The Journal of Emergency Medicine, Vol. 56, No. 2, pp. 127–134, 2019

0736-4679/$ - see front matter

https://doi.org/10.1016/j.jemermed.2018.09.048

Original Contributions

PREDICTORS OF SHORT INTENSIVE CARE UNIT STAY FOR PATIENTS WITH DIABETIC KETOACIDOSIS USING A NOVEL EMERGENCY DEPARTMENT–BASED RESUSCITATION AND CRITICAL CARE UNIT

Victoria L. Zhou, BA,* Frances S. Shofer, PHD,† Nikita G. Desai, MD,† Ilona S. Lorincz, MD, MSHP,‡ Nikhil K. Mull, MD,§ David H. Adler, MD, MPH,‖ and John C. Greenwood, MD†

*School of Medicine and Dentistry, University of Rochester, Rochester, New York, †Department of Emergency Medicine, Hospital of University of Pennsylvania, Philadelphia, Pennsylvania, ‡Department of Endocrinology, Diabetes, and Metabolism, Hospital of University of Pennsylvania, Philadelphia, Pennsylvania, §Division of General Internal Medicine, Department of Medicine, Perelman School of Medicine, University of Pennsylvania, Philadelphia, Pennsylvania, and ‖Department of Emergency Medicine, University of Rochester Medical Center, Rochester, New York

Corresponding Address: Victoria L. Zhou, BA, University of Rochester School of Medicine and Dentistry, 4308 Rexford Dr., Bethlehem, PA 18020

☐ **Abstract—Background: The resuscitation and critical care unit is a novel emergency department–intensive care unit designed to provide early critical care to emergency department patients for ≤24 h. Objectives: This study sought to identify clinical variables associated with short intensive care unit (ICU) stays in patients with diabetic ketoacidosis (DKA), who commonly require ICU-level care. Methods: We conducted a retrospective, single-center, cross-sectional study of DKA patients ≥18 years of age who presented to an academic, urban hospital emergency department over 16 months. Patient demographics and clinical variables extracted from medical records were compared between prolonged ICU stay patients of ≥24 h versus short ICU stay patients (SSPs) of <24 h. ICU care was defined as treatment in the resuscitation and critical care unit or inpatient ICU. Results: One hundred sixty-eight emergency department visits with a primary diagnosis of DKA were analyzed. There were 53 prolonged ICU stay patients, 58 SSPs, and 57 patients required no ICU time. SSPs had significantly higher initial serum bicarbonate (13.0 vs. 9.0 mEq/L, $p = 0.01$) and shorter anion gap closure time (9.8 vs. 14.4 hours, $p = 0.003$). Medication nonadherence was a significantly more frequent precipitant in SSPs (67.2% vs. 47.2%, $p = 0.03$). Initial anion gap, glucose, beta-hydroxybutyrate, and severity of illness scores were not significantly different between groups. After multivariate logistic regression adjusting for variables significant from univariate analysis, higher initial bicarbonate ($p = 0.04$) and medication nonadherence ($p = 0.03$) remained significantly associated with SSPs. Conclusions: Patients with DKA with short ICU stays have higher initial bicarbonate levels and are more likely to have medication nonadherence than patients requiring prolonged critical care. These variables may identify patients with DKA who are best treated in an emergency department–intensive care unit to potentially reduce inpatient ICU use.**

☐ **Keywords—diabetic ketoacidosis; intensive care unit; length of stay; medication adherence; resuscitation**

INTRODUCTION

Emergency department–based intensive care units (ED-ICUs) are an emerging care delivery model that provide early, aggressive critical care services in the ED setting

Reprints are not available from the authors.

RECEIVED: 1 June 2018; FINAL SUBMISSION RECEIVED: 16 September 2018;
ACCEPTED: 22 September 2018

(1). The overall goals of ED-ICUs include decreasing delays in ICU care, reducing the inpatient ICU volume, and minimizing hospital length of stay (LOS). The Resuscitation and Critical Care Unit (ResCCU) is an ED-ICU that opened at our institution in February 2017. The ResCCU is a clinical space designed with the goal of treating critically ill patients who require short-term ICU care (defined as <24 h). This study examines if diabetic ketoacidosis (DKA) is a diagnosis optimally treated in the ResCCU setting.

DKA is a serious acute complication of diabetes with a triad of uncontrolled hyperglycemia, ketone production, and metabolic acidosis. It is defined by the American Diabetes Association by initial clinical laboratory values of plasma glucose >250 mg/dL, positive urine or serum ketones, and arterial pH < 7.30 or serum bicarbonate <18 mEq/L, in addition to other diagnostic criteria (2). Our institution, similar to other institutions, has an automatic indication for ICU-level care with use of a continuous insulin drip. DKA may be an ideal diagnosis to treat in the ResCCU because the need for ICU-level care may last only a few hours. Despite patients with DKA having lower ICU mortality rates and shorter hospital LOS than matched nondiabetic ICU patients, interventions such as mechanical ventilation, vasopressor therapy, and renal replacement therapy may still be needed (3,4). Hospital costs remain substantial for patients with DKA, with a large portion related to inpatient ICU care. It is unknown what specific clinical markers may predict which patients with DKA require short versus long-term ICU care and therefore which patients with DKA would be best treated in the ED-ICU setting. In addition, because the ED-ICU model is a relatively new concept, there is limited previous literature studying clinical outcomes of care in the ED-ICU compared with care in the traditional inpatient ICU setting (5–7).

The aim of this study was to identify which patients presenting with DKA required short-term ICU care of <24 h and who therefore are ideal for treatment in the ED-ICU setting. We examined patient characteristics, clinical identifiers, physiologic variables, and outcomes that may predict short-term ICU care. With the goal of studying the impact of the ResCCU's opening, we compared the clinical outcomes of patients with DKA between the time periods of before and after the opening of the ResCCU.

MATERIALS AND METHODS

Study Design

We performed a retrospective analysis of adult patients with a primary diagnosis of DKA treated in the ED between July 2016 and September 2017. We obtained institutional review board approval and the study was determined as exempt.

Study Setting and Population

The ResCCU is a 5- to 6-bed ED-based ICU, and our medical ICU (MICU) is an 18-bed unit in an inner city, university-affiliated tertiary care hospital. The ResCCU is staffed by critical care trained emergency physicians and has the same ratio of nursing staffing as the MICU (2 patients to 1 nurse or 1 patient to 1 nurse). Patients treated in the ResCCU are not considered to be inpatients. Since its opening in February 2017, the ResCCU has been in a pilot period where it is open only 5 days a week (Monday through Friday). On weekends, patients presenting to the ED who would otherwise meet the criteria for treatment in the ResCCU are directly admitted to an inpatient ICU. Further details on criteria and guidelines for admission, discharge, and triage to the ResCCU can be found in the Supplement.

Subjects were required to be ≥18 years of age at the time of presentation, have a primary *International Classification of Diseases, 10th edition* diagnosis code of DKA for their hospital encounter, and were treated using a standard DKA management pathway that was updated to include new American Diabetes Association insulin titration recommendations in November 2016. The diagnostic criteria for DKA included: hyperglycemia (serum glucose or capillary glucose >250 mg/dL), ketosis (moderate urinary ketones of 2+ or ≥20 mg/dL or serum beta-hydroxybutyrate [BHB] >2 mmol/L), and acidemia (initial arterial blood gas pH ≤ 7.3 or initial serum bicarbonate ≤18 meq/L). We excluded recurrent visits if the patient was previously treated for DKA within the previous 30 days.

Study Protocol

Study investigators reviewed patient charts using their institution's electronic medical record systems and extracted patient demographics, medical history, ED encounter and hospital admission time points, vital signs, laboratory values, and follow-up data. Investigators randomly selected 10% of patient charts to check for interrater reliability between individuals performing chart abstraction.

We obtained available demographic and clinical data, including age, race, ethnicity, and gender; type of diabetes (I or II), medication regimen, and most likely documented DKA trigger(s); initial laboratory values (blood glucose level, basic electrolytes, and anion gap [AG], phosphate, serum BHB level, urinary ketones, and lactate), and blood glucose and lactate levels 4 to 6 h after the initial measurement. We calculated severity of illness scores including Sequential Organ Failure Assessment (SOFA) scores at 24 h and at 48–72 h, and Acute Physiology and Chronic Health Evaluation II (APACHE II) scores. We collected and calculated time metrics, including time of presentation and triage, time to AG closure, time to initiation of insulin infusion, time from initial presentation to transfer to ICU, ICU LOS, and inpatient hospital LOS. We recorded critical care interventions including the use of mechanical ventilation (intubation and noninvasive positive pressure ventilation), vasopressor therapy, volume of fluid resuscitation given in the first 6 h after presentation, and the use of renal replacement therapy. We collected follow-up data after initial ED resuscitation, including disposition, 7- and 28-day postdischarge survival, and 30-day readmission.

Key Outcome Measures

The primary outcome of interest was ICU care for <24 h. We divided patients into groups based on LOS in the ICU: ≥24 h of ICU-level care (prolonged ICU LOS), <24 h of ICU-level care (short ICU LOS), and no ICU time. We defined ICU-level care as treatment in the ResCCU or inpatient medical ICU. The group with no ICU time included patients admitted to the floor directly from the ED or patients directly discharged from the ED.

We compared clinical outcomes of the time period before ResCCU opening (July 2016 to January 2017) versus after ResCCU opening (February 2017 to September 2017). Outcomes of interest included transfer time of patient to ICU-level care, ICU LOS, and total hospital LOS. We defined transfer time as time from ED presentation to admittance to either the ResCCU or an inpatient ICU. We calculated ICU LOS as total time spent in the ResCCU or inpatient ICU.

Data Analysis

We collected and managed study data using REDCap electronic data capture tools hosted at our institution (8). We calculated mean values and standard deviations for all continuous variables. We determined median and interquartile ranges (IQRs) for continuous variables with a skewed distribution. We compared normally distributed continuous variables using the unpaired *t* test. We compared nonnormally distributed continuous variables using the Wilcoxon rank sum test and compared categorical variables using a chi-squared test or Fisher's exact test. We used logistic regression analysis to examine the relationship between all variables listed in Tables 1 and 2 and outcome of <24 h in the ICU (not including the group of patients who received no ICU care). We performed multivariate logistic regression analysis for all significant variables based on an a priori determination of $p < 0.05$ in univariate models. We considered a 2-tailed *p* value < 0.05 statistically significant in the multivariate model. We conducted all analyses using SAS software (version 9.4; SAS Institute, Cary, NC).

RESULTS

A total of 168 ED visits of 130 unique patients with the primary diagnosis of DKA were analyzed. Sixteen recurrent visits were excluded because patients had been treated for DKA in the previous 30 days. The median age was 36 years (IQR 23–55.8 years), 38.5% were male, and 71.5% were African American. Fifty-three visits resulted in a prolonged ICU stay, 58 resulted in a short ICU stay, and 57 required no ICU care. Demographic data, severity of illness scores, and LOS data of patients with DKA stratified by ICU LOS (prolonged, short, or no ICU) are shown in Table 1. Differences in clinical laboratory values, severity of illness scores, ED interventions, and time metrics stratified by ICU LOS are shown in Table 2.

Among possible precipitants for DKA episodes, medication nonadherence was the most common overall and was significantly more likely to be the precipitant of DKA in patients requiring short versus prolonged ICU-level care (67.2% vs. 47.2%, $p = 0.03$). Initial serum bicarbonate was significantly higher (13.0 vs. 9.0 mEq/L, $p = 0.01$) and AG closure time was significantly faster (median 9.8 vs. 14.4 h, $p = 0.003$) in the short ICU LOS group.

No significant difference was seen in severity of illness scores measured between short versus prolonged groups, including APACHE II scores (median 14 vs. 15.5), initial SOFA scores (1 vs. 2), and 48- to 72-h SOFA scores (0 vs. 0). There was no difference in median initial AG, lactate, or initial blood glucose between short versus prolonged ICU care patient groups. Patients requiring prolonged ICU care had significantly higher incidence of vasopressor therapy (9.4% vs. 0%, $p = 0.02$) and mechanical ventilation (9.4% vs. 0%, $p = 0.02$) in the ED. One patient who did not require ICU care required noninvasive positive pressure ventilation because of a previous diagnosis of obstructive sleep apnea. Four patients who did not require ICU care and 1 patient requiring ICU care for <24 h required renal replacement therapy because they were chronic dialysis patients who had missed an outpatient dialysis session, not because emergent dialysis was required.

Transfer time from the ED to ICU-level care did not significantly differ between groups. Overall hospital LOS was shorter for the short ICU LOS group (3 vs. 4 days, $p = 0.01$). Of all patients requiring ICU care, 12

Table 1. Baseline Characteristics of Patients with Diabetic Ketoacidosis Stratified by Intensive Care Unit Length of Stay

Descriptive Characteristics	ICU >24 h (n = 53)	ICU <24 h (n = 58)	No ICU Time (n = 57)	*p* Value* (>24 h vs. <24 h)
Median age, years (IQR)	30 (23–56)	34.5 (23–57)	30 (22–37)	0.4948
Male sex, n (%)	19 (35.9)	18 (31.0)	21 (36.9)	0.6878
Race/ethnicity, n (%)				0.3551
Black/African American	39 (73.6)	40 (69.0)	44 (77.2)	
Hispanic or Latino	3 (5.7)	2 (3.4)	2 (3.5)	
White	10 (18.9)	16 (27.6)	10 (17.5)	
Other	1 (1.9)	0 (0.0)	1 (1.8)	
Type of diabetes, n (%)				0.5550
1	36 (67.9)	37 (63.8)	43 (75.4)	
2	16 (30.2)	17 (29.3)	13 (22.8)	
Unknown	1 (1.9)	4 (6.9)	1 (1.8)	
Diabetes duration (years), median (IQR)	10 (5–16)	13 (4–20)	10.5 (7–18)	0.4370
Prescribed insulin, n (%)	46 (88.8)	50 (86.2)	51 (89.5)	1.0000
Precipitant for diabetic ketoacidosis, n (%)				
Medication nonadherence	25 (47.2)	39 (67.2)	36 (63.2)	0.0257
Infection	20 (37.7)	15 (25.9)	13 (22.8)	0.2213
Acute major illness	5 (9.4)	2 (3.5)	1 (1.8)	0.2554
Ethanol abuse	1 (1.9)	3 (5.2)	4 (7.0)	0.6197
New onset/diagnosis	4 (7.6)	3 (5.2)	2 (3.5)	0.7074
Device malfunction	3 (5.7)	0 (0.0)	0 (0.0)	0.1056
Pregnancy	1 (1.9)	0 (0.0)	1 (1.8)	0.4775
Other	10 (18.9)	8 (13.8)	10 (17.5)	0.6075
Unknown	7 (13.2)	9 (15.5)	8 (14.0)	0.7917
SOFA score (first 24 h), points, median (IQR)	2 (1–4)	1 (1–2)	1 (0–2)	0.2285
SOFA score (48–72 h after initial presentation), points, median (IQR)	0 (0–2)	0 (0–1)	0 (0–0)	0.0574
APACHE II score, points, median (IQR)	15.5 (11–22.5)	14 (10–19)	11 (7–15)	0.2825
Time to transfer to ICU, hours, median (IQR)	6.4 (3.9–8.1)	6.6 (3.7–9.8)		0.4780
Hospital LOS, days, median (IQR)	4 (2–8)	3 (2–5)	2 (1.33–4)	0.0103
Readmission within 30 days of discharge, n (%)	9 (17.0)	16 (27.6)	14 (24.6)	0.2555

APACHE II = Acute Physiology and Chronic Health Evaluation II; ICU = intensive care unit; IQR = interquartile range; LOS = length of stay; SOFA = Sequential Organ Failure Assessment.
* *p* Values calculated for continuous variables from analysis of variance (for normally distributed variables) or the Mann–Whitney *U* test (for nonnormally distributed variables using Monte Carlo estimation). *p* Values calculated using the Fisher's exact test for categorical variables. Relative percent of cohort presented for categorical variables.

Table 2. Clinical Laboratory Markers and Critical Care Interventions Stratified by Intensive Care Unit Length of Stay

Descriptive Characteristics	ICU >24 h (n = 53)	ICU <24 h (n = 58)	No ICU Time (n = 57)	*p* Value (>24 h vs. <24 h)
Initial glucose, mg/dL	502 (373–676)	572 (427–778)	494 (365–641)	0.1989
4-hour glucose after initial presentation, mg/dL	320 (247–507)	363 (218–510)	297 (231–367)	0.7775
Initial lactate, mmol/L	2.65 (1.8–3.5)	2.2 (1.7–3.2)	2.3 (1.4–2.8)	0.4988
4- to 6-hour lactate, mmol/L	2 (1.3–2.7)	1.7 (1.3–3)	1.8 (1.0–2.3)	0.5577
Initial anion gap	24 (20–29)	24 (20–28)	21 (17–26)	0.9971
Time to anion gap closure, h	14.4 (10.2–17.2)	9.8 (7.6–12.4)	9.2 (6.6–13.5)	0.0034
Time to start of insulin infusion, h	3.1 (2.3–4.5)	3.5 (2.4–5.0)	3.4 (2.7–4.8)	0.3920
Amount of crystalloid fluids received in first 6 h after presentation, L	2.7 (2.0–3.0)	2.4 (2.0–3.1)	2.2 (2.0–3.0)	0.8111
Initial bicarbonate, mEq/L	9.0 (6.0–13.5)	13.0 (9.0–15.0)	16.0 (14.0–19.0)	0.01
Initial beta-hydroxybutyrate, mmol/L	7.50 (3.85–10.6)	6.28 (4.54–9.68)	4.91 (2.77–7.44)	0.5892
Initial white blood cell count, total/mm^3	16.4 (10.6–21.8)	11.4 (8.8–14.8)	9.7 (7.3–14.8)	0.0005
Received mechanical ventilation during hospital stay, n (%)	5 (9.4)	0 (0.0)	1 (1.8)	0.0224
Received vasopressor therapy in the emergency department, n (%)	5 (9.4)	0 (0.0)	0 (0.0)	0.0224
Received renal replacement therapy during hospital stay, n (%)	3 (5.7)	1 (1.7)	4 (7.1)	0.3466

ICU = intensive care unit; IQR = interquartile range.
Values are presented as median (IQR).

(10.8%) patients had a hospital LOS <1 day and 16 (14.4%) patients had a hospital LOS ≥10 days. The 28-day mortality rate between groups was not significantly different, with 1 patient who expired in the short-stay group and 2 patients who expired in the prolonged ICU group (1.7% vs. 3.8%, $p = 0.61$). There was no significant difference in readmission 30 days after discharge between the short and prolonged ICU groups (16 vs. 9 readmissions, $p = 0.26$).

After logistic regression modeling for the outcome of ICU LOS <24 h, initial bicarbonate, AG closure time, and medication nonadherence were found to be the most significantly associated variables. Multivariate logistic regression analysis, adjusting for variables significant from univariate analysis, demonstrated that initial bicarbonate ($p = 0.04$) and medication nonadherence ($p = 0.03$) remained significantly associated with ICU LOS.

Interrater reliability for chart abstraction was 97.1%. Of 17,808 data elements captured, there were 256 missing data elements (1.4%). The data elements primarily missed included patients' medical history, including years since diagnosis of diabetes and number of years on insulin therapy.

Before Versus After ResCCU Opening

Eighty-nine patients presented with DKA to the ED in the time period before the ResCCU opened. Of those 89 patients, 51 were admitted directly from the ED to an inpatient ICU. Seventy-nine patients presented with DKA to the ED in the time period after the ResCCU opened. Of those 79 patients, 60 required ICU-level of care; 46 patients were treated in the ResCCU and 14 patients were directly admitted to an inpatient ICU on weekends when the ResCCU was not open. Four patients who were initially managed in the ResCCU required subsequent admission to the MICU, while all others were either subsequently admitted to a hospital medicine floor or discharged. Among the patients admitted to the MICU after initial ResCCU treatment, 3 had sepsis or septic shock from infectious sources and 1 had acute hypoxic respiratory failure from pulmonary edema. There was no difference between the before versus after ResCCU groups in baseline characteristics including age, race, and sex. Transfer time to ICU-level care was significantly shorter after ResCCU opening versus before ResCCU opening (median 5.3 vs. 7.1 h, $p = 0.005$). Among patients requiring ICU-level care, ICU LOS was significantly shorter for the time period after ResCCU opening versus before ResCCU opening (14.0 vs. 32.0 h, $p < 0.001$). There was no significant difference found between groups in 7- and 28-day mortality rates, 30-day readmission rates, and overall hospital LOS. In the time period after ResCCU opening, there was no significant difference in readmission rates between patients treated in the ResCCU versus those treated in the MICU on weekends when the ResCCU was not open (13 vs. 3 readmissions, $p < 0.91$).

DISCUSSION

In a retrospective data analysis of patients with DKA who were ≥18 years of age, we found a significant association between higher initial bicarbonate values and medication nonadherence as a DKA precipitant with a short course of ICU-level care. Although not significantly associated with prolonged ICU LOS in our logistic regression model, the variables of BHB, APACHE II scores, and initial SOFA scores may still have clinical utility in predicting which patients with DKA are more likely to need ICU care for ≤24 h. We also found that after the ResCCU opened, ICU LOS and transfer time to ICU-level care significantly decreased. Our findings have important implications for the prospective identification of patients who are best suited for treatment in an ED-ICU, a novel clinical practice model with the potential to decrease inpatient ICU use and expedite care of the critically ill.

Clinical Implications

Critical care services are a valuable resource with a limited capacity. Identifying which critically ill patients will rapidly stabilize after resuscitation could potentially improve inpatient ICU bed allocation. The results of our study support previous findings that patients with DKA often have a low severity of illness compared to other critically ill patients and usually respond to interventions within a short period of time (4,9). Median initial SOFA scores of both short and prolonged ICU stay groups were under the threshold used in previous studies to define organ failure, a SOFA score ≥3. As SOFA scores have been demonstrated to have good correlation with ICU outcomes, it follows that the patients with DKA in this study had low mortality rates (10). The mortality for DKA is <5%, and in our cohort only 1 patient with DKA suffered an in-hospital death and 98% of patients survived ≥28 days after hospital discharge. The low severity of illness scores and corresponding low mortality rates of this patient population point toward the possibility that admission of patients with DKA to inpatient ICUs may be unnecessary. The primary reason that our cohort of patients required ICU-level care was likely the need for a continuous insulin drip, rather than because of other organ dysfunction or interventions (e.g., vasoactive therapy, invasive mechanical ventilation) that would warrant ICU admission. Therefore, even those patients who had ICU LOS <24 h really did require ICU-level care for insulin drip monitoring. Our findings support previous cross-sectional observational studies showing that medication nonadherence is a leading cause of DKA, specifically in patients from inner cities (11). Compared with DKA precipitated by other causes, such as infection or acute major illness (myocardial infarction, stroke, etc.), medication nonadherence as a precipitant may help identify initially less sick patients with the potential for faster transition from ICU-level care.

Of the 3 DKA criteria (hyperglycemia, ketosis, and acidemia), higher initial bicarbonate levels, indicating less severe metabolic acidosis, predicted short ICU LOS. As metabolic acidosis and hyperglycemia themselves increase insulin resistance, it follows that patients with DKA with more severe acidosis take longer to respond to insulin therapy and correspondingly require longer length of ICU-level care (12). Therefore, of the many different laboratory values evaluated in the initial diagnosis and treatment of DKA, a focus on initial bicarbonate could aid in stratifying which patients will likely have a short ICU stay.

Multiple studies have reported on the negative impacts of delayed transfer of critically ill patients, including increased overall hospital LOS and higher ICU and in-hospital mortality rates (5,13). Therefore, by accelerating transfer times, the ED-ICU may have positive effects on these important patient outcomes. No significant difference was found between transfer time from ED to ICU-level care between prolonged versus short ICU LOS groups, but median transfer time to ICU-level care was significantly shorter in the time period after ResCCU opening. Along with shorter transfer times, the transfer of patients from ED to ED-based ICU care may improve patient handoffs and minimize pauses in resuscitation.

Financial Implications

In a multicenter retrospective analysis of 253 U.S. hospitals, Dasta et al. found that the mean cost of an ICU stay was >$10,000, for an average LOS of 8.5 days (14). They concluded that interventions resulting in decreased ICU LOS could lead to substantial reductions in total inpatient cost (14). Patients with DKA are frequent users of ICU-level care, and with DKA episodes representing >$1 of every $4 spent on direct medical care for adult patients with type I diabetes, it is imperative that ICU LOS and recurrence of DKA episodes be minimized (15). Our findings demonstrated that after the opening of our institution's ED-ICU, median ICU LOS significantly decreased among patients presenting with DKA who required ICU-level care. The ED-ICU model has great potential to be a cost-saving mechanism to decrease inpatient ICU admissions and decrease overall hospital LOS. The impact of the ED-ICU on ED and hospital costs has not been previously examined and would be an important next step in evaluating the value of this novel clinical setting. We are currently in the process of collecting a preliminary, publishable dataset to hopefully support that the ED-ICU provides more cost-effective care.

Limitations

This was a single-center study; therefore, our patient population was limited to those presenting to a large urban, academic center. Our study did not include patients with DKA from nonurban areas, those treated in community hospitals, or those treated in other institutions' ED-ICUs. Other limitations include that this was a retrospective analysis; therefore, laboratory and clinical markers were not always recorded or able to be found in patient records. Prospective studies generally have the highest value for validation of clinical decision rules, and would be the next step to generate a clinical prediction rule (16,17). Patients with DKA were identified relying on primary diagnosis coding, and therefore there is the possibility that some patients presenting with DKA were missed or that DKA was listed as a diagnosis erroneously. Using *International Classification of Diseases, 10th edition* primary diagnosis coding, however, ensured the highest specificity for identification of patients with DKA. This study may also be subject to incorporation bias because of the analysis of clinical variables that are used in the diagnosis of DKA, such as initial bicarbonate. Therefore, there is the possibility the sensitivity and specificity of these variables as predictors for short ICU LOS are overestimated.

CONCLUSIONS

We found that medication nonadherence as the precipitant for DKA and higher initial bicarbonate levels predicted shorter ICU LOS in patients with DKA. After ResCCU opening, patients requiring ICU-level care had shorter transfer time to ICU-level care and shorter LOS in the ICU. Further studies should be performed to help establish and validate clinical data points that predict short-stay ICU care, and identify optimal candidates for ED-based ICU resource allocation.

Acknowledgments—Supported by the University of Rochester School of Medicine Office for Medical Education Basic Science, Clinical, and Translational Research Year-Out Grant.

SUPPLEMENTARY DATA

Supplementary data related to this article can be found at https://doi.org/10.1016/j.jemermed.2018.09.048.

REFERENCES

1. Weingart S, Sherwin R, Emlet L, et al. ED intensivists and ED intensive care units. Am J Emerg Med 2013;31:617–20.
2. Kitabchi AE, Umpierrez GE, Miles JM, et al. Hyperglycemic crises in adult patients with diabetes. Diabetes Care 2009;32:1335–43.
3. Azevedo LCP, Choi H, Simmonds K, et al. Incidence and long-term outcomes of critically ill adult patients with moderate-to-severe diabetic ketoacidosis: retrospective matched cohort study. J Crit Care 2014;29:971–7.
4. Freire AX, Umpierrez GE, Afessa B, et al. Predictors of intensive care unit and hospital length of stay in diabetic ketoacidosis. J Crit Care 2002;17:207–11.
5. Chalfin DB, Trzeciak S, Likourezos A, Baumann BM, et al. Impact of delayed transfer of critically ill patients from the emergency department to the intensive care unit. Crit Care Med 2007;35:1477–83.
6. Aslaner MA, Akkaş M, Eroğlu S, et al. Admissions of critically ill patients to the ED intensive care unit. Am J Emerg Med 2015;33:501–5.
7. Tseng JC, Li CH, Chen KF, et al. Outcomes of an emergency department intensive care unit in a tertiary medical center in Taiwan: an observational study. J Crit Care 2015;30:444–8.
8. Harris PA, Taylor R, Thielke R, et al. Research electronic data capture (REDCap)—a metadata-driven methodology and workflow process for providing translational research informatics support. J Biomed Inform 2009;42:377–81.
9. Gershengorn HB, Iwashyna TJ, Cooke CR, et al. Variation in use of intensive care for adults with diabetic ketoacidosis. Crit Care Med 2012;40:2009–15.
10. Moreno R, Vincent J, Matos R, et al. The use of maximum SOFA score to quantify organ dysfunction/failure in intensive care. Results of a prospective, multicentre study. Intensive Care Med 1999;25:686–96.
11. Randall L, Begovic J, Hudson M, et al. Recurrent diabetic ketoacidosis in inner-city minority patients: behavioral, socioeconomic, and psychosocial factors. Diabetes Care 2011;34:1891–6.
12. Souto G, Donapetry C, Calviño J, et al. Metabolic acidosis-induced insulin resistance and cardiovascular risk. Metab Syndr Relat Disord 2011;9:247–53.
13. Parkhe M, Myles PS, Leach DS, Maclean AV. Outcome of emergency department patients with delayed admission to an intensive care unit. Emerg Med (Fremantle) 2002;14:50–7.
14. Dasta J, Mclaughlin T, Mody S, et al. Daily cost of an intensive care unit day: the contribution of mechanical ventilation. Crit Care Med 2005;33:1266–71.
15. Javor KA, Kotsanos JG, McDonald RC, et al. Diabetic ketoacidosis charges relative to medical charges of adult patients with type I diabetes. Diabetes Care 1997;20:349–54.
16. Wasson JH, Sox HC, Neff RK, et al. Clinical prediction rules. Applications and methodological standards. N Engl J Med 1985;313:793–9.
17. McGinn TG, Guyatt GH, Wyer PC, et al. Users' guides to the medical literature: XXII: how to use articles about clinical decision rules. Evidence-Based Medicine Working Group. JAMA 2000;284:79–84.

ARTICLE SUMMARY

1. Why is this topic important?

The emergency department–intensive care unit (ED-ICU) is a new clinical setting that is still in the process of learning to stratify which patients are ideally suited for treatment in the short-stay ICU space. Given that inpatient ICU beds are often filled to capacity, proper use of the ED-ICU will be key to the timely management of critically ill patients and the proper allocation of ICU resources.

2. What does this study attempt to show?

Diabetic ketoacidosis (DKA) may be an ideal diagnosis for treatment in the ED-ICU setting. This study sought to identify clinical variables associated with a short ICU stay of <24 h in patients with DKA.

3. What are the key findings?

Patients with DKA presenting with medication nonadherence as the precipitant of their DKA episode and higher initial bicarbonate levels are more likely to need a short course of ICU-level care for <24 h. After the opening of the ED-ICU at our institution, patients had shorter transfer times to ICU-level care and had shorter overall ICU lengths of stay than in the time period before the ED-ICU's opening.

4. How is patient care impacted?

The ED-ICU may be an ideal setting for treatment of patients with DKA, specifically those presenting with medication nonadherence as a precipitant and a less severe metabolic acidosis. Decreased transfer times to ICU-level care and earlier initiation of resuscitation of critically ill patients in the ED-ICU has the potential to improve patient outcomes, such as decreasing ICU length of stay and mortality.