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Chest CT Severity Score in COVID-19 Patients: Comparison between Diabetic and Non-Diabetic Patients

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Abstract

Background: The Coronavirus Disease 2019 (Covid 19) pandemic has become a significant challenge for the healthcare sector, with a high rate of morbidity and mortality. Co-morbid conditions like diabetes put the patients at higher risk for serious illness and complications.

Aim of Study: The current study aimed to use the CT chest severity score to assess the severity of lung affection caused by Covid-19 in diabetic and nondiabetic patients.

Patients and Methods: From January to June 2021, high resolution non-contrast Computed Tomography (CT) chest imaging was performed on a total of 120 patients. The computed tomography severity score (CTSS) was calculated after analysis of the images. The patients were grouped into mild and severe cases in both diabetic and nondiabetic groups.

Results: Among 120 confirmed cases of COVID-19 infection, 67 (55.8%) were diabetics and 53 (44.2%) were non-diabetics. Many CT chest findings were observed, including ground glass opacitiesand consolidations. CT chest severity scoring (CTSS) was calculated for each patient. The severe cases (CTSS >18) compromised 43.3% of diabetic patients and 26.4% of non-diabetic group. It was noticed that lower lobes are significantly more affected than upper lobe units on both sides and the posterior basal segments are the most frequently involved segments.

Conclusion: According to this study, COVID-19 patients with diabetes comorbidity are at greater risk of severe disease than those without diabetes. Therefore, Clinicians need to focus more on treating COVID-19 pneumonia patients who also have diabetes.

Key Words: *Computed Tomography chest imaging – CT severity score – CTSS – Diabetes mellitus – Covid 19.*

Introduction

SINCE it first appeared in Wuhan, China in December 2019, the coronavirus illness 2019 (COVID-19) has rapidly spread throughout the world **[1]**. Due of the pandemic's high infection rate, prompt and precise diagnosis is essential to achieve quick and optimum care **[2]**. A minority of the patients suffered pulmonary edema, acute respiratory distress syndrome (ARDS), or multiple organ failure with a high mortality rate, although the majority had mild symptoms and a generally favourable prognosis **[3,4]**. Patients with ARDS and associated co-morbidities such as chronic pulmonary illness, cardiovascular disease, hypertension, diabetes, and cancer have a greater mortality rate **[5]**.

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Diabetes mellitus is a chronic hyperglycaemic condition that can affect the body's immune response to SARS-CoV-2 **[6]**. Diabetes mellitus (DM) has been identified as a significant age-independent risk factor for the severity of COVID-19 pneumonia **[7]**. In patients with type II diabetes mellitus, insulin resistance and altered glucose homeostasis may lead to microvascular damage and interstitial fibrosis through inflammation. Progression of Covid 19 pneumonia, thromboembolism events and lung function impairment were observed in patients with type II diabetes mellitus **[8]**.

Chest computed tomography (CT) is highly advised in suspected COVID-19 cases for both initial examination and follow-up, due to the major involvement of the respiratory system **[9]**. The reverse transcription-polymerase chain reaction assay (RT-PCR), which calculates viral load from a nasopharyngeal swab or tracheal aspirate, is the gold standard diagnostic method for COVID-19 infection **[10]**. High resolution chest computed tomography (HRCT) has established 56-98% sensitivity in detecting COVID-19 at early presentation and can be helpful in correcting false-negative RT-PCR through the early stages of the disease. Recent studies reported low sensitivity of RT-PCR in the early stage (reaching from 37 to 71%), probably due to the low viral load in test specimens or laboratory inaccuracies **[11,12]**. The HRCT chest is crucial for detecting COVID-19, making a diagnosis, assessing its progression, and deciding on the best course of treatment. Although chest CT has a high sensitivity for diagnosing COVID-19, its specificity is limited because it may be difficult to distinguish COVID-19 from other viral illnesses on chest CT [13,14]. While there are a variety of chest CT abnormalities during COVID-19, multifocal ground-glass opacities and consolidations with a predominately peripheral distribution are the most frequent changes. Other CT abnormalities include bronchial wall thickening, crazy-paving pattern, and linear opacities [15,16].

There has not been much research done on the relationship between diabetic mellitus and the severity of lung disease in COVID-19 patients. Therefore, the current study aimed to use the CT chest severity score to assess the severity of lung affection caused by COVID-19 in diabetic and nondiabetic patients.

Patients and Methods

Patients and groups:

This is a retrospective study, approved by our Institutional Review Board, and as it was a retrospective study, written informed consent was not needed. This study involved 120 patients admitted to at the main Mansoura University Hospital in the period from January to June 2021. The World Health Organization (WHO) interim guidance, which defined confirmed cases as patients whose real-time reverse transcription polymerase chain reaction (RT-PCR) assay results for nasal and pharyngeal swab collections were positive, served as the basis for the diagnosis of COVID-19 in the current study [17]. All patients underwent non-contrast high resolution chest CT upon admission. The patients' clinical and laboratory data were revised, and in accordance, they were separated into two groups: Group A (the COVID-19 diabetic group) and group B (the COVID-19 non-diabetic group). Patients' confidentiality and privacy were respected in accordance with standards.

Patient selection:

The inclusion criteria:

• All patients suspected of having COVID-19 underwent routine non-contrast CT exams as per our hospital's protocol, and they were all admitted to the hospital for isolation and monitoring. Before receiving a CT scan, all patients had chest radiography upon admission. Because CT has a higher sensitivity to identify lung opacities than chest radiography, it was chosen as the assessment tool.

The Exclusion criteria:

• Patients with negative RT-PCR test.
• Pregnant patients.
• Patients with mild illness having minor clinical signs and clear chest radiographs of the lungs.
• Patients with a history of lobectomy, tuberculosis, or atelectasis.
• Patients with history of lung tumour.

Imaging technique:

In a supine position, a complete inspiration was employed to perform a thin slice CT scan from the lung apex to the adrenal gland using 128-multislice CT system. The following CT scanning parameters were used: matrix size of 512x512, tube voltage of 120kV, tube current of 177mAs, layer spacing of 0.8mm, and layer thickness of 1.5mm. For lung parenchyma, all CT images were examined at window widths and levels of 1000-2000 HU and 700-500 HU, respectively. Coronal and sagittal reconstruction was used. No intravenous contrast medium administered. The patients who were referred from the wards to the CT Department wore personal protective equipment (PPE) and N95 masks, and the CT technicians who performed CT for patients with suspected COVID-19 were obliged to wear protective clothing.

Chest CT severity score (CTSS) Assessment:

The same chest CT severity score created by Yang et al., 2020 was utilized by us to evaluate the COVID-19 burden on the scan that was collected upon admission [18].

Based on the Fleischner Society Nomenclature recommendations and comparable research, the chest CT scans for each of the 120 patients were assessed for the following features [19,20]: Ground glass opacity (GGO), consolidation, nodules, reticulation, thickening of the interlobular septum, crazy-paving pattern, linear opacities, subpleural curvilinear line, thickening of the bronchial wall, enlargement of the lymph nodes, pleural effusion, and pericardial effusion [21]. The CTSS is a technique that was previously used to describe ground-glass opacity, interstitial opacity, and air trapping in patients after SARS and was linked with clinical and laboratory data [18]. The anatomical eighteen lung segments of both lungs were divided into twenty regions, where the left lower lobe's anteromedial basal segment was separated into anterior and basal segmental regions, while the left upper lobe's posterior apical segment was divided into apical and posterior segmental regions. Using a system that assigns scores of 0, 1, and 2 if parenchymal opacification involved 0%, less than 50%, or equal to or more than 50% of each region, respectively, the lung opacities in each of the twenty lung regions were subjectively assessed on chest CT scans. The CTSS, which might theoretically range from 0 to 40 points, was defined as the sum of the individual scores in the twenty lung regions.

Two senior radiologists with more than ten years of experience independently assessed each CT image in a standard clinical picture archiving and diagnostic system workstation while being blinded to the clinical information and laboratory results.

Statistical analysis:

The collected data were analyzed using Statistical Package for Social Science (SPSS) windows package version 22.0 (IBM, Armonk, NY). The CT severity score was divided into three groups: mild (0-11), moderate (12-18), and severe (> 18). Then, for the purpose of analysis, the mild and moderate groups were combined. Quantitative data were expressed as median and interquartile range. Descriptive analysis for the continuous variables was conducted by frequencies and percentages. For all statistical tests, *p*-value of less than 0.05 was considered statistically significant.

Cohen's Kappa test was used to determine if there was an agreement between the two radiologists in both groups.

Results

Demographic and clinical data:

The study included 120 admitted cases of confirmed Covid 19 pneumonia, 70 males (58.3%) and 50 females (41.7%), 67 (55.8%). Their ages ranged from 25 to 75 years; the meanage was 50±14.6 years. They were diabetics and 53 (44.2%) were non-diabetics (Table 1). The survivors among diabetic patients were 57 patients and among non-diabetics were 50 patients. The CT severity score (CTSS) were calculated, and the cases were divided into mild case if CTSS is less than or equals to 18, and severe case if CTSS is more than 18. Number of mild cases was 77 case and severe cases was 43 cases. There was significant difference between both groups in mild and severe forms. In diabetic patients, the mild cases were 38/67 (56.7%) and severe cases were 29/67 (43.3%) of cases, while in non-diabetic patients the mild cases were 39/53 (73.6%) and severe cases were 14/53 (26.4%) of cases, as shown in Table (1). The most common CT findings were GGO and consolidations (Figs. 1,2). There was no significant difference between the diabetic and non-diabetic group as regards the lung involvement with GGO, yet the diabetic group had significantly more lung affection with consolidation compared to non-diabetic group.

Table (1): Demographic data and CT findings of 120 Patients with COVID-19 Pneumonia.

	Diabetic N=67	Non-Diabetic N=53	Total N=120
Survivors	57 (85.1%)	50 (94.3%)	107 (89.2%)
Non-survivors	10 (14.9%)	3 (5.7%)	13 (10.8%)
Mild cases	38 (56.7%)	39 (73.6%)	77 (64.2%)
Severe cases	29 (43.3%)	14 (26.4%)	43 (35.8%)
Ground glass opacities	65 (97%)	51 (96.2%)	116 (96.7%)
Consolidations	43 (64.2%)	22 (41.5%)	65 (54.2%)

N = Number of patients.
Data expressed as number with percentages in parentheses.

Imaging findings:

The inter-reader agreement was excellent. The scores provided by one of the two readers were randomly chosen for further analyses.

Table (2) showed the number and distribution of involved segments of both lungs in both groups.

Overall, the most frequently involved segments in both diabetic and non-diabetic groups are posterior segment of upper lobes, superior basal segment of lower lobes, anterior basal segments of lower lobes, lateral basal segment of lower lobes, medial basal segment of lower lobes as well as posterior basal segment of lower lobes.

As regards the posterior segment of the upper lobes, there was significant difference (p<0.001) between diabetic (left, 37 of 67 [55.2%]; right, 46 of 67 [68.7%]) and non-diabetic (left, 21 of 53 [29.3%]; right, 25 of 53 [47.2%]) groups.

As regards the superior segment of the lower lobes, there was significant difference (p<0.001) between diabetic (left, 40 of 67 [59.7%]; right, 44 of 67 [65.7%]) and non-diabetic (left, 27 of 53 [50.9%]; right, 27 of 53 [50.9%]) groups.

As regards the anterior basal segment of the lower lobes, there was significant difference (p<0.001) between diabetic (left, 43 of 67 [64.2%]; right, 44 of 67 [65.7%]) and non-diabetic (left, 30 of 53 [56.6%]; right, 28 of 53 [52.8%]) groups.

As regards the medial basal segment of the lower lobes, there was significant difference (p<0.001) between diabetic (left, 46 of 67 [68.7%]; right, 50 of 67 [74.6%]) and non-diabetic (left, 34 of 53 [64.1%]; right, 29 of 53 [54.7%]) groups.

As regards the lateral basal segment of the lower lobes, there was significant difference (p<0.001) between diabetic (left, 46 of 67 [68.7%]; right, 54 of 67 [80.6%]) and non-diabetic (left, 33 of 53 [62.2%]; right, 31 of 53 [58.2%]) groups.

As regards the posterior basal segment of the lower lobes, there was significant difference (p<0.001) between diabetic (left, 50 of 67 [74.6%]; right, 56 of 67 [83.7%]) and non-diabetic (left, 38 of 53 [71%]; right, 40 of 53 [75.5%]) groups.

In general, there is significant higher involvement of the posterior segments of the upper lobes and different segments of lower lobes in diabetic group compared to non-diabetic group. We noticed that lower lobe involvement is significantly higher than upper lobes on both groups. Also, we found that the posterior basal segments on both sides are the most involved segments regarding the number and severity.

There is total involvement of 189 segments in left upper lobe and 210 segments in right upper lobe in all patients. A total 130 lingular segments and 142 right middle segments were affected. The involved left lower lobe segments were 407 segments while the involved right lower lobe segments were 402. There was no significant difference between right and left lungs as regards the number of involved segments in both diabetic and non-diabetic patients.

Table (3) and Figs. (3,4) show the CT severity score for diabetic and non-diabetics patients classified into mild and severe cases. The average right lung score was 7/20 in mild cases in diabetic patients and 6/20 in mild non-diabetic patients. In severe cases, the average right lung score was 15/20 in diabetic group and 12/20 in non-diabetic group. The average left lung score was 8/20 in mild cases in diabetic patients and 7/20 in non-diabetic patients while in severe cases, the average left lung score was 17/20 in diabetic group and 14/20 in non-diabetic group. This table also shows average total right lung score in mild cases for diabetics 15/40 and severe cases 32/40 while average total left lung score in mild cases for non-diabetics 13/40 and severe cases 26/40. Significant difference was found between average total lung severity score between diabetic and non-diabetic patients (p-value <0.001). In each group, lower lobe scores were higher than middle-upper lobe values.

Table (2): Number of patients involved in each lung segment and comparison of scores between groups with and without diabetes for each lung segment.

Variable	Sample	Diabetic (67)		Non-Diabetic (53)	
		Mild (38)	Severe (29)	Mild (39)	Severe (14)
Right lung:					
Anterior segment (R):					
0	49	21	0	28	0
1	52	13	20	10	9
2	19	4	9	1	5
Apical segment (R):					
0	52	23	0	29	0
1	47	10	21	6	10
2	21	5	8	4	4
Posterior segment (R):					
0	49	21	0	28	0
1	47	12	19	8	8
2	24	5	10	3	6
Medial segment (R):					
0	46	22	0	24	0
1	54	11	21	13	9
2	20	5	8	2	5
Lateral segment (R):					
0	52	21	0	31	0
1	45	13	18	6	8
2	23	4	11	2	6
Superior segment (R):					
0	49	23	0	26	0
1	48	10	17	11	10
2	23	5	12	2	4
Anterior basal segment (R):					
0	48	23	0	25	0
1	48	9	18	12	9
2	24	6	11	2	5

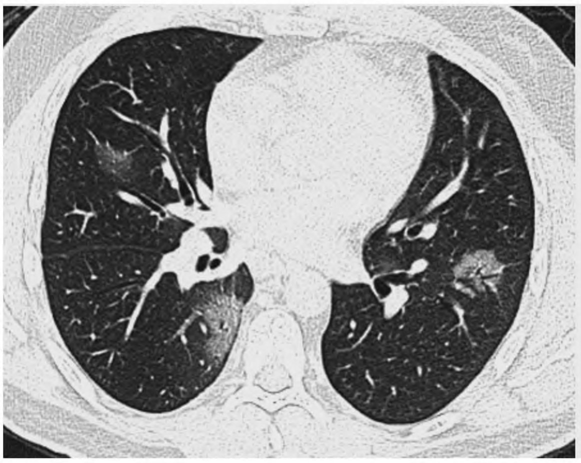
Table (2): Count.

Variable	Sample	Diabetic (67)		Non-Diabetic (53)	
		Mild (38)	Severe (29)	Mild (39)	Severe (14)
Medial basal segment (R):					
0	41	17	0	24	0
1	47	14	15	12	6
2	32	7	14	3	8
Lateral basal segment (R):					
0	35	13	0	22	0
1	46	12	13	14	7
2	39	13	16	3	7
Posterior basal segment (R):					
0	24	11	0	13	0
1	49	15	7	21	6
2	47	12	22	5	8
Left lung:					
Anterior segment (L):					
0	65	33	0	32	0
1	41	5	22	6	8
2	14	0	7	1	6
Apical segment (L):					
0	57	27	0	30	0
1	45	9	20	6	10
2	18	2	9	3	4
Posterior segment (L):					
0	62	30	0	32	0
1	42	7	21	5	9
2	16	1	8	2	5
Superior lingula segment (L):					
0	56	27	0	29	0
1	44	8	20	8	8
2	20	3	9	2	6
Inferior lingula segment (L):					
0	54	26	0	28	0
1	43	10	17	7	9
2	23	2	12	4	5
Superior segment (L):					
0	53	27	0	26	0
1	48	9	21	10	8
2	19	2	8	3	6
Anterior basal segment (L):					
0	47	24	0	23	0
1	48	8	19	12	9
2	25	6	10	4	5
Medial basal segment (L):					
0	40	21	0	19	0
1	50	11	18	16	5
2	30	6	11	4	9
Lateral basal segment (L):					
0	41	21	0	20	0
1	43	8	17	14	4
2	36	9	12	5	10
Posterior basal segment (L):					
0	32	17	0	15	0
1	46	11	11	18	6
2	42	10	18	6	8

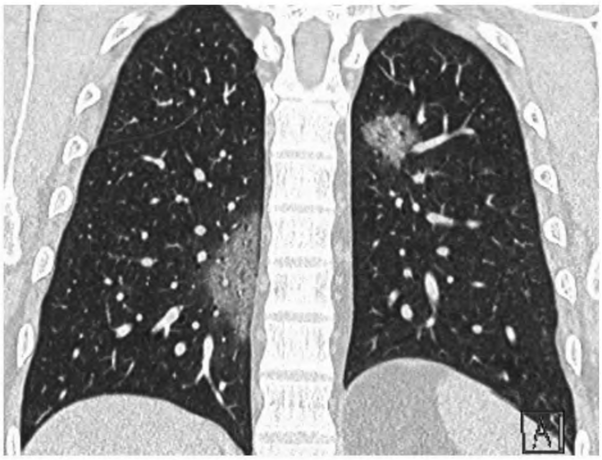
Table (3): Comparison between Left and Right Lung Scores, Lower Lung lobe Scores, and Upper-Middle Lung lobe Scores between the Diabetic and non-Diabetic Groups.

Variable	Diabetic (67)		Non-Diabetic (53)		*p*-value
	Mild (38)	Severe (29)	Mild (39)	Severe (14)	
Lung score	7 (3-9)	15 (11-19)	6 (3-9)	12 (9-15)	>.001
Right lung score	8 (3-10)	17(13-19)	7 (3-9)	14 (10-17)	>.001
Left lung score	15 (6-19)	32(24-38)	13 (6-18)	26 (19-32)	>.001
Total lung score	7 (3-9)	14 (12-18)	6 (2.5-9)	12 (10-15)	>.001
Middle and upper lung	8 (3-9)	16 (13-19)	7 (3-9)	14 (10-17)	>.001
Lower lung					

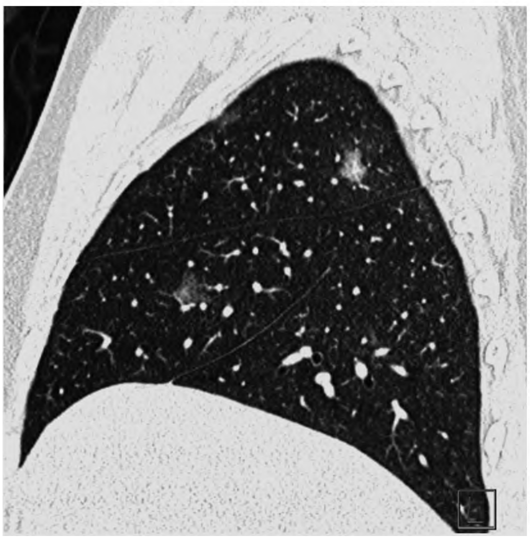
Data are presented as median and interquartile range.
p-value less than 0.05 was considered significant.



(A)



(B)



(C)

Fig. (1): A 53-year-old non-diabetic male patient with positive RT-PCR test results for SARS-CoV-2. Unenhanced chest CT (lung window), Axial (A), coronal (B) and sagittal (C) CT chest images showing bilateral multifocal rounded areas of ground glass opacities (GGO). CTSS=10 (mild form).

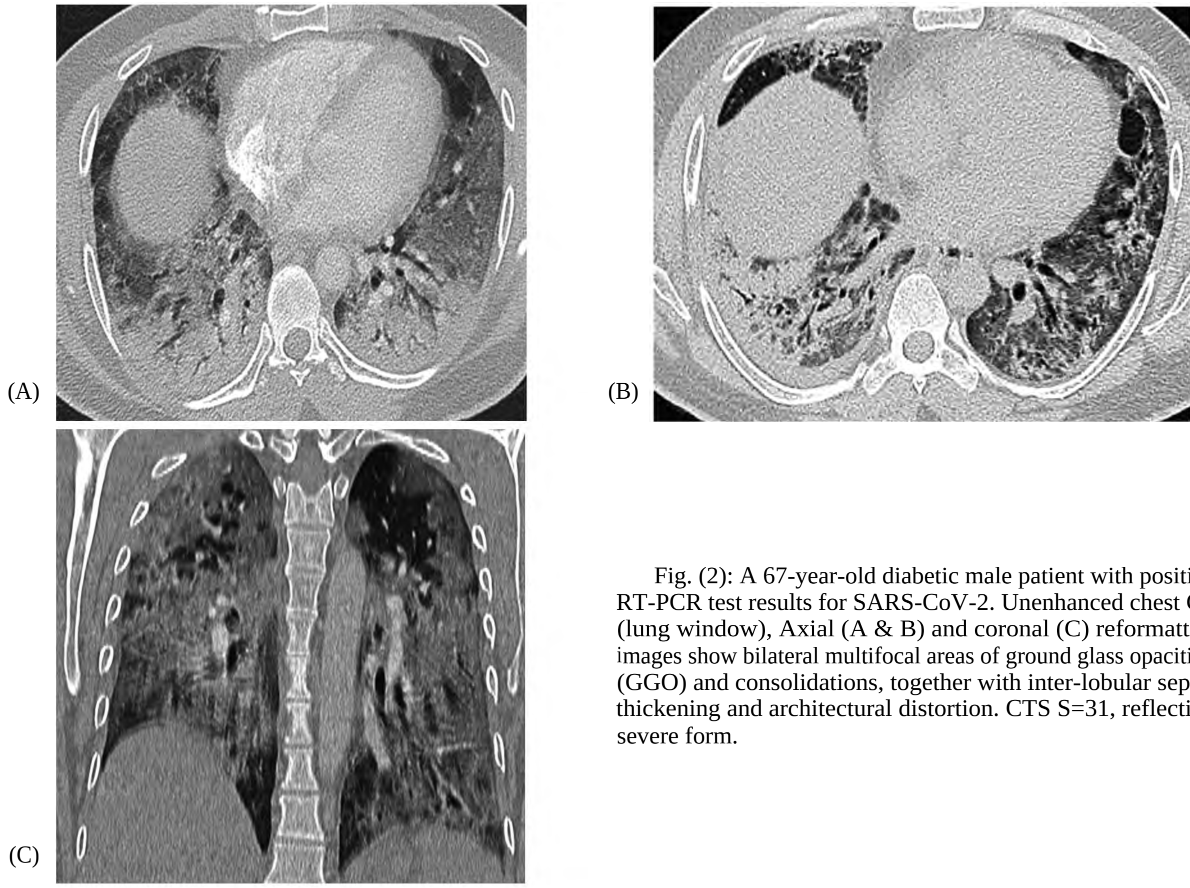


Fig. (2): A 67-year-old diabetic male patient with positive RT-PCR test results for SARS-CoV-2. Unenhanced chest CT (lung window), Axial (A & B) and coronal (C) reformatted images show bilateral multifocal areas of ground glass opacities (GGO) and consolidations, together with inter-lobular septal thickening and architectural distortion. CTS S=31, reflecting severe form.

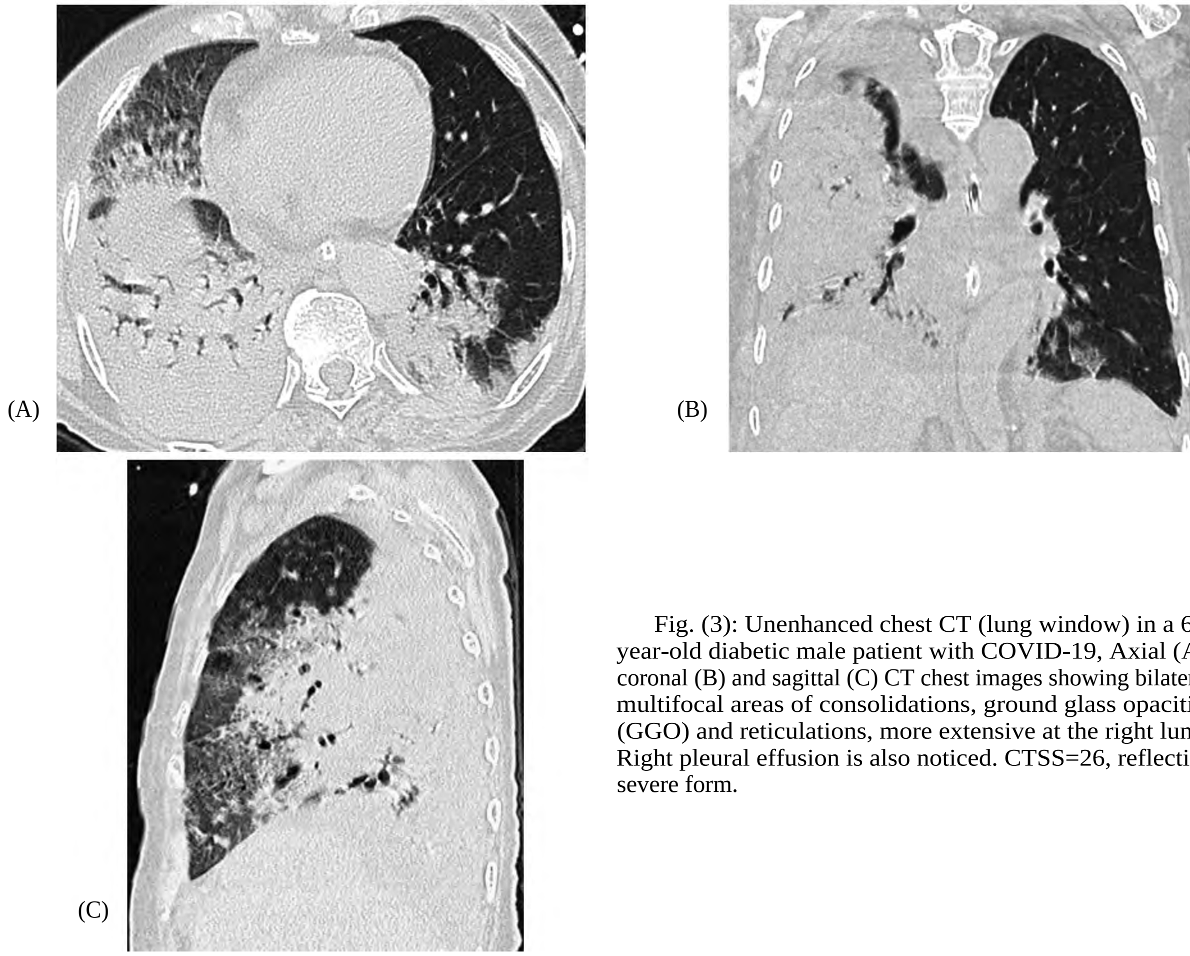
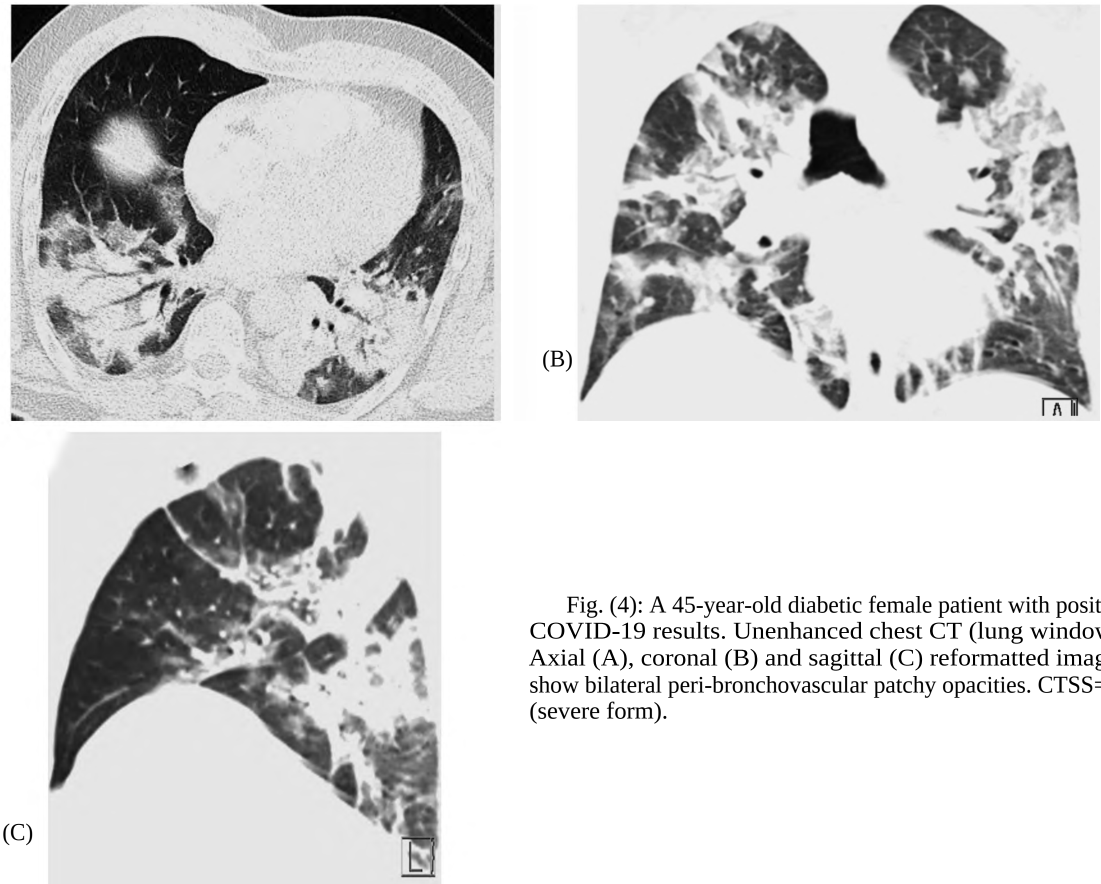


Fig. (3): Unenhanced chest CT (lung window) in a 60-year-old diabetic male patient with COVID-19, Axial (A), coronal (B) and sagittal (C) CT chest images showing bilateral multifocal areas of consolidations, ground glass opacities (GGO) and reticulations, more extensive at the right lung. Right pleural effusion is also noticed. CTSS=26, reflecting severe form.



(A) (B) (C)

Fig. (4): A 45-year-old diabetic female patient with positive COVID-19 results. Unenhanced chest CT (lung window), Axial (A), coronal (B) and sagittal (C) reformatted images show bilateral peri-bronchovascular patchy opacities. CTSS=22 (severe form).

Discussion

Chest CT plays an important role in COVID-19 screening, primary diagnosis, and evaluation [22,23]. Diabetes mellitus (DM) is a risk factor associated with severe illness in SARS-CoV-2 infection.

In our study, there is significant increase in number of severe cases in diabetic patients compared to non-diabetic patients. This copes with results of some previous studies [3,24,25]. The mortality rate in our study was 14.9% for diabetic and 5.7% for non-diabetic, which is in line with Zhang et al., results, who suggested that the severity and mortality rate of COVID-19 diabetic patients are higher than those without associated diabetes [26].Data from multiple retrospective clinical studies demonstrated that hyperglycemia and diabetes are separate risk factors for death following SARS infection and share comparable gene configurations [27].

In our study we found that there is no significant difference between diabetic and non-diabetic groups regarding ground glass opacity pattern in both lungs (p-value >0.005), but we found a significant difference in the pneumonic consolidation pattern between two groups, more prevalent in diabetic patients (p-value <0.001). This is consistent with the findings of Lu et al., [7]. They discovered that the total volume of ground glass density shadows in each lung lobe was the same in both groups, but that the total volume of consolidation was higher in the COVID-19 diabetes group than in the COVID-19 non-diabetic group [7].

We found that there is no significant difference between right and left lung involvement either in diabetic or non-diabetic groups with p-value >0.05. This is similar to the findings of Zhu et al., who hypothesized that diabetic individuals with well-controlled and poorly controlled diabetes both experienced the same incidence of right and left lung lesions [28].

Raoufi et al., found no significant difference in CT findings between well-controlled and poorly controlled DM patients [29]. In our study, we found that there is difference between diabetic group and non-diabetic group with p-value <0.001 regarding CT severity score.

In our study we found that there is significant difference (p-value <0.001) between right upper lobe unit (right upper lobe/middle lobe) and right lower lobe as well as left upper lobe/lingula and left lower lobe, with more consolidation and higher

CT severity score for lower lobar units on both sides. In these points, we agree with Lu and his colleagues [7].

Lu et al., [7] result suggests that novel coronavirus pneumonia patients with DM have a higher incidence of severe disease, which is consistent with our findings. It may be related to immune disorders and metabolic disorders in DM patients, leading to decreased ability of the body to clear the virus and rapid disease progression after infection with COVID-19.

Conclusion:

In conclusion, this study suggested that patients with COVID-19 pneumonia associated with diabetes have higher risk for severe disease than those without diabetes.

Recommendation:

This study still has significant limitations. Due to the small number of patients with COVID-19 and diabetes, the conclusions reached need to be examined further and supported by studies with bigger sample sizes and better empirical designs. So, we recommend consider diabetic patient in a special category by increasing care and precaution, giving them the priority for protection by vaccination, isolation as well as special care for them.

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درجة الشدة بالتصوير المقطعى للصدر فى مرضى كوفيد ١٩
مقارنة بين المرضى المصابين بالسكرى وغير المصابين بالسكرى

خلفية الدراسة : أصبحت جائحة فيروس كورونا ٢٠١٩ المستجد (كوفيد ١٩) تمثل تحدياً كبيراً لقطاع الرعاية الصحية، مع ارتفاع معدل الإصابة والوفيات. ومع وجود إصابة بأمراض أخرى مثل مرض السكرى فإن المرضى يكونون أكثر عرضة للإصابة بأعراض خطيرة ومضاعفات للمرض.

الهدف من البحث : تهدف الدراسة الحالية إلى استخدام درجة الشدة المقاس بالأشعة المقطعية للصدر لتقييم شدة تأثر الرئة الناجم عن كوفيد ١٩ فى مرضى السكرى وغير المصابين بمرض السكرى.

المرضى وطرق البحث : من يناير إلى يونيو ٢٠٢١، تم إجراء تصوير الصدر بالأشعة المقطعية عالية الدقة بدون صبغة على ١٢٠ مريضاً. وبتحليل الصور تم حساب درجة الشدة بالتصوير المقطعى (CTSS). تم تقسيم المرضى إلى حالات خفيفة وشديدة فى كل من مجموعات مرضى السكرى وغير المصابين بمرض السكرى.

نتائج البحث : من بين ١٢٠ حالة مؤكدة للإصابة بكوفيد-١٩، كان ٦٧ (٥٥.٨٪) مصابين بالسكرى و ٥٣ (٤٤.٢٪) غير مصابين بالسكرى. وقد لوحظت العديد من نتائج التصوير بالأشعة المقطعية، بما فى ذلك العتامة الزجاجية والتكثف الرئوى. تم حساب درجة الشدة بالتصوير المقطعى (CTSS) لكل مريض. الحالات ذات الاصابة الشديدة درجة الشدة أكبر من ١٨ شكلت ٤٣.٣٪ من مرضى السكرى و ٢٦.٤٪ من المرضى غير المصابين بالسكرى. كما لوحظ أن الفصوص السفلية هى الأكثر تأثراً بشكل ملحوظ من وحدات الفص العلوى على كلا الجانبين وأن القطاعات القاعدية الخلفية هى أكثر القطاعات تأثراً.

الخلاصة : وفقاً لهذه الدراسة، فإن مرضى كوفيد-١٩ المصابين بمرض السكرى هم أكثر عرضة للإصابة بأمراض خطيرة من غير المصابين بداء السكرى. لذلك يحتاج الأطباء إلى التركيز أكثر على علاج مرضى الالتهاب الرئوى كوفيد-١٩ الذين يعانون أيضاً من مرض السكرى.