Journal of Critical Care (2013) **28**, 804–809

ELSEVIER

Journal of Critical Care

Evaluation of glucose variability when converting from insulin infusion to basal-bolus regimen in a surgical-trauma intensive care unit☆,☆☆,★

Brian P. McKinzie PharmD, BCPS, BCNSP[a,*], Long To PharmD[b], Stuart M. Leon MD, FACS[c], Evert A. Eriksson MD, FACS, FCCP[c]

[a]*Department of Pharmacy Services, Medical University of South Carolina, PO Box 250584, Charleston, SC 29425*
[b]*Department of Pharmacy Services, Henry Ford Hospital, Detroit, MI*
[c]*Department of Surgery, Medical University of South Carolina, Charleston, SC*

Keywords:
Glucose variability;
Insulin;
Basal-bolus regimen;
Trauma;
Glucose

Abstract

Purpose: This study aimed to identify predictive factors resulting in glucose values greater than 200 mg/dL in patients with trauma transitioned from an insulin infusion to a basal-bolus subcutaneous insulin regimen.

Materials and Methods: Thirty-nine patients with trauma on goal enteral nutrition in the intensive care unit receiving an insulin infusion for at least 48 hours and transitioned to a basal-bolus regimen were retrospectively identified.

Results: Ten patients had hyperglycemic events after transition. Hyperglycemia was significantly associated with increased age (42 [17] years vs 56 [13] years, $P = .02$), admission glucose (128 [39] mg/dL vs 214 [91] mg/dL, $P = .015$), and insulin drip rate 48 hours before transition (87 [38] units/d vs 127 [49] units/d, $P = .012$). There was no difference between groups with respect to injury severity, demographics, or physiologic parameters. Multiple regression analysis revealed that increased age (odds ratio [OR], 1.215 [1.000-1.477]; $P = .05$), increased admission blood glucose (OR, 1.053 [1.006-1.101]; $P = .025$), and higher insulin infusion rates 48 hours before transition (OR, 1.061 [1.009-1.116]; $P = .020$) predisposed patients to severe hyperglycemic episodes.

Conclusions: Older patients with trauma and patients with higher blood glucose on admission are more likely to experience severe hyperglycemia when transitioned to basal-bolus glucose control. Higher insulin infusion rates at 48 hours before transition are also associated with severe hyperglycemia.

☆ Sources of support: No funding was received in association with this manuscript.
☆☆ Presented in poster format at the Society of Critical Care Medicine's 41st Critical Care Congress.
★ Conflicts of interest: There are no conflicts of interest to disclose.
* Corresponding author. Tel.: +1 843 792 5868; fax: +1 843 792 0566.
E-mail addresses: mckinzi@musc.edu (B.P. McKinzie), lto1@hfhs.org (L. To), leon@musc.edu (S.M. Leon), eriksson@musc.edu (E.A. Eriksson).

0883-9441/$ – see front matter © 2013 Elsevier Inc. All rights reserved.
http://dx.doi.org/10.1016/j.jcrc.2013.06.009

1. Background

Hyperglycemia is a common problem in the intensive care unit (ICU) and is often a manifestation of acute illness and injury. The stress of critical illness increases counter-regulatory hormone and cytokine concentrations, leading to increased glucose production, insulin resistance, and reduced glucose use [1–4]. One of the biggest challenges in managing hyperglycemia in critical illness is the ability to provide consistent glycemic control because elevated blood glucoses have been associated with increased ICU and hospital lengths of stay (LOSs), as well as increased morbidity and mortality [5–8].

To maintain consistent glycemic control in our surgical-trauma ICU patient population, a continuous insulin infusion protocol was developed to maintain tight glycemic control with consideration of transition to a basal-bolus insulin regimen when clinically stable; however, the transition from insulin infusion is not well described in this patient population. When transitioning from continuous insulin infusion to basal-bolus insulin therapy, we question whether critically ill patients in the trauma population achieve equivalent glycemic control. Therefore, the aim of this study is to evaluate the incidence of hyperglycemia, degree of glycemic variability, and factors resulting in blood glucose values greater than 200 mg/dL, within the first 48 hours of converting critically ill patients with trauma from an insulin infusion to basal-bolus subcutaneous insulin.

2. Methods

A retrospective evaluation of patients admitted to our 17-bed surgical-trauma ICU over a 3-year time frame (November 2007–December 2010) was performed after obtaining institutional review board approval. A pool of traumatically injured patients admitted to the ICU receiving a continuous insulin infusion for at least 48 hours and transitioned to basal-bolus insulin were identified from the pharmacy electronic medical record. From this, a random sample of 39 adult patients with trauma receiving goal enteral nutrition at the time of transition were selected for further evaluation. Each patient served as his/her own control. Exclusion criteria included patients younger than 18 years; patients on parenteral nutrition, vasopressors, or renal replacement therapy; or patients with interruptions in their enteral nutrition during the 96-hour time frame.

Patients admitted to our ICU are ordered to receive an intensive insulin protocol to maintain blood glucose levels between 80 and 110 mg/dL by either subcutaneous insulin or continuous intravenous insulin. Patients are placed on continuous intravenous insulin if they have 2 blood glucose measurements greater than 110 mg/dL or 1 blood glucose measurement greater than 140 mg/dL. While on the insulin infusion, blood glucoses are checked on an hourly basis by the nursing staff. Consideration is given to transition patients off of the insulin infusion to basal-bolus subcutaneous insulin if the following parameters were met: hemodynamically stable and not receiving vasoactive drugs, completion of stress dose steroids (if administered), enteral nutrition at goal rate for 24 hours, and blood glucose measurements within 80 to 110 mg/dL for 24 hours. Transitioned patients were converted to basal neutral protamine Hagedorn (NPH) insulin as well as sliding scale coverage with insulin aspart. Basal insulin doses were determined by reviewing the previous 24-hour intravenous insulin requirements and the patient's current insulin infusion rate. If any blood glucose measurements were less than 80 mg/dL, consideration was given to administer 80% of the total intravenous insulin requirement from the previous 24 hours; otherwise, up to 100% was allowed to be administered given as 2 divided doses of NPH insulin 12 hours apart. If any blood glucoses were greater than 140 mg/dL, the patient was not considered controlled and remained on the insulin infusion. Basal insulin was administered 2 hours before discontinuation of the insulin infusion to avoid hyperglycemia. Blood glucoses were then checked every 4 hours while on basal-bolus insulin therapy and covered with insulin aspart if elevated.

All blood glucose values were assessed during the 96-hour retrospective evaluation. Total insulin requirements were collected for the 48-hour period before transition (days −2 and −1) as well as the total basal-bolus insulin received for the 48-hour period after transition (days +1 and +2). Patient demographic data such as age, race, renal function, and body mass index were assessed. Each parameter of the Acute Physiology and Chronic Health Evaluation II (APACHE II) score, as well as prealbumin, was assessed to determine the patient's clinical and nutritional status at the time of transition. Other clinical parameters obtained include Injury Severity Score (ISS), Glasgow Coma Score (GCS), APACHE II score, reason for admission, LOS, respiratory status (mechanical ventilation vs room air), history of diabetes, and significant medications that may alter glucose values (eg, corticosteroids) during the 96 hours of retrospective evaluation.

Primary outcomes to be assessed were 2-fold: incidence of hyperglycemic events and a degree of glycemic variability in the first 48 hours after transition to basal-bolus therapy. Standard deviation was the measure of dispersion used to quantify glycemic variability. *Failure* was defined as 1 posttransition blood glucose of 200 mg/dL or greater. Secondary outcomes included identification of predictive factors resulting in a glucose values of 200 mg/dL or greater in ICU patients with trauma while they are being transitioned from an intravenous insulin infusion to a basal-bolus subcutaneous insulin regimen.

Unpaired *t* tests were performed on continuous data, and either χ^2 test or Fisher exact test was used when analyzing nominal qualitative data. Differences were considered statistically significant at $P \leq .05$. A multivariate regression