Diabetic ketoacidosis resolution: From the traditional way to guideline-based management in the MICU at University Medical Center, Lubbock, Texas

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ABSTRACT

Diabetes is a chronic, metabolic disease characterized by hyperglycemia which eventually can cause serious organ damage. The prevalence of diabetes has steadily increased over the past few decades, and approximately 1.4 million Americans are diagnosed with diabetes every year. Diabetes was the seventh leading cause of death in the United States in 2019. Diabetic ketoacidosis (DKA) is a serious complication of diabetes that can be life-threatening. It occurs more frequently in the patients with type 1 diabetes but can also develop in people with type 2 diabetes. It was determined that the average cost per DKA episode was $6,444, and that the annual cost of medical treatment in a diabetic patient with a prior episode of DKA was 2.67 times higher than a diabetic patient with no history of DKA. The criteria for DKA resolution at University Medical Center (UMC) in Lubbock, Texas, are different from current American Diabetes Association (ADA) guidelines. At UMC, a plasma bicarbonate ≥18 mEq/L, a venous pH > 7.3, and anion gap ≤12 mEq/L must be recorded twice (4 hours apart) before bridging to subcutaneous long-acting insulin administration. This time requirement could contribute to a longer time for DKA resolution and longer intensive care unit and hospital stays.

Keywords: Diabetic ketoacidosis, DKA resolution

INTRODUCTION

Diabetes is a chronic, metabolic disease characterized by elevated levels of blood glucose which eventually causes serious end-organ damage, including the heart, blood vessels, eyes, kidneys, and nerves. Type 1 diabetes or insulin-dependent diabetes is a chronic condition in which the pancreas produces little or no insulin by itself. Type 2 diabetes, usually in adults, occurs when the skeletal muscle and the liver become resistant to insulin or the pancreas produces some but not enough insulin to maintain normal blood glucose levels.

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Diabetic ketoacidosis (DKA) is a serious complication of diabetes that can be life-threatening. This metabolic disorder occurs more frequently in patients with type 1 diabetes but also occurs in the patients with type 2 diabetes.[1] The incidence of DKA was 55.5 per 1000 person-years (PYs) in a large US commercially insured population with type 1 diabetes in 2007–2019.[2] The incidence of DKA was higher in children than adults (108.0 vs. 44.8 per 1000 PYs) and was higher in females than males (62.9 vs. 48.6 per 1000 PYs).[2] Age-sex-standardized incidence of DKA decreased by 6.1% annually in 2018–2019 after a steady increase since 2011.[2]

Diabetic ketoacidosis is an expensive and serious but preventable complication of diabetes. It has been estimated that the annual cost of treating DKA in the U.S. exceeds $1 billion.[3] Javor et al. compared the costs of treating DKA relative to the costs of treating diabetes

without DKA during a 6-month period. They determined that the average cost per DKA episode was $6,444, and that the annual cost of medical treatment in a diabetic patient with a prior episode of DKA was $13,096, as compared with $4,907 for a diabetic patient with no history of DKA.[4]

Maldonado et al. analyzed 167 DKA admissions.[5] The mean age was 40 ± 13 years. The ethnic distribution was 49% African American, 32% Hispanic American, and 18% white. The total in-hospital cost of treating DKA was $1,816,255. The mean cost per hospitalization was $10,876 ± 11,024. The frequency distribution by category of DKA-precipitating factor was 18% acute illness, 59% noncompliance, and 23% new onset. There were differences in mean cost of DKA associated with the three categories: $20,864 ± 17,910 for acute illness, $11,863 ± 8,701 for new onset, and $7,470 ± 6,300 for noncompliance ($P < 0.0001$). The total cost for each category was $671,375 for acute illness, $694,082 for noncompliance, and $450,798 for new onset.

Motes et al. analyzed DKA patient characteristics at University Medical Center (UMC); the mean age was 38.1 ± 18.5 years, and 19% were male. Most of the precipitating causes were poor compliance, infection, and insulin pump malfunction. Mean blood sugar, anion gap, bicarbonate, and pH at the time of diagnosis were 546.4 ± 296.3 mg/dL, 31.8 ± 7.8 mEq/L, 10.1 ± 5.5 mEq/L, and 7.2 ± 0.2, respectively.[6]

The criteria for DKA resolution at UMC are different from current American Diabetes Association (ADA) guidelines, which are plasma glucose less than 200 mg/dL and two of the following criteria: plasma bicarbonate greater than or equal to 15 mEq/L, venous pH greater than 7.3, and anion gap ≤12 mEq/L. At UMC, a plasma bicarbonate ≥18 mEq/L, a venous pH > 7.3, and anion gap ≤12 mEq/L must be present twice consecutively (4 hours apart) before bridging to subcutaneous long-acting insulin administration. This time requirement could contribute to a longer time for DKA resolution and longer intensive care unit (ICU) and hospital length of stay.[6]

In this study, we tried to determine if following ADA guideline-based management would reduce the number of basic metabolic panel (BMP) tests and length of ICU stay, leading to reduced health care costs and hospital length of stays.

Method

Project participants included the pulmonary/critical care fellows, nurse practitioners, attendings physicians, internal medicine residents, and ICU nurses. Daily reminders were sent to ICU providers and all project participants to start bridging to long-acting insulin after DKA resolution × 1 time. Intervention period was of 1 month with daily reminders to ICU team on rounds and weekly reminders with emails.

Data were obtained from University Medical Center electronic medical record. Baseline data were collected 1 month prior to the intervention. Data from the intervention month were collected and compared to the baseline. The demographic information, number of BMPs per patient, length of ICU stays while the patient was admitted in ICU for DKA, and length of hospital stay of the control and interventional group were compared. This project was approved by the Texas Tech University Health Sciences Center Quality Improvement Review Board (QI-22094).

Results

Data from the intervention group were collected and compared to the control group. There were 16 and 15 patients with mean age of 44.5 and 40.2 years old in control and intervention group, respectively. There were 7 (43.8%) and 8 (53.3%) type 1 diabetes cases in control and intervention group, respectively. The most frequent DKA-precipitating factor was non-compliance 62.5% and 46.7% in control and intervention group, respectively. Characteristics of control and interventional group were shown in Table 1. Basic metabolic panels were collected from admission until bridging 6.7 ± 2.7 times in control group and 5.9 ±2.1 times in interventional group, which was decreased by 11.8% with this intervention. ICU length of stay and hospital length of stay in control group were 2.0 ± 1.0 and 5.9 ± 4.9 days, respectively. The ICU length of stay and hospital length of stay in interventional group were 1.9 ± 0.6 and 4.6 ± 2.7 days respectively.

Table 1. Study Details and Outcomes

Parameters	Control Group (n = 16)	Intervention Group (n = 15)
Male, N (%)*	10 (62.5%)	7 (46.7%)
Age, years, Mean ± SD**	44.5 ± 15.2	40.2 ± 14.4
Type 1 DM*	7 (43.7%)	8 (53.3%)
No insurance*	4 (25.0%)	5 (33.3%)
Trigger: noncompliance*	10 (62.5%)	7 (46.7%)
Trigger: infection*	3 (18.8%)	3 (20.0%)
Trigger: first time diagnosis*	2 (12.5%)	3 (20.0%)
Prior DKA in 1 year (times)**	0.7 ± 1.0	1.5 ± 2.2
Intubated patient*	1 (6.3%)	0 (0%)
Sepsis*	4 (25.0%)	1 (6.7%)
Body mass index, kg/m^2**	28.2 ± 6.5	28.8 ± 9.2
Hemoglobin A1C**	11.8 ± 2.42	12.11 ± 2.3
Blood glucose (mg/dL)**	618.5 ± 231.3	523.2 ± 333.8
Anion gap**	29.8 ± 7.9	25.8 ± 8.8
pH**	7.2 ± 0.2	7.2 ± 0.1
PCO_{2**}	36.0 ± 16.2	30.9 ± 9.4
HCO_{3**}	12.3 ± 5.2	10.7 ± 5.5
BMP from admission until bridging (times)**	6.7 ± 2.7	5.9 ± 2.1
ICU stay (days)**	2.0 ± 1.0	1.9 ± 0.6
Hospital stays (days)**	5.9 ± 4.9	4.6 ± 2.7
Readmission*	1 (6.3%)	0 (0%)
Complications*	1 (6.3%)	0 (0%)
Mortality*	1 (6.3%)	0 (0%)

*-Number (percent); **-Mean (standard deviation).

ICU stay was decreased by 3.5%, and hospital stay was decreased by 21.8% with this intervention. There were no readmissions, complications, or mortality observed in interventional group.

Discussion

This project did not meet the goal which was to reduce the number of BMP used for DKA patients in MICU at UMC Lubbock by at least 20% in 1 month and reduce the ICU lengths of stay by at least 20% in 1 month. However, the results showed that this intervention can reduce hospital stay by 21.8% without readmissions, complications, or mortality.

Conclusion

Following ADA guideline-based DKA management should reduce the number of BMPs ordered and length of ICU stays, leading to reduced health care costs and hospital length of stay with no significant increase in readmission, complications, and mortality. Clinicians should critically review the number of laboratory tests they order on patients with DKA.

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