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Time Course of Chest CT Lung Changes in COVID-19 Patients from Onset to Recovery

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Abstract

Background: The chest computed tomography (CT) has an important complementary role in diagnosis of COVID-19 disease. Computed tomography (CT) is widely used to evaluate the severity of COVID-19 infection and track disease progression.

Aim of Study: The aim of the study was to determine the changes in chest CT findings associated with COVID-19 pneumonia from initial diagnosis until patient recovery and clarifying the end result of chest affection in the following-up groups and evaluating the percentage of residual or fibrosis after viral cure.

Patients and Methods: It has been a long time since human kind has experienced a global pandemic. Nowadays in 2019, human kind is again to survive another worldwide spreading disease COVID-19. This SARS-COV-2 virus first appeared as a strange sort of respiratory tract infection with the first reported patient in Wuhan, China on December 2019. The new coronavirus disease has spread to every country around the world, forcing people to change their lives in new difficult ways.

Results: This cross-sectional study was conducted on 110 patients of proven cases of Covid-19 under follow-up with serial CT chest scan. From onset to first scan show that 98 (89.1%) were slow, 10(9.1%) were rapid and 2(1.8%) were abrupt. From onset to discharge the study shows that 101 patients (91.8%) had a slow disease progression, 7 patients (6.4%) had a rapid progression and 2 patients (1.8%) had an abrupt course of disease. From onset to hospitalization, the study shows that 3 patients (2.7%) were hospitalized.

Conclusions: Our findings suggest that periodic chest CT scans in COVID-19 patients (at least in a five-day interval during the first 13-15 days) are necessary and may provide useful information to guide clinical practice, especially allowing for more tailored therapies and holistic care models.

Key Words: *COVID-19 – Pneumonia – Chest CT scans – Progressions – Consolidation.*

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Introduction

IT has been a long time since human kind has experienced a global pandemic. Nowadays in 2019, human kind is again to survive another worldwide spreading disease COVID-19 **[1]**. This SARS-COV-2 virus first appeared as a strange sort of respiratory tract infection with the first reported patient in Wuhan, China on December 2019 **[2,3]**. The new coronavirus disease has spread to every country around the world, forcing people to change their lives in new difficult ways **[4]**.

COVID-19 is considered as a respiratory and vascular illness as its causative agent, SARS-CoV-2, mostly targets both respiratory and vascular systems. The SARS-CoV-2 virus has been known to attack the respiratory tract, destroy the lungs, leading to pneumonia, resulting in the acute respiratory distress syndrome and severe hypoxia **[5]**.

Previous studies found that this viral infection passes through three stages, the first stage in which virus shows no signs or symptoms in its host, the second phase in which symptoms have appeared but they are less severe and in third stage symptoms

List of Abbreviations:

COVID 19 : Coronavirus disease of 2019.
CT : Computed tomography.
FOV : Field of view.
HRCT : High resolution computed tomography.
MERS CoV : Middle East respiratory syndrome coronavirus.
SARS : Severe acute respiratory syndrome.
SARS-CoV-1 : Severe acute respiratory syndrome coronavirus 1.
SARS-COV-2 : Severe acute respiratory syndrome coronavirus 2.
WHO : World health organization.
mA : Milli-ampere.

become more severe where COVID-19 virus has gotten to its maximum number by proliferation **[6]**.

Considering its high sensitivity, computed tomography (CT) of the chest, principally high-resolution CT (HRCT), is the proper diagnostic tool in assessment of COVID-19 pneumonia, specifically in case of progressive course of the disease **[7]**.

Multifocal bilateral ground glass opacities are the most common CT signs of COVID 19 associated with patchy consolidation, being mainly peripheral in distribution, with higher involvement of the posterior segments of lower lobes. The "crazy paving" appearance can also be encountered **[8]**.

COVID-19 begins as interstitial pneumonitis and then disturbs lung parenchyma. A large variety of computed tomographic signs in COVID-19 have been mentioned in previous studies, and the CT signs change according to the phase of the disease, severity of the disease and related co-morbidities **[9]**.

Recent studies evaluated the CT chest imaging signs of COVID-19 patients from onset of the symptoms until recovery **[9]**. The highest severity of lung changes on CT chest was noted around 10 days after symptoms onset **[10,11]**.

The main aim of this study was to determine the changes in chest CT findings associated with COVID-19 pneumonia from initial diagnosis until patient recovery and clarifying the end result of chest affection in the following-up groups and evaluating the percentage of residual after viral cure.

Patients and Methods

Study design:

Ethics committee approval was obtained for this cross sectional analytic study. Informed consent was also obtained from all patients. We evaluated 110 patients of proven cases of PCR-Covid-19 under follow-up. The patients were referred from chest department of our institution from September 2021 to February 2022. COVID-19 cases were confirmed based on the WHO interim guidance **[12]**. This study was conducted in the radiology department of our institution. Data were analyzed on the basis of epidemiological and clinical data, laboratory tests, radiological findings, and progression and treatment information collected by nurses, physicians, or other professionals from electronic medical records. Our inclusion criteria did not specify any age or sex groups. We included all patients with PCR-proved COVID 19 during the previously mentioned study period. We excluded patients refusing to take part in the study or patient dedicated for differential diagnosis.

CT chest protocol:

Thin slice (Toshiba Aquilion 64) high-resolution non-contrast CT chest was used in patients exam. Considering the age and clinical data of the patients, preliminary CT examination may be done using standard-dose or low-dose protocol. The scanning parameters of the CT were the following: slice thickness = 1-1.5mm, FOV = 350mm x 350mm, tube rotation = 0.6-0.9 second and detector collimation = 1mm. The irradiation dose parameters were as follows: 120-130kVp and 100-200mA (considering the age and weight of the patient). No intravenous contrast was administrated.

CT evaluation:

Computed tomographic information from different scans were acquired from the institutional picture archiving and communication system (PACS). Serial CT chest exams were done since the onset of symptoms. Two radiologists evaluated the CT exams, one senior radiologist with more than 25 years of experience and the other one had more than 5 years of experience. Later, any discrepancy in opinions was resolved through a consensus. CT signs were dictated using the standard terms mentioned in the Fleischner Society glossary and peer-reviewed literature **[13]**.

According to the methodology in previous studies of COVID-19, our study used the samesemi-quantitative CT scoring system to evaluate the extension of the lung lesions in each lobe from 0 to 5 points (0, no lesion; 1, 5%; 2, 5%-25%; 3, 26%-49%; 4, 50%-75%; 5, more than 75%) **[14,15]**. The summation of the CT score in each lobe was calculated and considered as the total CT score, with values varying from 0 to 25, then a severity grading was given to each patient as follows: Mild if score is from 1 to 10, moderate from 11 to 19, and severe from 20 to 25. Twelve months after the onset of symptoms, cases with or without remaining CT changes were compared.

Statistical analysis **[16]***:*

Data were fed to the computer and analyzed using IBM SPSS software package version 20.0. (Armonk, NY: IBM Corp), **[17]**. Qualitative data were described using number and percent. The Kolmogorov-Smirnov test was used to verify the normality of distribution Quantitative data were described using range (minimum and maximum),

mean and standard deviation. Significance of the obtained results was judged at the 5% level. The used test was Chi-square test for categorical variables, to compare between different groups.

Results

Participant characteristics:

We evaluated 110 patients of PCR proven cases of Covid-19 under follow-up (57 males, 53 females; age range: 15-83 years; mean age: 53.14 years ± 12.834). The demographic data of the patients, initial symptoms and information regarding disease progression were shown in Table (1). Thirty seven patients (33.6%) had comorbities, including diabetes and/or hypertension. Thirty six patients (32.7%) had a history of drugs intake to treat diabetes or hypertension. Other initial symptoms included 13 patients with chest pain (11.8%), 17 patients with malaise (15.5%) and 5 patients had bony aches (4.5%). Regarding onset of symptoms, 106 patients (96.4%) had a gradual onset and 4 patients (3.6%) had an abrupt onset of symptoms with a duration ranging from 1 to 12 months. A total of 11 patients (10.0%) received vaccination against the COVID 19 virus. Mild cases represented 70.9% of our patients, 11.8% were moderate cases and 17.3% were severe cases. From onset of symptoms till the first scan 98 patients (89.1%) showed slow progression of the disease, 10 patients (9.1%) showed a rapid progression and 2 patients (1.8%) showed an abrupt progression. From onset of symptoms till discharge, 101 patients (91.8%) had a slow course of the disease, 7 patients (6.4%) had a rapid course and 2 patients (1.8%) had an abrupt course. Our data show that 3 patients (2.7%) were hospitalized.

Chest CT evaluation:

The total number of CT scans ranged from 1 to 3 scans with a mean value of 2.08±0.335. Table (2) and Fig. (1) show different CT scores for each lung lobe, acquired in the first, second and third lung scans. 1^{st} CT scan showed that 20 patients had severe infection, 74 patients (67.3%) had mild infection and 16 patients (14.5%) had moderate infection. The 2^{nd} CT scan showed that 28 patients (25.5%) had complete resolution, 2 patients (1.8%) had severe infection, 2 patients (1.8%) had mild infection, 1 patient (0.9%) had moderate infection, 21 patients (19.1%) had progressive course, 55 patients (50.0%) had regressive course and 1patient (0.9%) had stationary course. The 3^{rd} CT scan, which was formed for 10 of the 110 studied patients, showed that 6 patients (5.5%) had complete resolution, 2 patients (1.8%) had mild infection, 1 patient (0.9%) had appreciable regressive course and 1 patient (0.9%) had a regressive course (Table 3). Our data revealed that participants were divided into 2 groups, participants with complete resolution [36 patients (32.7%)] and participants who did not have a complete resolution [74 patients (67.3%)]. 66 patients (89.2%) amongst the patient with no complete resolution, showed residual atelectatic changes and 8 patients (10.8%) show lung fibrosis. There was a statistical significant difference between complete resolution of findings and lung fibrosis with a *p*-value of <0.001.

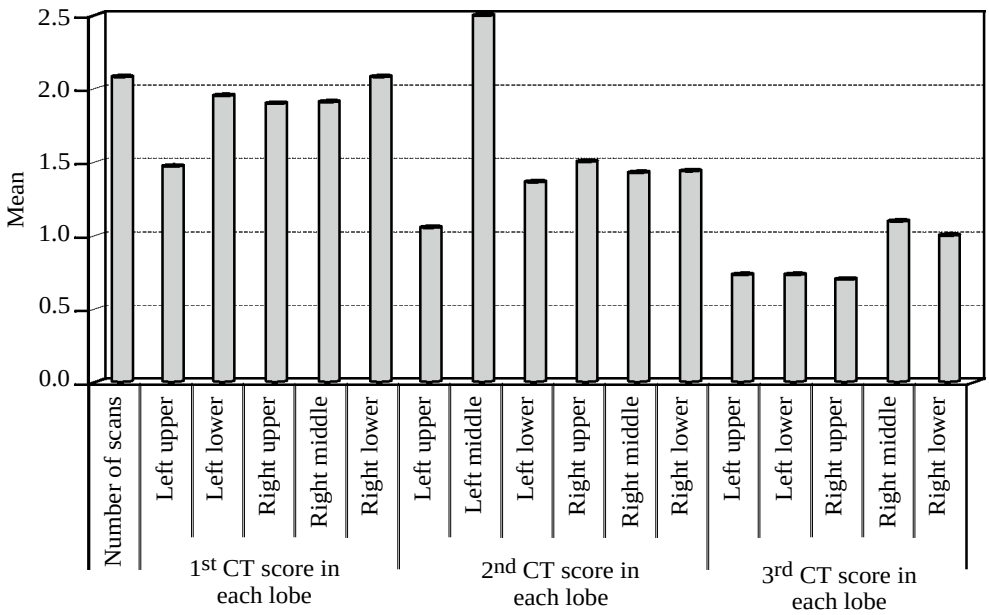

Fig. (1): Distribution of studied sample according to patient's number of scans and CT score in each lobe.

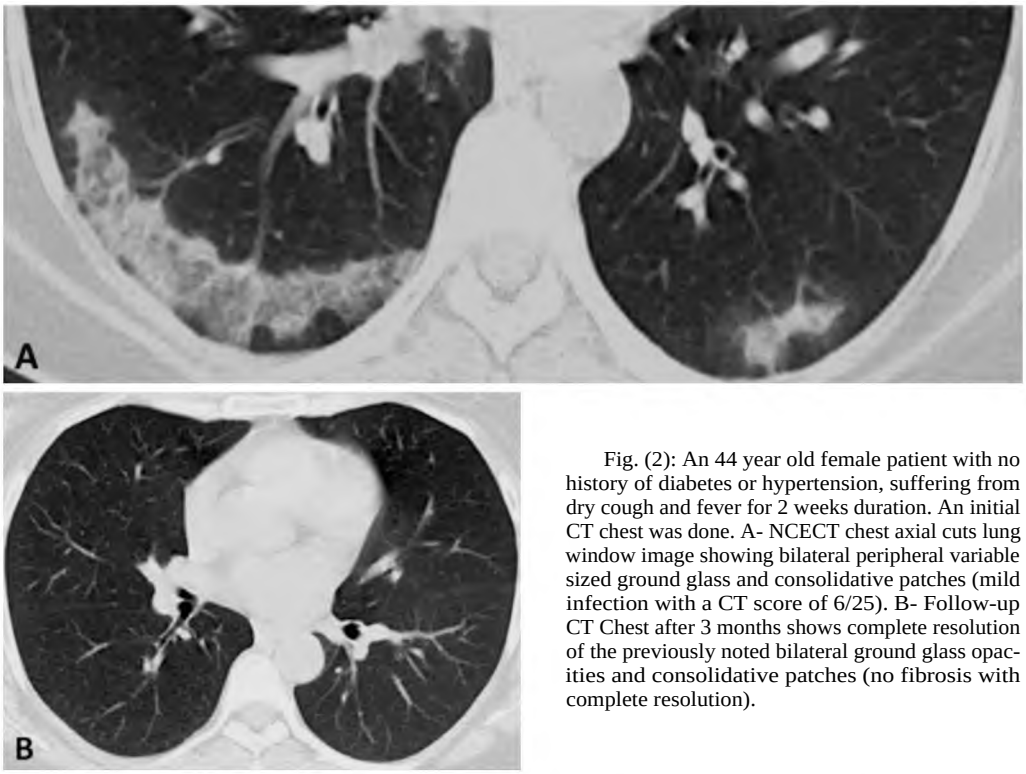

Fig. (2): An 44 year old female patient with no history of diabetes or hypertension, suffering from dry cough and fever for 2 weeks duration. An initial CT chest was done. A- NCECT chest axial cuts lung window image showing bilateral peripheral variable sized ground glass and consolidative patches (mild infection with a CT score of 6/25). B- Follow-up CT Chest after 3 months shows complete resolution of the previously noted bilateral ground glass opacities and consolidative patches (no fibrosis with complete resolution).

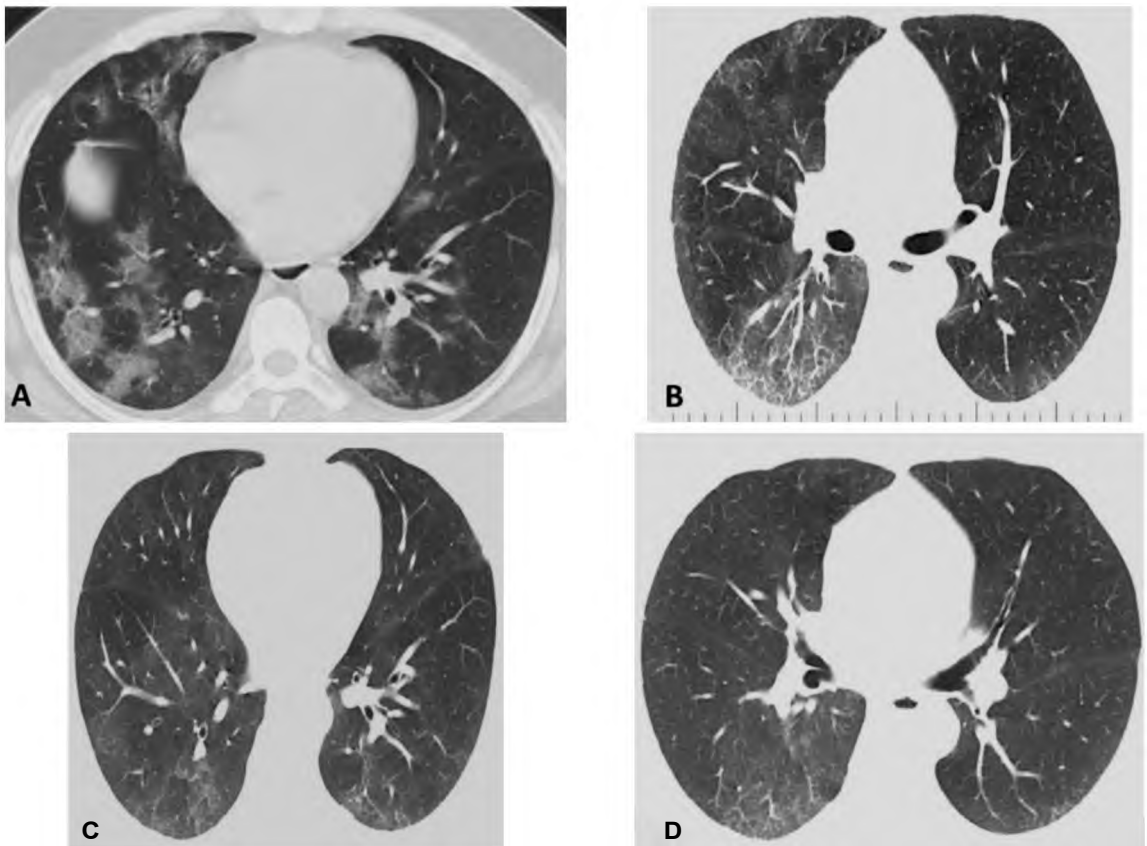

Fig. (3): A 60 year old male patient with history of type 2 diabetus and hypertension suffering from dry cough and fever for 1 week duration. A- An intial NCECT chest axial cuts lung window image showing bilateral crazy paving and peripheral ground glass opacification mainly affecting the lower lung lobes with a score of about 15/25 (moderate infection). B and C- A follow-up CT chest was done after one month revealing bilateral evident regression in density but no significant regression in extent of lung lesions, the lungs show bilateral faint ground glass opacification and crazy paving with a score of 7/25 denoting mild infection with sign of healing (regression course). D- Another follow-up CT chest after 4 months showing bilateral significant regression in density and extent of the previously described lungs lesions with a score of 4/25 (no fibrosis with no complete resolution).

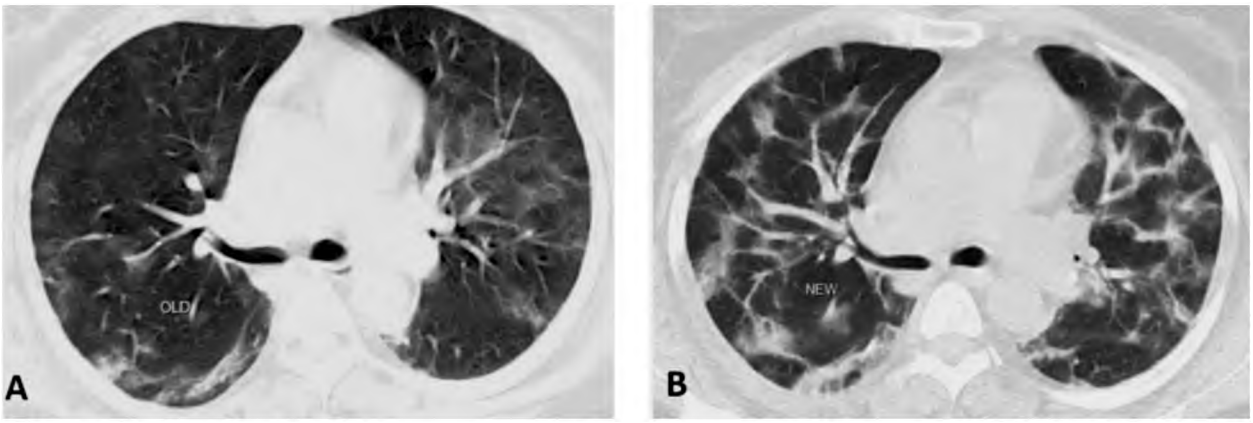

Fig. (4): A 58 year old female patient with history of type II diabetus and hypertension, suffering from dyspnea at rest and fever for 1 week duration. An initial CT chest was done. A- NCECT chest axial cuts lung window image showing bilateral predominantly peripheral ground glass opacification with a CT score of 20/25 (marked COVID 19 infection). B- Follow-up CT chest after 3 weeks showing progressive course as evidenced by increased number, extension and density of the previously noted extensive pulmonary parenchymal opacities with a CT score of 25/25 associated with lung fibrosis.

Table (1): Distribution of studied sample according to demographic and clinical data.

	Number	Percent
Age (years):		
≤20	1	0.9
21 - 30	2	1.8
31 - 40	19	17.3
41 - 50	20	18.2
51 - 60	39	35.5
>60	29	26.4
Range	15-83	
Mean ± S.D.	53.14±12.834	
Sex:		
Male	57	51.8
Female	53	48.2
Comorbidity:		
No	73	66.4
DM and/or HTN	37	33.6
Drug Intake:		
No	74	67.3
DM and/or HTN drugs	36	32.7
Symptoms:		
Dry cough	89	80.9
Fever	44	40.0
Dyspnea	30	27.3
Chest pain	13	11.8
Malaise	17	15.5
Bone ache	5	4.5
Onset of symptoms:		
Gradual	106	96.4
Abrupt	4	3.6
Duration of symptoms (months):		
Range	1-12	
Mean ± S.D.	3.44±2.182	
Vaccine data:		
No	99	90.0
Yes	11	10.0
Disease severity:		
Mild	78	70.9
Moderate	13	11.8
Severe	19	17.3
Total	110	100

Table (1): Count.

	Number	Percent
Disease progression:		
From onset to first scan:		
Slow	98	89.1
Rapid	10	9.1
Abrupt	2	1.8
From onset to discharge:		
Slow	101	91.8
Rapid	7	6.4
Abrupt	2	1.8
From onset to hospitalization:		
No	107	97.3
Yes	3	2.7

Table (2): Distribution of studied sample according to patient's number of scans and CT score in each lobe.

	Range	Mean ± S.D.
Number of scans	1-3	2.08±0.335
1st CT score in each lobe:		
Left upper	0-5	1.47±1.283
Left lower	0-5	1.95±1.350
Right upper	0-5	1.90±1.278
Right middle	0-5	1.91±1.500
Right lower	0-5	2.08±1.389
2nd CT score in each lobe:		
Left upper	0-5	1.05±1.322
Left middle	1-4	2.50±2.121
Left lower	0-5	1.36±1.475
Right upper	0-5	1.50±1.476
Right middle	0-5	1.43±1.518
Right lower	0-5	1.44±1.481
3rd CT score in each lobe:		
Left upper	0-4	0.73±1.348
Left lower	0-4	0.73±1.191
Right upper	0-5	0.70±1.567
Right middle	0-5	1.10±1.595
Right lower	0-4	1.00±1.342

SD: Standard deviation. CT: Computed tomography.

Table (3): Distribution of studied sample according to patient's CT Manifestations.

	Number	Percent
1st CT scan:		
Mild infection	74	67.3
Moderate infection	16	14.5
Severe infection	20	18.2
2nd CT scan:		
Complete resolution	28	25.5
Severe infection	2	1.8
Mild infection	2	1.8
Moderate infection	1	0.9
Progressive course	21	19.1
Regressive course	55	50.0
Stationary course	1	0.9
3rd CT scan:		
Not done	100	90.9
Complete resolution	6	5.5
Mild fibrosis	2	1.8
Appreciable regressive course	1	0.9
Regressive course	1	0.9

Discussion

This study evaluated 110 patients with PCR-proved COVID 19 disease over a study period. According to personal medical history data of the studied group, we found that 37 patients (33.6%) had diabetes mellitus and/or hypertension. Drug Intake was recorded in 36 patients (32.7%) for treatment of diabetes and hypertension. This was in line with previous studies **[18-21]**. Unlike previous studies **[10,11,19]**, initial symptoms of our studied group showed that 80.9% of patients had dry cough, followed by fever, dyspnea, chest pain, malaise and bone ache. Previous studies reported that the most common symptoms were fever followed by Cough. The majority of this study patients showed a gradual onset of symptoms with moderate disease severity. The study by Yun et al., **[10]** showed that there were 67 (21.97%) severe cases and 238 (78.03%) non severe cases. Another study by Xu et al., **[22]** reported that the majority of the 50 studied patients were moderate, followed by severe then critically ill patients. The severity of cases can vary from one study to another depending on the sample characteristic.

In our study, the total number of CT scans ranged from 1 to 3 scans with a mean value of 2.08±0.335. Mild infection was the predominant findings in the 1rst CT scan performed (67.3%). Regarding the 2nd CT scan, 19.1% of the patients had progressive course and 50.0% of the studied patients had a regressive disease course. The 3rd scan was not performed by many of our patients (100 patients). In the study done by Pan et al., **[19]** they reported that each patient underwent an average of 4±1 CT scans (range: 3-6). Their study also reported that the maximum lung involvement was noted at about 10 days from the beginning of symptoms. Yun et al., **[10]** revealed that in comparison to non-severe cases, severe patients experienced a longer duration of illness from onset to recovery and were subjected to more CT exams. Their study also reported that the total CT score reached its maximum value at around 13 days in non-severe cases and at 15 days in severe cases from the onset of symptoms. Further comparison noted that the second CT scan total score showed a significantly higher value than that of the first CT scan with a *p*-value of 0.03. Moreover, our results were supported by Zhuang et al., **[20]** who reported that the peak time of CT score was about 11 days. CT scan score reached a peak at the second scan performed with 15 cases and then was reduced gradually.

In the present study we found that 32.7% of patients showed a complete resolution (Fig. 2) which was in line with previous study **[18]**. However, Pan et al., **[19]** reported that the complete resolution rate gradually increased over time from 61% at 3 months to 75% at 12 months after symptom onset.

In the present study we found that there were 8of patients showing lung fibrosis and 66 patients with remaining atelectasis bands (Fig. 3) with a highly statistically significant differences between fibrosis and resolution. Which was concordant with previous studies **[10,20]**. Some authors consider fibrosis a sign of regression of disease severity and carries good prognosis **[23]**, but other authors consider it a sign of severe disease (Fig. 4) or a warning sign of development of interstitial fibrosis **[10,11,24]**. The development of pulmonary fibrosis is an important sequela in patients after severe respiratory infections **[20]**. Since the observation of substantial fibrotic consequences following infection of SARS-CoV-1 and MERS CoV **[25],** concern has been raised about the prevalence and persistence of lung fibrosis after COVID-19. Based on previous data, lung fibrotic-like changes (the presence of traction bronchiectasis, parenchymal bands, and honeycombing) were observed in 35% of the patients who recovered from severe COVID-19 at 6 months after illness onset **[20]**.

We had limitations in our study. First, there was a selection bias because many of discharged patients were not involved in the study because of a deficiency of CT chest data at admission. Second, we do not know whether the CT signs will show regression after a longer period of follow-up, which merits more clinical and radiologic follow-ups.

Nevertheless, taking into consideration that residual lesions usually do not change after 1 year in SARS, these CT signs in COVID-19 are probably lasting **[26]**. Third, we had a small sample size compared to the large number of patients affected with COVID 19 infection during the period in which our study was performed.

Conclusions:

Our study propose that periodic CT chest in patients with COVID 19 (at least done at a 5 days internal throughout the first 13 to 15 days) is essential and may offer valuable information to monitor clinical practice, specifically permitting for a more tailored treatment. Other studies with a greater sample size and lengthier follow-up are needed to find out the risk factors associated with adverse outcome.

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تحديد التغييرات فى نتائج التصوير المقطعى المحوسب للصدر المرتبطة بالالتهاب الرئوى كوفيد-١٩

يتطلب تشخيص كوفيد–١٩ الكشف عن المادة الوراثية الفيروسية المحددة فى العينات التى تم جمعها من الزنف أو الدم أو البراز أو إفرازات الجهاز التنفسى، ومع ذلك، فإن الحساسية المتغيرة لهذا الاختبار هى مشكلة تهدد صحتها. شوهدت إصابة الرئة الناتجة عن عدوى كوفيد–١٩ على شكل ضائقة تنفسية حادة فى حوالى ٣٠٪ من الحالات. يلعب التصوير المقطعى للصدر دوراً أساسياً فى تقييم كوفيد–١٩، حتى قبل ظهور الأعراض السريرية فى بعض الأحيان.

يظهر فحص الصدر بالأشعة المقطعية حساسية ٩٧٪ و ٧٥٪ لتشخيص المرضى الموجبين والسلبيين على التوالى ولكن بنوعية ٢٥٪ فقط. هناك دليل على القيمة الإنذارية للتصوير المقطعى المحوسب للصدر والذى أظهرته الدراسات الحديثة، حيث يمكن أن تتنبأ درجة معينة من الأشعة المقطعية بوفاة المرضى المصابين بـ كوفيد–١٩.

كان الغرض من الدراسة هو تحديد التغييرات فى نتائج التصوير المقطعى المحوسب للصدر المرتبطة بالالتهاب الرئوى كوفيد–١٩ من التشخيص الأولى حتى تعافى المريض وتوضيح النتيجة النهائية لتأثر الصدر فى المجموعات التالية وتقييم النسبة المئوية المتبقية بعد العلاج الفيروسى.

أجريت هذه الدراسة المقطعية فى قسم الأشعة. أجريت هذه الدراسة على ١١٠ مريضاً من الحالات المؤكدة لـ كوفيد–١٩ تحت المتابعة.

– أظهرت النتيجة الثانية للأشعة المقطعية أن ٢٨ (٢٥.٥٪) لديهم دقة كاملة ، ٢ (١.٨٪) لديهم عدوى ملحوظة، ٢ (١.٨٪) لديهم عدوى خفيفة، ١ (٠.٩٪) لديهم عدوى متوسطة، ٢١ (١٩.١٪) لديهم مسار تقدمى، ٥٥ (٥٠.٠٪) كان له مسار رجعى و ١ (٠.٩٪) كان له مسار ثابت.

– أظهرت الأشعة المقطعية الثالثة أن ٦ (٥.٥٪) لديهم دقة كاملة، ٢ (١.٨٪) مصابين بعدوى خفيفة، ١ (٠.٩٪) كان له مسار ارتداد ملموس و ١ (٠.٩٪) كان له مسار ارتدادى.

– فى الدراسة الحالية وجدنا أن هناك ٣٦ (٢٣.٧٪) من المرضى لديهم دقة كاملة.

– فى الدراسة الحالية وجدنا أن هناك ٨١ (٧٣.٦٪) من المرضى مصابون بالتليف.

– كانت هناك فروق ذات دلالة إحصائية عالية بين تليف وقرار.

– لم تكن هناك ارتباطات ذات دلالة إحصائية بين العمر ومظاهر التصوير المقطعى فى مختلف فحوصات التصوير المقطعى المحوسب.

بناءً على النتائج التى توصلنا إليها، نوصى بإجراء مزيد من الدراسات حول حجم العينة الأكبر وعلى نطاق جغرافى كبير للتأكيد على استنتاجنا.