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Diabetic Ketoacidosis (DKA): A Severe Diabetes Mellitus Disorder

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Abstract

Diabetic ketoacidosis (DKA) is a life-threatening medical emergency that requires immediate evaluation and treatment. It remains a significant complication of diabetes and is increasing alarmingly worldwide. It is an endocrine complication that involves hyperglycemia, anion gap metabolic acidosis, and ketosis. It is characterized by hyperglycaemia with glucose is greater than 11 mmol/l (200 mg/dl), capillary/venous pH is less than 7.3, bicarbonate (HCO_3–) is less than 15 mEq/l, serum anion gap is greater than 16 mmol/l, moderate to severe dehydration is seen and creatinine ratio is increased, and ketones (ketonemia and ketonuria ≥3 mmol/l) are present. It occurs in patients with type 1 diabetes (T1D), and type 2 diabetes (T2D); and early diagnosis, monitoring, and treatment are necessary for the welfare of the patients. Treatment of DKA involves volume expansion, insulin replacement, and prevention of hypokalemia. DKA can be prevented through the earlier recognition and initiation of insulin therapy. An attempt has been taken here to discuss the aspects of DKA in some detail.

Keywords: diabetic ketoacidosis, dehydration, insulin therapy, ketones

1. Introduction

Diabetes mellitus (DM) is the most common chronic disease in childhood with significant morbidity and mortality (Dahlquist & Kallén, 2005). There are two main hyperglycaemic crises related to DM: i) diabetic ketoacidosis (DKA), and ii) the hyperosmotic hyperglycaemic state (HHS) (Perilli et al., 2013; Mohajan & Mohajan, 2023a). Both of them differ only by the degree of dehydration and the severity of metabolic acidosis, and both need immediate diagnosis and treatment (Kitabchi, 2009). DKA is defined as an acute metabolic decompensation caused by increasing ketones in the blood (Porth, 2015). It is characterized by hyperglycaemia, hyperosmolarity, ketosis, and acidosis. It is a serious, life-threatening complication of diabetes that can progress to cerebral edema, coma, and even death, and high death-to-case ratio is 5 to 10% (Karrar et al., 2022). It usually occurs quickly, and takes days to develop DKA among adults but it can take hours in children with acute illness, insulin omission or insulin pump failure (Lee et al., 2017).

The incidence rate of DKA has increased alarmingly globally. Female patients are more likely to suffer from episodes of DKA than male patients (Vellanki & Umpierrez, 2018). DKA is diagnosed when the blood glucose is more than 11 mmol/l (200 mg/dl), capillary/venous pH is less than 7.3, osmolality is in 300-320 mOsm/l, serum anion gap is greater than 16 mmol/l, bicarbonate (HCO_3–) is less than 15 mEq/l, moderate to severe dehydration is seen, and ketones (Ketonemia and Ketonuria ≥3 mmol/l) are present (Foster & McGarry, 1983; Modi et al., 2017). It develops due to insulin insufficiency to meet the body's basic metabolic requirements of energy and accumulates ketones from the breakdown of glycogen, fats, and proteins (Wang et al., 2008).

Ketone bodies, such as acetone, acetoacetate, and β-hydroxybuterate (β-OHB) are produced in the liver from

acetyl-CoA liberated during lipolysis from fatty acids (Sacks et al., 2002). These provide alternative usable energy sources in the absence of intracellular glucose (Wolfsdorf et al., 2018). About 1 in 100 children with DKA develops cerebral edema that has a mortality rate of 21-24% (Morris et al., 1986).

2. Literature Review

The literature review is an introductory section of research that shows the works of previous researchers in the same field within the existing knowledge (Polit & Hungler, 2013). It is a secondary source and does not report a new or an original experimental work (Gibbs, 2008). It allows a researcher to identify relevant theories, methods, and gaps in the existing research (Creswell, 2014). Hani Raka Karrar and her coauthors have focused on the epidemiology, pathogenesis, diagnosis, management, and morbidity of DKA. They have observed that DKA may be life-threatening and lead to diabetic coma or death (Karrar et al., 2022). Brit Long and his coworkers have worked on euglycemic diabetic ketoacidosis (EDKA) to evaluate the pathogenesis, diagnosis, and management of the disease (Long et al., 2021).

Atchara Charoenpiriya and her coauthors have tried to determine the differences in biochemical parameters and diabetic ketoacidosis (DKA) severity in adult patients with T1D and T2D, and utilization of serum β-hydroxybutyrate (β-OHB) as a biomarker for DKA resolution is also evaluated. Moreover, they have examined the correlations between serum β-OHB, measured by the Ranbut assay, and pH, bicarbonate, and anion gap (Charoenpiriya et al., 2022). Xiao-yan Wu and her coworkers have wanted to assess the clinical characteristics, therapeutic outcomes, and associated predisposing factors of T1D patients with isolated or combined hyperglycaemic emergencies in China (Wu et al., 2020).

Gretchen Perilli and her coauthors have reviewed DKA and observed that by understanding DKA, including its pathogenesis, presentation, treatment, and prevention, admissions may be decreased and length of stay shortened (Perilli et al., 2013). Arleta Rewers has shown that DKA is caused by absolute or relative lack of insulin that leads to hyperglycemia, ketonemia, and acidosis. She has observed that the prevention of DKA at diagnosis of diabetes can be achieved by an intensive community intervention and education of healthcare providers to raise awareness (Rewers, 2012). Horng Ruey Chua and his coworkers have examined the efficacy and risk of bicarbonate administration in the emergent treatment of severe acidemia in DKA (Chua et al., 2011). Danie van Zyl has found that in Africa the mortality of DKA is unacceptably high with a reported death rate of 26 to 29% in studies from Kenya, Tanzania and Ghana. He focuses on the principles of diagnosis, monitoring and treatment of DKA, with special mention of new developments and controversial issues (van Zyl, 2008). Devajit Mohajan and Haradhan Kumar Mohajan have discussed the aspects of diabetes mellitus (DM) and its related diseases in a series papers (Mohajan & Mohajan, 2023b-g).

3. Research Methodology of the Study

Research is a vital and significant device to the academicians for the leading in academic world (Pandey & Pandey, 2015). On the other hand, methodology in any creative research is the organized and meaningful procedural works that follow scientific methods efficiently (Kothari, 2008). Therefore, research methodology is the collection of a set of principles for organizing, planning, designing, and conducting a good research (Legesse, 2014). To rationalize the selection of a research methodology, a researcher must understand its philosophical origins and unique characteristics (Rieger, 2019; Mohajan, 2018).

In this mini review paper, we have highlighted causes, and signs and symptoms of DKA. Then we have briefly discussed the risk factors and treatment of DKA. To prepare this paper, we have followed qualitative research approaches (Islam et al., 2010; Mohajan, 2013, 2018, 2022). We have tried our best to maintain the reliability and validity throughout the paper, and also have tried to cite references properly both in the text and reference list (Mohajan, 2015; Mohajan et al., 2013). In this paper, we have depended on the secondary data sources of optimization. To prepare this paper we have consulted books of famous authors, national and international journals, e-journals, handbooks, theses, etc. (Mohajan & Mohajan, 2023h-s).

4. Objective of the Study

The chief objective of this study is to discuss the diabetic ketoacidosis (DKA) of DM patients. The disorder DKA is the accumulation of ketone bodies in the blood of diabetes patients that results in metabolic acidosis. When the body burns fat for energy instead of sugar, ketones are produced. It is a potentially life-threatening condition that is caused by a lack of insulin in the body. Other minor objectives of the study are as follows:

- to show the causes of DKA,
- to search the symptoms of DKA, and
- to focus on the risk factors and treatment of DKA.

5. Causes of DKA

DKA occurs mostly in patients with type 1 diabetes (T1D) (70% to 90%) and is less common in those with type 2 diabetes (T2D) (10% to 30%), and mortality rate in DKA is about 4% (Kitabchi et al., 2009; Barski et al., 2013). Usually if T1D is remained undiagnosed and untreated for a long-time, DKA may develop very quickly. Some other causes of DKA are insulin omission or manipulation, pregnancy, infection, myocardial infarction, inadequate dosing of insulin and medications, weak monitoring, insulin pump or infusion site malfunction, etc. (Misra et al., 2013). For the development of DKA, an absolute or relative insulin deficiency is seen. In DKA, due to lack of insulin, there is decreased storage of glucose, increased breakdown of glycogen stores, and increased synthesis of glucose in both the liver and kidney. The hyperosmolar, hyperglycaemic, ketotic state causes cell dehydration and polyuria with great electrolyte and fluid loss (Perilli et al., 2013).

6. Signs and Symptoms of DKA

Primary symptoms of DKA are polyuria, Polydypsia, polyphagia, and weight loss (Newton & Rashkin, 2004). The more acute symptoms of DKA are nausea, vomiting, headache, dehydration, weakness, fatigue, myalgia, altered mentation, fruity-smelling breath, shortness of breath, blurry vision, dry mucous membrane, drowsiness, tachycardia, tachypnea, dry mouth, poor skin turgor, malaise, hypotension, deep sighing respiration, flushed face, confusion, increased heart rate, abdominal pain, and Kussmaul respirations (Kronenberg & Williams, 2008). Lethargy and somnolence are symptoms of more severe decompensation. Also decreased sensorial mental status, varies from sleepiness, drowsiness, confusion, semi coma, and coma during severe DKA (Edge et al., 2001; Wolfsdorf et al., 2018). Abdominal pain is a misleading manifestation, which can result in the late or misdiagnosis of DKA due to the presence of metabolic acidosis (Umpierrez & Freire, 2002).

7. Risk Factors and Treatment of DKA

Risk factors for DKA are insulin omission, infection, myocardial infarction (MI), abdominal crisis, trauma, and possibly continuous subcutaneous insulin infusion (CSII) therapy, thyrotoxicosis, cocaine, atypical antipsychotics, and possibly interferon (Hamblin et al., 1989; Wolfsdorf et al., 2018). The patient may present with wide range of manifestations like ketosis, ketoacidosis, ketoacidosis pre-coma and coma (Narasimham et al., 2015). Laboratory and bedside biochemical measurements for DKA, such as capillary blood glucose, urine or blood ketones, serum potassium, sodium, phosphate, and venous pH should be evaluated regularly (Eledrisi et al., 2006).

The treatment of DKA is fluid resuscitation, electrolyte replacement, insulin administration, and monitoring of the signs of cerebral edema and fluid overdose (Gosmanov et al., 2014). DKA is an entirely preventable condition, and treatment involves volume expansion, insulin replacement, and prevention of hypokalemia (Rewers, 2012). Some strategies can prevent DKA, such as diabetes education, regular blood glucose and ketones monitoring, diet and insulin monitoring, reduction or elimination of insulin during fasting. Intravenous (IV) fluid replacement and administration of insulin are common treatment of DKA (Singh et al., 1997). Medications for DKA are canagliflozin, dapagliflozin, and empagliflozin that reduce body weight, serum glucose, hemoglobin A1c levels, and blood pressure (Zelniker et al., 2019).

Total body potassium is decreased in DKA that may lead to severe hypokalaemia with cardiac arrhythmias, and potassium supplementation is necessary. The phosphate concentration may drop significantly during insulin administration that may result in muscle weakness and respiratory depression, and phosphate should be replaced (Wallace & Matthews, 2004).

8. Conclusions

Diabetic ketoacidosis (DKA) is the major life-threatening complications of diabetes that can be prevented, but unfortunately it is the main cause of morbidity and mortality of diabetes patients. The major risk factors for DKA are first presentation of disease, and discontinuation of diagnose and treatment. It is a common and severe complication of diabetes that is seen in both T1D and T2D patients. It is a medical emergency and requires urgent treatment with insulin and intravenous fluids. Both patient and family members need proper training of management of DKA during sick days. They must be sincere about the proper use of insulin of the patient. We hope that the physicians and all other healthcare professionals will identify the DKA and will treat it immediately.

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