Diabetic ketoacidosis diagnosis in a hospital setting

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Abstract

Context: Diabetic ketoacidosis (DKA) is an endocrine emergency that can occur in people with diabetes. Its incidence is estimated to be 220,340 hospital admissions each year. Treatment algorithms include fluid resuscitation, intravenous (IV) insulin infusion, and scheduled electrolyte and glucose monitoring. The misdiagnosis of DKA in the setting of hyperglycemic emergencies results in over-treatment and unnecessary increases in healthcare utilization and costs.

Objectives: The aims of this study were to determine how often DKA is overdiagnosed in the context of other acute hyperglycemic emergencies, to describe the baseline characteristics of patients, to determine the hospital treatments for DKA, and to identify the frequency of endocrinology or diabetology consultation in the hospital setting.

Methods: A retrospective chart review was conducted utilizing charts from three different hospitals within a hospital system. Charts were identified utilizing ICD-10 codes for admissions to the hospital for DKA. If the patient was over 18 and had one of the diagnostic codes of interest, the chart was reviewed for further details regarding the criteria for DKA diagnosis as well as admission and treatment details.

Results: A total of 520 hospital admissions were included for review. DKA was incorrectly diagnosed in 28.4% of the hospital admissions reviewed, based on a review of the labs and DKA diagnostic criteria. Most patients were admitted to the intensive care unit (ICU) and treated with IV insulin infusion (n=288). Consultation of endocrinology or diabetology occurred in 40.2% (n=209) of all hospital admissions, and 128 of those consults occurred in ICU admissions. The diagnosis of DKA was incorrect in 92 of the patients admitted to the medical surgical unit (MSU) and in 49 of patients admitted to the ICU.

Conclusions: Almost one third of hospital admissions for hyperglycemic emergencies were misdiagnosed and managed as DKA. DKA diagnostic criteria are specific; however, other diagnoses like hyperosmolar hyperglycemic syndrome (HHS), hyperglycemia, and euglycemic DKA can make an accurate diagnosis more complicated. Education directed at improving the diagnostic accuracy of DKA among healthcare providers is needed to improve diagnostic accuracy, ensure the appropriate use of hospital resources, and potentially reduce costs to the healthcare system.

Keywords: diabetes; diabetic ketoacidosis; diagnosis; hyperglycemia.
(HAGMA), but the anion gap is not part of the criteria needed for diagnosis. There are many conditions that cause HAGMA; notably, alcohol ketosis and starvation ketosis also have ketones present [8]. These other diagnoses should be considered as differential diagnoses that do not have the exact same criteria as a DKA diagnosis but present with some common diagnostic criteria. With the approval of the sodium glucose transporter-2 inhibitor (SGLT-2i) medication class, the recognition of euglycemic DKA has also increased because it is a potential side effect. Euglycemic DKA is defined as ketoacidosis with glucose less than 250 mg/dL [9]. HHS is another hyperglycemic emergency that should be considered in patients presenting with hyperglycemia. HHS diagnostic criteria include a plasma glucose level over 600 mg/dL, plasma osmolality greater than 320 mOsm/kg, and no ketosis. DKA treatment protocols focus on hydration, ketone clearance, osmolality greater than 320 mOsm/kg, and no ketosis. DKA diagnosis was incorrect. Erring on the side of caution to treat a patient suspected of having DKA is a common occurrence, and the spectrum of presentation is variable. Clinicians are treating their patients based on their knowledge and are treating what is most likely to increase mortality of the patient even if not diagnostically accurate. The purpose of this study was to describe DKA diagnosis in a hospital setting. Our study focuses on DKA diagnostic accuracy hypothesizing that overdiagnosis is common. Secondary interests include characteristics of patients admitted to the hospital for DKA, treatment utilized in the hospital, unit of admission, and frequency of endocrinology consultation.

**Methods**

This study was deemed exempt by the Institutional Review Board (IRB) at OhioHealth, and data was collected and stored in REDCap (Research Electronic Data Capture). A retrospective chart review was utilized to review hospital admissions between February 1, 2014, and January 31, 2021. Hospital admissions for hyperglycemic emergencies were identified utilizing ICD-10 codes for DKA. These codes included: E10.10 (type 1 diabetes with ketosis without coma), E10.11 (type 1 diabetes with ketosis with coma), E11.10 (type 2 diabetes with ketosis without coma), E11.11 (type 2 diabetes with ketosis with coma), E13.10 (other specified diabetes mellitus with ketoacidosis without coma), and E13.11 (other specified diabetes mellitus with ketosis with coma). Inclusion criteria were patients admitted, age of 18 or older, admission to one of three specific hospitals, and a diagnostic code consistent with DKA.

Demographic information was collected for each hospital admission. Each hospital admission was counted as a separate patient in this study; multiple patients may have had multiple hospital admissions. A team of physicians reviewed the charts for the same criteria applied to each hospital admission. The diagnostic criteria included lab values that were recorded for each admission to determine if the admission met the criteria for a DKA diagnosis. The criteria for DKA diagnosis included: serum glucose over 250 mg/dL, pH less than 7.3, bicarbonate level less than 18 meq/L, and elevated serum ketones (beta-hydroxybutyrate). This was then compared with the ICD-10 code for the admission to determine accuracy of the diagnosis. The correct diagnosis was not reassigned to these hospital admissions and was not quantified. The location of treatment (medical surgical unit (MSU) or intensive care unit (ICU)), the method of treatment (IV insulin vs. subcutaneous insulin), and the involvement of an endocrinologist or diabetologist consultation was also collected. If the patient was in the ICU step-down unit, then it was counted as an ICU visit.

All statistical analysis was performed utilizing IRB SPSS (Version 26). Descriptive statistics were calculated to describe and summarize the data. Means and standard deviations were utilized to describe continuous variables. Frequencies and percentages were utilized to describe categorical variables. Chi-squared tests were utilized to calculate differences between admission types for treatments and modes of management. The p value was set at ≤0.05 a priori.

**Results**

There were 520 hospital admissions for DKA identified utilizing the ICD-10 codes of E10.10, E10.11, E11.10, E11.11, E13.10, and E13.11. After reviewing hospital admissions for inclusion and exclusion criteria, 520 hospital admissions were included in this study. The average age of the patients was 38.5 ± 15.5, with an age range of 18–87 years old. The average hemoglobin A1c was 11.1 % ± 4.7, with 509 of the 520 patients having hemoglobin A1c results available. Most patients had type 1 diabetes (87.9 %, 457/520), whereas 11.9 % (62/520) had type 2 diabetes. The demographics are presented in Table 1.

Diabetes complications documented in the chart were not mutually exclusive, with some patients having more than one complication. Complications are presented in Figure 1. Some patients were on more than one treatment modality with oral agents, insulin pump, and multiple daily injections (MDI), whereas others were on no treatment. MDI was the most reported (n=381) treatment modality, insulin
pump was the second most reported (n=94), and 45 patients were not taking any medications prior to hospitalization, shown in Figure 2. It was also documented in the reviewed charts that 43 patients were utilizing continuous glucose monitors as part of their diabetes care regimen.

The cause of DKA admissions was included in the chart review. The most common cause was insulin omission at 274 (52.7%) admissions, followed by 121 (23.3%) admissions caused by infection, 73 (14.0%) in which the cause was unknown, and 48 (9.2%) attributed to a new diagnosis of diabetes. Three of these newly diagnosed cases were newly diagnosed with type 1 diabetes but had been misdiagnosed with type 2 diabetes and prescribed oral agents prior to hospital admission. Other causes were also captured in Figure 3.

With respect to hospital admissions, more patients were admitted to the ICU (290) than the MSU (223). There were three patients admitted to labor and delivery. Patients were uniformly treated with IV insulin infusion regardless of the unit to which they were admitted, as shown in Table 2. There was no statistically significant difference in how the inpatient insulin treatment was given between admission types (ICU vs. MSU, p=0.435). There was no statistically significant difference in subcutaneous insulin administration between admission types (p=0.765). Consultation of specialists, either endocrinology or diabetology, occurred in 209 (40.2%) hospital admissions, of which there were 180 endocrinology consults and 29 diabetology consults. Endocrinology or diabetology was consulted more often with admission to the ICU than admission to the MSU. There were 106 endocrinology consults and 22 diabetology consults occurring in the ICU admissions. Overdiagnosis of DKA was seen more on the MSU, with 42.2% (n=92) of admissions being incorrectly diagnosed whereas overdiagnosis in the ICU was seen in 17.1% (n=49) of admissions. Accuracy of diagnosis revealed that 71.6% (n=372) of admissions were correctly diagnosed with DKA. The alternative diagnoses of HHS or hyperglycemia were noted as the more accurate diagnoses in most of these cases that were not DKA.

**Discussion**

DKA is an endocrine condition taught in medical school. Internal medicine and emergency medicine residency programs allow for the most exposure to diagnosing DKA and initiating treatment. It can be deadly if the diagnosis is
missed. Desai et al. [11] report an increase in incidence of DKA but also a decrease in mortality. This retrospective chart review demonstrated that 28.4% of the patients treated for DKA did not actually meet the criteria for DKA. There are other differential diagnoses that are mistaken as DKA, e.g., HHS and hyperglycemia co-occurring with other causes of a HAGMA. The treatments are slightly different for each of these diagnoses, although protocols can include starting an IV insulin infusion in each case. HHS has a higher mortality rate than DKA, so diagnostic accuracy is important despite the shared use of insulin and fluid resuscitation. HHS can lead to dehydration, so more fluids are included in its treatment, and transitioning off the IV insulin infusion to subcutaneous insulin is done based on the serum osmolality. The DKA IV insulin transition parameters are based on the clearance of ketones and anion gap closure. Hyperglycemia without ketones can sometimes be treated with IV insulin infusion depending on various clinical circumstances. There are mild, moderate, and severe classifications of DKA diagnosis to further complicate diagnostic accuracy [12]. It is also reported that there are cases of DKA-HHS overlap syndrome, with a reported occurrence of 30% [13]. These patients met the criteria for both DKA and HHS including serum osmolality over 320 mOsm/kg, glucose over 600 mg/dL, pH less than 7.3, and positive for ketones [14]. Another consideration is that providers may be relying on a combined order set for both DKA and HHS to treat the glycemic emergency early in its course rather than considering the details for which glycemic emergency is the actual diagnosis. Diagnostic accuracy is not being considered when a patient is being treated.

Consistent with what is already known about DKA, our population had mostly type 1 diabetes, the most common cause was insulin omission, and the most common treatment was IV insulin infusion. The medication class, SGLT-2i, has also been associated with euglycemic DKA, in which the glucose is less than 250 mg/dL but other criteria for DKA are met [15]. Our study only had two identified DKA cases caused by this class of medication; however, as it continues to gain popularity with its cardiovascular and renal benefits, this side effect is likely to increase in incidence. Another consideration for the small number of DKA cases caused by SGLT-2i medications is that most of the hospital admissions in this review had type 1 diabetes yet this medication class is utilized to treat type 2 diabetes. Education for clinicians regarding this possibility will increase awareness. IV insulin infusion protocols are utilized in many hospitals both in the ICU and MSU and have become the main way that DKA is treated. One study compared IV insulin infusion treatment with subcutaneous insulin and outcomes following hospitalizations. The study determined that use of subcutaneous insulin was safe, that the DKA improved in approximately the same time frame, and that there was a decrease in the readmission rate [16]. Another study compared the use of subcutaneous insulin vs. IV insulin infusion in the treatment of mild DKA, concluding that there was a cost difference of $678 vs. $1,078, respectively, as well as a reduction of hospital stay of 16.9 h [17]. Consequently, the use of subcutaneous insulin instead of IV insulin infusions for hyperglycemia treatment
could lead to cost savings. It is also worth noting that the cost per day for room and board at one hospital for admission to MSU was approximately $2,420 and in the ICU was $6,156 [18]. Improved diagnostic accuracy could reduce ICU admission for DKA and lead to additional cost reductions.

Limitations

Our study had some strengths including the sample size and representation from urban and rural hospitals. There were, however, more admissions included from the urban hospitals. Inherent limitations of retrospective chart review studies include inaccurate and incomplete data as well as variance in the quality and location of data despite a common electronic medical record. Differences in documentation of information in the chart by different healthcare providers can lead to inconsistencies in the data set utilized for retrospective chart reviews.

Conclusions

DKA is a common diagnosis for which people with diabetes are admitted to the hospital. The diagnostic criteria appear straightforward, but not everything that is a hyperglycemic emergency is DKA and the other differentials are not as well known. HHS, mixed DKA-HHS, and then the classification of mild, moderate, and severe make diagnostic accuracy more complex. Although missing the diagnosis increases mortality, overtreatment can be costly to the health system. ICU admissions are more expensive than MSU admissions and the use of insulin infusions are more expensive than the use of subcutaneous insulin. Subcutaneous insulin can also be as effective in the treatment of DKA. Missing the diagnosis almost one third of the time demonstrates opportunity for provider education to review the criteria for diagnosis as well as billing accuracy to decrease overdiagnosis, improve patient care, and reduce healthcare costs.

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Competing interests: None reported.

References