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A review of the currently available clinical and radiological scoring systems for the management of Covid-19 patients.

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The ongoing Covid 19 pandemic caused by SARS-CoV-2, has undeniably posed a severe threat to global health. The SARS-CoV-2 is detected by real-time reverse transcriptase-polymerase chain reaction (RT-PCR) testing. RT-PCR is considered to be the gold standard diagnostic test for Covid 19, but due to certain limitations of RT-PCR, imaging has now emerged as a valuable complementary aid. Many CT findings are commonly seen in Covid 19, which might effectively help in diagnostic decision making, however it is important to note, that these findings are not specific for Covid 19. In this review, we discuss the currently available clinical and radiological scoring systems and comment on applicability.

Keywords: Scoring system, COVID-19, Clinical, radiological, SARS-CoV-2, WHO, CT Scan.

INTRODUCTION

The ongoing Covid 19 pandemic caused by SARS-CoV-2, has undeniably posed a severe threat to global health. Having emerged from Wuhan, China in December 2019, it has now managed to reach every corner of the world (Helmy et al. 2020). It led to a global health emergency and made it imperative for us to work towards deploying safe and effective vaccines. As per the latest guidelines by the WHO, AstraZeneca, Johnson and Johnson, Moderna and Pfizer are the vaccines that have met the necessary criteria for both safety and efficacy (WHO).

Coronaviruses are a large family of viruses that cause respiratory tract infections in humans, most of which lead to mild or common symptoms like fever, dry cough, and tiredness (WHO). However, few of them do lead to pulmonary edema, severe pneumonia, severe acute respiratory syndrome (SARS), and multiple organ failure, and some cases have even resulted in death (Huang et al.2020).

The SARS-CoV-2 is detected by real-time reverse transcriptase-polymerase chain reaction (RT-PCR) testing which is done mostly via a nasopharyngeal swab (WHO). Rapid antigen detection (RAD) immunoassays have also evolved to be preferred for point-of-care testing (POCT), as they are easy to carry out, inexpensive, and give quick results (Albert et al. 2021).

Chest X-ray can be preferred in Covid 19 patients in a resource-constrained environment where access to Computed Tomography (CT) is hindered however it is important to note that CXR has been suggested to be insensitive in the case of mild or early infection (Rubin, 2020). Also, in cases where there are visible features of severe respiratory deterioration, a CT would be preferable (Rubin, 2020). A major percentage of hospitalized Covid 19 patients revealed chest imaging findings that included bilateral lung involvement and ground-glass opacities, in an

article published for the first time back in January 2020 (WHO). Since then, a lot of articles have been published related to chest CT findings in Covid 19. Chest CT turns out to be crucial in moderate to severe cases while determining patients with exacerbation of the disease or secondary complications like superimposed pneumonia, PE, or heart failure (Kwee et al. 2020). It might play a huge role in determining results and guiding us when it comes to triage and clinical management of this disease in patients with moderate to severe respiratory symptoms (Kwee et al. 2020).

Many CT findings are commonly seen in Covid 19, which might effectively help in diagnostic decision making, however it is important to note that these findings are not specific for Covid 19 (Kwee et al. 2020). In addition, there is a huge risk of exposure to patients and healthcare personnel to SARS-CoV-2, and one will have to take various safety measures while performing CT in suspects or positive patients (Mossa-Basha et al.2020, Radiology Scientific Expert Review Panel).

In this review, we discuss and shed some light on the clinical and radiological scoring systems that are currently available.

CLINICAL SCORING SYSTEM:

Covid-19 scoring system (CSS):

According to a paper presented by Shang et al. in July 2020, a Covid-19 scoring system (CSS) was established (Shang Y et al 2021). A population of 452 severe Covid-19 patients with a median age of 66 years, was considered, but 60.2% of them had complications.

Variables like age, diabetes, coronary heart disease, procalcitonin, serum urea, lymphocyte percentage, C reactive protein, and D-dimer were found to be associated with mortality, using the LASSO binary logistic regression, and based on these, the CSS was established. After performing a multivariable analysis, it was concluded that old age, CHD, lymphocyte percentage, procalcitonin, and D-dimer is independent risk factors for mortality in Covid-19 patients. The CSS successfully classified severe patients into low-risk and high-risk groups, which was in turn useful for the clinicians to predict in-hospital mortality and further complications (Shang Y et al 2021) .

Clinical symptom-based scoring system (CSBSS):

This system was developed by Bhattacharya et al. in 2021 (Bhattacharya et al. 2021). The authors of this study claim that the formula generated in this system could be used in the healthcare setting before the RT-PCR results are generated since it is easy to apply and can be conveniently used in any healthcare setting.

The five clinical features that were used to develop this scoring system are fever >100 degrees F, cough, headache, myalgia, and loss of smell. Using the multivariable logistic regression analysis for these variables, scores were generated from their odds ratios and regression coefficients, for each of the aforementioned symptoms. The clinical score for each clinical symptom was achieved by dividing each of the coefficients by the smallest coefficient, i.e. 0.173, and then multiplying by 10.

Formula: Clinical symptom-based score = (41.7 x Fever >100°F) + (13.5 x Cough) + (15.8 x Headache) + (10 x Myalgia) + (94.7 x Loss of smell).

Values for the presence or absence of a symptom can be put as 1 or 0, respectively. (Bhattacharya et al.2021).

RADIOLOGICAL REVIEW SYSTEM:

Radiological studies have been known to play an important role in the diagnosis of many diseases. In reference to the current pandemic, imaging has been of prime importance when it comes to early diagnosis for triage, management, and making appropriate decisions related to isolation. In the radiological review system, we will give an insight into CXR and chest CT.

Chest X-Ray Imaging:

CXR is useful in the assessment of disease progression and alternative diagnosis in hospitalized patients (Rubin et al .2020). Although CT imaging has an extra edge over CXR due to its higher preciseness in identifying specific diseases, it is not a sustainable option to solely depend on CT since the risk for cross-infection to the healthcare professionals, in such a case, increases. Additionally, CXR can be a valuable diagnostic tool for monitoring the rapid progression of lung involvement and assessing the severity of the disease in critical Covid 19 patients (Borghesi et al. 2020).

A number of scoring systems have been developed by physicians from different parts of the world. These are:

SARI (Severe Acute Respiratory Infection) CXR severity scoring system:

This scoring system was developed by Taylor to make the process of assessing and grading patients with acute respiratory infection easier (Taylor E et al.2015). It has been described as a five-point scoring tool where the CXR findings are supposed to be categorized into: 1 = normal; 2 = patchy atelectasis and/or hyperinflation and/or bronchial wall thickening; 3 = focal consolidation; 4 = multifocal consolidation; and 5 = diffuse alveolar changes (Taylor E et al.2015). This scoring system was devised before the pandemic in 2015 and by far has been used only in one Korean study (Yoon SH et al.2020).

RALE Classification scoring system:

Radiographic Assessment of Lung (O)Edema (RALE) scoring system, which was originally proposed by Warren *et al.* back in 2018, was adopted and modified by Wong *et al.,* in 2020 (Warren MA et al.2018, Wong HYF et al.2020). As per this study, a score of 0–4 is supposed to be assigned to each lung depending on the extent of involvement by consolidation or ground-glass opacities (GGO).

0 indicating: no involvement; 1: <25% involvement; 2: 25%–50% involvement; 3: 50%–75% involvement; 4: >75% involvement (Wong HYF et al.2020). The scores for each lung are supposed to be summed up to produce the final severity score (Wong et al.2020). The highest chest radiography severity score recorded in this study was 8 (of a maximum possible score of 8).

This study involved a total of 64 patients from the age range- 16-96 years (mean age being 56 ± 19 years). The most common comorbidities observed in this population were hypertension (13 of 64; 20%) and diabetes (eight of 64; 13%). Consolidation was the most common finding (30 of 64; 47%), followed by ground-glass opacities (21 of 64; 33%) (Wong et al.2020).

CXR score:

This scoring system was proposed by Borghesi and Maroldi in March 2020. It has been specifically designed for semi-quantitative assessment of the severity as well as the progression of pulmonary involvement in Covid-19 patients (Borghesi et al. 2020). It consists of two steps of image analysis.

First step:

Here the lungs are divided into 6 zones (A, B, C, D, E, F) on the frontal chest projection where A, B, C zones belong to the right lung and D, E, F zones belong to the left lung as shown in the table below.

Second step:

Here within, a score (from 0 to 3) is assigned to each zone on the basis of lung abnormalities seen on frontal chest projection.

- Score 0: No lung abnormalities
- Score 1: Interstitial infiltrates

Zones	Right Lung	Left Lung
Upper level: above the inferior wall of the aortic arch	A	D
Middle level: below the inferior wall of the aortic arch and above the inferior wall of the right inferior pulmonary vein, (the hilar structures)	B	E
Lower level: below the inferior wall of the right inferior pulmonary vein (the lung bases)	C	F

- Score 2: Interstitial and alveolar infiltrates (interstitial predominance)
- Score 3: Interstitial and alveolar infiltrates (alveolar predominance)

The scores of all six lung zones are summed up in order to obtain an overall CXR score which can range anywhere from 0 to 18 (Borghesi et al. 2020).

The validity of this study was assessed on a hundred hospitalized patients (Borghesi A et al. 2020). The score in the reports ranged from 0 to 16 with a median of 6.5. Also, the score was seen to be higher in patients who died than in those who recovered (Borghesi et al. 2020).

Computed Tomography Imaging:

Although RT-PCR remains the gold standard for Covid-19 diagnosis, their results can be misleading due to errors in sampling and low virus load (Hui DSC et al.2019, WHO,. Peiris J et al.2003)There have been several studies describing the benefits of CT over RT-PCR. In a study by Fang *et al*., the detection rates for initial chest CT examination and RT-PCR were compared such that the detection rate for initial CT examination (50 of 51 patients, 98%) was higher than for the first RT-PCR test (36 of 51 patients, 71%) (*P*< .001)(Fang Y et al.2020). Another study by Xie et al. conducted in 2019, wherein 167 patients were evaluated among whom, 5 patients (3%) initially had negative findings at RT-PCR but positive findings at chest

CT(Xie X et al.2020).

Furthermore, according to a report of 1014 cases in China, by Ai *et al.*, chest CT has a higher sensitivity for the diagnosis of Covid-19 and can be considered as the primary tool for Covid-19 detection, especially in epidemic areas (Ai T et al.2020) (. They are easy to perform, fast, and help to detect early Covid-19 pneumonia with higher sensitivity.

Presenting you some of the scoring systems that have been developed over the past few years.

ABCD scoring system:

This scoring system by Salunke *et al.*, (Salunke AA et al.2020) as per our knowledge, is by far the first scoring system that has been proposed by Indian healthcare professionals. 4 variables namely A, B, C, D are proposed where A stands for Age, B stands for Blood tests (Leucopenia, lymphocytopenia, CRP level, LDH level, D-Dimer), C stands for Comorbidities (COPD, Cancer, Hypertension, Chronic renal failure, Diabetes mellitus) and Chest X-Ray plus CT scans (Ground glass and bilateral patchy shadows), and D stands for Dyspnea (Respiratory rate & O2 saturation). The maximum score that can be achieved using these variables is 14 and the minimum score is 0 (Salunke AA et al.2020).

Along with this, there are 3 colors assigned suggesting the severity of the diseases as follows:

Colour	**Green**	**Yellow**	**Red**
Score	0-4	4-8	>8
Disease severity	Mild	Moderate	Severe
Approach	Symptomatic treatment	Semi-critical care and O2 supplementation	Critical and Intensive care

These colors are specifically chosen for easier understanding and memorization by healthcare workers. This scoring system, however, wasn't validated and that's one of the biggest limitations of this study.

Chest CT severity score:

This scoring system was proposed by Yang et al in order to assess the severity of Covid-19 using a semi-quantitative approach(Yang R et al.2020). It was devised on the basis of lung opacification where both the lungs were divided into 20 different regions.

Each region was scored 0, 1, or 2 points depending upon the degree of parenchymal opacification. 0 score was given for 0% opacification, 1 for 1-50%, and 2 for 51-100%, respectively. Then all the scores in each of the 20 regions were added up to determine the overall CT severity score, ranging from 0 to 40 points.

The CT-SS threshold for severe Covid-19 in this study was 19.5 points, with 83.3% sensitivity and 94% specificity (Yang R et al.2020). A total of 102 Covid-19 confirmed patients (53 men and 49 women) from the age group 15-79 years, were included in this study. Out of 103, 18 cases were severe and the CT-SS was observed to be higher in severe cases as opposed to mild cases where it was comparatively lower(Yang R et al.2020).

Total severity score:

This scoring method was proposed by Kunwei et al. which were published in March 2020 (Li K et al.2020). This study involved 78 Covid positive patients (38 men and 40 women). Herein all the five lobes of both the lungs along with findings like ground-glass opacities, mixed ground-glass opacities, consolidation, interlobular septal thickening, etc. are told to be taken into consideration.

On the basis of the involvement of the aforementioned findings, each lobe can be awarded 0 to 4 points: 0 for 0% involvement, 1 for 1-25%, 2 for 26-50%, 3 for 51-75%, and 4 for 76-100%. All of these scores from each lobe would then be added to calculate the TSS. The TSS threshold for severe cases in this study turned out to be 7.5 points, with 82.6% sensitivity and 100% specificity.

CHEST CT SCORE:

This method is quite similar to the method that was just discussed. It was presented by Li et al in March 2020(Li K et al.2020). Again all 5 lobes of both the lungs were considered in this study with additional pathological findings that include ground-glass opacities, consolidations, linear opacities, nodules, inter-lobular septal thickening, crazy-paving pattern, bronchial wall thickening, sub-pleural curvilinear line, lymph node enlargement, pleural and pericardial effusion.

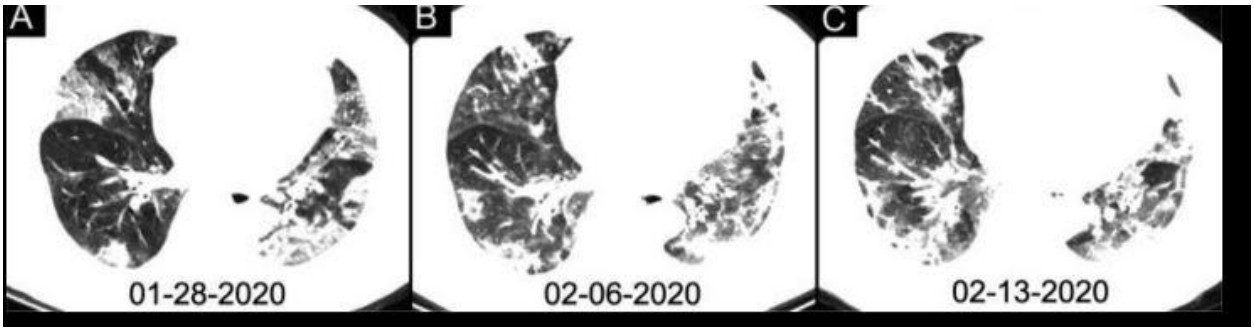

Figure 1 :shows the Chest CT images with typical mixed ground-glass opacities and multifocal consolidation shadows in bilateral lungs

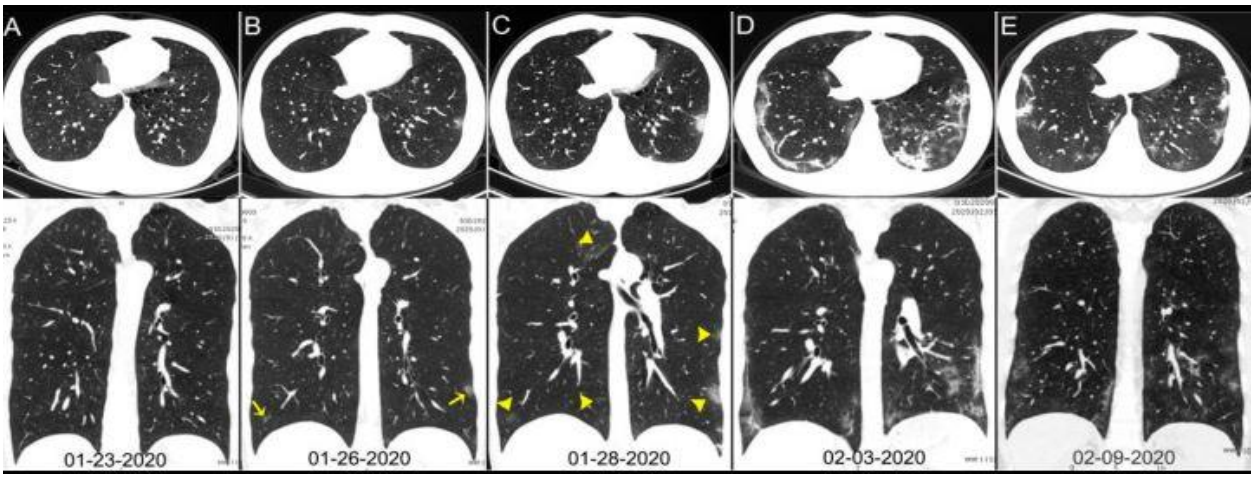

Figure 2: (A column) shows Normal chest CT with axial and coronal planes at the onset. (B column) shows Chest CT with axial and coronal planes shows minimal ground-glass opacities in the bilateral lower lung lobes (yellow arrows). (C column) shows Chest CT with axial and coronal planes with increased ground-glass opacities (yellow arrowheads). (D column) shows Chest CT with axial and coronal planes revealing the progression of pneumonia with mixed ground-glass opacities and linear opacities in the subpleural area. (E column) shows the Chest CT with axial and coronal planes revealing the absorption of both ground-glass opacities and organizing pneumonia.

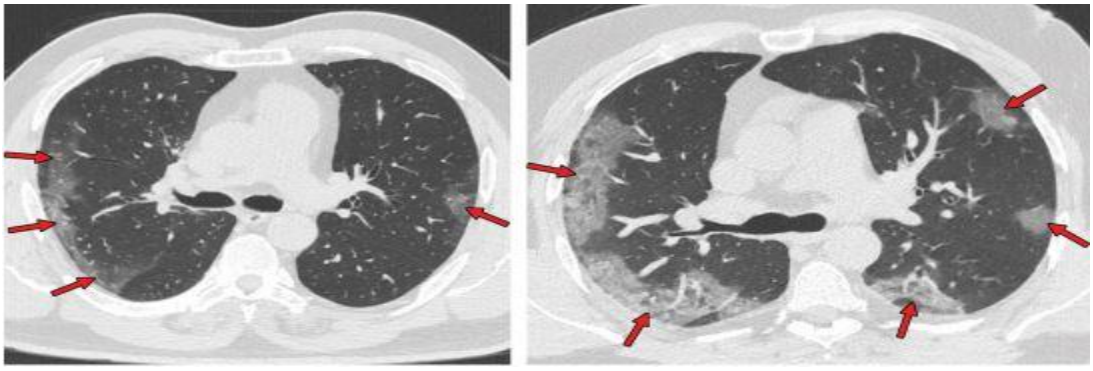

Figure 3: COVID-19 pneumonia with typical imaging features according to the Radiological Society of North America (RSNA) chest CT classification system (Kwee TC et al.2020 showing bilateral areas of ground-glass opacities (arrows).

As per this method, scores from 0 to 5 can be given depending upon the percentage of involvement. 0 for 0% involvement, 2 for 5-25%, 3 for 26-49%, 4 for 50-75% and 5 for > 75% involvement. All the scores from each lobe can then be added to obtain a sum ranging anywhere between 0 to 25 points. The threshold for severe cases in this study was 7, with 80.0% sensitivity and 82.8% specificity (Li K et al.2020).

The most important thing to bear in mind while considering CT as one of the important diagnostic modalities is to understand the increase in infection transmission risk to healthcare workers and the staff, since cleaning larger surfaces like CT machines, is quite complicated. Stringent guidelines and protocols have been made and implemented in a lot of healthcare settings (Radiology Scientific Expert Review Panel) but practically, in developing countries, especially when the number of cases is too high, it will always be riskier due to lack of appropriate resources.

PI scoring system:

A 35-scale semi quantitative scoring system was proposed in a study by Salahshour et al. in 2021 (Salunke et al.2020). This study involved 739(419 mean and 320 women) highly suspicious patients with the most common symptoms like dry cough, dyspnea, chills, pharyngitis, despite the absence of fever, with a positive history of exposure to the virus; out of whom, 439 were confirmed Covid-19 cases.

All the five lung lobes (right upper lobe, right middle lobe, right lower lobe, left upper lobe, left lower lobe) were assessed for ground-glass opacities and consolidation. A score from 0 to 5 was given for each pattern on the basis of the percentage of involvement; 0: no involvement, 1: ≤ 5%, 2: 6–25%, 3: 26–50%, 4: 51–75%, and 5: ≥ 76%.

The total GGO and consolidation scores were the sum of the scores of all the lobes.

The total PI score was calculated in 2 ways, one being the sum of total GGO scores and total consolidation scores, and the other being the sum of GGO and consolidation of all the five lobes. The PI score could range anywhere from (no involvement) to 35 (maximum involvement) (Salunke AA et al.2020).

CONCLUSION

With this comprehensive review, we suggest that despite the existence of many different scoring systems, in order to maintain uniformity across the assessment of clinical and radiological findings, there remains a need to produce a standardized scoring system, that can be used to dispense quicker diagnosis and ultimately better healthcare services, globally.

However, we further suggest that using the aforementioned scoring systems, will help with clinical diagnosis in most cases. The individual scoring systems will have advantages and disadvantages, and it must be recognized that the usage of these scoring systems, depends upon a mix of factors and it is upon the physicians to utilize them efficiently, by correctly assessing and analyzing their patients' specific conditions.

CONFLICT OF INTEREST

The authors declared that present study was performed in absence of any conflict of interest.

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