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Original Article

Clinical characteristics of hospitalized and home isolated COVID-19 patients with type 1 diabetes

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ABSTRACT

Background and aims: To elucidate the clinical features of COVID-19 patients with type 1 diabetes (T1D) under hospitalization and home isolation conditions.
Method: This retrospective study was conducted among 32 patients with COVID-19 and T1D, who sought treatment at the Prince Sultan Military Medical City, Riyadh, Saudi Arabia between May 01, 2020 and July 30, 2020. Patients data were extracted from electronic medical records.
Results: Of the total of 32 COVID-19 patients with T1D, 21.9% required hospitalization, while 78.1% underwent home isolation. Among the study population, 9.4% (3/32) were reported to have hypertension, 21.9% (7/32) had chronic pulmonary disease (CPD), 18.8% (6/32) had thyroid disorders, and 18.8% (6/32) had the celiac disease. Of the 32 studied patients, 68.8% (22/32) of them were reported as normal, while 28.1% (9/32) had chronic kidney disease (CKD) II and 3.1% (1/32) had end-stage renal failure. The most common symptoms observed among the hospitalized patients were nausea and vomiting (71.4%; 5/7), followed by fever (57.1%; 4/7), cough (42.8%; 3/7), sore throat (42.8%; 3/7), abdominal pain (42.8%; 3/7) and dyspnea (42.%; 3/7). The most common reasons for hospitalization were diabetic ketoacidosis (71.4%; 5/7) followed by bacterial pneumonia (14.3%; 1/7), fever (14.3%; 1/7), sore throat (14.3%; 1/7), severe hyperglycemia (14.3%; 1/7) and COVID-19 pneumonia (14.3%; 1/7). Except the severity of COVID-19 ($p = 0.0001$), none of the demographic and clinical parameters indicated statistically significant differences between patients requiring hospitalization and home isolation.
Conclusion: Majority of the COVID-19 patients with T1D recovered with conservative treatment at home. Diabetic ketoacidosis was the most common reason for hospitalization.

1. Introduction

During the latter part of 2019, a new coronavirus which induced severe acute respiratory syndrome (SARS-CoV-2) made its appearance in Wuhan (China) [1]. In the first half of 2020 Coronavirus Disease 2019 (COVID-19) spread like wildfire across several countries, after which it was formally announced to be a pandemic [2]. Globally, COVID-19 has triggered extensive damage to public health and precipitated economic crises on a worldwide level. Until August 23, 2020, the record shows that the COVID-19 has affected 227 countries and territories across the world, including Saudi Arabia [3].

The severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) is part of the SARS coronavirus family, well known to attack the pancreas, affecting both the exocrine and endocrine cells [4]. Earlier studies stated that diabetes had been related to reduced patient outcomes during the previous coronavirus epidemics, the SARS-CoV and Middle East Respiratory Syndrome (MERS) [5,6]. The postulation put forth was that diabetes predisposes to a dysregulated immune response culminating in a pathological condition of the lung [7,8]. Data are available on the higher incidence of severe acute respiratory distress syndrome, increased need for hospitalization and even mortality, in patients with type 2 diabetes (T2D). However, information continues to be very limited on the clinical outcomes for those patients with type 1 diabetes (T1D) together

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with confirmed COVID-19. Several reasons may be present to justify a low occurrence of COVID-19 in patients with T1D, particularly the T1D identified in the younger age groups and the lower incidence of the disease, as compared to the patients with T2D in the general populace [9,10]. On the contrary, from the surveys done in the recent past, individuals with T1D have also been found at risk of contracting severe COVID-19, necessitating a hospital stay [11]. There appear to be multifactorial reasons for the poor prognosis in individuals who have diabetes, which is indicative of the syndromic characteristics of diabetes and age, sex, ethnicity, comorbidities such as hypertension, cardiovascular disease, obesity, and a pro-inflammatory and pro-coagulative state, all make contributions towards adding up to the patient running the risk of experiencing inferior outcomes [11,12].

From a geographical perspective, the Kingdom of Saudi Arabia is one of the principal sovereign states in Western Asia, ranked at the second country for being the largest among the Arab countries. It is the fifth-largest country in Asia, with more than 34.8 million people, population-wise. The report of the 9th edition of the International Diabetes Federation (IDF) Diabetes Atlas (2019) shows that 27,800 children and adolescents in Saudi Arabia suffer from T1D. This propels Saudi Arabia to be listed among the top countries concerning the number of patients with TID. In terms of the rate of incidence of T1D, Saudi Arabia ranks 5th on a global scale (31.4 per 100,000 persons) [13]. Therefore, the risk of COVID-19 among patients with T1D signals greater alarm in Saudi Arabia, as a significant number of patients with T1D are present, who face particular concerns and challenges during this present and continuing COVID-19 pandemic. Therefore, in this study, the objective was to identify the clinical characteristics of COVID-19 patients with T1D who either require hospitalization or manage the disease with home isolation.

2. Methods

2.1. Study design and setting

This retrospective study was conducted among 32 patients with COVID-19 and T1D, who sought treatment at the Prince Sultan Military Medical City (PSMMC), Riyadh, Saudi Arabia between May 01, 2020 and July 30, 2020.

Our study revealed that all the patients had a clear diagnosis of T1D, based on the documentation their physicians had entered in the electronic medical records of the PSMMC. The study protocol received approval from the Research and Ethics Committee of PSMMC, Riyadh, Saudi Arabia.

2.2. Inclusion and exclusion criteria

This study included all patients diagnosed with T1D with COVID-19. The exclusion criteria for participating in this study included pregnant women having gestational diabetes, patients with T2D and diabetes diagnosed when the COVID-19 test was confirmed.

2.3. Measurements

Patients were diagnosed as COVID-19 positive based on the interim guidance of the World Health Organization, employing the nasopharyngeal and RT-PCR standard method of detection of SARS-CoV-2.

2.4. Home isolation

Only confirmed asymptomatic patients or clinically stable individuals with mild symptoms (with no oxygen requirements/and no evidence of pneumonia) were granted permission for home isolation [14].

2.5. Hospital admission severity criteria

1) Mild to moderate: Patients displaying clear upper respiratory and constitutional symptoms or individuals showing signs of early clinical or radiological pneumonia. 2) Severe: Patients exhibiting $\geq$1 of the symptoms mentioned, namely, respiratory rate $\geq$30/min, blood oxygen saturation $\leq$93%, PaO2/FiO2 ratio <300 or lung infiltrates >50% of the lung field within a 24- to 48-h time period and 3) Critical: Patients revealing $\geq$1 of the symptoms listed: acute respiratory distress syndrome (ARDS), sepsis, altered consciousness, multi-organ failure or cytokine release syndrome [14].

2.6. Data collection

For all the patients hospitalized, as well as for those on home or self-isolation, a review was done of their medical records and laboratory data. Data were collected on patient age, sex, body mass index (BMI), duration of diabetes, and hemoglobin A1c (HbA1c) value. In addition, we gathered information on any other comorbidities present in the patient, such as hypertension, cardiovascular disease (CVD), cerebrovascular disease, chronic pulmonary disease (CPD), thyroid disorder, celiac disease, chronic kidney disease (CKD), COVID-19 pneumonia, malignancy and glucose monitoring tool. We also noted records of the diabetes treatment for all the participants in this study.

2.7. Statistical analysis

The data were analyzed employing Microsoft Excel 2010 (Microsoft Corporation, Seattle, WA, United States) and the Statistical Package for Social Sciences version 22 (SPSS Inc. Chicago, IL, United States). The continuous variables are shown as the mean values $\pm$ SD, and the categorical variables are expressed in frequencies and percentages. In addition to the descriptive analysis, the unpaired *t*-test was done for normally distributed continuous variables, the Mann–Whitney *U* test was applied for the non-normally distributed continuous variables and chi-square test was utilized for the categorical variables.

3. Results

The demographic and mean values of the variables in the study are shown in Table 1. Females (56.3%; 18/32) were found to be more vulnerable to contracting the COVID-19 than the males. A higher proportion of the patients with COVID-19 were $\geq$20-year (62.5%; 20/32) age group, 56.3% (18/32) had BMI< 25, 93.7% (30/32) reported HbA1c values $\geq$ 7% and 56.3% (18/32) of the patients had been diabetics for <10 years. Further, 9.4% (3/32) of the patients were known to have hypertension, while 21.9% (7/32) suffered from CPD, 18.8% (6/32) had thyroid disorder, and 18.8% (6/32) were known to have the celiac disease. Of the 32 studied patients, 68.8% (22/32) were considered as normal, while CKD II was found in 28.1% (9/32) and end-stage renal failure was noted in 3.1% (1/32). Of the total number of T1D patients, 21.9% (7/32) were hospitalized, while 78.1% (25/32) developed only mild COVID-19, which, based on the local guidelines were manageable at home isolation. A mean hospital length of stay of 3.33 $\pm$ 2.5 days was noted for hospitalized patients.

In Fig. 1, the common symptoms observed in the hospitalized COVID-19 patients with T1D are listed. The most common symptoms observed among the hospitalized patients were nausea and vomiting (71.4%; 5/7) followed by fever (57.1%; 4/7), cough (42.8%;

Table 1
Demographic and clinical characteristics of the study population (n = 32).

Variables	Groups	Numbers	Percentage
Gender	Female	18	56.3
	Male	14	43.8
Age (years)	<20	12	37.5
	≥20	20	62.5
Body mass index (kg/m2)	<25	18	56.3
	≥25	14	43.8
Hemoglobin A1c (%)	<7%	2	6.3
	≥7%	30	93.7
Duration of Diabetes (years)	<10	18	56.3
	≥10	14	43.8
Continuous Glucose Monitoring	Yes	20	62.6
Insulin pump user	Yes	2	6.3
Cardiovascular disease	Yes	0	0
Hypertension	Yes	3	9.4
Chronic pulmonary disease	Yes	7	21.9
Cerebrovascular disease	Yes	1	3.1
Malignancy	Yes	0	0
Thyroid disorder	Yes	6	18.8
Celiac disease	Yes	6	18.8
Hospital length of stay (days)	Mean ± SD	3.33 ± 2.5	–
Death	Yes	0	0
Management site	Hospital	7	21.9
	Home	25	78.1

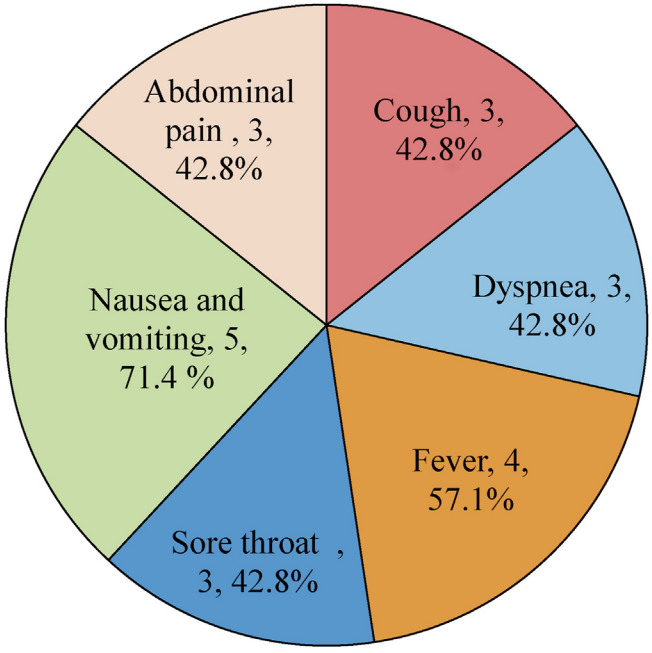

Fig. 1. Symptoms of COVID-19 among hospitalized patients with type 1 diabetes (n = 7).

3/7), sore throat (42.8%; 3/7), abdominal pain (42.8%; 3/7) and dyspnea (42.8%; 3/7).

In Table 2, the reasons for hospitalization of the participants in the study are listed. It was clear that DKA (71.4%; 5/7) was the most common cause of hospitalization, after which followed bacterial pneumonia (14.3%; 1/7), fever (14.3%; 1/7), sore throat (14.3%; 1/7), severe hyperglycemia (14.3%; 1/7) and COVID-19 pneumonia (14.3%; 1/7).

In Table 3, the differences are shown, in terms of the demographic and clinical factors to the hospitalization and home isolation of the T1D patients with COVID-19. No statistically significant relationship could be seen between patients requiring hospitalization and home isolation, with related to the age, HbA1c values or duration of diabetes. It was the similar case for patients with hypertension, CVD, cerebrovascular disease, CPD, malignancy as well as those experiencing the severity of the CKD ($p = > 0.05$). However, there was a significant difference noted between the different groups for COVID-19 severity ($p = 0.0001$).

4. Discussion

The present and advancing COVID-19 is an acute infectious respiratory infection that can cause severe pneumonia, which can culminate in death [15,16]. It now ranks as the top global health headline, raising severe public concern. Despite, the paucity of knowledge regarding the effects of the current COVID-19 pandemic on T1D is recognized, a few research works done in the first half of 2020, have suggested a bidirectional connection between T1D and COVID-19. In fact, diabetes has become well-known as an important risk factor necessitating hospital admission, severe illness and even mortality among patients who contract the COVID-19 [17–19]. However, it must be stated that all T1D patients do not show equal susceptibility to higher COVID-19-induced severity risk and death. There are definite clinical and biological features that are distinctive for the high-risk phenotypes among the individuals with diabetes and these crucial prognostic markers must be clearly classified [20]. In the current study, the aim is to explain the clinical features that distinguish the COVID-19 patients with T1D who required hospitalization from those patients managed on home isolation. To the best of our knowledge, this is the first study, that gives a detailed description of the COVID-19 in T1D patients, in the Middle East region, concerning the demographic data and clinical features.

Of the total of 32 COVID-19 patients with T1D, 21.9% required hospitalization, while 78.1% showed mild symptoms of COVID-19, which were managed with home isolation. Also, no event of death was noted in the small population sample of the study, which implies that even though hyperglycemia and DKA frequently occur in T1D individuals who contract COVID-19, several patients continue to manage this infection at home, and on the whole, there is a relatively low mortality rate. In a large study done in England, it was reported that of the 23,698 cases of COVID-19 requiring hospitalization, 7434 (31·4%) deaths were seen of T2D patients and only 364 (1.5%) of T1D individuals [17].

The current study revealed that in patients requiring hospitalization, the most common symptoms seen were nausea and vomiting (71.4%) with those of fever (57.1%), cough (42.8%), sore throat (42.8%), abdominal pain (42.8%) and dyspnea (42.8%). From an earlier study, from the Centers for Disease Control and Prevention, USA, the conditions of fever, cough, shortness of breath, myalgia, runny nose, sore throat, headache, nausea or vomiting, abdominal pain, diarrhea, or any combination of these were listed as the most significant symptoms for those affected by COVID-19 [21].

The results of the present study demonstrate that the patients with T1D who required hospitalization for COVID-19 treatment belonged to the older age group (23.4 vs 27.1 years), and showed no marked difference concerning gender, BMI, hypertension, HbA1c, and eGFR; it was the same case with those having a history of CVD and CKD patients between those needing to be hospitalized and those on self-isolation at home. These findings also concurred with an earlier report, which stated that there was no relationship between COVID-19 and HbA1c and the comorbidity profile, either in those patients admitted to the hospital or at home [22]. A report on Saudi Arabia highlighted the fact that children constituted the lowest percentage of confirmed COVID-19 cases, with the recovery rate showing no significant difference between children with comorbidities such as T1D and the healthy ones [23].

Table 2
Reason for hospitalization, treatment, site of hospitalization among COVID-19 patients with diabetes (n = 7).

Characteristic	Category	Numbers (Percentage)
Reason of hospitalization	Diabetic ketoacidosis (DKA)	5 (71.4)
	Bacterial pneumonia	1 (14.3)
	Fever	1 (14.3)
	Sore throat	1 (14.3)
	Sever hyperglycemia	1 (14.3)
	Covid-19 Pneumonia	1 (14.3)
Treatment	DKA treatment	4 (57.1)
	Antibiotics	2 (28.6)
	Favipiravir	1 (14.3)
	Supportive measures	2 (28.6)
	Hydroxychloroquin	1 (14.3)
Site of hospitalization	Medical word	6 (85.7)
	Intensive care unit	1 (14.3)

Table 3
Demographic and clinical variables associated with hospitalization among COVID-19 patients with type 1 diabetes.

Variables	Home/Self isolation (25)	Hospitalization (7)	P value
Gender (Female/Male)	14/11	4/3	0.649
Age (years)	23.4 ± 8.84	27.1 ± 6.1	0.411
Body mass index (kg/m2)	25.1 ± 6.75	23.4 ± 7.59	0.880
Hemoglobin A1c (%)	11.1 ± 2.66	8.68 ± 1.07	0.051
Duration of Diabetes (years, mean rank)	17.9	11.3	0.102
Continuous Glucose Monitoring (yes/no)	16/9	4/3	0.535
Insulin pump user (yes/no)	2/23	0/7	0.605
Cardiovascular disease (yes/no	0/25	0/7	1
Hypertension (yes/no)	3/22	0/7	0.464
Chronic pulmonary disease (yes/no)	5/20	2/5	0.489
Cerebrovascular disease (yes/no)	1/24	0/7	0.781
Malignancy (yes/no)	0/25	0/7	1
Thyroid disease (yes/no)	5/20	1/6	0.606
Celiac disease (yes/no)	4/21	2/5	0.394
C0VID-19 severity			**0.0001**
Mild	25	2	
Mild to moderate	0	4	
Severe	0	1	
Critical	0	0	
Creatinine	99.9 ± 27.2	57.2 ± 10.1	0.288
Estimated glomerular filtration rate (eGFR)	123 ± 65.9	139 ± 37.7	0.224
Chronic kidney disease (CKD)			0.131
CKD I	15	7	
CKD II	9	0	
CKD IIIa, IIIb, IV	0	0	
CKD V	1	0	
Death (yes/no)	0/25	0/7	1

Unpaired *t*-test for normally distributed continuous variables, **Mann–Whitney *U* test** for nonnormally distributed continuous variables, **Chi-square test** for categorical variables.

The results of the present study indicated that DKA (71.4%) was the most common reason for hospital admission among patients with T1D and COVID-19. Prior reports show that among patients having diabetes as a pre-existing condition, DKA may be a frequent complication induced by severe COVID-19 and be a sign of poor prognosis [24]. In fact, COVID-19 precipitated ketosis or ketoacidosis, and produced DKA in patients having diabetes. Ketosis raised the risk of hospital admission, the length of the hospital stay, as well as mortality rate [25]. Other studies also found high ketoacidosis incidence in patients hospitalized because of COVID-19 [26–28]. There was also a significant escalation in diabetic ketoacidosis and severe ketoacidosis in children and adolescents when they were diagnosed with diabetes during the time of the COVID-19 pandemic [26–28].

A few of the limitations in this study include its retrospective nature, the small size of the sample, limited social, demographic factors examined and the fact it was done only at a single center. To overcome the limitations cited, more research work, on a much greater scale, is urgently required.

5. Conclusion

To summarize, from this retrospective study, and within the limitation of the few cases investigated, the majority of the COVID-19 patients with T1D recovered with conservative treatment at home. Diabetic ketoacidosis was the most common reason for hospitalization. It is important to note that in the Saudi population, T1D is recognized as one among the major health issues. Therefore, it is essential for intensive research is emphasized, which would offer a clear picture of the clinical, social, and demographic factors of COVID-19 and its relationship to T1D.

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Declaration of competing interest

Authors have no conflict of interests.

References

[1] Zhu N, Zhang D, Wang W, et al. A novel coronavirus from patients with pneumonia in China, 2019. N Engl J Med 2020;382(8):727–33.
[2] Cucinotta D, Vanelli M. WHO declares COVID-19 a pandemic. Acta Biomed 2020;91(1):157–60.
[3] COVID-19 dashboard by the center for systems science and engineering (CSSE) at johns hopkins university (JHU)". ArcGIS. Johns Hopkins University. Retrieved 16 July 2020.
[4] Shi X, Gong E, Gao D, et al. Severe acute respiratory syndrome associated coronavirus is detected in intestinal tissues of fatal cases. Am J Gastroenterol 2005;100(1):169–76.
[5] Yang JK, Feng Y, Yuan MY, et al. Plasma glucose levels and diabetes are independent predictors for mortality and morbidity in patients with SARS. Diabet Med 2006;23(6):623–8.
[6] Alqahtani FY, Aleanizy FS, Ali El Hadi Mohamed R, et al. Prevalence of comorbidities in cases of Middle East respiratory syndrome coronavirus: a retrospective study. Epidemiol Infect 2018;147:1–5.
[7] Kulcsar KA, Coleman CM, Beck SE, Frieman MB. Comorbid diabetes results in immune dysregulation and enhanced disease severity following MERS-CoV infection. JCI Insight 2019;4(20):e131774. https://doi.org/10.1172/jci.insight.131774. 17.
[8] Chan KH, Thimmareddygari D, Ramahi A, Atallah L, Baranetsky NG, Slim J. Clinical characteristics and outcome in patients with combined diabetic ketoacidosis and hyperosmolar hyperglycemic state associated with COVID-19: a retrospective, hospital-based observational case series. Diabetes Res Clin Pract 2020;166:108279.
[9] Pitocco D, Tartaglione L, Viti L, Di Leo M, Manto A, Caputo S, Pontecorvi A. Lack of type 1 diabetes involvement in SARS-COV-2 population: only a particular coincidence? Diabetes Res Clin Pract 2020;164:108220.
[10] Robert AA, Al-Dawish A, Mujammami M, Dawish MAA. Type 1 diabetes mellitus in Saudi Arabia: a soaring epidemic. Int J Pediatr 2018;2018:9408370.
[11] Ebekozien OA, Noor N, Gallagher MP, Alonso GT. Type 1 diabetes and COVID-19: preliminary findings from a multicenter surveillance study in the U.S. Diabetes Care 2020;43(8):e83–5.
[12] Apicella M, Campopiano MC, Mantuano M, Mazoni L, Coppelli A, Del Prato S. COVID-19 in people with diabetes: understanding the reasons for worse outcomes. Lancet Diabetes Endocrinol 2020;8(9):782–92.
[13] International Diabetes Federation (IDF). Diabetes Atlas ninth edition. https://diabetesatlas.org/en/resources/; 2019.
[14] Saudi MoH protocol for patients suspected of/confirmed with COVID-19. https://www.moh.gov.sa/Ministry/MediaCenter/Publications/Documents/MOH-therapeutic-protocol-for-COVID-19.pdf.
[15] Wu F, Zhao S, Yu B, et al. A new coronavirus associated with human respiratory disease in China. Nature 2020;579(7798):265–9.
[16] Assaloni R, Pellino VC, Puci MV, et al. Coronavirus disease (Covid-19): how does the exercise practice in active people with type 1 diabetes change? A preliminary survey. Diabetes Res Clin Pract 2020;166:108297.
[17] Barron E, Bakhai C, Kar P, et al. Associations of type 1 and type 2 diabetes with COVID-19-related mortality in England: a whole-population study. Lancet Diabetes Endocrinol 2020;13. S2213-8587(20)30272-2.
[18] Holman N, Knighton P, Kar P, et al. Risk factors for COVID-19-related mortality in people with type 1 and type 2 diabetes in England: a population-based cohort study. Lancet Diabetes Endocrinol 2020;13. S2213-8587(20)30271-0.
[19] Klatman EL, Besançon S, Bahendeka S, Mayige M, Ogle GD. COVID-19 and type 1 diabetes: challenges and actions. Diabetes Res Clin Pract 2020;166:108275.
[20] Koliaki C, Tentolouris A, Eleftheriadou I, Melidonis A, Dimitriadis G, Tentolouris N. Clinical management of diabetes mellitus in the era of COVID-19: practical issues, peculiarities and concerns. J Clin Med 2020;9(7):2288. https://doi.org/10.3390/jcm9072288. 18.
[21] CDC COVID-19 Response Team. Coronavirus disease 2019 in children – United States, february 12–april 2, 2020. MMWR Morb Mortal Wkly Rep 2020;69:422–6.
[22] Vangoitsenhoven R, Martens PJ, van Nes F, et al. No evidence of increased hospitalization rate for COVID-19 in community-dwelling patients with type 1 diabetes. Diabetes Care 2020:dc201246. https://doi.org/10.2337/dc20-1246.
[23] COVID-19 recovery rate for children with chronic illness equal to healthy peers. 03 July 2020. https://www.arabnews.com/node/1698916/saudi-arabia.
[24] Palermo NE, Sadhu AR, McDonnell ME. Diabetic ketoacidosis in COVID-19: unique concerns and considerations. J Clin Endocrinol Metab 2020;105(8). https://doi.org/10.1210/clinem/dgaa360. dgaa360.
[25] Li J, Wang X, Chen J, Zuo X, Zhang H, Deng A. COVID-19 infection may cause ketosis and ketoacidosis. Diabetes Obes Metabol 2020. https://doi.org/10.1111/dom.14057.
[26] Kamrath C, Mönkemöller K, Biester T, et al. Ketoacidosis in children and adolescents with newly diagnosed type 1 diabetes during the COVID-19 pandemic in Germany. Jama 2020;324(8):801–4.
[27] Reddy PK, Kuchay MS, Mehta Y, Mishra SK. Diabetic ketoacidosis precipitated by COVID-19: a report of two cases and review of literature. Diabetes Metab Syndr 2020;14(5):1459–62.
[28] Pal R, Banerjee M, Yadav U, Bhattacharjee S. Clinical profile and outcomes in COVID-19 patients with diabetic ketoacidosis: a systematic review of literature. Diabetes Metab Syndr 2020;14(6):1563–9.