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Original article

Urinary Tract Infections and Inadequate Insulin Therapy as a Precipitating for Diabetic Ketoacidosis in Type 1 Diabetes Mellitus: Case Report

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ABSTRACT

Diabetic ketoacidosis (DKA) is a severe acute metabolic complication of diabetes mellitus. In this case, it was caused by Type 1 diabetes mellitus, as evidenced by a C-Peptide result of 0.33, coupled with poor insulin adherence. An 18-year-old girl presented with shortness of breath. She had a history of irregular insulin injections, indicating poor adherence. Physical examination revealed a lethargic appearance, apathetic consciousness, tachycardia (heart rate 127 beats/minute), and an axillary temperature of 37.8°C. Kussmaul breathing was also observed. Laboratory findings showed elevated white blood cells (15,950/µL), hyperglycemia (blood sugar 379 mg/dL), and severe metabolic acidosis (Blood Gas Analysis: pH 6.89, HCO3 1 mmol/L). Urinalysis indicated albumin +1, glucose +2, ketones +3, leukocytes +3, and the presence of bacteria. The patient was monitored in the Intensive Care Unit for five days, followed by three days in the general ward. DKA is characterized by hyperglycemia, hyperketonemia, and metabolic acidosis. Adherence to insulin therapy is crucial for achieving good glycemic control in patients with Type 1 diabetes. Discipline in management is key to preventing this condition and reducing DKA-related mortality.

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INTRODUCTION

Diabetes mellitus (DM) was the most prevalent group of metabolic disorders affecting the global population in 2021 (Oliveira et al., 2023). Type 1 diabetes, specifically, has a global prevalence of 5.9 per 10,000 people. Its incidence has increased rapidly over the past five decades, with current estimates at 15 per 100,000 people annually (Davies et al., 2022).

Type 1 diabetes results from autoimmune damage to the insulin-producing β-cells in the pancreatic islets, typically leading to severe endogenous insulin deficiency. This form of diabetes accounts for approximately 5-10% of all diabetes cases (Davies et al., 2022).

Diabetic ketoacidosis (DKA) is a potentially life-threatening acute complication in individuals with type 1 diabetes mellitus (T1D) (Hepprich et al., 2023). It is characterized by metabolic acidosis, ketosis, and uncontrolled hyperglycemia (Flores et al., 2020). The prevalence of DKA in T1D patients varies widely, ranging from 10 to 128 episodes per 1,000 people annually, with higher rates observed in poorly controlled diabetes (Ata et al., 2023).

CASE ILLUSTRATION

An 18-year-old female was admitted to the emergency department, referred from another hospital. The patient appeared weak, had difficulty communicating, and complained of shortness of breath that had started approximately 6 hours prior. She experienced continuous dyspnea when sitting or lying down, along with heartburn. These symptoms began in the morning and worsened throughout the day.

The patient had a history of irregular eating habits and had consumed spicy food several days ago while undergoing training at a hotel. Consequently, she had not been administering insulin regularly. The patient's family reported that she had experienced similar complaints before and had been hospitalized, but not as severely as this instance. She had been diagnosed with Type 1 diabetes mellitus 6 years ago and was on insulin therapy.

Physical examination revealed:

- General appearance: Lethargic, apathetic consciousness;
- Glasgow Coma Scale: E3V4M6

Vital signs:

- Blood pressure: 143/82 mmHg
- Heart rate: 127 bpm (tachycardia)
- Respiratory rate: 26/min
- Oxygen saturation: 99% with 4 lpm nasal cannula
- Axillary temperature: 37.8°C
- Body weight: 60 kg

Chest examination showed symmetry with regular S1S2 heart sounds, no intercostal retractions, Kussmaul breathing, and vesicular breath sounds. Abdominal examination revealed a soft abdomen without distension, epigastric tenderness, normal liver and spleen, tympanic sounds, and normal bowel sounds. Extremities were warm without edema.

Laboratory results:

- WBC: 15,950/µL
- Hemoglobin: 13.5 g/dL
- Hematocrit: 41.1%
- Platelets: 435,000/µL
- Sodium: 140 mmol/L
- Potassium: 5.5 mmol/L
- Chloride: 109 mmol/L
- Blood glucose: 221 mg/dL
- Urea: 17 mg/dL
- Creatinine: 0.7 mg/dL
- Arterial blood gas: pH 6.89, PCO2 6 mmHg, PO2 167 mmHg, HCO3 1 mmol/L, BE < -30 mmol/L, SO2 98%
- Urinalysis: Albumin +1, glucose +2, ketones +3, leukocytes +3, bacteria +

Treatment in the emergency room included oxygen therapy, fluid resuscitation with 0.9% NaCl, acidosis correction with NaHCO3 in 0.9% NaCl, and intravenous rapid-acting insulin (Lispro) via syringe pump. Ceftriaxone 1g BID was administered. Fluid intake and output were monitored every 24 hours.

The patient was monitored in the Intensive Care Unit for 5 days, followed by 3 days in the general ward. On the first day in the ICU, the patient remained weak and somnolent. A central venous catheter was inserted, and Kussmaul breathing had decreased. Fluid balance showed an input of 3814 mL and output of 3695 mL.

As the patient's condition improved, insulin therapy was switched to subcutaneous basal-bolus regimen. C-peptide examination was planned. By the third day, the patient reported improvement in shortness of breath and nausea, and was able to eat. On the fourth and fifth days, the patient's condition significantly improved, with better communication and appetite, and no fever. HbA1C result was 14.9%. On the fourth day, subcutaneous insulin glargine was added to the regimen, continuing with subcutaneous insulin lispro. The patient was then transferred to the inpatient ward. Over the next three days, nausea, fever, and heartburn resolved, vital signs normalized, and the C-peptide result was 0.03.

DISCUSSION

Diabetic ketoacidosis (DKA) is a severe acute metabolic complication of diabetes mellitus, characterized by hyperglycemia, ketonemia, and metabolic acidosis. In this case, DKA was caused by type 1 diabetes mellitus, which the patient had been diagnosed with six years prior, as evidenced by a C-Peptide result of 0.33.

Patients with type 1 diabetes have high insulin requirements, which can eventually deplete their body's insulin. This insulin deficiency leads to excessive fat breakdown, resulting in an accumulation of ketone bodies (Elendu et al., 2023). Insulin plays a crucial role in fuel homeostasis through its effects on the liver, muscle, and adipose tissue. It stimulates glycogen synthesis and the conversion of free fatty acids (FFA) into triglycerides, promoting energy storage.

In DKA, abundantly circulating FFAs are transported to the liver's mitochondria for oxidation, forming ketone bodies such as beta-hydroxybutyrate, acetone, and acetoacetate. While insulin normally regulates this process, insufficient insulin leads to excessive ketone production. Various conditions can trigger DKA, including infections (particularly pneumonia and urinary tract infections), new diabetes diagnoses, poor adherence to insulin therapy, or inadequate insulin doses.

Hormones such as glucagon, catecholamines, cortisol, and growth hormone significantly increase blood glucose through gluconeogenesis and glycogenolysis. These hormones can be released in response to stress, including infections like urinary tract infections and respiratory tract infections (Elendu et al., 2023). In this case, the patient demonstrated poor insulin adherence and laboratory examination revealed a urinary tract infection.

The catabolic state induced by these hormones causes increased lipolysis and proteolysis for glucose synthesis, exacerbating hyperglycemia (Elendu et al., 2023). Clinical presentations of DKA typically include symptoms of hyperglycemia such as polyuria, polydipsia, weakness, and weight loss. In severe cases, manifestations of acidosis may include lethargy, stupor, loss of consciousness, and respiratory distress.

Gastrointestinal symptoms like abdominal pain, nausea, and vomiting are common in DKA and usually resolve with treatment. Patients often present with signs of volume depletion,

including tachycardia, hypotension, decreased skin turgor, and dry oral mucosa. Body temperature can be normal or even low despite infection, primarily due to peripheral vasodilation.

Other physical signs may include Kussmaul respirations(rapid and deep breathing) with acetone (fruity) breath odor, alteration in mental status, shock and coma.(Belaunzarán-Zamudio et al., 2020) One examination aspect that can be confusing is abdominal tenderness, abdominal pain correlates with the level of acidosis.(Elendu et al., 2023) In this case the patient complained of shortness of breath, heartburn, nausea, On physical examination, the general appearance was lethargic, conscious apathetic, Heart rate 127x/minute(tachycardia), there is Kussmaul breathing, on abdominal examination there is tenderness regio epigastric. The diagnosis of DKA consists of a triad of hyperglycemia, ketonemia, and metabolic acidosis. The new American Diabetes Association definition of DKA includes a blood glucose level of 13.9 mmol/l (250 mg/dl).(Elendu et al., 2023) The second feature of DKA is the presence of ketones in the urine and/or serum.The third diagnostic aspect in DKA is the presence of acidosis, defined as serum bicarbonate level of ≤18 mmol/L and/or arterial pH ≤7.30.(Eledrisi & Elzouki, 2020) The accumulation of ketoacids results in high anion gap metabolic acidosis; the anion gap is calculated by the following formula: [Na − (Cl + HCO3)].(Eledrisi & Elzouki, 2020) In this case laboratory examination obtained of this patient there are hyperglicemia blood sugar was 379 mg/dl, ketonemia not obtained on this case because could not be do these laboratory examination, but on this patient found of ketones in the urine +3,serum bicarbocat was 1 mmol/L, arterial PH was 6.89, anion gap was 30. Other tests may show elevated white blood cell count (10,000–15,000 mm3), which is common in DKA and is attributed to dehydration, stress and demargination of leukocytes. In this case on the laboratory examination found that white blood cells was white blood cells was 15,950/µL, in the urine there are leukocytes +3, bacteria+.

Diagnostic criteria and severity of diabetic ketoacidosis

	Mild	Moderate	Severe
Plasma glucose (mmol/l)	>13.9	>13.9	>13.9
Arterial pH	7.25–7.30	7.00–7.24	<7.00
Serum bicarbonate (mmol/l)	15–18	10–14.9	<10
Urine ketones	+ +	+ +	+ + +
Serum ketones	+ + +	+ + +	+ + +
Anion gap	>10	>12	>12
Sensorium	Alert	Alert/drowsy	Stupor/coma
Serum sodium	Normal	Low	Low
Serum potassium	Normal	High	High
Serum phosphate	Normal	High	High

Therapy goals in patients with hyperglycemic crises include improving the circulatory volume and tissue perfusion, gradual reduction of serum glucose and osmolality, correcting electrolyte imbalance, and identifying and promptly treating comorbid precipitating causes. Successful treatment of DKA requires frequent monitoring of patients regarding the above goals by clinical and laboratory parameters.(Elendu et al., 2023) A patient with diabetic ketoacidosis might have normal potassium levels before the initiation of treatment; the medical practitioner should take caution to prevent severe hypokalemia after initiating insulin therapy. Severe hyperglycemic crises are recommended to be treated at least in the High Care Unit (HCU), with the criteria for blood ketone levels > 6 mmol/L, bicarbonate levels < 5 mmol/L, pH < 7.0, hypokalemia < 2.5 mmol/L, decreased consciousness , hemodynamic disorders, and anion gap >16.(PB Perkeni,2022) Intravenous (IV) fluid therapy expands the intravascular volume, improves renal perfusion and reduces peripheral insulin resistance by reducing levels of counter-regulatory hormones; the net result will be a reduction in blood glucose levels. Normal saline (0.9% sodium chloride) is recommended as the initial IV fluid replacement in DKA. Initial IV fluid replacement starts with 0.9% sodium chloride at a rate of 15–20 ml/kg (about 1–1.5 L) over the 1st hours (Eledrisi & Elzouki, 2020).

Administration of bicarbonate may help control acidosis in some patients. With these considerations in mind, bicarbonate is given only at lethal pH count, was <6.9 by giving NaHCO3 50-100 mEq for 2 hours and can be repeated every 2 hours until pH ≥ 7.0.(PB Perkeni,2022) Potassium monitoring should be carried out every 2 hours in patients receiving bicarbonate, bicarbonate is known to have potential side effects of hypokalemia. (PB Perkeni,2022) Bicarbonate administration can lead to post-treatment metabolic alkalosis as insulin mediated

ketoacid metabolism leads to both spontaneous bicarbonate generation and resolution of metabolic acidosis.(Patel et al., 2018) Acidemia engendered by metabolic acidosis promptly triggers hyperventilation that decreases PaCO2.(Kraut & Madias, 2010) Insulin is usually given through IV. route, starting with a bolus of regular insulin at a dose of 0.1 unit/kg body weight, and then, within 5 min followed by a continuous infusion of regular insulin of 0.1 unit/kg/hour.(Eledrisi & Elzouki, 2020) The important thing in maintaining the outcome of DKA patients is not to reduce blood sugar too quickly (50-75 mg/dL/hour), giving food as early as possible to stimulate endogenous insulin. (PB Perkeni,2022).

Resolution of DKA is indicated by a glucose level of 7.3 and/or an anion gap ≤12 mmol/L. The patient should be clinically stable and able to tolerate oral feeding. In this case patient was given oxygenation therapy, the patient received fluid rescucitation with NaCl 0.9%, and then correting an acidosis with NaBic. Drip rapid acting insulin (lispro) intravenous by syringe pump, ceftriaxone two time a day. The patient was treated in the ICU. Patient monitored by CVC to monitored the sufficient fluid in the body, After a few days treated in the the ICU patient getting more stable and can eat properly, then the laboratory examination show a result that's the blood gas analysis PH was 7.26, HCO3 was 10 ,sodium was 140 mmol/L, potassium was 4.8 mmol/L, chloride was 109 mmol/L, blood sugar was 194 mg/dL, urine output is sufficient, so the patient can move to general ward. During treated in the general ward the patient more stable and the symptoms were just resolved. The patient also are given education like prevention Ketoacidosis Diabetic that doesn't happen again, prevention the infection, good adherence to the medication.

Diabetic ketoacidosis is the most frequent and serious complication in patients with type 1 Diabetes Mellitus. Several factors that can trigger metabolic ketoacidosis its like a poor medication adherence and infections which cause an increase blood glucose level followed by ketogenesis and metabolic acidosis. Therapy goals in patients with hyperglycemic crises include improving the circulatory volume and tissue perfusion, gradual reduction of serum glucose and osmolality, correcting electrolyte imbalance, and identifying and promptly treating comorbid precipitating causes.

Adherence to insulin therapy is crucial to achieving good glycemic control for patients with type 1, discipline regarding insulin is one of the important thing to prevent complications in patients with type 1 diabetes mellitus. Furthermore, improve a healthy lifestyle such as exercising, consuming nourishing food, disciplined about the time when we have to eat and portions of meals, take sufficient rest, regularly checking with your doctor. It is important to be discipline because the key of preventive this disease, also to reduce the mortality of DKA.

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