ORIGINAL ARTICLE

Impact of screening and monitoring of capillary blood glucose in the detection of hyperglycemia and hypoglycemia in non-critical inpatients

Impacto do rastreamento e monitoramento de glicemia capilar na detecção de hiperglicemia e hipoglicemia em pacientes não graves internados

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ABSTRACT

Objective: To evaluate the impact of screening hyper and hypoglycemia measured by capillary glycemia and standard monitorization of hyperglycemic patients hospitalized in regular care units of Hospital Israelita Albert Einstein. **Methods:** The capillary glycemia was measured by the Precision PCx (Abbott) glucosimeter, using the PrecisionWeb (Abbott) software. The detection of hyper and hypoglycemia during the months of May/June were compared to those of March/April in 2009 and to the frequency of the diagnosis of diabetes in 2007. **Results:** There was an increase in the glycemia screening from 27.7 to 77.5% of hospitalized patients (p < 0.001), of hyperglycemia detection (from 9.3 to 12.2%; p < 0.001) and of hypoglycemia (from 1.5 to 3.3%; p < 0.001) during the months of May/June 2009. According to this action 14 patients for each additional case of hyperglycemia and 26 cases for each case of hypoglycemia were identified. The detection of hyperglycemia was significantly higher (p < 0.001) than the frequency of registered diagnosis related do diabetes in the year of 2007. **Conclusions:** the adoption of an institutional program of glycemia monitorization improves the detection of hyper and hypoglycemia and glycemia control in hospitalized patients in regular care units.

Keywords: Blood glucose/diagnosis; Hyperglycemia/diagnosis; Hypoglycemia/diagnosis; Inpatients

RESUMO

Objetivo: Analisar o impacto do rastreamento de hiper e hipoglicemia mensurada por glicemia capilar e da monitorização padronizada em pacientes hiperglicêmicos internados em unidades não graves do Hospital Israelita Albert Einstein. **Métodos:** A glicemia capilar foi mensurada com glucosímetro Precision PCx (Abbott), rastreada com *software* PrecisionWeb (Abbott). A detecção de hiper e hipoglicemia no bimestre Maio/Junho foi comparada ao bimestre Março/Abril de 2009 e ainda quanto à frequência de diagnósticos relacionados ao diabetes no ano de 2007. **Resultados:** Houve um aumento do rastreamento de glicemia de 27,7 para 77,5% dos pacientes internados (p < 0,001), na detecção de hiperglicemia (de 9,3 para 12,2%; p < 0,001) e de hipoglicemia (de 1,5 para 3,3%; p < 0,001) no bimestre Maio-Junho de 2009. Com essa iniciativa, foram rastreados 14 pacientes para cada caso adicional de hiperglicemia e 26 pacientes para cada caso de hipoglicemia. A detecção de hiperglicemia foi significantemente maior (p < 0,001) que a frequência de registros de diagnósticos relacionados ao diabetes no ano de 2007. **Conclusões:** a adoção de um programa institucional de monitoramento de glicemia melhora a detecção de hiper e hipoglicemia e o controle de glicemia em pacientes internados em unidades não graves.

Descritores: Glicemia/diagnóstico; Hiperglicemia/diagnóstico; Hipoglicemia/diagnóstico; Pacientes internados

INTRODUCTION

Diabetes is a disease of growing prevalence all over the world[1]. Population data of cities in São Paulo State indicate an increase prevalence of diabetes in the region, estimated to be approximately 12%[2]. In its initial stage, diabetes is frequently asymptomatic, and it is generally diagnosed through routine tests. Considering the low compliance to screening tests in the population, about half of the individuals affected are not aware of their diagnosis[3]. In hospitals, the prevalence of diabetes is higher than in the overall population, accounting for

25 to 35% of inpatients[4,5]. The prevalence is greater in high complexity units, varying between 10 and 12% in non-intensive units up to about 50% in intensive care units[5]. The higher prevalence can be explained by the association between diabetes and cardiovascular, metabolic and infectious complications that require hospitalization for treatment. Of the diabetic patients hospitalized, 4 to 10% do not know the diagnosis[5,6]. Despite the high prevalence, the diagnosis of diabetes is frequently omitted in the admission records, clinical progression reports and in hospital discharge summaries[5-7]. Additionally, transient blood glucose abnormalities associated to stress may occur in up to 12% of individuals with no past history of diabetes[8].

The presence of hyperglycemia due to diabetes or triggered by stress has a negative influence in the clinical course of patients admitted for any other reason. Every rise by 50 mg/dL in an inpatient increases perioperative mortality in non-cardiac and non-vascular surgeries by 52%, increases four times the risk of complications (renal failure, sepsis and death) in patients receiving parenteral nutrition, makes hospital stays 0.76 day longer and rises the cost by US$ 1,769.00 in those undergoing revascularization. On the other hand, the treatment of hyperglycemia in inpatients is facilitated by nursing continued care and it can reduce the incidence of complications and mortality[4,9-11].

Hypoglycemia has been recently associated with higher hospital mortality both in critical and noncritical patients[12-14]. Given the variety of symptoms associated to hypoglycemia and the presence of several comorbidities that cause symptoms in patients, blood glucose monitoring is fundamental in the diagnosis and treatment of hypoglycemia. Treatment of hypoglycemia requires oral administration of glucose in conscious patients (majority of cases) or intravenous administration in unconscious patients[14].

Glucose can be assessed in plasma or through capillary blood glucose test devices at the bedside complying with quality controls necessary for reliable measurements. According to recommendations and guidelines, blood glucose values in inpatients should not be higher than 180 mg/dL or lower than 60 mg/dL. The assistance of professionals trained in diabetes care, nutritional orientations and the use of standardized insulin therapy regimens lead to efficient and safe control of hyper and hypoglycemia and the costs of treatment are lower than those of complications[14].

Considering the high frequency of blood glucose abnormalities in inpatients, the asymptomatic character of the condition and the patient's lack of knowledge about hyperglycemia or diabetes, underreport of diabetes in medical charts, the influence of hyperglycemia in morbidity/mortality of inpatients, the availability of diagnostic test with well defined normalcy limits and of treatment, screening of the glucose abnormalities by means of capillary blood glucose could be an interesting improvement in quality of care, thus reducing duration and cost of hospitalization[14].

As from May 2009, the nursing coordinator and the medical director of Hospital Israelita Albert Einstein (HIAE) standardized the screening of glucose abnormalities in all inpatients and monitoring of blood glucose in four periods (before main meals and at 9:00 pm) in patients with abnormal glucose levels.

OBJECTIVE

To assess the impact of screening and monitoring of capillary blood glucose in diagnosis of hyper and hypoglycemia in patients at non-severe units.

METHODS

To evaluate the detection of diabetes at the HIAE, the medical charts of patients admitted between 2002 and 2007 were analyzed; a patient was considered diabetic if he or she had a record of diagnosis of the condition, complications due to diabetes (neuropathy or retinopathy), gestational diabetes according to the international classification of diseases (ICD-10) and prescription of insulin.

To evaluate the impact of blood glucose screening, the data of capillary blood glucose of all patients admitted to the Internal Medicine-Surgery units at HIAE, where non-critical patients were considered, from March 1st to June 30, 2009, a period during which the screening of capillary blood glucose was implemented. Patients were identified from their medical chart number during capillary blood glucose test. Those who did not undergo capillary blood glucose test were identified through discharge summary data provided by the hospital management system.

Capillary blood glucose was measured using a glucometer (Precision PCx (Abbott®). The quality control of this device is performed based on the coefficient of variation of measures in control solutions of standardized high and low concentrations of glucose, and is done every 24 hours. All glucose measurements were sent to the software PrecisionWeb by synchronization units (dock stations) at the admission units, allowing reports organized by patient, site of admission and blood glucose ranges.

The occurrence of hyperglycemia was defined as the measurement of at least one capillary blood glucose ≥ 200 mg/dL, regardless of fasting status or after a meal anytime during hospital stay. In outpatients, one measurement of plasma glucose higher than 200 mg/

dL allows diagnosis of diabetes[14]. The detection of hyperglycemia was defined as the ratio between the total number of charts and the respective blood glucose abnormality during admission and the total number of patients discharged during this period according to the following formula. Analysis of hypoglycemia used the same principles of hyperglycemia, and hypoglycemia was defined as capillary blood glucose ≤ 60 mg/dL.

Detection of hyperglycemia = (total number of medical charts with hyperglycemia) / total number of medical charts of patients discharged during this period

The software Excel (Microsoft) was used for descriptive analysis of data, and GraphPad (Prism) software for statistical analysis.

RESULTS

According to the analysis of recording diagnosis of diabetes and related complications in the medical charts, there was a significant increase in notification in patients hospitalized between 2002 and 2007, as described in table 1.

Table 1. Estimated frequency of diabetes according to patients' records at hospital admission, follow-up and discharge

	2002	2003	2004	2005	2006	2007
Register of diabetes	977	1,028	1,175	1,172	1,398	2,344
Total of inpatients	30,687	32,346	33,985	35,246	35,454	35,224
Estimated frequency (%)	3.2	3.2	3.5	3.3	3.9	6.7

According to the analysis of occurrence of hyper and hypoglycemia, a total of 8,365 patients were admitted to the Internal Medicine-Surgery units at HIAE from March to June 2009, of which 4,490 (53.7%) underwent capillary blood glucose measurement. In that, 907 presented hyperglycemia (10.8% of inpatients) and 206 had hypoglycemia (2.4% of inpatients).

As described in table 2, before standardization of blood glucose screening and monitoring, in March/April 2009, capillary blood glucose was measured in 1,115 out of 4,014 inpatients (27%), of which 373 presented hyperglycemia and 60 presented hypoglycemia. After starting screening and monitoring, in May/June 2009, capillary blood glucose was measured in 3,375 out of 4,350 inpatients (77.5%). A total of 535 patients were identified with hyperglycemia (12.3% of inpatients) and 146 with hypoglycemia (3.4% of inpatients). The increased blood glucose screening of inpatients was associated to a significant rise in detection of hyperglycemia by 32% (160 additional cases diagnosed) as well as in the detection of hypoglycemia by 124%

(86 additional cases). For each additional case of hyper and hypoglycemia detected, 14 and 26 more patients, respectively, were screened as compared to the previous bimester. The detection of hyperglycemia was significantly higher (p < 0.001) than the frequency of records of diagnoses related to diabetes in the last year of analysis (2007).

Table 2. Descriptive and comparative analysis of screened inpatients and detection of hyper or hypoglycemia from March to June 2009

Screening	March/April	May/June	p value*
Screening coverage – screened/inpatients (%)	1,115/4,014 (27.7)	3,375/4,350 (77.5)	< 0.001
Hyperglycemia** – patients (%)	373 (9.3)	534 (12.2)	< 0.001
Hypoglycemia** – patients (%)	60 (1.5)	146 (3.3)	< 0.001
Proportion hypo/hyper	1/6.2	1/3.6	< 0.01

* χ^2 test;   ** frequency in relation to total of inpatients.

DISCUSSION

In this study, standardization of screening and monitoring in four periods increased the detection of hyper and hypoglycemia in patients admitted to non-severe units. The frequency of blood glucose abnormalities was significantly higher than the proportion of patients diagnosed with diabetes, with complications associated to diabetes or with insulin prescription recorded in previous years in inpatients at all admission units of HIAE.

Screening of diabetes has been indicated to individuals with some risk factors, such as age over 45 years, overweight or high blood pressure – population subgroups with diabetes prevalence around 35%. Screening of individuals with risk factors for diabetes increases the sensitivity and specificity of the exams and reduces the number of individuals to be screened in each case found, thus diminishing costs. In the population aged over 45 years and hypertensive, it is necessary to screen between 13 and 48 individuals (median age group = 22.7 individuals) to identify one person with diabetes. In patients admitted to non-severe units, 14 additional individuals were screened compared to the previous bimester to identify an individual with hyperglycemia[14-18].

In population groups at risk for diabetes, the cost-effectiveness of screening is favorable even taking into account the long-term use of monitoring supplies and medications to prevent later outcomes, and the benefit of screening has been demonstrated[14-18]. Although there are no cost-effectiveness analyses of screening at the hospital, it is known that up to half of the expenses in patients with diabetes occur in hospital admissions and the protocols of blood glucose control reduce the chance of complications and mortality with favorable cost-effectiveness ratio[4]. Even with this data, analyses of cost-effectiveness of the blood glucose screening

are necessary for better understanding of the role of screening in the hospital setting.

Although most studies are focused on the influence of hyperglycemia in hospitalization outcomes, hypoglycemia is also associated to increased morbidity and mortality, both in patients at intensive care units and in lower complexity units[12-14]. Hypoglycemia generally occurs in individuals receiving oral medication or insulin to control hyperglycemia and it can be asymptomatic or manifest with unspecific symptoms. In this study, an increased detection of hypoglycemia was observed, which may be caused by greater use of oral hypoglycemic agents and insulin; however, since the increased proportion of cases of hypoglycemia was significantly higher than the rise in cases of hyperglycemia, this is probably due to the higher frequency of blood glucose monitoring in inpatients.

CONCLUSION

Screening of blood glucose in all patients upon admission and blood glucose monitoring at four periods lead to a significant increase in the detection of patients with hyper and hypoglycemia, which are frequently underdiagnosed conditions that influence the clinical course of inpatients in an unfavorable manner.

REFERENCES

1. International Diabetes Federation. Global Burden: Prevalence and Projections, 2010 and 2030. Diabetes Atlas. [cited 2010 Jul 28]. Available from: http://www.diabetesatlas.org/content/diabetes-and-impaired-glucose-tolerance

2. Bosi PL, Carvalho AM, Contrera D, Casale G, Pereira MA, Gronner MF, et al. Prevalência de diabetes melito e tolerância à glicose diminuída na população urbana de 30 a 79 anos da cidade de São Carlos, São Paulo. Arq Bras Endocrinol Metab. 2009;53(6):726-32.

3. Malerbi DA, Franco LJ. Multicenter Study of the Prevalence of Diabetes Mellitus and Impaired Glucose Tolerance in the Urban Brazilian Population Aged 30-69yr. The Brazilian Cooperative Group on the Study of Diabetes Prevalence. Diabetes Care. 1992;15(11):1509-16.

4. Moghissi ES, Korytkowski MT, DiNardo M, Einhorn D, Hellman R, Hirsch IB, Inzucchi SE, Ismail-Beigi F, Kirkman MS, Umpierrez GE; American Association of Clinical Endocrinologists; American Diabetes Association. American Association of Clinical Endocrinologists and American Diabetes Association consensus statement on inpatient glycemic control. Endocr Pract. 2009;15(4):353-69.

5. Wexler DJ, Nathan DM, Grant RW, Regan S, Van Leuvan AL, Cagliero E. Prevalence of elevated hemoglobin A1c among patients admitted to the hospital without a diagnosis of diabetes. J Clin Endocrinol Metab. 2008;93(11):4238-44.

6. Lisbôa HRK, Souilljee M, Cruz CS, Zoletti L, Gobbato DO. Prevalência de hiperglicemia não diagnosticada nos pacientes internados nos hospitais de Passo Fundo, RS. Arq Bras Endocrinol Metab. 2000;44(3):220-6.

7. Carral F, Olveira G, Aguilar M, Ortego J, Gavilán I, Doménech I, et al. Hospital discharge records under-report the prevalence of diabetes in inpatients. Diabetes Res Clin Pract. 2003;59(2):145-51.

8. Umpierrez GE, Isaacs SD, Bazargan N, You X, Thaler LM, Kitabchi AE. Hyperglycemia: an independent marker of in-hospital mortality in patients with undiagnosed diabetes. J Clin Endocrinol Metab. 2002;87(3):978-82.

9. Thompson CL, Dunn KC, Menon MC, Kearns LE, Braithwaite SS. Hyperglycemia in the hospital. Diabetes Spectrum. 2005;18:20-7

10. Cheung NW, Napier B, Zaccaria C, Fletcher JP. Hyperglycemia Is Associated with adverse outcomes in patients receiving total parenteral nutrition. Diabetes Care. 2005;28(10):2367-71.

11. McAlister FA, Man J, Bistritz L, Amad H, Tandom P. Diabetes and coronary artery bypass surgery. Diabetes Care. 2003;26(5)1518-24.

12. Turchin A, Matheny ME, Shubina M, Scanlon JV, Greenwood B, Pendergrass ML. Hypoglycemia and clinical outcomes in patients with diabetes hospitalized in the general ward. Diabetes Care. 2009;32(7):1153-7.

13. Mechanick JI, Handelsman Y, Bloomgarden ZT. Hypoglycemia in the intensive care unit. Curr Opin Clin Nutr Metab Care. 2007;10(2):193-6.

14. American Diabetes Association. Standards of medical care in diabetes-2010. Diabetes Care. 2010;33 Suppl 1:S11-61.

15. American Diabetes Association. Screening for diabetes. Diabetes Care. 2002;25 Suppl:S1-S24.

16. Ealovega MW, Tabaei BP, Brandle M, Burke R, Herman WH. Opportunistic screening for diabetes in routine clinical practice. Diabetes Care. 2004;27(1):9-12.

17. Centers for Disease Control and Prevention. The cost-effectiveness of screening for type 2 diabetes. CDC Diabetes Cost-Effectiveness Study Group, Centers for Disease Control and Prevention. JAMA. 1998;280(20):1757-63.

18. Hoerger TJ, Harris R, Hicks KA, Donahue K, Sorensen S, Engelgau M. Screening for type 2 diabetes mellitus: a cost-effectiveness analysis. Ann Intern Med. 2004;140(9):689-99.