Original Article

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Glucose control in critically ill patients: A single-center cross-sectional study

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ABSTRACT

Background: The global burden of diabetes is alarmingly increasing. These patients constitute a distinct hospitalized group requiring specialized care. Hospitals should strive for the best standards of care (namely, glucometrics) to optimize inpatient blood glucose. Our study aims to assess the quality of blood glucose control in critically ill inpatients. **Methods**: Eighty-five consecutive patients admitted to our hospital were prospectively followed up for their entire hospital stay or up to 7 days, whichever came first. Each patient's blood glucose measurement was recorded according to ward protocol. Indices included total blood glucose per ward, per patient-day, or patient-stay, and percentage blood glucose levels per predefined cut points to assess the incidence of hypo-, eu- and hyperglycemia. The trial registration number at Clinicaltrials.org is NCT04800861. **Results**: Total data consisted of 645 blood glucose tests out of 85 patients and 284 patient-day results, with an average of 2.27 tests per patient-day and 7.59 measurements per patient stay. The percentage of blood glucose in the range (80–180 mg/dL) was different per model, with patient-day showing the highest results of (48.24%) while the percentage of patients with hypoglycemia (blood glucose<60mg/dL) was highest per patient stay (1.18%). **Conclusions**: Patients whose glucose levels were within 80–180 are less than 50% in our cohort. Actions need to be put in place urgently.

Keywords: diabetes mellitus, inpatient, performance measure, glycemic control, critical care unit, glucometrics.

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INTRODUCTION

Our health system lacks a solid infrastructure capable of providing appropriate health services to help with patient compliance, overcome obstacles, and reduce economic costs at the individual and community levels. The World Health Organization (WHO) 2017 stated that general government expenditure on health is 4.8% of GDP. Diabetes, which is expected to reach nearly 700 million by 2045 and has a prevalence rate of nearly 11.1%, represents a preventable health burden.[1]

Hospitalized patients with diabetes or new hyperglycemia are scattered in all hospital departments. The relationship between blood glucose (BG) levels and morbidity and mortality takes the form of a J-shape curve

in which the adverse outcomes increase at both ends. The accepted average glucose level is between 140 and 180 mg/dL in intensive care units, and the glucose level of 180 to 210 mg/dL or 110-to 140 mg/dL can be accepted in certain patients, meaning there is no strict agreement on glucose levels that apply to all.[2,3] Several professional societies concerned with diabetes have set standards of care for many aspects of diabetes, including screening, diagnosis, and management in certain clinical situations, such as intensive care units, pregnant women, and many others, but a unified standard glucose management for patients hospitalized in medical or surgical units is lacking. Many medical research and articles have been published to address this issue to find a standardized protocol that can be actionable and applied clinically. Goldberg et al. introduced the term glucometrics, which is widely accepted but ill-defined.[4] He states that glycemic control means average BG level at 80–139 mg/dL.[4] In a multicenter study conducted in the United States, an attempt was made to find a specific standard point of care (POC) for BG levels in hospitalized patients to improve the quality of patient care.[5] Hendrickson et al. conducted bedside glucometer checking of BG in several hospital departments. The results divided the BG levels into weak, good, and very good.[6] As far as know, Iraqi hospitals do not formally track this performance measure (inpatient glucometrics), and our study attempts to be the first to assess the quality of performance of BG monitoring for patients in the ICU/CCU in an attempt to improve our hospital care and take it as a standard criterion for those who are admitted to medical or surgical units.

MATERIALS AND METHODS

This is an investigator-driven, cross-sectional study conducted in Critical Care Units (CCU/ICU) in Al-Fayhaa Teaching Hospital (a secondary university teaching hospital) from June 2020 to February 2021. The study design and protocol were approved by the Al-Fayhaa Teaching Hospital's local institutional review board, and the trial is registered in clinicaltrials.org as NCT04800861. The upper limit of 180 mg/dL according to the American Diabetes Association (ADA) Standard of Care 2022 and the lower limit of 80 mg /dL was considered long as it did not fall within the definition of hypoglycemia according to published studies.

Patients were initially screened at admission for ICU or CCU for diabetes history or any random BG over 180 mg/dL. The former patient was followed up to confirm newly diagnosed diabetes as determined by the treating physician. If diabetes was confirmed and treatment with insulin was recommended, the patient was included in our analysis. Exclusion criteria were patients with diabetic ketoacidosis or requiring intravenous insulin administration.

Briefly, 85 consecutive patients admitted to our hospital were selected and prospectively followed up for their entire hospital stay or up to 7 days, whichever came first. The study measurements included the total BG measurements per ward, average BG measurement weighted per patient-stay for up to 7 days, whichever came first, average BG measurements weighted per patient per day (patient-day), and percentage of the previously mentioned parameters achieving a priori defined cut points per ward or patient/stay. The cut points were selected a priori to reflect hypoglycemia (BG<60 mg/dL) or various hyperglycemia thresholds as initially suggested by Goldberg and other newer studies. Our well-trained team collected demographic data and wrote down the first diagnoses of patients sent to the ICU and followed them up throughout their hospital stay or the first seven days from their admission date. Follow-up included BG tests using POC meters (Accu-Chek, Roche, Mannheim, Germany) according to the hospital ward protocol to assess the glucometer score of our institute. Observations were not meant to interfere with the daily work of the ICU.

The included variables were assessed for distribution type. The categorical variables were presented as percentages and count. The continuous variables were inspected for normality using a PP plot. If deemed normal, they were presented as a mean and standard deviation; otherwise, as a median and interquartile range. Parametric tests were used in the analysis unless necessary and stated in the table otherwise. All data were recorded and fed to a spreadsheet, and IBM SPSS 23 was used to analyze the data.

The local hospital institutional review board approved the study protocol (Ref No. 32, dated 12-09-2019).

Informed consent was taken from the head of the department (CCU or ICU) or from the patient if he was conscious and oriented.

RESULTS

As shown in Table (1), the total data consisted of 645 blood sugar tests out of 85 patients and 284 patient-day results, with an average of 2.27 tests per patient and 7.59 measurements per patient stay, respectively.

The cohort data set showed that the average BG of the total measurements per ward was 241.5 mg/dl, which is relatively similar to the other variables from the patient day and patient stay. The percentage of BG in the range (80–180 mg/dL) was different per measurement model, with patient-day showing the highest results (48.24%). On the other hand, the percentage of patients with hypoglycemia (BG <60mg/dL) was the highest per our patient stay (1.18%).

When studying the hyperglycemia incidence, it was found that if it was >180 mg/dl or more than 300mg/dl, the level was highest per patient-stay model (77.47% and 56.47%, respectively). The frequency per patient stay model was higher in those groups of BG >180 mg/dl or more than 300mg/dl (77.47% and 56.47%, respectively).

Table 1: Blood glucose measurement as assessed between different models (total population, patient-day, and patient)

Measurement	Model		
	Population 645	Patient-day 284	Patient-stay 85
BG measurement	645	2.27	7.59
Mean ± SD	241.5 (101.77)	238 (86.14)	236.7 (74.78)
% BG in range (80-180)	29.77%	48.24%	23.53%
% Hypoglycemia (<60)	0.16%	0.35%	1.18%
%Hyperglycemia (>180)	70.07%	51.41%	77.47%
% Hyperglycemia (>300)	25.74%	39.08%	56.47%

DISCUSSION

Using bedside glucometers POC to monitor and control glucose levels for patients in intensive care is an easy and safe method with instant results compared to central laboratory testing, which is impractical and not commensurate with the patient's critical condition. The more times the BG is checked, the more the glucose profile is reflected in a patient-day model.[4] In our study, POC tests were below the acceptable target. These values reflect poor glycemic control in all three models, even though our hospital has fewer than 300 beds and is classified as a central institute.

The published studies did not agree on the definition of accepted BG for patients in ICUs, based on conflicting clinical evidence. Additionally, stress hyperglycemia, which is an elevated BG during acute illness, has had poor clinical outcomes compared to diabetics.[7]

An accepted performance is that patients achieve good BG control (within a specified target of at least 75% of the time). The three models did not show patients achieving this target BG level, even mean BG above 180 mg/dL (241.5 mg/dL, 238 mg/dL, and 236.7 mg/dL for population, patient-day, and patient, respectively). The population model 29.77%, and the patient stay model 23.53%, which are nearly approximate, differ clearly from the patient-day model 48.24%, which is consistent with the study by Goldberg and Karrie et al., which states that the patient-day reflects the most impressive results In a study at the Mayo Clinic by Cruz et al. on patients transferred from intensive care to the general wards for more than or equal to three days, in which POC was used to assess the levels of BG for the first three days, the levels of glucose more than 200 mg/dl were found to represent 25%, 20%, and 21% on the first, second, and third day, respectively. Although this study differs, in terms of design, from our study, as it is retrospective for patients in general wards using POC in monitoring glucose levels, it was noted that the glucose level was more than the required target and the percentage of hypoglycemia less than hyperglycemia, attributing this to the lack of awareness of health care workers and their fear of low sugar.[8]

Karrie determined that the rate of hypoglycemia events should be less than 3% for a level of 70 mg /dL and less than 0.5% for less than 40 mg/dL. Compared to our patient-day weighted POC in the ICU, the hypoglycemia events were extremely low at 0.35%. This finding might reflect our practice setting, which favors hyperglycemia as a safer alternative than acute hypoglycemia is.[6,9]

We did not divide hypoglycemia into severe and mild but took it together at less than 60 mg/dL. The results showed lower hypoglycemia rate in the population model than in the other two models. This result is simply a characteristic of the model itself as the number of events is constant, and the event rate varies inversely with the denominator, which is much larger in the population model than in the patient or patient-day model. This aligns with Goldberg's study earlier.[4]
Of note in the three analytical models is that the percentage of hyperglycemia for either >180 mg /dL or >300 mg /dL is elevated. This finding indicates that the

glucose in the range is lower than the recommended target and that POC tests are not proportionate to the critical situation of the patient in the ICU many times. These results reflect the lack of early intervention for hyperglycemia by adjusting insulin doses. Glucose levels of more than 180 mg/dL are nearly equal in the population and patient model and higher in the patient-day model. The percentage of glucose of more than 300 mg/dL is higher in the patient and on patient day than in the population model. These results differ significantly from Goldberg et al.'s results in the ICU (0% of the three models), and the general medical ward (12.8%, 21.8%, and 39.0% of population, patient-day, and patient, respectively), and the reason is the use of insulin pump and the number of POC tests.[4]

The education program was studied by Denise P et al. who in hospital terms, whether inpatient or ICU in a retrospective study found that POC hyperglycemia in three successive years, 2014, 2015, and 2017, were 23.5%, 19.6%, and 19.3%, respectively and were significantly improved as well. Severe hyperglycemia more 300 mg/dl were seen in 2.5%, 2.2%, and 1.8% respectively in that order of the years, but no significant hypoglycemia changes were seen in 0.9%, 1.8%, and 1.0% (p-0.711), respectively, in that order of years. These results are much lower than our study mandating that hospitals and healthcare professionals need a lot of educational awareness of the dangers of glucose excursions and their adverse clinical outcomes, which have not been studied.[10] The BG level was not assessed for patients in intensive care, who were using insulin pumps.

CONCLUSIONS

The POC test is a safe and easy method for detecting glucose excursion, but it requires regulation and identification of a valid device that can be generalized to health institutions. Accordingly, the study confirms that a high percentage of patients did not receive an optimal BG control, and this may be a great opportunity through this study to improve BG levels in ICU patients.

Limitation:

Several limitations should be mentioned here. First, this is a single-center experience. Although we think this practice is common in Iraq, we cannot be sure yet. Second, BG measurements were made using blood glucometers. These machines are necessarily standardized or periodically tested. Using sophisticated glucose measurements is theoretically possible but might affect external validation of the current trial of real Iraqi ICU practices.

The other thing not addressed in this study is the lack of comparative analysis and the clinical outcomes of those patients admitted to the ICU with variable glucose excursion.

Compliance with ethical standards

Hospital IRB approved the protocol, and arrangements for patient consent were made and included in the method section.

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