Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Obesity Medicine 22 (2021) 100316

Contents lists available at ScienceDirect

Obesity Medicine

journal homepage: www.elsevier.com/locate/obmed

Type 2 diabetes is associated with increased risk of critical respiratory illness in patients COVID-19 in a community hospital

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ARTICLE INFO

Keywords:
Type 2 diabetes
SARS-CoV-2
COVID-19
Respiratory failure

ABSTRACT

Background: Type 2 diabetes (T2D) is the leading non-communicable disease worldwide and is associated with several microvascular and macrovascular complications. Individuals with T2D are more prone to acquiring selected types of infections and are more susceptible to complications due to these infections. This study aimed to evaluate the relationship between T2D and COVID-19 in the community setting.

Methods: This was a single-center retrospective analysis that included 147 adult patients with laboratory-confirmed COVID-19 admitted to a community hospital. Demographics, medical history, symptoms and signs, laboratory findings, complications during the hospital course, and treatments were collected and analyzed. The Kaplan-Meier method was used to describe the probability of intubation in patients with T2D as compared with patients without T2D. The hazard ratio for intubation in the survival analysis was estimated using a bivariable Cox proportional-hazards model.

Results: Of 147 patients, 73 (49.7%) had a history of T2D. Patients with T2D had higher requirement of ICU admission (31.5% vs 12.2%; p = .004), higher incidence of ARDS (35.6% vs 16.2%, p = .007), higher rates of intubation (32.9% vs 12.2%, p = .003), and higher use neuromuscular blocking agents (23.3% vs 9.5%, p = .02). In the survival analysis at 28 days of follow-up, patients with T2D showed an increased hazard for intubation (HR 3.00; 95% CI, 1.39 to 6.46).

Conclusion: In our patient population, patients with COVID-19 and T2D showed significantly higher ARDS incidence and intubation rates. The survival analysis also showed that after 28 days of follow-up, patients with T2D presented an increased risk for shorter time to intubation.

1. Introduction

Diabetes is a chronic disease characterized by abnormally high blood glucose levels resulting from an impairment in insulin action or secretion. Diabetes is the leading non-communicable, chronic pandemic disease worldwide and is associated with several complications. Over time, high blood glucose can damage the body's small and large blood vessels, causing an increased risk for microvascular and macrovascular complications (Beckman and Creager, 2016). Based on the epidemiological evidence, individuals with diabetes are more prone to acquiring selected types of infections, and they are also more susceptible to certain complications from these infections (Critchley et al., 2018; Muller et al., 2005; Shah and Hux, 2003). SARS-CoV-2 is a novel coronavirus that causes COVID-19, which was declared a pandemic as of March 11, 2020, by the World Health Organization (WHO). As of July 1, 2020, 10.3 million cases have been reported, with an estimated fatality rate of 0.5%–3.5% (World Health Organization, 2020).

Diabetes is one of the most frequent comorbidities reported in patients with COVID-19. Among patients with confirmed COVID-19, the proportion with diabetes was 22% in one study of 191 patients (Zhou

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https://doi.org/10.1016/j.obmed.2020.100316
Received 19 November 2020; Received in revised form 24 December 2020; Accepted 27 December 2020
Available online 30 December 2020

et al., 2020) and 16.2% in another cohort of 1099 patients (Guan et al., 2020). Notably, a report of 72,314 COVID-19 cases found higher mortality in patients with diabetes (7.3% vs. 2.3% overall) (Wu and McGoogan, 2019). There have been a plethora of publications since the pandemic breakout. At the same time, many of the studies have confirmed the association of diabetes with worse outcomes. However, most populations vary in their epidemiological characters and health system. This study investigates the association of diabetes with COVID-19 outcomes in patients admitted to a community hospital in Illinois, USA.

2. Methods

In this single-center, retrospective cohort study, we included patients subsequently admitted to AMITA Health Saint Francis Hospital from March 1 to April 30, 2020, with symptomatic COVID-19. Data were abstracted from Electronical Medical Records among all patients with laboratory-confirmed COVID-19 by RT-PCR (Abbott™ RealTi*me*™ SARS-CoV-2 assay). Diabetes was defined as a diabetes history listed in the chart or newly documented glycohemoglobin of ≥6.5% on admission. We collected demographic data, symptoms, signs, lab results, treatments, hospital courses, and complications.

Descriptive statistics were used to summarize the data; categorical variables were described as frequency rates and percentages, and continuous variables were described using median and interquartile range values. We used the Mann-Whitney *U* test, Chi-squared test, or Fisher's exact test to compare differences between patients with and without diabetes when appropriate. Given mortality findings, the primary analysis focused on invasive mechanical ventilation. We used a Kaplan-Meier curve to describe the probability of intubation in patients with diabetes compared to patients without diabetes. Patients without the event were right-censored at day 28 of follow-up. Survival curves were compared using the Log-Rank test, where a two-sided P value of less than 0.05 was considered statistically significant. The hazard ratio for intubation in the survival analysis was estimated using a bivariable Cox proportional-hazards model. All statistical analyses were performed using SPSS Version 23.0. (Armonk, NY: IBM Corp).

3. Results

A total of 147 patients were included. The median age was 69 years (interquartile range [IQR], 59-79 years), with 58 (40%) being female, and 73 (49.7%) had a history of diabetes. Among patients with diabetes, the median age was 73 years (IQR, 59–76 years), and 41.1% were female. The median BMI was 26.6 (IQR, 22–32), and the median glycated hemoglobin (HbA1c) was 6.3% (IQR, 5.7–7.7%). (Table 1).

The most common underlying comorbidities were hypertension (68.7%), followed by dementia (29.3%), chronic obstructive pulmonary disease (COPD) (20.4%), chronic kidney disease (CKD) (17.0%), congestive heart failure (CHF) (13.6%), coronary artery disease (CAD) (12.9%), history of cancer (9.5%), and asthma (8.2%). Compared with patients without diabetes, patients with diabetes had significantly higher hypertension rates (Table 1).

For all patients, the most common presentation was fever (76.1%) and shortness of breath (72.6%), followed by cough (57.1%). Other symptoms included altered mental status (15.0%), chest pain (4.1%), nausea or vomiting (9.6%), sore throat (6.8%), and anosmia (4.8%). Clinical presentations were similar between the two groups, except patients without diabetes had more nausea or vomiting (Table 1). Among patients with diabetes, the values of white blood cell count, the absolute neutrophils count, serum creatinine, and lactate were numerically significantly higher than those without diabetes. In contrast, patients with diabetes had numerically/significantly lower levels of as compared to those without diabetes. Other laboratory results are shown in Table 2.

Regarding inflammation-related markers, patients with diabetes presented significantly higher levels of D-dimer compared to patients without diabetes. Other inflammation-related markers are shown in Table 3.

Table 1
Demographics and clinical presentation of patients with COVID-19 and with and without Type 2 Diabetes.

	Total (n = 147)	With T2D (n = 73)	Without T2D (n = 74)	P value
Age	69 (59–79)	73 (59–76)	74 (58–80)	0.878
Female	58 (40%)	30 (41.10%)	28 (37.84%)	0.686
BMI	26.6 (22–32)	28.5 (23.1–33.2)	25 (20.9–30.6)	0.019
LTCF	78 (53%)	37 (50.7%)	32 (43.25%)	0.366
Glycohemoglobin	6.3 (5.7–7.7)	7.3 (6.4–8.2)	5.7 (6.4–8.2)	0.001
Hypertension	101 (68.7%)	60 (82.2%)	41 (55.4%)	0.001
Dementia	43 (29.3%)	17 (23.3%)	26 (35.1%)	0.147
COPD	30 (20.4%)	12 (16.4%)	18 (24.3%)	0.307
CKD	25 (17.0%)	15 (20.5%)	10 (13.5%)	0.280
CHF	20 (13.6%)	9 (12.3%)	11 (14.9%)	0.811
CAD	19 (12.9%)	10 (13.7%)	9 (12.2%)	0.811
Cancer history	14 (9.5%)	4 (5.5%)	10 (13.5%)	0.158
Asthma	12 (8.2%)	8 (11.0%)	4 (5.4%)	0.177
Mortality	41 (28.1%)	19 (26.0%)	2 (30.1%)	0.713
Fever	113 (76.1%)	53 (72.6%)	60 (81.1%)	0.246
SOB	106 (72.6%)	49 (68.1%)	57 (77.0%)	0.267
Cough	84 (57.1%)	38 (52.1%)	46 (62.2%)	0.245
AMS	22 (15.0%)	15 (20.5%)	7 (9.5%)	0.068
Chest pain	6 (4.1%)	3 (4.2%)	3 (4.1%)	1.0
Nausea/Vomiting	14 (9.6%)	3 (4.2%)	11 (4.9%)	0.04
Sore Throat	10 (6.8%)	3 (4.2%)	7 (9.5%)	0.327
Anosmia	7 (4.8%)	4 (5.6%)	3 (4.1%)	0.717

[a] Continuous variables are presented as median (interquartile range). Categorical variables are presented as counts with percentages (%).
[b] P value less than 0.05 indicates statistically significant difference among patients with and without T2D.
[c] AMS: Altered mental status; BMI: Body mass index; CHF: Congestive Heart Failure; CKD: Chronic kidney disease; COPD: Chronic obstructive pulmonary disease; LTFC: Long-term care facility; SOB: Shortness of breath; T2D: Type 2 Diabetes.

Further, we analyzed the complications developed in our patients and compared their number and effects on patients with and without diabetes. Among the total COVID-19 patients analyzed, transaminitis was the most commonly observed complication (48.3%), followed by acute kidney injury (AKI) on admission (42.9%), ARDS (26.0%), myocardial ischemia (20.8%), prolonged corrected QT interval (15.6%), GI bleed (6.2%), new-onset arrhythmia (5.5%), venous thromboembolism (VTE) (4.1%) and stroke (1.4%). Patients with diabetes presented statistically significant higher ARDS rates and numerically higher transaminitis, AKI on admission, prolonged QTc, and stroke than patients without diabetes. On the other hand, patients without diabetes developed a significantly higher percentage of new-onset, GI bleed, and myocardial ischemia (Table 4).

Finally, we analyzed the outcome measures (Table 5). A significantly higher percentage of patients with diabetes required diuretics, invasive mechanical ventilation, intensive care unit (ICU) admission and neuromuscular blocking agents compared to patients without diabetes. Likewise, a numerically higher percentage of patients with diabetes required pressor support on admission or later during the hospital course and required prone positioning compared to the patients without diabetes. Interestingly, mortality rates were higher among patients without diabetes compared with patients with diabetes. However, a Log Rank test showed a statistically significantly different intubation survival distribution between patients without and with diabetes (p = .002), with patients with diabetes having a 75% chance of sooner intubation (hazard ratio for intubation, 3.00; 95% CI, 1.39 to 6.46) (Fig. 1).

Table 2
Labs on presentation of patients with COVID-19 and with and without Type 2 Diabetes.

	Normal Range	Total (n = 147)	With T2D (n = 73)	Without T2D (n = 74)	P value
WBC	4.0–11.0 k/mm cu	7.90 (5.10–12.00)	8.4 (5.50–12.65)	7.25 (4.67–11.77)	0.104
Absolute Lymphocyte count	0.6–3.4 k/mm cu	0.90 (0.70–1.40)	1 (0.6–1.5)	0.99 (0.77–1.32)	0.945
Absolute Neutrophil count	1.7–7.7 k/mm cu	5.9 (3.9–9.5)	6.3 (3.8–9.7)	5.6 (3.9–8.9)	0.393
Red blood cells	3.63–5.04 m/mm cu	4.40 (4.01–4.99)	4.37 (3.84–4.99)	4.49 (4.09–4.99)	0.291
Hemoglobin	12.0–15.3 g/dl	12.9 (11.4–14.4)	12.5 (10.8–13.9)	13.1 (11.9–14.6)	0.013
Platelets	150 - 450 k/mm cu	201 (165–275)	232 (168–310.5)	184.5 (163.75–238.50)	0.028
Sodium	133–144 mmol/L	136 (133–141)	136 (132.5–140)	136 (133–142.2)	0.319
Creatinine	0.6–1.3 mg/dl	1.11 (0.80–1.82)	1.21 (0.90–2.11)	0.99 (0.77–1.64)	0.075
Aspartate aminotransferase (AST)	13–39 IU/L	33 (23–60)	35.0 (21.0–60.00)	33.5 (23.0–59.75)	0.724
Alanine aminotransferase (ALT)	7.0–52.0 IU/L	25 (15–41)	27.00 (16.00–41.00)	23.5 (15.00–44.00)	0.527
Lactate dehydrogenase	140–271 IU/L	280 (198.25–399.75)	329 (200.75–433.5)	259.5 (197.75–350.5)	0.074
Lactic acid	0.7–2.0 mmol/L	1.70 (1.20–2.20)	1.75 (1.20–2.12)	1.70 (1.0–2.3)	0.806
Brain natriuretic peptide	0.0–100.0 pg/ml	101.50 (42.25–245.50)	124.5 (73.25–309 .25)	97.0 (36.75–198.0)	0.156

[a] Continuous variables are presented as median (interquartile range). Categorical variables are presented as counts with percentages (%).
[b] P value less than 0.05 indicates statistically significant difference among patients with and without T2D.
[c] AST: Aspartate aminotransferase; ALT: Alanine aminotransferase; T2D: Type 2 Diabetes; WBC: White blood cell count.

Table 3
Inflammatory markers on presentation of patients with COVID 19 with and without T2D.

	Normal Range	Total (n = 147)	With T2D (n = 73)	Without T2D (n = 74)	P value
D-dimer	0–622 ng/ml	1150 (601.25–3382.75)	1296.50 (821–5075.25)	914.0 (445.25–1976.7)	0.033
Ferritin	24–336 ng/ml	426 (171–1203.50)	448 (175.75–1326)	412 (155.25–989)	0.557
CRP	0.0–0.9 mg/dl	10 (4.90–15.90)	10.25 (4.30–17.02)	10.0 (5.10–13.95)	0.392
ESR	0–20 mm/h	65 (35.50–90)	67.00 (36.00–97.50)	64.00 (35.00–83.00)	0.344
CK	30–223 IU/L	138 (58.50–299.50)	141 (78–267)	133 (51.75–345.75)	0.924
PCT	0.20–0.49 ng/ml	0.53 (0.26–2.53)	0.59 (0.28–3.8)	0.5 (0.24–2.1)	0.935

[a] Continuous data are presented as median (interquartile range). Categorical variables are presented as counts with percentages (%).
[b] P value less than 0.05 indicates statistically significant difference among patients with and without T2D.
[c] CK: Creatinine kinase; CRP: C-reactive protein; ESR: Erythrocyte sedimentation rate; PCT: Procalcitonin; T2D: Type 2 Diabetes.

Table 4
Complications during hospital course of patients with COVID 19 with and without T2D.

	Total (n = 147)	With T2D (n = 73)	Without T2D (n = 74)	P value
Transaminitis	71 (48.3%)	38 (52.1%)	33 (44.6%)	0.411
AKI during admission	63 (42.9%)	35 (47.9%)	28 (37.8%)	0.245
Developed ARDS	38 (26.0%)	73/26 (5.6%)	73/12 (16.4%)	0.014
Myocardial injury	30 (20.8%)	12 (16.7%)	18 (25.0%)	0.305
Prolonged QTc	23 (15.6%)	12 (16.4%)	11 (14.9%)	0.401
GI bleed	9 (6.2%)	4 (5.6%)	5 (6.8%)	1.00
New onset arrhythmia	8 (5.5%)	4 (5.4%)	4 (5.6%)	1.00
VTE	6 (4.1%)	3 (50.0%)	3 (50.0%)	1.00
Stroke	2 (1.4%)	2 (2.7%)	0	0.245

[a] Continuous data are presented as median (interquartile range). Categorical variables are presented as counts with percentages (%).
[b] P value less than 0.05 indicates statistically significant difference among patients with and without T2D.
[c] AKI: Acute kidney injury; ARDS: Acute respiratory distress syndrome; VTE: Venous thromboembolism; T2D: Type 2 Diabetes.

Table 5
Clinical outcomes of patients with COVID 19 with and without T2D.

	Total (n = 147)	With T2D (n = 73)	Without T2D (n = 74)	P value
ICU admission	32 (21.8%)	23 (31.5%)	9 (12.2%)	0.005
Required Proning	21 (14.3%)	14 (19.2%)	7 (9.5%)	0.104
Required neuromuscular blocking	24 (16.3%)	17 (23.3%)	7 (9.5%)	0.027
Required pressor on admission	13 (8.9%)	9 (12.3%)	4 (5.5%)	0.157
Required pressor during hospitalization	29 (19.9%)	17 (23.3%)	12 (16.4%)	0.300
Required diuretics	55 (37.9%)	34 (47.2%)	21 (28.2%)	0.027
ICU stay (Days)	8 (3 – 14.25)	9 (3–14)	6 (2–17)	0.791
Hospital stay (Days)	7 (5–13)	8 (5–15)	7 (4–11)	0.700

[a]Continuous data are presented as median (interquartile range). Categorical variables are presented as counts with percentages (%).
[b]P value less than 0.05 indicates statistically significant difference among patients with and without T2D.
[c]ICU: Intensive Care Unit; T2D: Type 2 Diabetes.

4. Discussion

In our patient population, patients with COVID-19 and diabetes showed significantly higher ICU admission requirements, higher ARDS incidence, and higher intubation rates. The survival analysis also showed that patients with diabetes presented a significantly shorter time to intubation. Our findings support previous reports where diabetes was a significant risk factor for worse presentation and outcomes in patients with COVID-19. Yan et al. (Yan et al., 2020) found that patients with diabetes were at more risk of ICU admission and mechanical ventilation. Zhu et al. (Zhu et al., 2020) found that patients with diabetes needed more medical interventions and had more frequent multiple organ injury events than patients without diabetes. Huahua et al. (Yi et al., 2020) found that patients with diabetes and COVID-19 developed more severe disease, had more complications (such as ARDS and AKI), required ICU admission more often, and had higher mortality than patients without diabetes. Sardu et al. (Sardu et al., 2020) also support similar findings. Roncon et al. (Roncon et al., 2020) demonstrated that patients with diabetes and COVID-19 had a higher ICU admission and mortality risk and found that diabetes was the second more common

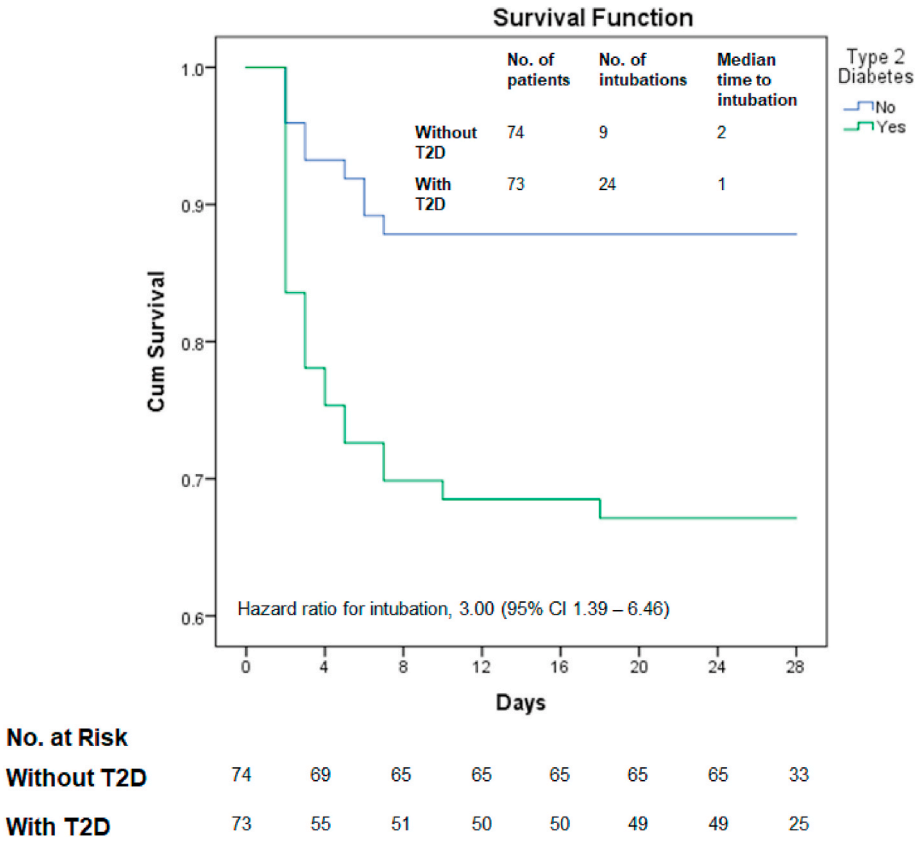

Fig. 1. Survival analysis of time to intubation in patients with and without Type 2 Diabetes.

comorbidity in their population. Finally, a meta-analysis of 30 studies (6452 patients) (Huang et al., 2020) showed higher mortality, severe COVID-19 disease, ARDS, and disease progression in the subgroup analysis, and diabetes was overall associated with poor composite outcomes.

Although diabetes did not have an evident impact on mortality in our study, this has been demonstrated by previous reports. In the study by Yang et al. (Yan et al., 2020), patients with severe COVID-19 and diabetes had worse survival rates than patients without diabetes. In their study, the median survival duration from hospital admission in patients with severe COVID-19 with and without diabetes was 10 days and 18 days, respectively. In our study, the median hospital stay for people with diabetes with COVID-19 was 8 days versus 7 days for patients without diabetes. Bode (Bode et al., 2020) et al. also found that patients with diabetes had higher mortality and more extended hospital stay. They also found that hyperglycemia (serum glucose>180 mg/dL, as set by American Diabetes Association guidelines [American Diabetes Association, 2020]) was also associated with these adverse events. The study by Alkundi et al. (Alkundi et al., 2020) also supports the same.

Inflammatory responses play a critical role in the progression of COVID-19 (Stebbing et al., 2020). The exact mechanism is not well understood. Accumulating data suggest direct virus endothelial injury and cytokine/complement mediated endothelial injury, and inflammation leading to hypercoagulability. Elevation of inflammatory markers such as procalcitonin (PCT), serum ferritin, erythrocyte sedimentation rate (ESR), C-reactive protein (CRP) and interleukin-6 (IL-6), creatine kinase (CK), D-dimer has been reported to be significantly associated with the high risks of the development of severe COVID-19 and subsequent mortality (Cheng et al., 2020). In our patient population, the elevation of D-dimer in patients with diabetes and COVID-19 was significantly higher than in patients without diabetes. A D-dimer greater than four times the normal upper limit from baseline has been shown to predict in-hospital mortality in patients with COVID-19 (Zhang et al., 2020), which points that patients with diabetes and elevated D-dimer are at greater risk of mortality.

Patients with diabetes have been known to present more severe infections than patients without diabetes. This may be due to the cardiovascular or renal complications of diabetes. It may also be because diabetes is a chronic inflammatory condition that affects the body's response to viral agents. Uncontrolled hyperglycemia has also been implicated in the severity of disease associated with different viruses such as the 2009 pandemic influenza A (H1N1), SARS-CoV, and MERS-CoV. Hyperglycemia promotes the synthesis of glycosylation end products and cytokines, leading to oxidative stress and tissue inflammation. It also causes blunting of the immune response as it affects lymphocyte, macrophage, neutrophil, and complement functions adversely (Hussain et al., 2020). Studies have shown that the SARS-CoV-2 enters endothelial cells through the angiotensin-converting enzyme 2 (ACE2) protein. ACE2 is highly expressed in endothelial tissue. Its consumption leads to a local increase of angiotensin-II, causing vasoconstriction and cytokines release through endothelial activation. Furthermore, endothelial cell dysfunction and microthrombi formation caused by COVID-19 is further worsened from pre-existing microangiopathy associated with poorly controlled diabetes (Whyte et al., 2020). Lastly, ACE2 pathway imbalances can also lead to β-cell dysfunction in the pancreas resulting in more hyperglycemia and worse vasculopathy and coagulopathy (Cuschieri and Grech, 2020).

On the other hand, diabetes can cause microvascular injury in the lung, leading to decreased diffusion capacity for carbon monoxide (DLCO). The injury is directly related to the levels of HbA1cand the presence of other microvascular complications such as diabetic neuropathy, retinopathy, and nephropathy. This entity has been described as a "diabetic lung" and can predispose to increased COVID-19 severity (Whyte et al., 2020).

Overall, the COVID-19 pandemic affected care-making, making glycemic control and close follow-up of patients with diabetes more

difficult. Glycemic control during acute illness and infection is also challenging to achieve. On top of the usual precautions to mitigate COVID-19 spread, these variables must also be considered to prevent the severity of COVID-19 in patients with diabetes effectively. (Peric and Stulnig, 2020).

Our study is not without limitations. This was a single-center study with patients from a community hospital, and generalizing data would not be appropriate. Additionally, our sample size was small, which may have contributed to the fact that we did not find any differences in mortality among patients with and without diabetes.

In conclusion, in our patient population from a community hospital setting, patients with COVID-19 and diabetes showed significantly higher ARDS incidence, intubation rates, and increased risk for shorter time to intubation. Our findings support previous reports where diabetes was shown to be a significant risk factor for worse presentation and outcomes in patients with COVID-19.

Funding

There has been no financial support for this work.

Ethics approval

Approval for this work was obtained through AMITA Health Institutional Review Board and Ethics Committee.

Consent to participate

Informed consent was waived because of the retrospective nature of the study.

Availability of data and material

Data and materials used for this work are available upon reasonable request.

CRediT authorship contribution statement

Ekta Shrestha: Conceptualization, Project administration, Data curation, Writing - original draft, Formal analysis. **Mariam Charkviani:** Project administration, Data curation, Writing - review & editing. **Clio Musurakis:** Data curation, Writing - review & editing. **Aswin Ratna Kansakar:** Writing - review & editing. **Amrit Devkota:** Data curation, Writing - review & editing. **Rabin Banjade:** Data curation, Writing - review & editing. **Prasun Pudasainee:** Writing - review & editing. **Solab Chitrakar:** Data curation, Writing - review & editing. **Alisha Sharma:** Data curation, Writing - review & editing. **Mina Sous:** Data curation, Writing - review & editing. **Shanmugha Padhamanbhan:** Data curation, Writing - review & editing. **Harvey J. Friedman:** Supervision. **Guillermo Rodriguez Nava:** Methodology, Formal analysis, Writing - original draft.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgments

We dedicate this work to the Nutrition Service staff in our institution.

Abbreviations

ACE2	angiotensin-converting enzyme 2
AKI	Acute kidney injury
ARDS	Acute respiratory distress syndrome
CKD	Chronic kidney disease
COPD	Chronic obstructive pulmonary disease
CHF	Congestive heart failure
CAD	Coronary artery disease
COVID-19	Coronavirus disease 2019
CRP	C-reactive protein
CK	Creatinine kinase
DLCO	Diffusion capacity for carbon monoxide
ESR	Erythrocyte sedimentation rate
GI	gastrointestinal
HbA1c	Glycated hemoglobin
ICU	Intensive Care Unit
IL-6	Interleukin-6
IQR	Interquartile range
PCT	Procalcitonin
SARS-CoV-2	Severe acute respiratory syndrome virus 2
VTE	Venous thromboembolism
WHO	World Health Organization

References

Alkundi, A., Mahmoud, I., Musa, A., Naveed, S., Alshawwaf, M., 2020. Clinical characteristics and outcomes of COVID-19 hospitalized patients with diabetes in the United Kingdom: a retrospective single centre study [published online ahead of print, 2020 June 10]. Diabetes Res. Clin. Pract. 165, 108263. https://doi.org/10.1016/j.diabres.2020.108263.

American Diabetes Association, 2020. 15 . Diabetes care in the hospital: standards of medical care in diabetes-2020. Diabetes Care 43 (Suppl. 1), S193–S202. https://care.diabetesjournals.org/content/43/Supplement_1/S193. (Accessed 12 April 2020).

Beckman, J.A., Creager, M.A., 2016. Vascular complications of diabetes. Circ. Res. 533 118 (11), 1771–1785.

Bode, B., Garrett, V., Messler, J., et al., 2020. Glycemic characteristics and clinical outcomes of COVID-19 patients hospitalized in the United States [published correction appears in J diabetes Sci Technol. 2020 jun 10;:1932296820932678]. J. Diabetes Sci. Technol. 14 (4), 813–821. https://doi.org/10.1177/1932296820924469.

Cheng, K., Wei, M., Shen, H., Wu, C., Chen, D., Xiong, W., 2020. Clinical characteristics of 463 patients with common and severe type coronavirus disease (In Chinese). Shanghai Med. J. 1–15.

Critchley, J.A., Carey, I.M., Harris, T., DeWilde, S., Hosking, F.J., Cook, D.G., 2018. Glycemic control and risk of infections among people with type 1 or type 2 diabetes in a large primary care cohort study. Diabetes Care 41 (10), 2127–2135. https://doi.org/10.2337/dc18-0287.

Cuschieri, S., Grech, S., 2020 May 22. COVID-19 and diabetes: the why, the what and the how. J. Diabet. Complicat. 107637. https://doi.org/10.1016/j.jdiacomp.2020.107637.

Guan, W.J., Ni, Z.Y., Hu, Y., et al., 2020. Clinical characteristics of coronavirus disease 2019 in China. N. Engl. J. Med. 382 (18), 1708–1720. https://doi.org/10.1056/NEJMoa2002032.

Huang, I., Lim, M.A., Pranata, R., 2020. Diabetes mellitus is associated with increased mortality and severity of disease in COVID-19 pneumonia - a systematic review, meta-analysis, and meta-regression. Diabetes Metabol. Syndr. 14 (4), 395–403. https://doi.org/10.1016/j.dsx.2020.04.018.

Hussain, A., Bhowmik, B., do Vale Moreira, N.C., 2020. COVID-19 and diabetes: knowledge in progress. Diabetes Res. Clin. Pract. 162, 108142. https://doi.org/10.1016/j.diabres.2020.108142.

Muller, L.M., Gorter, K.J., Hak, E., et al., 2005. Increased risk of common infections in patients with type 1 and type 2 diabetes mellitus. Clin. Infect. Dis. 41 (3), 281–288. https://doi.org/10.1086/431587.

Peric, S., Stulnig, T.M., 2020. Diabetes and COVID-19. Wien Klin. Wochenschr. 132, 356–361. https://doi.org/10.1007/s00508-020-01672-3.

Roncon, L., Zuin, M., Rigatelli, G., Zuliani, G., 2020. Diabetic patients with COVID-19 infection are at higher risk of ICU admission and poor short-term outcome. J. Clin. Virol. 127, 104354. https://doi.org/10.1016/j.jcv.2020.104354.

Sardu, C., Gargiulo, G., Esposito, G., et al., 2020. Impact of diabetes mellitus on clinical outcomes in patients affected by Covid-19. Cardiovasc. Diabetol. 19, 76. https://doi.org/10.1186/s12933-020-01047-y.

Shah, B.R., Hux, J.E., 2003. Quantifying the risk of infectious diseases for people with diabetes. Diabetes Care 26 (2), 510–513. https://doi.org/10.2337/diacare.26.2.510.

Stebbing, J., Phelan, A., Griffin, I., Tucker, C., Oechsle, O., Smith, D., 2020. COVID-19: combining antiviral and anti-inflammatory treatments. Lancet Infect. Dis. 20 (4), 400–402.

Whyte, M.B., Vas, P., Heiss, C., Feher, M.D., 2020. The contribution of diabetic microangiopathy to adverse outcomes in COVID-19. Diabetes Res. Clin. Pract. 164, 108217. https://doi.org/10.1016/j.diabres.2020.108217.

World Health Organization, 2020. Coronavirus Disease (COVID-19) Situation Report-163.

Wu Z, McGoogan JM. reportCharacteristics of and Important Lessons from the Coronavirus Disease 2019 (COVID-19) Outbreak in China: Summary of a Report of 72 314 Cases from the Chinese Center for Disease Control and Prevention [published online ahead of print, 2020 February 24]. JAMA.

Yan, Y., Yang, Y., Wang, F., et al., 2020. Clinical characteristics and outcomes of patients with severe covid-19 with diabetes. BMJ Open Diabetes Res. Care 8 (1), e001343. https://doi.org/10.1136/bmjdrc-2020-001343.

Yi, Huahua, Jin, Xiaoyan, Chen, Rong, Liu, Bing, Dong, Xuan, Xiong, Weining, Yang, Dexiang, Guo, Yi, Zhou, Min, 2020 July 29. Clinical characteristics and outcomes of coronavirus disease 2019 infections among diabetics: a retrospective and multicenter study in China. J. Diabetes. https://doi.org/10.1111/1753-0407.13098.

Zhang, L., Yan, X., Fan, Q., et al., 2020. D-dimer levels on admission to predict in-hospital mortality in patients with Covid-19. J. Thromb. Haemostasis 18 (6), 1324–1329. https://doi.org/10.1111/jth.14859.

Zhou, F., Yu, T., Du, R., et al., 2020. Clinical course and risk factors for mortality of adult inpatients with COVID-19 in Wuhan, China: a retrospective cohort study [published correction appears in Lancet, 2020 Mar 28;395(10229):1038] [published correction appears in Lancet. 2020 Mar 28;395(10229):1038] Lancet 395 (10229), 1054–1062. https://doi.org/10.1016/S0140-6736(20)30566-3.

Zhu, L., She, Z.G., Cheng, X., et al., 2020. Association of blood glucose control and outcomes in patients with COVID-19 and pre-existing type 2 diabetes. Cell Metabol. 31 (6), 1068–1077. https://doi.org/10.1016/j.cmet.2020.04.021 e3.