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Diabetic Ketoacidosis Approach in the Emergency Department: Review Article

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Abstract

Background: Diabetic ketoacidosis (DKA) is an endocrinological emergency that occurs as a direct result of a total or relative deficiency of insulin and is potentially life-threatening. Lack of insulin results in attenuation of the other regulatory hormones. **Objectives:** In this paper, we will review the available literature discussing the features, diagnosis, and emergency management of DKA. **Methodology:** We conducted the literature search within the PubMed database using the keywords: "Ketoacidosis" and "DKA treatment" and "insulin" and "diabetic" with dates from 1990 to 2020. **Review:** DKA presents clinically in a triad of metabolic acidosis, hyperglycemia, and hyperketonemia, and/or hyperketouria. In most cases, DKA is accompanied by a varying level of circulatory collapse. Individuals who suffer from type 1 diabetes mellitus (T1DM) that is poorly controlled are by far the most vulnerable to DKA. The management goals of DKA revolve around the control of four different imbalances which are (1) hyperglycemia, (2) hypovolemia, (3) electrolytes imbalance, and (4) management of precipitating factors. **Conclusion:** In conclusion, the management of DKA is complex and needs cautious attention while restoring glucose level, hydration status, and electrolytes imbalance. Emergency physicians are a cornerstone in the management of DKA and should be aware of its importance.

Keywords: Ketoacidosis, DKA treatment, insulin, diabetic.

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Introduction

Diabetic ketoacidosis (DKA) is an endocrinological emergency that occurs as a direct result of a total or relative deficiency of insulin and is potentially life-threatening (Priyadi et al., 2019; Abd Allah et al., 2018; Alkhoshaiban and Almeman, 2019) The condition was first described in the late 1880s and remained universally fatal until the introduction of insulin some 35 years after its description. Lack of insulin results in attenuation of the other regulatory hormones (Gosmanov et al., 2004).

DKA presents clinically in a triad of metabolic acidosis, hyperglycemia, and hyperketonemia, and/or hyperketouria (Umpierrez et al., 2006). In most cases, DKA is accompanied by a varying level of circulatory collapse. Individuals who suffer from type 1 diabetes mellitus (T1DM) that is poorly controlled are by far the most vulnerable to DKA (Gosmanov et al., 2004). However, DKA could also be encountered in individuals with poorly controlled, advanced type 2 diabetes mellitus (T2DM). DKA can occur when there is a stressful condition that affects the body. For example, acute medical or surgical illnesses can precipitate DKA. By far, the most common cause of DKA is infection; in particular urinary tract infections and gastroenteritis (Kitabchi and Nyenwe, 2006; Kitabchi et al., 2009).

DKA has long been considered a major feature of T1DM, however, we now understand that DKA could also occur in individuals with newly diagnosed T2DM, a condition termed ketosis-prone T2DM. Though ketosis-prone T2DM has been documented in all populations, epidemiological surveys show an increased risk among certain populations namely; people of African or Hispanic origin (Umpierrez et al., 2006).

The significant morbidity and high utilization of healthcare resources have been associated with DKA. For instance, around 10% of admitted to hospitals with diabetes mellitus as the reason for admission have DKA (Kitabchi and Nyenwe, 2006; Randall et al., 2011). DKA is considered extremely expensive to treat. In countries that lack a national healthcare system, such as the USA, the cost of treating one episode of DKA is estimated at little more than 25,000 US dollars. In countries where a well-established national healthcare system excites, such as the UK, the cost is much lower, approximately 2,000 US dollars (Kitabchi et al., 2009).

The frequency of DKA varies greatly around the world. For example, in the UK, the rate is estimated to be around 4% of type 1 diabetics develop DKA every year. In Malaysia, the condition affects one-quarter of the individuals with T1DM annually. The mortality rate associated with DKA in the presence of effective and prompt management is below 5% (Gosmanov et al., 2004).

The mainstay of DKA treatment is fluid replenishment and insulin. Insulin can be delivered either subconsciously or intravenously, depending on the severity. Typically, DKA patients present with a varying degree of hypokalemia for which potassium supplement is usually required (Umpierrez et al., 2006). Kalemic control can face further deterioration as insulin is introduced to the body. Regular monitoring of blood sugar and potassium levels must be done throughout the management course. In most cases, DKA can be traced back to an underlying infection. If an infection is identified, antimicrobial management is usually added (Umpierrez et al., 2006; Gosmanov et al., 2004; Randall et al., 2011).

Methodology:

We conducted the literature search within the PubMed database using the keywords: “Ketoacidosis” and “DKA treatment” and “insulin” and “diabetic” with dates from 1990 to 2020. We also used the Google Scholar database for additional literature searches. After reading the abstracts, we manually selected the relevant papers for this review. In regards to the inclusion criteria, the articles were selected based on the inclusion of one of the following topics; Ketoacidosis and DKA treatment. Exclusion criteria were all other articles that did not have one of these topics as their primary endpoint.

Review:

Diagnosis

The diagnosis of DKA is made in the presence of hyperglycemia (blood glucose >250 mg/dL), acidosis (arterial pH of ≤7.30 and/or bicarbonate level of ≤18 mEq/L), and an anion gap of >10–12. The presence of ketones in the urine and/or serum strengthen the diagnosis of DKA (Kitabchi et al., 2009). The diagnosis of DKA could be difficult in cases where an advanced chronic kidney disease (CKD) is present. Patients with CKD are likely to have chronic metabolic acidosis which is difficult to differentiate from the acidosis that accompanies DKA (Kitabchi et al., 2009). In such patients, a higher cutoff level of anion gap () is usually needed to determine the diagnosis of DKA (>20) (Basnet et al., 2014; Nyenwe and Kitabchi, 2011).

Emergency management overview

The management goals of DKA revolve around the control of four different imbalances which are (1) hyperglycemia, (2) hypovolemia, (3) electrolytes imbalance, and (4) management of precipitating factors. By far, the overwhelming majority of patients with DKA present to the emergency department, and thus, emergency physicians are responsible for initiating basic resuscitation which includes fluids. Thereafter, the diagnosis of DKA can be confirmed through various basic metabolic parameters and proper treatment is started. Table 1 shows the different DKA management phases and milestones needed to be achieved in each phase.

Table 1. DKA management phases.

Phase I (0–6 h)	Phase II (6–12 h)	Phase III (12–24 h)
Perform history and physical exam and order initial laboratory studies	Continue biochemical and clinical monitoring	Continue biochemical and clinical monitoring
Implement a monitoring plan (biochemical and clinical)	Change isotonic fluids to hypotonic fluids if corrected Na normal/high	Adjust therapy to avoid complications
Give intravenous bolus of isotonic fluids	If glucose is <200–250 mg/dL, add dextrose to intravenous fluids	Address precipitating factors
Start insulin therapy (after fluids started and only if K >3.3 mmol/L)	Adjust insulin infusion rate as needed	If DKA resolved, stop intravenous insulin and start subcutaneous insulin
Consult the diabetes team	Maintain K at 3.3–5.3 mmol/L range	Consult diabetes educator

Fluid replenishment

It is estimated that an average of 8 L of inter-and intra-cellular fluid is lost in patients with DKA. One major goal of the DKA management plan is to replace the total fluid deficits within 24-36 hours. The majority of this process takes place in the emergency department where approximately one-half of the replacement fluid is administered during the first 8 hours. Isotonic saline is considered the initial fluid of choice (Basnet et al., 2014; Nyenwe and Kitabchi, 2011).

If renal function is not severely compromised and enhance peripheral action of insulin, stimulating osmotic diuresis will aid intravascular and extravascular volume resuscitation in the decrease of hyperglycemia (insulin effects on glucose transport are decreased by hyperglycemia and hyperosmolarity). Intravenous

fluids should be switched to dextrose-containing 0.45% NaCl solution to prevent hypoglycemia when glucose levels fall below 200–250 mg/dL, and/or insulin infusion rate should be decreased. Special considerations should be given to patients with congestive heart failure and chronic kidney disease (Kitabchi et al., 2009; Caputo et al., 1997). These patients tend to retain fluids; therefore, caution should be exercised during volume resuscitation in these patient groups. Urine output monitoring is an important step in patients with hyperglycemic crises (Basnet et al., 2014; Caputo et al., 1997).

Insulin treatment

One essential step in the management protocol of DKA is insulin administration. Insulin stimulates glucose metabolism in the periphery. It also inhibits gluconeogenesis and glycogenolysis and suppresses ketogenesis. Insulin can be delivered either intravenously or subcutaneously (Rosenthal and Barrett, 1985). Intravenous insulin administration is the more preferred route of insulin administration in cases of DKA for its rapid action. It is advised to initiate intravenous fluid management before starting insulin infusion as it might worsen dehydration (Umpierrez et al., 2004).

It is recommended that an initial bolus dose (0.1 U/kg) of regular insulin to be started immediately. This should be followed by continuous insulin infusion. Glucose level is anticipated to drop by at least 10% in the first hour of treatment. If the glucose fails to drop by 10%, an additional bolus dose of regular insulin (0.1 U/kg) can be given while insulin infusion is continued. As the blood glucose level approached the 200-250 mg/dL range, the dose of insulin infusion can be lowered by half (Ersöz et al., 2006; Goyal et al., 2010).

Potassium supplement

Close monitoring of serum potassium level is required as a part of DKA management. The correction of hyperglycemia and acidosis through the administration of insulin push potassium to intracellular spaces resulting in hypokalemia. Acute hypokalemia can result in arrhythmias and cardiac arrest (Kitabchi et al., 2008; Umpierrez et al., 2004).

If potassium level drops to <3.3 mEq/L during DKA treatment, insulin infusion should be stopped and intravenous admonition of potassium should be commenced. If the potassium level is maintained between 3.3 and 5.3 mmol/L, 20–30 mEq/L of potassium could be routinely added to the fluids. No potassium replacement is required if the potassium levels >5.3 mmol/L (Caputo et al., 1997; Umpierrez et al., 2004).

Conclusion:

In conclusion, the management of DKA is complex and needs cautious attention while restoring glucose level, hydration status, and electrolytes imbalance. Clinical guidelines should be followed to achieve a successful resolution of DKA. Emergency physicians are a cornerstone in the management of DKA and should be aware of its importance.

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