IMPROVING STRESS-INDUCED HYPERGLYCEMIA MANAGEMENT IN THE INTENSIVE CARE SETTING

by

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A DNP Project Submitted to the Faculty of the

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As members of the DNP Project Committee, we certify that we have read the DNP project prepared by Anaya Elgrably entitled "Improving Statin-Induced Hyperglycemia Management in the Intensive Care Setting" and recommend that it be accepted as fulfilling the DNP project requirement for the Degree of Doctor of Nursing Practice.

Terry A. Badger, PhD, RN, FMHICNS-BC, FAAN — Date: December 11, 2017

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Final approval and acceptance of this DNP project is contingent upon the candidate's submission of the final copies of the DNP project to the Graduate College.

I hereby certify that I have read this DNP project prepared under my direction and recommend that it be accepted as fulfilling the DNP project requirement.

DNP Project Chair Terry A. Badger, PhD, RN, FMHICNS-BC, FAAN — Date: December 11, 2017

STATEMENT BY AUTHOR

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SIGNED: Alonya Elgrably

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ABSTRACT

Background: Uncontrolled stress-induced hyperglycemia has been shown to increase mortality, prolong ICU length of stay, increase complications, and prolong ICU length of stay. The inadequate management of stress-induced hyperglycemia in the intensive care setting is a persistent gap in quality care.

Objective: To implement an evidence-based Stress-induced hyperglycemia protocol in the ICU at NorthBay Medical Center.

Design: Descriptive design with pre-and post-intervention measurement.

Setting: The Intensive Care Unit at NorthBay Medical Center.

Patients: 22 patients with stress-induced hyperglycemia. Eligible patients had a blood glucose level great than or equal to 150 mg/dL.

Intervention: Patients with a blood glucose level greater than or equal to 150 mg/dL were started on sliding scale insulin therapy. Patients with a blood glucose level greater than 180 mg/dl the patient were started on an insulin infusion. If the blood glucose levels were $\leq$100 mg/dl, insulin therapy was discontinued to prevent hypoglycemia. Blood glucose levels were integrated into ICU multidisciplinary rounds to ensure all patients with stress-induced hyperglycemia were identified.

Measurements: ICU length of stay, hospital length of stay, average high blood glucose levels, and number of patients who met criteria but were not started on insulin therapy were measured.

Results: The average ICU length of stay pre-protocol implementation (M=4.18, SD=2.48) was greater than the average ICU length of stay post-protocol implementation (M=2.18, SD=1.83). This difference is statistically significant t (20) =2.15, p=0.044; d 0.95. There was no significant

difference between pre-protocol implementation hospital length of stay (M=9.27, SD=9.50) and post-protocol implementation hospital length of stay (M=6.27, SD=3.82); t (20) =0.97, p=0.343. There was no significant difference in average blood glucose levels pre-implementation (M=197, SD=69) and post-protocol implementation (M=189, SD=40); t (20) =0.31, p=0.76. Over half (55%) of the patients in the pre-implementation group met criteria for stress-induced hyperglycemia, however, insulin therapy was not initiated by the ICU healthcare provider. Post-implementation, there was 100% compliance with initiating therapy on those patients that met criteria.

INTRODUCTION

Hyperglycemia is common during times of critical illness or injury (Bosarge & Kerby, 2013). Stress-induced hyperglycemia (SIH) is defined as "a transient plasma glucose level higher than 200mg/dL in patients who are normally euglycemic" (Bosarge & Kerby, 2013, p. 287). Stress-induced hyperglycemia is a normal metabolic stress response due to injury or acute illness. During critical illness or injury, the body produces more glucose while decreasing insulin production; as a result, there is an increase in insulin resistance due to the overproduction of stress hormones and cytokines (Bosarge et al. 2013).

Hyperglycemia during critical illness increases mortality and complication rates and increased lengths of stay in intensive care units (ICUs) (Draznin, Gilden, Golden, & Inzucchi, 2013). According to Jacobi et al. (2012), hyperglycemia increases the mortality rate for patients with coronary artery disease, cerebrovascular accidents, pneumonia, acute kidney injury, and sepsis. Patients with stress-induced hyperglycemia experience more complications, have prolonged hospitalizations, have higher hospitalization costs, and have higher 30-day readmission rates (Buehler et al. 2015).

Initiation of insulin therapy has shown to significantly decrease ICU length of stay and ventilator days in ICU patients. Optimizing glycemic control in ICU patients not only decreases mortality and complication rates but it also has a cost saving benefit for the organization. Draznin et al. (2013) found that initiating insulin therapy decreased length of stay by 1.8 days, resulting in a savings of $7,580 per patient. This is especially important considering decreasing reimbursement rates by the Federal Government and private insurance companies.

Hyperglycemia management is significant knowledge gap in nursing. In a recent study by Hargraves (2014), 39% of advanced practice nurses did not know the evidenced-based guidelines for hyperglycemic management and 22% said that they were unclear of when to start insulin therapy. Many nurses in ICUs do not implement a hyperglycemic protocol for all patients admitted to the ICU with hyperglycemia and are not using evidence-based practice guidelines for hyperglycemic control. Implementing an evidence-based approach to manage stress-induced hyperglycemia will provide the clinical framework for the standardization of glucose management in this patient population.

Local Problem

NorthBay Medical Center is a Level II Trauma Center that offers neurosurgery, cardiothoracic, vascular, orthopedic, and acute care surgery services. Most patients admitted to the ICU are surgical patients. Over the last two years there has been a dramatic rise in the number of complications associated with hyperglycemia. The most frequently occurring complication is surgical site infections. Since 2014 there have been 13 cases of surgical site complications contributed to uncontrolled hyperglycemia. This number is more than double from two years prior (NorthBay Medical Center, 2016). Richards et al. (2014) found that surgical patients with hyperglycemia are at a higher risk for developing a surgical site infection than patients who were euglycemic. The initial impetus for this project was the investigator's observation of the increased rate of surgical site infections, however, surgical site infections are but one of many complications that can influence ICU length of stay. For the purposes of this project, I was most interested in measuring how complications related to uncontrolled hyperglycemia affects ICU length of stay. Improving glucose control in the NorthBay ICU

should result in decreased complications, thus reducing ICU length of stay and reduce costs (Richards et al. 2014).

Purpose

The purpose of this DNP project was to create an evidence-based stress-induced hyperglycemic protocol that would trigger insulin therapy for all patients admitted to the ICU with a blood glucose level greater than 150mg/dL and determine if implementing this protocol would influence length of stay. Obtaining current evidence-based protocols from other medical centers helped to answer several important clinical practice questions. First, what blood glucose level should trigger insulin therapy? Currently, there are two clinical practice guidelines with two different starting ranges. The American Diabetes Association recommends starting insulin when the glucose level is greater than or equal to 140mg/dL (American Diabetes Association [ADA], 2016). The Society of Critical Care Medicine (SCCM) recommends starting insulin when the glucose is greater than or equal to 150mg/dL (Jacobi et al. 2012). Secondly, what should the glucose target range be? The ADA (2016) recommends a target range of 140mg/dL-180mg/dL in nonsurgical patients and 80mg/dL-180mg/dL for perioperative patients. The SCCM guidelines recommend a range of 150mg/dL-180mg/dL for all patients (Jacobi et al., 2012). Third, when should insulin therapy be stopped? Both the ADA (2016) and the SCCM (2012) agree that insulin therapy is discontinued if the glucose level is less than or equal to 80mg/dL.

The early identification of key stakeholders was a priority for the development, implementation, and sustainability of this project. Stakeholders offered valuable insight into the clinical problem and offered administrative support and resources that helped propel the project forward and sustain the practice change after implementation (Polit & Beck, 2017). The key

stakeholders for this project included: Alonya Elgrably, ICU Nurse Practitioner; Dr. Maqbool Ahmed, ICU Medical Director; Neeta Bhasin, ICU Pharmacist; and Shelley Johnson, ICU Director. This project was developed from observations in clinical practice and discussions with key stakeholders.

Study Question

In intensive care patients with stress-induced hyperglycemia, does the initiation of subcutaneous or intravenous insulin therapy compared to no administration of insulin decrease ICU length of stay?

FRAMEWORK AND SYNTHESIS OF EVIDENCE

Theoretical Framework

The theoretical framework that guided this DNP project was the Theories of Integrated Care. This model is a conceptual model that was developed and used in the outpatient setting by primary care physicians and case managers to improve the coordination and delivery of health care services for specific patient populations across the continuum (Valentijn, Schepman, Opheij, & Bruijnzeels, 2013). The management of hyperglycemia spans many disciplines which includes physicians, allied health professionals, pharmacists, nursing, and dieticians. Although the Theories of Integrated Care was initially designed for the outpatient coordination of care, the theory has been successfully implemented in the acute care setting (Naylor, Alderwick, & Honeyman, 2015). Naylor et al. (2015) report that utilization of integrated care teams was associated with a 33% reduction in hospital length of stay, a 15% reduction in patients being discharged to nursing homes, and a 15% reduction in mortality.

As such, this framework was the most appropriate for my DNP project. The World Health Organization (WHO) (2016) has defined integrated health services delivery as:

> "an approach to strengthen people-centered health systems through the promotion of the comprehensive delivery of quality services across the life-course, designed according to the multidimensional needs of the population and the individual and delivered by a coordinated multidisciplinary team of providers working across settings and levels of care" (p. 4).

To improve the management of the stress-induced hyperglycemic patient population it was important to evaluate the daily actions that are performed by various health care disciplines so that inefficient processes could be identified and improved upon (Valentijn et al. 2013). The multidisciplinary team needed to collaborate effectively to examine the current clinical pathways, assign tasks and activities to the team, and develop a monitoring feedback system to help sustain the practice change over time (Grol, Bosch, Hulsher, Eccles, & Wensing, 2007).

Mechanisms for Integration

The Theories of Integrated Care focuses on four major types of mechanisms for integration, these include functional integration, organizational integration, service integration, and clinical integration (Van der Klauw, Molema, Groten, & Vrijhoef, 2014).

Functional Integration

Functional integration is the integration of administrative support and non-clinical back-office functions and the provision for financial incentives (Van der Klauw et al., 2014). This type of integration incorporates the use of clinical information technology to communicate to clinicians (Van der Klauw et al. 2014)

Organizational Integration

Organizational integration is when organizations combine through mergers or coordinated provider networks (Van der Klauw et al. 2014). NorthBay Healthcare has an outpatient clinic where assigned patients receive primary care services. If a patient was diagnosed with diabetes mellitus during their admission, follow up care was arranged prior to discharge.

Service Integration

Service integration is the integration of different clinical services at the organization level through teams of multidisciplinary professionals (Van der Klauw et al. 2014). This mechanism of integration was a key part of my DNP project. Hyperglycemic management requires input and collaboration from the providers, pharmacists, nurses, and dieticians. It was vital that the integration of the various services was organized and patient-centered.

Clinical Integration

Clinical integration is the integration of care delivered by health care providers to patients using a process such as shared clinical practice guidelines and protocols that span across multiple disciplines and offer quality care with proper resource utilization (Van der Klauw et al. 2014). The development of the stress-induced hyperglycemic protocol will standardize the management of this patient population. The protocol spanned across multiple disciplines, including: medicine, pharmacy, nutrition, and nursing. Thus, my project contributed to the quality of patient care by optimizing glycemic management resulting in decreased complications and improved patient outcomes.

Concepts

The Theories of Integrated Care is a conceptual model that was developed in the primary care setting (Valentijn et al. 2013). The holistic basis in primary care is that care is person-focused and disease-focused (Valentijn et al. 2013). Person-focused care incorporates both a biological and psychosocial component to a person's perspective on their health status. Thus, a specific disease state can affect both biologic responses and emotional responses to the patient's situation (Valentijn et al. 2013). It is important to understand a person's perceived needs, personal preferences, moral, and religious values in the delivery of health care services. On the other hand, disease-focused care consists of the health care providers' perspective of the medical problem and goals of care focus on the treatment of the disease. Health care providers must recognize that a person's state of health is affected by a person's psychological and biological state and it is important to include the patient in the decision-making process (Valentijn et al. 2013).

SYNTHESIS OF EVIDENCE

To gain a better understanding of how hyperglycemia contributes to complications and increase morbidity and mortality in the critically ill, a comprehensive literature search was conducted using Cumulative Index of Nursing and Allied Health Literature (CINAHL) and PubMed. Inclusion criteria for articles included: published in the last 5 years, English language, and human species. Medical Subject Headings (MeSH) used to index articles found in PubMed. The following key words were used: "hyperglycemia management," "hyperglycemia," "critical illness," and "complications of hyperglycemia." Original reports of randomized clinical trials, meta-analyses, consensus statements, and clinical practice guidelines were evaluated. Other

sources include literature published by the Society of Critical Care Medicine (2012) and the American Association of Clinical Endocrinologists and American Diabetes Association (2009). The search yielded 135 results. Articles were excluded if they did not pertain to hyperglycemia, critical illness, or insulin therapy. Table 1 describes 10 articles that were especially relevant to the purpose of this DNP Project.

TABLE 1. *Literature Review*

Reference	Research Question/ Hypothesis	Theoretical Framework	Design	Sample (N) and Setting	Data Collection (Instruments/Tools	Findings
Chan, M., Tseng, J., Hsu, K., Shih, S.Yi, C., Wu, C., & Kou, Y. (2016). A minimum blood glucose value less than or equal to 120 mg/dL under glycemic control is associated with an increased 14-day mortality in nondiabetic intensive care unit patients with sepsis and stress hyperglycemia. *Journal of Critical Care*, *34*, 69-73. http://dx.doi.org/10.1016/j.jcrc.2016.04.002	Is the minimum blood glucose value of 120 ml/dL during the first 72 hours after admission associated with an increased 14-day In patients with SIH?		A retrospective analysis of prospectively acquired clinical data.	N=127 An intensive care unit in a larger tertiary hospital in Taiwan.	All data were collected prospectively during the hospitalization of septic patient requiring glucose control.	Patients with a glucose level lower than 120 mg/dL had a significantly higher 14-day mortality rate (p=0.01)

TABLE 1. – *Continued*

Reference	Research Question/ Hypothesis	Theoretical Framework	Design	Sample (N) and Setting	Data Collection (Instruments/Tools	Findings
Draznin, B., Gilden, J., Golden, S., & Inzucchi, S. (2013, July). Pathways to quality impatient management of hyperglycemia and diabetes: a call to action. *Diabetes Care*, *36*, 1807-1814. http://dx.doi.org/10.2337/dc07-2456	The goal of the consensus group was to identify existing research gaps, barriers of glucose management.		8 aspects of inpatient glucose management were identified. These included 4 system-based issues: barriers of inpatient glucose control, implementation and effectiveness of glucose management teams, standardization of blood sugar measurement and benchmarking data, and fiscal impact of inpatient glucose control. 4 patient-based issues: Sliding scale vs. prandial dosing, glucose control in patients undergoing organ transplantation, and transition to outpatient glucose management.		Researchers reviewed multiple consensus documents for recommendations for more research related to inpatient hyperglycemia management.	Suggest solutions and future research needed included: Define hypo/hyperglycemia. Evaluate efficacy of scheduled versus sliding scale insulin. Determine best approach to treatment of iatrogenic hyperglycemia due to steroids.

TABLE 1. – *Continued*

Reference	Research Question/ Hypothesis	Theoretical Framework	Design	Sample (N) and Setting	Data Collection (Instruments /Tools	Findings
Guo, Y., Zhou, Y., Zhang, S., Wei, QHuang, Y., Xia, W., & Wang, S. (2014). Optimal target range for blood glucose in hyperglycemic patients in a neurocritical care unit. *Diabetes & Vascular Disease Research*, *11*, 352-358. http://dx.doi.org /10.1177/14791 6411453580	What is the optimal target range for hyperglycemic management in patients with critical neurological injury.		Retrospective data was extracted from 890 hyperglycemic patients with a blood glucose >200mg/dL who were admitted to the neuroscience critical care unit. The patients were divided into two groups: 1) intensive glucose control and moderated control. The groups were also stratified based on diabetic patients and patients with SIH. During NCCU admission all BG measurements, type of insulin administered (SQ or IV), nutritional status was identified. Blood glucose level was measure upon admission to ICU and every morning at 6am. Upon admission, all patients were started on IV insulin. The glucose target range was 110-180mg/dL	N=890 patients with blood glucose >200. Participants were divided into intensive control (<140) and moderate control (140-180) groups.	The retrospective data was extracted from the chart review. Data collection included: Hgb A1C and demographic information. Blood glucose level were measured by capillary blood using ACCU-CHEK glucometer or venous blood and arterial blood when able	The primary outcome measure was death from any cause. The secondary outcome measures were inpatient death, number of days in the ICU and total hospital days, severe hypoglycemia <40mg/dL 614 patients were identified as having DM while 276 patients were identified as having SIH. Both groups required a higher mean dose of insulin to maintain a glucose <140mg/dL. The mortality of patients with DM whose BG levels were maintained <140mg/dL compared with the moderate glucose control subgroup was significantly higher (p=0.034). However, mortality was lower in the SIH patient with tighter glycemic control at <140. There was no difference in mortality rates between the two subgroups. Intensive glucose control significantly decreased the number of patients with diabetes with detectable infection (p=0.041) The intensive glucose control group patients with diabetes was noted to have a decreased LOS in the NCCU.

TABLE 1. – *Continued*

Reference	Research Question/ Hypothesis	Theoretical Framework	Design	Sample (N) and Setting	Data Collection (Instruments/Tools	Findings
Hargraves, J. (2014, May). Glycemic control in cardiac surgery: implementing and evidence-based insulin infusion protocol. *American Journal of Critical Care*, *23*, 250-258. http://dx.doi.org/10.4037/ajcc2014236	Did nursing knowledge of glycemic control in cardiac surgery patients after development of an insulin infusion protocol and an educational intervention was implemented?	The IOWA Model of Evidence-based Practice to Promote Quality Care and Jean Watson's Theory of Human caring provided the framework for the nursing practice model.	A clinical practice guideline was created to target moderate glycemic control in the ICU. The insulin infusion was initiated when the blood glucose was 150 mg/dL which was recommended by the Society of Thoracic Surgeons rather than the standard of 180 mg/dL. Insulin was titrated using the Yale protocol. Nursing knowledge was assessed by using a pretest/posttest before and after the educational intervention. The new protocol was presented to nursing staff.	Sample: 30 ICU nurses Setting: A 10-bed ICU in a large 567-bed teaching hospital in New Jersey	Pre/posttest scores were tabulated on the paper test. Test scores and blood glucose data were transferred to Excel spreadsheet for statistical analysis. Descriptive and inferential statistics were used to compare nurses' pre/post test scores	There was no significant difference between the SIH subgroups and LOS. There was a statistically significant improvement in nursing knowledge regarding hypoglycemia and the current ADA guidelines after receiving the educational intervention ($t=-8.18$, $SD=11.75$, $p<0.001$).

TABLE 1. – *Continued*

Reference	Research Question/ Hypothesis	Theoretical Framework	Design	Sample (N) and Setting	Data Collection (Instruments/Tools	Findings
Jacobi, J., Bircher, N., Krinsley, J., Augs, M., Braithwaite, S., Deutschman, C., ... Schunemann, H. (2012). Guidelines for the use of an insulin infusion for the management of hyperglycemia in critically ill patients. *Critical Care Medicine*, *40*, 3251-3276. http://dx.doi.org/10.1097/CCM.0b013e3182653269	What are the aspects of insulin therapy that facilitate safe and effective infusion therapy for a defined glycemic end point?		A guideline task force composed of volunteers from the Society of Critical Care Medicine. The task force members developed a list of clinical questions regarding the appropriate utilization of insulin infusion to achieve good glycemic control.		Literature searches were conducted using PubMed, OVID, and Clinicaltrials.gov. Published clinical trials were used as primary support for guideline statements. Each study was evaluated and given a level of evidence using the GRADE system. Throughout the development of the guideline, task force members placed an emphasis on patient safety and the risk versus benefit. Discussion among the task force led to consensus regarding recommendations. The final draft was voted upon for approval.	SCCM task force recommendations included: a blood glucose >150 mg/dL should trigger initiation of insulin therapy and glucose levels <180 mg/dL should be absolutely maintained. A blood glucose ≤70 is associated with an increase in mortality Blood glucose should be monitored every 1-2 hours while receiving insulin infusion. POC glucose meters are acceptable but not optimal for routine BG testing. BG should be test by arterial or venous whole blood sampling instead of finger stick for patient in shock, on vasopressor therapy or with severe peripheral edema. Subcutaneous insulin may be used in selected patients.

TABLE 1. – *Continued*

Reference	Research Question/ Hypothesis	Theoretical Framework	Design	Sample (N) and Setting	Data Collection (Instruments/Tools	Findings
Kataja, A., Tarvasmaki, T., Lassus, J., Cordosp, J., Mebazaa, A.,Koberq, L., ... Harjola, V. (2016). The association of admission blood glucose level with the clinical picture and prognosis in cardiogenic shock-results from the cardshock study. *International Journal of Cardiology*, *226*, 48-52. http://dx.doi.org/10.1016/j.ijcard.2016.10.033	Is there an association between admission blood glucose and mortality in patients with cardiogenic shock?		This was a multicenter prospective, observational study.	N=211 Adult patients who were found to be in shock within 6 hour of developing hypotension were included. Setting: nine tertiary hospitals in eight countries across Europe.	Data on patient characteristics and medical history were collected. EKG and lab work were performed on all patients	Stable ICU patients should be placed on a sliding scale protocol discontinuing the insulin infusion. Severely hyperglycemic patients were the most likely to have an ACS etiology of CS (p=0.03) They were also more likely to get intubated (p<0.001) Blood lactate level was significantly higher and arterial pH lower among patients with severe hyperglycemia when compared to patients with normoglycemia, moderate or mild hyperglycemia (p,0.001)

TABLE 1. – *Continue*d

Reference	Research Question/ Hypothesis	Theoretical Framework	Design	Sample (N) and Setting	Data Collection (Instruments/Tools	Findings
Kramer, A., Roberts, D., & Zygun, D. (2012). Optimal glycemic control in neurocritical care patients: a systematic review and meta-analysis. *Critical Care*, *16*(R203), 1-13. Retrieved from http://ccforum.com/content/16/5/R203	Is hyperglycemia or hypoglycemia a marker for greater severity of neurological damage or does it directly contribute to secondary injury?		Investigators performed a systematic review and meta-analysis of randomized controlled trials comparing intensive insulin therapy with conventional glycemic control among patients with TBI, ischemic or hemorrhagic stroke, anoxic encephalopathy, CNS infections and spinal cord injury.	N=1248 neurocritical care patients.	RCTs involving neurocritical care patients were obtained by searching OVID, MEDLINE, EMBASE, the Chochrane Central register of Controlled Trials. Two investigators abstracted data in an unblinded fashion using a standardized form. Studies were pooled using Comprehensive Meta-Analysis .	Patients with hyperglycemia who did not have a known history had more adverse outcomes than patients with a known history of DM (OR 1.10, CI 95%, p=0.005) Maintaining tight glycemic control (BG 70-140 mg/dL) hand no significant impact on mortality (RR 0.99, 95% CI, p=0.88). However, patients who had tight glycemic control had significantly less unfavorable neurological outcomes (RR 0.91, 95% CI, p=0.04). Surprisingly, patients had significantly improved outcomes when patient in the conventional control group (140-180 mg/dL) were permitted to be have a higher glucose threshold of >200 mg/dL (p=0.002)

TABLE 1. – *Continued*

Reference	Research Question/ Hypothesis	Theoretical Framework	Design	Sample (N) and Setting	Data Collection (Instruments/Tools	Findings
Moghissi, E., Korytkowski, M., DiNardo, M., Einhorn, D., Hellman, R., Hirsch, I., …Umpierrez, G. (2009, May/June). American association of clinical endocrinologists and American diabetes association consensus statement on inpatient glycemic control. *Endocrine Practice*, 15 (4), 1-17. Retrieved Fromhttps://www.aace.com/files/inpatientglycemiccontrol.pdf	Does optimizing glycemic control improve clinical outcomes for patients with SIH? What glucose target range should be used in various patient populations? What options are available for glucose control in the clinical setting?		Investigators focused primarily on recent studies with RCT design that investigated patient outcomes with protocols targeting normalization of blood glucose levels.	An extensive review of RCTs was conducted by investigators.	Included patients from surgical and medical ICUs, patients with acute MI, and patients undergoing organ transplantation	Insulin therapy should be started for patients with hyperglycemia and glucose should not be allowed to be greater than 180mg/dL.

TABLE 1. – *Continued*

Reference	Research Question/ Hypothesis	Theoretical Framework	Design	Sample (N) and Setting	Data Collection (Instruments/Tools	Findings
Moghissi, E., Korytkowski, M., DiNardo, M., Einhorn, D., Hellman, R., Hirsch, I., …Umpierrez, G. (2009, May/June). American association of clinical endocrinologists and American diabetes association consensus statement on inpatient glycemic control. *Endocrine Practice*, 15 (4), 1-17. Retrieved From https://www.aace.com/files/inpatientglycemiccontrol.pdf	Does optimizing glycemic control improve clinical outcomes for patients with SIH? What glucose target range should be used in various patient populations? What options are available for glucose control in the clinical setting?		Investigators focused primarily on recent studies with RCT design that investigated patient outcomes with protocols targeting normalization of blood glucose levels.	An extensive review of RCTs was conducted by investigators.	Included patients from surgical and medical ICUs, patients with acute MI, and patients undergoing organ transplantation	Insulin therapy should be started for patients with hyperglycemia and glucose should not be allowed to be greater than 180mg/dL.

TABLE 1. – *Continued*

Reference	Research Question/ Hypothesis	Theoretical Framework	Design	Sample (N) and Setting	Data Collection (Instruments/Tools	Findings
Richards, J., Hutchinson, J., Mukherjee, K., Jahangir, A., Mir, H., Evans, J., ... May, A. (2014). Stress Hyperglycemia and surgical site infection in stable nondiabetic adults with orthopedic injuries. *Trauma Acute Care Surgery*, *76*, 1070-1075. http://dx.doi.org/10.1097/TA.0000000000000177	Is stress-induced hyperglycemia associated with surgical site infections in stable nondiabetic patients with orthopedic injuries?		A prospective observational pilot study.	N=171 Nondiabetic patients with isolated orthopedic injuries requiring acute operative intervention.	Scheduled bedside finger stick BG checks were done twice a day. All values were recorded in the patient's EHR and were stored in a secured database.	Insulin therapy should be started for all patients with hyperglycemia to maintain a blood glucose less than 180mg/dL Validated insulin infusion protocols with low rates of hypoglycemia are recommended.
Van Vught, L., Wiewel, M., Klouwenberg, P., Hoogendijk, A., Scicluna, B., Ong, D., ... Van der Poll, T. (2016, July). Admission hyperglycemia in critically ill sepsis patients: association with outcome and host response. *Critical Care Medicine*, *44*, 1338-1346. http://dx.doi.org/10.1097/CCM.0000000000001650	Is an elevated blood glucose that is present on admission associated with poor outcomes in septic patients?		A prospective observational cohort study.	N= 987 patients with sepsis. The study was conducted in the ICU at two tertiary hospitals	Multiple serum biomarkers indicative of key host responses were collected and values were recorded in the patients HER.	Crude 30-day mortality was significantly higher in patients with seer hyperglycemia compared with euglycemic patients (p=0.08).

Patient Populations, Units and Stress-Induced Hyperglycemia

All the articles reviewed had participants who were all adults and who were admitted to an intensive care unit. Some of the ICU units are mixed medical-surgical intensive care units while others are department specific and include a neurosurgical, cardiac, and surgical intensive care unit. Other commonalities in these articles were the patient population included patients with stress-induced hyperglycemia and patients with a known history of diabetes mellitus and the definition of hypoglycemia is consistently defined as <70mg/dL across the literature. One issue that seemed to be lacking across the literature was the differentiation of nutritional status during the studies. There was no clear separation or identification of patients that were eating regular meals, patients that were Nil per os (NPO or nothing by mouth), and those who were receiving either enteral or parenteral feedings. Understanding nutrition status is key to evaluating the effectiveness of an insulin protocol and identifying barriers to meeting target glucose When the stress-induced hyperglycemia protocol is implemented a patient's nutritional status will be evaluated. To avoid hypoglycemia, those patients who were NPO were not started on the protocol despite having an elevated blood glucose level.

Definition of Hyperglycemia

There was variance in the definition of the hyperglycemia. Many of the research articles supported that hyperglycemia is a blood glucose level >140 mg/dL while the study by Richards, et al. (2014) defines hyperglycemia as a blood glucose >125 mg/dL. There is also an inconsistency in setting the mean blood glucose target throughout many of the studies. Many studies define the mean blood glucose target range to be 140 mg/dL-180 mg/dL. While other studies defined the mean blood glucose target range to be 110 mg/dL-140 mg/dL. For the

purposes of this project, hyperglycemia was defined as a blood glucose level greater than 150 mg/dL.

Variation in Methods

Three methodological designs were identified in the literature review. Forty percent of the literature performed retrospective chart reviews. Another forty percent of the studies were prospective, multicenter studies. Only twenty percent of the studies included randomized controlled studies, which offers a stronger level of evidence compared to the two prior methods use. This DNP project also used a retrospective chart review. The greatest variation between studies was noted to be that each study also utilized different insulin management protocols.

Strengths

The literature supports that hyperglycemia is an important and significant practice problem because hyperglycemia is associated with increased complication rates and adverse outcomes in the critically ill. Most of the literature supports that severe hyperglycemia is defined as being >180 mg/dL, except for van Vught, et al. (2016) who defines hyperglycemia as being > 200 mg/dL. For this project, hyperglycemia was defined as >150 mg/dL and severe hyperglycemia was defined at >180 mg/dL. The consensus supports that Intensive Insulin Therapy (IIT) should be initiated when a patient's blood glucose is greater than 180 ml/dL and that utilizing a tight glucose target range of 80 mg/dL-110 mg/dL significantly increases the risk of developing hypoglycemia. Based on the literature, intensive insulin therapy was initiated when the blood glucose level is greater than 180 mg/dL. For this project, intensive insulin therapy was initiated when the blood glucose level was greater than 180 mg/dL.

Weaknesses

Most the literature focused on the glycemic management of the surgical ICU patient while Chan et al. (2016) explored patients with sepsis. Kataja et al. (2016) examined the hyperglycemic management of patients with cardiogenic shock. There was no consistency throughout the literature on the measurement of blood glucose. Researchers measured blood glucose using arterial, venous, or capillary blood samples. This was a concern when considering the accuracy of blood glucose levels based on each testing. In this project, glucose levels were measured using capillary blood samples. In addition, the participants were not separated by nutritional status as this consideration would affect patient outcome. For example, it would be much easier for a patient who was not taking anything by mouth to achieve an optimal glucose target range versus the patient who was receiving total parenteral nutrition, which is higher in calories making normoglycemia more difficult to attain.

Gaps

The literature supports that to prevent complications and adverse outcomes both hypoglycemia and hyperglycemia should be avoided. However, there was a lack of agreement of what the blood glucose target should be. The American Association of Clinical Endocrinologists and American Diabetes Association (AACE/ADA) Consensus Statement (2009) recommends initiating insulin therapy of critically ill patients and using a blood glucose target of 140 mg/dL-180 mg/dL. The Society of Critical Care Medicine Clinical Guidelines (2012) recommends initiating insulin therapy and using a blood glucose target of 150 mg/dL-180 mg/dL. The largest gap in the literature was that there is not one insulin infusion protocol that has been shown to be

more efficacious than others. This makes it difficult for clinicians to adopt a specific protocol as the standard of care in hyperglycemic management.

Limitations

Many studies were limited by the fact that the sample populations were not classified by patients with stress-induced hyperglycemia (SIH) or patients with a known history of diabetes mellitus (DM). Guo et al. (2014) found that the patients with a known history of diabetes had a higher mortality rate when their target glucose levels were <140 mg/dL compared to the patients in the SIH subgroup. These findings are compelling and may suggest that patients with diabetes should be managed less aggressively than those with SIH. The scientific community would greatly benefit from more research on this specific patient population. Another limitation was that the blood glucose testing time frames varied greatly across all studies. Times varied from checking glucose levels every 30 minutes, hourly, every two hours, every four hours, and every 12 hours. This made it difficult to evaluate the effectiveness of the specific protocol as more frequent monitoring would allow for more frequent adjustment of insulin doses and affect the time it takes to get glucose level into the target. The time to reach target blood glucose range was not measured during the project.

The review of the literature supports that poorly controlled hyperglycemia in the intensive care setting increases morbidity and mortality. This is especially true for the surgical patient population. This body of knowledge should include more studies on the medical ICU patient population. Hyperglycemic management would improve by the development a standardized protocol for insulin therapy. To achieve standardization, there needs to be consensus of how the professional community defines hyperglycemia, agreement with a blood

glucose target range, and frequency of glucose testing. There is still important work to be done to further evaluate the needs and host response of the critically ill patient with a known history of diabetes. As the Gou et al. (2014) study has illustrated, diabetic patients benefit from a less aggressive target than those with only stress-induced hyperglycemia. There should also be an algorithmic approach to initiating therapy based on glucose level, a patient's known history of diabetes mellitus, and consideration of iatrogenic hyperglycemia due to corticosteroid use.

Based on this synthesis of the evidence, this DNP project 1) used all adult patients admitted to the ICU, 2) defined hyperglycemia as a blood glucose level of 150 mg/dL, 3) initiated insulin therapy on patients with a blood glucose greater than 150 mg/dL, 4) initiated intensive insulin therapy on all patients with a blood glucose greater than 180 mg/dL. ICU length of stay can also be affected by hypoglycemia. The decision to initiate insulin therapy at 150mg/dL versus the American Diabetic Association's recommendation to start at 140 mg/dL was to avoid causing iatrogenic hypoglycemia. Because there is no significant reduction in mortality when insulin therapy is initiated at 150mg/dL compared to 140 mg/dL the 150mg/dL glucose goal was selected as the glucose target for initiating insulin and 100 mg/dL was the target for the discontinuation of insulin (Jacobi, et al. 2012). In the landmark study NICE-SUGAR Trial investigators reported a significant increase in mortality and hypoglycemic events in patients enrolled in the intensive insulin group using a glucose target of 81-108 (NICE-SUGAR Study Investigators, 2009). The literature search had mixed results of ICU length of stay. Guo et al. (2014) reported that patients in the intensive insulin group had a decreased length of stay. However, Hargraves (2014) reported no significant difference in length of stay between the Insulin therapy group and the control group.

METHODS

Design

This DNP project was a quality improvement project that implemented an evidence-based stress-induced hyperglycemia protocol to decrease complications related to stress-induced hyperglycemia in the intensive care setting. The design was a descriptive pre-and post-protocol implementation study. Data was collected pre-and post-protocol implementation to determine if using the protocol influenced outcomes.

Participants

The target population included 1) male and female patients admitted to the ICU including trauma and medical/surgical ICU patients, 2) adults aged 18 years or older who were in the intensive care unit during the 30 days prior to the implementation of the protocol and following the implementation of the protocol and 3) had a blood glucose level greater than 150 mg/dL. Data was collected on all patients that fit the criteria within a 30-day period prior to implementing the protocol and 30 days following implementation of the protocol. To categorize trauma patients, patients were given an injury severity score (ISS) which is calculated based on the extent of their injuries. Trauma patients with an ISS between 0-25 were included. Patients with ISS scores greater than 25 were not included because they have higher morbidity and mortality rates and prolonged length of stay which can affect outcome data (Trauma.org website, n.d.). Medical/Surgical patients admitted to the ICU had an Apache II score calculated to determine mortality. Patients with an Apache II score of 29 or less were included. Patients with an Apache II score 30 or greater were excluded due to high mortality of 75% or greater. Exclusion criteria were having a known history of diabetes, having a blood glucose level less

than 150mg/dL or an ISS score greater than 25 or Apache II score greater than 29. Patients whose blood glucose never exceeded 180 mg/dL were placed in the category of meeting the Society of Critical Care Medicine clinical practice guidelines and any patient with a blood glucose level greater than 180 mg/dL was categorized as not meeting the guidelines. At NorthBay Medical Center, approximately 3-4 patients were admitted to the ICU per week. All patients were screened for inclusion however approximately 50% fit the criteria for stress-induced hyperglycemia. Twenty-two patients were included in the study.

Ethical Considerations

This DNP project was a quality improvement project. To evaluate the effectiveness of the intervention I needed to access patients protected health information in their electronic medical record. I adhered to the Standards for Privacy of Individually Identifiable Health Information, known as the "Privacy Rule" (The Department of Health and Human Services [HHS], 2003). This rule was issued by the department of Health and Human Services (HHS) to implement the requirement of the Health Insurance Portability and Accountability Act (HIPAA) of 1996 (HHS, 2003). I adhered to the HIPAA rules while performing chart reviews. I obtained approval from both the University of Arizona and NorthBay Healthcare Institutional Review Boards prior to implementing my DNP project or collecting any protected health information.

Respect for Persons

Respect for persons is based on two ethical principles: first, individuals are autonomous agents and secondly, those with diminished autonomy are entitled to protection (United States, National Commission for the Protection of Human Subjects of Biomedical and Behavioral Research, 1979). An autonomous subject is able to make their own decisions and act on these

decisions without the researcher circumventing their decisions (United States, National Commission for the Protection of Human Subjects of Biomedical and Behavioral Research, 1979). Those subjects that do not have the capacity for self-determination are granted protection. I did not anticipate any ethical conflict with respect for persons as the focus of my project was to create a stress-induced hyperglycemia protocol to be used as standard medical management. As insulin therapy is a standard of care for hyperglycemia, patients maintained their right to refuse care if they did not want to receive medical treatment. All abstracted data from the electronic medical record was de-identified and stored in a locked cabinet.

Beneficence

The principle of beneficence requires that a person's decisions are respected and that researchers must do no harm, maximize benefits, and minimize potential risks (United States, National Commission for the Protection of Human Subjects of Biomedical and Behavioral Research, 1979). The benefits of improved glucose control have been maximized by the inclusion of patients with stress-induced hyperglycemia in addition to treating patients with a known history of diabetes mellitus. Patients on insulin therapy were at risk for developing hypoglycemia which can be a dangerous complication. Because of this risk, the blood glucose parameter for discontinuation of insulin therapy was increased to 100mg/dL instead of the recommendation to stop therapy when the blood glucose level was 80mg/dL to minimize risk for hypoglycemia.

Justice

The principle of justice is that there is a fair distribution of services or resources and an injustice occurs when a person who would benefit from a treatment is denied the right to receive

it (United States, National Commission for the Protection of Human Subjects of Biomedical and Behavioral Research, 1979). I did not experience any conflict with the principle of justice as all patients who had stress-induced hyperglycemia were offered insulin therapy.

Vulnerable Populations

Vulnerable groups need special protection as they are unable to provide meaningful informed consent (Polit & Beck, 2017). NorthBay Medical Center is in the same county as the California State Prison and California Medical Facility Prison. Inmates often received care in the intensive care unit (ICU). Critically ill children do not receive care in our ICU, instead they transfer to various pediatric tertiary care centers in the region. Pregnant women were treated in the intensive care unit. All patient's right for self-determination was respected and their wish to deny insulin therapy was honored.

Stress-induced hyperglycemia has been shown to increase ICU length of stay, have prolonged ventilator days, and cause complications that increase overall mortality (Draznin et al. 2013). The literature supports that initiating insulin therapy in patients with a blood glucose level greater than 150 mg/dL decreases complications associated with hyperglycemia, decreases healthcare costs, and results in improved health outcomes in this patient population (Buehler et al. 2015). Implementing a stress-induced hyperglycemic protocol at NorthBay Medical Center should have a positive impact on the ICU length of stay due to improved glucose control and reduction of complications associated with uncontrolled hyperglycemia.

Setting

The setting for this project was the Intensive Care Unit (ICU) at NorthBay Medical Center. The hospital is a Level II Trauma Center, a STEMI receiving center, and a Primary

Stroke Center. The ICU is a mixed unit; the patient population is largely comprised of trauma, neurosurgery, cardio-thoracic surgical patients, and a smaller portion of medical ICU patients.

Stress-Induced Hyperglycemic Protocol

Prior to implementation of the protocol, the stress-induced hyperglycemic protocol was presented to the Critical Care Committee for approval. The Modified Yale Protocol and the Insulin Sliding Scale Protocols were already in place and currently being used in the management of diabetic patients. However, I wanted to study the outcome of consistent implementation of the stress-induced hyperglycemic protocol to show if there was an improvement in ICU length of stay when implemented on a consistent basis. There was no need to get approval from the Pharmacy and Therapeutics Committee as these insulin protocols already existed. To help identify patients with hyperglycemia, blood glucose levels were reviewed on every ICU patient during the multidisciplinary rounds. The intensivists and ICU nurse practitioners monitored patient's blood glucose levels and initiated therapy per protocol.

ICU nurses notified providers if their patient's blood glucose was greater than 150 mg/dL so that therapy could be initiated per the stress-induced hyperglycemic protocol. The ICU pharmacist calculated the total daily doses and started sliding scale coverage. All patients with a blood glucose <180 mg/dL were started on a mild sliding scale. If the blood sugar could not be kept in between the range of 140 mg/dL-180 mg/dL the sliding scale coverage was increased to moderate or aggressive sliding scale to achieve a blood glucose range of 140 mg/dL-180 mg/dL.

The stress-induced hyperglycemic protocol was adapted from the perioperative hyperglycemia algorithm at Emory University (Duggan, Klopman, Berry, & Umpierrez, 2016) and was used in the NorthBay ICU. Upon admission to the ICU, every patient had their blood

glucose checked every four hours for the first twenty-four hours. The intensivist or critical care nurse practitioner ordered a Lispro mild sliding scale insulin coverage for all patients with a blood glucose level greater than 150 mg/dL. The sliding scale was titrated to a moderate or aggressive sliding scale if blood sugars continue to be greater than 150 mg/dL. If the blood glucose level was greater than 180 mg/dL an insulin infusion was started. The insulin infusion was titrated using the Modified-Yale Protocol. The ICU already used the Modified-Yale Protocol for insulin titration. It is both an effective and safe protocol for insulin titration (Ngalob et al. 2014).

If the patient did not have a known history of diabetes and had two episodes in which the blood glucose was greater than 180 mg/dL a HbA1C test was ordered to evaluate for new onset diabetes mellitus. There were no findings of occult diabetes during the project. To transition from intravenous to subcutaneous insulin, 80% of the 24-hour insulin dose was calculated as the total daily dose (TDD) subcutaneous dose; 50% of this was administered as the basal insulin and 50% as the prandial insulin (when the patient was eating). At NorthBay, the critical care pharmacist performed the insulin calculation to ensure accuracy and safety of the order set.

Patients with stress-induced hyperglycemia and no known history of diabetes who were on an insulin infusion rate less than two units/hour was managed with correctional insulin only and did not require transition to a basal regimen (Duggan et al. 2016). The blood glucose level that triggered initiation of insulin therapy was increased to 150mg/dL to align with the Society of Critical Care Medicine clinical practice guidelines (Jacobi et al. 2012). The blood glucose level that triggered discontinuation of insulin therapy was increased to 100mg/dL to avoid hypoglycemic episodes.

Data Collection Procedures

Data collection was performed by electronic medical record review. The demographic data on the trauma patients included age, gender, ISS score, Apache II score, and ethnicity. I also collected data on ICU length of stay, mean glucose levels both pre-and-post implementation of the protocol, the total number of patients screened, the number of patients with SIH, the number of patients that did not meet the criteria, and the number of patients that met the criteria, but the protocol was not implemented by the provider. ICU length of stay was measured as an indirect measurement of complications. Total hospital length of stay was also measured. Upon approval by both the University of Arizona and NorthBay IRBs, I performed a retrospective medical record review of ICU patients, their length of stay, and mean glucose levels. Following protocol implementation, I conducted another review and compared outcomes pre-and post-implementation to evaluate if implementing the stress-induced hyperglycemia protocol decreased ICU length of stay.

Data Analysis

The data was de-identified and entered into an Excel spreadsheet for data analysis. A two-tailed independent samples t-test was performed to compare the means between the pre-intervention sample and the post-intervention sample to determine if there was statistically significant difference among ICU length of stay, hospital length of stay, and the mean blood glucose level among the patients. The pre/post intervention comparison was conducted to answer the following questions: Did the intervention group have a lower mean blood glucose when compared to the pre-intervention group? Did the intervention group have a shorter ICU length of stay when compared to the pre-intervention group? Did the intervention group have a shorter

hospital length of stay when compared to the pre-intervention group? Did the percentage of patients who met criteria but were not started on the protocol decrease compared to the pre-intervention and intervention group?

Expected Timeline

The final proposal was submitted in July 2017. IRB applications were submitted in August 2017. The intervention was completed November 15, 2017. The final project defense was on December 11, 2017.

RESULTS

A total of 69 patients were screened, 47 did not meet inclusion criteria and were excluded. Of these 47, 31 were excluded because they did not have hyperglycemia and 16 were excluded because they were receiving corticosteroids. No participants were excluded due to high ISS or Apache II scores. The sample consisted of 22 (n=22) ICU patients (Table 2). There were 11 pre-implementation and 11 post-implementation. There were 15 male patients (n=15) and seven female patients (n=7). Of these patients, 14 were medical/surgical ICU patients (n=14) and eight were trauma patients (n=8).

Ages ranged from 18 to 90 years old with a mean age of 54-years-old (M=54, SD=21). The mean Apache II score for the pre-implementation group was 13.8 (M=13.8, SD=5.8). The mean Injury Severity Score was 9.5 (M=9.5, SD=7.8). The mean Apache II score for the post-implementation group was 13 (M=13, SD=4.2). The mean Injury Severity Score was 2.5 (m=2.5, SD=0.70). The post implementation mean ISS score was affected by the fact that there were only 2 trauma patients in the sample. During the implementation phase of this project, there was a

significant decrease in trauma patient census, thus, decreasing the number of trauma patients in the post-implementation sample.

TABLE 2. *Characteristics of the Sample*

Characteristic	Male (n=15)	Female (n=7)
Trauma (%)	27	5
Medical/Surgical (%)	41	27
Mean Age	47	63
Min Age	18	39
Max Age	90	84

A two-tailed independent-samples t-test was conducted to compare ICU length of stay, hospital length of stay, and average blood glucose levels pre/post-protocol implementation (Table 3). The average ICU length of stay pre-protocol implementation (M=4.18, SD=2.48) was greater than the average ICU length of stay post-protocol implementation (M=2.18, SD=1.83). This difference is statistically significant t (20) =2.15, p=0.04; d= 0.95. The effect size for this analysis was meaningful as it exceeds Cohen's convention for a large effect (d=.80). The 95% confidence level interval for the mean difference was [0.06 to 3.94]. There was no significant difference between pre-protocol implementation hospital length of stay (M=9.27, SD=9.5) and post-protocol implementation hospital length of stay (M=6.27, SD=3.82); t (20) =0.97, p=0.34. The 95% confidence level interval for the mean difference was [-3.44 to 9.44]. There was no significant difference in average blood glucose levels pre-implementation (M=197, SD=69) and post-protocol implementation (M=189, SD=40); t (20) =0.31, p=0.76. The 95% confidence level interval for the mean difference was [-42.84 to 57.75]. I found that 55% patients in the pre-implementation group met criteria for stress-induced hyperglycemia, yet the ICU healthcare provider did not initiate insulin therapy.

TABLE 3. *Independent Samples t-test*

Variable	t	df	p	d
ICU Length of Stay	2.15	10	0.044	0.95
Hospital Length of Stay	0.97	10	0.343	
Average Glucose Level	0.31	10	0.76	

There was 100% compliance with initiating therapy on those patients that met criteria post-implementation. These results suggest that the implementation of the SIH protocol decreases ICU length of stay and improves provider compliance but does not affect overall hospital length of stay or reduce average blood glucose levels during hospitalization in patients with stress-induced hyperglycemia.

DISCUSSION

Summary

Implementation of the stress-induced hyperglycemia protocol provided a clear algorithm to guide intensive care providers in the management of stress-induced hyperglycemia. Integrating blood sugar management into the daily multidisciplinary rounds ensured that blood glucose was managed effectively and efficiently. The nurses embraced the new protocol and were instrumental in identifying patients with stress-induced hyperglycemia and notifying the provider to initiate the protocol. Overall, glycemic management improved following the implementation of the protocol.

Strengths of the Study

The strength of the intervention was that clinicians now had a clear guideline to follow in the management of stress-induced hyperglycemia. Prior to the protocol, providers followed various blood glucose goals and there was no consistency to when insulin therapy was started.

Following implementation, providers approach to blood glucose management was more consistent resulting in improved glycemic control and decreased ICU length of stay. To sustain this practice change, blood glucose was embedded into the ICU multidisciplinary process to maintain utilization of the protocol. Implementation of this initiative is an excellent example of outcomes that can be affected by the role of a DNP. As a doctorally prepared nurse practitioner, it is my role to navigate through a complex healthcare system, synthesize new knowledge, translate evidence-based practice into clinical practice, and advocate for the delivery of quality care for patients.

Limitations of the Study

Initially, the stress-induced hyperglycemia protocol was trialed on the ICU trauma patient population. Due to low trauma patient census the inclusion criteria was expanded to include general medical/surgical ICU patients as well as trauma patients; the NorthBay Institutional Review Board approved this expansion.

Interpretation

Improved glycemic control, decreased ICU and hospital length stay were expected outcomes from the implementation of the protocol. Although ICU length of stay was significantly decreased, overall hospital length of stay was not affected. This could be due to Hospitalist discontinuation of the protocol once the patient was transferred out of the intensive care unit, unfortunately this data was not tracked. Hospitalists do not have the capacity to hold multidisciplinary rounds due to their large patient census and there is no existing protocol for nurses to notify providers of elevated blood glucose levels in non-diabetic patients. Expansion of the protocol to all units should be considered as there is an opportunity to improve patient

outcomes. Future QI efforts will be focused on educating nurses and physicians about the management of stress-induced hyperglycemia to improve glycemic management hospital-wide.

Conclusion

After demonstrating the feasibility of the Stress-induced Hyperglycemia protocol implementation in the NorthBay Intensive Care Unit and its success in decreasing ICU length of stay and increasing consistency in ICU provider's adherence to stress-induced hyperglycemia guidelines, the protocol should be integrated throughout all patient care units. Implementation of the protocol in the ICU did not require any additional employees. The costs associated with increased usage of insulin is negligible, especially when compared to the cost savings associated with decreasing ICU length of stay.

This study demonstrates that a relatively simple quality improvement project aimed at improving stress-induced hyperglycemia management in the ICU is feasible and can be sustained over time. Most important, the findings suggest that this program may offer substantial long-term benefits if it were expanded to all patient care units throughout the hospital. The one question that remains unanswered is whether hospital length of stay can be reduced if patients remain on the stress-induced hyperglycemia protocol throughout their entire hospitalization. A future study examining this would help further elucidate the benefits of a stress-induced hyperglycemia protocol. As a DNP prepared nurse practitioner, I propose to lead the initiative to implement this stress-induced protocol to all patient care units within the organization. The findings of this study help to illustrate how one small practice change can result in improved patient outcomes and healthcare delivery, reduction of complications, and significant cost savings for the organization.

APPENDIX A:

NORTHBAY MEDICAL CENTER'S MODIFIED YALE PROTOCOL

NORTHBAY HEALTHCARE	**Page No.** 1 of 5	**Number:** 625
ADMINISTRATIVE MANUAL	**Effective Date:** December 2009[1]	
System [ ] [x] **Hospitals**	**Required Review:** Every 3 years	
	Reviewed: 2/16	
	Revised: 11/12	
Policy [x] **Procedure** [x]	**Responsible Position:** Director, Critical Care Services	
Title: Insulin – Modified Yale Protocol	**Approval Requirements:** VP, Chief Nursing Officer Pharmacy & Therapeutics/Infection Control Committee Medicine Department Emergency Department Medical Executive Committee Board of Directors	

I. PURPOSE:

A. To outline the management of adult critically ill patients using the Modified Yale Protocol continuous insulin infusion to control high blood glucose levels.

B. Initiation of this protocol requires a Provider Order.

II. SUPPORTIVE DATA*

A. Normalization of blood glucose levels using Modified Yale Insulin Protocol improves outcomes in intensive care units. Intensive insulin infusion therapy to maintain blood glucose levels reduces mortality. It also reduces incidence of bloodstream infections, incidence of acute renal failure, need for prolonged ventilatory support, and the duration of ICU stay.

B. Randomized controlled trial data indicates that lowering blood glucose between 140-180mg/dl levels improved outcomes in critically ill patients.

C. The Modified Yale Insulin Protocol is designed to:

1. Keep glucose in a target range, minimizing the risk of hypoglycemia and preventing undesirable hypoglycemic effects.

2. Offer consistent and predictable drug delivery compared to subcutaneous insulin where peripheral perfusion or edema creates erratic drug delivery.

[1] This policy was approved under the title: Adult ICU Insulin Infusion {2/01/16}

D. Key Points:

1. Target Blood Glucose (BG) levels: 140-180mg/dl
2. Common clinical interventions such as corticosteroids, vasopressors and enteral/parenteral nutrition predispose patients to elevated blood glucose
3. The Modified Yale Insulin protocol is to be used for critically ill hyperglycemic adult patients.
4. For patients with Diabetic Ketoacidosis (DKA) or hyperglycemic hyperosmolar states (HHS) prescriber to consider *DKA specific* order set

E. Three main elements used to adjust Modified Yale Insulin Protocol:

1. The current point of care blood glucose value
2. The previous point of care blood glucose value
3. The current Insulin drip infusion rate

F. Modified Yale Insulin Protocol:

1. Obtain a Provider Order for standard adult insulin drip (100 units regular insulin/100mL NS). The order should include SPECIAL INSTRUCTIONS "Modified Yale Insulin Protocol".
2. To calculate bolus and determine initial Modified Yale Insulin Protocol rate, sample initial point of care BG and divide result by 100, then round to nearest 0.5 units. (Note: bolus dose = initial infusion rate.)
3. Notify physician if point of care BG result is out of range.

Examples: 1. Initial BG=325mg/dl: 325÷100 = 3.25, round to nearest 0.5 units (in this case, up) to 3.5: IV bolus 3.5 units and start infusion at 3.5 units/hr. 2. Initial BG =174mg/dl: 174÷100 = 1.74, round to nearest 0.5 units (in this case, down) to 1.5; IV bolus 1.5 units and start infusion at 1.5 units/hour

G. Blood glucose (BG) monitoring:

1. Check BG hourly until stable (3 consecutive values within target range). In hypotensive patients, capillary blood glucose (i.e., finger sticks) may be inaccurate and obtaining the blood sample from indwelling vascular catheter is acceptable as long as there are no dextrose containing solutions infusing)
2. Then check the BG every 2 hours; once stable for 12 hours then BG checks can be spaced to q 4 hours IF:
   a. No change in clinical condition AND
   b. No change in nutritional intake.
3. If any of the following occur, resume hourly BG monitoring until the BG is again stable (3 consecutive BG values within target range):

   a. Any change in the insulin infusion rate (i.e. BG out of target range)

b. Initiation and or termination of steroid therapy
c. Initiation, termination, or rate change of nutritional support (TPN, PPN, tube feeding, dextrose containing continuous infusions, etc)

H. Changing the Insulin Rate:

1. **Step 1:** Determine the CURRENT BG LEVEL reference the corresponding column in the table.
2. **Step 2:** Determine the HOURLY BG CHANGE from the prior BG level – If the last BG was measured 2-4 hours before the current BG, calculate the hourly rate.
   Note: **Hourly BG Change = (current BG –** previous BG) ÷(current time – previous time)
   Example: If the BG at 2pm was 150 mg/dl and the BG at 4pm is now 120 mg/dl; the hourly BG changes is -30 mg/dl ÷2 hours = -15 mg/dl/hr]
3. **Step 3:** Identify the CELL (from the table below) associated with your current BG level, follow the column down to find the cell that contains your hourly BG change. Then move to the far right column for

INSTRUCTIONS to determine your rate of change: Table A

CURRENT LEVEL				
BG –100-139 mg/dl	**BG –140-179 mg/dl**	**BG –180-220 mg/dl**	**BG ≥ 221 mg/dl**	**INSTRUCTIONS**
		BG ↑ by >50 mg/dl/hr	**BG ↑**	**↑ INFUSION by "2Δ"**
	BG ↑ by > 25 mg/dl/hr	**BG ↑ by 1-50 mg/dl/hr or BG UNCHANGED**	**BG UNCHANGED or BG ↓ by 1 - 25 mg/dl/hr**	**↑ INFUSION by "Δ"**
BG ↑	**BG ↑ by 1-25 mg/dl/hr BG UNCHANGED, or BG ↓ by 1 - 25 mg/dl/hr**	**BG ↓ by 1 - 50 mg/dl/hr**	**BG ↓ by 26 - 75 mg/dl/hr**	**NO INFUSION CHANGE**
BG UNCHANGED BG ↓ by 1 - 2 mg/dl/hr	**BG ↓ by 26 - 50 mg/dl/hr**	**BG ↓ by 51 - 75 mg/dl/hr**	**BG ↓ by 76 - 100 mg/dl/hr**	**↓ INFUSION BY "Δ"**
BG ↓ by > 25 mg/dl/ see below *	**BG ↓ by > 50 mg/dl/hr**	**BG ↓ by >75 mg/dl/hr**	**BG ↓ by > 100 mg/dl/hr**	**HOLD x 30 minutes then ↓ INFUSION by "2Δ"**

*** D/C INSULIN INFUSION; √ BG q 30 minutes. When BG ≥ 100 mg/dl, restart infusion @ 75% of the most recent rate.**

To determine the change in your hourly drip rate:

Step 1: Identify your current drip rate in the far left column in Table B.

Step 2: Follow the row to the right that corresponds with the instructions given in Table A Table B

Current Rate (units/hr)	Δ = Rate Chang (units/hr)	2Δ = 2 x Rate Change (unit/hr)
< 3	0.5	1
3 - 6	1	2
6.5 - 10	1.5	3
10.5 - 14.5	2	4
15 - 19.5	3	6
20 - 24.5	4	8
≥ 25	**≥ 5**	10 (consult MD)

I. If BG <70 mg/dl:
1. **Step 1:** STOP INSULIN INFUSION
2. **Step 2:** Give 1 amp (25gm) D50 IV push; recheck and document BG q 15 minutes if BG less than 100 repeat D50 and notify Provider
3. **Step 3:** When BG ≥ 100 mg/dl, wait 1 hour, then restart infusion at 75% of previous rate.

J. If BG 71-99 mg/dl:
1. Step 1: STOP INSULIN INFUSION
2. Step 2: Recheck and document BG every 30 minutes.
3. Step 3: When BG≥100 mg/dl restart insulin infusion at 75% of previous rate.

K. Goals:
1. Blood sugar stable between 140 and 180 mg/dl
2. No episodes of hypoglycemia
3. Continuous glucose source is maintained
4. Patient's BG returns to baseline, and/or diabetic management (which may or may not include subcutaneous insulin)

ADOPTED FROM/REFERENCES:

- Yale Insulin Protocol, 2/2004
- California Pacific Medical Center Insulin Protocol, 7/2004
- University of Minnesota Insulin Infusion Protocol, Summer 2006

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