IMPACT OF A NURSE-MANAGED HYPERGLYCEMIC INTENSIVE INSULIN

PROTOCOL ON GLUCOSE CONTROL

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Abstract

RESEARCH SUBJECT: Impact of a Nurse-Managed Hyperglycemic Intensive
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Many critically ill patients have poorly controlled glucose levels which can lead to increased mortality, morbidity, and length of stay. Tight glycemic control in the critically ill patient is challenging to manage by both nurses and physicians (Holzinger et al., 2008). The purpose of this study is to compare the effectiveness of a nurse-managed hyperglycemia protocol to that of a standardized hyperglycemia protocol with critically ill patients. Study inclusion criteria for the sample of 50 intensive care unit (ICU) patients will be a ICU stay of longer than 48 hours and to have received insulin for longer than 24 hours. Data collected will be blood glucose at 48 hours post-ICU admission, length of time of blood glucose levels less than 150 and 110, and daily insulin dosage. Group 1 will include 25 consecutively selected admitted ICU patients, who receive the standardized hyperglycemia protocol. Group 2 will include 25 ICU patients consecutively admitted after nurse and physician education and implementation of a nurse-managed hyperglycemia protocol. Statistical analysis will include comparisons of group differences in blood glucose, times, and insulin dosage. Findings of this study will provide information on the effectiveness of a nurse-managed hyperglycemia protocol.

Chapter I

Introduction

Diabetes is a large and soon to be growing pandemic internationally affecting

public health (Jack, 2003). Diabetes is the fifth leading cause of death in most countries

globally. The number of individuals coping with diabetes, primarily type 2 diabetes, has

drastically increased and is expected to explode exponentially within the next several

decades (Gucciardi, DeMelo, Lee, & Grace, 2007). A large number of individuals

admitted to Intensive Care Units nationwide have a pre-existing diagnosis of either type 1

or type 2 diabetes (Langdon & Shriver, 2004). The incidence of diabetes is increasing

significantly as it currently affects more than twenty million Americans and is projected

to affect thirty nine million Americans by the year 2050. In 2005, the cost of diabetes was

approximately 149 billion dollars and ranked eighth among the fifteen most costly

medical conditions within the United States (Krein, Funnell, & Piette, 2006).

Diabetes is poorly controlled in the United States. Less than two percent of all

adult diabetics receive quality care to optimally manage blood glucose (Clark, Synder,

Meek, Stutz, & Parkin, 2001). Diabetes is a chronic illness and the leading cause of

acquired blindness, end-stage renal disease, and lower limb amputation unrelated to

trauma. (Krein et al., 2006). Diabetes causes increased hospitalizations, increased cost of

healthcare, and many complications including early death (Langdon & Shriver, 2004).

Diabetes has been associated with poor outcomes in the hospitalized patient and attributed to immunosuppression, cardiovascular complications, thrombosis, hemodynamic and hematological changes (Boucher et al., 2007). Diabetes significantly contributes to cardiovascular disease, which is the number one cause of death in the United States with sixty five percent of diabetic patients dying of cardiovascular disease (Fisher & Kapustin, 2007).

Although evidence supporting tight glycemic control for Type 2 diabetics has been widely spread, glycosated hemoglobin results have not significantly improved within the past decade (Parchman, Pugh, Wang & Romero, 2007). Evidence shows that patients that live with a high glycosated hemoglobin inevitably suffer from preventable diabetic complications (Fisher & Kapustin, 2007). Intensive glucose therapy has been shown to decrease glycosated hemoglobin which reduces the risk of diabetic complications compared to moderate glucose control. Recent research has highlighted the importance of intensive glucose control to improve quality and outcomes in diabetic management (Huang, Qi Zhang, Gandra, Chin, & Meltzer, 2008).

Research studies have revealed that approximately one third of all patients have hyperglycemia on admission to tertiary care facilities, twelve percent of which have no history of diabetes. Hyperglycemia significantly negatively impacts prognosis for the critically ill patient (DiNardo, Korytkowski, & Siminerio, 2004). Patients admitted with a normal or near normal blood glucose are found to have lower mortality rates than those admitted with hyperglycemia (Langdon & Shriver, 2004). Higher admission glucose results are associated with an increased likelihood for developing congestive heart failure, cardiogenic shock, and need for coronary bypass grafting. Hyperglycemia has also been

attributed to poor outcomes such as severe disability and death among acute stroke patients. (DiNardo, et al., 2004).

Background and Significance

Healthcare costs in the United States exceed an astronomical $1 trillion annually which can be attributed to the increasing number of elderly individuals, chronic disease, increased illness severity, large number of individuals requiring prolonged ventilatory support, extended ICU stays, and frequent hospital re-admissions. People are living longer, yet have many comorbid chronic disease processes, such as diabetes, to manage which is very challenging for the healthcare system (Douglas, Daly, Kelley, O'Toole, & Montenegro, 2007).

Glucose control has become a critical element in the management of critical illness due to an astounding amount of research that signifies that hyperglycemia leads to adverse clinical events (Aragon, 2006). Hyperglycemia often occurs in acutely ill patients with no prior history of diabetes. Hyperglycemia that is inadequately controlled is associated with myocardial infarction, acute coronary syndrome, stroke, postoperative wound infections and trauma (Krinsley, 2004). Hyperglycemia negatively affects fluid balance, infection predisposition, morbidity, increases the risk for renal failure, polyneuropathy and mortality in critically ill patients (DiNardo et al., 2004).

Hyperglycemia and insulin resistance are the result of the stress and inflammatory response during critical illness and injury (Dossett et al., 2008). Hyperglycemia can arise after a traumatic event or stressor such as acute illness. Increased glucogenesis, hepatic glucogenesis, and altered insulin use in peripheral tissue causes this hyperglycemia in metabolically stressed individuals (Perkins, 2004). Hyperglycemia negatively affects the

immune system thus increasing susceptibility to infections (Langdon & Shriver, 2004). Intensive insulin therapy reduces complications such as acute renal failure, critical illness neuropathy, and bloodstream infections by about forty percent. Current research findings demonstrate that stress-related hyperglycemia episodes should be managed with consistent blood glucose measurements and intensive insulin therapy (Perkins, 2004).

Tight glycemic control achieved by aggressive insulin administration has proven to improve patient outcomes and decreases mortality and morbidity in the Intensive Care setting (Boucher et al, 2007). Maintaining tight glycemic control is associated with decreased complications, infections, and length of stay. By controlling glucose in the critically ill, adverse outcomes such as renal failure and prolonged mechanical ventilation are substantially decreased. Research indicates that maintaining blood glucose in normal ranges improves outcomes in the critically ill. With this overwhelming body of evidence, many critical care units nationwide have designed and implemented glycemic control protocols to tightly maintain blood glucose (Aragon, 2006).

Glycemic control protocols are designed to maintain normoglycemia. Normoglycemia is achieved by frequently monitoring blood glucose levels and titrating intravenous insulin infusions within the desired glucose ranges specified by the protocol. Intravenous insulin infusions are the foundation for management of hyperglycemia in critically ill patients, due to the rapid onset, the rapid rate of response, and more predictable dosing with abnormalities in circulation of many critically ill patients (Gerard, Neary, Apuzzo, Giles, & Krinsley, 2006). The goal of the glycemic control protocol is to limit the duration of hyperglycemia by safely accomplishing the targeted blood glucose

levels within the shortest time possible. Once normoglycemia is achieved, frequent blood glucose monitoring is necessary to detect and treat hypoglycemia (Aragon, 2006).

While glycemic control protocols are extremely beneficial to patients, nurses and physicians frequently struggle to maintain normoglycemia. Nurses have been vocal regarding challenges to glucose control such as lack of education, increased workload and protocol deviations. Dillard & Aragon (2005) examined the safety, compliance, and effectiveness of a new set of standardized physician orders for intravenous insulin infusion. Many comments and suggestions came from the nursing staff regarding the order set and processes for glucose control, which revealed an educational deficit that had not been expected. Nurses verbalized that education was needed to explain the benefit of controlling blood glucose levels in order to appropriately use the protocols and understand the rationale for increased blood glucose monitoring and frequent insulin dosage adjustments (Aragon, 2006).

Blood glucose control in the hospital setting has been shown to reduce healthcare costs and improves patient outcomes (Noschese et al., 2008). The significance of this study is to demonstrate that a nurse directed tight glycemic protocol effectively and safely manages blood glucose in the intensive care setting. Hyperglycemic critically ill patients will greatly benefit from the utilization of this protocol by experiencing normoglycemia.

Statement of the Problem

Hyperglycemia at the time of ICU admission is an independent risk factor for increased mortality and morbidity (Oeyen, Hoste, Roosens, Decruyenaere, & Blot, 2007). Tight glycemic control using an insulin protocol or algorithm is associated with improved

outcomes during acute illness. Nurses play an essential role in managing hyperglycemia and maintaining tight glycemic control. Through collaboration and planning among the multidisciplinary team, tight glycemic control protocols can be developed and implemented within the critical care setting. Critical to the successful utilization of this protocol, must be a degree of understanding among the nursing staff with regards to the benefits of tight glycemic control.

Purpose of Study

The purpose of this study is to compare the effectiveness of a nurse-managed hyperglycemia protocol to that of a standardized hyperglycemia protocol on control of hyperglycemia in critically ill patients. This is a reproduction of Holzinger et al. (2008) research. The findings of study are intended to demonstrate the effectiveness of a nurse driven glucose management protocol to adequately maintain normoglycemia in the critical care environment.

Research Question

The research question that guides this study is: Is a nurse-managed hyperglycemia intensive insulin protocol more effective than a standardized hyperglycemia intensive insulin protocol in maintaining normoglycemia in critically ill patients?

Conceptual Framework

The Humanistic Nursing theory is used to guide and describe everyday nursing by offering a framework that is developed from the lived experiences of the nurse and patient. The core of humanistic nursing is existentialism which is a philosophical way of viewing and understanding life. The humanistic theory guides the nurse to explore his/her frame of reference and promotes the development of trusting relationships to enhance

well-being. Nurses then build relationships with their patients to foster health and well-being. This theory encourages nurses provide holistic emotional, spiritual and physical care, promoting comfort and wellness behaviors, education, patient advocacy, and therapeutic communication to all patients. All these activities are coordinated in hopes of encouraging the patient to gain independence and return to optimal wellness (Patterson & Zderad, 1988). Using the humanistic nursing theory as a framework, nurses can nurture patients and actively strive to maintain glycemic control, thus improving health and well being in the critical care setting.

Definition of Terms

Hyperglycemia

Conceptual Definition: The presence of an abnormally high concentration of glucose in the blood (Jack, 2003).

Operational Definition: Blood glucose will be measured by fingerstick every two hours using the GlucoTouch Glucometer.

Hyperglycemic Intensive Insulin Protocol

Conceptual Definition: Guidelines to maintain blood glucose within a defined range using intravenous insulin infusion and titration (Holzinger et al., 2008).

Operational Definition: Nurses in this study will follow hyperglycemia intensive insulin protocols for blood glucose control in order to maintain glucose levels within the defined range.

Limitations

Limitations of this study include limited generalizability due to the small sample size as well as the local study setting. An additional limitation is that numerous ICU

nurses will be implementing the nurse-managed hyperglycemic intensive insulin protocol and protocol deviations may occur.

Assumptions

The following assumptions underlie this study:

1. Nurses and physicians will attend nurse-managed hyperglycemic intensive insulin protocol educational sessions.

2. Nurses will use the nurse-managed hyperglycemic intensive insulin protocol and titrate interventions as directed.

Summary

Hyperglycemia is detrimental to the critically ill patient, causing a multitude of complications including death. To control hyperglycemia, hyperglycemic control protocols are used in the critical care setting. The purpose of this study is to compare the effectiveness of a nurse-managed hyperglycemic intensive insulin protocol to that of a standardized hyperglycemic intensive insulin protocol on control of glucose in critically patients. The Humanistic Nursing theory will be used as a framework to guide the nurse to build relationships with their patients, thus providing holistic emotional, spiritual and physical care, promoting comfort and wellness behaviors, education, patient advocacy, and therapeutic communication to all patients. The significance of this study will be to highlight that normoglycemia can be achieved using a nurse-managed hyperglycemia intensive insulin protocol.

Chapter II

Literature Review

Introduction

Many critically ill patients have poorly controlled glucose levels which in turn can lead to diabetic complications which can increase mortality and morbidity and increase hospital length of stay. Literature suggests that critically ill patients admitted with a normal or near normal glucose are more likely to have lower mortality rates and better outcomes than those admitted with hyperglycemia. Healthcare education must focus on the importance of maintaining glucose levels to appropriately understand tight glycemic control in the critically ill (Langdon & Shriver, 2004). The purpose of this study is to evaluate the effectiveness of a nurse directed education program on control of glucose in intensive care patients. This current study replicates the work of Holzinger et al. (2008). The literature review is organized into five sections: (a) theoretical framework; (b) hyperglycemia; (c) glucose control; (d) nursing influence on tight glucose control; and (e) tight glycemic control protocols.

Theoretical Framework

Paterson and Zderad developed the Humanistic Nursing Theory, which is the study of the existence and reality of nursing. The basis of the Humanistic Nursing Theory is that "nursing is an intersubjective transactional relationship between a nurse and a patient who are human beings existing in the world" (Patterson & Zderad, 1988, p. 7).

This theory is used to guide and describe everyday nursing by offering a framework that is developed from the lived experiences of the nurse and patient. Humanistic nursing practice allows the nurse to approach nursing care as an experience, which is then reflected upon to develop a sense of presence in nursing situations to expand upon nursing science (Patterson & Zderad, 1988).

Humanistic nursing involves the phenomenological experiences of each person and the exploration of those experiences. The root of humanistic nursing is existentialism which is the philosophical approach to understanding life. Each individual person is faced with a multitude of choices when making decisions; these choices decide the direction and meaning of each individual's life. Existentialism refers to viewing each individual as (a) being capable of self-awareness; (b) being free and responsible; (c) searching for identity within relationships; (d) searching for the meaning in life; (e) experiencing anxiety or dread; and (f) experiencing life and death to understand the art of living. Being aware of nursing existentialism, one must develop awareness for an authenticity with one's self. Sensory responses allow the nurse to uniquely develop consciousness which shapes the quality of one's being and presence with others. To develop valid presence that is displayed to others, the nurse must believe that his/her presence is valuable and genuinely makes a difference in the lives of others (Patterson & Zderad, 1988).

Phenomenology is the methodology of a phenomenon's meaning to an individual and influences the development of existentialism by analyzing the human situation from the individuals' perceptions. The phenomenology of humanistic nursing includes five phases. The first phase is the preparation of the nurse to come to know; which means that

the nurse strives to be caring and being open to experiences and other's views. The second phase is the nurse knowing others intuitively which includes developing an intimate knowledge of another individual. The third phase is the nurse knowing another scientifically which is separateness from what is known. The fourth phase involves relating, comparing and contrasting situations to expand understanding. The final phase is the process of working with known realities to intuitively form a paradoxical truth (Patterson & Zderad, 1988).

Humanistic nursing practice theory encourages the nurse to explore his/her unique thoughts and perspectives to develop trusting relationships that enhance well-being (Patterson & Zderad, 1988). Nurses then build relationships with their patients and nurture them towards health and well-being. Each day, nurses strive to provide holistic, diligent, humanistic nursing care while working within the constraints of the nursing environment. Nurses meet individuals across the life span and are in a unique position to help individuals who may be in physical, emotional, social and/or spiritual pain. Humanistic nursing promotes a commitment to provide patients with quality, comprehensive, nonjudgmental nursing care. Critical to helping the nurse fulfill this obligation is a degree of comfort in dealing with diverse populations and disease processes. When nurses communicate with their patients and family members, they have a clearer understanding of their patients' needs and can determine if they or someone else can provide a caring presence. The nurse, as a caring professional, may contribute meaningfully to the wellness of the patient and significant others through some of life's most difficult and challenging transitions (Patterson & Zderad, 1988).

The unity, continuity, consistency and uniqueness within make a person an individual, thus different from other living beings. Each person is different in their needs and abilities, but the same in regards to their desire for needing care which allows nurses to greatly impact a person's well being and overall health. Humanistic nursing theory provides nurses with the foundation to provide holistic emotional, spiritual and physical care, promoting comfort and wellness behaviors, education, patient advocacy, and therapeutic communication to all individuals in need in a multitude of settings. All these activities are coordinated in hopes of encouraging the patient to gain independence and optimal wellness. Health and well being are promoted by encouraging patients and significant others to care for themselves and constantly strive to enhance the well being, self esteem and dignity (Patterson & Zderad, 1988). Using the humanistic nursing theory as a framework, nurses can nurture patients and actively strive to maintain glycemic control, thus improving health and well being in the critical care setting.

Hyperglycemia

Hyperglycemia is common among critically ill patients, particularly those with trauma, acute stroke, myocardial infarction, and sepsis. Cely, Arora, Quartin, Kett, & Schein (2004) examined the relationship of baseline glucose control and acute stimuli with hyperglycemia in medical ICU patients.

The study took place in a medical ICU (MICU) of a university affiliated hospital in Miami, Florida. The population included MICU patients. The sample included 100 patients who met criteria for illness severity with an APACHE (acute physiology and chronic health evaluation) score greater than 11, anticipated length of stay greater than 48 hours, and did not have diabetic ketoacidosis, hyperglycemic hyperosmolar state, or

hemoglobinopathies. Demographic data included age, gender, ethnicity, and insurance status (Cely et al., 2004).

For this study, hemoglobin A1C was measured using Variant II within 120 hours of admission to the MICU. Nurses used the OneTouch SureStep plasma calibrated glucometer for bedside glucose measurements. Blood glucose levels between measurements were estimated using linear interpolation. To compare frequencies between groups, a Fisher exact test was used. Glucose control models were developed using stepwise linear regression. Statistical analyses were performed using NCSS 2000 (Cely et al., 2004).

Findings from Cely et al. (2004) were that patients who had abnormal baseline glucose control experienced significantly more hyperglycemia episodes than patients with normal baseline control. Patients were categorized as normal, abnormal or unevaluable baseline control based on glycosylated hemoglobin results. Hyperglycemia (glucose >110 mg/dL) was present in all groups. Using multiple regression the authors found that glycosylated hemoglobin, corticosteroid dose and carbohydrate administration was independently associated hyperglycemic time ($p < .05$), while body mass index and APACHE scores did not correlate with the time blood glucose was greater than 110 mg/dL (Cely et al., 2004).

Cely et al. (2004) concluded that hyperglycemia is common in critical illness even in patients without abnormal baseline glucose control. Acute stressors and baseline glucose regulation are directly correlated with hyperglycemia. The authors concluded that patients with low glycosylated hemoglobin results were less likely than patients with normal glycosylated hemoglobin results to develop hyperglycemia during critical illness.

Hyperglycemia frequently occurs in acutely ill patients with no history of diabetes. Research recommends maintaining blood glucose levels less than 110 mg/dL in critically ill patients to decrease mortality. Rady, Johnson, Patel, Larson, & Helmers (2005) studied the relationship between critically ill patient characteristics, such as a history of diabetes to glycemic control using insulin therapy and mortality.

The setting for this study was a tertiary care center medical, surgical, and coronary closed 20 bed intensive care unit (ICU) at Mayo Clinic Hospital in Arizona (Rady et al., 2005). This three year case-control descriptive study was conducted after implementation of a glycemic management protocol. Participants were involved in the study if they were admitted to this unit and eighteen years or older (Rady, et al, 2005). The final sample included 7,285 patients. Rady et al. (2005) included demographic data related to: age, gender, comorbid conditions, body mass index and other pertinent data.

A multidisciplinary team consisting of physicians and nurses collaborated to develop a glycemic management protocol consisting of short-acting insulin administered either subcutaneously or intravenously as a continuous infusion. All patients admitted to the ICU were placed on this nurse driven protocol which allowed nurses to address glycemic control without a physicians' order. Nurses used whole blood to obtain glucose values using an Accu-Check Inform System which was calibrated daily. Upon protocol implementation, plasma glucose assays were obtained using Roche/Hitachi 912 Analyzer which was calibrated three times daily. The total amount of insulin administered including time, date, insulin amount and route of administration was recorded using LastWord 4.1. Characteristics and severity of critical illness was determined using the Sequential Organ Failure Assessment (SOFA) score (Rady et al., 2005).

Rady et al. (2005) found that out of the 7,285 patients, a total of 2,826 (39%) required insulin for glycemic control of which 1,083 (15%) had a history of diabetes mellitus. Nondiabetic patients requiring insulin were more likely to have congestive heart failure (14% versus 10%, p< .001), chronic liver disease (11% versus 5%, p < .001) or surgical admission (65% versus 42%, p<.001) than the control group. The control group had a median glucose level of 118 mg/dL (range of 97 to 153 mg/dL) and a mortality rate of 5%. Nondiabetic patients had a median blood glucose level of 134 mg/dL (range 110 to 181 mg/dL) with a mortality rate of 10%. Diabetic patients had a median glucose level of 170 mg/dL (range of 121 to 238 mg/dL) with a mortality rate of 6%. Diabetic patients who did not survive had longer periods of glucose levels greater than 200 mg/dL than diabetic survivors. Nondiabetic patients who expired had longer periods of glucose values greater than 144 mg/dL compared with nondiabetic survivors. Poor glycemic control in nondiabetic patients was associated with increased insulin need and increased mortality. Rady et al. (2005) found that critical care characteristics that were predictive of poor glycemic control included advanced age, history of diabetes, cardiac surgery, postoperative complications, illness severity, nosocomial infections, prolonged mechanical ventilation, or concurrent medications.

Rady et al. (2005) concluded that characteristics of critical illness influenced glycemic control and clinical outcomes greatly. Worse outcomes were associated with acute insulin resistance in nondiabetic patients. The authors suggested that future research should be focused on examining the effects of insulin administration and optimal glycemic control in the critically ill patient.

Hyperglycemia significantly impacts clinical outcomes and economic costs among critically ill patients. Systemic infections initiate a trauma induced hypermetabolic reaction that increases hepatic glucose construction and reduces insulin mediated glucose uptake. The purpose of the study was to determine whether the "extent or severity of hyperglycemia upon onset of ICU acquired bloodstream infection (BSI) correlates with outcome in a well defined heterogeneous population of severely ill patients" (Vandijck et al., 2008).

The setting was the medical, surgical, cardiosurgical, and burn ICU of a tertiary care referral centre in Belgium. The population included ICU patients who developed a bloodstream infection. The sample included 130 patients with a microbiologically documented ICU acquired bloodstream infection. Demographic data included age, gender, ICU length of stay, hospital length of stay, and other pertinent information (Vandijck et al., 2008).

Morning blood glucose results were assessed one day prior and five days after onset of ICU obtained bloodstream infection. Hyperglycemia was divided into three groups of >150 mg/dL, >175 mg/dL, and > 200 mg/dL. Participants were grouped in two groups: survivors and non-survivors. Group comparisons were made using Chi square and Fisher's exact tests for variable with in hospital mortality estimated by logistic regression (Vandijck et al., 2008).

Vandijck et al. (2008) found that there were no differences among survivors and non-survivor's morning blood glucose levels. Although, there was a trend of increased blood glucose levels with the inception of a bloodstream infections among nonsurvivors, whereas a decreased trend in survivors. Hyperglycemia (<175 mg/dl) was observed more

frequently in non-survivors. The researchers found that factors such as antibiotic resistance (p=.004) and hyperglycemia (<175mg/dL) upon onset of a bloodstream infection were independently associated with in-hospital mortality, whereas a history of diabetes (p =.041) was linked with better outcomes (Vandijck et al., 2008).

Vandijck et al. (2008) concluded that hyperglycemia <175 mg/dL with the onset of a bloodstream infection is connected with poor outcomes. An ICU acquired bloodstream infection coupled with hyperglycemia is associated with an increased risk of adverse outcomes in the critically ill population.

Glucose Control

Hyperglycemia leads to many complications such as critical illness polyneuropathy, bacteremia and acute renal failure in critically ill medical and surgical patients. To prevent such complications and reduce mortality and morbidity, strict glycemic control is recommended. It is challenging for both physicians and nurses to maintain tight glycemic control due to a lack of understanding, knowledge, and collaboration. The purpose of this study was to compare the effectiveness of a nurse-managed hyperglycemia intensive insulin protocol to that of a standardized hyperglycemia intensive insulin protocol in the critically ill patient (Holzinger et al., 2008).

Criteria for inclusion into the study were patients with an ICU stay of 48 hours or longer and to have received continuous IV insulin for more than 24 hours. During an observational baseline period with use of the standardized hyperglycemic intensive insulin protocol, 36 consecutively admitted ICU patients were included as study

participants. Data collected were blood glucose levels, length of time of blood glucose levels of less than 150 and 110, hourly insulin dosage, and daily insulin dosage.

Next, five educational sessions were conducted regarding the importance of strict glycemic control along with nurse-physician collaboration in developing and implementing a nurse-managed hyperglycemic intensive insulin protocol. The new hyperglycemia protocol was developed.

After implementation of the new nurse-managed hyperglycemic intensive insulin protocol, 44 patients were entered into the study. The same data was collected for this patient group as for the group of patients who were managed with the standardized hyperglycemic intensive insulin protocol.

Data was measured as median with calculations to measure length of time blood glucose was less than 110 mg/dL and greater than 150 mg/dL. The Mann-Whitney U test was used to differentiate between numeric data, when needed. GraphPad Prism software was used for statistical analysis (Holzinger et al., 2008).

Holzinger et al. (2008) found that there was a significant increase in insulin dosage and decrease in median blood glucose levels after the nurse-managed hyperglycemic intensive insulin protocol was implemented. There was a significant decrease ($p<.001$) in the length of time that a patient's blood glucose remained out of the expected range between 110 mg/dL and 150 mg/dL. The authors also found that maintaining normoglycemia in known diabetics was extremely challenging compared with non-diabetic patients. Using the nurse-managed hyperglycemic intensive insulin protocol, the rate of hypoglycemia was 16% with no adverse effects found. Findings also

included that a nurse-managed protocol and enhanced educational efforts improved glucose control in the MICU (Holzinger et al., 2008).

Holzinger et al. (2008) concluded that education and collaboration between the physicians and nurses led to normoglycemia a high percentage of time. With a nurse managed tight insulin algorithm, patients reached target glucose levels and stayed within range longer than insulin therapy administered at the physicians' discretion.

Hyperglycemia increases mortality and morbidity in the critically ill patient. Critically ill patients that experience tight glycemic control using intravenous insulin protocols have decreased complications and improved outcomes. In 2008, Dossett et al. conducted a study to examine the affects of blood glucose variability associated with mortality in the surgical ICU.

The setting was a surgical and trauma ICU in a large tertiary academic medical center. Ventilated, trauma, or surgical patients who were admitted over a six month time period and placed on insulin protocol to maintain normoglycemia were included in this retrospective study (Dossett et al., 2008). Patients were excluded from the study if less than five blood glucose values were completed. The final sample consisted of 858 patients, primarily males with the majority being trauma. The sample provided 46,474 data points. For statistical analysis, Dossett et al. (2008) included demographic data including age, gender, diagnosis and other pertinent information.

Data was collected using the Sure Step Professional Blood Glucose System. An automated care provider order entry system was used to achieve and maintain normoglycemia using an intravenous insulin therapy protocol. If blood glucose exceeded 110 mg/dL, the intravenous insulin protocol was initiated and titrated based on blood

glucose. The variability of blood glucose was obtained by comparing standard deviation, percentile values, successive blood glucose fluctuations and calculation of the triangular index for glucose related indices (Dossett et al., 2008).

Findings from Dossett et al. (2008) were that there is a difference in blood glucose variability among trauma and surgical ICU patients in spite of similar mean blood glucose levels. Of the 858 patients included in this study, there was a fourteen percent mortality rate. Admission mean blood glucose levels were similar between survivors and nonsurvivors ($p > 0.05$). Although, nonsurvivors did have greater variability with a larger maximum glucose of 216 mg/dL compared with survivors maximum glucose of 199 mg/dL. In fact, Dossett et al. (2008) determined that increased blood glucose variability is associated with mortality in surgical ICU patients.

Additional findings of this study found that even with comparable mean blood glucose levels, insulin dosage was considerably different among survivors and nonsurvivors. Dossett et al. (2008) found that the mean insulin dosage was significantly lower in survivors with infusions at 3 units/hour ($p = .003$) than nonsurvivors with infusions at 3.6 units/hour. Survivors experienced decreased variability for blood glucose, insulin dosage, and successive blood glucose variability.

Dossett et al. (2008) concluded that mean glucose coupled with glucose variability are strong indicators of mortality in the critically ill patient. Insulin protocols should be tailored to minimize glucose fluctuation to prevent adverse outcomes. Future research should be aimed at determining factors that minimize blood glucose variability, which likely includes the contributions of clinical and genetic influences.

Nursing Influence on Tight Glucose Control

Tight glycemic control has become a gold standard in critically ill patients to decrease morbidity and mortality. Evidence based practice demonstrates that nurses are critical to successfully titrating insulin protocols in order to maintain tight glycemic control in the critical care setting. Bedside nurses struggle to utilize tight glycemic control protocols appropriately due to short staffing, increased workloads, lack of education, and fear of hypoglycemia. The purpose of the DuBose et al. (2009) study was to examine the role bedside nurses play in accomplishing tight glycemic control, particularly if improvements are shown after nursing involvement in the development, implementation and maintenance of a tight glycemic control protocol.

The setting was a Surgical-Trauma Intensive Care Unit (STICU) within a large teaching hospital in Los Angeles, California. The population included 135 critically ill patients receiving tight glycemic control and 23 STICU nurses. During a three month observational time period, insulin practices and glucose control were evaluated using an existing tight glycemic control protocol. After this time period, nursing education that consisted of a comprehensive review of glycemic control was provided for all trauma ICU nurses. Upon completion of this education, surveys were completed by the nursing staff about their input regarding seven components of the protocol. These components included: (a) protocol level initiation, (b) insulin initiation rate, (c) goal range for tight glycemic control, (d) incremental adjustments based on glucose results, (e) time period for measurement of glucose, (f) blood glucose level considered hypoglycemic and requiring intervention, and (g) when to restart insulin infusion after stoppages. The nurses' input on these seven components were used to develop a new tight glycemic

control protocol. A subsequent nursing education inservice on the new tight glycemic control protocol was provided that highlighted increased nursing responsibilities related to initiation, assessment and maintenance of tight glycemic control. Three months later, glycemic control three months prior to the nursing education was compared to the glucose control results after implementation of the new protocol (DuBose et al., 2009).

Glycemic control data prior to and after the new protocol implementation was gathered using medical record and laboratory review. The nursing survey of the initial protocol and the nursing survey of the new protocol were calculated as a percentage. Outcomes included (a) number of glucose measurements, (b) hours from protocol initiation to goal, (c) hypoglycemic events with blood glucose less than 60 mg/dL, (d) mean blood glucose, and (e) episodes of hypoglycemic coma and death. The outcomes were compared to the initial protocol time period and the new protocol time period. Mean glucose values were determined using a Chi-squared test to determine a *p* value for this variable (DuBose et al., 2009).

Findings from DuBose et al. (2009) were that nursing input did not change considerably between the initial protocol and the new protocol regarding the seven factors of tight glycemic control protocols. The majority of nurses agreed with six of the seven factors and 82.6% opposed using strict protocols that did not give leeway for nursing judgment. Nurses preferred a stringent glucose protocol with the autonomy to use nursing judgment to adjust insulin dosage based on nursing assessment (DuBose et al., 2009).

DuBose et al. (2009) also found that using the new protocol, the mean blood glucose decreased from 137.8 mg/dL to 128.2 mg/dL between the two time periods. With

the new protocol and subsequent nursing education, the time range to protocol initiation decreased from 36 hours to 9 hours, therefore decreasing the amount of glucose measurements from 3,811 to 2,984 which decreased nursing workload. Although hypoglycemic events requiring intervention increased with the new protocol from one to five, no hypoglycemic comas were noted during the study (DuBose et al., 2009).

The investigators (DuBose et al., 2009) found that nursing involvement and accountability positively influenced glycemic control in the trauma ICU. The authors concluded that involving nursing with the initiation, assessment and maintenance of tight glycemic control protocols resulted in safe and successful glucose control. Future recommendations included involving nursing staff in the early stages of protocol development to ensure appropriate nursing education to guarantee successful protocols.

Tight Glycemic Control Protocols

There are many adverse outcomes associated with hyperglycemia such as stroke, myocardial infarction, acute coronary syndrome, and postoperative would infections in the critically ill patient. Intensive glucose management improves patient outcomes, mortality and morbidity. The purpose of this study was to determine the effect of an intensive glucose management protocol on medical-surgical intensive care patients (Krinsley, 2004).

The study took place in the 14 bed medical surgical intensive care unit within a community teaching hospital in Stramford, Connecticut. The population included 1,600 consecutively admitted ICU patients. Eight hundred patients were admitted prior to protocol implementation with the remaining 800 patients admitted after protocol

implementation. Krinsley (2004) included demographic data consisting of age, gender, ethnicity, and other pertinent data.

Data was collected and stored in the ICU database that was maintained by two individuals and updated daily. The glycemic protocol required frequent blood glucose monitoring by the nurses. Plasma glucose measurements were performed using Vitros 950 and Vitros 250 chemistry analyzers. Intravenous insulin infusion was initiated if two consecutive blood glucose results were greater than 200 mg/dL. Using the SPSS 11.0 statistical package, statistical analysis was performed. Differences between the baseline group and the treatment group in the development of new renal insufficiency while in the ICU were assessed using the Fisher exact test (Krinsley, 2004).

Krinsley (2004) found no significant differences among the prior to and the after implementation group in regards to gender, age, ethnicity, APACHE score, or percentages admitted to medical versus surgical service. The glucose management protocol substantially improved glucose levels without considerably increasing hypoglycemic events. The mean glucose for the initial group was 152.3 mg/dL which decreased to 130.7 mg/dL in the treatment group (p<.001). The protocol decreased 56.3% of glucose values 200 mg/dL or higher (Krinsley, 2004).

Subsequently after protocol initiation, the number of patients requiring packed red blood cells transfusions decreased. Krinsley (2004) also found that the number of patients who developed renal insufficiency while in the ICU decreased from 12 to 3 (p=.03 by Fisher exact test). Mortality decreased 29.3% during protocol utilization compared to the baseline group. Mean length of stay decreased from 3.58 days in the baseline group to

3.19 days in the intervention group (p=.11). Krinsley (2004) found no additional staffing requirement after implementation of the protocol.

Krinsley (2004) concluded that the protocol significantly improved glycemic control and was connected with decreased mortality, organ dysfunction and decreased length of stay. Future research should evaluate insulin protocols as a low cost method of adequately controlling blood glucose and thus becoming the standard of care in the critically ill.

Research has shown that Surgical ICU patients have better outcomes with tight glycemic control. Medical ICU (MICU) patients may also require glucose control in order to experience better outcomes. Bland et al. (2005) conducted a study to determine what the comparison and compliance of intensive glucose control with modified conventional control was in the medical intensive care unit and also to determine if tight glycemic control required more staffing.

The setting took place at Loma Linda University Medical Center. All MICU patients who had been receiving mechanical ventilation for less than 24 hours were eligible for the study. Demographic data included age, sex, primary diagnosis, length of stay and other pertinent data. The participants were randomized into an intensive glucose control group and a modified conventional blood glucose control group. The intensive glucose control group had a target of 80 to 110 mg/dL with an insulin infusion administered if the initial blood glucose was greater than 110 mg/dL. The modified conventional group had a target of 180 to 200 mg/dL with an insulin infusion administered if blood glucose was greater than 200 mg/dL. The study was comprised of 10 randomly assigned patients, split between the intensive and modified conventional

group. All MICU nurses participated with mandatory glucose control educational session including the rationale for tight glycemic control in the critically ill (Bland et al., 2005).

Blood samples were obtained by finger lancet or from an arterial catheter. Blood glucose level was measured at the bedside with Accu-Chek comfort curve strips and an Accu-Chek Advantage Model 777 glucometer. B Braun Outlook 200 Safety Infusion System pumps were used to deliver insulin infusions consisting of 100 units of regular human insulin in 100 mL of isotonic sodium chloride solution (Bland et al., 2005).

Bland et al. (2005) found that mean glucose levels were 177.4 (SD, 45.5) mg/dL for the modified conventional group and were 105.3 (SD, 26.3) mg/dL for the intensive group. Fifty percent of the blood glucose results for the intensive group were within range compared to 72% in the modified conventional group (p<.001). Severe hypoglycemia episodes (<40 mg/dL) in both groups were rare and uncomplicated. The nurses reported that it was difficult to manage more than one participant and suggested that the algorithm could be improved with smaller insulin incremental adjustments (Bland et al., 2005).

Bland et al. (2005) concluded that target levels for blood glucose were achieved with both nurse managed protocols. Severe hypoglycemia was rare and uncomplicated regardless of type of glucose control. The authors concluded that additional staffing may be needed for intensive glucose control.

Hyperglycemia is common in the critically ill and associated with significant complications. Research has shown that maintaining glycemic control in the critically ill substantially reduces morbidity and mortality. Rea et al. (2007) conducted a

study to implement three different insulin protocols and evaluate patient outcomes through maintenance of tight glycemic control.

The study took place at an ICU within an academic medical center Pennsylvania, a cardiothoracic surgical ICU within a community teaching hospital in North Carolina, and medical, surgical and cardiac ICUs within a community teaching hospital in Wisconsin. The population critically ill patients needing glycemic control. The sample within all three facilities included all critically ill patients who were admitted to these units. Criteria for inclusion in the study were admission to these units (Rea et al., 2007).

In Pennsylvania, the medical director, nursing director and clinical pharmacist collaborated to develop an intensive intravenous insulin protocol to tightly manage glycemic control. Nurses were educated and the protocol was presented as a way to improve care and potentially improve mortality. The protocol gave the nurses more autonomy to address glucose control. Variables measured included the ability for the nurses to accurately follow the protocol, time to achieve blood glucose range, and the number of blood glucose measurements in target range during utilization of the protocol (Rea et al., 2007).

In North Carolina, the nurse manager, pharmacist, physicians and bedside nurses worked together to design a hyperglycemic management protocol with a blood glucose goal range of 100 to 149 mg/dL. The bedside nurses were educated with regards to the benefits of tight glycemic control. Patients were also educated preoperatively about possibly receiving insulin therapy while in the ICU. After six months of protocol implementation, physicians agreed to decrease the blood glucose range to 90 to 119

mg/dL. Using nursing feedback, the protocol was revised to address hypoglycemic concerns (Rea et al., 2007).

In Wisconsin, the ICU medical director, cardiothoracic surgeons, nurse practitioners, bedside nurses and pharmacists developed an insulin protocol with a goal range of 80 to120 mg/dL. Extensive nursing support and education was performed to increase nursing comfort with this aggressive hyperglycemic treatment course. Nursing compliance with this protocol improved as nurses became more familiar with the protocol (Rea et al., 2007).

Rea et al. (2007) found that protocol introduction within these three facilities directly improved patient outcomes. Some differences between the protocols were influenced by the type of institution, such as nursing autonomy and nursing involvement in the development and implementation of the protocol (Rea et al., 2007).

Rea et al. (2007) concluded that the intravenous glycemic management protocols implemented in the three facilities were successfully embraced by the nurses and physicians. The multidisciplinary team including a pharmacist dedicated to the ICU and extensive nursing education contributed significantly to the success of these protocols. The authors suggested that having dedicated Critical Care pharmacists greatly improve the compliance and success with aggressive insulin therapy protocols.

Tight glycemic control during acute illness is positively associated with decreased adverse effects and improved outcomes (Oeyen, et al., 2007). Due to the overwhelming evidence regarding tight glycemic control in the critically ill patients, the authors implemented Van den Berghe et al. (2003) insulin protocol within their facility. The purpose of this study was to evaluate adherence, effectiveness and safety of an insulin

protocol with a tight glycemic range of 81 to 110 mg/dL in critically ill patients while identifying factors associated with adequate glucose control (Oeyen et al., 2007).

The setting was a 22 bed SICU and 14 bed MICU in a Belgian tertiary care, university teaching hospital. Participant criteria consisted of MICU or SICU admission, anticipated ICU stay of a minimum 72 hours, greater than 16 years old, presence of an arterial catheter, and need for therapy. Exclusion criteria included diagnosis of diabetic ketoacidosis, cardiac surgery and transfers from other facilities (Oeyen et al., 2007). The sample included 16 SICU and 14 MICU patients for a total of 30 participants. Oeyen et al. (2007) included demographic data related to: age, sex, illness severity and other demographic data. Each nurse received one hour of instruction on the new insulin protocol before implementation and a 4-week training period before the study began.

Bedside glucometers (GlucoTouch) were used to measure glucose using undiluted heparinized arterial blood. Glucometers were quality controlled monthly. The ICU nurses exclusively managed the frequency of glucose measurements and rate of insulin infusion. To assist the nurses with this new protocol implementation, bedside protocol guidelines were available. Nurses documented deviations from protocol along with time, date, glucose measurement and infusion rate. Data was collected prospectively (Oeyen et al., 2007).

Oeyen et al. (2007) assessed the insulin protocol was for adherence, efficacy, and safety. Adherance was defined as correct dosage of insulin according to blood glucose and protocol. Nonadherance was defined as an adjustment that was not indicated by the protocol. The efficacy of the protocol was determined by the amount of hours that glucose readings remained within the defined parameters. Safety was determined by the

frequency of hypoglycemia events, number of times the blood glucose was 60 mg/dL or less and the number of times dextrose was needed to correct the hypoglycemia (Oeyen et al., 2007).

Linear regression and x^2 tests were used to evaluate data. Detection of independent factors influencing blood glucose was accomplished by using multivariate linear regression. These factors include the worst values for "white blood cell count, level of C-reactive protein, core temperature, ratio of PaO_2 to fraction of inspired oxygen, number of platelets, and levels of bilirubin and creatinine; all the exact daily values for caloric intake, blood glucose measurements,insulin dose, and adherence; and all the daily codes for binary variables (0 = no; 1 = yes) for the use of corticosteroids, ventilatory support, and vasoactive medication" (Oeyen et al., 2007). Significant variables were regarded as independently related to appropriate daily blood glucose control, which was defined as hours daily spent with in target range (Oeyen et al., 2007).

During the 352 protocol implementation days, there were a total of 6,016 glucose results. Protocol adherence was 71% and directly associated with satisfactory daily blood glucose control. Protocol deviations consisted of acceptable blood glucose levels (29%), hyperglycemia (64.5%), and severe hyperglycemia (43.7%). Protocol efficacy was only 42% of the implementation time spent within the defined parameters for glucose control. Protocol safety was measured by the amount of hypoglycemic events. Of the 6,016 glucose results, there were only 111 hypoglycemic events (1.8%). Only 34 events (0.6%) required rescue dextrose administration. There were no residual effects or complications from periods of hypoglycemia, although hypoglycemia was a major concern implementing tight blood glucose protocol (Oeyen et al., 2007).

Oeyen et al. (2007) concluded that adherence to glycemic protocol accounted for two-thirds of daily glucose measurements and correlated with sufficient glucose control. Efficacy of glucose protocol accounted for only 42% of time within target range. Frequent hypoglycemic episodes occurred, 60% of patients experienced at least one hypoglycemic episode. Based on the frequency of hypoglycemia, the authors recommend further research the effectiveness of less tightly managing blood glucose levels and therefore reducing hypoglycemic episodes.

Hyperglycemia is associated with adverse complications and poor outcomes in critically ill patients therefore the American Association of Clinical Endocrinologists and the American Diabetes Association recommends tight glycemic control in hospitalized patients. To comply with these recommendations, many hospitals have implemented tight glycemic protocols (TGCPs) to tightly control glucose. It is unknown if these TGCPs, which range from simple to complex, are more beneficial than others in relation to clinical outcomes, nursing time, expense, and potential for medical errors. The purpose of a study by Malesker et al. (2007) was to assess the efficiency and effectiveness of tight glycemic protocols in critically ill patients.

The study took place in the critical care units of hospitals within the metropolitan area of Omaha, Nebraska. The study included three separate evaluations including time motion study, chart review of TGCP deviations, and nursing survey. The time motion study was performed by a third party observer using a stopwatch to evaluate the time that it took to treat patients with the tight glycemic protocol. To determine TGCP deviations, charts were retrospectively reviewed to evaluate the number of times deviation from protocol happened. A nursing survey was used to evaluate knowledge and satisfaction

with the TGCP. The population included critical care patients from four Omaha area hospitals. Of this population, there was a mean age of 63 years, with a majority of men 68%, 57% surgical, and 43% medical. During a 30 day time period, the time motion sample included 38 patients cared for by 47 nurses with 454 blood glucose results. The protocol deviations sample included 75 patients. Of the 220 nurses asked to participate, sixty nurses completed the nursing survey (Malesker et al., 2007).

In three hospitals critical care units, patients treated with a TGCP were assessed by third party observers using a stopwatch for time motion analysis. Elapsed time was defined as "the interval between the time a nurse picked up the point-of-care glucometer and the time activities related to that blood glucose result were completed" (Malesker et al., 2007). Elapsed time was then divided by (a) the time that it took to receive a blood glucose result using the glucometer, (b) time that it took to treat a blood glucose result, and (c) time that it took to record the blood glucose result in the chart. The time that it took to treat a blood glucose result was then broken down into four intervals: (a) interval when an elevated blood glucose reading activated the initiation of an insulin infusion, (b) interval when a glucose reading was elevated above the threshold of normal and required a change in insulin infusion, (c) interval when blood glucose was within defined parameters, and (d) interval when glucose result was hypoglycemic (Malesker et al., 2007).

A retrospective study of four hospitals reviewed consecutive critical care patients' charts to evaluate for protocol deviation. Protocol deviations included were: "(a) obtaining blood glucose determinations at a time different than the time indicated in the TGCP, (b) administering an insulin dose different from that indicated in the TGCP, and

(c) failure to follow any other instructions in the TGCP" (Malesker et al., 2007, p. 590). Timing deviations were defined as blood glucose readings either fifteen minutes prior to or fifteen minutes after the scheduled time. Administration deviations were defined administering insulin at any other dose than was specified by the TGCP (Malesker et al., 2007).

Four study-affiliated ICUs were invited to participate in the nursing survey to determine nurse satisfaction with the TGCP and the nurses' knowledge of appropriate usage of their facilities TGCP. The survey consisted of seven multiple choice questions with answers based on a Likert scale and then three open ended questions (Malesker et al., 2007).

Findings from Malesker et al. (2007) determined that of the 454 blood glucose results, 188 did not require therapy, whereas 188 results were elevated and triggered initiation of a TGCP with a mean elapsed time 32.56 (SD, 12.83) minutes. Two hundred forty glucose results were elevated and required a change in insulin infusion with a mean elapsed time 10.65 (SD, 3.24) minutes. Eight results were indicative of hypoglycemia and required hypoglycemic intervention with a mean elapsed time 2.24 (SD, 1.67) minutes. The elapsed time from glucometer pickup to result was 5.18 (SD, 1.12) minutes. The elapsed time from meter pickup to documentation of normal blood glucose result was 9.25 (SD, 2.14) minutes. Of this time, approximately 5 minutes (mean, 5.17; SD, 3.96) of patient care was delivered after glucose result and almost 9 minutes (mean, 8.90; SD, 5.90) transpired before nurse documentation of glucose result (Malesker et al., 2007).

Malesker et al. (2007) also found approximately 75% of glucose results resulted in TGCP deviation. There were 734 deviations from the TGCP in 75 patients with 57% (n = 418) deviating from scheduled glucose measurements, 38% (n=279) deviated from correct insulin dose, and 5% (n=37) deviated from properly utilizing the TGCPs' algorithm instructions. Each patient experienced about nine deviations (with a range of 1-23 per patient) from the TGCP. Due to the fact that this was retrospective data, it was unclear if any of the deviations resulted in adverse patient outcomes (Malesker et al., 2007).

The findings of this study also determined that seventy percent of nurses believed that the TGCP increased workload due to the frequency of blood glucose measurements. Of the participants, 42 (56%) felt that the TGCP was easily administered. Of the remaining nurses, 32% felt that the algorithm was too complicated and 38% of all participants felt that determining the correct insulin infusion rate was the most common error with the protocol (Malesker et al., 2007).

Malesker et al. (2007) concluded that nurses spend a great deal of time following the TGCP with a substantial amount of deviations that can lead to errors. The authors suggested that future education and assessment should be conducted to monitor the effectiveness of tight glycemic control protocols.

Blood glucose control in the hospitalized patient improves patient outcomes and decreases medical costs. Insulin is effective in controlling blood glucose, yet is one of the top high risk medications associated with medical mistakes. Noschese et al. (2008) studied the effects of a standardized diabetic management order set on glycemic control in the hospital setting.

The setting was a 716 bed tertiary care academic medical center. The population included 70 patients within two organ transplant units whom needed glucose management. The study criteria included an order for a diabetic medication and at least three days of glucose data within a designated six month time span. The initial three days of data was used to determine the patients' response to the intervention and track glucose outside of specified range (Noschese et al., 2008).

A diabetes knowledge survey was administered to physicians to identify knowledge deficits of glycemic goal setting, hypoglycemic event interventions, moving patients from an insulin infusion to subcutaneous insulin, and adjusting medications for nutrition. A diabetes order set was developed to address oral hyperglycemic medications, sliding scale, continuous insulin infusion and inpatient glucose management. The study used one unit as a control and the other unit piloted the diabetes order set. Data including orders for diabetic medications, insulin orders, hypoglycemia events and hyperglycemia were collected and compared using two-sided Fisher exact tests. A satisfaction survey was administered to physicians and nurses to determine ease of use, form availability, and perceived benefit to patient care (Noschese et al., 2008).

Noschese et al. (2008) found that there were more orders for scheduled insulin therapy (p=.008) and less orders for correctional insulin in the order set unit versus the control unit. More appropriate orders were written in the order set unit 91% compared to 80% in the control unit (p=.137). The order set was used 71% of the time in the order set unit and 10% of the time in the control unit which was contributed to physicians who also treated the order set unit using the order set. There was no significant difference among the units in the amount of mild hypoglycemic events (40-69 mg/dL) with no episodes in

either unit of severe hypoglycemia (<40 mg/dL). The medical and nursing staff reported high satisfaction when utilizing the order set. The survey results included 80% liked using the diabetes order set, 87% agreed that the order set was easy to use, 94% stated that the form was accessible, and 88% felt that the order set improved patient care (Noschese et al., 2008).

The authors concluded that diabetes order sets can be safely implemented within the hospital setting. For the order set to be successfully accomplished, the multidisciplinary team included nurses, physicians, and pharmacists to design and implement the order set. Noschese et al. (2008) concluded that the diabetes order set must be understandable and likeable to be used effectively and consistently.

Summary

Hyperglycemia is a serious complication of critical illness that causes a great deal of harm to the critically ill. With appropriate education, nurses can significantly improve patient outcomes by utilizing glucose control protocols to maintain tight glycemic control. This literature review suggests that tight glycemic control obtained using an easily understood insulin protocol that was created by multidisciplinary team collaboration improves patient outcomes. The benefit of a tight glycemic control protocol in the critical care environment considerably improves glycemic control and is associated with decreased mortality, organ dysfunction and decreased length of stay.

This literature review also implies that further research should focus on determining the most effective and safe blood glucose range for tight glycemic control. Glucose should be tightly controlled in a range that is safe, yet does not promote

hypoglycemic episodes. Many researchers disagree regarding what specific glucose range constitutes appropriate and safe tight glycemic control for each critically ill individual.

With extensive continuing education, nursing involvement and accountability can greatly improve glycemic control in the ICU. Nursing education which includes the pathophysiology of critical illness combined with hyperglycemia pathology greatly enhance nursing understanding for the rationale of tight glycemic control ,which in turn play a significant role in the successful implementation of these protocols. Nursing involvement and participation with the initiation, assessment and maintenance of tight glycemic control protocols result in safe and successful glucose control in critically ill hyperglycemic patients. This proposed research study will examine the effectiveness of a nurse-managed hyperglycemia protocol in maintaining normoglycemia in group of ICU patients.

Chapter III

Methodology and Procedures

Introduction

Hyperglycemia at the time of ICU admission is an independent risk factor for increased mortality and morbidity, but outcomes can be improved significantly with tight glycemic control (Oeyen et al., 2007)**.** Tight glycemic control is often difficult for nurses and physicians to achieve and maintain (Holzinger et al., 2008). While research studies have demonstrated that multidisciplinary collaboration is essential to management of hyperglycemia, few studies have emphasized the efficacy of nurse-managed protocols to effectively maintain normoglycemia in the critically ill.

The purpose of this study is to compare the effectiveness of a nurse-managed hyperglycemia protocol to that of a standardized hyperglycemia protocol on hyperglycemia management of critically ill patients.

Research Question

The research question that directed this study is: Is a nurse-managed hyperglycemia intensive insulin protocol more effective than a standardized hyperglycemia intensive insulin protocol in maintaining normoglycemia in critically ill patients?

Population, Sample and Setting

The sample will be 50 critically ill patients admitted to the intensive care unit in an acute care hospital in Oklahoma City will be used for this study. Mercy Health Center was founded in 1947 and serves a six county area with a population of 1.09 million people. The health care facility employs 2,778 co-workers and 878 physicians. This full-service tertiary hospital is a not-for-profit facility that serves the community. The facility is licensed by the state of Oklahoma, accredited by the Joint Commission on Accreditation of Healthcare Organizations, and is certified by Medicate and Medicaid (Mercy Health Center, 2010).

Inclusion criteria for study participants will be a ICU stay of longer than 48 hours and to have received insulin for longer than 24 hours. Data collected will be blood glucose at 48 hours post-ICU admission, length of time of blood glucose levels less than 150 and 110, hourly insulin dosage, and daily insulin dosage. Statistical analysis will include comparisons of group differences in blood glucose, times, and insulin dosage.

Protection of Human Subjects

The study proposal will be reviewed by the Ball State University Institutional Review Board and the Mercy Institutional Review Board to ensure the participant's rights are protected. The Chief Nursing Officer and Critical Care Committee will grant authorization to conduct this study. Patients will be screened for inclusion criteria upon admission to the ICU. Study participation is voluntary..

Procedures

If the patient is a candidate and informed consent is obtained, he or she will entered as a participant in the standardized hyperglycemic intensive insulin protocol

group or as a participant in the nurse-managed hyperglycemic intensive insulin protocol group. Participants will be monitored closely for hypoglycemia and hypoglycemic interventions will be administered when necessary

Group 1 will include 25 consecutively selected admitted ICU patients, who receive the standardized hyperglycemia protocol. Data collected will be blood glucose at 48 hours post-ICU admission, length of time of blood glucose levels less than 150 and 110, and daily insulin dosage.

After data collection is complete for Group 1, nurses will attend educational sessions that explain the pathophysiology of hyperglycemia, improved outcomes using a tight glycemic control protocol, and instruction regarding the new nurse-managed hyperglycemic intensive insulin protocol to be implemented for this study. After implementation of the new nurse-managed hyperglycemic protocol, participants will be enrolled in group 2. Group 2 will include 25 ICU patients consecutively admitted after d implementation of the nurse-managed hyperglycemia protocol.

Instrumentation

Blood glucose will be measured by fingerstick every two hours using the GlucoTouch Glucometer, which directly uploads results into the electronic medical record. For validity and reliability, GlucoTouch Glucometer will undergo every twelve hour calibration testing to ensure accuracy of results. Each ICU nurse will titrate insulin dosage as outlined by either the standardized hyperglycemic intensive insulin protocol or the nurse-managed hyperglycemic intensive insulin protocol depending upon the study participant's assigned group. Data will be collected using the electronic medical record including blood glucose results, insulin administration, and hypoglycemic interventions.

Research Design

The research study will be a comparative descriptive design. The comparative descriptive design examines and describes differences in variables in two or more groups that occur naturally in the setting (Burns & Grove, 2005).

Intended Method for Data Analysis

Data including blood glucose results over time, hourly and daily insulin dosage, and hypoglycemic interventions will be analyzed using statistical computer software. Data will be reported as median (interquartile range). The area under the curve will be calculated to measure the amount of time that patients' glucose levels were less than 110 mg/dL and greater than 150 mg/dL. The Mann-Whitney U test will be used when necessary to compare numeric differences. Demographic data will be analyzed using descriptive statistics. The control and intervention group will be compared using t-tests to evaluate for differences in age, gender, ethnicity, and baseline glucose on admission. A p value of .05 or less will be considered significant.

Summary

Methods and procedures are used to evaluate the effectiveness of nurse directed education program on glucose management algorithms to control glucose in intensive care patients. Participants are critically ill patients admitted to an ICU within a large, metropolitan, tertiary hospital in Oklahoma. The research design is comparative descriptive. This study is a replication of Holzinger et al. (2008) prior research and will attempt to demonstrate that with a nurse-managed hyperglycemic intensive insulin protocol critically ill patients have longer periods of normoglycemia than with

standardized hyperglycemic intensive insulin protocol with insulin doses ordered at the

discretion of the physician.

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