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Original Research

# Evaluation of a Diabetic Ketoacidosis Order Set in Adults With Type 1 and Type 2 Diabetes at a Tertiary Academic Medical Centre: A Retrospective Chart Audit

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## Key Messages

- Our diabetic ketoacidosis (DKA) order is effective and safe for managing DKA in patients with type 1 and type 2 diabetes.
- The order set was equivalent, in DKA management outcomes, to individual physician management in an academic care setting.
- The median length of stay was shorter in the order set group (3.53 days) vs. the historical cohort (4.6 days) (p=0.102) and may reduce health-care expenditures.
- The order set has the potential to ensure standardization of care across a health-care organization and may be of value in settings where less expertise in DKA management is present.

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ABSTRACT

*Objective:* To assess safety and efficacy compared to a historical cohort. Clinical practice guidelines recommend that patients with diabetic ketoacidosis (DKA) be treated with a standardized protocol. We created a multifaceted order set to promote best-practice management of DKA.
*Methods:* We performed a retrospective cohort study of admissions to internal medicine for DKA in adults during a 4.5-year period; 2.25 years before and after order-set initiation. Groups were compared using independent samples t tests and Pearson chi-square or Fisher exact test (categorical data). The Mann-Whitney U test was used for continuous data not normally distributed.
*Results:* The order-set cohort consisted of 47 admissions, 72.3% with type 1 and 27.7% with type 2 diabetes. The historical cohort consisted of 59 admissions, 69.5% with type 1 and 30.5% with type 2 diabetes. There were no significant differences in initial laboratory values between patients with type 1 and type 2 diabetes in both cohorts. The median length of hospital stay approached significance in the order-set cohort: 3.53 days (2.5 to 5.1); in the historical cohort, the median length of stay was 4.6 days (2.44 to 8.99) (p=0.102).
*Conclusion:* A standardized DKA order set was as effective and safe in type 1 and type 2 diabetes as individual physician management in an academic care setting. Further study is needed to assess its value in community hospital settings with less expertise and fewer diabetes specialty services.


*Mots clés :*
acidocétose diabétique
à l'hôpital

RÉSUMÉ

*Objectif :* Évaluer la sécurité et l'efficacité par rapport à une cohorte historique. Les lignes directrices de pratique clinique recommandent que les patients souffrant d'acidocétose diabétique (ACD) soient traités

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prise en charge
ensemble d'ordonnances
protocole

selon un protocole normalisé. Nous avons créé un ensemble d'ordonnances à plusieurs facettes pour promouvoir de meilleures pratiques de prise en charge de l'ACD.
*Méthodes :* Nous avons réalisé une étude de cohorte rétrospective auprès d'adultes admis en médecine interne en raison d'une ACD durant 4,5 ans; 2,25 ans avant et après l'introduction de l'ensemble d'ordonnances. Nous avons utilisé les tests t pour échantillons indépendants et le test du chi carré de Pearson ou le test exact de Fisher (données catégorielles) pour comparer les groupes. Nous avons utilisé le test U de Mann-Whitney pour les données continues non distribuées normalement.
*Résultats :* La cohorte soumise à l'ensemble d'ordonnances comptait 47 patients admis, dont 72,3 % avaient le diabète de type 1 et 27,7 % avaient le diabète de type 2. La cohorte historique comptait 59 admissions, dont 69,5 % avaient le diabète de type 1 et 30,5 % avaient le diabète de type 2. Il n'y avait aucune différence significative dans les valeurs initiales de laboratoire entre les patients atteints du diabète de type 1 et les patients atteints du diabète de type 2 des 2 cohortes. La durée médiane du séjour à l'hôpital atteignait une significativité dans la cohorte soumise à l'ensemble d'ordonnances: 3,53 jours (de 2,5 à 5,1). Dans la cohorte historique, la durée médiane du séjour était de 4,6 jours (de 2,44 à 8,99) ($p = 0,102$).
*Conclusion :* Un ensemble d'ordonnances normalisé pour l'ACD était aussi efficace et sécuritaire chez les patients atteints du diabète de type 1 ou les patients atteints du diabète de type 2 que la prise en charge individuelle des patients par les médecins dans un contexte universitaire de soins. D'autres études sont nécessaires pour évaluer sa valeur dans le contexte d'hôpitaux communautaires ayant moins d'expertise et moins de services spécialisés en diabète.



## Introduction

Diabetic ketoacidosis (DKA) is 1 of the most serious acute complications of diabetes mellitus, and it can occur in both type 1 and type 2 diabetes (1). It is characterized by hyperglycemia, elevated anion gap (AG) metabolic acidosis and increased serum ketones (2). If untreated, it can lead to obtundation and death (3). DKA is a common cause for hospital admission. According to recent data from the US Centers for Disease Control, there were 140,000 US hospital discharges that included DKA as the first-listed diagnoses in 2009, representing a 75% increase from 80,000 in 1988 (4). In patients with type 2 diabetes, the incidence of DKA is estimated to be in the range of 0.32 to 2.0 per 1,000 patient-years (1), whereas in patients with type 1 diabetes, the incidence is higher, at 4.6 to 8.0 per 1,000 patient-years (5).

Several consensus algorithms have been published; they identify the key components of DKA management, including those of the American Diabetes Association (5), the Joint British Diabetes Societies (6) and Diabetes Canada (7). Several studies have shown the benefits of using standardized protocols for DKA management. Thuzar et al compared 71 admissions for DKA treated with a standardized DKA protocol vs. a control group and found that the protocol group (N=35) had significantly shorter lengths of stay, shorter times to normalized serum bicarbonate and fewer episodes of hypokalemia and hypoglycemia (8). Waller et al examined the introduction of an integrated care pathway outlining the sequences and timings of treatment of DKA and found a reduction in the time to initiate intravenous fluid and intravenous insulin (9). However, 1 previous study in a large UK teaching hospital identified that the presence of clinical guidelines alone for DKA management was insufficient to ensure optimal care (10) because the DKA guidelines were followed less than 25% of the time.

Order sets are conveniently grouped medical orders that work to standardize diagnosis and treatment following pre-established clinical guidelines. Order sets decrease variation in care and enhance compliance with treatment guidelines. Several studies have demonstrated the positive value of standardized order sets for medical admissions (11,12) and inpatient diabetes management (13–17). Only 2 previous studies have evaluated the impact of order sets on DKA treatment (18,19). Bull et al demonstrated that implementation of a DKA order set decreased time in intensive care units (ICUs) and hospital lengths of stay, time to AG normalization and rates of hypoglycemia compared to those before implementation (18). Beik et al evaluated an order set for both DKA and hyperosmolar hyperglycemic states and showed reduction in ICU stays and times to AG closure, with no difference in the rates of hypoglycemia (19).

We created an original and comprehensive order set for the management of DKA for use in our Canadian tertiary care academic hospital. It was based on Diabetes Canada's 2013 Clinical Practice Guidelines for the Prevention and Management of Diabetes in Canada (20). Our order set differs from others in that it includes highly detailed instructions for oral intake; vitals and monitoring; initial and ongoing laboratory investigations; point-of-care testing; intravenous fluid replacement based on degree of dehydration, hypernatremia and the need for fluid restriction; potassium management; insulin infusion; dextrose administration; as well as transition to antihyperglycemic agents once DKA has resolved. The purpose of this retrospective observational cohort study was to assess the safety and efficacy (time to AG closure, length of hospital stay) of this multifaceted order set for patients with DKA compared to a historical cohort not treated with the order set to identify noninferiority.

## Methods

We used a convenience sample to perform a retrospective audit of admissions to internal medicine for DKA in adult patients (≥18 years of age) over a 4.5-year period from September 2011 to March 2016. The timeline included 2.25 years before and 2.25 years after the initiation of the DKA order set. Ethics approval was received from the Queen's University and Affiliated Teaching Hospitals' Research Ethics Board. Cases were identified on the basis of discharge diagnoses, and admissions for hyperosmolar hyperglycemic states were excluded. All patients were treated in a step-down ICU setting. Patients were excluded if they left the hospital against medical advice during DKA treatment, if they were were pregnant, if they were transferred to the ICU during their hospitalization or if the DKA protocol was altered. The distinction between type 1 and type 2 diabetes was based on a comprehensive chart review and was determined by patients' characteristics, previous diagnoses, antihyperglycemic therapy preadmission and, when available, glutamic acid decarboxylase antibody and C-peptide testing. Descriptive statistics were used to describe patients' characteristics. Data were analyzed using IBM SPSS (v. 24.0 for Windows; Armonk, New York, United States). Descriptive statistics

were used to describe patients' characteristics. Groups were compared using independent samples t tests (continuous data) and Pearson chi-square or Fisher exact test (categorical data). The Mann-Whitney U test was employed for continuous data that were not normally distributed. No adjustments were made for multiple comparisons, and a p value of $<0.05$ was used as the definition of statistical significance.

## Results

During the time period studied, there were 106 admissions that met the inclusion criteria: 59 in the historical cohort (HC) and 47 in the order set cohort (OSC). Of the admissions using the DKA order set, 72.3% were patients with type 1 diabetes, and 27.7% were patients with type 2 diabetes (Table 1). In the historical cohort, 69.5% were patients with type 1 diabetes and 30.5% had type 2 diabetes (Table 1). Females had more DKA admissions in both cohorts: 74.5% in the OSC and 59.3% in the HC (p=0.102). The mean age for admitted people who used the DKA order set was 40.7 years (SD ± 17.4) (type 1 diabetes: 33.2 years [SD ± 12.7]; type 2 diabetes: 60.2 years [SD ± 12.2]). The mean age for the historical cohort was 45.4 years (SD ± 16.3) (type 1 diabetes: 41 years [SD ± 14.6]; type 2 diabetes: 55.4 years [SD ± 15.9]). Most patients in both cohorts were treated with multiple daily injections (OSC 87.2%; HC 84.7%; p=0.160). The most common DKA precipitants for patients with type 1 diabetes were insulin omission (OSC 35.3%; HC 48.8%); unknown (OSC 32.4%; HC 22.0%); infection (OSC 17.6%; HC 17.1%); and first presentation of diabetes (OSC 11.8%; HC 2.4%). The most common precipitants for patients with type 2 diabetes were non-insulin antihyperglycemic medication or insulin omission (OSC 46.2%; HC 44.4%); unknown (OSC 38.5%; HC 27.8%); and infection (OSC 7.7%; HC 16.7%). The order set was used in 84% of DKA admissions after its introduction in 2013. Three patients were excluded from the OSC because the DKA protocol was not followed precisely.

There were no significant differences in laboratory parameters at presentation between admitted patients treated with the DKA order set vs. the historical cohort (Table 2). The mean plasma glucose on presentation was 33.4 mmol/L (SD ± 14.9) for OSC and 31.2 mmol/L (SD ± 12.0) for HC (p=0.441). The mean AG on presentation was 24 mmol/L (SD ± 7.1) for OSC and 24 mmol/L (SD ± 7.5) for HC (p=0.780). The mean initial serum bicarbonate was 14.0 mmol/L (SD ± 6.3) for OSC and 13.0 mmol/L (SD ± 6.0) for HC (p=0.402). The mean initial serum beta-OH butyrate was 7.3 mmol/L (SD ± 4.3) for OSC and 7.4 mmol/L (SD ± 4.2) for HC (p=0.950). The mean initial serum potassium was 5.1 mmol/L (SD±1.6) for OSC and 4.9 mmol/L (SD ± 1.2) for HC (p=0.429).

The mean time from initial AG measurement to first internal medicine orders was 5.0 h (SD ± 5.0) for OSC and 5.4 h (SD ± 5.9) for HC (p=0.73). However, before the initiation of the order set or the initiation of treatment by the internal medicine service, most patients had received some form of intravenous fluids and intravenous insulin, ordered by the emergency department physicians, although these orders were highly variable and not prescribed according to any standardized protocol.

The mean time for AG closure from the time orders written by the internal medicine department was 4.0 h (SD ± 3.9) for the OSC and 5.2 h (SD ± 3.5) for the HC (p = 0.09) (Table 3). Data were not collected on re-emergence of ketoacidosis after transition to subcutaneous insulin. The mean number of episodes of hypokalemia ($<3.3$ mmol/L) while the AG was $>12$ mmol/L was similar for both cohorts: 0.17 (SD ± 0.529) for the OSC (total number of patients affected=5) and 0.41 (SD ± 1.39) for the HC (total number of patients affected=8) (p=0.285). Only 1 episode of hypoglycemia (capillary blood glucose $<4.0$ mmol/L) while the AG was $>12$ mmol/L occurred in the HC and none occurred in the OSC. The hypoglycemic episode did not require third-party assistance and was not associated with seizure or loss of consciousness. The median length of stay was 3.53 days (2.5 to 5.1) for the OSC and 4.6 days (2.44 to 8.99) for the HC (p=0.102).

## Discussion

This retrospective chart audit indicates that our standardized, multifaceted DKA order set is effective and safe in patients with type 1 and type 2 diabetes. In addition, the order set was equivalent in DKA management outcomes compared to individual physician management in academic care settings. There were no significant differences between the cohorts in occurrences of hypoglycemia and hypokalemia.

Occurrences of hypoglycemia and hypokalemia were minimal, and there were no adverse outcomes. All patients who experienced hypokalemia during treatment of DKA presented with low initial serum potassium levels ($<3.3$ mmol/L). Prescribers should be especially wary if there is hypokalemia at presentation because this is a significant risk factor for worsening of hypokalemia during DKA treatment. Guidance concerning bicarbonate administration was not included in our order set. Subsequent to the study's completion, our order set was adjusted to incorporate both bicarbonate administration and additional potassium supplementation (Supplementary Appendix 1).

**Table 1**
Patients' characteristics on admission for the DKA order set and historical cohorts

| | Order set cohort (n=47) | | Historical cohort (n=59) | |
|---|---|---|---|---|
| | Type 1 diabetes (n=34) | Type 2 diabetes (n=13) | Type 1 diabetes (n=41) | Type 2 diabetes (n=18) |
| Mean age (years) (SD) | 33.24 (±12.7) | 60.2 (±12.2) | 41.0 (±14.6) | 55.4 (±15.9) |
| Females (%) | 73.5 | 76.9 | 63.4 | 50.0 |
| Males (%) | 26.5 | 23.1 | 36.6 | 50.0 |
| Antihyperglycemic therapy | | | | |
| MDI (%) | 82.4 | 100 | 85.4 | 83.3 |
| CSII (%) | 17.6 | 0 | 12.2 | 0.0 |
| Other (%) | 0 | 0 | 2.4 | 16.7 |
| Precipitant for DKA | | | | |
| Infection | 6 (17.6%) | 1 (7.7%) | 7 (17.1%) | 3 (16.7%) |
| Omission | 12 (35.3%) | 6 (46.2%) | 20 (48.8%) | 8 (44.4%) |
| CSII failure | 0 (0%) | 0 (0%) | 3 (7.3%) | 0 (0%) |
| First presentation | 4 (11.8%) | 0 (0%) | 1 (2.4%) | 0 (0%) |
| Other* | 1 (2.9%) | 1 (7.7%) | 1 (2.4%) | 2 (11.1%) |
| Unknown | 11 (32.4%) | 5 (38.5%) | 9 (22.0%) | 5 (27.8%) |

*CSII*, continuous subcutaneous insulin infusion; *DKA*, diabetic ketoacidosis; *MDI*, multiple daily injections.
* Other means: cardiovascular cause, such as myocardial infarction or stroke; sodium-glucose cotransporter-2 inhibitor; steroid induced.

**Table 2**
Initial laboratory results on presentation to the emergency department for both cohorts

| | Order set cohort (n=47) | | | | Historical cohort (n=59) | | | | OSC vs HC |
|---|---|---|---|---|---|---|---|---|---|
| | Type 1 diabetes at presentation (n=34) | Type 2 diabetes at presentation (n=13) | All admissions at presentation | p value | Type 1 diabetes at presentation (n=41) | Type 2 diabetes at presentation (n=18) | All admissions at presentation | p value | All admissions at presentation p value |
| Mean initial plasma glucose (mmol/L) | 32.3 (SD ± 15.5) | 36.3 (SD ± 13.2) | 33.4 (SD ± 14.9) | 0.41 | 31.9 (SD ± 12.6) | 30.1 (SD ± 10.9) | 31.2 (SD ± 12.0) | 0.59 | 0.44 |
| Mean initial AG (mmol/L) | 23.5 (SD ± 6.9) | 24.9 (SD ± 7.73) | 24 (SD ± 7.1) | 0.56 | 24.2 (SD ± 8.0) | 24.4 (SD ± 6.1) | 24 (SD ± 7.5) | 0.91 | 0.78 |
| Mean initial serum bicarbonate (mmol/L) | 13.9 (SD ± 4.3) | 14.3 (SD ± 6.5) | 14.0 (SD ± 6.3) | 0.83 | 13.0 (SD ± 5.7) | 12.8 (SD ± 6.9) | 13.0 (SD ± 6.0) | 0.91 | 0.40 |
| Mean initial beta-OH butyrate | 7.2 (SD ± 4.3) | 7.6 (SD ± 4.5) | 7.3 (SD ± 4.3) | 0.74 | 7.9 (SD ± 4.2) | 6.3 (SD ± 4.3) | 7.4 (SD ± 4.2) | 0.20 | 0.95 |
| Mean initial serum potassium (mmol/L) | 5.1 (SD ± 1.5) | 4.9 (SD ± 1.7) | 5.1 (SD ± 1.6) | 0.71 | 5.0 (SD ± 0.9) | 4.6 (SD ± 1.7) | 4.9 (SD ± 1.2) | 0.42 | 0.43 |

*AG*, anion gap; *HC*, historical cohort; *OH*, hydroxy; *OSC*, order set cohort.

The time reported to normalize the AG appears short compared to other studies, which have reported values closer to 10 to 13 h (19,21). It is important to recognize that our analysis is based on the time our order set was initiated in the OSC or the time insulin orders were written by the internal medicine department in the HC, and it did not account for the previous time period. Before initiating the order set, most patients had received intravenous fluids and insulin ordered by emergency department physicians, but they were variable and not ordered according to any standardized hospital protocol.

Our order set is more detailed and directive than those previously published (18,19). It has been designed to increase patient safety and provide nursing with specific orders that do not require interpretation. Previously published order sets have indicated fluid ranges that require nursing interpretation (18). In our order set, fluid replacement is selected by the prescriber based on the degree of dehydration, hypernatremia and need for fluid restriction. Potassium replacement has been calculated to ensure that the potassium concentration in the intravenous fluids does not exceed 20 mmol/L (22) and the infusion rate does not exceed 20 mmol/h in a peripheral intravenous or 40 mmol/h in a central line (23). Orders for oral potassium supplementation (oral or nasogastric) in addition to the intravenous route are provided for patients with severe hypokalemia. When initially implemented at our institution, the order set was available only as a paper version but has since been made available via electronic entry. This permits increased visibility and enhances access to promote use and to evaluate outcomes of evidence-based management of DKA.

We acknowledge that it is challenging to write order sets that permit management of DKA from initial presentation to resolution. Individual patients' characteristics need to be considered by the clinicians, as does the response to therapy. We embedded several prompts in our order set for nursing staff to notify prescribers for reassessment of therapy. In addition, the order set requires close monitoring by nursing staff and is recommended for use only in the emergency department or intensive care/step-down unit settings. It is possible that no significant differences in outcomes were observed between the OSC and the HC due to the high-quality 24-hour in-hospital care provided by the house staff in our tertiary academic center, and it would be interesting to evaluate the order set in other health-care settings such as nonteaching hospitals. Although it did not reach statistical significance, there was a trend indicating that the median length of stay was shorter in the OSC group (3.53 days) vs. the HC (4.6 days) (p=0.102), and the potential exists to represent a savings in health-care expenditures.

We acknowledge several limitations to our study. It was a single-centre, descriptive, retrospective study and does not have the strength of a randomized controlled trial. Patients who were admitted directly to or were transferred to the ICU were not included in this study. In the OSC, 3 patients (6%) were excluded from the analysis because the protocol was not followed. Unfortunately, indications for discontinuing the order set were not documented. It is possible that the characteristics of these patients and their responses to the order set might have been different. In addition, emergency department treatment varied greatly before the initiation of the order set and orders being written by the internal medicine service, and we were unable to account for this variability in practice in our analysis. Recognizing the established benefits of using standardized protocols and the safety and effectiveness of this specific order set, we feel it would be beneficial for the order set to be initiated by emergency department physicians as their initial treatment rather than waiting for it to be initiated by the admitting internal medicine service, and education is being developed for this prescriber group. Furthermore, our study did not evaluate the glycemic control of patients when the DKA protocol was completed or the re-emergence of ketoacidosis after the

**Table 3**
Response to DKA treatment for the DKA order set and historical cohorts

| | Order set cohort (n=47) | Historical cohort (n=59) | p value |
|---|---|---|---|
| | All DKA admissions | All DKA admissions | |
| Mean time for AG normalization (h) | 4.0 (SD ± 3.9) | 5.2 (SD ± 3.5) | 0.090 |
| Time for internal medicine orders from obtainment of initial AG measurement) (h) | 5.0 (SD ± 4.3) | 5.4 (SD ± 5.9) | 0.726 |
| Mean number of episodes of hypokalemia (<3.3 mmol/L) while AG >12 mmol/L | 0.17 (SD ± 0.529) | 0.41 (SD ± 1.39) | 0.283 |
| Mean number of episodes of BG <4 mmol/L while AG >12 mmol/L | 0 | 0.02 (SD ± 0.130) | 0.375 |
| Median length of stay (days) | 3.53 (2.5–5.1) | 4.6 (2.44–8.99) | 0.102 |

*AG*, anion gap; *BG*, blood glucose; *DKA*, diabetic ketoacidosis.

transition to subcutaneous insulin. This is a limitation of our study and an opportunity for further research. Additionally, quality-improvement studies addressing the satisfaction of nurses, residents and physicians with the order set would be of value.

## Conclusions

A standardized DKA order set was effective and safe in patients with type 1 and type 2 diabetes and was equivalent in DKA management outcomes compared to individual physician management in an academic care setting. Education is needed to ensure timely initiation of the order set by all prescribers (emergency department physicians and the admitting internal medicine service). Further study assessing the efficacy and safety of our DKA order sets in a nontertiary care settings would be of value.

## Supplementary Material

To access the supplementary material accompanying this article, visit the online version of the *Canadian Journal of Diabetes* at www.canadianjournalofdiabetes.com.

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Kingston Health Sciences Centre order sets were made in partnership with PatientOrderSets.com.

## Author Disclosures

Conflicts of interest: none.

## Author Contributions

AC, EK, HY, SM, RH contributed to conception and research design, acquisition of data, analysis and interpretation of data, wrote the manuscript, and gave final approval of the version to be published. WH contributed to analysis and interpretation of data.

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**Supplementary Appendix 1.**

**Kingston Health Sciences Centre Diabetic Ketoacidosis (DKA) Order Set (Adult)**

**Consults**
Diabetes Consult Service
☐ Dietitian
☐ Endocrinology

**Diet**
☐ Clear fluids to Diabetic Diet
☐ NPO
☐ Other: _____

**Vitals and Monitoring**
*** Replaces admission order set orders***

**Vitals**
☐ Temperature, HR, RR, BP, $SpO_2$ q4 h and prn
OR
☐ Temperature, HR, RR, BP, $SpO_2$ q _____ h and prn

**Monitoring**
☐ Intake and Output q8 h
OR
☐ Intake and Output q _____ h for _____ h
☐ Insert urinary catheter to support measurement of output

**Lab Investigations**

**STAT**
☒ Serum ketones, serum lactate, glucose, electrolytes
☐ CBC with differential, creatinine, magnesium, phosphate ***(unnecessary to order if completed in the last 24 hours)***
☐ A1C ***(unnecessary to order if completed within last two months and results available on PCS)***
☐ Arterial blood gas for pH ***(recommended if serum bicarbonate less than 12)***
OR
☐ Venous blood gas

**Optional**
☐ Blood culture
☐ Urine culture
☐ Serum hCG (pregnancy test) in women of reproductive age
☐ CK and troponin
☐ Other: _____

**Ongoing**
☒ Electrolytes, bicarbonate, Anion Gap, creatinine q2h until anion gap is less than or equal to 12 and potassium is in normal range (3.5 to 5.2 mmol/L) for two sequential results, then once daily for 2 days

**Point of Care Testing**
☒ Capillary blood glucose q1h until blood glucose less than 14 mmol/L, then q2h for 24 hours, then reassess

**Diagnostic Imaging Investigations**
☐ ECG
☐ CXR

**IV Fluids**
☒ Insert two large bore intravenous catheters
  ☒ IV # 1 administer IV solution as per table #1
  ☒ IV # 2 infuse 10% dextrose (D10W) as main line and insulin infusion as a concurrent infusion per table #2 on page 4
☐ Fluid restricted patients: Individualized order ***(potassium chloride administration not to exceed 20 mmol/h in peripheral IV*** **OR** *40 mmol/h in central line with continuous cardiac monitoring*

**IV Table #1**

☒ If anuric (no urine output with Foley): Hold potassium chloride administration and notify physician or nurse practitioner

| IV Solution | Potassium chloride (KCL) Administration (mmol/L) | | |
|---|---|---|---|
| | Potassium greater than 5 mmol/L | Potassium 3.3 to 5 mmol/L | Potassium less than 3.3 mmol/L |
| ☐ **Severe dehydration/hypotension**<br>0.9% sodium chloride (0.9% NaCl)<br>2,000 mL/h for 2 hours **THEN**<br>500 mL/h for 4 hours **THEN**<br>250 mL/h for 4 hours **THEN**<br>125 mL/h | None | KCl 20 mmoL/L in first liter of IV fluid, **THEN**<br>No KCl in second liter of IV fluid, **THEN**<br>KCl 20 mmol/L of IV fluid | KCl 20 mmol/L in first four liters of IV fluid **THEN**<br>KCl 40 mmol/L of IV fluid |
| ☐ **Mild to moderate dehydration**<br>0.9% sodium chloride (0.9% NaCl)<br>1,000 mL/h for 2 hours **THEN**<br>500 mL/h for 4 hours **THEN**<br>250 mL/h for 4 hours **THEN**<br>125 mL/h | None | KCl 20 mmol/L of IV fluid | KCl 20 mmol/L in first two liters of IV fluid **AND** Give two Potassium Citrate effervescent Tablets (K-Lyte®) 25 mEq potassium/tablet PO or NG. **THEN** KCl 40 mmol/L of IV fluid |
| ☐ **With mild to moderate dehydration and hypernatremia**<br>0.45% sodium chloride (0.45% NaCl)<br>1,000 mL/h for 2 hours **THEN**<br>500 mL/h for 4 hours **THEN**<br>250 mL/h for 4 hours **THEN**<br>125 mL/h | None | Add 20 mmol/L KCl | KCl 20 mmol/L in first two liters of IV fluid **AND** Give two Potassium Citrate effervescent tablets (K-Lyte®) 25 mEq potassium/tablet PO or NG **THEN**<br>KCl 40 mmol/L of IV fluid |

**IV Table #2 - Insulin Infusion**

***Do not start** insulin infusion unless serum potassium is greater than 3.3 mmol/L. **Hold** intravenous insulin infusion if serum potassium decreases to less than or equal to 3.3 mmol/L***

**When initial serum potassium is greater than 3.3 mmol/L:**

☒ Mix 100 units of insulin Regular in 100 mL 0.9% sodium chloride (0.9% NaCl) (1 unit/mL)
☒ Start insulin infusion at _____ units/h *(0.1 units/kg/h)*
☒ Adjust insulin infusion rate using algorithm below
☒ If blood glucose is greater than 14 mmol/L and is decreasing by less than 2.5 mmol/L OR increasing while on IV insulin, call prescriber for adjustment of insulin infusion.

**If serum potassium decreases to 3.3 mmol/L or less:**

☒ Hold intravenous insulin infusion
☒ Serum electrolytes hourly
☒ Notify prescriber for potassium replacement orders
☒ May restart intravenous insulin infusion at previous rate once serum potassium is greater than 3.3 mmol/L

| Glucose (mmol/L) | Insulin Infusion | D10W Rate (mL/h) |
|---|---|---|
| Less than 4 | Stop insulin infusion: Implement Medical Directive for Hypoglycemia. Measure glucose every 15 minutes until glucose is greater than or equal to 5 mmol/L. Then resume IV insulin infusion at x 0.25 of the previous rate and measure blood glucose in 1 hour. | 250 |
| 4.1 to 5 | Decrease insulin infusion by 50%, measure glucose in one hour | 225 |
| 5.1 to 8 | Continue current rate | 200 |
| 8.1 to 12 | Continue current rate | 175 |
| 12.1 to 14 | Continue current rate | 150 |
| 14.1 to 17 | Continue current rate | 50 |
| 17.1 to 20 | Continue current rate | 25 |
| Greater than 20 | Continue current rate | 10 |

**IV Sodium Bicarbonate**

☒ If arterial pH is less than 6.9, mix 100 mmol (2 ampoules) of sodium bicarbonate in 400 mL of sterile water with 20 mmol potassium chloride and infuse over 2 hours. *(May require central line).*
☒ Repeat sodium bicarbonate infusion every 2 hours until arterial pH is greater than 7.0. (Caution: when the serum bicarbonate increases, the serum potassium may fall, and more aggressive potassium replacement may be required).

**Medications**

**Transition to Subcutaneous Insulin**

☒ If anion gap is less than/equal to 12 mmol/L, notify physician to reassess fluid and Insulin orders (*Physician to consider Subcutaneous Insulin or restarting Subcutaneous Insulin Pump and discontinuing IV Insulin*)

☒ If Subcutaneous Insulin is ordered, discontinue IV insulin 2 hours after first Subcutaneous Insulin dose is given or after patient's own Subcutaneous Insulin Pump is reinitiated

☒Discontinue IV fluids when able to tolerate oral diet

***Prescriber to complete the appropriate Diabetes Management Order Set***

Refer to:

Diabetes Management Order Set (NPO Patient)
Diabetes Management Order Set (Patient Eating Meals)
Diabetes Management Order Set (Tube Feeding/Parenteral Nutrition)
Diabetes Management Order Set (Insulin Pump Therapy)
Diabetes Management Order Set (Intravenous Insulin Therapy)