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ULTRASONOGRAPHY COMPARED TO CT SCAN FOR THE ASSESEMENT OF SEVERITY IN PATIENTS WITH COVID-19 PNEUMONIA: EXPERIENCE OF A MAJOR TERTIARY REFERRAL HOSPITAL IN INDIA

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ABSTRACT A study was conducted to assess the severity of COVID-19 pneumonia by ultrasonography compared to computed tomography. 50 patients, older than 18 years, referred to a major territory care centre in India between June and December 2021 with any two of the three criteria: fever, Spo2<94% on room air, and shortness of breath were studied. Patients proven to have COVID-19 pneumonia with either RT-PCR/RAT or Computed tomography scan were excluded from the study. Lung ultrasound was performed by two experienced physicians using a portable ultrasound device. A modified Lung Ultrasound Score for COVID-19 was compared with a computed tomography scan performed using a single inspiratory phase in a commercial multi-detector computed tomography scanner. **Results:** The correlation coefficient between the lung ultrasound score and the computed tomography severity score (r) was 0.79 (strong correlation) with a p value <0.00001 (significant as p value <0.05). In patients with moderate to severe disease, the correlation was stronger. **Conclusions:** Our study showed that there is a good correlation between the lung ultrasound score and Computed tomography severity score. Lung ultrasound may help as an alternative method for diagnosing and isolating COVID-19 pneumonia patients during the peaks of the pandemic. Lung ultrasound score exhibited similar accuracy compared with chest computed tomography in the detection of lung abnormalities in COVID-19 patients.

KEYWORDS : Lung Ultrasound, Computed tomography, Covid-19.

BACKGROUND

The novel coronavirus disease of 2019 (COVID-19) has posed an immense and urgent threat to global health. [1]Health care systems, and emergency departments, have been overwhelmed by the COVID-19 pandemic. Adequately managing available resources may be the key to saving lives.

The ideal imaging modality would be highly specific for COVID-19 and useful for early classification of patients as having mild, moderate, or severe pneumonia. It should allow for frequent repeat examinations to monitor progress. It should be available to the clinician at the bedside, without the necessity of bringing additional staff and equipment into contaminated areas or moving infectious patients into clean areas. Finally, it should be cheap.[2] Of the imaging modalities available, none fulfils all these criteria, but perhaps ultrasound may come close. In comparison with ultrasound, chest Computed tomography (CT) is costly and a scarce resource in many settings. Chest radiography has logistical issues and yields far less information than chest CT. [3]

The standard of reference for confirming COVID-19 relies on microbiological tests such as real-time polymerase chain reaction (RT-PCR) or sequencing. CT can be used as an important complement to RT-PCR for diagnosing COVID-19 pneumonia. [3]

A large series based on 1014 patients reported a 97% sensitivity of chest CT for the diagnosis of COVID-19. [4] Thus, CT can play a pivotal role in the early detection and management of COVID-19 pneumonia [5], at least for patients who have been symptomatic for more than three days. [6]

ULTRASOUND FEATURES OF COVID-19

Lung ultrasound (LU) is an easy-to-learn and reliable method [-12]. No advanced machinery or software is required. As COVID-19 disease progresses, changes in the lung parenchyma begin in the distal regions of the lung and progress proximally. The pathological progression of COVID-19 pneumonia is therefore well suited to a surface imaging technique such as LU.

Giovanni and Luna Gargani et al. were among the first to study the sonographic features of COVID-19 pneumonia and described multiple B-lines and irregularities in the pleural line.[13] Ericr Abrams and Gabriel et al. investigated multiple ultrasound patterns in the evaluation of COVID-19 pneumonia, including fused B-lines or comet tail artefacts under the pleura, interrupted pleural lines, subpleural irregular lesions, or consolidations.[14] Yao Zhang et al. used a pictorial presentation to summarise multiple ultrasound features in COVID-19 pneumonia. These included multiple B-lines, patchy pulmonary consolidation, and a thickened pleural line.[15] As the disease progresses, the following are summaries of sonographic changes in patients with COVID-19 pneumonia[16-19]

1. Thickening of the pleural line with pleural line irregularity
2. B-lines in a variety of patterns, including focal, multifocal, and confluent
3. Consolidations in a variety of patterns, including multifocal small, non-translobar, and translobar with occasional mobile air bronchograms.
4. Appearance of A-lines during the recovery phase.
5. Pleural effusions are uncommon.

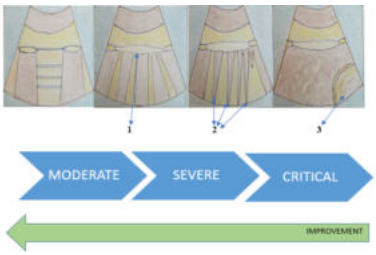

Figure 1-Ultrasound features of Covid-19 pneumonia-1. Irregular thickening of the pleural line, 2. B-lines in focal, multifocal, and confluent patterns, 3. Consolidations in multifocal small, non-translobar, and translobar patterns

Figure 2: Lung ultrasound and CT thorax image of a severe COVID-19 patient: pleural line irregularity with subpleural consolidations (yellow arrows), bilateral ground glass opacity noted in the CT scan (red arrows)

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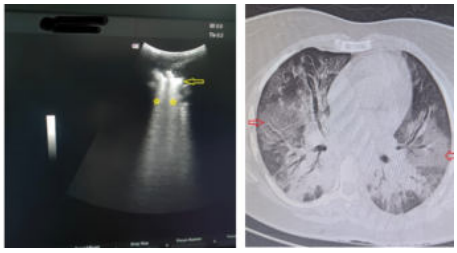


Figure 3: Lung ultrasound and CT thorax image of COVID-19; image of pleural line irregularity (yellow arrow) and B-lines (yellow star); image of a moderate COVID-19 patient. Bilateral subpleural ground glass opacities in the middle and posterior lobes (red arrows)

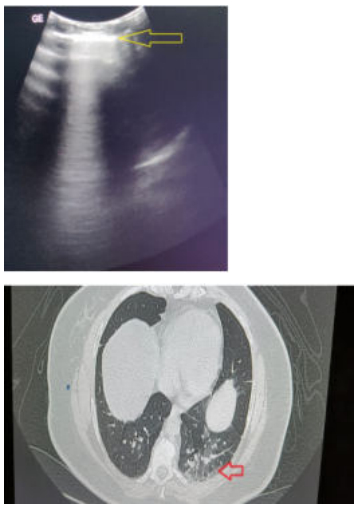


Figure 4: Lung ultrasound and CT thorax image of mild COVID patients with thickened pleura (yellow arrow) and mild subpleural ground glass opacities in the left posterior lobe (red arrow).

Aims and objectives
1. severity of COVID-19 pneumonia by ultrasonography compared to a CT scan.

Methods:
We included data on all suspected COVID-19 patients admitted to the emergency department of a major tertiary referral hospital in India between June 1 and December 31, 2021.
Study design: It was a prospective single centre observational study.

Inclusion criteria:
All patients aged greater than 18 years who presented to the emergency department of a tertiary referral hospital with at least two of the below three features: fever, Spo2<94% on room air, and shortness of breath were included in the study.

Exclusion criteria:
Proven COVID-19 pneumonia cases where either a RT-PCR, RAT, or CT scan report was already known were excluded from the study.

Conduct of the study:
LU was performed by two experienced physicians using a portable ultrasound device (Philips CX50) with a convex transducer (5 Mhz). After abdominal preset selection (no compound; filters off; general frequency setting), focus was set on the pleural line, depth at 6 cm, and low gain (i.e., to evaluate pleural gliding). After sterilising the probe with 0.5% chlorhexidine gluconate solution, it was covered with an arthroscopy plastic cover. Patients were examined in a sitting position (when possible), with focus on the designated areas of lung already defined in the study. Physicians worked as per hospital infection control protocol.

Methods:
We included data on all suspected COVID-19 patients admitted to the emergency department of a major tertiary referral hospital in India between June 1 and December 31, 2021.

Study design: It was a prospective single-centre observational study.

Chest CT scans were performed when the inclusion criteria were matched, using a single inspiratory phase in a commercial multi-detector CT scanner (Philips ingenuity 128, Philips Medical Systems, Cleveland, USA). To minimise motion artifacts, patients were instructed to hold their breath where possible; CT images were then acquired during a single breath-hold.

Data collection and analysis:
The major CT demonstrations were described using internationally accepted standard nomenclature defined by the CT severity index. [20] A semi-quantitative scoring system was used to quantitatively estimate the pulmonary involvement of all these abnormalities based on the area involved. Each of the five lung lobes was individually scored from 0 to 5 as follows: 0: no involvement; 1: 5% involvement; 2: 25% involvement; 3: 26%–49% involvement; 4: 50%–75% involvement; 5: >75% involvement. The total CT score was the sum of the individual lobar scores and ranged from 0 (no involvement) to 25 (maximum involvement).

To reduce inter-observer variability, we modified the scoring tool used by de Alencar JCG et al. and formed a new criterion which is as follows: A lines = 0 points, increased B lines along with subpleural consolidations and pleural thickening = 1 point for each area of the thorax. This is a novel criterion with total score ranged from 0 (normal) to 12 (worst pulmonary aeration). [21-22] We further classified disease severity as per the LU score as follows: 0–3 is mild, 4–7 is moderate, and more than 7 is severe disease. We gave a cut-off for diagnosing COVID-19 as a score of 3 or more.

Statistical methods:
Descriptive and inferential statistical analysis was carried out. Results on continuous measurements are presented as mean + standard deviation (SD), and results on categorical measurements are presented in numbers and percentages. Significance is assessed at 5%. The following assumptions on data were made:

1. LU score and CT score are variables that were considered in the study. Based on the above scores, COVID cases were classified as mild, moderate, or severe. All bodily-related parameters are normally distributed. [23]

2. Cases were selected randomly and investigated.
Cohen's kappa (κ) test was used to compare abnormal chest CT findings with abnormal LUS and chest X-ray findings. The intraclass correlation coefficients (ICC) were used to assess the degree of agreement between the LUS score and the CT TSS. An ICC of 0.50 was considered poor, 0.50-0.75 was considered moderate, 0.75-0.90 was considered good, and 0.90-1 was considered excellent.

The statistical software SPSS 22.0 and R environment ver 3.2.2 were used for the analysis of the data, and Microsoft Word and Excel were used to generate graphs, tables, etc.

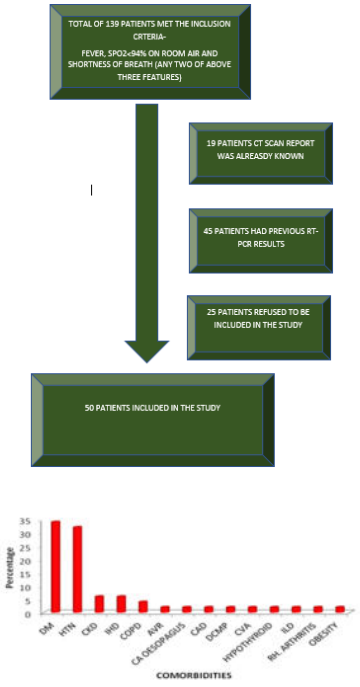
RESULTS

Table 1-gender distribution

Gender	No. of Patients	%
Female	20	40.0
Male	30	60.0
Total	50	100.0

Out of 50 patients in the study population, 40% (20 patients) were female and 60% (30 patients) were male. There was no difference in

the results of the lung ultrasound or CT scan between men and women.



Graph 1-Comorbities of the study population

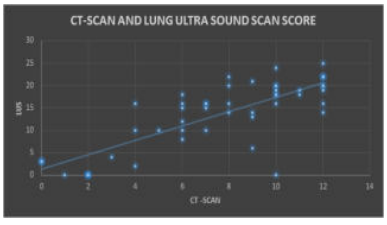
The above graph compares the comorbidities in the study population. Out of 50 patients, 60% (30 patients) had comorbidities, and among them, the most prevalent comorbidities were found to be diabetes and hypertension.

Table 2 – Distribution of Lung Ultrasound score.

Lu score	No. Of patients	%
Mild	9	18.0
Moderate	14	28.0
Severe	27	54.0
Total	50	100.0

mean ± SD: 7.40±3.71

All the patients in the study underwent lung ultrasound for its correlation with a CT scan. Out of 50 patients in the study, 18% (9 patients) had a mild, 28% (14 patients) had a moderate, and 54% (27 patients) had a severe LU score. The mean LU score was 7.40 (SD of 3.71).



Graph 2-Scatterplot of LU vs CT severity score

The correlation between the LU and CT severity scores was better observed in the moderate and severe categories, as shown in the above scatterplot graph.

Table 3: Association of LU score with CT severity score of patients studied

LUS SCAN / CT SCAN	MILD	MODERATE	SEVERE	TOTAL
MILD	9	1	2	12
MODERATE	-	10	7	17
SEVERE	-	3	18	21
TOTAL	9	14	27	50

Correlating LU score and CT severity score: A total of 9 patients had a mild LU score, and all 9 patients had a mild CT severity score. Out of 14 patients with a moderate LU score, 10 patients had a moderate CT severity score, 3 patients had a severe CT severity score, and 1 patient had a mild CT severity score. Out of 27 patients with a severe LU score, 18 patients had a severe CT severity score, 7 patients had a moderate CT severity score, and 2 patients had a mild CT severity score.

The correlation coefficient between LU score and CT scan was found to be R = 0.79 (strong correlation) with a p value <0.00001 (significant as p value <0.05).

Table 4-Comparison of CT and LU score

CT SCAN	LU Score		TOTAL
	NORMAL (</= 3)	ABNORMAL (> 3)	
NORMAL (< 8)	9	3	12
ABNORMAL (≥ 8)	0	38	38
TOTAL	9	41	50

Discussion:

Principal findings

In our study, the LU score and CT severity score were compared for assessing the severity of COVID-19 pneumonia. Our study showed that there is a good correlation between the LU score and the CT severity score. The correlation was stronger in cases of severe disease and weaker in cases of mild disease.

Strengths

Several studies have evaluated the efficacy of the LU score in the assessment of the severity of COVID-19 pneumonia. de Alencar JCG et al. designed a LU score that predicted the outcome in the emergency department. The patient with the higher score required ICU care (mean LUS with < 50% involvement on chest CT, 15 ± 6.7 vs. 21 ± 6.0 with > 50% involvement, p < 0.001) and ICU admission (AUC: 0.71, OR 1.14, 95% CI 1.07 to 1.21; p < 0.001). They also correlated the CT scan with the LU and found that higher LU scores were associated with higher CT severity values. [20] We also noticed a higher CT score in patients with higher LU scores. However, the LU scores used in all previous studies were complicated and difficult to perform in ED. Sofia et al. described ultrasonic and clinical findings at different clinical stages in COVID-19. [24] B-lines were seen in early COVID, while whiteout lungs were seen in ARDS or late stages. We also noticed B-lines to be among the early findings in COVID-19 patients. Another two studies reported that the LU features of COVID-19 pneumonia and ARDS can be used to assess disease severity in 20 patients with COVID-19 pneumonia. [25,26] According to two narrative reviews, the LU score could be used to objectively grade COVID-19-related lung injuries. [19,27] All of these studies' findings are consistent with ours. All previous studies recorded were retrospective, while this is a prospective study. Ours is one of the first studies to have been reported on the Indian subcontinent. We also have found a good sensitivity of LU in moderate and severe disease, which has not been studied before. We have simplified the COVID-19 LU score from 36 to 12 points, making it an easier bedside scoring system that reduces inter-observer variability. Hence, our study brings a new narrative to the process of screening patients in the fight against COVID-19.

Limitations

Findings from LU are non-specific. These LU score findings can be seen in various other illnesses, such as other viral pneumonias and various non-infectious diseases (chronic obstructive pulmonary disease, neoplastic lymphangitis, pulmonary fibrosis, and interstitial pulmonary disease). This was the case in three patients who had a severe LU score but a negative RT-PCR report. However, the homogeneous interstitial pattern suggests the cardiogenic oedema diagnosis, while a heterogeneous interstitial pattern, mainly in combination with subpleural consolidation and/or pleural thickening, might suggest, especially during the pandemic situation, pneumonia caused by SARS-Cov-2. [28]

As our hospital is a tertiary referral centre, many patients were referred to us after a RT-PCR diagnosis or a CT report. Hence, many patients had to be excluded from our study as per the study's exclusion criteria. Though our study highlights the benefits of LU scores and their good correlation with the CT thorax, it is a single-centre prospective observational study of 50 patients. Ultrasound is a user-dependent

procedure and can have bias while working in a stressful environment treating critically ill patients. During the peak of the pandemic, around 80% of patients admitted to our emergency department needing oxygen support were COVID-19. Our study was conducted between the second and third waves in India. Still, there is a possibility that the findings of our study may not be applicable in a non-pandemic setting.

Implications

LU can be used in emergency departments as a day-to-day screening tool to analyse the progress of the disease. LU scores may be a more objective way to monitor this progression. LU can be used to diagnose COVID-19 pneumonia during peaks of the future pandemic when resources may be stretched and CT scans and/or RT-PCR tests may not be readily available. Moderate and severe patients as per the LU score may indicate that patients are possibly suffering from COVID-19 and should be isolated even if a RT-PCR report is not immediately available and a CT scan is unavailable or not possible.

Conclusions

Our study showed that there is a good correlation between the LU score and the CT severity score. LU may help as an alternative method for diagnosing and isolating COVID-19 pneumonia patients during the peaks of the pandemic when CT availability may be limited and RT-PCR and antigen tests have long turnaround times. To validate our findings about the role of LU in the severity assessment and diagnosis of COVID-19 pneumonia, more prospective randomised controlled trials are needed.

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