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Potential of Conventional Chest Radiography as a diagnostic and follow up imaging tool in COVID pandemic era

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ABSTRACT

Background - The present radiological COVID literature is mainly confined to the CT findings . Using High Resolution Computed tomography (HRCT) as a regular 1st line investigation put a large burden on radiology department and constitute a huge challenge for the infection control in CT suite.

Materials and methods - A prospective study of 700 consecutive COVID positive cases who underwent Chest Xray (CXR) and HRCT thorax were included in the study. Many of these CXR were repeated and followed up over a duration of time to see the progression of disease.

Results - 392/700 (56%) were found to be negative for radiological thoracic involvement. 147/700 (21%) COVID positive patients showed lung consolidations, 115/700 (16.5%) presented with GGO, 40/700 (5.7%) with nodules and 42/700 (6%) with reticular–nodular opacities. 150/700 patients (21.4 %) had mild findings with total RALE severity score of 1-2. More extensive involvement was seen in 104/700 (14.8 %) and 43/700 (6.2%) patients, who had severity scores of 3-4 and 5-6 respectively. 11/700 patients had a severity score of >6 on their baseline CXR. Those with severity score of 5 or more than 5 (54/700, 7.7%) required aggressive treatment with mean duration of stay of 14 days, many of them died also (23/54, 42.5%).

Conclusion - In cases of high clinical suspicion for COVID-19, a positive CXR may obviate the need for CT. Additionally, CXR utilization for early disease detection and followup may also play a vital role in areas around the world with limited access to CT and RT-PCR test.

Key words: Chest Radiography, COVID- 19, HRCT scan

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1. INTRODUCTION

Corona virus disease-19 (COVID- 19) is one of the most dangerous pandemics human generation had ever faced. The initial cases were seen in Wuhan, China, in late December 2019 before spreading globally [1].

The spread of disease is so quick that it has affected thousands of people in very short period of time as we have already witnessed the havoc it has created in many of the well developed and developing countries, many of them having excellent medical infrastructure and facilities.

The present radiological COVID literature is largely confined to the CT findings which, of course , is more sensitive than chest X ray (CXR) .But using High Resolution Computed tomography (HRCT) as a regular 1st line investigation put a large burden on radiology department and constitute a huge challenge for the infection control in CT suite. According to American College of Radiology reports ,imaging services may be hampered by the process of decontamination required after scanning and hence portable chest X ray may be used to minimize the risk of cross infection [2] .

In the countries like India having an average and limited medical infrastructure , where the COVID cases are increasing many folds day by day, the role of CXR for evaluation of features can be very handful. As the prevalence of COVID-19 is increasing, the need of the hour is to recognize COVID- 19 features on every imaging modality and X ray is no exception as they are readily available and can be applied to mass populations very easily with very low effective radiation dose as compared to HRCT, and that too in a cost effective way.

Furthermore, in cases of high clinical suspicion for COVID-19, a positive CXR may obviate the need for CT. Additionally, CXR utilization for early disease detection may also play a vital role in areas around the world with limited access to reliable real-time reverse transcription polymerase chain reaction (RT-PCR) COVID testing.

Therefore, the purpose of our study is to better understand the main radiographic features of COVID-19 pneumonia, by describing the main CXR findings in a selected cohort of patients and correlating the radiolgraphic appearance with HRCT thorax examination and patients outcome. The authors also tried to emphasis the importance of chest X rays in follow up of COVID patients during the progression of disease, as doing HRCT is not possible for followup on a large scale, atleast in Indian perspective.

2. MATERIALS AND METHODS

Population and Methodology

A prospective study of 700 consecutive COVID positive cases was done in the Radio diagnosis department of Kalinga institute of medical sciences, Bhubaneswar, India. All the patients who presented with clinical signs and symptoms of COVID-19, found to be COVID positive on Reverse transcriptase - polymerase chain reaction (RT-PCR) tests and underwent CXR and HRCT thorax were included in the study. COVID positive patients who lack either CXR or HRCT were excluded from the study.

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All CXR were acquired as Digital Radiographs following usual standard protocols by Imaging will be done by portable Xray unit 100 mA Siemens Multimobile 2.5,and processed with Care stream DV 6950 CR system. CXR were obtained in the postero-anterior (PA) or antero -posterior (AP) projection as per the condition of patient. Follow-up CXR were usually taken in the AP projection using portable X-ray machine in isolation wards.

All the CTs were done by a newly installed dedicated 64 slices Seimens 'Somatom go. UP' CT scanner with SAFIRE technology. High resolution CT (HRCT) thorax scan were done and slice thickness of 1mm, reconstructed to 0.5 mm was taken using standard protocols. KV and mAS used were 130 and 100 respectively

Imaging analysis

In order to evaluate radiological features, two senior Radiologists blinded to clinical and laboratory findings analysed the CXRs and HRCT scans. Any discrepancy amongst the two radiologists was reviewed by another senior radiologist.

Following the Fleischner Society: Glossary of Terms for Thoracic Imaging protocol, radiographic features including consolidation, ground glass opacities (GGO), and pulmonary nodules were diagnosed [3]. Distribution of the lung changes was categorized into (i) Upper, middle , lower or no zonal involvement; (ii)peripheral predominance, perihilar predominance (peripheral and perihilar demarcation was defined as halfway between lateral edge of the lung and hilum), or neither; and (iii) right, left, or bilateral lung involvement. Presence of pleural effusion was also recorded. Radiograph Scoring

To quantify the extent of infection, a severity score was calculated by adapting and simplifying the Radiographic Assessment of Lung Edema (RALE) score proposed by Warren et al [4] A score of 0-4 was assigned to each lung depending on the extent of involvement by consolidation or GGO (0 = no involvement; 1 = <25%; 2 = 25-50%; 3 = 50-75%; 4 = >75% involvement). The scores for each lung were summed to produce the final severity score

To find the accuracy of CXR in detecting imaging features in COVID positive patients we compared them with HRCT thorax findings. Many of these CXR were repeated and followed up over a duration of time to see the progression of disease.

3. RESULTS

There were 539 males (77%) and 161 females (23%), with a mean age of 55 years (range 10 to 86 years).Most of the patients were asymptomatic (57%). Fever, shortness of breath and cough were the most frequent symptoms accounting for 17%, 13% and 9% respectively. The age and clinical features distribution at the time of admission is depicted in the Graph 1 and 2 respectively.

CXRs of 700 patients were analysed, out of which, 392 (56%) were found to be negative for radiological thoracic involvement. The following features were more commonly observed: 147/700 (21%) COVID positive patients with lung consolidations, 115/700 (16.5%) with GGO, 40/700 (5.7%) with nodules and 42/700 (6%) with reticular–nodular opacities. In COVID positive patients, we also found signs nonspecific for COVID-19 pneumonia as cardiomegaly (5%), pleural effusion (2.8%) and cavitatory lesions (1%). Out of the patients with positive findings on CXRs peripheral predominance (65%) and lower zone distribution

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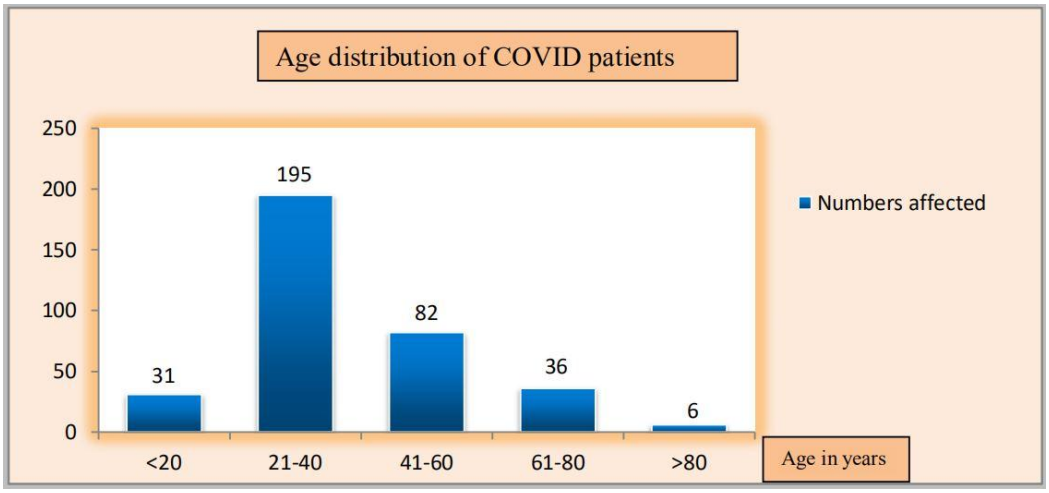
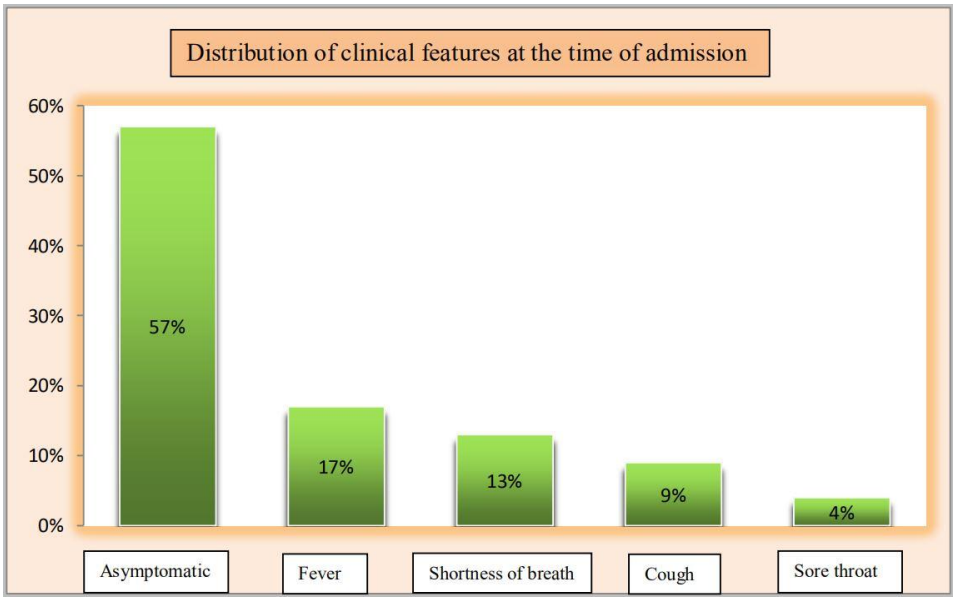
(69.4%) were the most common. Bilateral involvement (74.7%) was most frequent than unilateral one.The CXR findings are depicted in Graph 3.

Graph - 1



Graph - 2



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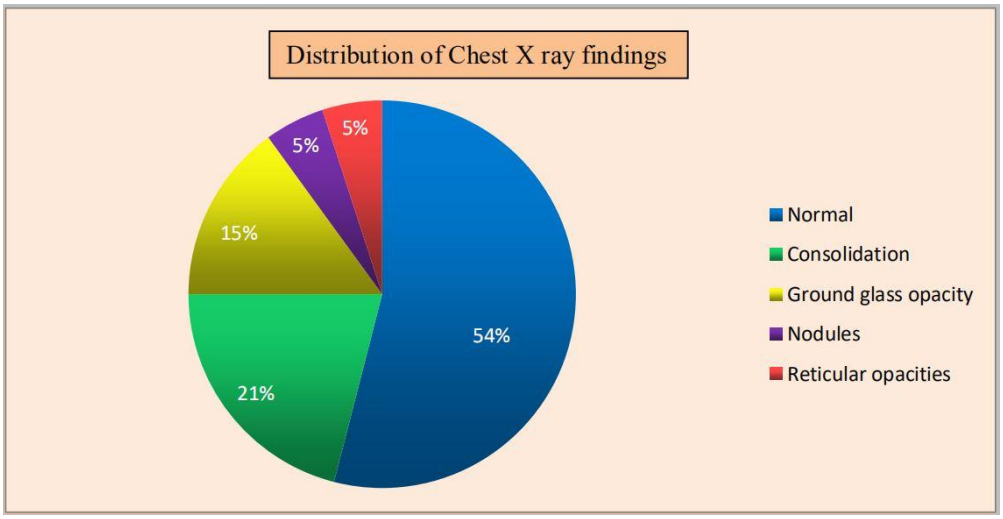
Graph - 3



Baseline CXR findings

All patients had baseline CXRs upon presentation. 392/700 patients (56 %) had normal baseline CXRs. 150/700 patients (21.4 %) had mild findings with total severity score of 1-2. More extensive involvement was seen in 104/700 (14.8 %) and 43/700 (6.2%) patients, who had severity scores of 3-4 and 5-6 respectively. 11/700 patients had a severity score of >6 on their baseline CXR.

Importance of Chest X ray in following the progression of disease

Patients with CXRs findings were correlated with clinical course of disease. Of the 392 patients who had normal baseline CXRs, 65 developed abnormalities on follow-up, all of them eventually became featureless on follow up CXRs after proper conservative management. Similarly, those with severity score of 1-2 or 3-4 were managed conservatively and discharged after mean duration of 10 days. Those with severity score of 5 or more than 5 (54/700, 7.7%) required aggressive treatment with mean duration of stay of 14 days, many of them died also (23/54, 42.5%). The highest CXR severity score recorded was 8 (of maximum possible score of 8).

The importance of CXRs in followup the patients during the course of the disease is demonstrated by the illustrations given below (Fig 1, 2, 3, 4, 5).

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FIG - 1

DAY- 1 DAY - 7 DAY - 12

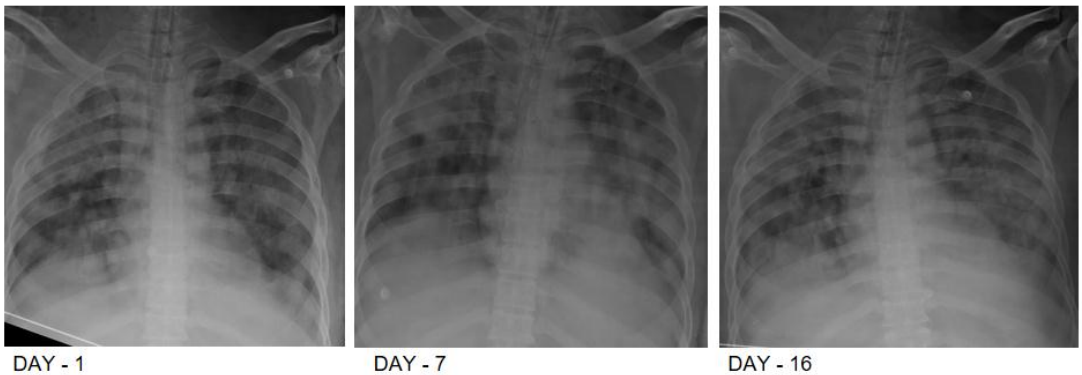
A 70 years old male patient was admitted with chief complaints of fever, cough and breathlessness for 2 days. His baseline chest X ray on Day 1 revealed peripheral GGO which worsen during the course of disease and on day 12 diffuse bilateral pneumonic consolidation was evident. RT-PCR showed COVID positive status. He was treated conservatively with antibiotics, antivirals and Methylprednisolone with proper ventilator support. Eventually during the course of disease he developed severe hypoxia and succumbed to death on day 15.

Fig - 2

DAY - 1 DAY - 4 DAY - 6

A 65 years old male patient was admitted 4 days after the onset of symptoms like fever with chills and sudden onset of loss of consciousness . Patient was found to be positive on RT-PCR and showed progressive consolidation on Chest X ray during the course of disease. He also had history of DM and HTN. Patient was intubated and managed on antibiotics and platelet infusion. Inspite of all resuscitative methods patient could not be revived and was declared dead due to severe ARDS on Day 9 from the admission date. The Findings of Chest Xrays were correctly correlated with the progression of clinical severity of the disease.

Fig - 3



DAY - 1 DAY - 7 DAY - 16

A 49 Yr old male presented with fever , dry cough , breathlessness since 5 days. on admission patient is conscious and oriented , BP -120 / 70 mm Hg , Pulse- 96/min , RR - 22/min , SPo2 - 94 % at room air. Patient was admitted as a suspect of covid 19 , was confirmed as positive on RT-PCR later. As the symptoms worsen,he was shifted to ICU on Day 3. Inspite of aggressive conservative treatment,he developed severe ARDS and found to be dead on day 18. A series of X ray was done to follow up the patient with the course of disease. The findings of Chest Xray were correlated with the severity of disease.

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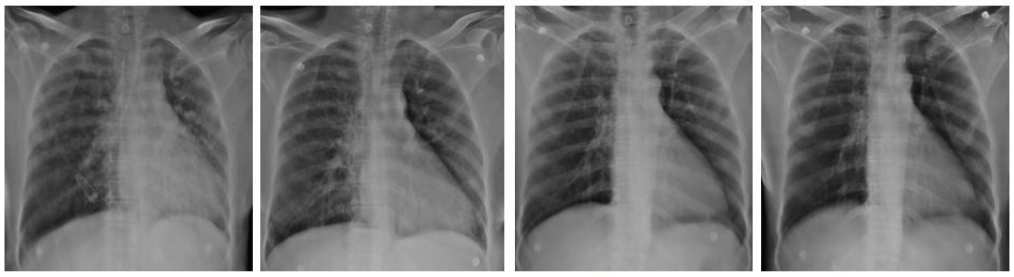
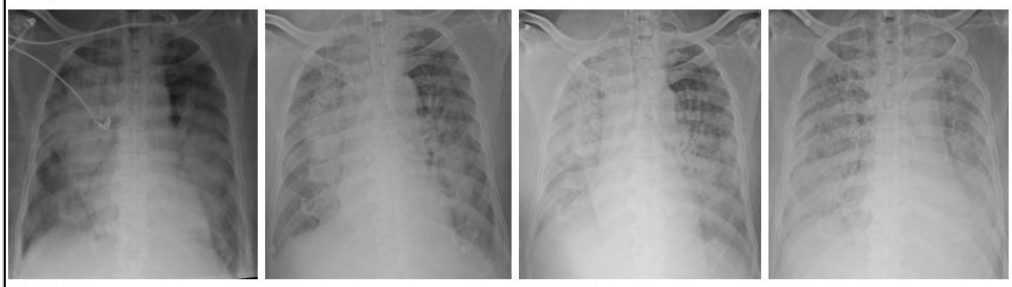
Fig - 4



DAY - 1 DAY - 3 DAY - 7 DAY - 12

A COVID positive 51 years old female patient admitted with complaints of fever, shortness of breath and altered sensorium for 7 days. She was a known case of COPD with irregular treatment. Chest Xray done on day 1 showed ill defined GGO in bilateral lung fields which gradually resolved due to proper conservative management over the period of stay. The Chest Xrays were done at appropriate intervals to keep an eye on the progression of disease. On Day 15, she was found to be negative for COVID and was discharged from the isolation ward.

Fig - 5



DAY - 1 DAY - 4 DAY - 7 DAY - 9

A 60 yearsold male COVID positive patient was admitted with the chief complaints of shortness of breath, dry cough and fever since 3 days with one episode of hemoptysis . Patient was a known case of DM and Hypertension.He was treated conservatively with fluids, antibiotics,Methylprednisolone and ventilator support.On Day 11 he developed fall in saturation and bradycardia leading to asystole and as per ACLS protocol CPR was started immediately due to which patient was revived after 30 mins.Then, again after 10 mins patient developed bradycardia which could not be managed by any resuscitative measures and patient died on the day 11 due to respiratory and cardiac failure. The series of Chest X ray was extremely helpful to trace the progression of severity of disease.

Chest x-ray correlation with CT

HRCT thorax of 700 patients was done. 210 scans showed consolidation which was correctly identified by CXRs in 147 patients with a sensitivity of 70 %. Similarly, out of 196 patients showing GGO on HRCT, 115 were correctly detected by CXR with a sensitivity of 59%. Accuracy of CXR was found to be 42.5 % and 43.7 % for nodules and reticular opacities respectively. CXR showed sensitivity of 60.6%, 47.6% and 76.1% for pleural effusion, cavitatory lesions and cardiomegaly respectively. The overall sensitivity of CXR in detecting COVID lesions is found to be 55.1%. Comparison of CXR with HRCT is summarized in table- 1.

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TABLE-1 : Sensitivity of Chest X-ray for different lung abnormalities In COVID positive patients taking CT chest as a comparing imaging tool (n=700)**.**

Characteristics	**No. Of findings Correctly matched with HRCT**	**No. Of findings not correctly matched with HRCT**	**Sensitivity**
Consolidation	147	63	70%
Ground glass opacities	115	81	59%
Pulmonary nodules	40	54	42.5%
Pleural effusion	20	13	60.6%
Reticular opacities	42	54	43.7%
Cavitatory lesion	10	11	47.6%
Cardiomegaly	16	5	76.1%
Overall sensitivity of CXR in comparison to HRCT			55.1%

4. DISCUSSION

The main feature of consolidation on chest x-ray in COVID-19 pneumonia is consistent with previously published case series. Consolidation was the most common finding (147/700, 21%), followed by GGO (115/700, 16.5%). Early COVID-19 investigators have noted that the air-space disease tends to have a lower lung distribution and is most frequently bilateral [5]correlating well with our study showing a peripheral (65%) and lower zone distribution (69.4%) with bilateral involvement (74.7%). Pleural effusion and cavitation were not common (2.7% and 1% respectively). The severity of CXR findings peaked at 10-12 days from the date of symptom onset. As opposed to community acquired bacterial pneumonia which tends to be unilateral and involving a single lobe [6], COVID-19 and other viral pneumonias typically produce lung opacities in more than one lobe. Identifying multifocal air-space disease on CXR can be a significant clue to COVID-19 pneumonia.

We demonstrated that the common CT findings of bilateral involvement, peripheral distribution, and lower zone dominance can also be appreciated on CXR. The proportion of patients in our study exhibiting abnormal radiographic findings (308/700, 44%) is little lower than that in the case series of 9 patients published by Yoon *et al.[7]* (5/9, 56%).

Our results suggest that CXR can play a role in the initial screening of COVID-19. Ground glass densities observed on CT may often have a correlate that is extremely difficult to detect on CXR (59% sensitivity). A normal chest radiograph does not exclude covid-19 pneumonia. No single feature of covid-19 pneumonia on a chest radiograph is specific or diagnostic, but a combination of multifocal peripheral lung changes of ground glass opacity and/or consolidation, which are most commonly bilateral, may be present. Diagnosis might be complicated as covid-19 pneumonia may or may not be visible on chest radiograph.In the scenario where there is high clinical suspicion of COVID-19 it is conceivable that a positive CXR may obviate the need for a CT, thus reducing burden on CT units in this pandemic.

An important factor in the reliability of X-ray findings could be the time elapsing between the appearance of initial symptoms and the imaging procedure. While no obvious signs of the

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disease were visible in the X-rays within the first three-four days after the onset of coughing and fever, they were quite obvious In the later phase of disease (10-14 days) [8].

Mobile X-ray equipment has the additional advantage that it can be taken directly to the patient's bedside. As the Fleischner Society summarizes, the risk of transmitting COVID-19 that exists while a patient is on the way to CT is thereby effectively ruled out [9]. If possible, mobile systems are recommended, particularly to reduce the challenges of decontaminating equipment [10].

Our study has several limitations. AP images from portable machines produce a poorer quality image when compared with a PA chest radiograph done in a dedicated radiography facility, therefore can be more difficult to interpret. Limitations of AP chest radiograph include reduced inspiratory effort because of the patient's positioning (potentially exacerbated by their illness), resulting in sub-optimal imaging; lung changes may therefore appear more marked or localised infection may be missed; the heart can also appear magnified.

In summary, we describe the features of COVID-19 on CXR, to complement the publications on CT. Baseline CXR had a sensitivity of 56% in our cohort. As the COVID-19 pandemic threatens to overwhelm healthcare systems worldwide, CXR may be considered as a tool for screening and followup tool for COVID-19.

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