Comparison of Total CT Severity Score with British Society of Thoracic Imaging score for Adult COVID19 Patients

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ABSTRACT:

BACKGROUND:

COVID-19 disease represented pandemic severe respiratory syndrome affecting hundreds of millions all over the world. The computerized tomography (CT) with polymerase chain reaction tests represented the common diagnostic methods.

OBJECTIVE:

To compare COVID-19 severity scores between CT scan Total Severity Score (TSS) and British Society of Thoracic Imaging (BSTI) scores in addition to compare the CT scan severity score of COVID-19 with different clinical data.

PATIENTS AND METHODS:

A descriptive observational cross sectional study was carried out inX-ray Institute/ Medical Complex/ Baghdad/ Iraqbetween 1st of June, and 31st of November, 2020 on a sample of 100 patients with COVID-19. The data was collected from the patients or their relatives. Severity of COVID-19 disease was classified according to TSSand according to BSTIscore.

RESULTS:

There was a highly significant association between severe BSTICT score and moderate CT scan TSS ($p<0.001$). Severity was significantly increased among patients with severe BSTI CT score of COVID-19 patients ($p<0.001$). The characteristics related to increased CT severity score of COVID-19 infection are elderly age, male gender, cough, fever, dyspnea, past medical history, delayed CT, and hypoxia.

CONCLUSION:

CT scan is helpful for diagnosis and severity categorization of COVID-19 infection and the CTBSTI score of COVID-19 severity is directly related to CTTSS.

KEYWORDS: COVID-19, CT scan, Total Severity Score.

INTRODUCTION:

Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) or coronavirus disease 2019 (COVID-19), was firstly described in a series of 41 individuals presenting with undetermined forms of pneumonias in Wuhan, China, during December 2019 [(1)]. Since its first observation, SARS-CoV-2 infection outbreak has transformed into an unprecedented worldwide healthcare emergency which recently reached the necessary epidemiological criteria to be declared pandemic by the World Health Organization [(2)]. The spread of the infection has been closely exponential in Italy which became, as of April 1, 2020, one of the world's centers of the outbreak together with the USA, with a total of 105,792 cases and the highest number of SARS-CoV-2 related deaths (12,430) according to the latest World Health Organization (WHO) reports [(3)]. These numbers are unfortunately expected to increase as reported by Remuzzi et al in a recent modeling prediction published on *The Lancet*, despite the aggressive containment policy that has been imposed by the Italian government [(4)].

The computerized tomography (CT) has a reported high sensitivity in patients infected by SARS-CoV-2, the reason why it is largely used to help patient management [(5)]. A high incidence of bilateral ground glass opacities (54%) has been reported in a cohort of 82 asymptomatic carriers boarded on the international cruise ship "Diamond Princess" . Those findings, observed in what temporarily became the largest cluster of SARS-CoV-2 cases outside China, potentially opened a major concern regarding a possible clinico-radiological dissociation in asymptomatic individuals, and its potential impact on clinical decision-making [(6)].

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The pathologic findings that can be detected at the chest CT scan during COVID-19 are different, among them consolidation, linear opacities, a crazy-paving pattern, bronchial wall thickening, and extra-pulmonary lesions [7, 8]. The extent and severity of these lesions has a major influence on the prognosis. Measuring pulmonary involvement of COVID-19 quantitatively using CT may help the clinician in defining severity of the case [9].

AIMS OF STUDY:

To compare COVID-19 severity scores between CT TSS with BSTI score, and to compare the CT scan TSS of COVID-19 with different clinical data.

PATIENTS AND METHODS:

Study design and settings: this study was descriptive cross sectional study carried out in the X-ray Institute in Medical Complex/Baghdad City/Iraq between 1st of June, and 31st of November, 2020. The inclusion criteria were adult patients (≥18 years) with clinical features of COVID-19 infection and positive reverse transcription polymerase chain reaction assay (RT-PCR). The exclusion criteria were adolescents and children, pregnancy, autoimmune diseases, malignancy, renal failure, liver diseases, hematological diseases and patients who refuse to participate in the study.

The COVID-19 infection was diagnosed according to Iraqi Ministry of Health Guidelines by the presence of clinical features of COVID-19 (fever, fatigue, cough, shortness of breath, loss of smell, etc) concurrent with positive (RT-PCR) test and positive findings by computerized tomography (CT) scan. A sample of 100 patients with COVID-19 was selected after taking their approval to participate in the study. Approval was taken from the Scientific committee of the Iraqi board of diagnostic radiology with oral informed consent taken from all patients.

Data collection: through direct interview and fulfilling of prepared questionnaire which include the followings: Age and gender, clinical presentations (Loss of smell, loss of sense of test, fever, headache, cough, weakness and dyspnea). CT was done using 128 row detector multislice helical CT system (Aquilion Toshiba, Japan), Kv 120,Slice thickness of 0.5 mm rotation time 0.5 sec. Kvp 120, Automatic modulator ranging from 50-210 mAs depend on body mass index of the patient in standard dose protocol. CT-scan characteristics of COVID-19 (Ground-glass opacification/opacity, consolidation, mixed, foci, patch, diffuse, scattered, unilateral, bilateral, left, right, posterior, anterior and Bronchiectasis changes), Severity score of CT scan of COVID-19 patients (Number of focal abnormalities, maximum diameter and total severity score) and CT score according to BSTI (Mild, moderate and severe). Total severity score was calculated by measurement of scores of lung lobes (RUL, RML, RLL, LUL and LLL), the total TSS score was classified into [10]: <8 Mild, 9-15 Moderate, >15 Severe. Regarding British Society of Thoracic Imaging (BSTI) score was classified into mild (up to 3 numbers of focal abnormalities and up to 3 cm maximum diameter) and moderate/severe (more than 3 numbers of focal abnormalities and more than 3 maximum diameters) and differentiation between moderate and severe form is subjective depending on clinical assessment [11].

Statistical analysis: the data of patients were analyzed using Statistical Package for Social Sciences (SPSS) version 23 for windows. Outcomes were arranged in as means and standard deviation. Chi square test and Fishers exact test were used for categorical variables. One way ANOVA analysis was used to compare between more than two means. P value of 0.05 or less was regarded as significant.

RESULTS:

This study included 100 patients with COVID-19 with a mean age of 43.6±11.4 years; Male were more than female with male to female ratio as 1.7:1. CT scan characteristics were ground-glass opacification/opacity (77%), consolidation (66%), mixed (43%), foci (18%), patch (68%), diffuse (2%) and scattered (7%). The CT scan in general was normal in 2% of COVID-19 patients and abnormal in 98% of them. The number of focal abnormalities was 3 and more for 74% of COVID-19 patients, while maximum diameter was 3 and more for 49% of COVID-19 patients. The CT scan severity score was mild (≤8) for 55.1% of COVID-19 patients with abnormal CT scan and moderate (9-15) for 44.9% of them. The BSTI CT scan severity score showed that 42.9% of COVID-19 patients with abnormal CT scan had mild severity, 44.9% of them had moderate severity and 12.2% of them had severe COVID-19 disease. There was a significant association between increased age of patients, male gender and moderate CT severity and ($p=0.01$ and $p<0.001$ respectively). No significant differences were observed between mild and moderate CT severity score regarding loss of smell, loss of sense of test, headache and weakness, whereas clinical presentations of cough,

fever and dyspnea were significantly related to moderate CT severity score (p<0.05) (***Table 1***). A highly significant association between positive past medical history like diabetes and hypertension and moderate CT severity score (p<0.001) (***Table 2***)

Table 1: Distribution of clinical presentations according to CT severity score.

Variable	CT severity score				P-value
	Mild		Moderate		
	No.	%	No.	%	
Loss of smell	26	48.1	27	61.4	0.1* NS
Loss of sense of test	15	27.8	15	34.1	0.5* NS
Fever	19	35.2	30	68.2	0.001* S
Headache	19	35.2	17	38.6	0.7* NS
Cough	47	87.0	44	100.0	0.01** S
Weakness	35	64.8	28	63.6	0.9* NS
Dyspnea	16	29.6	28	63.6	0.001* S

**Chi-square test, **Fishers exact test, S=Significant, NS=Not significant.*

Table 2: Distribution of medical history according to CT severity score.

Past medical history	CT severity score				P-value
	Mild		Moderate		
	No.	%	No.	%	
Negative	46	85.2	16	36.4	<0.001* S
Asthma	3	5.6	4	9.1	
Diabetic	3	5.6	0	-	
Hypertension	2	3.7	18	40.9	
Renal disease	0	-	1	2.3	
Diabetes and hypertension	0	-	2	4.5	
Cardiovascular diseases	0	-	3	6.8	

**Fishers exact test, S=Significant.*

No significant differences were observed between mild CT scan severity and moderate CT scan severity regarding ground-glass opacification/ opacity (p=0.4), diffuse (p=0.8) and scattered characteristics (p=0.4), whereas a highly significant association between consolidation, focci and patch and moderate CT scan severity (p<0.001, p<0.001 and p<0.001 respectively). (***Table 3***)

Table 3: Distribution of CT scan characteristics according to CT severity score.

Variable	CT severity score				P-value
	Mild		Moderate		
	No.	%	No.	%	
Ground-glass opacification/opacity	44	81.5	33	75.0	0.4* NS
Consolidation	26	48.1	40	90.9	<0.001* S
Foci	17	31.5	1	2.3	<0.001* S
Patch	26	48.1	42	95.5	<0.001* S
Diffuse	1	1.9	1	2.3	0.8** NS
Scattered	3	5.6	4	9.1	0.4** NS

*Chi-square test, **Fishers exact test, NS=Not significant, S=Significant.

A highly significant association between higher number of focal abnormalities and moderate CT scan severity (p<0.001). A highly significant association was observed between increased maximum diameter of CT and moderate CT scan severity (p<0.001). There was a highly significant association between severe BSTI CT score and moderate CT scan severity (p<0.001). (***Table 4***)

Table 4: Distribution of CT scan scores according to CT severity score.

Variable		CT severity score				P-value
		Mild		Moderate		
		No.	%	No.	%	
Number of focal abnormalities	<3	25	46.3	0	-	<0.001*S
	≥3	29	53.7	44	100.0	
Maximum diameter	<3	45	83.3	5	11.4	<0.001*S
	≥3	9	16.7	39	88.6	
CT score according to BSTI	Mild	42	77.8	0	-	<0.001*S
	Moderate	12	22.2	32	72.7	
	Severe	0	-	12	27.3	

**Chi-square test, S=Significant.*

All CT severity score measures (RUL, RML, RLL, LUL and LLL scores) were significantly increased in patients with severe BSTI CT score (p<0.05). The TSS was significantly increased compared to severe BSTI score (p<0.001) (***Table 5***).

Table 5: Distribution of CT scan severity score according to BSTI severity score.

Variable	BSTI score			P-value
	Mild	Moderate	Severe	
	Mean±SD	Mean±SD	Mean±SD	
RUL score	0.5±0.4	1.2±0.5	1.8±0.3	<0.001*S
RML score	1.1±0.6	1.8±0.4	2.5±0.5	<0.001*S
RLL score	1.7±0.7	2.7±0.4	3.3±0.4	<0.001*S
LUL score	0.2±0.5	0.4±0.5	1±0.01	<0.001*S
LLL score	1.9±1.1	2.5±0.6	2.6±0.5	0.004*S
TSS score	5.6±1.4	8.9±1.1	11.3±1.3	<0.001*S

*One way ANOVA analysis, S=Significant.

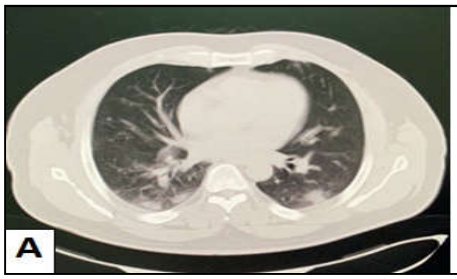

Figure 1A: Axial CT image of 51years old COVID patient show bilateral peripheral nodules 5days after onset of fever (Mild TSS).

Figure 1B: Axial CT Image of 36years old male COVID patient show bilateral peripheral GGO superimposed by consolidations interlobarseptal thickening mainly on the left lower lobe (Moderate TSS).

DISCUSSION:

The computerized tomography (CT) is the most effective imaging module for diagnosis and severity categorization of COVID-19 although low specificity of CT scan in viral infections, but it is characterized with high sensitivity that make it typical for assessment of COVID-19 severity [10].

The current study showed a highly significant association between BSTI CT scan severity score and CT scan total severity score ($p<0.001$). This finding is consistent with results of Inui et al [12] case control study in Japan on 100 symptomatic patients suspected with COVID-19 infection which found that BSTI CT-scan severity score had high inter-observer agreement with other CT scan severity scores. However, another study conducted in China by Yang et al [13] found that CT scan total severity score is the most accurate score in severity classification of COVID-19 pulmonary infection that should be used quickly for early evaluation. The TSS score of CT scan in the present study was significantly increased among patients with severe BSTI CT scan score of COVID-19 patients ($p<0.001$). In Egypt, a prospective cross sectional study carried out by Hafez on 200 patients with COVID-19 chest infection reported that total severity score is the best CT scan score for severity categorization of COVID-19 viral infection with mean score of 11.2 for mild to moderate severity [14]. In Iraq, the literatures on CT scan severity scores are scarce; however, a study conducted by Hassan et al [15] on 20 COVID-19 patients and 28 non-COVID-19 pneumonia patients in AL-Yarmouk Teaching Hospital revealed that the chest CT scan is a significant tool for diagnosis and severity evaluation of COVID-19 infection. In China, another study carried out by Ai et al [16] on 258 patients' undergone RT-PCR test found that 67% of patients turned from negative to positive test showed initial positive chest CT findings.Many authors are working to detect the relationship between CT findings andpoor clinical outcomes in addition to develop a proper severity score and an applicable prognostic value [17]. The CT scan imaging revealed decreased lung segments number affected (mean 7.5 segments) is related to mild COVID-19 symptoms with changes that are concentrated commonly at periphery of the parenchyma. Inversely, increased number of affected segments (mean 17.5) is predicting more severe cases of COVID-19 chest infection with opacities mainly at center and peripheries and air bronchogram, interlobular septal thickening, pleural effusion and mediastinal lymphadenopathy [18]. For more accuracy and simple application, the British Society for Thoracic Imaging (BSTI) developed a structured reporting classification for chest radiography in COVID-19 dependable on the characteristics, location and zonal predominance of the radiological alterations [19]. All CT scan severity score measures (RUL, RML, RLL, LUL and LLL scores) in present study were significantly increased among patients with severe BSTI CT scan score of COVID-19 patients ($p<0.05$). These findings are in agreement with results of Borakati et al [20] study in UK on 1198 patients presented for RT-PCR test and found that CT scan had high sensitivity and low specificity in diagnosis of COVID-19 chest infection and they also reported a high correlation between BSTI CT scan severity classification and different lobe measures assessed according to TSS score. The current study found that higher TSS scores of COVID-19 patients were related significantly with number of focal abnormalities and maximum diameter. These findings are similar to results of Omar et al [21] study in Egypt which stated that assessment of COVID-19 severity score of TSS is dependable on number of focal abnormalities and maximum diameter.

The main significant CT scan characteristics associated with increased (moderate) severity of COVID-19 infection in the present study were consolidation, patch, bilateral, right, posterior and anterior CT characteristic. These findings are in agreement with results of many literatures such as Carotti et al [22] study in Italy, Ye et al [23] study in China & Liu et al [24] study in China.

The current study found a significant association between increased age of COVID-19 patients and male gender and moderate severity of CT scan ($p=0.01$). This finding is similar to results of Feng et al [25] study in China, Xiao et al [26] retrospective single-centerstudy in China and Al-Mosawe et al [27] prospective cross-sectional analytic study in Iraq.

The present study also showed that COVID-19 clinical presentations of cough, fever and dyspnea were significantly related to moderate CT scan severity ($p<0.05$).These findings were similar to results of Shen et al [28] study in China. The current study found a highly significant association between COVID-19 patients with positive past medical history like diabetes and hypertension and moderate CT scan severity ($p<0.001$).

This finding is consistent with results of Li et al [29] study in China,However, the findings of the current study are inconsistent with results of Raoufi et al [30] study in Iran which found no significant difference in CT scan severity score between diabetic and non-diabetic COVID-19 patients. This inconsistency might be due to differences in COVID-19 infection incidence of the disease and discrepancy in population groups affected between two countries in addition to differences in severity of the disease.

CONCLUSION:

The computerized tomography British Society of Thoracic Imagingscore of COVID-19 severity is directly related tocomputerized tomography total severity score with acceptable agreement in mild and moderate cases till TSS = 11.3, above this score; some of the moderate cases according to TSS are severe according to BSTI guideline in correlation with data.The common CT characteristics for moderateCOVID-19 disease are bilateral, consolidation,right, posterior and anterior lesions. The characteristics related to increased CT severity score of COVID-19 infection are elderly age, male gender, cough, fever, dyspnea, past medical history, delayed computerized tomography and hypoxia,.

REFERENCES:

1. Hui DSC, Zumla A. Severe Acute Respiratory Syndrome: Historical, Epidemiologic, and Clinical Features. Infect Dis Clin North Am. 2019; 33:869-89.
2. Azhar EI, Hui DSC, Memish ZA, Drosten C, Zumla A. The Middle East Respiratory Syndrome (MERS). Infect Dis Clin North Am. 2019; 33:891-905.
3. Perlman S, Netland J. Coronaviruses post-SARS: update on replication and pathogenesis. Nat Rev Microbiol. 2009; 7:439-50.
4. Flaxman S, Mishra S, Gandy A, Unwin HJT, Mellan TA, Coupland H, et al. Estimating the effects of non-pharmaceutical interventions on COVID-19 in Europe. Nature. 2020;584:257-61.
5. Clark A, Jit M, Warren-Gash C, Guthrie B, Wang HHX, Mercer SW, et al. Global, regional, and national estimates of the population at increased risk of severe COVID-19 due to underlying health conditions in 2020: a modelling study. Lancet Glob Health. 2020; 8:e1003-e1017.
6. Chan JF, To KK, Tse H, Jin DY, Yuen KY. Interspecies transmission and emergence of novel viruses: lessons from bats and birds. Trends Microbiol. 2013;21:544-55.
7. Yoon SH, Lee KH, Kim JY. Chest radiographic and CT findings of the 2019 novel coronavirus disease (COVID-19): analysis of nine patients treated in Korea. Korean J Radiol. 2020;21:494–500.
8. Wu R, Wang L, Kuo HD. An update on current therapeutic drugs treating COVID-19. CurrPharmacol Rep. 2020; 11:1–15.
9. Salaffi F, Carotti M, Tardella M, Borgheresi A, Agostini A, Minorati D, et al. The role of a chest computed tomography severity score in coronavirus disease 2019 pneumonia. Medicine (Baltimore). 2020; 99:e22433.
10. Wasilewski PG, Mruk B, Mazur S, Półtorak-Szymczak G, Sklinda K, Walecki J. COVID-19 severity scoring systems in radiological imaging - a review. Pol J Radiol. 2020; 85:e361-e368.
11. Hare SS, Tavare AN, Dattani V. Validation of the British Society of Thoracic Imaging guidelines for COVID-19 chest radiograph reporting. ClinRadiol. 2020; 75:710.e9-710.e14.
12. Inui S, Kurokawa R, Nakai Y, Watanabe Y, Kurokawa M, Sakurai K, et al. Comparison of Chest CT Grading Systems in Coronavirus Disease 2019 (COVID-19) Pneumonia. RadiolCardiothorac Imaging. 2020; 2:e200492.
13. Ran Yang XL, Liu Huan, Zhen Yanling. Chest CT severity score: An imaging tool for assessing severe COVID-19. Radiol: Cardiothoracic Image. 2020; 2:6-9.
14. Hafez M. The mean severity score and its correlation with common computed tomography chest manifestations in Egyptian patients with COVID-2019 pneumonia. Egyptian Journal of Radiology and Nuclear Medicine. 2020;51:254.
15. Hassan BM, Khalil MA, Abdulhameed RA, Al-Anbari AJK. A Comparative Study on the Chest CT Scan Radiological Findings and Hematological Parameters of COVID–19 and NON–COVID-19 Pneumoniapatients in Al-Yarmouk Teaching Hospital in Baghdad, Iraq. Medico Legal Update. 2020; 20: 833-40.

16. Ai T, Yang Z, Hou H. Correlation of chest CT and RT-PCR testing for coronavirus disease 2019 (COVID-19) in China: A report of 1014 cases. Radiology. 2020;296:E32–E40.
17. Tabatabaei S, Talari H, Moghaddas F, Rajebi H. CT Features and Short-term Prognosis of COVID-19 Pneumonia: A Single-Center Study from Kashan, Iran. Radiology: Cardiothoracic Imaging. 2020;2:e200130.
18. Yu M, Xu D, Lan L, Tu M, Liao R, Cai S, et al. Thinsection Chest CT Imaging of Coronavirus Disease 2019 Pneumonia: Comparison Between Patients with Mild and Severe Disease. RadiolCardiothorac Imaging. 2020;2:e200126.
19. COVID-19 BSTI Reporting templates. 2020. Available at: https:// www.bsti.org.uk/covid-19-resources/covid-19-bstireporting
20. Borakati A, Perera A, Johnson J, Sood T. Diagnostic accuracy of X-ray versus CT in COVID-19: a propensity-matched database study. BMJ Open. 2020;10:e042946.
21. Omar S, Motawea AM, Yasin R. High-resolution CT features of COVID-19 pneumonia in confirmed cases. The Egyptian Journal of Radiology and Nuclear Medicine. 2020; 51:121.
22. Carotti M, Salaffi F, Sarzi-Puttini P. Chest CT features of coronavirus disease 2019 (COVID-19) pneumonia: key points for radiologists. Radiol Med. 2020;125:636-46.
23. Ye Z, Zhang Y, Wang Y. Chest CT manifestations of new coronavirus disease 2019 (COVID-19): a pictorial review. EurRadiol. 2020; 30:4381–89. COVID-19 pneumonia: Focus on pregnant women and children. J Infect. 2020;80:e7-e13.
24. Liu H, Liu F, Li J, Zhang T, Wang D, Lan W. Clinical and CT imaging features of the
25. Feng Z, Yu Q, Yao S, Luo L, Zhou W, Mao X, et al. Early prediction of disease progression in COVID-19 pneumonia patients with chest CT and clinical characteristics. Nat Commun. 2020;11:4968.
26. Xiao J, Li X, Xie Y, Huang Z, Ding Y, Zhao S, et al. Maximum chest CT score is associated with progression to severe illness in patients with COVID-19: a retrospective study from Wuhan, China. BMC Infect Dis. 2020;20:953.
27. Al-MosaweAM, Abdulwahid HM, Fayadh NAH. Spectrum of CT appearance and CT severity index of COVID-19 pulmonary infection in correlation with age, sex, and PCR test: an Iraqi experience. The Egyptian Journal of Radiology and Nuclear Medicine. 2021;52:40.
28. Shen ZJ, Lu N, Gao LL, Lv J, Luo HF, Jiang JF, et al. Initial chest CT findings in COVID-19: correlation with clinical features. J Zhejiang UnivSci B. 2020;21:668-72.
29. Li D, Zhang Q, Tan Y. Prediction of COVID-19 Severity Using Chest Computed Tomography and Laboratory Measurements: Evaluation Using Machine Learning Approach. JMIR Med Inform. 2020; 8:e21604.
30. Raoufi M, Khalili S, Mansouri M, Mahdavi A, Khalili N. Well-controlled vs poorly-controlled diabetes in patients with COVID-19: Are there any differences in outcomes and imaging findings? Diabetes Res ClinPract. 2020; 166:108286.