

Utilization of Computerized Order Entry Protocols in the ICU for Glucose Management

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Abstract

This paper reports the results of an evaluation of a computer-based protocol for managing patient blood glucose. The computerized protocol, having proven successful in the Surgical ICU, was implemented in the Trauma ICU. Five nurses in the Trauma ICU were interviewed and observed while using the computer-based protocol for blood glucose management. Results of the evaluation indicated that while the computerized features, such as the calculation of insulin drip rate and patient chart scanning, were helpful, nurses were spending more time and energy than before computerization to manage patient blood glucose, and that the computerized recommended treatments were often inappropriate due to the unique patient population. Suggestions for modification of the protocol to accommodate the different patient population and needs of the Trauma ICU are provided. Also, a usability test before the implementation of the new design and a follow-up assessment soon after implementation are highly recommended.

Keywords: usability, clinical decision-support, computer interface

1. Introduction

Continuous evaluation and adjustment of blood glucose to maintain normoglycemia (blood glucose values 80-110 mg/dl) during critical illness reduces morbidity and mortality [1]. At Vanderbilt University Medical Centre (VUMC), the importance of tight glucose control in critically ill patients has resulted in efforts to translate strict glycemic control into daily clinical practice via a standardized glycemic control protocol (GCP). Until recently, the underlying processes were paper-based, where the treatment dosages recommended by the protocol were hand calculated and logged on a paper flow sheet. In an effort to automate the treatment dosage calculations and computerize the data logging process, a team of Vanderbilt clinicians and informaticians developed a

computerized glycemic control protocol. This protocol was then integrated into the Computerized Provider Order Entry (CPOE) system.

Implemented over a year ago, it had reportedly been proven successful in the Surgical Intensive Care Unit (ICU). Without modifications, the computerized protocol was recently implemented in the Trauma ICU. Since its implementation in October 2005, informal feedback from the Trauma ICU nursing staff indicated that nurses had noticed an increase in the fluctuation in patient blood glucose while following the glucose management protocol. They had also noticed a number of inappropriate treatment suggestions by the computerized protocol. These observations point to the lack of utility and usability, and suggest potential flaws in the design. An evaluation of the system in the context of the Trauma ICU was needed.

CPOE systems provide a useful platform for integrating knowledge into clinicians' workflow by presenting just-in-time treatment advice tailored to the needs of individual patients [2]. Therefore, CPOE systems have been touted as being effective tools to implement evidence-based protocols. In VUMC's CPOE system, protocols can be implemented as order sets or as complex advisors with rule-based decision support. They are typically initiated by entering the protocol orders, by physicians responsible for the patient, and are executed by the nurses at the bedside. In cases where the physician had not entered the order, an experienced nurse may perform the preventive steps as part of routine care. However, these actions may not be standardized as they are not part of the prescribed treatment.

1.1. Purpose

The goal of the study was to evaluate the utility and usability of the CPOE-based glycemic control protocol. The objectives of this study were to 1) identify system constraints that affect the usability of the computerized protocols in the ICU, in particular, the glycemic protocol, and 2) provide design guidelines for the system engineers to improve the usability and utility of the application. Here we report the results from the synthesis of user feedback in the evaluation phase, and the recommendations for the system designers.

2. Methods

2.1. Setting

The study was conducted at Vanderbilt University Medical Centre (VUMC). VUMC includes Vanderbilt University Hospital (VUH), a 630-bed academic tertiary care teaching facility with approximately 31,000 admissions per year. Of the facility's approximately 3200 annual trauma admissions, 600 to 700 are admitted to the 14-bed dedicated Trauma ICU. The study was approved to be exempt from regular review by the Vanderbilt University IRB. Verbal consent was obtained from the subjects.

2.2. Subjects

Five Trauma ICU nurses (all female) participated in this study. Subjects ranged in age from 24 to 27 years. The average amount of nursing experience amongst the nurses was 2.4 ± 0.8 years (mean \pm SEM;

range: 0.5 - 5 yrs). The average length of time subjects had worked in the Trauma ICU was 1.4 ± 0.42 years (0.5 - 3 yrs). All nurses had been working in the Trauma ICU before the implementation of the computerized protocol.

2.3. WizOrder

WizOrder is VUMC's CPOE system with integrated decision support [3,4,5,6,7,8]. Currently, all inpatient orders are entered using WizOrder. Approximately 15,000 orders are entered into WizOrder per day with 75% of them being directly entered by physician staff, including attending physicians, interns, residents, and fellows. The rest are entered by other clinical staff (such as nurses, pharmacists, and others) after clinicians generate verbal or written orders. Baseline CPOE system features at the time of study included: 1) drug allergy and drug-drug interaction checks, 2) interventions to promote cost effective care, 3) over one thousand order sets encapsulating "best of care" practices, 4) linked patient-specific access to educational resources and biomedical literature, and 5) a programmable rules engine used to deliver web-based decision support modules for the implementation of guidelines [5].

2.4. Procedures

2.4.1. Interviews

Semi-structured interviews with individual nurses were conducted in the ICU. See Appendix for sample questions.

2.4.2. Case observations

Selected nurses were observed as they interacted with the CPOE interface during patient management. The nurses were asked to talk aloud as they interacted with the CPOE system. Probing questions from the investigator were asked as appropriate.

3. Results & Discussion

3.1. Task analysis of glycemic control protocol

The steps taken by the bedside nurses in conducting glycemic control are depicted in Figure 1. This standardized procedure is normally repeated every 2 hours for each patient. Once the patient blood glucose level is measured, the computerized protocol is used to obtain the recommended treatment.

Figures 2(a) and (b) illustrate the screens of the

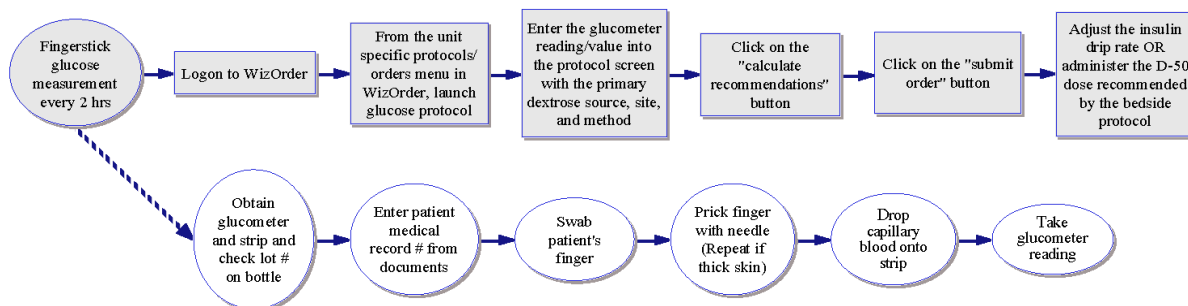


Figure 1. Steps for measuring patient blood glucose and obtaining recommended treatment using the computerized protocol. This procedure is repeated every 2 hours.

glycemic control protocol within the CPOE system. Figure 2(a) is the initiation screen, primarily used by the ordering physicians to initiate the protocol if the patient's most recent laboratory glucose value is out of the target range (greater than 110 or less than 80). In addition to calculating the initial therapy rate, this initiation step generates a nursing order for continuous evaluation and adjustment of patient's blood glucose per protocol (e.g., every two hours). Once initiated, it is the responsibility of the bedside nurse to comply with the recommendations of the protocol. Figure 2(b) is the protocol screen used by the bedside nurse. As illustrated, the application displays the past blood glucose data and recommends a treatment based on the current blood glucose value entered by the bedside nurse.

3.2. User feedback

Mainly, the nurses' feedback could be grouped into two categories. One category was concerned with the implementation of a computerized system for tracking and managing the physician orders and for documenting their nursing activities. The other was concerned with utility of the GCP (i.e., the recommendations and the decision support offered by the computerized protocol).

3.2.1. CPOE

With respect to the Computerized Provider Order Entry (CPOE) system, nurses all agreed that it was helpful to their work. In general, it was convenient and reduced the amount of paperwork nurses had to handle. It was now easier to read doctors' orders, thereby eliminating the need to read doctors' handwriting and double-check the order with the responsible physician. In addition, the nurses now have more freedom to act on and streamline the

implementation of the order, as opposed to having to notify the physician each time there is discrepancy in the order and implementation.

The usability of the CPOE interface seems to be satisfactory. Nurses appreciated the computerized features which included drug dose recommendations, the fast scanning of patient information, and the general user-friendly appearance of the system. Two of the five nurses could not identify any good features about the CPOE, when asked. This does not necessarily mean that there is nothing good about the system. More likely, it means that the system has been successfully integrated into the daily work routine and has become unremarkable. This is a common observation in technology adoption. Indeed, the nurses who noted the good features were able to recall the tedious work process before the CPOE implementation, or could remember using a less friendly system at another hospital prior to working at this Trauma ICU. However, one nurse expressed concern about the use of computerized charting of patients. In particular, because it allows doctors to view the charts from any location in the hospital, there is a possibility that doctors would reduce their visits to see patients in the ICU. There were also concerns about privacy issues related to computerized charting that are beyond the scope of this study.

3.2.2. Glycemic control protocol (GCP)

With respect to the glycemic control protocol (GCP) that is contained in the CPOE, there was overwhelming dissatisfaction expressed by the nurses. Nurses unanimously agreed that it did not improve their work. In fact, utilizing the glucose management protocol was more time-consuming than when the process was paper-based, which relied entirely on the nurses' judgment and ability to calculate the correct dosage of insulin and/or sugar.

WizOrder Popup

Insulin Drip Initiation

1 Initial Bedside Glucose:
 mg/dL

2 Define Blood Glucose Range:
(Recommend low = 80 and high = 110 in SICU. Glucose target ranges should be lower for pregnant patients.)
 Low Target: mg/dL
 High Target: mg/dL

3 Select Protocol:

4

5 Regular Human Insulin Drip Rate:
 unit(s)/hour

Bedside Glucose Test Interval:

Suggested IV D50 Dose if hypoglycemic or below target range now:
 ml

6 IMPORTANT:
 Patient should have a dextrose source while on insulin drip unless clinically contraindicated. Please order this separately after exiting this page. This requirement is met by TPN or on-going feeding tube.

The system will automatically generate the following orders:
 (1) Activate May04 protocol for insulin drip titration
 (2) Bedside glucose testing at the specified frequency
 (3) Insulin drip at the specified rate

7 Optional parameters for notification of House Officer (in addition to those specified by the protocol):

1. if blood glucose is LESS than: mg/dL
 2. if blood glucose is GREATER than: mg/dL
 3. if insulin drip rate suggested by computer is GREATER than: unit(s)/hour

Figure 2a. Screen shot of the CPOE-based glycemetic control protocol initiation screen.

WizOrder Popup

1 Current lab with trends for Patient

Bedside Glucose

Chem Lab Glucose

Resp Lab Glucose

No Data Available

Patient Has Been Off Protocol: Reason: Previous Blood Glucose (mg/dL): Current Insulin Drip Rate (units/hr):

Date (MM/DD/YY)	Time (HH:MM)	Blood Glucose (mg/dL)	Primary Dextrose Source	Site	Method	Comments
02/28/06	09:13	<input type="text"/>	<input type="radio"/> TF <input type="radio"/> TPN <input type="radio"/> D10 >=30ml/hr <input type="radio"/> D5 >=100ml/hr <input type="radio"/> None	Arterial	Meter	120 character limit

OR

4 Blood Glucose You Just Entered:
 None entered
(Re-enter above if incorrect)
 Current Insulin Drip Order: 7.2 unit(s)/hour
 Recommendations:
 Regular Human Insulin Infusion Rate (unit(s)/hour): None
 D50W by IV push (ml): None

5 Orders:

New Insulin Infusion Rate: unit(s)/hour
 Bedside Glucose Test Interval:
 D50W by IV push: mL
 Comments: (40 character limit)

Figure 2b. Screen shot of the CPOE-based glycemetic control protocol used by the bedside nurse.

The major complaint that the nurses had about the GCP was that the decision support/dosage recommendation was often inappropriate. In particular, nurses cite the overly frequent recommendation of injecting D-50, a concentrated dextrose solution, by the protocol as an inappropriate one. This action was reportedly a rare practice before the implementation of the computerized protocol. However, with the implementation of the CPOE-based GCP, nurses were administering D-50 on a daily basis. The inevitable consequence is that patients “bottom out” following the injection of D-50, requiring the nurses to monitor and adjust the blood sugar by the insulin drip more frequently. This usually required the nurses to check on the patient every 15 minutes, as opposed to every 2 hours. With more than 2 patients undergoing this treatment, the nurses had difficulty keeping up with the workload. This occurrence seemed to be more prevalent when the patients were not diabetic, or if the patients did not have blood sugar problems upon arriving to the Trauma ICU.

Furthermore, even though the literature suggests “frequent” monitoring of patient blood glucose [1], the frequency with which the patients’ fingers are pricked to obtain blood glucose measure was considered by the nurses to be too high (every 2 hours), especially for the non-diabetic patients in the Trauma ICU. In fact, nurses judged that there is no need to initiate this protocol on every patient in the Trauma ICU, unlike the patient population in the Surgical ICU where all patients must be monitored for blood glucose. The recommendations in this protocol do not apply to patients with spinal cord and head injuries. Therefore, the development and incorporation of a set of criteria in the CPOE for initiating the GCP on Trauma ICU patients is recommended.

When asked to recommend specific changes in the redesign of the CPOE system, nurses suggested that the initiation or the recommendations for non-diabetic and non-sugar dependent patients be differentiated from the diabetic population. The recommendations should take into account the patient history, age, weight, etc. (Trauma ICU patients are generally 18-35 years of age, while the Surgical ICU patients are generally much older with co-morbidities). Also, the accuracy for recommended dosage should be improved, including a finer granularity of the dosage scale.

While the computerized calculation of the insulin drip rate was a welcomed feature for the nurses, a cautionary note was voiced by a nurse who was concerned about how computerization changed the

way nurses performed their job. For instance, once during computer down time, orders had to be entered on paper charts and drip rate calculated by hand. One nurse noted her own over-reliance on the CPEO for the drip rate calculation since its implementation. A backup method was desired for drip rate calculation, such as a look-up table.

When asked to compare the GCP with another protocol within the CPOE, nurses describe their experience with the electrolyte replacement protocol as the opposite and much more preferable. In the electrolyte replacement protocol, nurses have the authority to take action without going to the doctor for every decision. The recommendations for the electrolytes are straightforward and do not depend on the patient’s weight.

Evidently frustrated, one nurse indicated that everything about the GCP was redundant. Another nurse indicated that the recommendation for D-50 dextrose was redundant. In fact, she now ignores the recommendation whenever it is provided by the CPOE, as do other nurses. Nurses claimed to have achieved better patient outcomes with their own methods. To validate the claims by the frontline nurses, the rate of non-compliance should be examined in conjunction with patient outcome data.

3.3. Recommendations

Based on the analysis results, it is recommended that the CPOE-based glycemic control protocol be modified. Some of the issues raised by users/nurses could be resolved with the development and integration of some GCP initiation criteria that account for patient population (e.g., insulin-dependent patients) and individual characteristics (e.g., most recent blood glucose measurements and trends in past responses to treatments). By factoring in occurrences in which care providers overruled or ignored the computerized recommendation in subsequent recommendations, the accuracy of the decision support component, as well as the recommendation compliance rate, would be improved. A backup method for drip rate calculations and treatment recommendations during computer downtime in the ICU is also recommended (e.g., a look-up table).

Furthermore, training or education should be provided to the staff about the functionality and applicability of the computerized protocol, and what the “recommended” treatment means. Nurses should be empowered to over-ride the recommendations with their better judgement, especially given their extensive

experience with the patient population. The level of frustration experienced at times of conflict between experience and the computerized treatment recommendation would be greatly reduced.

Lastly, a usability test should be performed before the implementation of the re-designed system, and a follow-up assessment should be conducted shortly after implementation to refine the final design.

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Appendix. Sample interview questions

1. Demographic information: age and gender, years of work experience, years at Vanderbilt, time in this ICU.
2. How long have you worked in the ICU?
3. How long have you used the CPOE system?
4. How long have you used the CPOE protocols for blood glucose management?
5. Has the CPOE improved your work? If yes, how? If no, why not?
6. What features of the CPOE do you like? Why?
7. What features do you not like? Why not?
8. What should be re-designed?
9. What features are redundant?
10. What is missing that would be helpful to your work?
11. Anything else you would like to add that would help the designers of the system?
12. Have you or do you work at other hospitals where blood glucose management protocols are more effective?

13. Are there other management protocols in the system which are more effective? Why?

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