COMPARISON OF THE CLINICAL OUTCOMES OF HYPERGLYCEMIC CRISES IN COVID-19 POSITIVE AND COVID-19 NEGATIVE PATIENTS: A RETROSPECTIVE COHORT STUDY

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Abstract

Background. Patients with diabetes mellitus are more vulnerable to COVID-19 infection and exhibit more severe manifestations and worse clinical outcomes. Since the start of the COVID-19 pandemic, there has been a noted increase in the incidence of hyperglycemic crises in hospitals, and this involves both patients with COVID-19 infection and patients without COVID-19 infection. Aside from COVID-19 infection, the factors that are responsible for this increase in incidence of hyperglycemic crises may include reduced medical services, fear of seeking health care, and psychosocial factors. In the Philippines, there is a lack of data comparing these two subsets of patients. This study aims to give a comparison of the clinical outcomes of COVID-19 positive and COVID-19 negative patients who presented with hyperglycemic crises during the COVID-19 pandemic.

Methods. This is a retrospective cohort study of adult patients with hyperglycemic crisis on admission from March 1, 2020 to February 28, 2022 at the St. Luke's Medical Center Global City. Their medical records were reviewed to determine their clinical background, presenting clinical manifestations, non-COVID-19 acute conditions, biochemical and clinical parameters, treatment regimen, and clinical outcomes.

Methods. We analyzed 15 COVID-19 positive patients and 38 COVID-19 negative patients who had a hyperglycemic crisis on admission. Patients who were COVID-19 positive were found to be significantly older (mean age of 59 years) than COVID-19 negative patients (mean age of 46 years) (p = 0.0197). The COVID-19 positive group also had a significantly higher proportion of patients with malignancy (p = 0.031), urinary tract infection on admission (p = 0.039), and more frequently received steroids concurrent with treatment for hyperglycemic crisis (p = 0.002). The COVID-19 positive group had a significantly higher proportion of in-hospital mortality before resolution of hyperglycemic crisis (p = 0.008), as well as development of acute respiratory failure (p = 0.000). On the other hand, the COVID-19 negative group had a significantly higher proportion of patients who developed acute kidney injury during hospitalization (p = 0.026). There were no statistically significant differences in terms of time to resolution of DKA, development of hypoglycemia or hypokalemia, length of ICU and hospital stay, or development of cardiac decompensation and acute liver injury.

Conclusion. Patients hospitalized with hyperglycemic crisis who also had a COVID-19 infection had a higher in-hospital mortality rate than patients who were COVID-19 negative. Contributing factors may include older age and concurrent steroid treatment, which were more frequent among patients with COVID-19 infection. Aggressive treatment of hyperglycemic crisis in COVID-19 patients is warranted. Efforts to prevent hyperglycemic crises should be improved

Keywords. Intestinal Tuberculosis, Clinical features, Indicators, Ileocecal involvement.

Background of the Study

Patients with multiple pre-existing medical conditions, including diabetes mellitus, have been shown to be more vulnerable to COVID-19 infection, and to exhibit more severe manifestations and worse clinical outcomes [1]. Several studies suggested that COVID-19 leads to transient insulin resistance and hyperglycemia that predisposes to hyperglycemic crises. The virus can also cause cellular destruction of the islets of Langerhans [2,3].

Hyperglycemic crises which include diabetic ketoacidosis (DKA) and hyperglycemic hyperosmolar

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state (HHS) are the two most common acute metabolic complications of diabetes [4]. While the most common predisposing factor is infection, other factors which make patients prone to developing hyperglycemic crises include discontinuation or inadequate insulin therapy, acute states such as pancreatitis, myocardial infarction, and cerebrovascular accident, and use of drugs that affect carbohydrate metabolism such as corticosteroids, thiazides, sympathomimetic agents, pentamidine, and antipsychotic drugs [5]. Since the start of the COVID-19 pandemic, there has been a noted increase in the incidence of hyperglycemic crises in hospitals, both in children and in adults [6]. Strategies for effective distribution of essential medical resources during the pandemic are necessary to prevent further loss of life due to exacerbation of chronic diseases such as diabetes mellitus. The increase in the incidence of hyperglycemic crises also highlights the need for increased vigilance in patients with diabetes mellitus who develop COVID-19 infection.

COVID-19 infection can precipitate hyperglycemic crises. However, the increased incidence of hyperglycemic crises during the pandemic actually involved both patients with COVID-19 infection and patients without the infection [7]. This shows that there are other underlying factors aside from the COVID-19 infection itself that predispose to hyperglycemia. These may have included reduced utilization of medical services, fear of seeking health care, and more complex psychosocial factors. While there have been multiple studies on COVID-19 patients who developed hyperglycemic crises, there are few studies that also involve non-COVID patients who developed hyperglycemic crises during the time of the pandemic [6,8]. One study in the United States sought to characterize patients with DKA with and without COVID-19. They found that the majority of patients hospitalized for DKA were actually COVID-19 negative, but mortality was higher in those who were COVID-19 positive [9]. They were unable to determine the cause for the considerably higher mortality in the COVID-19-positive population, but they suggest that obesity and a more severe COVID-19 infection state can be contributing factors [9]. Multiple factors, aside from the presence of COVID-19 infection, can affect the outcome in hyperglycemic crises. Complications during treatment, which include hypoglycemia, hypokalemia, and cerebral edema, have been associated with poor outcomes and increased mortality [9]. High serum creatinine, comorbidity, and sepsis have also been found to be independent predictors of mortality [9]. Whether these factors significantly differ between COVID-19 positive and negative patients is unknown.

In the Philippines, there is a lack of data comparing these two subsets of patients. This study aims to compare the clinical outcomes of COVID-19 positive and COVID-19 negative patients who presented with hyperglycemic crises during the COVID-19 pandemic. This will guide the management of patients with hyperglycemic crises. It will also promote efforts to improve follow-up of patients and to further educate diabetic patients on the prevention of hyperglycemic crises.

Study Objectives

General Objective

To compare the clinical outcomes between COVID-19 positive and COVID-19 negative patients who were admitted for hyperglycemic crises from March 2020 to February 2022.

Specific Objectives

1. To describe the clinical profile of COVID-19 positive and COVID-19 negative patients who were admitted for hyperglycemic crises during the time of the COVID-19 pandemic
2. To determine the proportion of COVID-19 positive patients among those who were admitted for hyperglycemic crisis during the time of the COVID-19 pandemic
3. To compare the clinical outcomes between COVID-19 positive and COVID-19 negative patients who were admitted for hyperglycemic crises during the time of the COVID-19 pandemic, in terms of time to resolution, complications during treatment, length of intensive care unit and hospital stay, in-hospital mortality, and development of organ dysfunction.

Method

This was a retrospective cohort study of patients with hyperglycemic crises on admission from March 1, 2020 to February 28, 2022 at the St. Luke's Medical Center Global City. The patients were included if they were 18 years old and above and were able to meet the criteria for diabetic ketoacidosis or hyperglycemic hyperosmolar state as stated by the American Diabetes Association. They were excluded if they were pregnant, transferred from another hospital, or were transferred to another hospital before resolution of hyperglycemic crises could be achieved. The patient census of the Internal Medicine and Endocrinology departments were reviewed to determine the patients who had hyperglycemic crises on admission during the study period. The medical records of these patients were then accessed for data collection.

The following data were gathered: 1) clinical background (age, sex, body mass index, prior diagnosis of diabetes mellitus and follow-up, presence of comorbidity, medication use), 2) presenting clinical manifestations (non-constitutional, respiratory, and gastrointestinal symptoms, mental status alteration) and presence of other acute non-COVID conditions, 3) biochemical and clinical parameters (long-term glucose control, diagnosis of hyperglycemic crisis, severity of diabetic ketoacidosis, initial blood glucose level, anion gap, effective serum osmolality, estimated glomerular filtration rate), 4) treatment regimen (insulin regimen, highest hourly insulin requirement, steroid administration), and 5) clinical outcomes (time to achieving capillary blood glucose <200 mg/dL, time to resolution of hyperglycemic crisis, development of complications during treatment, length of stay in the intensive care unit and hospital, in-hospital mortality before and after

resolution of hyperglycemic crisis, and development of organ dysfunction).

Sample size was calculated based on the test of hypothesis for the difference in mortality rate among patients with hyperglycemic crisis who are COVID-19 positive versus COVID-19 negative. Assuming that mortality rate among COVID-19 positive patients is 30% and among COVID-19 negative patients is 5% (Paquel et al, 2021), with an alpha error of 5%, power of 90%, and a one-tailed alternative hypothesis, sample size calculated was 38 per group for a total of 76 for 2 groups. Descriptive statistics were employed. The categorical variables describing the demographics and biochemical parameters of patients are presented as means and standard deviation for quantitative data, and frequency and percentage for qualitative data. The level of significance was set at alpha 0.05.

The study abided by the Principles of the Declaration of Helsinki (2013) and was conducted along the Guidelines of the International Conference on Harmonization-Good Clinical Practice (ICH-GCP), E6 (R2) and other ICH-GCP 6 (as amended); National Ethical Guidelines For Health and Health-Related Research (NEG HHRR), 2017. The study was reviewed and approved by the SLMC Institutional Ethics Review Committee. Patient confidentiality was respected, and anonymity of patient records was ensured.

Results

We analyzed 15 COVID-19 positive patients and 38 COVID-19 negative patients who had hyperglycemic crises on admission from March 1, 2020 to February 28, 2022 at the St. Luke's Medical Center Global City. Table 1 lists the comparison of the clinical background of COVID-19 positive and COVID-19 negative patients. Patients who were COVID-19 positive were found to be significantly older than COVID-19 negative patients, with a mean age of 59 years in the COVID-19 positive group and 46 years in the COVID-19 negative group. The COVID-19 positive group also had a significantly higher proportion of patients with malignancy (lung, brain, and breast cancer). There were no statistically significant differences between the two groups in terms of sex, body mass index, prior or new diagnosis of diabetes mellitus, follow-up within the past year, presence of comorbidities other than malignancy, and medication use. The total population was 49% female and 51% male. The majority of the COVID-19 positive patients were overweight (BMI 23-27.5) and majority of the COVID-19 negative patients were obese (BMI 27.5-40) based on the Asia-Pacific guidelines. The majority of the two groups were previously known to have type 2 diabetes mellitus. The most common comorbidity in the two groups was hypertension.

Table 1. Clinical background of patients with hyperglycemic crisis

	COVID-19 positive patients (n=15)	**COVID-19 negative patients (n=38)**	**Total (n=53)**	***p*-value**
Age, in years (mean, SD)	59.4 (18.8)	46.2 (17.7)	49.9 (18.8)	0.0197
Sex, n (% female)	8 (53.3)	18 (47.4)	26 (49.1)	0.696
BMI, kg/m^2				
Starvation (<14.9), n (%)	0 (0.0)	0 (0.0)	0 (0.0)	0.255
Underweight (15-18.4), n (%)	3 (20.0)	2 (5.6)	5 (9.8)	
Normal (18.5-22.9), n (%)	3 (20.0)	11 (30.6)	14 (27.4)	
Overweight (23-27.5), n (%)	6 (40.0)	10 (27.8)	16 (31.4)	
Obese (>27.5), n (%)	3 (20.0)	13 (36.1)	16 (31.4)	
Morbidly Obese (>40), n (%)	0 (0.0)	0 (0.0)	0 (0.0)	
Diagnosis of diabetes mellitus				
Known T1DM, n (%)	1 (6.7)	3 (7.9)	4 (7.5)	0.218
Known T2DM, n (%)	12 (80.0)	19 (50.0)	31 (58.5)	
Newly diagnosed, n (%)	2 (13.3)	14 (36.8)	16 (30.2)	
Follow-up prior to admission				
Follow-up within past year, n (%)	2 (40.0)	3 (30.0)	5 (33.3)	0.699
No recent follow-up, n (%)	3 (60.0)	7 (70.0)	10 (66.7)	

Comorbidities, n (%)				
Hypertension	6 (40.0)	17 (44.7)	23 (43.4)	0.754
Ischemic heart disease	0 (0.0)	1 (2.6)	1 (1.9)	0.526
Heart failure	0 (0.0)	1 (2.6)	1 (1.9)	0.526
Cerebrovascular disease	0 (0.0)	1 (2.6)	1 (1.9)	0.526
Chronic kidney disease	1 (6.7)	4 (10.5)	5 (9.4)	0.665
Chronic liver disease	0 (0.0)	1 (2.6)	1 (1.9)	0.526
Chronic respiratory disease	0 (0.0)	1 (2.6)	1 (1.9)	0.526
Malignancy	3 (20.0)	1 (2.6)	4 (7.5)	0.031
Autoimmune disease	1 (6.7)	0 (0.0)	1 (1.9)	0.526
Medication use				
Intake of ARB or ACE, n (%)	4 (26.7)	7 (18.4)	11 (20.8)	0.505
Use of insulin, n (%)	6 (42.9)	11 (28.9)	17 (32.7)	0.343
Use of rapid insulin, n (%)	6 (42.9)	8 (21.1)	14 (26.9)	0.116
Compliance with medications, n (%)	8 (80.0)	14 (58.3)	22 (64.7)	0.228

The presenting clinical manifestations and acute non-COVID conditions of the two groups are listed in Table 2. The COVID-19 positive group had a significantly higher proportion of patients who presented with cough, dyspnea, and abdominal pain. Patients in both groups also had myocardial infarction, cerebrovascular accident, pneumonia, cellulitis, urinary tract infection, and acute pancreatitis on admission. The COVID-19 negative group had a significantly higher proportion of patients who had urinary tract infection on admission.

Table 2: Presenting clinical manifestations of patients with hyperglycemic crisis

	COVID-19 positive patients (n=15)	COVID-19 negative patients (n=38)	Total (n=53)	*p*-value
Non-constitutional symptoms, n (%)				
Fever	4 (26.7)	9 (23.7)	13 (24.5)	0.820
Weakness	7 (46.7)	16 (42.1)	23 (43.4)	0.763
Decrease in appetite	4 (26.7)	16 (42.1)	20 (37.7)	0.296
Muscle pain	3 (20.0)	4 (10.5)	7 (13.2)	0.359
Respiratory symptoms, n (%)				
Cough	8 (53.3)	2 (5.3)	10 (18.9)	0.000
Dyspnea	12 (80.0)	12 (31.6)	24 (45.3)	0.001
Sore throat	3 (20.0)	2 (5.3)	5 (9.4)	0.098
Gastrointestinal symptoms, n (%)				
Abdominal pain	1 (6.7)	19 (50.0)	20 (37.7)	0.003
Nausea/vomiting	0 (0.0)	0 (0.0)	0 (0.0)	n/a
Diarrhea	2 (13.3)	1 (2.6)	3 (5.7)	0.129
Mental status alteration, n (%)	5 (33.3)	14 (36.8)	19 (35.9)	0.810
Presence of other acute non-COVID condition, n (%)				
Myocardial infarction	1 (6.7)	1 (2.6)	2 (3.8)	0.487
Cerebrovascular accident	1 (6.7)	2 (5.3)	3 (5.7)	0.842
Pneumonia	2 (13.3)	9 (23.7)	11 (20.8)	0.403
Cellulitis	0 (0.0)	6 (15.8)	6 (11.3)	0.102
Urinary tract infection	0 (0.0)	9 (23.7)	9 (17.0)	0.039
Acute pancreatitis	2 (13.3)	5 (13.2)	7 (13.2)	0.986

A comparison of the biochemical and clinical parameters at admission between the two groups is shown in Table 3. It shows that the two groups had no statistically significant difference in terms of long-term glucose control, initial blood glucose level, baseline anion gap, effective serum osmolality, or estimated glomerular filtration rate. The majority of the study subjects in both groups had an HbA1c of >9%. The mean baseline blood glucose level and anion gap were 475 mg/dL and 23, respectively, in the COVID-19 positive group and 468 mg/dL and 26, respectively, in the COVID-19 negative group. There was no statistically significant difference in the type of hyperglycemic crisis (diabetic ketoacidosis or

hyperglycemic hyperosmolar state) that was present in both groups.

Table 3: Biochemical and clinical parameters at admission of patients admitted with hyperglycemic crisis

	COVID-19 positive patients (n=15)	COVID-19 negative patients (n=38)	Total (n=53)	*p*-value
Long-term glucose control, n (%)				
Poor (HbA1c >9%)	11 (73.3)	32 (84.2)	43 (81.1)	0.456
Adequate (HbA1c 7-9%)	3 (20.0)	3 (7.9)	6 (11.3)	
Good (HbA1c <7%)	1 (6.7)	3 (7.9)	5 (7.5)	
Hyperglycemic crisis, n (%)				
Diabetic ketoacidosis	13 (86.7)	37 (97.4)	50 (94.3)	0.061
Hyperglycemic hyperosmolar state	2 (13.3)	0 (0.0)	2 (3.8)	
Initial blood glucose level, mg/dL(mean, SD)	474.7 (101.1)	467.5 (134.2)	469.5 (124.8)	0.852
Anion gap (mean, SD)	23.0 (9.7)	26.1 (7.4)	25.2 (8.1)	0.210
Effective serum osmolality (mean, SD)	296.1 (16.6)	289.2 (14.4)	291.1 (15.2)	0.136
Estimated glomerular filtration rate (mean, SD)	60.3 (30.5)	50.6 (29.3)	53.3 (29.7)	0.290

The treatment regimen of the two groups is compared in Table 4. Both groups were managed primarily with continuous insulin infusion and had comparable highest hourly insulin requirements. The mean highest hourly insulin requirement in the COVID-19 positive and COVID-19 negative groups was at 0.6 and 0.4 unit per kilogram body weight, respectively. A significantly higher proportion of COVID-19 positive patients were given steroids during treatment for hyperglycemic crises.

Table 4: Treatment regimen of patients admitted for hyperglycemic crisis

	COVID-19 positive patients (n=15)	COVID-19 negative patients (n=38)	Total (n=53)	*p*-value
Insulin regimen, n (%)				
Intravenous	11 (73.3)	34 (89.5)	45 (84.9)	0.166
Subcutaneous	0 (0.0)	1 (2.6)	1 (1.9)	
Combination	4 (26.7)	3 (7.9)	7 (13.2)	
Highest hourly insulin requirement (units/kgBW)	0.6 (0.4)	0.4 (0.3)	0.4 (0.3)	0.689
Steroid administration	8 (53.3)	5 (13.2)	13 (24.5)	0.002

The clinical outcomes of both groups are shown in Table 5. The mean time to achievement of blood glucose level <200 mg/dL and time to resolution of diabetic ketoacidosis were at 13 and 15 hours, respectively, in the COVID-19 positive group, and at 21 and 24 hours, respectively, in the COVID-19 negative group, without statistically significant difference between the two groups. The COVID-19 negative group has a higher proportion of patients who developed hypokalemia during treatment of hyperglycemic crisis, although not significant. The proportion of patients who developed hypoglycemia was similar in both groups. There is no statistically significant difference between the two groups in terms of length of intensive care unit (ICU) stay and hospital stay. The mean lengths of ICU stay in the COVID-19 positive and COVID-19 negative groups were at 6 and 3 days, respectively. The mean lengths of hospital stay in the COVID-19 positive and COVID-19 negative groups were at 14 and 8 days, respectively. However, the COVID-19 positive group has a significantly higher proportion of in-hospital mortality before resolution of hyperglycemic crisis, as well as development of acute respiratory failure. On the other hand, the COVID-19 negative group has a

significantly higher proportion of patients who developed acute kidney injury during hospitalization.

Table 5: Outcomes of patients admitted with hyperglycemic crisis

	COVID-19 positive patients (n=15)	COVID-19 negative patients (n=38)	Total (n=53)	*p*-value
Time to CBG 200 mg/dL in hours (mean, SD)	13.1 (6.6)	14.7 (6.9)	14.2)6.8)	0.437
Time to resolution of DKA in hours (mean, SD)	21.3 (15.7)	23.8 (11.5)	23.2 (12.4)	0.553
Treatment complication, n (%)				
Hypoglycemia	2 (13.3)	3 (7.9)	5 (9.4)	0.542
Hypokalemia	4 (30.8)	14 (37.8)	18 (36.0)	0.648
Length of ICU stay, in days (mean, SD)	5.9 (7.8)	2.8 (3.7)	3.7 (5.4)	0.056
Length of hospital stay, in days (mean, SD)	14.4 (13.5)	8.4 (8.4)	10.1 (10.4)	0.058
In-hospital mortality before resolution of crisis (n, %)	4 (26.7)	1 (2.7)	5 (9.6)	0.008
In-hospital mortality after resolution of crisis (n, %)	0 (0.0)	1 (2.7)	1 (2.0)	0.534
Development of organ dysfunction, n (%)				
Acute respiratory failure	9 (60.0)	5 (13.2)	14 (26.4)	0.000
Cardiac decompensation	6 (40.0)	8 (21.0)	14 (26.4)	0.159
Acute liver injury	1 (6.7)	0 (0.0)	1 (1.9)	0.108
Acute kidney injury	11 (73.3)	15 (39.5)	26 (49.1)	0.026

DIscussion

This study consisted of a cohort of patients who had hyperglycemic crises on admission during the COVID-19 pandemic and the clinical outcomes between the COVID-19 positive and COVID-19 negative patients were compared. We found that the COVID-19 positive group had significantly higher in-hospital mortality before resolution of the hyperglycemic crisis. This finding is consistent with a previous study in 2021 by Pasquel et al that also sought to compare the characteristics and mortality of US patients hospitalized with DKA with and without COVID-19 [10]. Likewise, Kempegowda et al 2021 observed similar findings, wherein mortality rate was significantly higher in COVID-19 positive (20.0%) than COVID-19 negative patients (3.2%) [11].

Our study also found that the COVID-19 positive group was significantly older and had preexisting malignancy, received concurrent steroid treatment, and developed acute respiratory failure. These four factors may have all contributed to the increased mortality in the COVID-19 positive group. It is known that diabetic ketoacidosis has worse mortality in older (≥65 years) compared to younger (<65 years) patients. The presence of malignancy along with cancer-specific treatment that the patients received can also affect their immune response and physiologic reserve [12]. Concurrent steroids which were frequently given to oxygen-requiring COVID-19 patients also further aggravated the hyperglycemia and inflammation in diabetic ketoacidosis and hampered its resolution, thereby leading to worse outcomes [13]. Respiratory failure also worsened the stress state on the body, which compounded the effects previously mentioned [14].

The COVID-19 negative group had significantly more patients who had urinary tract infections and who subsequently developed acute kidney injury although this did not appear to affect the length of ICU or hospital stay, which was comparable in both groups. A higher proportion of patients who presented with cough, dyspnea, and abdominal pain were COVID-19 positive group. This was expected, since these are common symptoms of COVID-19 infection.

From inflammation and glucocorticoids resulting in insulin resistance to direct infection of islets of Langerhans causing beta cell failure, a wide variety of pathologies have been postulated linking COVID-19 and hyperglycemic crisis [15]. While COVID-19 predominantly affects the respiratory tract, SARS-CoV-2 has the capability to infect various cell types and frequently induces extrapulmonary complications. Pancreatic islet cells may express ACE2 and other SARS-CoV-2 entry receptors, and endocrine cells derived from human pluripotent stem cells are susceptible to infection [15]. Additionally, obesity and insulin resistance may

contribute to a weakened immune system and a more severe infection with SARS-CoV-2. In fact, population-level investigations have found that obese COVID-19 patients have an increased risk of developing complications [15]. Moreover, viral infection may exacerbate hyperglycemia and systemic insulin resistance. The pathophysiology underlying hyperglycemia in COVID-19 requires additional research [15].

At the start of the COVID-19 pandemic, there have been concerns regarding the frequent contact between healthcare professionals and patients which can contribute to disease transmission. Subcutaneous rapid acting insulin which is to be given at less frequent intervals compared to intravenous insulin has also been proposed as an alternative treatment regimen in order to limit the contact of healthcare professionals with COVID-19 patients in non-severe cases of hyperglycemic crisis. However, given the finding of increased in-hospital mortality in COVID-19 positive patients with hyperglycemic crisis, decreasing patient contact through the use of subcutaneous insulin regimen or less frequent laboratory testing might not be ideal.

Due to the worse outcomes in patients who have COVID-19 infection, there should be increased efforts to prevent hyperglycemic crises in patients with known diabetes mellitus. This may include closer follow-up, more aggressive blood sugar control, and education on proper diet and exercise despite quarantine measures.

The limitation of this study is the small cohort of COVID-19 positive patients. This may be improved by including patients from other hospitals. Also, the retrospective nature of the study limited us on which variables can be collected through secondary data review. On the other hand, a strength of the study is the objective and clear diagnosis criteria for diabetic ketoacidosis or hyperglycemic hyperosmolar state consistent with the American Diabetes Association guidelines.

Conclusion

Patients hospitalized with COVID-19 and hyperglycemic crisis had a higher in-hospital mortality rate before resolution of hyperglycemic crisis, compared to those who did not have COVID-19 infection. Contributing factors may have included older age and concurrent steroid treatment, which are more frequent among patients with COVID-19 infection. Aggressive treatment of hyperglycemic crisis in COVID-19 patients is warranted. Efforts to prevent hyperglycemic crises should be improved.

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