Impact of Intravenous Insulin Protocols on Hypoglycemia, Patient Safety, and Nursing Workload

By: Sauer, Penny MSN, RN, CCRN; Van Horn, Elizabeth R. PhD, RN, CCRN

Sauer, P. & Van Horn, E. R. (2009). Impact of intravenous insulin protocols on hypoglycemia, patient safety, and nursing workload. *Dimensions of Critical Care Nursing, 28,* 95-101. DOI: 10.1097/DCC.0b013e31819af06d

Made available courtesy of Lippincott, Williams & Wilkins:
http://journals.lww.com/dccnjournal/pages/default.aspx

*****Reprinted with permission. No further reproduction is authorized without written permission from Lippincott, Williams & Wilkins. This version of the document is not the version of record. Figures and/or pictures may be missing from this format of the document.*****

Abstract:

The practice of tight glycemic control using an intravenous insulin infusion has been adopted in many clinical settings, and although beneficial patient outcomes have been clearly documented, the therapy poses potential risks to patient safety related to hypoglycemia and increases nursing workload. This article examines these issues through a review of current research on tight glycemic protocols. Strategies for nurse leaders are provided to improve patient safety and support bedside nurses in the administration of insulin infusion protocols.

Article:

The stress of critical illness often leads to hyperglycemia, even in patients without a history of diabetes, and hyperglycemia in critically ill patients has been associated with an increased infection rate and an impaired immune response.1-6 An increase in catecholamine release, hepatic gluconeogenesis, or relative insulin resistance may be the cause of hyperglycemia in critically ill patients.7 Other causes may include the use of corticoid steroids, vasopressors, or total parental nutrition.2 Certain medical conditions also increase the risk of stress-induced hyperglycemia including sepsis, acute myocardial infarction, stroke, surgery, and trauma.4

Impaired glycemic control has been associated with adverse outcomes in patients with myocardial infarction and acute coronary syndrome, stroke, postoperative complications, and trauma. Krinsley 4 found higher mortality rates for patients who did not maintain glycemic control while in the intensive care unit (ICU). These and similar findings have prompted more research to determine whether controlling blood glucose with an insulin infusion leads to better patient outcomes.1,4,8 In a study of 1,548 surgical intensive care patients, Van den Berghe and colleagues 6 found that in-hospital mortality was decreased by 34% with the use of an intravenous (IV) insulin protocol. Similar research found that use of a continuous insulin infusion to control glucose levels decreased morbidity and reduced predicted mortality for diabetic patients who had cardiovascular surgery.1

The American Association of Clinical Endocrinologists advocates the use of insulin infusions to maintain blood glucose levels between 80 and 110 mg/dL in critically ill patients.9 The American Diabetes Association's (ADA's) 2006 position statement also recommends tight glycemic control, with the goal of maintaining blood glucose level at less than 110 mg/dL for critical care patients.10

The critical care nurse is responsible for the maintenance of tight glycemic control, which involves following an insulin protocol, usually consisting of preprinted physician order sets that allow the nurse to control the patient's blood glucose level with minimal additional physician orders. Glycemic control is

generally achieved through the use of a continuous IV insulin infusion. Although the research literature clearly shows that tight glycemic control is beneficial, the therapy is not without risk. The Institute for Safe Medication Practices lists insulin as a high-alert medication because of the risk of significant patient harm in case of error.11 The primary risk to patient safety in administering insulin intravenously is hypoglycemia. Intravenous insulin has a rapid onset of action and may cause severe hypoglycemia, which, if untreated, can result in neurological impairment or death.7 The insulin infusion is adjusted based on blood glucose testing done at the bedside, which facilitates immediate adjustments of the insulin infusion, but requires time and attention from the nurse.

The practice of tight glycemic control has been adopted in many clinical settings, and although beneficial patient outcomes have been clearly documented, the therapy poses potential risks to patient safety related to hypoglycemia and increases nursing workload. This article examines these issues through a review of current research on tight glycemic protocols. Strategies for nurse leaders are provided to improve patient safety and support bedside nurses in the administration of insulin infusion protocols.

METHODS

The Matrix method by Garrard 12 was used to conduct a systematic review of published studies. The review was conducted with various databases. Only articles from peer-reviewed medical and nursing journals, available in English, and published from 2001 to 2007 were considered. The search was also limited to research studies on adult patients, in hospital ICUs, and who experienced hyperglycemia and were treated with a continuous insulin infusion. A total of 57 articles were examined, and 7 met all the criteria. A snowball technique was used to search references from the articles to identify additional information sources.12 Two additional articles were found that reported results from a study already included in the matrix, for a total of 9 articles reporting findings from 7 studies on tight glycemic control by an insulin infusion.

Information was also sought about hypoglycemia, nurses' workload, and patient safety as it related to tight glycemic control. Again, databases were searched for articles in various nursing and medical journals from 2001 to 2007. Search terms included tight glycemic control with qualifiers of hypoglycemia, patient safety, nurses' workload, and accuracy of bedside glucose testing. This search resulted in the identification of 6 additional articles. These studies were added to the review, for a total of 15 articles.

RESULTS

The studies on tight glycemic control included 1 randomized controlled trial, 2 comparative studies, 2 with combined prospective/retrospective designs, 1 prospective observational, and 1 descriptive study. Sample sizes ranged from 20 to 1,548 subjects. Most subjects were male; ethnicity was not reported consistently enough for comparison. The studies were conducted at international sites and a variety of ICU settings. Additional information is provided in Table 1. Three articles examined blood glucose testing, and 3 studies examined hypoglycemia and/or nurses' workload.

First Author	Year	N	Setting	Hypoglycemia Definition	Hypoglycemia Incidence
Furnary et al[1]	2003	3,554	Cardiothoracic surgery unit	BG <75 mg/dL	Not reported
Van den Berghe et al[18]	2003	1,548	Surgical intensive care unit	BG <40 mg/dL	5.2%
Krinsley[4]	2004	800	Medical surgical intensive care unit	BG <60 mg/dL (mild)	1.02%
				BG <40 mg/dL (marked)	0.34%
Kanji et al[2]	2004	100	Medical intensive care unit and surgical intensive care unit	BG <45 mg/dL	4%
Kee et al[3]	2006	103	Cardiothoracic intensive care unit	Not reported	Not reported
Osburne et al[5]	2006	20	Intensive care unit	BG <80 mg/dL	6.9%
Oeyen et al[19]	2007	30	Surgical intensive care unit and medical intensive care unit	BG <60 mg/dL	1.8%

Abbreviation: BG, blood glucose level.

TABLE 1 Summary of Studies Using IV Insulin Protocols

Blood Glucose Measurement

Blood glucose levels must be measured frequently to ensure glycemic control. All of the studies examined used bedside glucose monitoring devices (point of care), but the sample source differed among studies. One study obtained blood samples from an arterial line exclusively, 2 studies obtained blood from either an arterial line or finger stick (capillary sample), and 3 studies used finger stick only.

Obtaining blood glucose results from the laboratory is not feasible for management of insulin infusions because of both the cost and the time lapse between sample collection and availability of results, but it is considered the most accurate test and may be considered the criterion standard by many. Because laboratory testing is not practical or cost-effective, bedside testing is used for rapid reporting of blood sugar results for insulin infusion adjustments. According to the literature, the best practice in bedside testing is the blood gas/chemistry analyzer, but not all hospitals may have these machines available at the bedside. Two studies found that capillary testing with a bedside glucometer was correlated with laboratory findings.13,14 Research by Kanji and colleagues 15 did not support these findings, but the treatment groups within the study differed significantly from those in the other studies. More research is needed in this area, but based on current evidence, it is reasonable to recommend that blood glucose monitoring be performed at the bedside, with arterial blood if possible. If an arterial line is not available, then capillary glucose levels should be checked. For patients receiving vasoactive drugs, with moderate peripheral edema, or with abnormal hematocrit or carbon dioxide levels, an arterial blood sample should be obtained.14,15 Regardless of the source of blood for bedside testing, the results should be confirmed by laboratory results at least once a day. If there is any question of the validity of the bedside results, then bedside values should be correlated with the laboratory results.

Hypoglycemia

The most significant risk to patient safety when the blood glucose level is controlled within narrow parameters is hypoglycemia. The ADA defines hypoglycemia as a blood glucose level of 70 mg/dL or less and recommends treatment with glucose or carbohydrate and a recheck in 15 minutes.10

Hypoglycemia can develop quickly. Symptoms include shakiness, dizziness, sweating, hunger, pale skin, behavioral changes, and confusion.16 Many of these symptoms may be difficult to recognize quickly in critically ill patients, especially if the patient is sedated and mechanically ventilated. Hypoglycemia that is not treated quickly can lead to severe neurological consequences including confusion, agitation, coma, and death.7

Although the normal fasting blood glucose level for an adult is 70 to 110 mg/dL,17 none of the studies reviewed here used 70 mg/dL as the definition of hypoglycemia (see Table 1). The lack of consistent definitions of hypoglycemia creates difficulty in comparing the incidence of hypoglycemia across studies. A total of 4 studies used a hypoglycemic threshold less than the ADA-recommended level of 70 mg/dL.10 Clearly, the incidence of hypoglycemia will increase as the defined blood value for hypoglycemia increases. However, among the studies reviewed here, the one with the lowest defining value for hypoglycemia (<40 mg/dL) found a high incidence of hypoglycemia, indicating a problem in maintaining optimal glycemic control in study patients.

The reported incidence of hypoglycemia varied from 1.36% to 6.9% (see Table 1).1-5,18,19 This variation in rate can be attributed to inconsistent definitions of hypoglycemia.

Few studies have examined the efficacy and safety of insulin protocols for critically ill patients. One such study conducted with 30 ICU patients found that 60% of the patients had at least 1 hypoglycemic event, and 37% of patients required a dextrose bolus.19 The efficacy of the insulin protocol was low, with blood glucose levels remaining in the target range of 81 to 110 mg/dL only 42% of the total time the protocol was implemented. Most blood glucose levels were managed within the protocol standards, resulting in an adherence rate of 71%. Justification for protocol deviations was provided in only 5% of the cases and included alterations in nutrition or patient transport. Van den Berghe and colleagues 18 also examined reasons for hypoglycemia and found that 62% of hypoglycemic events were related to an interruption of enteral feeding without appropriate adjustments in insulin rate infusion.

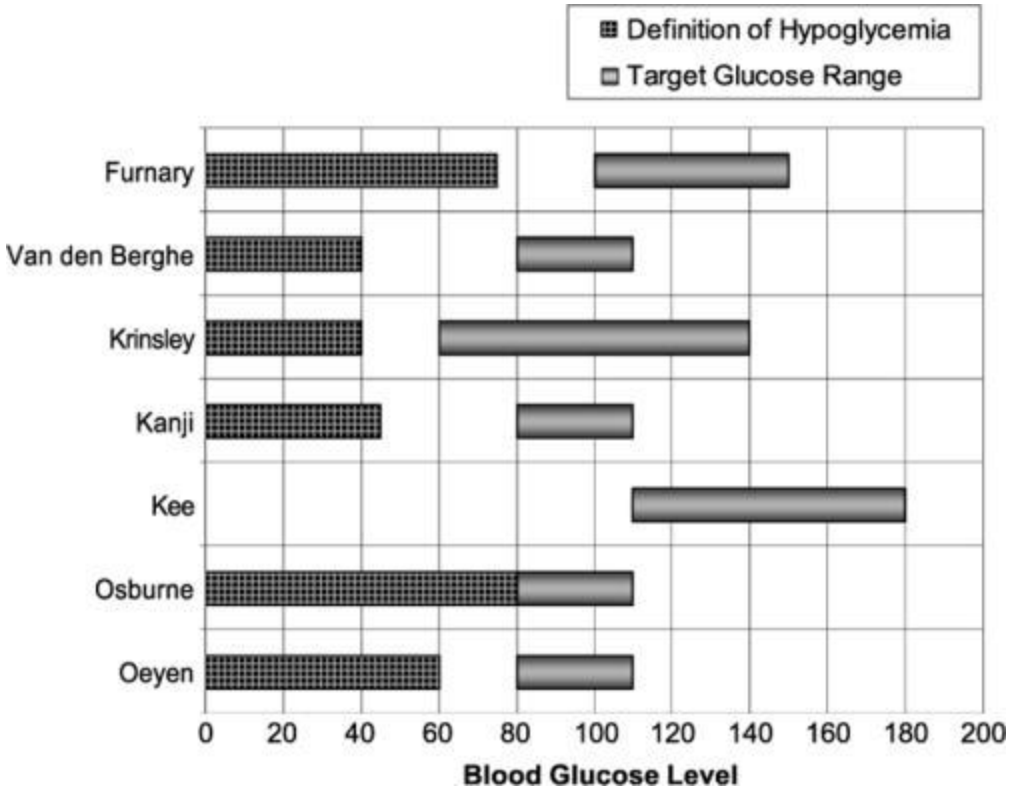

Figure 1. Target glucose and hypoglycemia ranges.

When examining patient safety issues regarding insulin infusions and tight glycemic control, it is important to consider not only at what blood level hypoglycemia is defined, but also how the target glucose range is defined. The studies of tight glycemic control reviewed here had different target glucose ranges (see Figure 1). Also, in most of the studies, there was a gap between the lower level of target blood glucose and the upper range of hypoglycemia. Some studies defined this area as low, whereas others left it undefined. When a study patient had a blood glucose result that fell into this area, the patient may have been experiencing clinical signs of hypoglycemia that were not reported as a hypoglycemic event according to the protocol.

Considering that greater than half of the studies had a gap that fell below the ADA definition of hypoglycemia as a blood sugar level of less than 70 mg/dL,10 it is likely that the incidence of clinical hypoglycemia was higher than reported in these studies. In addition, insulin protocols that have an undefined gap between the lower level of target blood glucose and defined hypoglycemia may pose a safety risk to patients, as clinical hypoglycemia may occur that is not adequately addressed by the protocol. Further research is needed to examine the impact of the use of IV insulin protocols on patient safety, because this is an important issue that has not yet been adequately addressed in the research literature.

Insulin Protocols and Nursing Workload

The American College of Endocrinology and ADA consensus statement on impatient diabetes glycemic control states, "Nurses are essential for successful implementation of protocols, orders sets, more intensive glucose monitoring, and educational programs targeting enhanced glycemic control."20(p1958) The task force also notes that the time and effort required of nurses to implement tight glycemic control

can overburden the nursing system.

Safe implementation of an insulin infusion protocol requires frequent blood glucose monitoring and calculation and titration of the insulin infusion rate, which increases the bedside nurse's workload. Only 1 study of tight glycemic control specifically addressed the increased nursing workload associated with managing an insulin protocol. Krinsley 4 found that initiation of the IV insulin protocol and the increased workload associated with its use did not cause a significant change in staffing requirements in the ICU. However, examination of staffing requirements at the unit level may be too broad of a measure to accurately assess the increased workload placed on an individual nurse managing an insulin protocol.

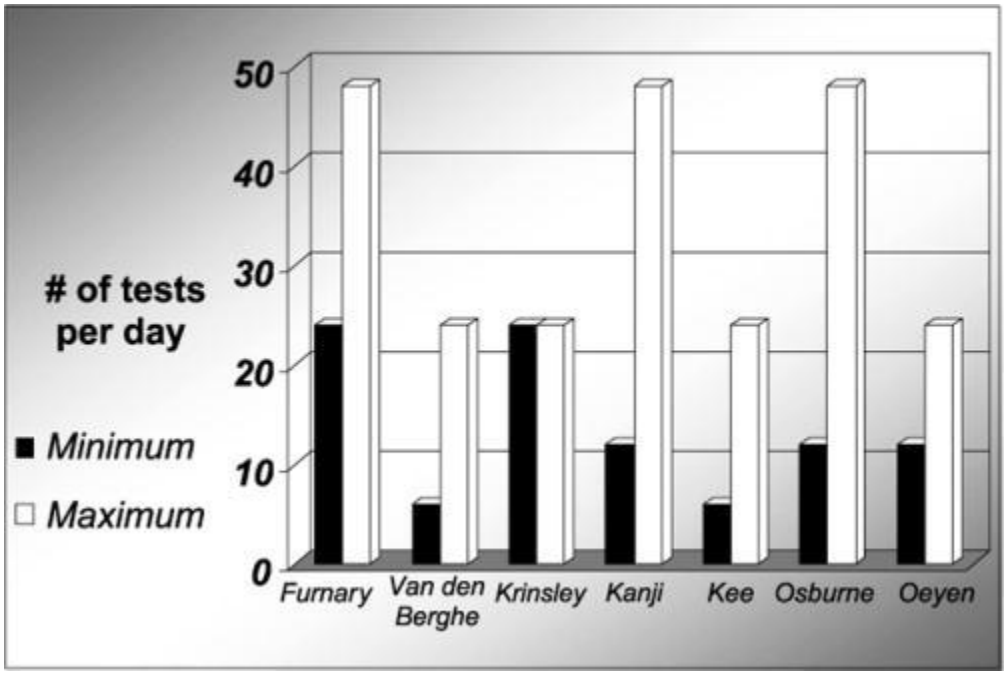

Figure 2. Frequency of glucose testing per protocol.

Two factors that indicate the increase in nurses' workload include the number of blood glucose checks required in a 24-hour period and the degree of difficulty in calculating the proper insulin infusion rate. The studies examined here prescribed the minimal and maximum numbers of blood glucose tests to be completed in a set period (see Figure 2). The minimum number of tests in a 24-hour period was 6 (every 4 hours), and the maximum number of tests was 48 (every 30 minutes). One study did not have any variability in blood glucose measurements as the protocol required hourly checks only.4 The level of variability in potential number of glucose checks demonstrated by most studies makes nursing workload assessments and staffing planning very difficult, as a patient with labile blood sugars will produce a much greater nursing workload than a patient with stable blood sugar levels requiring less frequent monitoring and fewer insulin drip titrations.

The degree of difficulty in calculating the proper insulin infusion rate is subjective, and it can vary from independent calculations conducted by the nurse, to reading a titration table or chart, to inserting numbers into a bedside device, such as a Glucommander, or computer program that automatically calculates insulin drip titrations. Two of the insulin protocols had simple tables that indicated what the

rate of insulin should be for a specific blood glucose level.1,4 Van den Berghe 21 insulin protocol also had a simple table, but used indefinite terms such as approaching normal or falling steeply to direct the nurse in insulin drip management. The use of vague terms leaves much room for interpretation and individual discretion by the nurse in blood glucose management. Kanji and colleagues 2 modified a simple titration table to include the previous blood glucose level. Users were directed to the new insulin infusion rate by locating the current and previous blood glucose level on the chart and following titration directions. This method adds another step to the process and possibly introduces error, but allows for more individual treatment of patients.

Osburne and colleagues 5 used the Columnar Insulin Dosing Chart. Blood glucose ranges are divided into 3 large groups of hyperglycemic, within target, and hypoglycemic. The instructions on the table indicate in which of 10 columns the correct insulin infusion rate is found, and the nurse is directed to a left or right column according to either an increase or decrease in the patient's blood glucose level from the prior test. The Columnar system is complicated, but aided by the use of color coding to define the differing blood glucose ranges. There is more opportunity for error in reading this table, and its use may require additional time from the bedside nurse. However, the protocol allows for more precise adjustments to the insulin infusion.

The most complicated insulin infusion algorithm among the studies consisted of a table with blood glucose ranges on one side and directions for insulin titrations. A decrease in blood glucose directed the nurse to decrease an infusion by one-third or two-thirds of the previous rate.3 The use of fractions to calculate a current drip rate must be done meticulously, can be time consuming, and is overall not a user-friendly approach to insulin drip management. In addition, it requires an infusion pump that can administer a drip rate to the 10th decimal, which can also potentially increase the risk for error.

Two studies examined nurses' perspectives on the impact of tight glycemic control on workload. The first surveyed 60 nurses using an insulin protocol in which the insulin infusion rate was determined from a simple table, with no calculations required.22 Deviations from the protocol were high, with approximately 75% of all blood glucose measurements associated with a protocol deviation, averaging to greater than 9 per patient. This number is quite high, considering that each deviation from the protocol involves additional steps in the glucose management process and may also require a call to the patient's physician. One possible explanation for the high percentage of protocol deviations may be due to nurses' distrust of the effectiveness and safety of the protocol. Nearly a third of the nurses (32%) disagreed that the protocol was effective in preventing patient hypoglycemia; therefore, they may have initiated protocol deviations if they thought the insulin protocol was too aggressive in lowering blood glucose and placed the patient at an increased risk for hypoglycemia.

A majority of the nurses surveyed (70%) indicated that the protocol increased their workload, primarily because of the increased frequency of blood glucose measurements.22 Difficulty in using the protocol was also noted. Eighteen percent of nurses reported difficulty in determining the appropriate insulin infusion rate, and 32% reported the algorithm as an obstacle to glycemic control because it was either too complicated or did not adequately control blood glucose levels. The reported level of difficulty in administering the protocol is concerning, as 60% of the nurses surveyed had been in practice for 5 or

more years, and the largest percentage of nurses (41%) surveyed had greater than 10 years of experience.

In a similar study, 66 nurses responded to survey questions about their perceptions of insulin protocols on nursing workload.23 Although nurses agreed that tight glycemic control is an important part of patient care, over 60% reported concerns about work effort through narrative comments, with many reporting it was too much work (24%) or took too much time (44%). Some nurses (15%) reported that the protocol was difficult to administer on two patients simultaneously. In this study, 90% of the blood glucose monitoring was performed by nurses.

The research reviewed here reveals several factors that increase nursing workload. Blood glucose monitoring every 30-60 minutes adds considerably to nurses' workload, especially in the busy ICU environment. Difficulty in determining the correct dose of insulin also clearly affects nurses' workload. Reading complicated tables, protocols, and performing math calculations increase the time needed to determine the proper insulin infusion rate, and can increase the probability of error.

Implications for Nurse Leaders

The benefits of tight glycemic control need to be weighed against the risk of hypoglycemic events. To achieve the best outcomes for patients, a multidisciplinary approach to implementing tight glycemic control is helpful. A standardized order set, standardized insulin infusion concentration, and adequate number of glucose testing devices at the bedside can increase patient safety and reduce nursing workload. As the use of insulin protocols increases, nurses may find that there are an inadequate number of glucometers available to meet the needs of several patients receiving insulin infusions. In a study that examined barriers to insulin infusion protocols, Goldberg and Inzucchi 24 found that time spent searching for an available glucometer (increased workload) was one of the most common complaints by nurses.

Administrative support of the practice of tight glycemic control is important to ensure adequate resources for nurses including education regarding protocol use and adequate staffing levels. Some of the reported difficulty in using glycemic control protocols may be reduced through the advent of more education for nursing staff. Goldberg and Inzucchi 24 found that nursing resistance to protocol implementation was decreased when education was provided that focused on the purpose and benefits of insulin protocols and addressed nurses' fears of causing hypoglycemia. Malesker and colleagues 22 also concluded that the high level of nonadherence to the protocol in their study may have resulted from inadequate nursing education and fears of hypoglycemia. Regarding staffing levels, nurse leaders should consider the increased demands on nursing time that insulin protocol management requires when making staffing assignments. Also, the use of support personnel, such as nurse aids or technicians, in performing bedside glucose checks should be maximized to aid in decreasing nursing workload.

To address these concerns, nurse leaders should ensure that insulin protocols are selected that define hypoglycemia at levels that more closely follow the standards set by the ADA 10 and that adequate

education is provided to nurses regarding the risks of hypoglycemia and the proper administration of insulin protocols. In addition, deviations from protocols should be monitored, and nursing input should be regularly sought regarding the feasibility and effectiveness of the protocols in maintaining glycemic control within safe parameters. Issues that affect either nursing workload or patient safety should be addressed and evaluated on a regular basis. The establishment of a quality control team designed to monitor insulin protocol effectiveness and nursing satisfaction may be a useful strategy in addressing these issues.

Directions for Future Research

The benefits of tight glycemic control have been well documented. More research, however, is needed on the risk to patient safety related to hypoglycemia during tight glycemic control. Suggestions for further research and insulin protocol development include (1) the use of a standard definition of hypoglycemia to allow the true incidence of hypoglycemia to be determined and to facilitate comparisons across studies, (2) definitions for target blood sugar range and hypoglycemia that do not contain a gap where clinical hypoglycemia could occur that is not addressed by the protocol, (3) considerations for both nursing time and increased workload related to the frequency of blood glucose checks, and (4) the methods required to determine insulin infusion rate titrations.

Nurse researchers should take the lead in further investigating tight glycemic control protocols. There are barriers in every institution to safe implementation of these protocols that may be best researched and addressed by nurses, as they are the primary providers who manage the protocols at the bedside and are able to provide a front-line assessment of their efficiency, effectiveness, and impact on both patient safety and nurse workload. The number of deviations from insulin protocol and the causes of those deviations should also be investigated further to aid in the refinement of protocols to maximize their effectiveness and patient safety. Staff education is essential for putting tight glycemic controls into practice, and the amount of education provided should be considered when protocol deviations are examined. Nurses' workload should be further studied to determine the impact of insulin protocols on staffing requirements. A key piece of this research should focus on the relationship between increased time demands caused by tight glycemic control and patient safety.

Tight glycemic control is beneficial and safe for most patients. With some changes in practice aided by further research, the benefits of tight glycemic control can be realized by more patients in a safer environment.

Acknowledgment

The authors thank Elizabeth Tornquist for her editorial assistance in the preparation of this article.

References

1. Furnary AP, Gao G, Grunkemeier GL, et al. Continuous insulin infusion reduces mortality in patients with diabetes undergoing coronary artery bypass grafting. J Thorac Cardiovasc Surg. 2003;125(5):1007-1021.

2. Kanji S, Singh A, Tierney M, Meggison H, McIntyre L, Hebert PC. Standardization of intravenous insulin therapy improves the efficiency and safety of blood glucose control in critically ill adults. Intensive Care Med. 2004;30:804-810.

3. Kee CA, Tomalty JA, Cline JM, Novick RJ, Stitt L. Change in practice patterns in the management of diabetic cardiac surgery patients. Can J Cardiovasc Nurs. 2006;16:20-27.

4. Krinsley JS. Effect of an intensive glucose management protocol on the mortality of critically ill adult patients. Mayo Clin Proc. 2004;79:992-1000.

5. Osburne RC, Cook CB, Stockton L, et al. Improving hyperglycemia management in the intensive care unit. Diabetes Educ. 2006;32:394-403.

6. Van den Berghe G, Wouters P, Weekers F, et al. Intensive insulin therapy in critically ill patients. N Engl J Med. 2001;345(19):1359-1367. HTML Full Text

7. Copstead LC, Banasik JL. Pathophysiology. 3rd ed. St. Louis, MO: Elsevier Saunders; 2005.

8. Van den Berghe G. Insulin therapy for the critically ill patient. Clin Cornerstone. 2003;5:56-63.

9. American Association of Clinical Endocrinologists. American Association of Clinical Endocrinologists medical guidelines for clinical practice for the management of diabetes mellitus. Endocr Pract. 2007;13(suppl 1):1-66. http://www.aace.com/pub/pdf/guidelines/DMGuidelines2007.pdf. Accessed September 24, 2007.

10. American Diabetes Association. Standards of medical care position statement. Diabetes Care. 2006;29(suppl 1):S4-S43.

11. Institute for Safe Medication Practices. ISMP's list of high-alert medications. Institute for Safe Medication Practices. http://www.ismp.org/tools/highalertmedications.pdf. Published 2007. Accessed October 11, 2007.

12. Garrard J. Health Sciences Literature Review Made Easy. 2nd ed. Sudbury, MA: Jones and Bartlett; 2007.

13. Karon BS, Gandhi GY, Nuttall GA, et al. Accuracy of Roche Accu-Chek inform whole blood capillary, arterial, and venous glucose values in patients receiving intensive insulin therapy after cardiac surgery. Am J Clin Pathol. 2007;127:919-926.

14. Lacara T, Domagtoy C, Lickliter D, et al. Comparison of point-of-care and laboratory glucose

analysis in critically ill patients. Am J Crit Care. 2007;16:336-346.

15. Kanji S, Buffie J, Hutton B, et al. Reliability of point-of-care testing for glucose measurement in critically ill adults. Crit Care Med. 2005;33:2778-2785. HTML Full Text Request Permissions

16. American Diabetes Association. Hypoglycemia-all about diabetes. American Diabetes Association. http://diabets.org/type-1-diabetes/hypoglycemia.jsp. Accessed November 4, 2007.

17. Kee JL. Laboratory and Diagnostic Tests With Nursing Implications. 7th ed. Upper Saddle River, NJ: Pearson Prentice Hall; 2005.

18. Van den Berghe G, Wouters PJ, Bouillon R, et al. Outcome benefit of intensive insulin therapy in the critically ill. Insulin dose versus glycemic control. Crit Care Med. 2003;31:359-366. HTML Full Text Request Permissions

19. Oeyen SG, Hoste EA, Rossens CD, Decruyenaere JM, Blot SI. Adherence to and efficacy and safety of an insulin protocol in the critically ill: a prospective observational study. Am J Crit Care. 2007;16:599-608.

20. Garber AJ, Moghissi ES, Buonocore D, et al. American College of Endocrinology and American Diabetes Association consensus statement on inpatients diabetes and glycemic control. Diabetes Care. 2006;29:1955-1962.

21. Van den Berghe G. Insulin therapy in critical illness. Can J Diabetes. 2004;28:43-49.

22. Malesker MA, Foral PA, McPhillips AC, Christensen KJ, Chang JA, Hilleman DE. An efficiency evaluation of protocols for tight glycemic control in intensive care units. Am J Crit Care. 2007;16:589-598.

23. Aragon D. Evaluation of nursing work effort and perceptions about blood glucose testing in tight glycemic control. Am J Crit Care. 2006;15:370-377.

24. Goldberg PA, Inzucchi SE. Selling root canals: lessons learned from implementing a hospital insulin infusion protocol. Diabetes Spec. 2005;18:28-38.