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Evaluation of the timing and coordination of prandial insulin administration in the hospital

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ABSTRACT

Aims: The objective of this study was to examine the relationship between measures of coordinated insulin delivery and capillary blood glucose (CBG) levels among hospitalized patients and to assess nurse perceptions of insulin administration.
Methods: Hospitalized patients ($n = 451$) receiving rapid acting insulin analog (RAIA) using carbohydrate counting were retrospectively analyzed. Nurses ($n = 35$) were asked to complete an 18-item anonymous survey assessing perception of RAIA dosing.
Results: The median time from breakfast CBG to RAIA dose was 93 (IQR 57-138) min. There was no association between timeliness measures and mean CBG at lunch or dinner. Hypoglycemia was rare ($N = 2$). More than half (54%) of nurses were confident all of the time in determining the correct dose of RAIA, though none were confident in administering it on time. The majority of nurses perceived an electronic dosing calculator and a patient reminder to notify the nurse at the end of the meal favorably.
Conclusions: The data demonstrate suboptimal coordination of CBG monitoring and insulin doses using a flexible meal insulin dosing strategy, though there was minimal impact on glycemic control. Nurses reported high confidence in the ability to calculate the correct insulin dose but not in the ability to administer it on time.

1. Introduction

Hyperglycemia is common in the hospital [1,2] and is associated with intense resource utilization [3,4]. Outside of the intensive care unit, inpatient hyperglycemia is associated with increased mortality and length of stay, as well as more complications and admissions to extended care facilities [5,6]. Randomized controlled trials demonstrate the efficacy of basal bolus insulin regimens which contain both a carbohydrate and a correction component compared to so-called sliding scale insulin alone [6,7]. This is reflected in existing expert guidelines [8,9]. However, the literature is mixed with respect to the need for prandial insulin among hospitalized patients with type 2 diabetes [10,11] and how it is adminis-

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tered (as set meal doses or varied according to carbohydrate intake) [12–15]. Nevertheless, as insulin regimens increase in frequency and complexity, an increase in errors is possible.

Insulin is consistently considered to be a high risk medication due to a narrow therapeutic index and frequent dosing errors [16–18]. Adverse events related to insulin use have increased over time and such events may be disabling or life-threatening [19,20]. Insulin errors are twice as likely to lead to harm as those involving other medications [21]. A National Health System (NHS) audit in the United Kingdom reported that 55% of patients hospitalized with type 2 diabetes requiring insulin had a medication error [22]. Those with a medication error were twice as likely to experience severe hypoglycemia. In a retrospective study of 116 hospitalized patients utilizing standardized order sets (without computerized provider order entry [CPOE]), 64% of patients had at least one error, amounting to 0.53 errors per patient day [23]. In addition, we reported significant errors in insulin doses whether prandial insulin is administered as fixed or flexible (according to carbohydrate intake) doses, even when ordered using CPOE [12]. However, it is less clear how the timing and coordination of insulin doses with respect to glucose monitoring and meal times affects glucose control.

Professional society guidelines emphasize proper coordination of capillary blood glucose (CBG) monitoring, insulin administration and meal delivery for the safe administration of insulin in the hospital [7,8,9,24]. Coordination of these tasks is an expectation for Joint Commission disease specific care certification [25], and is emphasized by the Institute for Healthcare Improvement [26]. The Institute for Safe Medicine Practices lists timing of medication dosing as one of 5 critical factors in medication safety [27]. A coordinated effort involves multiple key players. Dietary personnel control delivery of meal trays while CBG monitoring is often performed by nursing assistants, and the nurse administers insulin. This may create situations where CBG monitoring, meal delivery, and insulin administration can get disjointed.

Safe administration must consider the time-action profile of prandial insulin. A typical prandial insulin dose consists of a prandial component, intended to counteract the effects of exogenous carbohydrate intake, and a correctional component, which addresses pre-existing hyperglycemia. Thus, a mistimed insulin dose may result in a peak insulin level that occurs too early or too late relative to the meal and lead to hyperglycemia or even hypoglycemia. Moreover, a correction dose that is based upon a CBG level that is too close in time to a previous insulin dose may cause stacking of insulin doses and hypoglycemia. Similarly, if the correction dose is based upon a CBG level that was obtained too far in the past, it may not reflect the current glucose levels. Rapid acting insulin analogues (RAIA) may improve postprandial glucose control and provide more flexibility for the timing of insulin administration relative to meals compared to regular human insulin. Therefore, RAIAs are frequently used in the hospital setting. The RAIA dose is ideally delivered immediately before meals, although it may be given safely immediately postmeal (generally within 30 min of the start of the meal) [28,29].

There are few studies addressing the effects of timing and coordination of insulin administration outside of the ICU, where the majority of insulin is administered. There were 3 objectives for this study (Fig. 1). (1) The first objective was to examine the relationship between measures of coordinated prandial insulin delivery and glucose control in a retrospective sample, for which the primary outcome was mean glucose at lunch. (2) The second objective was to conduct an initial process evaluation of mealtime insulin delivery and obtain patient perspectives from a prospective sample. (3) The third objective was to evaluate nurses' perception of the accuracy and timing of insulin administration.

2. Materials and methods

2.1. Study setting and design

This is an observational study examining the current glucose management process in an inpatient setting on medical surgical units at a single academic medical center. At the study institution, most patients receive flexible meal dosing according to carbohydrate intake using simple order panels (low, standard, or high doses), plus or minus basal insulin, based upon glucose control and pre-admission therapy [12,30]. Nurses typically administer RAIAs immediately following a meal, though pre-meal dosing is acceptable if a patient is confident in what he/she plans to eat. Barcoding technology enables automatic records of the date, time and dose administered within the medication administration record.

All insulin panels for prandial insulin include a standing CBG order for monitoring at meals and bedtime. Patient care associates (PCAs) generally perform CBG monitoring and inform the nurse. The meter date and time is synchronized with the EMR and meters are downloaded each shift. In order to make the readings immediately available to providers and staff, the PCAs also manually enter the bedside glucose measurements into the EMR. Hypoglycemia is managed using the institution's hospital guideline. Point-of-care glucose is monitored using the Nova StatStrip® glucometer.

Meals are delivered at standard times for patients on carbohydrate controlled diets. All meal trays come with a list of items and the respective carbohydrate content, which is then documented by the PCA or the nurse. The patients are encouraged by the nursing staff to activate their bedside call light when they are nearing completion of their meal. However, nurses also need to monitor administration times on the Medication Administration Record and periodically check in with patients who have prandial insulin orders in order to calculate and administer the meal dose.

In this study, we collected retrospective data to investigate the relationship between coordination of glucose measurements and insulin doses at breakfast with subsequent glucose control later in the day. In order to assess the validity of the interval between glucose measurement and insulin dose administration we also prospectively identified patients and asked them to manually document their meal times and communications to nurses. We also surveyed both patients and nurses regarding their perception of the glucose management process. Data for the retrospective portion of the study was collected from January 1, 2015 to December 31, 2015 and data from the prospective portion was collected from June 1, 2015 to December 31, 2015.