common diseases in Saudi Arabia, afflicting an estimated 17.9% to 30% of the population^[1-4]. This can be attributed to the high prevalence of overweight (69%), obesity (33%), and other factors including poor physical activity and genetic influence^[1,5]. Good blood glucose control in inpatients has been related to better quality of care and fewer complications^[6]. Hyperglycemia has been associated with an increased risk of acute myocardial infarction and congestive heart failure^[7]. The American Association of Clinical Endocrinologists and American Diabetes Association (2009) consensus statement on inpatient glycemic control states that there is a “strong association between hyperglycemia and poor clinical outcomes, including prolonged hospital stay, infection, disability after discharge from the hospital, and death” in the non-intensive care unit (ICU) surgical setting^[8].

Hypoglycemia is associated with increased mortality and adverse outcome in hospitalized patients^[9]. Furthermore, insulin use in hospitals has been identified as one of the commonest drugs involved in medication errors: Recorded at a rate of 1.72 errors per patient period of treatment^[10,11]. This study aims to estimate the prevalence of hyperglycemia and hypoglycemia and to evaluate the treatment of inpatients with hyperglycemia at King Abdulaziz University Hospital (KAUH), Jeddah, Saudi Arabia.

Method

A cross-sectional study was performed on patients who were hospitalized at KAUH between May 1 and May 7, 2012. The Biomedical Ethics Committee of King Abdulaziz University approved the study.

All adult patients hospitalized during the study period were included. All patients who were younger than 18 years, hospitalized

in the ICU, pediatric wards or the emergency room, and those who had gestational diabetes were excluded.

For all patients included in the study, data was collected from hospital inpatient files, charts, and the hospital information system. The patients' blood glucose values were recorded from the day that samples were collected, in addition to the results of all blood glucose tests that had been performed up to one week prior. The type of treatment administered for blood glucose management was also documented.

For the purpose of this study, hyperglycemia is defined as a blood glucose level > 200 mg/dL (10 mmol/L) and hypoglycemia as any blood glucose level < 60 mg/dL^[6]. This study further categorizes hyperglycemia into mild (200 to 250 mg/dL) and severe (> 250 mg/dL). Persistent hyperglycemia was defined as at least one blood glucose value > 200 mg/dL for three consecutive days.

Patients were categorized into three groups: Patients with type 1 DM, type 2 DM, and those with hyperglycemia, who developed blood glucose levels ≥ 200 mg/dL during hospitalization but were not known to have diabetes before admission.

The Statistical Package for the Social Sciences, version 16 (SPSS Inc., Chicago, IL, USA) and Excel 2007 (Microsoft Corp., Seattle, WA USA) were used to analyze data. Pearson's chi-square (χ^2) equation was used to study the significance of the results. Statistical significance was set at P-value < 0.05 .

Results

This study includes 280 inpatients (113 men and 167 women) from the medical, surgical, obstetrics and gynecology wards, and the emergency and isolation units. The patients' age ranged from 18-101 years (mean, 49.4 years). Only 4.9% of the patients were admitted primarily for diabetes; the rest of the patients were admitted for non-diabetes-related causes.

The prevalence of diabetes and hyperglycemia was 39.3%. Thirteen (4.6%) patients had type 1 diabetes, 85 (30.4%) had type 2

diabetes, and 12 (4.3%) non-diabetic patients developed hyperglycemia during hospitalization (Table 1).

Table 1. Prevalence of type 1 diabetes, type 2 diabetes, and hyperglycemia among adult inpatients and prevalence of hyperglycemia and hypoglycemia among the three groups.

	Diabetes		Hyperglycemia	P-value
	Type 1	Type 2		
Prevalence	4.6 %, n=13	30.4%, n=85	4.3%, n=12	0.0001
Hyperglycemia	92.3%	81.2%	N/A	0.0001
Severe Hyperglycemia	38.1%	17.6%	8.3%	0.0001
Persistent Hyperglycemia	61.5%	48.2%	50.0%	0.0001
Hypoglycemia	38.5%	14.1%	16.7%	0.0001

Three insulin regimens, regular insulin sliding scale, insulin glargine, and insulin aspart, and neutral protamine Hagedorn and regular insulin sliding scale, were commonly used in the management of blood glucose. Eighty-one of the 110 patients with diabetes or hyperglycemia were treated with one of these insulin regimens: 61 (75.3%) were on regular insulin sliding scale, 9 (11.1%) were on insulin glargine and insulin aspart, and 11 (13.6%) were on neutral protamine Hagedorn and regular insulin sliding scale. The 29 remaining patients were excluded due to using other treatments such as oral hypoglycemic drugs, insulin glargine alone, and neutral protamine Hagedorn alone.

Hyperglycemia was significantly more frequent in patients with type 1 diabetes than in patients with type 2 diabetes (92.3% in type 1 diabetes versus 81.2% in type 2 diabetes; P-value = 0.0001). Similarly, severe hyperglycemia was more frequent in patients with type 1 diabetes (38.5% in type 1 diabetes versus 17.6% in type 2 diabetes; P-value = 0.0001). The type of insulin regimen used did not significantly affect the prevalence of hyperglycemia (P-value = 0.365) or severe hyperglycemia (P-value = 0.186) in the patients (Tables 2 and 3).

The overall prevalence of persistent hyperglycemia was 50%. Patients with type 1 diabetes had significantly more persistent hyperglycemia (61.5%) than patients with type 2 diabetes (48.2%) and those with hyperglycemia (50%) (P-value < 0.0001). The type of

insulin regimen administered did not have a significant effect on the prevalence of persistent hyperglycemia (P-value 0.203) (Table 4).

Table 2. Insulin type versus hyperglycemia.

			Hyperglycemia		Total
			No	Yes	
Insulin.Type	Regular ISS	Count	10	51	61
		% within Insulin.Type	16.4%	83.6%	100.0%
		% of Total	12.3%	63.0%	75.3%
	Lantus and Novorapid	Count	0	9	9
		% within Insulin.Type	.0%	100.0%	100.0%
		% of Total	.0%	11.1%	11.1%
	NPH and regular ISS	Count	1	10	11
		% within Insulin.Type	9.1%	90.9%	100.0%
		% of Total	1.2%	12.3%	13.6%
Total		Count	11	70	81
		% within Insulin.Type	13.6%	86.4%	100.0%
		% of Total	13.6%	86.4%	100.0%

Chi-Square (χ^2) Tests			
	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	2.015 [†]	2	.365
Likelihood Ratio	3.227	2	.199
Linear-by-Linear Association	.999	1	.318
No. of Valid Cases	81		

ISS: Insulin Sliding Scale; NPH: Neutral Protamine Hagedorn insulin; [†]Two cells (33.3%) have expected count less than 5. The minimum expected count is 1.22.

Table 3. Insulin type versus severe hyperglycemia.

			Severe Hyperglycemia		Total
			No	Yes	
Insulin.Type	Regular ISS	Count	50	11	61
		% within Insulin.Type	82.0%	18.0%	100.0%
		% of Total	61.7%	13.6%	75.3%
	Lantus and Novorapid	Count	5	4	9
		% within Insulin.Type	55.6%	44.4%	100.0%
		% of Total	6.2%	4.9%	11.1%
	NPH and regular ISS	Count	9	2	11
		% within Insulin.Type	81.8%	18.2%	100.0%
		% of Total	11.1%	2.5%	13.6%
Total		Count	64	17	81
		% within Insulin.Type	79.0%	21.0%	100.0%
		% of Total	79.0%	21.0%	100.0%

Chi-Square (χ^2) Tests			
	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	3.360 [†]	2	.186
Likelihood Ratio	2.867	2	.238
Linear-by-Linear Association	.323	1	.570
N of Valid Cases	81		

ISS: Insulin Sliding Scale; NPH: Neutral Protamine Hagedorn insulin; [†]Two cells (33.3%) have expected count less than 5. The minimum expected count is 1.89.

Table 4. Insulin type versus persistent hyperglycemia.

			Persistent Hyperglycemia (3days)		Total
			No	Yes	
Insulin.Type	Regular ISS	Count	29	32	61
		% within Insulin.Type	47.5%	52.5%	100.0%
		% of Total	35.8%	39.5%	75.3%
	Lantus and Novorapid	Count	2	7	9
		% within Insulin.Type	22.2%	77.8%	100.0%
		% of Total	2.5%	8.6%	11.1%
	NPH and regular ISS	Count	3	8	11
		% within Insulin.Type	27.3%	72.7%	100.0%
		% of Total	3.7%	9.9%	13.6%
Total		Count	34	47	81
		% within Insulin.Type	42.0%	58.0%	100.0%
		% of Total	42.0%	58.0%	100.0%

Chi-Square (χ^2) Tests			
	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	3.194 [†]	2	.203
Likelihood Ratio	3.352	2	.187
Linear-by-Linear Association	2.477	1	.116
N of Valid Cases	81		

ISS: Insulin Sliding Scale; NPH: Neutral Protamine Hagedorn insulin; [†]Two cells (33.3%) have expected count less than 5. The minimum expected count is 3.78.

The prevalence of hypoglycemia in patients with type 1 diabetes, type 2 diabetes, and hyperglycemia was 38.5%, 14.1%, and 16.7%, respectively (P-value = 0.0001). The type of insulin regimen administered did not have a significant effect on the prevalence of hypoglycemia (P-value = 0.113).

Discussion

This study aimed to estimate the prevalence of hyperglycemia and hypoglycemia among a group of adult inpatients and to evaluate the use of insulin sliding scale in preventing hyperglycemia and

hypoglycemia at KAUH. The results demonstrate that the prevalence of diabetes and hyperglycemia was 39.3%. This figure is higher than in the literature, with one-quarter to one-third of hospitalized patients reported as having diabetes and/or experiencing significant hyperglycemia during hospitalization^[6,12,13]. The high prevalence in the study can be attributed to the fact that diabetes is a major health problem in Saudi Arabia, with an overall prevalence estimated at 23.7%^[3].

This study found that hyperglycemia, severe hyperglycemia, and persistent hyperglycemia were significantly more frequent in patients with type 1 diabetes, demonstrating the need for immediate action and the difficulty in improving blood glucose levels in patients with type 1 DM. Similarly, hypoglycemia was significantly more frequent in patients with type 1 diabetes than in patients with type 2 diabetes, which is in keeping with the results from other studies^[6,14,15]. Patients with type 1 DM have been reported to be more prone to hypoglycemia mainly because the use of exogenous insulin to achieve glycemic control precludes the body's initial mechanism to prevent hypoglycemia^[16]. Furthermore, findings from one study showed that even when compared with insulin-treated type 2 diabetic patients, hypoglycemic events were more common in individuals with type 1 DM^[17].

This study found that the type of insulin regimen administered did not significantly affect the prevalence of hyperglycemia and severe hyperglycemia among patients with type 1 and type 2 diabetes. Similarly, this study found that the type of insulin regimen administered did not significantly affect the prevalence of hypoglycemia. However, scheduled basal/bolus insulin is recommended over "sliding scale insulin" as the former is designed to prevent hyperglycemia, whereas the latter only attempts to lower the hyperglycemia after it has occurred. A study comparing scheduled basal/bolus insulin to sliding scale insulin showed that a significantly higher percentage of patients achieved goal glucose levels in the basal/bolus group than in the sliding scale group (66% versus 38%) without an increase in hypoglycemia^[18,19]. However, this study did not find the basal-bolus regimen to be superior to the regular insulin

sliding scale. This can be attributed to the small number of patients who were on the basal-bolus regimen ($n = 9$) as compared with the majority who were on regular insulin sliding scale ($n = 61$). Moreover, no specific insulin protocol was followed in all three groups of patients (hyperglycemia, type 1 and type 2 diabetic).

Persistent hyperglycemia has been reported to occur in 18-38% of diabetic inpatients^[6]. In the current study, persistent hyperglycemia occurred in 50% of the study population and up to 61.5% of the patients with type 1 diabetes. This reflects poor glycemic control, which has been reported to be a marker of poor quality of hospital care^[20].

In this study most of the patients with diabetes or hyperglycemia were on the regular insulin sliding scale ($n = 61$, 75.3%) and this may explain the high level of persistent hyperglycemia, which occurred in 50% of the study population, as previous studies have demonstrated the inferiority of regular insulin sliding scale in comparison to the basal-bolus regimen^[18,19]. Another study showed that the administration of sliding-scale insulin by itself was found to be associated with a 20 mg/dL higher mean glucose level per patient-day^[21].

Upon reviewing Tables 2, 3, and 4, one finds that 61 patients were on the regular insulin sliding scale and the percentage of these patients with persistent hyperglycemia, and severe hyperglycemia was 52.5% and 18%, respectively. The glargine (Lantus) and aspart (Novorapid) group included only nine patients and the percentage with persistent hyperglycemia, and severe hyperglycemia was 77.8% and 44.4%, respectively. The Neutral Protamine Hagedorn (NPH) and regular insulin sliding scale group included 11 patients and the percentages with persistent hyperglycemia, and severe hyperglycemia were 72.7% and 18.2%, respectively. From a first glance, this study would suggest regular insulin sliding scale is better in controlling hyperglycemia but Pearson's chi-squared analysis did not show a significant difference between the three groups. It appears the basal-bolus group was not placed on enough insulin from the start and were not given additional corrective insulin aspart doses as needed.

Indeed, the basal-bolus regimen has been shown to be better than the regular insulin sliding scale in previous studies. However, this regimen needs to be administered correctly, meaning that doses need to be calculated according to body mass index, associated co-morbid conditions (*e.g.*, hemodialysis), age, use of steroids and degree of insulin resistance. Also, for the basal-bolus regimen to be effective additional corrective doses of aspart must be administered as needed. In the hospital studied, no specific protocol is set forth for the basal-bolus regimen.

Uncontrolled hyperglycemia in hospitalized patients is associated with adverse outcomes and longer lengths of stay^[7,8,22]. Acute illness, inconsistent caloric intake, and changes from home medications are all obstacles to managing inpatient hyperglycemia. Controlling glucose and avoiding hypoglycemia is challenging even for experienced clinicians.

The current study shows shortcomings in the management of inpatient hyperglycemia. A larger prospective study is warranted to determine safer and more effective ways of managing serum glucose levels in inpatients at KAUH. More importantly, the authors suggest that insulin protocols should be developed and implemented in order to reduce persistent hyperglycemia and hypoglycemia among diabetic and hyperglycemic inpatients at KAUH^[23].

The idea of this study is two-part. First, to determine the prevalence of hyperglycemia among adult inpatients, which was determined to be 39.3%. This is higher than the one-quarter to one-third that has been reported in the literature and can be explained by a higher prevalence of diabetes in Saudi Arabia compared to the rest of the world. This study is novel in determining the prevalence of hyperglycemia among adult inpatients in a Saudi hospital. The second part is to determine whether different insulin regimens yield differing effect on blood glucose control and in particular whether the basal-bolus regimen performed better than regular insulin sliding scale. In regards to the second part of the study, the conclusion was negative, with explanations set forth above.

This study had some limitations. The small number of patients who were on long-acting insulin did not permit relevant comparisons with patients on other insulin regimens, thus causing difficulty in assessing the efficacy of treatment.

Disclosure of Benefit

The authors have no conflict of interest.

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مدى إنتشار إرتفاع وإنخفاض السكر لدى المرضى الكبار المنومين بمستشفى جامعي بالسعودية

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المستخلص. غرض الدراسة هو تحديد نسبة إنتشار إرتفاع وإنخفاض السكر لدى المرضى الكبار المنومين بمستشفى جامعة الملك عبد العزيز بجدة ودراسة فاعلية استخدام الانسولين حسب سلم متدرج في تجنب إرتفاع وإنخفاض السكر. جمعت بيانات ٢٨٠ مريض منوم بين ١-٢٠١٢/٥/٧م وأتضح ان نسبة إنتشار إرتفاع السكر لدى المرضى كان ٣٩,٣%. نسبة انتشار ارتفاع السكر الشديد لدى مرضى السكر النوع الاول كان ٣٨,٥% ولدى مرضى السكر النوع الثاني كان ١٧,٦%. إنخفاض السكر كان منتشرأ أكثر لدى مرضى السكر النوع الأول (٣٨,٥%) مقارنة بمرضى السكر النوع الثاني (١٤,١%). نوعية أسلوب الانسولين المستخدم لم يؤثر على نسبة انتشار إرتفاع أو إنخفاض السكر. نسبة الإنتشار العالية لإرتفاع وإنخفاض السكر لدى المرضى الكبار المنومين يستوجب مراجعة الأساليب المتبعة لضبط السكر بمستشفى جامعة الملك عبد العزيز.