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CASE REPORT

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Treatment of septic shock in two pediatric patients with severe diabetic ketoacidosis using invasive hemodynamic monitoring: a case report

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Abstract

Background Diabetic ketoacidosis (DKA) is a life-threatening complication of diabetes mellitus. DKA associated with shock is a rare condition that occurs due to the fluid deficit or septic shock. It is not easy to differentiate these two conditions by clinical judgment and laboratory findings. Although the fluid therapy is the mainstay in DKA treatment, it looks like a double-edged sword—underhydration may result in organ failure whereas overhydration may lead to pulmonary and cerebral edema (CE).

Case presentation Herein, we report on two pediatric patients presenting with DKA and septic shock. The first patient was an 8-year-old boy newly diagnosed with type 1 diabetes mellitus (T1DM) who presented with DKA and septic shock. We used a device for continuous hemodynamic monitoring (proAQT) to estimate his volume status. The patient was extubated 48 hours of hospitalization; the DKA was resolved after 52 hours of admission. He was discharged home in good condition on the 5th day. The second patient was a 13-year-old girl, a known case of T1DM, who presented with mixed DKA- hyperosmolar-hyperglycemic state (HHS) and septic shock. She was intubated and treated according to the data derived from pulse Contour Cardiac Output (PiCCO). After 3 days, she was extubated and transferred to the ward in good condition.

Conclusion Using invasive hemodynamic monitoring in critically ill children with severe DKA and hypotension might guide the physicians for hydration and selecting the most appropriate inotrope.

Keywords Diabetic ketoacidosis, Invasive hemodynamic monitoring, Septic shock, Case report

Background

Diabetic ketoacidosis (DKA) is one of the hyperglycemic emergencies that may occur in diabetic patients. The diagnostic criteria of DKA include hyperglycemia (blood glucose > 11 mmol/L [198 mg/dL]), venous pH < 7.3 or serum bicarbonate level < 15 mmol/L, and ketonemia (blood β-hydroxybutyrate ≥ 3 mmol/L) or moderate to severe ketonuria [1]. Another serious complication in diabetic patients is extreme hyperglycemia (blood glucose > 33.3 mmol/L [600 mg/dL]), effective serum osmolality > 320 mmol/kg (mOsmol/kg H2O), venous pH > 7.25, and absent or minimal ketosis, which is defined as hyperglycemic-hyperosmolar state (HHS) [1].

Risk factors of DKA include the lack of taking insulin at the right time or omitting it, history of previous episodes

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Discussion and conclusions

We presented two patients with DKA and septic shock. They both had severe DKA, hypotension, and hypoxemia. Their hemodynamic variables were measured using invasive hemodynamic monitoring devices. The recommendation of the International Surviving Sepsis Campaign for children is to employ advanced hemodynamic indices, besides clinical data [11]. Although there are several methods of invasive hemodynamic monitoring in our center, we used two less invasive methods—ProAQT and PiCCO. PiCCO provides more hemodynamic parameters to assess volume status and variables to determine the volume overload [10].

Regarding the issue of volume depletion in DKA, the main goal of fluid therapy is preserving adequate circulation to the vital organs and restoring the deficiency of the fluid over 24–48 hrs. Both overhydration and underhydration are harmful, management of patients with DKA and hypotension would be more complicated. Invasive hemodynamic monitoring should thus be used to determine when to start hydration and how much fluid should be given to the patient, when to stop hydration, and which inotrope should be initiated [11, 12].

Leukocytosis is generally seen in patients with DKA. However, when white blood cell counts are > 20,000/μL, we should consider sepsis and start appropriate antibiotics as delayed treatment increases the mortality [13, 14]. Our patients had leukocytosis of more than 20,000/μL; they were clinically suspected to have infection. The causative organisms in blood cultures were Streptococcus and Klebsiella spp. in the first and second patients, respectively; antibiotic was started in the first hour of admission in the second patient, but it was started on the 6th hour of admission in the first case when he was admitted in PICU.

Hypovolemia and sepsis are the main factors in patients with DKA and shock. However, it is not easy to differentiate these two solely based on physical examinations. It often seems better to use a combination of these two, but it is essential to determine what to choose for increasing the BP (fluid vs inotrope) or which inotrope should be started. Although hydration of the patient with more than 30 mL/kg in the first 8 h is rarely recommended in DKA management [1, 11], our first patient received 50 mL/kg of hydration in the first 2 h; the second received up to 60 mL/kg.

There is a controversy about the etiology of CE. Some suppose that rapid fluid administration with rapid changes in serum osmolality is responsible for this disorder [15]. Therefore, CE was considered during the treatment and after the first hydration, as the patient's hemodynamic parameters improved. According to SVV, we could give him bolus hydration, but we did not. The reason was that we preferred to use laboratory data along with these hemodynamic variables.

The higher mortality rate in patients with DKA in underdeveloped countries can be attributed to sepsis, septic shock, delayed recognition, CE, and renal failure [16].

For managing patients with severe DKA and hypotension, we cannot solely rely on clinical examination and laboratory data to save the vital organs. Underhydration may result in organ failure such as renal failure; overhydration, on the other hand, may lead to pulmonary and Especially in other situations such as: DKA with renal failure or heart failure which we can not hydrate the patients as routine, Therefore, it would be better to use invasive hemodynamic monitoring or even non- invasive tools (according to availability of equipment in each center) in critically ill patients to guide the physicians for hydration and selecting the most appropriate inotrope;but To date, there are no experiments that investigated the acceptable range of hemodynamic parameters to guide fluid therapy in patients with DKA,or DKA with shock; so additional studies are required to identify the safe ranges.

Abbreviations

AST	Aspartate transaminase
ALT	Alanine aminotransferase
BP	Blood pressure
BUN	Blood urea nitrogen
CE	Cerebral edema
CI	Cardiac index
CPK	Creatine phosphokinase
Cr	Creatinine
CRP	C-reactive protein
DKA	Diabetic ketoacidosis
EVLWI	Extravascular lung water index
GEDI	Global end-diastolic index
ITBI	Intra-thoracic blood volume index
LDH	Lactate dehydrogenase
MAP	Mean arterial blood pressure
PiCCO	Pulse contour cardiac output
PICU	Pediatric intensive care unit
PPV	Pulse pressure variation
PVPI	Pulmonary vascular permeability index
SCVO2	Central venous O2 saturation
SVRI	Systemic vascular resistance index
SVV	Stroke volume variation
T1DM	Type 1 diabetes mellitus
VBG	Venous blood gas
WBC	White blood cell count

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Authors' contributions

AS conceptualized and led the study, managed the clinical aspects of the patient, and drafted the manuscript. FZ reviewed and critically revised the manuscript. All the authors approved the final version of the manuscript, and are accountable for all aspects of the work.