Making a Diabetic Ketoacidosis Computerized Order Set User-Friendly

Heidi M. Checketts, BSN, RN, DNP-Candidate

University of Utah

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Executive Summary

Clinicians in the Shock-Trauma Intensive Care Unit (STICU) at Intermountain Medical Center have spoken frustration about the current diabetic ketoacidosis (DKA) order set. Both providers and nurses are often confused by these orders. This confusion has lead to delayed order implementation likely resulting in slower resolution of DKA. The STICU is a teaching unit consisting of fellows, residents, interns, and students rotating through on a short term basis, which may be anywhere from one day to one month. Due to this structured turnover, these clinicians are unable to familiarize themselves with the multiple order sets, which inhibit them from always being an effective resource for the bedside nurse. Thus, the providers and nursing staff needed the order set revised and clarified to create greater efficiency and improve patient care in the setting of DKA. The current order set was recently expanded to the Intermountain Healthcare Corporation.

The purpose of this project was to revise the DKA order set used in the STICU.

Flowcharts were created addressing the most confusing components of the order set. In the near future, the developed flowcharts will be embedded within different sections of the order set for clarification of treatment processes. The flowcharts developed diagram fluid, electrolyte, and insulin therapy creating less confusion through the progression of DKA treatment. Content experts were consulted to provide feedback on the order set and flowchart throughout the revision and development processes.

Four objectives were identified for this project. The first objective was revisions to the DKA order set used within Intermountain Healthcare. A copy of the current order set was obtained and reviewed with the medical director of STICU. Meetings were scheduled as needed to address the proposed changes. The second objective was the development of flowcharts using the revised order set. Computer support experts were consulted about the creation and usability of the flowcharts in an electronic format embedded into the order set. The third objective was the initial presentation of the revised order set and flowcharts to the STICU medical director. Subsequent presentations to other clinicians have been completed by multiple meetings addressing changes to the DKA order set and implementation of new flowcharts. Feedback has been and continues to be obtained through the use of a Likert-styled questionnaire. Informal feedback has also been welcomed. Approval for the changes is being obtained with the expectation that the revised order set will be available soon. The final objective was the submission of an abstract for a poster presentation at the Excellence in Trauma and Critical Care Conference this fall.

This project was important for several reasons. A quality improvement problem was identified in the STICU. Treatment of DKA is fairly defined with specific treatment goals. Yet, there have been problems effectively treating DKA using the Intermountain Healthcare computerized order set. It is anticipated that a more effective order set will improve provider and nurse understanding regarding treatment of DKA in the STICU, ultimately improving patient care.

The project committee members are Nancy Allen, PhD ANP-BC, Denise Ward DNP, ACNP-BC, FNP-BC, and Katie Ward DNP, WHNP-BC, ANP-BC. The content experts are James Orme MD, medical director of STICU, and Jane Jeffrie Seley DNP, a diabetes nurse practitioner at New-York Presbyterian Hospital.
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Making a Diabetic Ketoacidosis Computerized Order Set User-Friendly

**Problem Statement**

Intermountain Healthcare has many computerized order sets that clinicians have developed over the years that have helped standardize the treatment of different diagnoses. One such order set is for the treatment of diabetic ketoacidosis (DKA). The DKA order set was developed by a critical care attending physician and an endocrinologist at Intermountain Medical Center (J. Orme, personal communication, November 15, 2012). The Shock-Trauma ICU (STICU) at Intermountain Medical Center (IMC) admits many patients who have the diagnosis of DKA. In 2012, STICU admitted 104 patients with the diagnosis of DKA (K. Kuttler, personal communication, August 27, 2013). There were a total of 132 patients with DKA admitted to all of the critical care units at IMC and an additional 28 admitted to LDS Hospital’s ICU in 2012 (K. Kuttler, personal communication, August 27, 2013). The critical care units of Intermountain Healthcare all utilize this same order set.

The STICU is a teaching unit, and this can present challenges. With fellows, residents, and students who rotate through the unit from a day to week(s) to month blocks, it is difficult for them to familiarize themselves with the DKA order set. The nursing staff has a high turn-over rate which decreases the number of staff gaining expertise with all of the order sets. This leads to the perfect scenario for errors to take place. The resident physicians initiate the DKA order set. However, the problem has been identified by nursing staff members and medical residents that the DKA order set is challenging to interpret.

DKA is a life-threatening emergency. Van Ness-Otunnu and Hack (2013) stressed the importance of treating DKA and HHS by stating, “These life-threatening endocrine emergencies demand swift repeated clinical and laboratory assessment; monitoring; correction of
DKA ORDER SET

hypovolemia, acidemia, hyperglycemia, ketonemia, and electrolytes, and treatment of precipitating causes.” (p. 1). DKA is relatively straightforward to treat. When care providers do not understand the order set to treat DKA, treatment and resolution of DKA may be delayed due to treatment not being initiated in a timely manner. This results in increased cost to the patient and the system with use of resources including a critical care bed and staff.

Clinical Implications

The current healthcare environment is focused heavily on decreasing medical errors. This project is based on improving the quality of care for patients admitted with DKA. Juran (1989) states that quality improvement includes revising processes in an effort to decrease error rates. When order sets are confusing to care providers, there is a risk of errors being made.

Nolan (2007) discussed the pertinence of quality and safety in the overall care management strategy of healthcare organizations. It is important when an idea is brought forth to improve quality and safety. The goal of this project was to do both. The need was identified for an improvement in an order set in which care providers struggle with both interpreting and following its instructions. Multiple staff members in STICU expressed their struggles with the DKA order set. There have also been instances where the attending physician on has been frustrated with a resident not following the order set due to their lack of understanding of it. This has lead to the delayed or mistreatment of patients with the diagnosis of DKA. Improving the treatment of patients is especially important in the current healthcare environment (Batalden & Davidoff, 2007).

Clinicians are under great scrutiny to prioritize the utilization of health care resources (ACP, 2011). Cost-savings to both patients and systems is important. By streamlining the treatment of DKA stay fewer hours to days in the ICU and in the hospital. Revision of the DKA
order set and creation of treatment flowcharts aimed to improve the management and treatment of DKA patients at Intermountain Medical Center’s STICU.

**Objectives**

Four objectives were determined for this project. The first objective was the revision of the current DKA order set used within Intermountain Healthcare. The second objective was the development of the flowchart using the revised order set. The third objective was the presentation of the revised order set and flowchart to the medical director initially and then other clinician stakeholders. The final objective was the submission of an application for a poster presentation at an appropriate conference.

**Literature Review**

**Literature Search Strategy**

The majority of the literature search for this project was done on the PubMed database. Search terms included both single term searches and combined word searches using diabetic ketoacidosis, hyperglycemic emergencies, hyperosmolar hyperglycemic state, hyperglycemic hyperosmolar nonketotic coma, fluid management, insulin management, algorithms, flowcharts, diabetes, treatment, diagnosis, and complications. The search was often narrowed to include free full text articles. All inclusive searches were included and abstracts were reviewed to ensure no additional information was being missed by narrowing to free full text articles. When the search on PubMed did not yield information needed, general web-based searches were used. The Center of Disease Control website was used. This also allowed for search on the sites of professional organizations. General web searches were useful in identifying treatment guidelines that use flowcharts.
Background

The incidence of diabetes in the United States has more than tripled since 1980 (CDC, 2011). The number of individuals diagnosed with diabetes in Utah in 1994 was 45 per 1000. The last reported number was 122 individuals per 1000 in 2010 (CDC, 2011). With the incidence of diabetes increasing, the numbers of individuals admitted to the hospital with diabetes is also increasing. Umpierrez et al. (2009) reported that greater than 100,000 hospital admissions each year in the United States are due to diabetic ketoacidosis (DKA). There has been a 42 percent increase in the number of hospitalizations for DKA from 1985 to 2005 (Elsevier, 2012). With the average cost per patient per hospitalization at 13,000 dollars (Huang et al., 2013) and the direct and indirect estimated costs of 2.4 billion U.S. dollars annually (Elsevier), expediting the treatment and resolution of DKA will benefit each patient admitted with the diagnosis.

Huang et al. (2013) identified the three types of hyperglycemic crises: DKA, hyperosmolar hyperglycemic state (HHS), and a mixed syndrome including both DKA and HHS. HHS and DKA are the “two most serious metabolic complications of diabetes” (Kitabchi, Umpierrez, Murphy, and Kreisberg, 2006, p. 2739). The most common hyperglycemic emergency experienced in patients with diabetes mellitus is DKA (Umpierrez & Kitabchi, 2003). With the rise in the incidence of diabetes in the population, it is essential for healthcare providers to be familiar with the most common hyperglycemic emergency found in individuals diagnosed with diabetes. Individuals diagnosed with type 1 or type 2 diabetes are susceptible to developing this potential complication, though it is more often seen in individuals with type 1 (Umpierrez & Kitabchi). Recognizing the seriousness of the problem or the life-threatening nature of the problem may motivate individuals to better understand the treatment for DKA and HHS.
Risk Factors

One important aspect when treating DKA is identifying the underlying cause. The two most common causes of DKA are infection and insufficient or inadequate insulin management (Barski et al., 2012; Kitabchi et al., 2006). Other precipitating causes are myocardial infarction, pancreatitis, cerebrovascular accident, drugs, surgery and trauma (Kitabchi et al., 2006; Umpierrez & Kitabchi, 2003). Van Ness-Otunnu and Hack (2013) further specified the potential precipitating causes of DKA including drug classes and drugs such as sympathomimetics, corticosteroids, pentamidine, thiazide diuretics, atypical antipsychotics, cocaine, and calcium channel blockers and endocrine issues such as adrenal disorders and hyperthyroidism, and shock states.

Critical care clinicians and nurses should be aware of risk factors for mortality from DKA. These risk factors may include changes in a patient’s heart rate, blood pressure, neurological state, medical history, and the precipitating cause of DKA, and anemia. The above variables should be considered by an emergency department clinician and should guide the clinician to admit the patient to an appropriate unit for treatment of DKA. Huang et al. (2013) recently developed a prediction rule that assists critical care and emergency room physicians with classifying patients into disposition groups and mortality risk. The researchers enrolled 295 patients from January 2004 to December 2010. Once the patient meets the criteria of suffering from a hyperglycemic crisis, the score titled Predicting Hyperglycemic Crisis Death (PHD) can be calculated in the emergency department. The mortality risk is for 30 days. The variables used to calculate the score were the absence of tachycardia and the presence of hypotension, anemia, severe coma, cancer history, and infection. The mortality in the low risk group was 0%. The intermediate risk and high risk groups’ mortality were 25.5% and 59.5%, a substantial increase
from that of the low risk group. Determining PHD score can assist providers with making a decision about the disposition of a patient. A high risk patient definitely warrants an ICU admission. A limiting factor identified by Huang et al. was that the PHD score can serve only as a prognostic estimate. The score can be used as a tool coupled with experienced clinical judgment and the integration of objective data and other information discovered during interaction with a patient or family. To further validate the PHD scoring tool, it needs to be utilized in a broader population base. Though the tool will not be used in the order set due to its need of further evaluation, consideration will be given to including an information section on the above risk factors to make the ordering clinician more aware of the risk of mortality to their patient.

There are important risk factors that have been identified that predict 30-day mortality in DKA patients. Barski et al. (2012) conducted a retrospective cohort study that evaluated the clinical characteristics, hospital management, and clinical outcomes in a patient with DKA. The study population was comprised of 220 patients. The authors identified certain factors that were associated with an increased risk in 30-day mortality. These factors were advanced age, mechanical ventilation, and a bedridden state. Special consideration should be given to said factors when considering the disposition of a patient in an emergency department with DKA.

**Diagnosis**

Correctly diagnosing DKA and HHS is essential to establishing a treatment plan. A consensus statement written in 2003 by the American Diabetes Association identified aspects of diagnosing DKA and HHS (Kitabchi et al., 2006). Diagnosis includes a history and physical examination, obtaining laboratory data, and consideration of other potential diagnoses. Radiographic studies and electrocardiograms are also included in the laboratory findings section
(Kitabchi et al., 2006). The consensus statement describes the assessment findings as “the classic presentation of patients with DKA includes a history of polyuria, polydipsia, weight loss, vomiting, abdominal pain, dehydration, weakness, mental status change, and coma” (p. 2741).

Laboratory values should be obtained on any patient considered to be potentially in DKA. The initial laboratory evaluation includes serum ketones, electrolytes with a calculated anion gap, urine ketones by dipstick, arterial blood gas, complete blood count with differential, plasma glucose, blood urea nitrogen, and creatinine (Kitabchi et al., 2006). Since the consensus statement was made, Arora, Henderson, Long, and Menchine (2011) conducted research that disputes the use of urine ketones by dipstick. They found the point-of-care β-hydroxybutyrate test was equally sensitive in detecting DKA as the urine dipstick but more specific than the urine dipstick. Thus, they argue that the urine dipstick may be unnecessary to perform. Evaluation of laboratory findings is essential for establishing a treatment plan in the management of a patient with DKA.

**Treatment**

The management of DKA is quite straightforward. However, if the treatment of DKA is not thorough, it can be detrimental to a patient. There are three main areas that need to be addressed in a patient with DKA. They are fluid management, insulin therapy, and electrolyte management (De Beer et al., 2008; Kitabchi, Umpierrez, Fisher, Murphy, & Stentz, 2008; Kitabchi et al., 2006). Fluid management has been controversial. Van Zyl, Rheeder, and Delport (2012) conducted a study to determine whether Lactated Ringer’s (LR) intravenous (IV) solution was superior to normal saline (NS) for fluid management. The study results failed to show that LR was superior to NS. However, van der Heijden and Berend (2012) found flaws in the study design because electrolytes should have been measured as a study outcome. Normal saline is the
standard IV fluid used for the initial resuscitation of a patient with DKA unless the patient is hypernatremic in that case 0.45% saline may be chosen (De Beer et al., 2008; Kitabchi et al., 2008; Kitabchi et al., 2006; Van Ness-Otunnu & Hack, 2013). In a flowchart created by De Beer et al., colloid fluid may also be used instead of NS if a patient is hypotensive. Colloid fluids may include packed red blood cells, fresh frozen plasma, hetastarch, and albumin to name a few.

Insulin therapy must also be addressed when managing a DKA patient. Kitabchi et al. (2008) reflected back on 30 years of experience with DKA and HHS. They reviewed seven prospective randomized controlled trials conducted from 1976 to 1986 addressing insulin administration. The seven protocols used in the studies were (a) high-dose versus low-dose insulin in adult DKA; (b) route of insulin administration comparing intravenous dosing to intramuscular or subcutaneous injection; (c) loading versus no-loading dose of insulin; (d) high-dose versus low-dose insulin in pediatric patients with DKA; (e) metabolism of low-dose insulin in DKA; (f) the use of phosphate therapy in DKA; (g) the use of bicarbonate therapy in DKA.

These seven studies resulted in the development of research driven protocols for the use of insulin in the management of DKA and HHS. The insulin management protocol has indications for subcutaneous dosing for an uncomplicated DKA patient and IV route dosing for complicated DKA and HHS.

Electrolyte management is another essential part of managing patients with DKA. Potassium levels should be used to determine when insulin therapy is initiated. If hypokalemia is suspected in a patient with DKA, insulin administration should be held until a potassium lab value has been obtained and the results interpreted (Van Ness-Otunnu & Hack, 2013). Potassium levels need to be check frequently due to the cellular shifts. James Orme (personal communication, November 7, 2013) has suggested a basic metabolic panel and phosphorous
monitoring every four hours should be sufficient for the protocol revision for STICU. Van Ness-Otunnu and Hack suggest the goal potassium level of 4 to 5 milliequivalents per liter.

Bicarbonate administration also is used in the treatment of patients with DKA. Generally, this is reserved for patients with a pH less than 6.9 or 7.0 (Kitabchi et al., 2006; Van Ness-Otunnu & Hack, 2013). Kitabchi et al. (2008) suggests that studies supporting the use of bicarbonate administration for pH levels between 6.9 and 7.0 are limited and further research is needed with a large number of subjects. The authors also state that randomized studies have not established the efficacy of the use of bicarbonate in patients with pH values less than 6.9. Ultimately, bicarbonate administration appears to be a grey area in DKA management research.

Use of Flowcharts and Algorithms

The World Health Organization (2008) discussed quality improvement in one of their published manuals. In this manual, the benefits of flowcharts are that they can make a process easier to visualize, thus making it easier to both understand and improve. Furthermore, flowcharts can be used for simple or complex processes and can provide a way to diagram a sequential order of events. The management of DKA is an excellent way to utilize a flowchart due to defined areas needing addressed for treatment and the step-wise approach a clinician can take to treating DKA.

Flowcharts have been created for the treatment of different diagnoses. Dargan, Wallace, and Jones (2002) created a flowchart based of evidence based practice to manage salicylate poisoning. The flowchart provides a step-by-step approach to the manage of the disorder. Kitabchi et al. (2008) provided a flowchart addressing IV fluids, insulin, and potassium administration. Flowcharts are very commonly used in establishing treatment guidelines that will be disseminated to large audiences for clinical use and most clinicians are familiar with how to
use them. The American Diabetes Association (2004) published three flowcharts addressing the
treatment of hyperglycemic crises. The treatment of hypertension may also be guided by a
flowchart (NHS, 2006). Flowcharts are commonly used in medicine guiding treatment of
multiple disease processes.

Summary

In summary, this literature review addressed background information describing the
evolution of diabetes incidence in recent years and the resulting costs accumulating from
episodes of DKA. Clinicians’ understanding of the risk factors associated with DKA is essential
to identify any concomitant disorders and potential interventions to decrease the likelihood of a
patient with diabetes developing DKA in the future. Regarding the diagnosis and treatment of
DKA patients, physical exam findings and laboratory data have been discussed and studies
addressing treatment specifically fluid management, electrolyte replacement, and insulin
administration have provided a base for the development of a flowchart to accompany the
revised order set.

Conceptual Framework

The model that supports my DNP project is the ACE Star Model of Knowledge
Transformation. There are five stages of knowledge transformation identified by the ACE Star
Model. They are discovery research, evidence summary, translation to guidelines, practice
integration, and process/outcome evaluation. (Stevens, 2004)

The goal of this project is to revise a physician order set used for the treatment of diabetic
ketoacidosis (DKA) and then create a flowchart to provide a more stepwise approach to
progressing through the order set. The ACE Star Model’s stages provide the steps needed to meet
the goals of my scholarly project (Figure A1).
In the ACE Star Model the stages of discovery research and evidence summary are important for my gaining knowledge about the current treatment recommendations for the treatment of DKA and for supporting the use of flowcharts. Once the knowledge is synthesized in the summary phase of the ACE Star Model, it will need to be translated into guidelines that are represented by the translation phase in the model. These guidelines will be the basis of what needs to be included in the revised order set and flowchart.

An essential part of this project is the implementation of the work into practice in the Shock-Trauma ICU. Revisions based on evidence based practice recommendations will support the stage of practice integration. In the ACE Star Model, the final stage is evaluating the use of the order set and flowchart in practice.

The ACE Star Model depiction is circular (Figure A1) with forward progression through the stages. This model further supports my project, due to there being no official endpoint to the model. There is outcome evaluation, which provides a temporary endpoint. However, there is constant discovery of new knowledge. The order set and flowchart will need to undergo revisions in the future when new research becomes available. The ACE Star Model allows for such.

**Implementation and Evaluation**

This project was defended using a PowerPoint presentation to receive the permission from the graduate school of nursing to begin the project. The defense presentation has been included in Appendix G. The first objective of this project was to revise the DKA order set used at Intermountain Medical Center. A copy of the current order set utilized to treat DKA patients was obtained and revisions were submitted to James Orme. The revisions to the order set has been critically evaluated by James Orme and Josh Ferguson who is a Nurse Practitioner working
for Intermountain Healthcare writing computerized order sets. Evaluation of this objective has been tracked by keeping a record of the meetings with Dr. Orme to ensure all aspects of the DKA order set have been reviewed. The revised order set is in the final approval stages. Thus, it is not available in a printable format at this time. Screenshots have been included to show the format of the computerized order set and is similar to what the ordering provider sees (Appendix C).

The second objective was to create a flowchart based from the order set. The intent was for the flowchart to include timing of lab draws and methods for drawing the labs, fluid management, basic insulin therapy management as Shock-Trauma ICU utilizes a computerized insulin drip protocol, and electrolyte replacement. As the project progressed, it was recognized that multiple flowcharts needed to be created. Therefore, flowcharts were created: 1) addressing fluid replacement in early phase of DKA (Figure B4) and maintenance phase of DKA (Figure B5), 2) electrolyte management including potassium and magnesium replacement (Figures B1 and B2), 3) insulin management (Figure B3). The evaluation of this objective has been completed by utilizing the content experts for this project. Their expertise has ensured that the flowcharts are accurate and optimize treatment of the DKA patient population in the STICU and is understandable. Communications with all experts has been logged to ensure suggestions were not missed when developing the final product.

The third objective was to present the revised DKA order set and flowchart to Shock-Trauma ICU’s medical director. Recommended revisions have been made and approval has been given for the order set to be revised. The revised order set and flowcharts will be presented to the remaining Shock-Trauma attending physicians and nursing staff. Feedback will be objectively measured prior to implementation. Evaluation of this objective will be achieved by creating a
brief presentation for the nursing staff working in the STICU. A questionnaire with both Likert scale questions and open-ended questions has been developed that asks about the clinicians’ understanding of both the order set and the flowchart that is embedded within the order set (Appendix E). Questions include whether the information is clear and understandable and whether there are any aspects that are not addressed that need to be considered prior to implementing the changes in Shock-Trauma ICU.

The final objective for this project was to broaden the dissemination of the order set and flowcharts. The project was presented during the poster presentation for the graduate school of nursing. A copy of the poster has been included in Appendix H. Once approval is given, formal education will be delivered to the STICU nurses. Other critical care units within the Intermountain Healthcare will be contacted and formal education for their staff will be given if desired. An abstract for a poster presentation has been submitted to the *Excellence in Trauma and Critical Care Conference* this fall (Appendix F).

**Results**

**Objective Evaluation**

The first objective of this project was the revision of the current DKA order set used within Intermountain Healthcare. A first draft of the recommended revisions has been completed. James Orme has reviewed the suggested revisions and changes have been made to the order set. Changes to the order sets order of major heading were suggested. However, limitations placed on the individual revising order sets did not allow for major format changes. While revising the order set, it was identified that information tabs within the order set would be helpful for ordering clinicians particularly clinicians in smaller community hospitals within Intermountain Healthcare (J. Ferguson, personal communication, January 31, 2014). A document has been
started with pertinent information to add to the order set document (Appendix D) for these smaller hospitals. A barrier to optimizing this objective is the limitation to what can be changed within the template of the order set. Acceptance of the order set by both of my content experts is also important to this objective being met in its entirety. The changes to the order set have to be made by an individual who has the training and access to do so. Thus, a barrier is the limitations on the time of the individual making the changes.

The second objective of this project was developing a flowchart. Multiple flowcharts were created. The flowcharts have been created, thus, meeting this objective. James Orme approved the flowcharts. Jane Jeffrie Seley reviewed the flowcharts and suggested making them more interesting. The barrier to making the flowcharts more interesting is the limitations on printing in only black and white and confusing the progression of the flowchart.

The third objective was the presentation of the revised order set and flowcharts to the medical director of STICU and other clinician stakeholders. The revised order set and flowcharts were presented to the medical director, James Orme. Implementation of the suggested changes depends on approval of pharmacy. Unidentified barriers may exist that will not be known until pharmacy has been presented with the proposed changes. The plan is to make changes as appropriate to ensure a majority of the suggested revisions are approved.

The final objective was submitting an abstract for a poster presentation. The Trauma Team at IMC has agreed to accept poster presentation applications for the conference this September, which they have not done in the past. Due to their willingness to make this change on behalf of this project, an abstract will be submitted for the Excellence in Trauma and Critical Care Conference (Appendix F).
**Possible Unintended Consequences**

An unintended consequence of this project is that an ordering clinician may not recognize outlier characteristics of a patient with DKA that are not addressed in the order set. The order set is meant to be applicable to the majority of patients admitted to a critical care unit with the diagnosis of DKA. Another possible unintended consequence is the DKA order set being used for a patient not correctly diagnosed. The order set does not address the criteria used to diagnose DKA within it. However, the order set has never addressed differential diagnoses. A linked information tab will be created with information on diagnosing DKA.

**Limitations**

A limitation to accomplishing the objectives of this project are the pending acceptance of the recommended order set changes and embedment of the flowcharts within the order set, which are in the final phases. The changes have been made to the order set by the nurse practitioner who creates and edits order sets. The order set has been sent on for approval. The flowcharts can be embedded once approval has been given. Jane Jeffrie Seley recommended changes to the order set, which may not be implemented due to limitations within the corporation.

Dissemination of the information to staff members who are employed in STICU will be done by mini inservices during shifts and during staff meetings after it was identified that there was a need for DKA education. All staff members may not receive face-to-face teaching. Information will be e-mailed to the staff.

**Recommendations**

This project should be expanded in the future. My intention is to expand a portion of this project to the emergency departments in the Urban Central Region of Intermountain Healthcare. This will be done by creating a decision making flowchart addressing whether a patient with
Diabetic ketoacidosis can be treated in the emergency department with subcutaneous insulin and discharged home or needs admittance to an inpatient setting. There is a potential that a rural hospital may choose different management than a tertiary care center due to resource availability. If a patient is determined to require a hospital admission, the emergency physician will then decide whether the patient needs to be treated with an insulin drip or can be managed with subcutaneous insulin injections. If an insulin drip is needed, the patient will need to be admitted to an ICU.

The goal with making a decision to admit to a critical care unit is to expedite the admitting process to within a couple of hours after a patient has presented to the emergency department with DKA. The intention is the initiation of the insulin drip protocol in the emergency department. Currently, insulin administration in the emergency department is done by physician preference with no standardization, which may lead to the complication of blood glucose levels dropping too quickly or slowly. The insulin drip has been shown to be effectively used in the DKA patient population. The expansion of this project is to improve the quality of care during the transition of a patient from the emergency department to inpatient status.

Conclusion

The complication of DKA is a potentially life-threatening emergency (Van Ness-Otunnu & Hack, 2013). With the incidence of diabetes continuing to rise in population (CDC, 2011), it is essential clinicians understand the how to treat DKA. Since DKA is a condition that resolves relatively quickly with treatment, delays in appropriate treatment cost the patient and healthcare system. Clinicians are under pressure to utilize healthcare resources appropriately (APC, 2011). Streamlining the treatment of disease processes when applicable will benefit both patients and healthcare systems. Each individual is a stakeholder in the United States’ healthcare systems.
Identifying quality improvement projects is crucial to continuing to improve patient care. This project aims to improve the quality of care provided to the DKA patient population treated within the Intermountain Healthcare system by making the DKA computerized order entry set more user-friendly.
References


Appendix A

ACE Star Model of Transformation
Figure 1

CONCEPTUAL FRAMEWORK:
ACE STAR MODEL OF KNOWLEDGE TRANSFORMATION

ACE Star Model of Knowledge Transformation © Stevens 2004
ACE Star Model of Knowledge Transformation. Used with permission, adapted from "The ACE Star Model", by K.R. Stevens. The University of Texas Health Science Center at San Antonio. Copyright 2012.
Appendix B

Fluid, Electrolyte, and Insulin Flowcharts
**Figure 1**

**Potassium Replacement - Phase 1**

- **K ≤ 3.3 mmol/L**
  - Replace potassium at 10 mEq/hr IV. Hold insulin therapy.
  - Check potassium level every 2 hours until level > 3.3 mmol/L.

- **K > 3.3 mmol/L**
  - Replace potassium per protocol. Give potassium at 10 mEq/hr IV until potassium > 4 mmol/L.
  - Check potassium level every 4 hours and continue repletion per Phase 1 recommendations until transitioned to Phase 2 recommendations.

- **K ≥ 5 mmol/L**
  - Hold potassium repletion. Infuse IV insulin per protocol.
  - Check potassium levels every 2 hours until < 5 mmol/L.

*If K ≤ 3.3 mmol/L, consider giving infusing potassium at 20 mEq/hr (must have separate written order). Pt. must be on telemetry. Concentrations of potassium with >10 mEq/100 ml require a central line. If needing to infuse potassium through peripheral IV, potassium concentration must be no more than 10 mEq/100 ml.*
**Potassium replacement - Phase 2**

Replace potassium per normal replacement protocol. Only use IV replacement until patient has transitioned to PO intake. See table below:

<table>
<thead>
<tr>
<th>Potassium level Mmol/L</th>
<th>Oral potassium replacement</th>
<th>IV Potassium Replacement</th>
<th>IV Magnesium replacement</th>
<th>Laboratory</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.7 or less (serum creatinine &lt;1.8)</td>
<td>Potassium chloride 60 mEq oral once</td>
<td>Potassium chloride 40 mEq IV over 4 hours and then 20 mEq IV over 2 hours (total of 60 mEq)</td>
<td>Magnesium sulfate 8 Gm IV or 16 hours</td>
<td>Potassium (K) level 3 hours following oral administration and 30 minutes following IV completion</td>
</tr>
<tr>
<td>3.7 or less (serum creatinine 1.8 or greater)</td>
<td>Potassium chloride 40 mEq oral once</td>
<td>Potassium chloride 40 mEq IV over 4 hours</td>
<td>Magnesium sulfate 4 Gm IV over 8 hours</td>
<td>Potassium (K) level 3 hours following oral administration and 30 minutes following IV completion</td>
</tr>
</tbody>
</table>
**Glucose/Insulin Management**

- **K ≤ 3.3 mmol/L**
  - Hold insulin therapy. Refer to Potassium Replacement - Phase 1 flowchart

- **K > 3.3 mmol/L**
  - Start IV insulin per computerized protocol with goal glucose of 90-140 mg/dL
    - When glucose is ≤ 250 mg/dL, start D5W @ 80 mL/hr & continue IV insulin per protocol
      - When patient feels hungry, trial PO intake - trial with water initially
        - If patient tolerates PO intake, contact pharmacy for subcutaneous insulin orders
          - Discontinue IV insulin 2 hours after initial subcutaneous insulin dose administered
Figure 4

**Fluid Management – Step 1**
Discuss with treatment provider

- **Minimal fluid losses expected** (e.g., ↓ renal function)
  - Monitor closely for s/s of intravascular volume depletion:
    - Tachycardia (heart rate > 100 bpm)
    - Low urine output (UOP) (< 0.5 ml/kg/hr)
    - Hypotension (SBP < 90 mmHg)

- **High fluid losses expected**
  - High urine output (early phase) or low/no urine output (late phase)
  - Tachycardia
  - Hypotension

  - NS @ 500 ml/hr for total of 2 liters
  - Reassess after 2 liters given. If pt continues to have s/s of intravascular volume depletion (hypotension, tachycardia, low UOP) &/or glucose is > 250 mg/dL, continue NS @ 500 ml/hr & discuss fluid management with provider

  - Once patient no longer has signs of intravascular volume depletion & glucose is < 250 mg/dL, refer to Fluid Management - Step 2
**Fluid Management - Step 2**

- **Na ≤ 141 mmol/L**
  - Administer 0.9% sodium chloride to replace urine output up to 500 ml/hr *
  - When glucose < 250 mg/dL, start D5W@ 80 ml/hr
  - Continue sodium chloride to replace urine output
  - Continue replacement of urine output with IV fluids until patient ready to trial PO intake
  - Once patient is ready to trial PO intake, give water initially to evaluate toleration of intake
  - When patient tolerating PO intake, discontinue all IV fluids

- **Na > 141 mmol/L**
  - Administer 0.45% sodium chloride to replace urine output up to 500 ml/hr *

*Notify treatment provider if urine output is > 500 ml/hr for 2 consecutive hours*
Appendix C

DKA Revised Computerized Order Set Screenshots
DKA Revised Computerized Order Set Screenshots

**General Information**

- **Primary diagnosis:** Diabetic ketoadidasis
- **Secondary diagnosis:**
- **Attending:**
- **Contact number:** (888) 400-0063
- **Contact number:** (615) 237-3054
- **Contact number:**
- **Contact number:**

**Orders**

**Step 1 - Initial DKA Fluid Replacement Orders**

- 0.9% NaCl 2 mL IV every 12 hours, before and after medication administration, and following blood administration for PERIPHERAL VENOUS CATHETER

- 0.9% NaCl 2 mL IV once over 66 minutes

**Step 2 - Subsequent DKA Fluid Replacement Orders**

- If glucose greater than 250 mg/dL, after initial fluid replacement given, notify treating provider for additional IV fluid orders
- If glucose less than 250 mg/dL, after initial fluid replacement given, and patient NOT easily to eat, change IV drip to:
  - 0.9% NaCl (IV infusion sodium 140 mEq/L, or less) or 0.45% NaCl (IV infusion sodium 141 mEq/L), or greater 5 - 500 mL/hr IV drip; titrate to match urine output
Appendix D

Information Tabs
Diabetic Ketoacidosis
Background, pathogenesis, precipitating factors

BACKGROUND

Diabetic ketoacidosis (DKA) is a life-threatening emergency. DKA requires swift repeated clinical and laboratory assessment; monitoring; correction of hypovolemia, acidemia, hyperglycemia, ketonemia, and electrolytes, and treatment of precipitating causes. Identifying and treating the precipitating cause is essential and a central aspect for caring for the DKA patient. (Van Ness-Otunnu & Hack, 2013)

PATHOGENESIS

DKA most commonly occurs in individuals with type 1 diabetes but may also occur in individuals with type 2 diabetes. The pathogenesis of DKA is from the lack of insulin (exogenous or endogenous) due to either the lack of production or relative deficiency of the insulin not being sufficient to meet the individual’s needs which results in the increased production of catabolic hormones (glucagon, cortisol, catecholamines, growth hormone). The deficiency in insulin results in hyperglycemia due to the decrease use of peripheral insulin and increased hepatic product of glucose and ketosis due to production of ketoacids as an alternative energy source. Pathogenic features of DKA are diagrammed below:

PRECIPITATING CAUSES

<table>
<thead>
<tr>
<th>INFECTIOUS:</th>
<th>PSYCHOLOGICAL/SOCIAL:</th>
</tr>
</thead>
<tbody>
<tr>
<td>SEPSIS</td>
<td>INADEQUATE EXOGENOUS INSULIN</td>
</tr>
<tr>
<td>PNEUMONIA</td>
<td>ANOREXIA</td>
</tr>
<tr>
<td>URINARY TRACT INFECTION</td>
<td>STARVATION KETOSIS</td>
</tr>
<tr>
<td>MENINGITIS</td>
<td></td>
</tr>
</tbody>
</table>
**Sepsis**

**Microbiology Consideration**

**BACKGROUND**

One important aspect when treating DKA is identifying the underlying cause. The two most common causes of DKA are infection and insufficient or inadequate insulin management (Barski et al., 2012; Kitabchi et al., 2006). Identifying the infectious cause, if present, is essential and will allow for tailored treatment with antibiotic therapy.

**CRITERIA FOR CONSIDERATION OF SEPSIS- OBTAINING CULTURES**

Systemic manifestations of infection: if high probability of pt having severe sepsis, consider additional treatment and management per Surviving Sepsis Campaign Guidelines. (Dellinger et al., 2013)

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>CRITERIA</th>
</tr>
</thead>
<tbody>
<tr>
<td>General</td>
<td>- Fever &gt;38.3°C or hypothermia with core temp &lt;36°C</td>
</tr>
<tr>
<td></td>
<td>- Heart rate &gt;90/min or &gt;2 SD above the normal value for age</td>
</tr>
<tr>
<td></td>
<td>- Tachypnea</td>
</tr>
<tr>
<td></td>
<td>- Altered mental status</td>
</tr>
<tr>
<td>Hemodynamic</td>
<td>- SBP &lt;90mmHg, MAP &lt;70mmHg or SBr&gt;40mmHg in adults or less than 2 SD below normal for age</td>
</tr>
<tr>
<td>Organ dysfunction</td>
<td>- Arterial hypoxemia (PaO2/FiO2 &lt;300)</td>
</tr>
<tr>
<td></td>
<td>- Acute oliguria (urine output &lt;0.5ml/kg for at least 2 hours despite fluid resuscitation)</td>
</tr>
</tbody>
</table>

**REFERENCE**

- Creatinine increase by >0.5 mg/dL or 44.2 mmol/L
- Coagulation abnormalities (INR > 1.5 or aPTT > 60s)
- Thrombocytopenia (platelet count < 100,000 µL⁻¹)
- Hyperbilirubinemia (plasma total bilirubin > 4 mg/dL or 70 µmol/L)

**Inflammatory**
- Leukocytosis with WBC > 12,000 µL⁻¹
- Leukopenia with WBC < 4000 µL⁻¹
- Normal WBC with > 10% immature forms
- Plasma C-reactive protein more than 2 SD above normal value
- Plasma procalcitonin more than 2 SD above the normal value

**REFERENCES**


Appendix E

Questionnaire
DKA ORDER SET

Questionnaire

Making a Diabetic Ketoacidosis Computerized Order Set User-Friendly
Heidi Checketts
DNP Scholarly Project

DKA Order Set & Flowchart Questionnaire

<table>
<thead>
<tr>
<th>Questions</th>
<th>Strongly Disagrees</th>
<th>Disagrees</th>
<th>Neutral</th>
<th>Agrees</th>
<th>Strongly Agrees</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 The order set is clear?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>2 The order set is understandable?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 The order set is improved?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 Fluid management information is clear?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 Electrolyte management information is clear?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 Insulin management information is clear?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7 The order set is organized well?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8 The flowcharts clarify the goals of treatment?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9 The flowcharts are a good addition to the order set?</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

The goal for this project is to make DKA treatment clear and understandable. I would like your feedback about the order set and flowchart.

Please feel free to write any additional comments / recommendations below. Please be specific.

Feedback by e-mail or phone is also welcomed.
E-mail: heidi.checketts@imail.org
Cell phone: 801-589-8583

*Note: all feedback may not be able to be accommodated due to program limitations, but I would like to know for future reference.
Appendix F

Poster Abstract
Poster Abstract

Excellence in Trauma and Critical Care Conference
Abstract Submission

Presentation title: Making a Diabetic Ketoacidosis Computerized Order Set User-Friendly

Objectives: Diabetic ketoacidosis (DKA) is a life-threatening emergency. Medical treatment is essential for its resolution. This was a quality improvement project focusing on revising the current diabetic ketoacidosis (DKA) order set and the creation flowcharts to further clarify treatment processes. The DKA order set used within the Shock-Trauma ICU (STICU) at Intermountain Medical Center was identified as being confusing to both the ordering clinicians and nursing staff initiating treatments. The provider model of STICU is academic and based upon a one month medical resident rotation. This has created a scenario by which residents are unable to become familiar with the multiple computerized order sets utilized to treat the mixed patient population of STICU. As a result, the medical provider is not able to be an effective resource for nursing to provide clarification despite being the ordering clinician.

Design and methodology: A literature review was completed to establish the current evidence used for the treatment of individuals diagnosed with DKA. The current order set was obtained and reviewed with the guidance and assistance of content experts. Content experts included a critical care physician who has decades of DKA treatment experience and diabetes nurse practitioner who has experience with flowchart creation. Other experts consulted in the development of this project included a nurse practitioner who develops order sets at Intermountain Healthcare, computer informaticist, and nurses who implement the orders. Pharmacists and other critical care physicians are also on the final review committee for order set changes.

Results: The order set was revised. Multiple flowcharts were created addressing the goals of treatment for DKA including fluid replacement, electrolyte management, and insulin therapy. The overall intention for use regarding developed flowcharts’ is for embedment within the order set for reference as well as availability to those executing the orders (nursing staff). Limitations related to this project were related to computerized formatting (having to work within the confines of the current order set program) and institution’s specific guidelines for potassium administration.

Conclusion: Evidenced based computerized DKA order set was revised. User-friendly flowcharts were created. Future study is needed to identify possible decreases in medical errors, time to resolution of diagnosis, costs, and length of stay related to DKA regarding implementation of changes. This project is being expanded to develop a flowchart to standardize the treatment of DKA in the emergency department at Intermountain Medical Center.

Author Name & Credentials: Heidi Favero, BSN, RN, DNP-Candidate, CCRN, CFRN
Author Email Address: Heidi.checketts@imail.org
Author Phone Number: 801-589-8583
Appendix G

Defense Power Point
SIGNIFICANCE AND IMPLICATIONS

- 42% increase in number of hospitalizations for DKA from 1985 to 2005 (Elsevier, 2012)
- DKA results in direct & indirect cost of 2.4 billion U.S. dollars annually (Elsevier, 2012)
- ~13,000 dollars per patient per hospitalization for DKA (Huang et al., 2013)
- Delayed or slowed treatment of DKA prolongs patients' ICU stay and overall hospital stay
- Improving quality and cost containment are essential in today’s healthcare environment (Bipartisan Policy Center, 2012)
LITERATURE REVIEW

- Background
  - DKA is most common hyperglycemic emergency in patients with diabetes mellitus (Covington & Schade, 2010)
- Risk Factors
  - Infection, inadequate/insufficient insulin management, MI, pancreatitis, CVA, drugs, surgery, trauma (Covington et al., 2010; Ferguson & Paskalov, 2010)
- Diagnosis
  - Symptoms, labs
- Treatment
  - Fluids, electrolytes, and insulin therapy
- Use of flowcharts/algorithms
  - WHO (2008). Flowcharts make a process easier to visualize, understand, and improve

IMPLEMENTATION & EVALUATION

<table>
<thead>
<tr>
<th>Objectives</th>
<th>Implementation</th>
<th>Evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Revise DKA Order Set</td>
<td>Obtain copy of current order set</td>
<td>Notes will be kept from meetings with Dr. Orme</td>
</tr>
<tr>
<td>Meet with Dr. Orme about changes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Develop flowchart based on revised order set</td>
<td>Create a basic flowchart</td>
<td>Content experts will critically evaluate flowchart</td>
</tr>
<tr>
<td>Work with computer support experts</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Computer support experts will evaluate usability</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

CONTINUED IMPLEMENTATION & EVALUATION

<table>
<thead>
<tr>
<th>Objectives</th>
<th>Implementation</th>
<th>Evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Present revised order set &amp; flowchart approval</td>
<td>Present revised order set to Dr. Orme for approval</td>
<td>Administer questionnaire to patients to receive objective feedback</td>
</tr>
<tr>
<td></td>
<td>If approval given, present revised order set and flowchart to nursing staff in a staff meeting</td>
<td>+ Informal feedback</td>
</tr>
<tr>
<td>Submit for a poster presentation</td>
<td>Identify an appropriate conference to submit for poster presentation</td>
<td>Project Chair will be given copy of submission</td>
</tr>
</tbody>
</table>

SUMMARY

- STICU clinicians find the current DKA order set difficult to follow
- DKA order set will be revised and accompanying flowchart will be created
- A flowchart will facilitate the rapid treatment and resulting resolution of DKA

ACKNOWLEDGEMENTS

- Committee:
  - Project Chair: Nancy Allen, PhD, ANP-BC
  - Program Director: Denise Ward, DNP, ACNP-BC, FNP
  - DNP/MS Program Director: Katie Ward, DNP, WHNP-BC, ANP
- Content Experts:
  - James Orme, MD
  - Medical Director of Shock-Trauma ICU
  - Jane Jeffreys Staley, DNP, MPH, BC-ADM, CDE, CDT-C
  - Diabetes Nurse Practitioner, New York Presbyterian

Lastly, to my husband and son who could not do this without their ongoing patience and perseverance as I pursue my scholarly goals

REFERENCES


Appendix H

College of Nursing Poster
PURPOSE

To improve the care of patients admitted to Intermountain Healthcare hospitals with the diagnosis of diabetic ketoacidosis (DKA)

OBJECTIVES

To revise the computerized DKA order set
Create flowcharts addressing the main goals of DKA treatment
- Fluid management
- Electrolyte replacement
- Insulin administration
To present revised order set to physicians and nurses in the Shock Trauma ICU
To submit an abstract for a poster presentation

BACKGROUND

Incidence of diabetes in the U.S. has more than tripled since 1980.
In Utah, diabetes has increased from 4% in 1994 to 12% in 2010
104 patients with DKA admitted to Shock Trauma ICU at Intermountain Medical Center in 2012
132 patients admitted to all ICUs at Intermountain Medical Center in 2012
DKA results in direct and indirect costs of 2.4 billion U.S. dollars annually
~13,000 dollars per patient per hospitalization for DKA
DKA is the most common hyperglycemic emergency in patients with diabetes mellitus
House staff have reported difficulty with the DKA order set and frequently cancel the orders due to confusion delaying the progression of treatment
Nursing staff have reported confusion with the DKA order set and how the orders progress particularly with fluid and electrolyte management

IMPLEMENTATION/EVALUATION

IMPLEMENTATION

A copy of the current order set was obtained and revisions were made
Flowcharts were created addressing fluid, electrolyte and insulin management
A presentation has been given to the STCU physicians and nursing staff
An abstract was submitted to the Excellence in Trauma and Critical Care Conference

EVALUATION

Content experts: James Orme, MD, and Jane Jeffrey Salyer, DNP provided critical evaluation of the order set and flowcharts; revisions were made
Physicians and nurses provided feedback on a Likert-styled questionnaire with open-ended questions; revisions were made
Abstract for poster presentation submitted for the Trauma Conference to be held in September

CONCLUSIONS/IMPLICATIONS

CONCLUSIONS

Evidence-based DKA computerized order entry set
Flowcharts that are user-friendly in the DKA order set and useful for education purposes
Future study needed to determine if order entry set:
- Decreases the likelihood of medical errors by clarifying the management of DKA
- Decreases the length of stay resulting in decreased cost to the patient and hospital system

IMPLICATIONS

Other departments (i.e., Emergency Department) are considering adapting the DKA order set for their environment
This project could serve as a template to other order sets or processes confusing to providers