A RETROSPECTIVE OBSERVATIONAL STUDY TO EVALUATE THE EFFECTIVENESS OF COMPUTED TOMOGRAPHY CHEST SEVERITY SCORINGS IN CORRELATION WITH CLINICAL PROGRESSION AND OXYGEN REQUIREMENT IN CORONAVIRUS INFECTED PATIENTS

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ABSTRACT:

INTRODUCTION:Human coronavirus hadstarted its widespread pandemic from the year of 2019. Although, molecular analysis are used for diagnosis,Computed Tomography (CT) of chest,had played a major role in assessing the severity of COVID-19.

AIM:To evaluate the effectiveness of CT 40 point and CT 25point severity scoring (CT-SS) systems in correlation with oxygen saturation.

MATERIALS AND METHODS:A total of 395 patients COVID-19 patients with CT chest imaging were included. The CT-40 SSdependsupon parenchymal opacification. Scores of 0, 1, and 2 were given for which parenchymal opacification involved were 0%, < 50% and ≥ 50% respectively. Score of 1-12 is mild; Score of 13-19 is moderate; Score >20 is severe. The CT-25SSdependsupon lobar involvement. i.e., ≤ 5% - Score 1, 5%-25% - Score 2, 26%-50% -Score 3, 51-75% - Score 4,>75% - Score 5.Mild is ≤ 7, Moderate is 8-17, Severe is ≥ 18.

ANALYSIS AND RESULTS:The spearman correlation co-efficient for CT-40 SS and CT-25 SS was found to be r =-0.7636 and r = -0.6665 respectively, based on the r value CT-40 SS is better than CT-25 SS. Increase in CT-SS results in decreased O2 saturation. The sensitivity and specificity of CT40 SS in correlation to O2 saturation was found to be 88% and 78% respectively with area under ROC curve of 0.885. The sensitivity and specificity of CT 25 SS in correlation to O2 saturation was found to be 79% and 80% respectively with area under ROC curve of 0.912.

CONCLUSION:CT-SS had contributed an important role and proven its efficacy in assisting physicians for assessing the progression of COVID -19.

Key words: Coronaviruses, Computed Tomography, O2 saturation, CT-Severity Score (CT-SS)

INTRODUCTION:

Human coronaviruses (HCoVs) belong to family of severe acute respiratory syndrome (SARS) group of viruses. The viral membrane gives the appearance of a crown, which means corona in Latin. They have 16 non-structural proteins and 4 major structural proteins. Among the beta-CoV lineage group of viruses, class A virus encodes hemagglutinin esterase (HE), which is functionally like Spike (S) protein. [1,2]

The characteristic features include their proof-reading mechanism and large genome sizes (nearly 32 kb). Virulence of strains is based on lower mutation rate and increased fidelity, which results in expansion of RNA virus genomes. [3,4]SARS-CoV are initially encountered by Toll-like receptors, one of the components of innate immune system . They recognize distinct microbial antigens and directly activate immune mediators leading to inflammatory and immune responses.[5]

Patients have clinical symptoms such as fever, headache, sore throat, cough, loss of taste, loss of smell, rhinorrhoea, nausea, vomiting, shortness of breath, chest pain, myalgia, arthralgia, diarrhoea, etc Among the clinical symptoms, fever is the most common symptom . Coronaviruses can be seen upto 2 weeks in stool samples with the average time of seroconversion in 20 days.[6,7]

The common co-morbidities which favour the spread of COVID -19 infection is patients with underlying uncontrolled diabetes , hypertension , heart disease , cerebrovascular conditions and patients with long term steroid medications.[8,9]

Oxygen saturation has the key role to identifythe disease progression in monitoring the course of disease. Since covid-19 infection itself is a prothrombotic state, it leads to the development of endothelitis and microthrombi formation which results in hypoxia causing pulmonary vasoconstriction and finally leading to decrease in Oxygen saturation. World Health Organisation (WHO) had framed the category of severity of infection in relation to oxygen saturation. [10,11]

Besides diagnosis of COVID 19 microbiologically, Radiological imaging modalities like X ray and Computed Tomography (CT) played a major role in arriving the diagnosis. According to imaging examination by CT, Bilateral pulmonary parenchymal and peripherally placed ground-glass opacities (GGO), consolidative pulmonary opacities, Linear opacities,GGOs with Rounded morphology and Crazy-paving appearance are some of the commonly encountered imaging findings.

To assess the disease progression in terms of oxygen (Spo2) saturation,CT- 40 SS and CT-25 SS are widely used, which is mainly based on extent of parenchymal and lobar involvement respectively. [15,16]

MATERIALS AND METHODS

DATA COLLECTION:

After getting ethical committee approval obtained from Institutional ethical committee of Melmaruvathur Adhiparasakthi Institute of Medical Sciences and Research (MAPIMS), Chengalpattu, we collected clinical data of COVID 19 patients for analysis from a medical records department, from April 2021to June 2021.For those patients, High Resolution Computed Tomography (HRCT) of chest imaging was done in Department of Radiodiagnosis using GE 32 slice CT scanner at the time of admission.

Our study group was composed of 395 patients who were suspected to have COVID-19 infection and confirmed from samples of throat swab and nasopharyngeal swab using RT-PCR and Tru-NAAT tests.

Inclusion and Exclusion Criteria:

Patients under 20 to 85 years old, positivefor RT-PCR or Tru-NAAT tests and with typical findings of COVID-19 in CT-Chest were included . Patients less than 20 years and more than 85 years old, patients lost to follow-up, suboptimal HRCT scan due to significant motion artefacts, and with atypical findings for COVID-19 on CT were excluded from the study. The CT – 40 and CT-25 SS were correlated with Oxygen saturation level of the patients at the time of admission.

HRCT protocol: Patients were asked to lie in a supine position and with an adequate breath hold for few seconds , HRCT was carried out .Scanning parameters were as follows: Scan direction is from caudal to cranial , tube voltage (140 kV), tube current (160 mA) -Smart mA dose modulation, slice thickness of 2.5mm with a pitch of 1.75mm/rotation , rotation time (0.98 s), and scan length (8-10 s). After completion of CT, images were sent to medsynapse and reported via Picture Archiving and Communication Systems (PACS).

HRCT Image Interpretation: CT analysis was done for characteristic findings of COVID-19 pneumonia. According to RSNA Consensus statement, some common patterns are Bilateral, Multilobar, posterior peripheral GGO, Multifocal rounded GGO with or without consolidation and with or without visible intralobular lines (crazy-paving), Perihilar or diffuse GGO , Non-peripheral consolidatory changes etc.[14]Imaging analysis was done by radiologists having greater than 10 years of experience for evaluating the extent of lung involvement by using 40 point and 25 point CT SS systems.

The 40point CT SS is based on extent of parenchymal opacification. The 18 anatomical segments of both lungs are divided into 20 regions, in which posterior segment of the left upper

lobe is subdivided into apical and posterior segments, whereas anteromedial basal segment of the left lower lobe is subdivided into anterior and basal segments.[15]

Individual Segmental Scoreswith Grading Based On Parenchymal involvement By CT-40 Scoring System (YANG et al) [15]. (Table 1 and Table 2)

TABLE 1: SCORING WITH RESPECT TO SEGMENTAL INVOLVEMENT FOR CT-40 SS:

SEGMENT INVOLVEMENT	SCORE
0 %	0
< 50 %	1
>50 %	2

TABLE 1 describes that as per CT-40 severity scoring system,depending upon parenchymal opacification, scores of 0, 1, and 2 were given for which parenchymal opacification involved were 0%, < 50% and ≥ 50% respectively

TABLE2:GRADING OF CT -40 SS:

SCORE	CATEGORY
1-12	MILD
13-19	MODERATE
>20	SEVERE

Table 2 describes that for CT-40 SS, Score of 1-12 is mild, Score of 13-19 is moderate; Score >20 is severe.

25 point CT severity scoring system is based on extent of lobar involvement. The five lobes of lung are right upper, right middle, rightlower, left upper and left lower lobes.[16]

Individual Lobar Scores and Grading Based on Ct-25 Scoring System (CHANG et al).[16] (Table 3 and Table 4)

TABLE 3: SCORING WITH RESPECT TO LOBAR INVOLVEMENT FOR CT-25 SS:

LOBAR INVOLVEMENT	SCORE

Less than or equal to 5%	1
5-25%	2
26-49%	3
50-75%	4
>75%	5

Table 3 describes the percentage of lobar involvement with their respective scores.

TABLE 4:GRADING OF CT -25 SS:

SCORE	CATEGORY
≤ 7	MILD
8-17	MODERATE
≥ 18	SEVERE

Table 4 describes the grading of mild, moderate and severe category for CT-25 SS.

STATISTICAL ANALYSIS AND RESULTS:

Analysis was based on the following parameters: Age, gender, clinical symptoms, comorbidities, whether the patient is on regular medications for comorbidities,Vaccination status, Spo2 saturation level and maximum O2 requirement in the form of supplements. The entire analysis was done on STATA v14 software.

Among 395 patients, 278 were males and 117 were females. Mean age was found out to be 44.3 years with Standard deviation of 11.7.Females have severe lung involvement (35%) when compared to males (32%). The common symptoms of COVID 19 were mentioned in Fig 1.

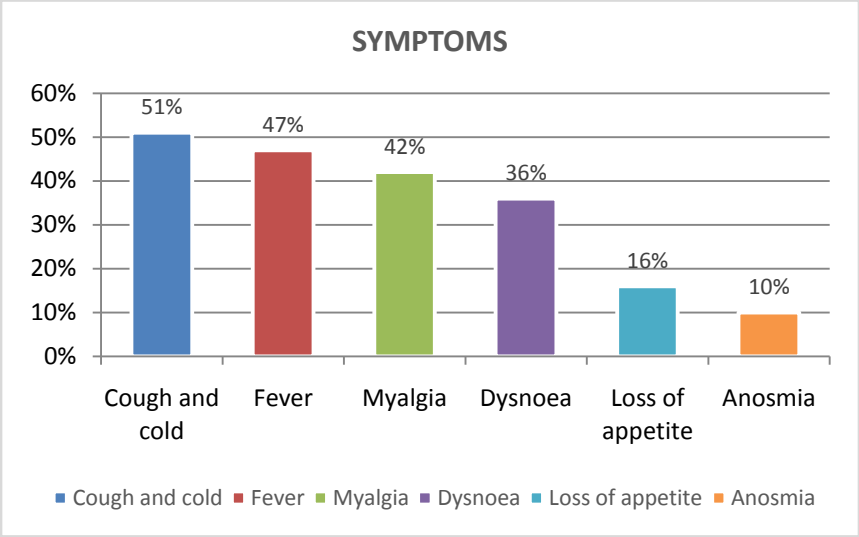

Figure 1: Symptoms of COVID 19

Of 395 patients, around 37% of patients had co morbidities like Type II Diabetes mellitus, Hypertension, Heart disease, thyroid disorders etc, Among them,Diabetes mellitus contributed to 81.8%, followed by Hypertension (33.56%) and Heart disease (12%). About 20.8% of patients have concurrent Diabetes mellitus and Hypertension.

Regarding vaccination status, 75% of patients were found to be unvaccinated, 15 % of them were partially vaccinated (Vaccinated with one dose) and 10 % of them were completely vaccinated. The use of oxygen supplements by patients during admission were mentioned in Fig 2.

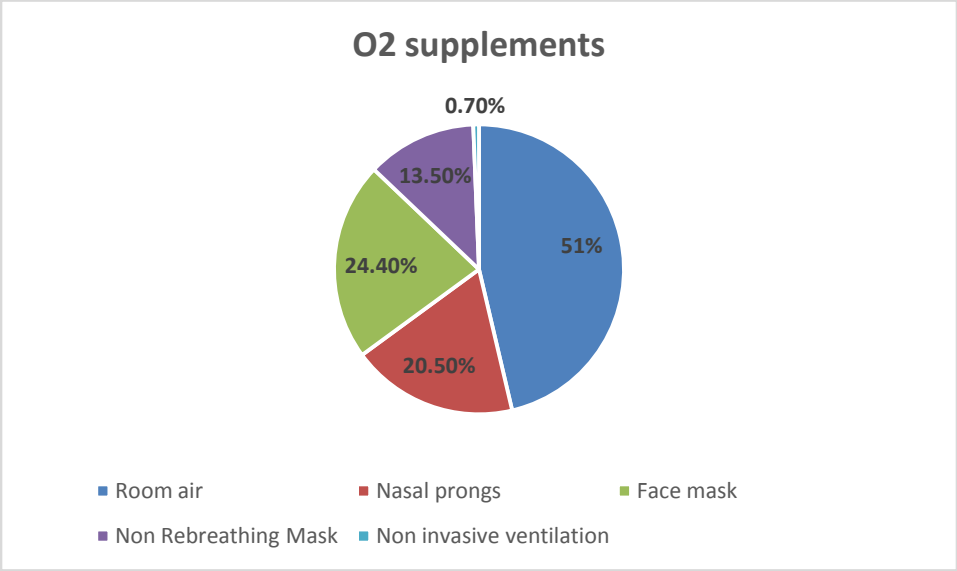

Figure 2 Oxygen supplements usage

Using chi-square test, we have found a statistically significant correlation (P<0.05) between age of patients and severity of lunginvolvement for both CT-40 and CT-25 SS. This explains that that as the age progresses, extent of parenchymal involvement increases.
For CT-40 scoring system, P value was found to be statistically significant <0.05 for patients with symptoms such as cough and cold, fever, dyspnea, and comorbidities such as Diabetes mellitus and Hypertension. For CT 25 SS, P value was <0.05 for patients with symptoms such as diarrhea, myalgia, fever, dyspnea, loss of appetite and comorbidities such as Diabetes mellitus and Hypertension. There was also significant relationship (P<0.05) between the vaccination status and degree of lung involvement. i.e., Patients who were vaccinated had less severe lung involvement in comparison with Unvaccinated patients.
The mean value of CT scores out of 40 was 15.5 and out of 25 was 9.7. Fig 3 explains the percentage of lung involvement in mild, moderate and severe category based on both CT 40 & CT 25 SS with respect to Oxygen saturation.

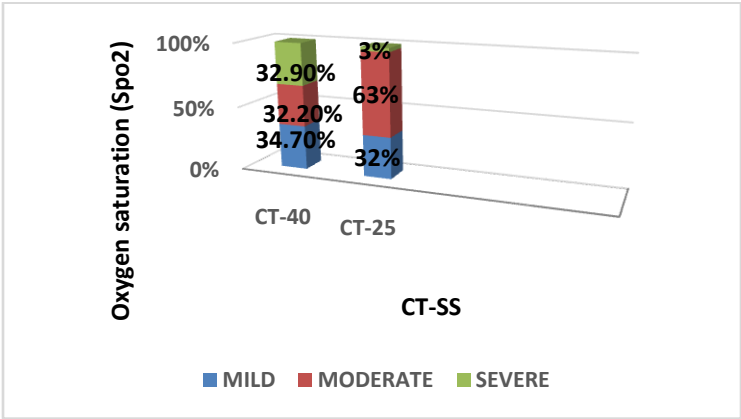

Figure 3: Percentage of population having various degree of lung involvement with respect to Spo2 levels

Since the data are not normally distributed, spearman's correlation was used to test the significance between Spo2 and CT severity index. On analysis, from the scatter plot curve, we have found that as the CT 40 and CT 25 severity score increases, there is decrease in oxygen saturation, resulting in worsening of symptoms and usage of oxygen supplements, thus leading to the negative correlation co-efficient of r = - 0.7636 and r = - 0.6665 respectively (Fig 4,5).

r= -0.7636 r= -0.6665

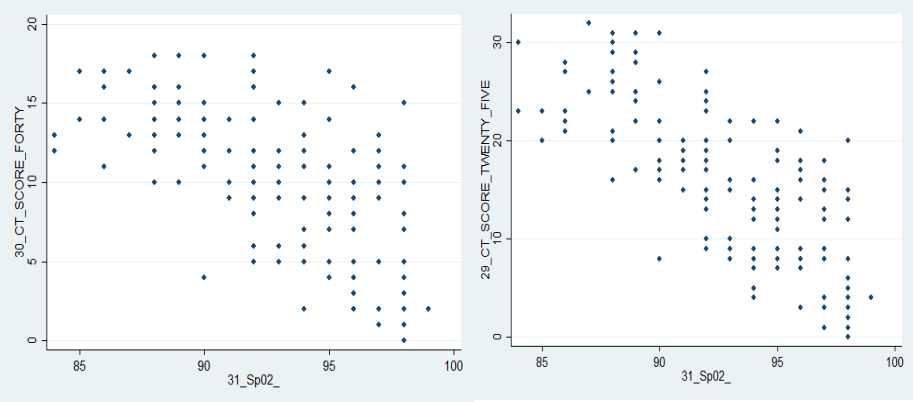

Figure 4Scatter plot curve for CT-40 SSFigure 5Scatter plot curve for CT-25 SS

The ROC curve analysis for CT-40 SS in correlation with O2 saturation is described below. The area under ROC curve for classifying patients into mild, moderate, and severe grade of lung involvement was 0.8565 with a standard error of 0.0139 and 95% confidence interval of 0. 8853.The sensitivity and specificity were found to be 88 % and 78% respectively with the mean cut-off score of 15.5 (Fig 6).

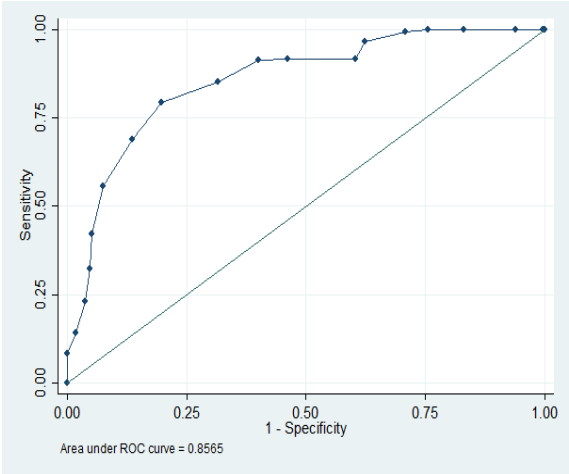

Figure 6 ROC curve for CT-40 SS

The ROC curve analysis for CT- 25 SS in correlation with O2 saturation is described below. The area under the ROC curve for classifying patients into mild, moderate, and severe grade of lung

involvement was 0.9126 with a standard error of 0.0188 and 95% confidence interval of 0.8195. The sensitivity and specificity were found to be 79 % and 80% respectively with the mean cut-off score of 10.5 (Fig 7).

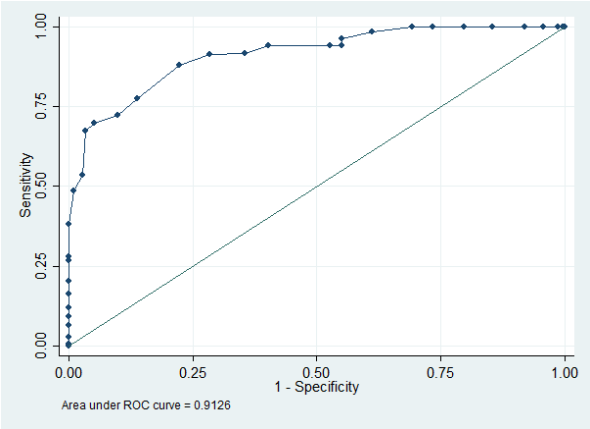

Figure 7 ROC curve for CT-25 SS

Hence, among both the scoring system, CT-40 SS was found to have more negative correlation in clinical comparison with O2 saturation.

DISCUSSION:

COVID-19 infection, one of the emergingpandemics from the year of December 2019 had shown its rising and falling trends in the spread of infection till date. [1,2] The diagnosis of infection was mainly based on RT-PCR and Tru-NAAT analysis.[12] Due to lack of testing laboratories, delayed test results, inadequate manpower, the diagnosis of COVID-19 infection had been delayed, which in turn leads to worsening of prognosis.

Many literatures had shown that clinical symptoms range from common cold to more worsening complications like acute respiratory distress syndrome (ARDS), pneumonia, multi-organ failure, and even death.They had also proved that patients with associated comorbidities like diabetes mellitus , hypertension, obesity are more prone to develop aggravated progression of the disease. [8,9] Our study also proved the statistically significant ($P<0.005$) relationship between COVID-19 and co-morbidities.

A meta-analysis study conducted among 1786 patients was to identify the prevalence of various comorbidities in COVID 19 patients. The study results revealed that hypertension (15.8%) was the most common co-morbidity followed by cardiac and cerebrovascular diseases (11.7%), and diabetes (9.4%).The least common co-morbidity was associated immunodeficient disorders (0.01%).[9]Our study found out that Type 2 Diabetes Mellitus was the commonest co-morbidity with 81.8%

WHO categorised COVID-19 patients based on clinical symptoms and signs into mild , moderate and severe. Mild category includes patients having Respiratory Rate <24/min and Spo2>94. Moderate category includes patients having Respiratory Rate 24-30 /min Spo2 and 90-94. Severe category includes patients having Respiratory Rate >30/min and Spo2<90. Of these, patients under mild category are managed in home conservatively. Patients under moderate and severe category require inpatient admissions. [11]

Previous studies of Ghufran etal had shown that CT-25 SS had proved its statistical significance of $P < 0.005$ with clinical outcome, raised inflammatory markers, maximum Oxygen requirements. They also stated the significant correlation between risk factors of COVID-19 and Intensive Care Unit admission.[16]Our study shows a sensitivity and specificity of 79%and 80% respectively in comparison of O2 saturation with CT-25 SS.

Yang etal had made a retrospective analysis of chest CT imaging with CT-40 SS and given a sensitivity of 83.3 % and specificity of 94 % in categorising patients with mild and severe lung involvement clinically correlating with disease progression.[15] Our study also provided sensitivity and specificity of 88% and 78% respectively while analysing the progression of disease with O2 saturation and CT-40 SS.

Major limitation in our studyis CT-SS classification is based on parenchymal and lobar involvement in the form of lung opacification, but there was no histopathological confirmation of lung findings. Second, this study included only a limited number of populations who are treated as in-patients, because many of the population are still unaware of the symptoms or else those people were treated as infected with any organisms other than COVID-19 and got died before they got admitted. Third, under reporting of symptoms and co-morbidities also contributed to variable outcome of results.

CONCLUSION:

CT scanhave an important role in assisting clinicians for assessment of COVID-19 infections in terms of disease progression and probable outcome. Overall, the CT SS has proved its statistical significance with oxygen saturation and usage of oxygen supplements. Among them, the CT-40 SS proved to be more significant than CT-25 SS in correlating with clinical symptoms and oxygen saturation. However, more research work will be needed from various studies for further clarification of CT imaging in view of getting better prognosis for COVID-19.

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