Case Report

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Limited significance of bicarbonate therapy in the treatment of diabetic ketoacidosis: a rare case report in the periphery of Nepal

Pran Shrestha, MD[a,*], Ajaya Raj Gautam, MD[b], Sibika Malla, MBBS[d], Susmita Parajuli, MBBS[c], Rupak K.C., MBBS[b]

Introduction and importance: An uncontrolled hyperglycaemia accompanied by metabolic acidosis and an increase in total body ketone, if left untreated, has the potential to develop into complications, including diabetes ketoacidosis (DKA). Management of this complication with IV hydration, IV Insulin, and potassium (KCL) maintenance is a comprehensive approach. On the contrary, bicarbonate therapy is generally not regarded as a standard treatment due to its unfavourable outcome.

Case presentation: The authors present a case of a 21-year-old female who was brought in a semiconscious state to the emergency department with complaints of pain in the abdomen, headache, and vomiting. DKA was diagnosed following the patient's symptoms and arterial blood gas analysis report. She was managed with IV fluids, IV insulin, and KCL.

Clinical discussion: Generally, pH less than 6.8 has a poor patient survival outcome. Here, the patient presented with pH less than 6.6, where she was managed with the standard regimen without the need to administer bicarbonate therapy.

Conclusion: DKA is a life-threatening condition that can be precipitated by non-adherence to medications and infections with IV insulin and hydration playing a pivotal role in its management while bicarbonate offers no beneficial effect.

Keywords: bicarbonate therapy, case report, diabetic ketoacidosis, medication non-adherence, Nepal

Introduction

Diabetic ketoacidosis (DKA) often manifests as an acute complication of uncontrolled diabetes mellitus. Ketoacidosis tends to affect females and the young population[1]. Elderly and patients with comorbidities diagnosed with DKA experience a substantial 5% increase in mortality[2]. Aggressive administration of intravenous fluids and intravenous insulin is the essential standard of care for managing DKA[3].

Recently in numerous studies, bicarbonate therapy has been found to lead to deleterious effects such as paradoxical central nervous system (CNS) acidosis, intracellular acidosis, cerebral oedema, and hypokalemia[4,5]. There is no evidence of measurable benefits in patient outcomes or reduction in hospital stays[6,7]. We present a case of a 21-year-old female who showed improvement with standard care alone negating the use of bicarbonate therapy. This case report has been reported in line with the SCARE 2023 guidelines[8].

HIGHLIGHTS

- A rare case of diabetic ketoacidosis with pH less than 6.617 was reported in the periphery of Nepal.
- The overall mortality of diabetic ketoacidosis in the adult population is 1%.
- Significant improvement without the administration of bicarbonate therapy.
- First recorded case of survival at such severe pH in Nepal.

Timeline

The patient presented to the emergency room in a semiconscious state brought in by ambulance at our institution on 29 October 2023 and was admitted to the ICU after stabilizing her vitals and transferred out to the medicine ward subsequently. Her duration of stay at the ICU was 4 days and the ward for observation was 2 days. Written informed consent to write and publish this case report and data was taken from her, a day before her discharge. Ethical approval was not required for case reports at our institution.

Case summary

A 21-year-old unmarried female from Deukhari, Dang presented to the emergency department of Rapti Academy of Health Sciences (RAHS), Ghorahi, Dang, Lumbini province,

[a]Anesthesia and Critical Care Medicine, Rapti Academy of Health Sciences, [b]Internal Medicine, Rapti Academy of Health Sciences, [c]Pediatrics, Rapti Academy of Health Sciences, Ghorahi and [d]Emergency Medicine, B&B Hospital, Patan, Nepal

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*Corresponding author. Address: Department of Anesthesia and Critical Care Medicine, Rapti Academy of Health Sciences (RAHS), Ghorahi-14, Lumbini Province, Nepal. Tel.: +977 985 121 3475. E-mail: Shrestha.pran75@gmail.com (P. Shrestha).

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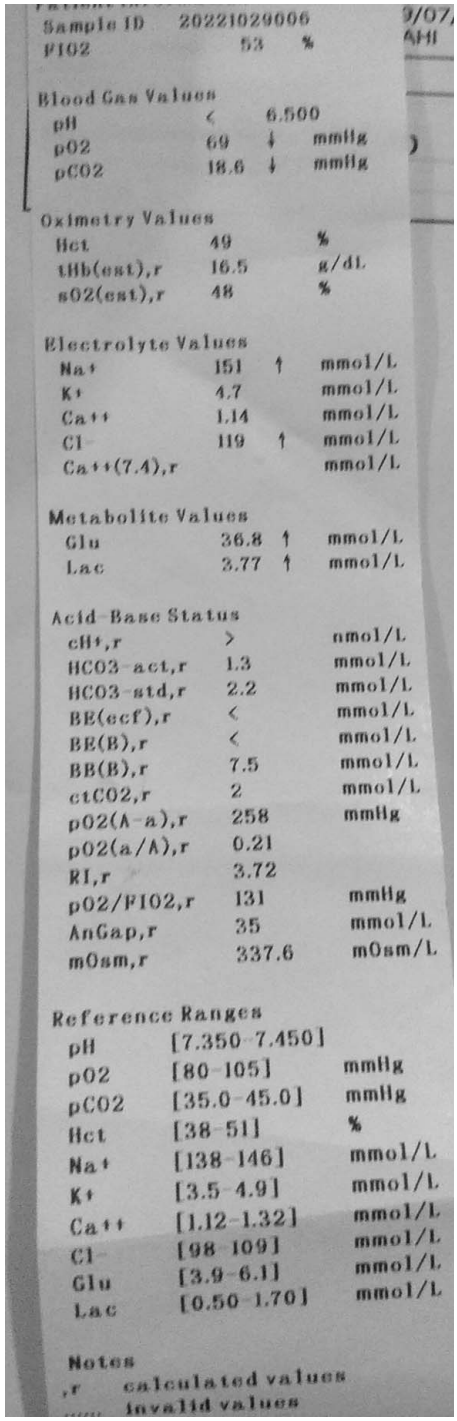
Nepal in a semiconscious state, experiencing pain over the abdomen, along with a headache and vomiting. The patient appeared drowsy; her Glasgow Coma Score (GCS) was 11. She has been previously diagnosed with diabetes mellitus (DM) and was prescribed medication (Tab. METFORMIN 500 mg BD) by a healthcare worker in the local polyclinic, but she did not adhere to the treatment consistently as per the medication history taken from her parents. Her vital signs were recorded: blood pressure (B.P.) 130/80 mm Hg, heart rate 116 bpm, and respiratory rate 32 breaths/min with kussmauls respiration. The lab reports indicated a random blood sugar (RBS) of 607 mg/dl, Serum sodium was 135 meq/l, Serum potassium was 4.1 meq/l, Serum Urea was 80 mg/dl and Serum Creatinine was 0.7 mg/dl. Her venous blood gas (VBG) sample showed a pH of less than 6.5, pCo2 18.6 mmHg, Hco3-std, r 2.2 mmol/L, Na^+ 151 mmol/l, K^+ 4.7 mmol/l (Fig. 1). She was diagnosed with DKA, and medication non-adherence was identified as the root cause of her condition. Subsequently, it was discovered that her condition was compounded by an infection, as indicated by her total leucocyte count from the lab investigations done.

Infusion with normal saline and IV regular insulin was initiated at the emergency department. IV regular insulin was given at a dose of 10 U at 7:20 pm and another 10 U at 8:40 pm, along with Inj. piperacillin and tazobactam 4.5 gm IV Stat. Based on the patient's Bicarbonate level, initiation of the sodium bicarbonate therapy was considered, but unfortunately, it wasn't accessible around the nearby area due to the shortage of the medication at that time.

Afterward, the patient was shifted to the ICU, and arterial blood gas (ABG) analysis was performed (Fig. 2). A maintenance dose of regular insulin 5 units/hour was continued via an infusion pump. The fluid regimen included plasma-lyte, with infusions divided as follows: 1 l over 2 h, followed by another 1 l over 4 h, an additional 1 l over 4 h, and finally, the last 1 l was infused over 6 h. Additionally, the patient received an injection of KCL (potassium chloride), initially at a dose of 40 milliequivalents over 2 h which was later increased to 60 meq in 500 ml NS over 6 h.

The following day, the patient's condition showed improvement in lab reports, with a potassium level of 3.6 mmol/l, pH reaching 7.088 mmHg, and bicarbonate level increasing to 7.9 mmol/l. Plasma-lyte 150 ml/h continued, and after 6 h a follow-up ABG indicated pH 7.32, pCo2 19.1 mm Hg, Na^+ 142 mmol/l, K^+ 2.9 mmol/l, and bicarbonate level was improved to 13.3 mmol/l. IV fluid was continued and Inj. KCL was increased to 80 meq IV over 6 h. After 3 days of ICU stay, significant improvement was observed in ABG with a pH of 7.456, pCo2 of 33 mmHg, and bicarbonate level of 24 mmol/l (Table 1).

The patient was shifted to the ward where a diabetic diet was initiated and kept under observation for 2 days. She was started under a basal-bolus insulin regimen during her stay. She was discharged with Regular insulin 6 units subcutaneously (s.c.) before lunch and dinner along with Glargine 14 Units (s.c.) before sleep. She was appropriately counselled regarding the potential outcomes of not adhering to the medications and was educated about the indicators of hypoglycemia. She has consistently attended monthly outpatient visits at the Department of Medicine, RAHS for follow-up.


Sample ID 20221029006
FIO2 53 %

Blood Gas Values			
pH	<	6.500	
pO2	69	↓	mmHg
pCO2	18.6	↓	mmHg

Oximetry Values			
Hct	49		%
tHb(est),r	16.5		g/dL
sO2(est),r	48		%

Electrolyte Values			
Na+	151	↑	mmol/L
K+	4.7		mmol/L
Ca++	1.14		mmol/L
Cl-	119	↑	mmol/L
Ca++(7.4),r			mmol/L

Metabolite Values			
Glu	36.8	↑	mmol/L
Lac	3.77	↑	mmol/L

Acid-Base Status		
cH+,r	>	nmol/L
HCO3-act,r	1.3	mmol/L
HCO3-std,r	2.2	mmol/L
BE(ecf),r	<	mmol/L
BE(B),r	<	mmol/L
BB(B),r	7.5	mmol/L
ctCO2,r	2	mmol/L
pO2(A-a),r	258	mmHg
pO2(a/A),r	0.21	
RI,r	3.72	
pO2/FIO2,r	131	mmHg
AnGap,r	35	mmol/L
mOsm,r	337.6	mOsm/L

Reference Ranges		
pH	[7.350-7.450]	
pO2	[80-105]	mmHg
pCO2	[35.0-45.0]	mmHg
Hct	[38-51]	%
Na+	[138-146]	mmol/L
K+	[3.5-4.9]	mmol/L
Ca++	[1.12-1.32]	mmol/L
Cl-	[98-109]	mmol/L
Glu	[3.9-6.1]	mmol/L
Lac	[0.50-1.70]	mmol/L

Notes
,r calculated values
..... invalid values

Figure 1. Venous blood gas analysis at the time of presentation.

Discussion

A 21-year-old single female from Deukhari, Dang who initially presented at the emergency department in a semiconscious state with the symptoms of abdominal pain, headache, and vomiting, was treated with Intravenous fluids and Insulin and showed improvement in her condition from admission to discharge. In the management of DKA, it is necessary to address dehydration,

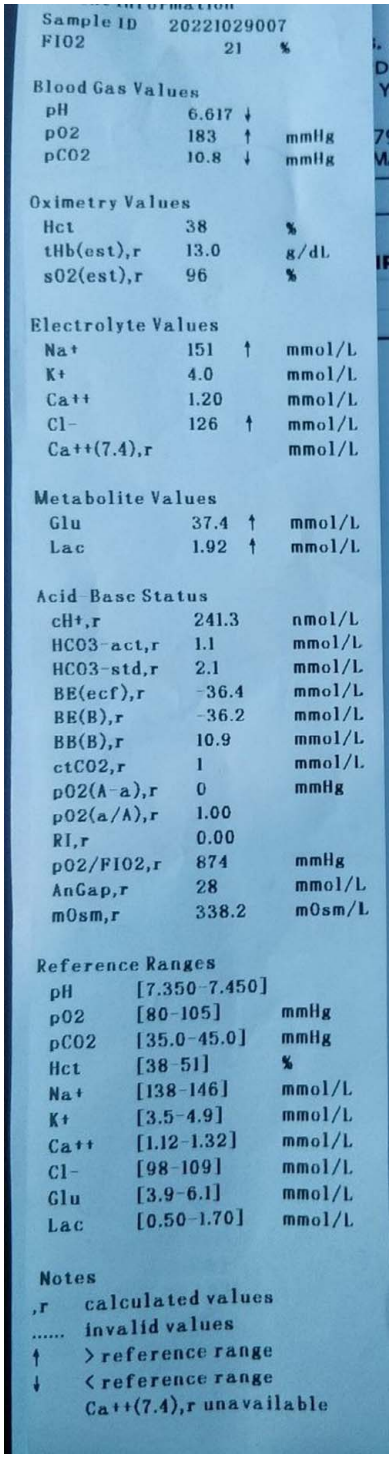


Figure 2. Arterial blood gas (ABG) analysis at ICU.

Table 1

Blood investigation report of the patient during the treatment course

Arterial blood gas (ABG) analysis report

Parameters	29/10/2022 at the time of the presentation	After 8 h	2nd day	3rd day	4th day
pH	6.617	7.088	7.32	7.45	7.456
Pa CO2 (mmHg)	10.8	16.4	19	24.2	33
Pa O2 (mmHg)	183	106	90	83	78
HCO3 (mmol/l)	2.1	7.9	19	19.4	24
S. Na + (mmol/l)	151	149	139	138	139
S. K + (mmol/l)	4	3.6	3.2	3	3.7
Chloride - (mmol/l)	126	130	120	110	108
Lactate (mmol/l)	1.92	1.01	0.62	0.57	0.49
Anion gap (mmol/l)	28	18	15	13	10
Complete blood count report					
Hb/Hct %	10.8	10	10	8.1	7.6
Total count (/cumm)	34 000	27 400	27 400	13 300	8700
Neutrophil (/cumm)	79	86	86	89	65
Lymphocyte (/cumm)	21	8	8	10	30
Platelet (in lakhs)	3.57	2.2	2.2	2.49	2.18

Hb, haemoglobin; Hct, haematocrit.

electrolyte abnormalities, and hyperglycaemia, while also it is crucial to anticipate potential complications to improve patient outcomes. In our study, a diagnosis of diabetic ketoacidosis was established following the patient's clinical symptoms and laboratory findings. According to the American Diabetic Association (ADA) 2006 criteria, our case falls under severe DKA[9]. The patient has received treatment for her condition, and there has been a notable improvement from their initial state upon presentation, as evidenced by the reports. A comparable study on DKA survival was reported previously in Nepal where the case was administered, a treatment similar to ours but the cases differed in age groups and severity of DKA[10]. DKA was reported to be due to non-compliance with medication in our case. A similar finding was observed in the descriptive cross-sectional study conducted at tertiary-level hospitals in Nepal's central and eastern parts[11,12].

The use of alkali owes to potential detrimental effects including the worsening of hypokalemia, intracellular acidosis, delay in keto anions metabolism, and paradoxical acidosis[13]. In the study conducted by Ozurkl and colleagues, the administration of bicarbonate therapy did not influence the patient's outcome. A similar finding was observed by Viallon and colleagues where two groups were compared with or without bicarbonate therapy. Meanwhile, the pCO2 and anion gap should also be considered to determine patient outcomes[1,14]. In both studies, patients who did not receive bicarbonate therapy still managed to recover. In our study as well, bicarbonate therapy was not administered, we still observed positive advancements in the patient's health conditions. The study of a 14-year-old female was reported by Dr Ayush where she exhibited notable improvement in her DKA symptoms presenting with a pH of 6.66, without the use of bicarbonate therapy[15]. In comparison, our patient displayed improvement on the very next day with her rise in pH from 6.61 to 7.08 following the administration of a similar treatment. These findings suggest that the administration of bicarbonate therapy may not substantially impact the overall outcome.

In a retrospective cohort study comparing two groups of patients with severe ketoacidosis (pH <6.9): one receiving the bicarbonate therapy and the other not receiving it, it was found that bicarbonate therapy did not reduce the time for the acidosis to resolve or duration of hospital stay. Interestingly, in both

groups, the time taken for acidosis resolution was 8 h, which is similar to our case[16]. In a study conducted by Lutterman *et al*.[7], there was no significant difference in the rate of neurological recovery or mortality between the two groups.

ADA guidelines suggest that sodium bicarbonate is still prescribed to patients with a pH less than 7, however, in our case sodium bicarbonate was not accessible in the vicinity during that time[17]. Ozark and colleagues also advised considering pH and pco2 as relying solely on pH for bicarbonate therapy is insufficient. Similarly, Ritu and colleagues also supports the assertion made by the research conducted by Ozurkand colleagues Subsequently, the benefits of bicarbonate therapy in treating DKA (pH <7) was also demonstrated by Lever *et al*.[1,3,6]. Sodium Bicarbonate should be reserved for moderately severe cases of acidemia, specifically when the pH less than 7.20 and bicarbonate less than 12 mmol/l as its use should be individualized to each condition and should be administered in an unstable patient and patient with acute kidney injury (AKI). In children, bicarbonate should not be given unless the acidemia is markedly severe and remains unstable even after the initial administration of Normal saline[18]. However, in our study, bicarbonate therapy was not required as the patient showed improvement with the standard protocol alone.

Conclusion

Diabetic ketoacidosis is a life-threatening complication following both type 1 and type 2 DM. The condition can be controlled using IV insulin and IV fluids, while bicarbonate offers no beneficial effect on the disease outcome and may cause more harm than good, even in patients with severe DKA. Many literatures have revealed that bicarbonates used for early and rapid correction of acidosis have been found to lead to paradoxical CNS acidosis, intracellular acidosis, cerebral oedema, and hypokalemia, thus worsening oxygen availability. Our case report illustrated the possibility of survival of the patient without the use of bicarbonate. Despite the limited resources and the challenges faced, our prompt intervention facilitated the successful treatment of the case. However, to understand the potential outcomes of both using and abstaining from sodium bicarbonate, further studies need to be conducted in the future.

Ethical approval

Since our study is a case report. It doesn't require approval from ethical review committee.

Consent

Written informed consent was obtained from the patient for publication of this case report. A copy of the written consent is available for review by the editor-in-chief of this journal on request.

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Author contribution

P.S.: conceptualization, project administration, supervision, writing—review and editing. A.R.G.: conceptualization, project administration, writing—review and editing. S.M.: formal analysis, writing—original draft, writing—review and editing. S.P.: writing—original draft, writing—review and editing. R.K.C.: resources, supervision, writing—original draft, writing—review and editing.

Conflicts of interest disclosure

None.

Research registration unique identifying number (UIN)

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Guarantor

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Data availability statement

The corresponding author confirms the availability of data upon request.

Provenance and peer review

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