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Triple threat: New presentation with diabetic ketoacidosis, COVID-19, and cardiac arrhythmias

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ABSTRACT

Patients with diabetes have increased susceptibility to infection with Severe acute respiratory syndrome-coronavirus 2 and increased morbidity and mortality from Coronavirus disease 2019 (COVID-19) infection. Mortality from COVID-19 is sometimes caused by cardiac arrhythmias. Electrolyte disturbances in patients with diabetic ketoacidosis (DKA) can increase the risk of cardiac arrhythmias. Despite these correlations, little has been reported about the co-incidence of these three conditions: COVID-19, DKA and cardiac arrhythmias. In this case report we describe two children with COVID-19, new-onset DKA and cardiac arrhythmias. These cases emphasize the importance of close cardiac and electrolyte monitoring in patients with COVID-19 infection.

1. Introduction

While COVID-19 is often a mild disease in children [1], there may be more severe manifestations in children with certain comorbidities. Adults with diabetes have increased expression of ACE 2 which may play a role in increasing susceptibility to infection with SARS-CoV-2 and increased morbidity and mortality from COVID-19 infection [2-4]. Mortality from COVID-19 can be caused by cardiac arrhythmias [5]. Electrolyte disturbances increase the risk of cardiac arrhythmias, and patients with DKA are at risk for electrolyte disturbances. Despite these correlations, little has been reported about the co-incidence of COVID-19, DKA, and cardiac arrhythmias.

2. Case 1

A healthy, 17-year-old female presented to a community hospital with one day of altered mental status, fever, nausea, and vomiting. Her labs suggested severe DKA with pH 6.84, bicarbonate 4 mEq/L, anion gap 25 mEq/L, glucose 644 mg/dL. Her initial potassium was 1.9 mEq/L. She was treated with two liters of normal saline and started on an insulin drip at the community hospital. Her SARS-CoV-2 PCR test at that time was positive.

During transport to a pediatric tertiary care center, she had worsening mental status and an abnormal rhythm. Hypertonic saline was administered by the transporting team. On emergency department arrival, her heart rate was 150 bpm with a wide QRS complex consistent with ventricular tachycardia (Fig. 1a). She was oriented to person and place, with good femoral pulses. Her blood pressure was 127/70, her oxygen saturation 97% on room air. Her initial laboratory testing is shown in Table 1. She was treated with lidocaine, magnesium, and calcium gluconate with conversion to sinus tachycardia with PVC and intermittent Mobitz type I heart block (Fig. 1b and c). She was admitted to the pediatric intensive care unit with no further arrhythmias. Her arrhythmia was presumed to be ventricular tachycardia due to severe acidosis.

3. Case 2

A 12-year-old male with a family history of type 2 diabetes presented with two days of vomiting, increased thirst, and fatigue without other infectious symptoms. He was brought to the emergency department by EMS for decreased responsiveness. Blood glucose in the field was 550 mg/dL.

On arrival, his heart rate was 130 bpm, blood pressure was 104/64, and oxygen saturation was 98% in room air. Initial laboratory evaluation was consistent with severe DKA (Table 1). SARS-CoV-2 PCR at that time was positive.

During resuscitation with intravenous fluids, his heart rate increased to 240 bpm (Fig. 2). He was treated with 12 mg of adenosine without change. A second 12 mg adenosine push resulted in slowing of the heart rate. His blood pressure declined to 87/51 and he had worsening mental status. On further review of the rhythm by the

Abbreviations: COVID-19, Coronavirus disease 2019; ACE 2, Alveolar angiotensin-converting enzyme; DKA, Diabetic ketoacidosis; SARS-CoV-2, Severe acute respiratory syndrome-coronavirus 2; PCR, Polymerase chain reaction; PVC, premature ventricular complexes; g, gram(s); mg, milligram(s).

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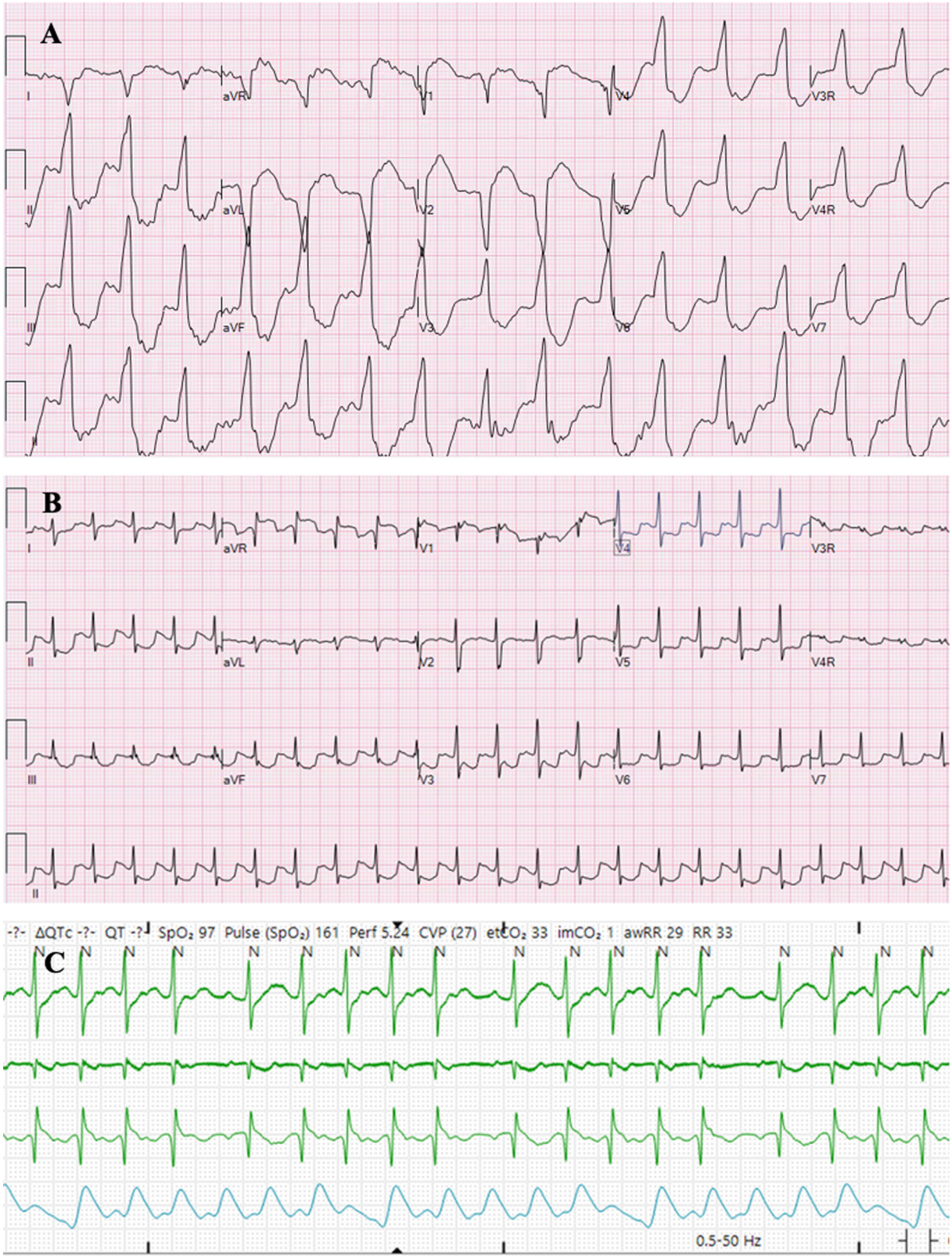

Fig. 1. 17-year-old presenting with new onset DKA, COVID-19 and wide complex tachycardia. A. ECG with wide QRS complex, right axis deviation and presumed ventricular tachycardia. B. ECG shortly after lidocaine and magnesium showing sinus tachycardia with diffuse ST changes. C. Telemetry rhythm strip with sinus tachycardia and Mobitz I second degree AV block. ECG = electrocardiogram, AV = atrioventricular.

Table 1
Blood tests of each patient.

Parameter	Patient 1	Patient 2	Normal Values	Unit
pH	6.84	6.98	7.35–7.45	
Bicarbonate	3.7	6.3	16–25	mmol/L
Glucose	337	>700	57–117	mg/dL
White blood cells	29.07	19.04	4.19–9.43	K/mcL
Anion gap	30	25	3–11	mEq/L
Hemoglobin A1c	11.1	10.8	3.5–6.1	%
Sodium	160	145	133–143	mmol/L
Potassium	2.9	4.1	3.3–4.7	mmol/L
Magnesium	4	2.3	1.5–1.9	mg/dL
Phosphorous	0.9	2.5	3.2–5.0	mg/dL
Calcium	9	9.5	9–10.7	mg/dL

electrophysiologist, the R-R interval was noted to be irregular, making atrial fibrillation or atrial flutter with variable atrioventricular block (2:1, 3:1) more likely. He was sedated, intubated, and cardioverted with conversion to sinus rhythm. He had no subsequent arrhythmias and was extubated during his first hospital day. His DKA resolved with insulin and fluids. His arrhythmia was presumed to be due to electrolyte disturbances.

4. Discussion

We present two cases of concurrent COVID-19 infection, DKA, and cardiac arrhythmias. This is, to the best of our knowledge, the only reported cases of these diagnoses presenting simultaneously. The relationship between cardiac rhythm disturbances and DKA has been well

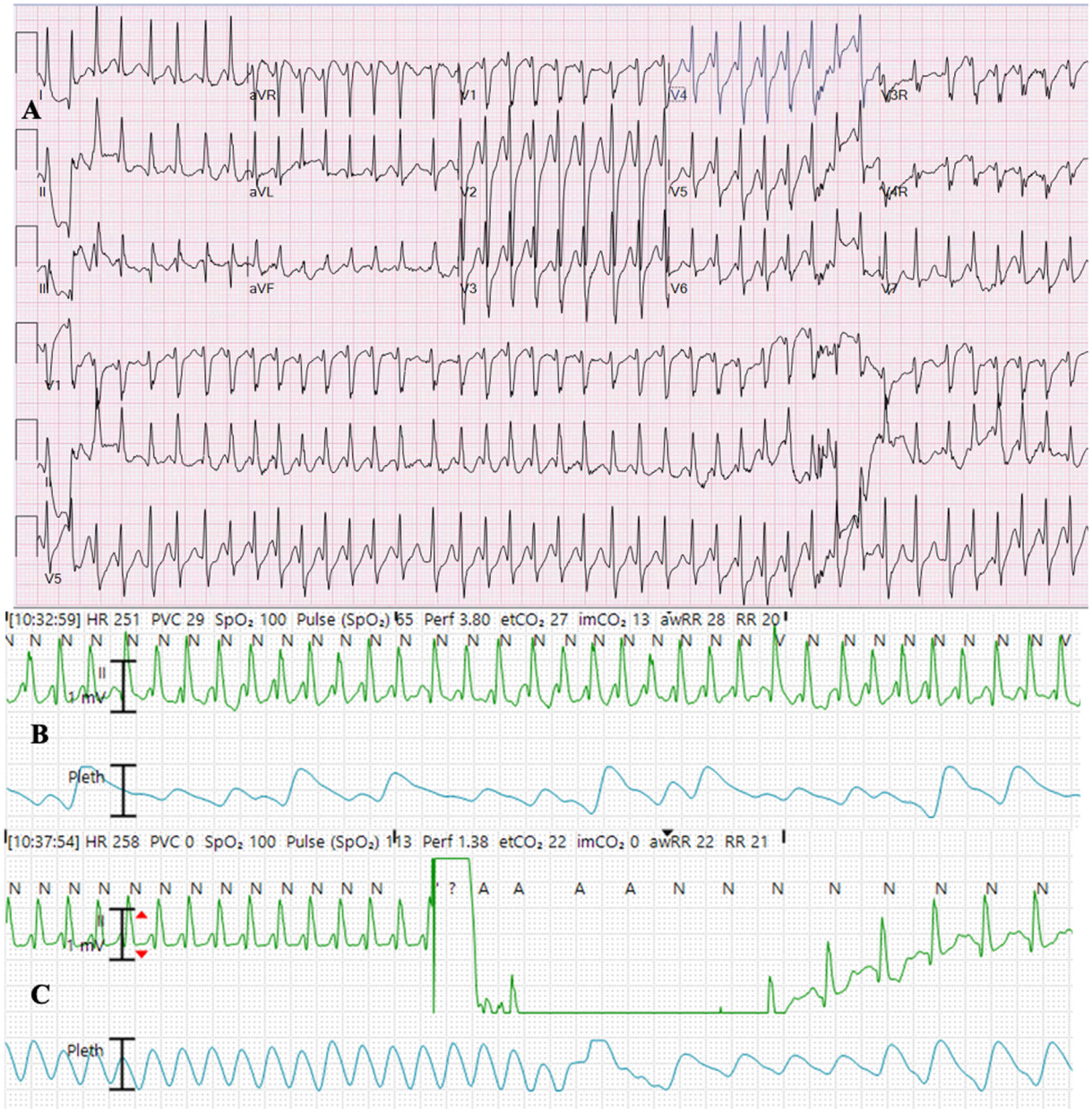

Fig. 2. 12-year-old presenting with emesis, thirst and altered mental status leading to diagnosis of DKA with COVID-19 positivity. A. ECG after sudden onset of narrow complex tachycardia, unresponsive to adenosine. B. After adenosine, ECG and telemetry demonstrated an irregular R-R interval consistent with atrial fibrillation or atrial flutter with variable AV conduction, thus explaining why the tachycardia had not terminated with adenosine. C. Synchronized cardioversion resulted in prompt return of sinus rhythm. AV = atrioventricular, ECG = electrocardiogram.

established; recently, associations between COVID-19 infection and cardiovascular disease and diabetes have emerged.

COVID-19 likely unmasks existing DM and precipitates DKA. SARS-CoV-2 attaches to ACE2 receptors throughout the body, including beta cells of the pancreas, subsequently impairing insulin secretion [6]. Injury to beta cells may also occur through pro-inflammatory cytokines or by enhancing autoimmunity in genetically predisposed people [6].

COVID-19 also produces a broad range of cardiovascular effects including myocarditis, myocardial infarction, cardiomyopathy, arrhythmias, and cardiac arrest [7,8]. Arrhythmias may occur in the setting of viral illness due to hypoxia, inflammatory stress, or abnormal metabolism [9]. Additionally, viral myocarditis can elicit cardiac conduction disease [10]. Increased cytokines and inflammation of conduction tissue may lead to subsequent arrhythmias. Arrhythmias have been reported in up to 17% of patients with COVID-19 [11,12]. Electrolyte abnormalities, particularly hyperkalemia, seen in DKA may precipitate dysrhythmias through decrease the rate of action potential upstroke and increase junctional resistance within the myocardium [13,14].

In both cases described above, the patients presented with significant acidosis and electrolyte abnormalities, which were thought to be contributing factors in precipitating their arrhythmias. Standard treatment of DKA includes fluid resuscitation, potassium repletion, and insulin replacement. It is important to note that in case one, the patient did not receive potassium repletion prior to fluid resuscitation and insulin replacement, which may have precipitated the arrhythmia. While in patients with DKA and COVID-19 the treatment remains largely the same [15], patients with COVID-19 may have higher insulin needs [16]. In addition, the concomitant use of vasopressors or steroids can impact insulin requirements [17].

In these patients with COVID-19, DKA, and an arrhythmia, deciphering whether the arrhythmia was caused by the potential cardiovascular effects of COVID-19 infection and inflammation of conducting cardiac myocytes or the acidosis and electrolyte abnormalities from DKA was challenging, and multidisciplinary evaluation and management needed be aimed at both underlying pathologies. It is also possible that, in the absence of respiratory symptoms and high community spread, a positive COVID test may have been incidental and not necessarily contributory to the pathology.

5. Conclusion

Described here are two pediatric patients with arrhythmias in the setting of new onset DKA and COVID-19. Systemic inflammation in COVID-19 can trigger DKA and a predisposition to arrhythmias, and metabolic derangement in DKA can also result in arrhythmias. These cases emphasize the importance of close cardiac and electrolyte monitoring for critically ill patients with COVID-19.

Author statement

Dr. Howard, conceptualized the report, drafted the original manuscript, and reviewed and edited the manuscript.

Dr. Basu conceptualized the report, and reviewed and edited the manuscript.

Dr. Sherwin conceptualized the report, and reviewed and editedthe manuscript.

Dr. Cohen conceptualized the report, drafted the original manuscript, and reviewed and edited the manuscript.

All authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

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Declaration of Competing Interest

The other authors have no example conflicts of interest to disclose.

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