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Lung Ultrasound as a Bed Side Tool for the Early Identification of Covid Pneumonia

Dr Arjun Vijay, Dr. Johnson K Varghese
Senior Specialist- VPS Lakeshore Hospital Kochi, Head of the Department and Lead Consultant - Department of Emergency Medicine, Aster Medcity Kochi

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ABSTRACT

OBJECTIVES: The objective of the study was to investigate Lung Ultra Sound (US) findings and their associated frequencies in patients with COVID-19 and to establish a correlation between lung ultrasound findings and CT chest and see if lung ultrasound can be used as a bed side tool for the early identification of COVID pneumonia.

METHODOLOGY: COVID Positive patients aged 18 years or more with respiratory symptoms were prospectively evaluated for their lung ultrasound findings and CT scan findings during April 2020 to October 2020.

Study Design: Prospective Observational Study

Inclusion Criteria : Age >18, COVID positive, Fever, cough, dyspnea, severe sore throat.

Exclusion Criteria : Age <18 years, COVID negative patients, patient who doesn't have CT chest within 24 hours

Sample Size : 160

Statistical Analysis : IBM SPSS STATISTICS VERSION 20

RESULTS: A total of 300 patients presented to the Emergency Department during the study period, of which 140 patients were excluded. Out of the 140 patients, 20 patients refused to be part of the study, 90 patients didn't have CT chest within 24 hours, 10 patients were less than 18 years, and 20 patients were COVID negative with post COVID symptoms. Out of the 160 patients, all were subjected to CT Chest as well as Lung Ultrasound.

CONCLUSION: This study showed that in comparison with CT Chest of patients with COVID Pneumonia, Lung Ultrasound findings too had significant sensitivity, and hence the Lung US findings can be used to reflect both the infection duration and disease severity of COVID pneumonia patients.

I. INTRODUCTION

Coronavirus disease-19 (COVID-19) is the first pandemic infectious disease. It is caused by a novel coronavirus, which is also known as severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). Its genome mainly arises from the same group of RNA-viruses that caused severe acute respiratory syndrome (SARS) and Middle East respiratory syndrome (MERS).[1] A new public health crises threatened the world with the emergence and spread of 2019 novel coronavirus. The virus which originated in bats, was transmitted to humans through an unknown intermediary animals in Wuhan, Hubei province, China in December 2019. The disease is transmitted by inhalation or contact with infected droplets. Symptoms ranges from usually fever, cough, breathlessness, fatigue, sore throat, and malaise. The disease is usually mild in most; whereas in some, mainly the elderly and those with comorbidities, it may progress to pneumonia, acute respiratory distress syndrome (ARDS) and multi organ dysfunction.

AIMS AND OBJECTIVES

- Primary objective: To investigate US findings in patients with COVID-19 and its usage as a bedside tool for the early prediction of COVID pneumonia.
- Secondary objective: To establish a correlation between lung ultrasound findings and CT chest.

II. REVIEW OF LITERATURE

STUDY1[7]

- The purpose of this study was to investigate the imaging features of emerging COVID-19 pneumonia on chest ultrasound (US), radiographs (CXR) and computed tomography (CT) examinations performed at admission and to provide a comprehensive radiological literature review on ongoing radiological data from recent publications. In this retrospective single-center study, they enrolled consecutive patients from February 15, 2020, to March 15, 2020, with laboratory-confirmed SARS-CoV-2 hospitalized in Valduce Hospital (Como, Italy). Multi-modality imaging findings were evaluated and compared. Literature research was conducted by them through

a methodical search on Pubmed and Embase databases.

- The results showed that Fifty-eight patients (36 men, 22 women; age range, 18–98 years) were included in the study. Among these, chest US, CXR, and CT were performed respectively in twenty-two, thirty-two and forty-two patients. Lung US findings were consistent with diffuse B lines (100%) and subpleural consolidations (27.3%). CXR showed prevalent manifestations of consolidations (46.9%) and hazy increased opacities (37.5%). Typical CT features included bilateral and multilobar ground-glass opacities (GGO) with (59.5%) and without (35.7%) consolidations having a predominantly peripheral distribution (64.3%). Other imaging features included crazy paving pattern (57.1%), fibrous stripes (50%), subpleural lines (35.7%), architectural distortion (28.6%), air bronchogram sign (26.2%), vascular thickening (23.8%) and nodules (2.4%). Also, enlarged lymph nodes (14.3 %) and pleural effusion (7.1%) were observed. The literature review identified twenty-six original studies supporting their imaging chest findings.
- They concluded stating that the spectrum of chest imaging manifestations of COVID-19 pneumonia upon admission includes B lines and consolidations on US, consolidations and hazy increased opacities on CXR, and multifocal GGO with consolidations on CT.

STUDY 2[8]

- This study was conducted to determine the misdiagnosis rate of radiologists for coronavirus disease 2019 (COVID-19) and thereby to evaluate the performance of chest CT in the diagnosis and management of COVID-19. The CT features of COVID-19 were reported and compared with the CT features of other viruses to familiarize radiologists with possible CT patterns.
- This study included the first 51 patients with a diagnosis of COVID-19 infection confirmed by nucleic acid testing (23 women and 28 men; age range, 26–83 years) and two patients with adenovirus (one woman and one man; ages, 58 and 66 years). They reviewed the clinical information, CT images, and corresponding image reports of those 53 patients. The CT images included images from 99 chest CT examinations, including initial and follow-up CT studies. They compared the image reports of the initial CT study with the laboratory test results and noted CT patterns suggestive of viral infection.COVID-19 was misdiagnosed as a common infection at the initial CT study in two inpatients with underlying disease and COVID-19. Viral pneumonia was correctly diagnosed at the initial CT study in the remaining 49 patients with COVID-19 and two patients with adenovirus. These patients were isolated and obtained treatment. Ground-glass opacities (GGOs) and consolidation with or without vascular enlargement, interlobular septal thickening, and air bronchogram sign are common CT features of COVID-19.
- The “reversed halo” sign and pulmonary nodules with a halo sign are uncommon CT features. The CT findings of COVID-19 overlap with the CT findings of adenovirus infection. There are differences as well as similarities in the CT features of COVID-19 compared with those of the severe acute respiratory syndrome.
- They concluded that chest CT had a low rate of missed diagnosis of COVID- 19 (3.9%, 2/51) and may be useful as a standard method for the rapid diagnosis of COVID-19 to optimize the management of patients. However, CT is still limited for identifying specific viruses and distinguishing between viruses.

STUDY 3[9]

- The pandemic of COVID-19 is seriously challenging the medical field in many parts of the world. The novel corona virus SARS-CoV-2 has a specific tropism for the low respiratory airways, but causes severe pneumonia in a very low percentage of patients. However, the rapid spread of the infection during this pandemic is causing the need to hospitalize a high number of patients. Pneumonia in COVID-19 has peculiar features and can be studied by lung ultrasound in the early stages to suspected patients. The sonographic signs are non-specific when considered alone, but observation of some aspects of vertical artifacts can enhance the diagnostic power of the ultrasound examination.
- The combination of sonographic signs in patterns and their correlation with blood examinations in different phenotypes of the disease may allow for a reliable characterization and be of help in triaging and admitting patients.

STUDY 4[10]

- Even though chest CT is the standard imaging modality in early diagnosis and management of coronavirus disease (COVID-19), the use of lung ultrasound (US) presents some advantages over the use of chest CT and may play a definite role in the workup of COVID-19. The objective of their study was to investigate US findings in patients with COVID-19 and the relationship of the US findings with the duration of symptoms and disease severity.Their study duration was from March 3, 2020, to March 30, 2020.

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During this period, consecutive patients with a positive reverse transcriptase polymerase chain reaction test result for the virus that causes COVID-19 were enrolled in this study. Lung US was performed, and the imaging features were analyzed. The Fisher exact test was used to compare the percentages of patients with each US finding between groups with different symptom durations and disease severity.

- Their study population comprised 28 patients (14 men and 14 women; mean age ± SD, 59.8 ± 18.3 years; age range, 21–92 years). All 28 patients (100.0%, 28/28) had positive lung US findings. The most common findings were the following: B-lines (100.0%, 28/28), consolidation (67.9%, 19/28), and a thickened pleural line (60.7%, 17/28). A thickened pleural line was observed in a higher percentage of patients with a longer duration of the disease than in those with a shorter duration of the disease, and pulmonary consolidations were more common in severe and critical cases than in moderate cases.
- Typical lung US findings in patients with COVID-19 included B-lines, pulmonary consolidation, and a thickened pleural line. In addition, their results indicate that lung US findings can be used to reflect both the infection duration and disease severity.

III. METHODOLOGY

Study Design- This study is a Prospective observational study.

Setting - The setting of this study was Aster Medcity, Kochi, Kerala, India. This study was conducted in the Emergency Department. The protocol was approved by the Institutional Board of Scientific committee.

Study Duration- A period of 7 months (April 2020 – October 2020)

Hypothesis- The study hypothesized that there was a significant role played by lung ultrasound as a bed side tool for the early identification of COVID pneumonia than subjecting the patient to Chest CT.

Null Hypothesis- The study hypothesized that there was no significant role played by lung ultrasound as a bed side tool for the early identification of COVID pneumonia than subjecting the patient to Chest CT.

Sampling

Sample Size- The subjects to be evaluated in the study included 160 patients who were COVID Positive. This prospective observational study was approved by our local institutional review board. From April, 2020, to October, 2020, a total of one hundred and sixty patients (96 men, 64 women; age range, 18 to 83 years) with confirmed COVID-19 by RT-PCR assay and hospitalized in Aster Medcity (Kochi, India), were included.

A Bed side lung ultrasound finding compared with CT chest taken within 24 hours of patients with positive reverse transcriptase polymerase chain reaction presented to the emergency department were done. The data was transcribed into a structured proforma and analyzed statistically. Each chart was reviewed and those which underwent CT chest were included in the study. All the CT chest scan reports and images of the group were reviewed. All positive scans were re-assessed with reports.

INCLUSION CRITERIA:

- All patients above 18 years who were COVID Positive.
- COVID Positive patients with Fever, cough, dyspnoea, severe sore throat.

EXCLUSION CRITERIA:

- All patients with age <18 years
- COVID negative patients.
- Patient who doesn't have CT chest within 24 hours

Patients were randomized using a computer generated random number table.In this study we aimed to systematically assess the chest imaging manifestations of COVID-19 pneumonia with the description and comparison of US and CT findings detected in 160 patients admitted in our hospital.

EQUIPMENTS USED:

- GE Healthcare LOGIQ Doppler Ultrasound Machine
- CT Philips Gemini Scanner
- Sterile gloves

IMAGE ACQUISITION:

Bedside US was performed in the emergency room using linear probe. For each examination, B-mode evaluation was performed and serial images and video clips were recorded. CT examinations were performed using a multi-detector CT scanner with 64 channels. The detailed parameters for CT acquisition were as follows: tube voltage, 120 kVp; tube current, standard (reference mAs, 60–120); slice thickness, 1.0 mm; reconstruction interval, 1.0 mm. All CT images were acquired at full inspiration with the patient in the supine position and without contrast medium.

IMAGE ANALYSIS:

All US images were stored and reviewed by myself, and CT images were stored and

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reviewed by two radiologists in consensus (P.R. and J.S. with 4 and 3 years of experience in imaging).

US images were examined for the assessment of the following signs:

- Thickened pleural line
- B-lines
- Consolidation and
- Pleural effusion

STATISTICS:

Data were analyzed on IBM SPSS STATISTICS VERSION 20 software. Normally distributed data were checked for Sensitivity, Specificity, Positive Likelihood ratio, Negative likelihood ratio.

STATISTICS	VALUE	95% CONSENSUS INTERVAL
SENSITIVITY	91.03%	85.16 % – 95.14%
SPECIFICITY	80.00%	51.91% - 95.67%
POSITIVE LIKELIHOOD RATIO	4.55%	1.65% - 12.54%
NEGATIVE LIKELIHOOD RATIO	0.11%	0.06% - 0.20%

All the statistical parameter values shows to be significant the resultant value being within the range of consensus interval stating the results to be significant.

IV. RESULTS

A total of 300 patients presented to the Emergency Department during the study period, of which 140 patients were excluded. Out of the 140 patients, 20 patients refused to be part of the study, 90 patients didn't have CT chest within 24 hours, 10 patients were less than 18 years, and 20 patients were COVID negative with post COVID symptoms. Out of the 160 patients, all were subjected to CT Chest as well as Lung Ultrasound.

PATIENT POPULATION AND RADIOLOGICAL EXAMINATIONS

The total number of patients categorized based on sex was 96 men (60%), 64 women (40%) -**Table1**. Among the 160 patients selected for the study clinical features presented were, fever in eighty-three patients (51.87%), cough in seventy-one patients (44.37%), dyspnea in hundred-six patients (66.25%) and severe sore throat in twenty-one patients (13.12%) -**Table2**

Lung US and Chest CT were retrieved from all the patients.

Gender	N
Male	96
Female	64

Table 1: Demographic table showing gender of the subjects

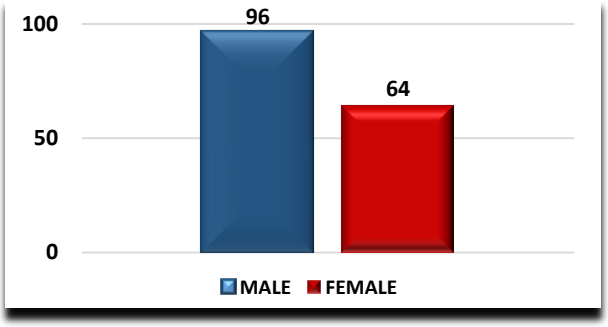

CHART 1: Demographic chart showing gender distribution of the subjects

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Clinical Feature	N
Fever	83
Cough	71
Dyspnoea	106
Severe Sore Throat	21

Table 2: Clinical Features presented in the patients

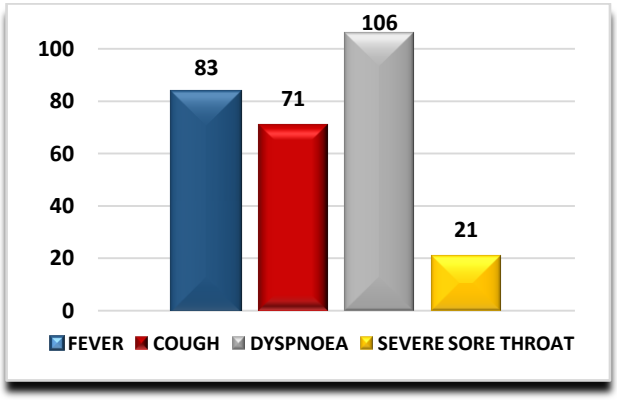

CHART 2: Comparison of Clinical Features presented in the patients

US FINDINGS

Lung US was performed in a total of hundred-sixty patients. In eighty cases, US showed B lines patterns due to interlobular septa thickening or hazy opacities that did not obscure the underlying bronchial structures or pulmonary, with the bilateral distribution. Subpleural consolidation was observed in fifty patients, a thickened pleural line in fourteen patients and pleural effusion in eighteen patients-**Table 3**

LUS FINDINGS	N
Consolidation	50
B Lines	80
Pleural Effusion	18
Thickened Pleural Lines	14

Table 3: LUS findings in the patients

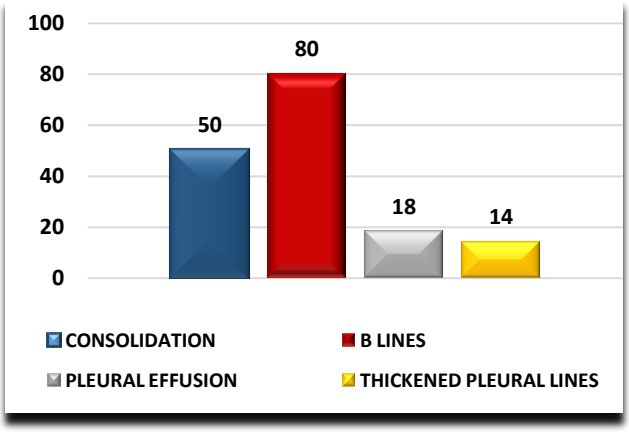

CHART 3: Comparison of LUNG ULTRASOUND findings in the patients

CT FEATURES

Chest CT examinations were obtained in a total of hundred-sixty patients. In one hundred-nineteen cases, CT showed consolidation. Pleural effusion was recorded by chest CT in twenty-six patients and thickened pleural lines were demarcated in five patients -**Table 4**

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CT CHEST FINDINGS	N
Consolidation	119
B Lines	-
Pleural Effusion	26
Thickened Pleural Lines	5

Table 4: CT Chest findings in the patients

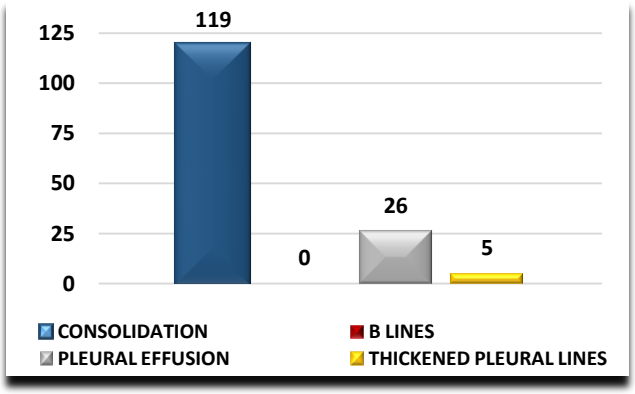

CHART 4: Comparison of CT Chest findings in the patients

A total of 160 subjects were taken up for the study, among which all were subjected to Lung Ultrasound as CT Chest. A total of 132 patients had positive findings in both LUS and CT Chest and these were categorized as True Positive. 3 of the patients had findings in LUS, but didn't show any findings in the CT Chest, they were categorized as False Positive.

A set of 13 patients had positive findings in the CT Chest but on the contrary they showed negative findings in LUS. These were categorized as False Negative. About 12 patients were negative in both CT and LUS. They were termed under True Negative.

Disease					
Test	Present	n	Absent	n	Total
Positive	True Positive	a= 132	False Positive	c= 3	a + c = 135
Negative	False Negative	b= 13	True Negative	d= 12	b + d = 25
Total		a + b = 145		c + d = 15	

Table 5: Categorization of the Positive and Negative Findings.

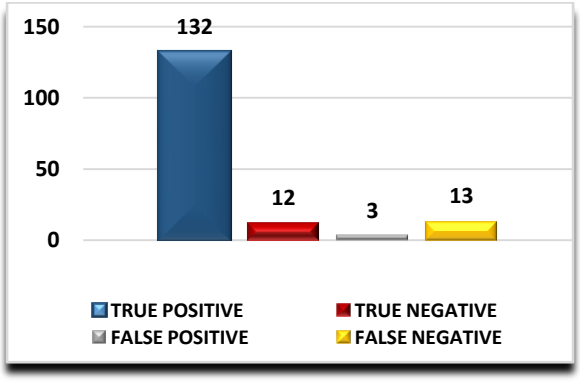

CHART 5: Categorization of Findings

V. DISCUSSION

In various infectious diseases like Ebola hemorrhagic fever, bedside US had been used in the isolation unit for lung imaging of patients to gain information for undertaking proper medical management.[11] Our study shows that the sensitivity as well as the specificity of lung US to detect abnormalities in COVID-19 patients is high as well as comparable to that of chest CT. The most common lung US findings were consolidation, B-lines, pleural effusion and thickened pleural lines.On lung US, the B-lines are visualized as multiple vertical echogenic reverberation artifacts extending from the lung surface.

Previous studies have shown high interobserver variability for assessment of B-lines, with percentage ranging from 92.2% to 95.1%.[12,13]However, the detection of B-lines does not allow clinicians to differentiate among different causes, such as acute respiratory distress syndrome, pulmonary fibrosis, or viral pneumonia.[14] B-lines were present in all patients in our study regardless of disease duration and severity. However, the results showed that the frequencies of a thickened pleural line were related to the time course of COVID-19: US showed a thickened pleural line in higher percentages of patients as the duration of disease increased.

Like interlobular and intralobular septa thickening visualized on chest CT, a thickened pleural line on US can reflect pulmonary fibrosis. Recognizing these changes in lung US findings will not only enable to understand the pathophysiology and nature history of COVID-19, but also helps us to predict disease progression. In

addition to providing early diagnosis of COVID-19, chest CT can be used to evaluate the severity of the disease.[15-17] Similar to chest CT, our study shows that pulmonary consolidation depicted on lung US may serve as an alert in patient management. Pulmonary consolidation is visualized on lung US as tissue-like hypoechoic regions, which reflect highly reduced air flow and increased quantity of inflammatory cellular exudate. Lung US can provide a specific evaluation to identify which patients with COVID-19 have the severe and critical forms of the disease. US, which is not that invasive, is repeatable in critically ill patients, which ensures that monitoring of the severity of the disease and the effects of therapies can be easily carried out. This capability is particularly important in situations in which chest CT is not available, such as in isolation wards and ICUs.

This prospective observational study has several limitations. First, the sample size was small with only 160 patients, and series repeated lung US studies were not performed to confirm its ability to evaluate either disease progression or treatment efficacy. Second, no patients with a negative RT-PCR result for COVID-19 were included to calculate the specificity of lung US. However, we believe that it is impossible to effectively confirm or rule out the diagnosis of COVID-19 simply on the basis of lung US findings. Finally, correlation with timing of the onset of symptoms should be considered. When the LUS pattern is the result of several days of disease, it is potentially less evolving than similar patterns observed at initial phase. The correlation of the LUS pattern with some blood exams is also useful. The typical blood assays picture in COVID-19 is based on the evaluation of leukocyte count, lactate dehydrogenase, procalcitonin, and others. The leukocyte count, which is almost invariably reduced in COVID-19, is especially helpful. Negative serum procalcitonin allows to support the diagnosis of COVID-19 in patients showing LUS signs of pneumonia.

As with the CT severity score suggested by Yang et al.[16], a lung US severity score should be proposed to more accurately illustrate disease severity and facilitate comparison in follow-up studies. Finally, like other US techniques, lung US is operator-dependent and may not be as effective in inexperienced hands. Lung US was highly sensitive for detecting abnormalities in patients with COVID-19, and B-lines, a thickened pleural line, and pulmonary consolidation were the most commonly observed features. A thickened pleural line was more frequently observed on US in patients with longer time intervals after the initial onset of symptoms. Finally, pulmonary consolidation may be helpful in identifying patients with severe and critical forms of COVID-19.

Current studies shows that the sensitivity of lung US to detect abnormalities in patients with COVID-19 is high and comparable to that of chest CT.

Limitations of the Study

The main limitation of this study was the reduced sample size. On the other hand, the main disadvantages of LUS are the difficulty of maintaining distance from the patient and the inter-operator variability. Chest CT is particularly useful in evaluating disease progression or resolution, being able to objectively identify even the smallest changes.

VI. CONCLUSION

In COVID-19, imaging has an important role in the diagnostic steps, as swabs can sometimes be negative. Moreover mutations are happening every now and then making diagnosis of the variants of disease a hurdle task. Chest X-ray has low sensitivity, especially in the early phase of the disease and in mild cases. In contrast to it, Lung US and HRCT have a high sensitivity in detecting pulmonary interstitial involvement. Implementation of LUS during the COVID-19 outbreak is of profound interest. LUS allows identification of early signs of interstitial pneumonia.

The greater sensitivity of Lung US compared with CT can be explained by the fact that SARS-CoV-2 often induces lesions in the posterior and inferior areas of the lung, in the subpleural region, which is particularly suitable for LUS investigations. Patterns with combination of different signs allow differentiating positive high probability from intermediate probability of the disease and indicate alternative diagnoses. Moreover, COVID-19 pneumonia is characterized by alveolar-interstitial damage with inflammatory exudation/edema, and LUS is highly sensitive to variations in the balance between air and fluids in the lung.

LUS is a low-cost and radiation-free method, useful in children and pregnant women. It allows a bedside approach and needs disinfection of only a small contact area, so it could be particularly useful during triage and in ICUs. Moreover, LUS might even be performed in patient's homes, reducing the waiting times for CT in emergency departments, which are often overcrowded and more invasive.

The correlation of different LUS patterns with the clinical condition at presentation, timing of symptoms onset and a few blood exams, allow a better characterization of the disease at presentation in the Emergency Department.

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