Sudan University of Science and Technology
College of Graduate Studies

Evaluation of COVID 19 by using Computed Tomography

دراسة كوفيد 19 باستخدام الاشعة المقطعية المحوسبة

A Research submitted for partial fulfillment for the Requirements of M.Sc. degree in Diagnostic Radiologic Technology

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2022

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بسم الله الرحمن الرحيم

قال تعالى:

(فَاذْكُرُونِي أَذْكُرْكُمْ وَاشْكُرُواْ لِي وَلاَ تَكْفُرُونِ)

صدق الله العظيم

البقرة الاية {152}

DEDICATION

This research project is dedicated to all Candles that glowed up to Lighten ourway

To my parents

To our teachers, doctors and professors.

ACKNOWLEDGEMENT

This research project would not have been done without ***ALLAH*** and the support of many people.

Our deepest gratitude to our supervisor ***Dr. Babiker Abdulwahab Awad Allah*** for his encouragement, guidance and to our co-supervisor ***Dr. Hussein Ahmed Hassan*** for his great supporthelped us in this research.

Our warmth gratitude and thanks to Diagnostic Radiology- Department staff in Sudan University of Sciences and Technology.

I wish to thanks our radiologist ***Dr. Rahama Abdlla*** for helping me.

Abstract

Background: The third fatal coronavirus is the novel coronavirus (SARS-CoV-2) that causes novel coronavirus pneumonia (COVID-19) which first broke out in December 2019. Patients will develop rapidly if there is no any intervention, so the risk identification of severe patients is critical.

Objective: aimed to evaluate of COVID 19 by using computed tomography. ***Material and methods:*** A total of 50 patients who had Chest (HRCT) and confirmed positively with COVID-19 using real time polymerase chain reaction RT-PCR were included in this study.

Results:

(44 %) were males and (56 %) were females. The age was categorized into three groups, the majority of patients infected with COVID-19 were aged 50 – 60 years old (47 %) and (43 %) have age more than 70 years old aged between 40 to 59 years. The incident of hypertension and diabetes in our patient was high (51%). Where (43 %) of total patients had moderate where (57 %) of them have severe symptoms. Study also found that COVID-19 distributed as GGOs, consolidation with a surrounding halo sign, Bilateral or local patchy shadowing and Interstitial abnormalities in 56 % of patients with COVID-19. there was no significant difference (*p value* = 0.691 and 0.884 > 0.05, respectively) between gender and age with both medical history and clinical symptoms of patients who infected with COVID-19 where there is a statistical difference in comparing with age groups (*p value* = 0.000 < 0.05). and there is a statistical difference in correlation between CT findings and age groups (*p value* = 0.000 < 0.05). ***Conclusion:*** Chest CT played an important role in the diagnosis and follow up of COVID-19.

مستخلص

الفيروس التاجي القاتل الثالث هو فيروس كورونا الجديد (SARS–CoV–2) الذي يسبب الالتهاب الرئوي الناجم عن فيروس كورونا الجديد (COVID–19) الذي ظهر لأول مرة في ديسمبر 2019. سيتطور المرضى بسرعة إذا لم يكن هناك أي تدخل ، وبالتالي فإن تحديد المخاطر من المرضى الخطير أمر بالغ الأهمية.

الهدف: تقييم COVID 19 باستخدام التصوير المقطعي. المواد والطرق: تم تضمين ما مجموعه 50 مريضًا لديهم صدر (HRCT) وأكدوا بشكل إيجابي مع COVID–19 باستخدام تفاعل البوليميراز المتسلسل في الوقت الحقيقي RT–PCR في هذه الدراسة. نتائج:

(44٪) ذكور و (56٪) إناث. تم تصنيف العمر إلى ثلاث مجموعات ، وكان غالبية المرضى المصابين بــ COVID–19 تتراوح أعمارهم بين 50 و 60 عامًا (47٪) و (43٪) تزيد أعمارهم عن 70 عامًا وتتراوح أعمارهم بين 40 إلى 59 عامًا. كانت حادثة ارتفاع ضغط الدم والسكري لدى مريضنا عالية (51٪). حيث (43٪) من إجمالي المرضى لديهم أعراض متوسطة بينما (57٪) منهم يعانون من أعراض شديدة. وجدت الدراسة أيضًا أن COVID–19 تم توزيعه على شكل GGOs ، ودمجًا مع علامة الهالة المحيطة ، والتظليل غير المكتمل الثنائي أو المحلي والتشوهات الخلالية في 56 ٪ من المرضى المصابين بــ COVID–19. لم يكن هناك فرق معنوي (قيمة p = 0.691 و 0.884 <0.05 على التوالي) بين الجنس والعمر مع كل من التاريخ الطبي والأعراض السريرية للمرضى المصابين بــ COVID–19 حيث يوجد فرق إحصائي في المقارنة مع الفئات العمرية (قيمة 0.000 = p< 0.05). وهناك فرق إحصائي في الارتباط بين نتائج التصوير المقطعي المحوسب والفئات العمرية (القيمة الاحتمالية = 0.000< 0.05). الخلاصة: لعب التصوير المقطعي للصدر دورًا مهمًا في تشخيص ومتابعة COVID–19.

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LIST OF ABBREVIATIONS

ACE	Angiotensin-Converting Enzyme
ACI	Acute Cardiac Injury
AKI	Acute Kidney Injury
ALC	Absolute Lymphocyte Count
ALI	Acute Lung Injury
ARDS	Acute Respiratory Distress Syndrome
CCL	Chemokine (C-C motif) Ligand
CFR	Case Fatality Rate
CHD	Congestive Heart Disease
CoV	Coronavirus
COVID	Corona Virus Disease
COVID-19	Coronavirus Disease 2019
CRT	Cathode Ray Tube
CT	Computed Tomography
CT-SS	Computed Tomography- Scoring System
CVDs	Cardio Vascular Diseases
CXCL	Chemokine (C-X-C motif) Ligand
DLD	Diffuse Lung Disease
DM	Diabetes Mellitus
FMH	Federal Ministry of Health in Sudan
GGOs	Ground-Glass Opacities
H1N1	Hemagglutinin Type 1 and Neuraminidase Type 1
H5N1	Hemagglutinin Type 5 and Neuraminidase Type 1
Hel	Helicase
HRCT	High Resolution Computed Tomography
IFN	Interferon
IHD	Ischemic Heart Disease
IL	Interleukin
ILD	Interstitial Lung Disease
IPC	Infection Preventive and Control
MERS	Middle East Respiratory Syndrome
PE	Pleural Effusion
PHEIC	Public Health Emergency Of International Concern
PR	Pulse Rate
RNA	Ribonucleic Acid

RR	Respiratory Rate
RT-PCR	Reverse Transcription–Polymerase Chain Reaction
SARS	Severe Acute Respiratory Syndrome
SARS CoV-2	Severe Acute Respiratory Syndrome Corona Virus 2
SOB	Shortness Of Breath
SPSS	Statistical Package for Social Sciences
TGF	Transforming Growth Factor
TLC	Total Leukocyte Count
TMPRSS2	Transmembrane Protease Serine 2
TNF	Tumor Necrosis Factor
UK	United Kingdom
USA	United States of America
WBC	White Blood Cells
WHO	World Health Organization

CHAPTER ONE

(INTRODCTION)

1-1 Introduction: -

Coronavirus disease 2019 (COVID-19), a highly infectious disease, is caused by a new coronavirus called SARS-CoV-2. The SARS-CoV-2 infection leads to pulmonary interstitial damages, which may cause severe pneumonia, acute respiratory distress syndrome, multiple organ failure, and death . Currently, the gold standard diagnostic test for COVID-19 is a real-time reverse transcription polymerase chain reaction of the viral nucleic acid . However, many studies have demonstrated the importance of using chest computed tomography in the management of COVID-19 patients. Recent studies have found that chest computed tomography have higher sensitivity values compared to RT-PCR when diagnosing COVID-19 (*Zhong et al, 2003*) .

According to chest CT has a sensitivity of 97%, with RT-PCR as a reference standard. Besides, a study conducted on 51 COVID-19 patients revealed that diagnosing through chest computed tomography only misses 3.9% of the positive cases. The severity and the time course of the disease may lead to different computed tomography patterns in COVID-19 patients. The main hallmarks of CT manifestations of COVID-19 are ground glass opacities, and consolidated pulmonary opacities (*Zhong et al, 2003*). Li et al).

reported that these two features were both present in 28% of their COVID-19 patients dataset *(Wang et al, 2013).*

Ground glass opacities are present in most of the patients with a predominantly bilateral distribution in the posterior, subpleural, and peripheral lung areas. ground glass opacities is defined as a hazy area of increased opacity within which pulmonary vessels remain visible. There can be several causes of ground glass opacities such as partial filling of air spaces, interstitial thickening, partial collapse of alveoli, increased capillary blood volume, or a combination of these *(Anuraget al, 2020).* This computed tomography feature is considered to be one of the earliest visible computed tomography manifestation as well as the most common imaging findings . As the time gap between the first symptoms and the chest computed tomography execution increases, so does the frequency of consolidation, and bilateral and peripheral lung disease. Other features like linear opacities and crazy-paving pattern can also appear. Ten African countries have recently shown a massive increase in the number of infected patients, making up for almost 80% of all cases in Africa. Over 70% of deaths have occurred in just five countries: Algeria, Egypt, Nigeria, South Africa and Sudan (Altayb et al, 2020). Sudan is the second largest country in Africa, with a total population of 43 849 260, located in the northeastern part of Africa, neighbored by countries with a high number of COVID-19 cases. The first case in Sudan was reported on 13 March 2020, and up to 3 July 2020 there are 9894 confirmed cases and 616 deaths. The case fatality rate was 6.23%. There is variation in case fatality rate, which in some cities (like Khartoum) was low (3.8%), but in others (like North Darfur) it was very high (31.7%) (Altayb et al, 2020). Corona virus belongs to a family of viruses that may cause various typical symptoms such as fever, cough, breathing difficulty and fatigue. However, a few patients with SARS-CoV-2 develop severe pneumonia, pulmonary edema, acute respiratory distress syndrome , multiple organ failure, or even death (Yan et al, 2020). Since the outbreak of COVID-19, there were continuous literature regarding early chest computed tomography imaging manifestations: most patients presented with multifocal ground-glass opacities involving multiple lung lobes and had a predominantly sub pleural distribution at admission (Shi et al., 2020; Huang et al., 2020; Yang et al., 2020). The extent of lesions had a tendency to be more extensive and the lesions had an increased density on follow-up computed tomography scans (Pan et al, 2020).

Therefore, we aim to quantitatively assess the characterization of COVID-19 patterns and severity using High Resolution Computed Tomography among Sudanese patients in the common type COVID-19 pneumonia cases and analyze the correlation between chest computed tomography manifestations and its severity.

1-2 Problem of study:

Millions of people diagnosed with COVID-19 are undergoing CT scans and all patients' images will be studied by a radiologist to determine Features that will appeared in the image. because COVID -19 is anew disease not all signs are familiar to the radiologist, so we must study these signs that appear on CT scan image and tell the radiologist what needs to know to determine whether the patients have COVID 19 or not and is the CT scan accurate in diagnosing the disease.

1-3Objectives:

1-3-1General objective:

To evaluate of COVID 19 sings by using computed tomography.

1-3-2 Specific objective:

To determine the demographic characteristics (gender and age) medical history and clinical symptoms in patients with COVID-19.

To identify the (HRCT) chest findings of COVID-19.

To Correlate between gender and age with medical history of the patient.

To Correlate between gender and age with clinical symptoms.

To Correlate between gender and age with CT Findings.

To Correlate between medical history and clinical symptoms with CT Findings.

1-4 Thesis outlines:

The study contains five chapters:

- **Chapter One**: A general introduction, which consists of an introduction, problem of the study, justification and objectives.
- **Chapter Two**: The literature review and previous studies.
- **Chapter Three**: Materials and methods.
- **Chapter Four**: Results.
- **Chapter Five:** Discussion, Conclusion and recommendations.

References – Appendix.

CHAPTER TWO

(Theoretical background literature review)

Theoretical background

2-1Anatomy

The lungs are the organs of respiration. They are composed of a sponge like material, the parenchyma are surrounded by the visceral pleura. The large conical shaped lungs extend up to or slightly above the level of the first rib at their apex, and down to the dome of the diaphragm at their wide concave-shaped bases or diaphragmatic surfaces. Each lung has a mediastinal or medial surface that is opposed to the mediastinum and a costal surface that is opposed to the inner surface of the rib cage. Each lung also has inferior, anterior, and posterior borders. The inferior border extends into the costo-diaphragmatic recess of the pleural cavity, and the anterior border of each lung extends into the costo-mediastinal recess of the pleural cavity. Two prominent angles can be identified at the medial and lateral edges of the lung bases. The medial angle is termed the cardiophrenic sulcus, and the lateral angle is termed the costophrenic sulcus. *(Borod,2008).*

The lungs are divided into lobes by fissures that are lined by pleura. The right lung has three lobes (superior [upper], middle, and inferior [lower]), whereas the left lung has just superior (upper) and inferior (lower) lobes. The inferior lobe of the right lung is separated from the middle and superior lobes by the oblique (major) fissure. Separating the middle lobe from the superior lobe is the horizontal (minor) fissure. An oblique fissure also separates the superior and inferior lobes of the left lung. The left lung has a large notch on the medial surface of its superior lobe called the cardiac notch and a tongue-like projection off its inferoanterior surface termed the lingula. Each lung has an opening on the medial surface termed the hilum. This opening acts as a passage for mainstem bronchi, blood vessels, lymph vessels, and nerves to enter or leave the lung and is commonly referred to as the root of the lungs *(Borod,2008)*

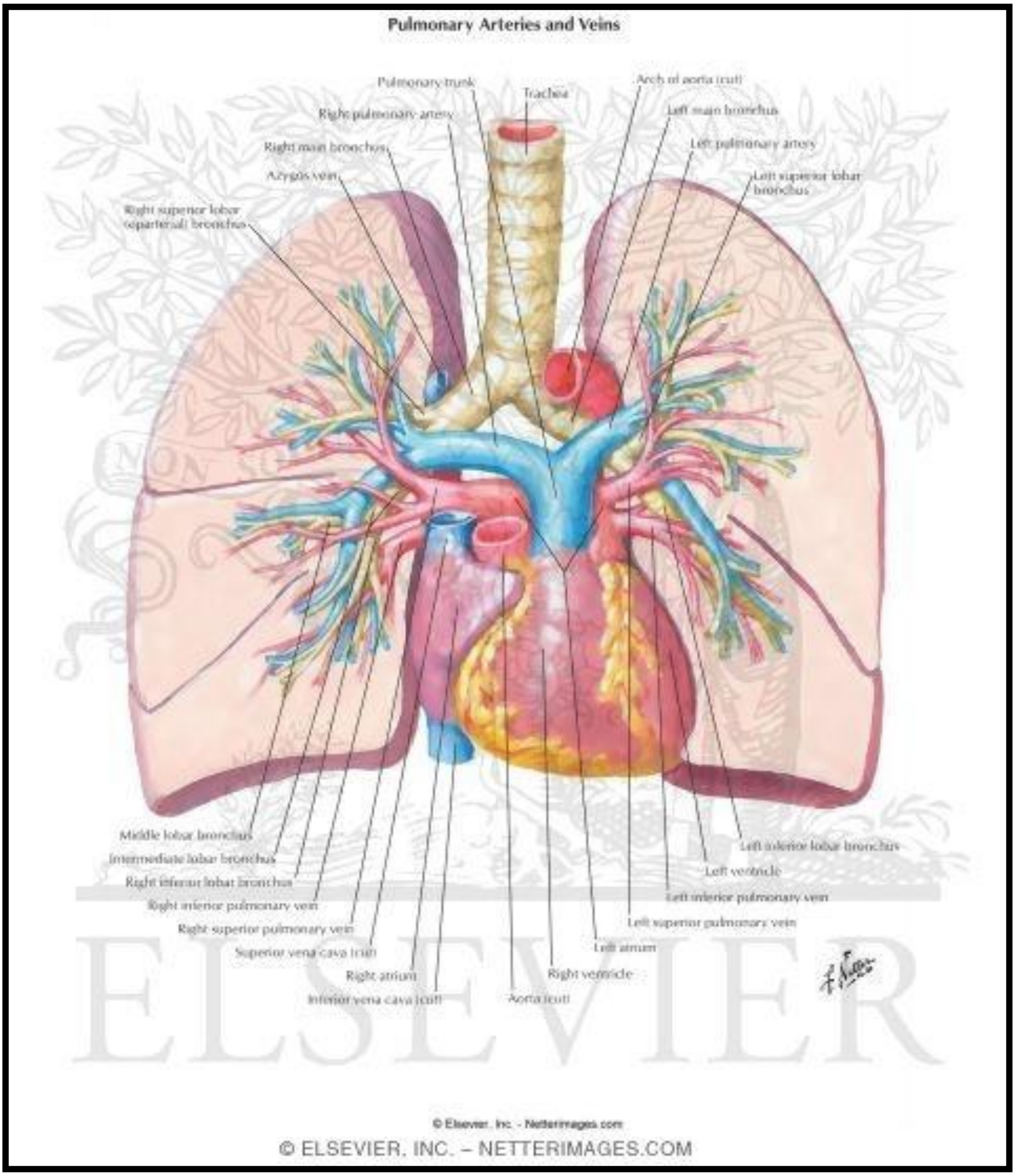

Figure 2-1:- show Pleura, Visceral Pleura, Left Lung, Parietal Pleural, Left Pleural Cavity, Mediastinum, Right Pleural Cavity, Right Lung(netter atlats 2021)

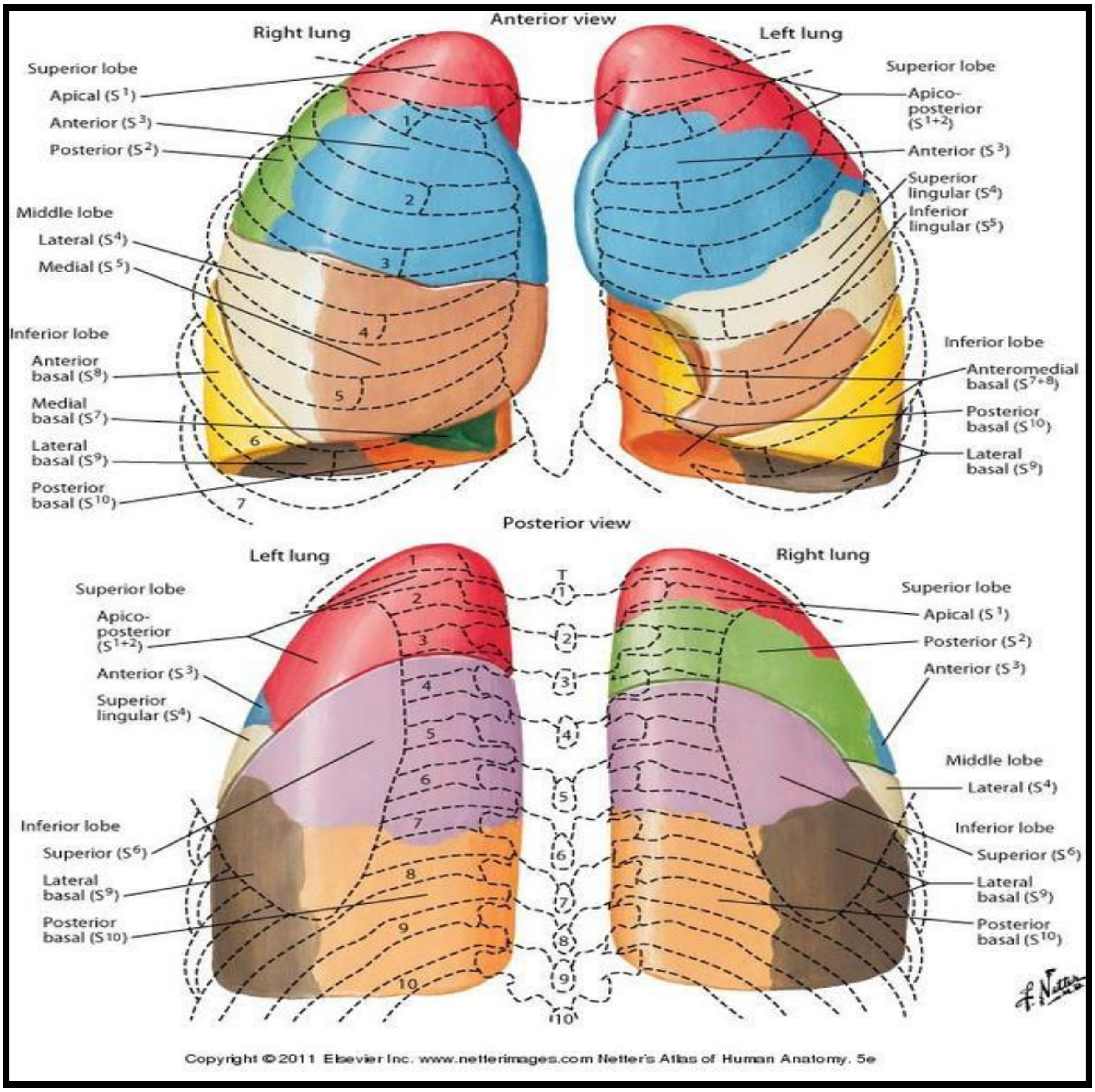

Figure 2-2: show anterior and posterior view of lungs parts(natters atlas2021)

2-1-1The apex of the lung

The round, tapered superior end or apex of the lung extends through the superior thoracic aperture in to the root of the neck. Here, it lies in close contact with the dome formed by cervical pleura, called the capsule of the pleura. *(Snell RS, 2011)*

2-1-2The base of the lung

This is the concave diaphragmatic surface of the lung, which is related to the dome of the diaphragm. The base of the right lung is deeper because the right dome rises to amore superior level. Its inferior border is thin and sharp where it enters the costodiaphragmtic recess. *(Snell RS, 2011)*

2-1-3 The root of the lung

The root serves as the attachment of the lung and is the highway for transmission of the structures entering and leaving the lung at the hilum.it connects the medial surface of the lung to the heart and trachea and is surrounded by the reflection of the parietal to the visceral pleura. *(Snell RS, 2011).*

2-1-4The haulm of the lung

This is where the root of attached to the lung. It contains the main bronchus. Pulmonary vessels. Lymph vessels, bronchial vessels, lymph vessels and nerves entering and leaving the lung. *(Snell RS, 2011).*

2-1-5 Lobes and fissures of the lung

The lung is divided into lobes by fissures. The right lung has horizontal and oblique fissure, where the left lung has only one the oblique fissure. The left lung is divided into upper and lower lobe by along deep oblique fissure. The right lung is divided in to upper, middle, and lower lobes by horizontal and oblique fissures, the horizontal fissure separates the upper and middle lobes and oblique fissure separates the lower from middle and upper lobes. The upper lobe is smaller than in the left lung, and the middle is wedge shaped. *(Snell RS, 2011)*

2-1-6Surfaces of the lung

Each lung has three surfaces [costal, mediastinal, and diaphragmatic], which are named according to their **relationships:**

2-1-6-1 The costal surface of the lung

This surface is large, smooth, and convex. It is related to the costal pleura, which separates it from the ribs, costal cartilages, and the innermost intercostals muscles. The posterior part of this surface is related to the thoracic vertebrae because of this area of the lung is sometimes referred to as the vertebral of the costal surface. *(Snell RS, 2011).*

2-1-6-2 The mediastinal surface of the lung

This medial surface is concave because it related to the middle mediastinum containing the pericardium and heart *(Snell RS, 2011).*

2-1-6-3 The diaphragmatic surface of the lung

This deeply concave surface often referred to as the base of the lung, rests on the convex dome of the diaphragm. The concavity is deeper in the right lung because of the higher position of the right dome. Laterally and posterior the diaphragm position surface is bounded by thin sharp margin that projects into the cost diaphragmatic recess of pleura. *(Snell RS, 2011).*

2-1-7 Borders of the lung

Each lung has three borders: anterior, posterior and inferior:

2-1-7-1 The anterior border of the lung

This border is thin and sharp and overlaps the pericardium. There is an indentation in the anterior border of the left lung, called the cardiac notch. In each lung the anterior border separates the costal surface from the mediastinum surface. *(Snell RS, 2011).*

2-1-7-2The posterior border of the lung

This border is board and rounded and lies in the deep concavity at the side of the thoracic region of the vertebral Colum, called Para vertebral gutter. *(Snell RS, 2011).*

2-1-7-3The inferior border of the lung

This border circumscribes the diaphragmatic surface of the lung and separates the diaphragmatic surface from the costal surface. *(Snell RS, 2011).*

2-1-8 Vessels of the lung

2-1-8-1The arterial and Venus blood supply

The supply to the walls of the bronchi and smaller air passages is through branches of the right and left bronchial arteries and the venous return is mainly through the bronchial veins. On the right side they empty into the azygos vein and on the left into the superior intercostal vein. *(Ross and Wilson, 2014)*

2-1-8-2The nerve supply

This is by parasympathetic and sympathetic nerves. The vagus nerves (parasympathetic) stimulate contraction of smooth muscle in the bronchial tree, causing bronchoconstriction, and sympathetic stimulation causes bronchodilatation. *(Ross and Wilson, 2014).*

2-1-8-3The lymphatic vessels and lymph nodes

Lymph is drained from the walls of the air passages in a network of lymph vessels. It passes through lymph nodes situated around the trachea and bronchial tree then into the thoracic duct on the left side and right lymphatic duct on the other. *(Ross and Wilson, 2014).*

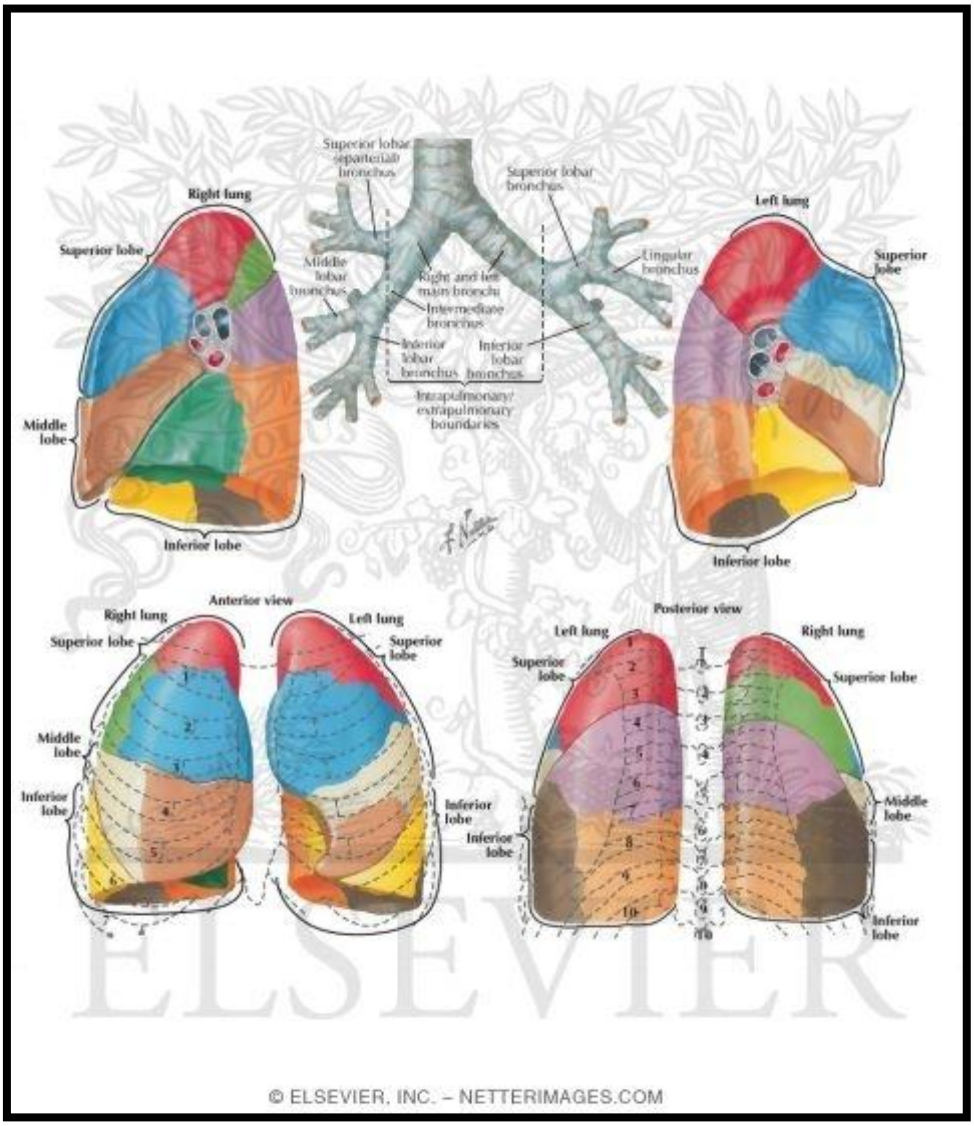

Figure 2-3:show lungs bronchi, border and anterior and posterior view (netter atlas)

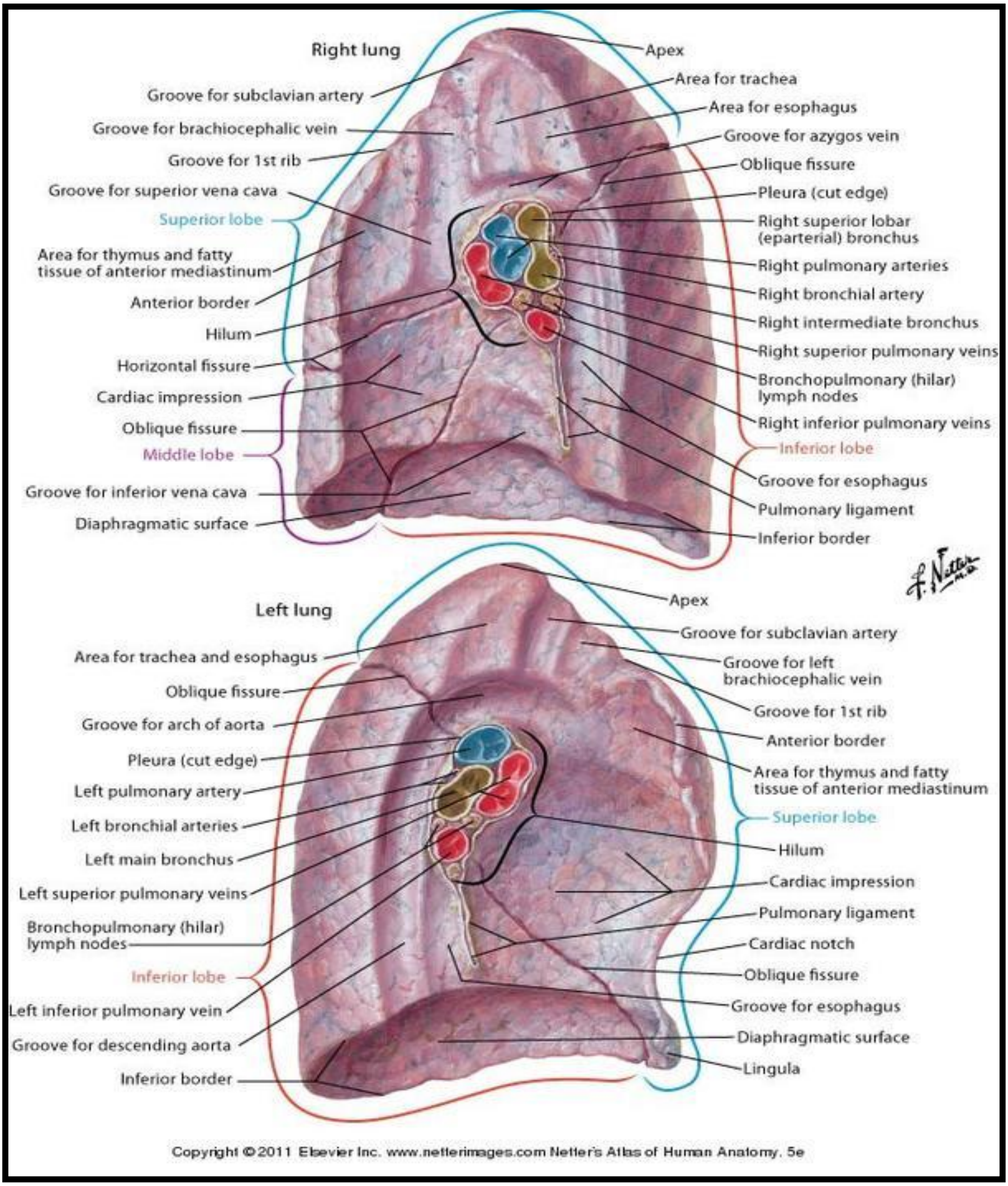

Figure2-4:show left and right lungs(netters atlas)

2-2Physiology

2-2-1 Functions of Respiratory System:

Through breathing and exhalation, the respiratory system facilitates the exchange of gases between the air and the blood and the blood and the body cells. The respiratory system also helps us to smell and create sound. *(Tortora, G.J.2018).*

The respiratory system also has the function of: regulation of blood pH, which occur in coordination with the kidneys, defence against microbes and control of temperature due to loss of evaporate. *(Tortora, G.J.2018)*..

2-2-2Muscles of Respiration

Respiratory muscles are of two types:

-Inspiratory muscle: include primary inspiratory muscles which are diaphragm, and accessory inspiratory muscles.

-Expiratory muscles: include primary expiratory muscles which are the internal intercostal muscles, and accessory expiratory muscle which are the abdominal muscle. *(K Sembulingam,) 2012*

2-2-3Work of Breathing

Work of breathing is the work done by respiratory muscles during breathing to overcome the resistance in thorax and respiratory tract. During respiratory processes, inspiration is an active process and the expiration is a passive process. So, during quiet breathing, respiratory muscles perform the work only during inspiration and not during expiration. During the work of breathing, the energy is utilized to overcome three types of resistance; airway resistance, elastic resistance of lung and thorax and non-elastic viscous resistance. *(K Sembulingam, 2012).*

2-3Lung pathologies

2-3-1Coronavirus

Coronaviruses are enveloped single-stranded RNA viruses that are zoonotic in nature and cause symptoms ranging from those similar to the common cold to more severe respiratory, enteric, hepatic, and neurological symptoms. Other than SARS-CoV-2, there are six known coronaviruses in humans: HCoV-229E, HCoV-OC43, SARS-CoV, HCoV-NL63, HCoV-HKU1, and MERS-CoV. Coronavirus has caused two large-scale pandemics in the last two decades: SARS and MERS *(Adhikari et al, 2020).*

2-3-2Morphology

Coronaviruses are enveloped, icosahedral, symmetrical particles with spike-like projections on their membranes that give them the shape of crown ("Corona" in Latin) and hence the name. They are varying between 80–220 nm in diameter. They have large single-stranded, positive- sense, nonsegmented RNA genome, of about 26–32 kb size. Till date, the detailed ultrastructure of this virus remains incompletely understood. From India, the first report on the ultrastructure of the virus was based on negative staining on a throat swab sample after fixation in glutaraldehyde, demonstrating that the virus is round with an average size of 70–80 nm and a cobbled surface structure having envelope projections *(Bal et al, 2020).*

2-3-3Epidemiology

The first case of human transmission of COVID-19 was identified in the city of Wuhan, Hubei province in China. Epidemiologists suggest that the initial outbreak was associated with a seafood market, where other wild animals were also sold for human consumption. Subsequent viral genomic and structural studies from samples of infected individuals confirmed that the infective virus is a new seventh member of CoVs. Bats were considered a source of infection with high diversity of CoVs. Pangolins act as the intermediate hosts. The cause for a transspecies transmission is still not clearly known. Epidemiologists confirmed that there was a person-to-person transmission through close contact, by droplets and aerosols in the initial outbreak *(Bal et al, 2020).*

The timing of the second and third phases of the spread outside Wuhan city to other parts of China and other countries (more than 200) coincided with the mass movement during the celebrations of the Chinese New Year. With an explosive increase in the number of cases, the WHO declared this outbreak a public health emergency of international concern on January 30, 2020, and as a pandemic on March 11, 2020. According to the WHO, the global confirmed cases, as on July 18, 2020, are 13,824,739 with a mortality of 591,666. The top most affected regions in the descending order are America, Europe, Eastern Mediterranean, and Western Pacific. *(Bal et al, 2020).*

According to the WHO update, as on July 18, 2020, there were 1,038,716 total cases all over India with mortality of 26,273. The worst-hit states include Maharashtra, Tamil Nadu, Delhi, Gujarat, Uttar Pradesh, Rajasthan, and West Bengal. However, the mortality rate in India is one of the lowest (around 2.53%) as compared to the overall global mortality rate of around 4.28%. The effective reproduction number (R) is a measure of the expected number of cases that is generated from one case. For COVID-19, it is between 2.8 and 3.3, indicating that it has higher rate of transmissibility and pandemic risk than that of SARS-CoV (R of 1.77) *(Bal et al, 2020)*. The COVID-19 pandemic has resulted in over 450,000 deaths globally, and approximately 1% of these deaths have been reported in Africa. Despite the high prevalence of COVID-19 risk factors, namely: hypertension, diabetes, chronic pulmonary disease, cardiovascular diseases (CVDs) such as rheumatic heart disease, compromised immunity and obesity, low case fatality rates have been recorded in many parts of Africa so far. COVID-19 severity has been shown to be worse in patients with CVD and hypertension *(Chakafana et al, 2020)*.

Sudan -like most countries in the world -breathes under the impact of the Corona pandemic, which entered the country and the first case of the disease was discovered in Sudan on 13.3.2020 after the death of the patient and the injury was number two for a foreigner on 20.3.2020 *(Bezerra and Santos,2020)*.

To our knowledge, there have been no previous studies it was conducted to predict the prevalence of COVID-19 in Sudan as the number of daily cumulative cases continues. To grow significantly, it increased to more than 4 thousand cases in total and from that the precautionary measures began to close the airport followed by the appearance of a few numerical cases, and after the exception of opening the airport and borders for the stuck Sudanese to enter Sudan and receiving news of their failure to submit to the quarantine period necessary to examine the disease and prevent its spread, the disease began to spread more broadly, which driven the authorities to increase precautionary measures and prevent travel between states and prohibit partial roaming in all states. After the cases increased dramatically in the state of Khartoum, the authorities adopted a policy of complete prohibition and closure to prevent further outbreaks *(Bezerra and Santos,2020)*.

2-3-4Transmission

SARS-CoV-2 mutates rapidly, undergoes frequent recombinations, and easily crosses the species barrier, causing frequent novel cross-species infections. It is transmitted between humans through both direct (droplet and human-to-human transmission) and indirect (contaminated objects and airborne contagion) contacts from both symptomatic and asymptomatic patients (Bal et al, 2020). Many domestic and wild animals, including camels, cattle, cats, and bats, may serve as hosts for coronaviruses. It is considered that, generally, animal coronaviruses do not spread among humans. *(Adhikari et al, 2020)*.

However, there are exceptions, such as SARS and MERS (Middle East Respiratory Syndrome), which are mainly spread though close contact with infected people via respiratory droplets from cough or sneezing. With regard to COVID-19, early patients were reported to have some link to the Huanan Seafood Market in Wuhan, China, suggesting that these early infections were due to animal-to-person transmission. However, later cases were reported among medical staff and others with no history of exposure to that market or visiting Wuhan, which was taken as an indication of human-to-human transmission *(Adhikari et al, 2020).*

2-3-5Pathogenesis

The COVID-19 infection has brought to the forefront the intricate interplay and balance between the inflammatory, immunological, and hemostatic responses. Furthermore, the basis for the discrepant symptomology and their severity may lie within the genetic and acquired differences in host immune system. Pathological features such as infiltration in the infected tissue by macrophages, and the presence of lymphopenia and neutrophilia on hematological examination, serve as an indirect evidence of a strong immunological component to this infection. Hence, our understanding of the pathogenesis can form the basis of guiding treatment strategies and design vaccines (Bal *et al*, 2020)

Coronavirus infection is typically limited to the mucosal cells of the respiratory tract. Pneumonia caused by SARS coronavirus is characterized by diffuse edema resulting in hypoxia. The binding of the virus to angiotensin-converting enzyme-2(ACE-2) on the surface of respiratory tract epithelium may contribute to the dysregulation of fluid balance that causes the edema in the alveolar space *(levison, 2014).*

The report shows that the ARDS is the main cause of death by COVID-19.One of the main mechanisms for ARDS is the cytokine storm which is a deadly uncontrolled systemic inflammatory response resulting from the release of large amounts of pro-inflammatory cytokines (IFN-α, IFN-γ, IL-1β, IL-6, IL-12, IL-18, IL-33, TNF-α, TGFβ, etc.) and chemokines (CCL2, CCL3, CCL5, CXCL8, CXCL9, CXCL10, etc.) by immune effector cells. This cytokine storm will trigger a violent attack by the immune system to the body, cause ARDS and multiple organ failure, and finally lead to death in severe cases *(Li et al, 2020).*

2-3-6Incubation period

There were 181 confirmed cases with identifiable exposure and symptom onset windows to estimate the incubation period of COVID-19. The median incubation period was estimated to be 5 days, and 97.5% of those who develop symptoms will do so within 11.5 days of infection. These estimates imply that, under conservative assumptions, 101 out of every10, 000 cases will develop symptoms after 14 days of active monitoring or quarantine *(Lauer et al, 2020).*

2-3-7Signs and symptoms

The main clinical symptoms of COVID-19 patients were fever, cough, myalgia or fatigue, expectoration, dyspnea and headache or dizziness *(Li et al, 2020).*

Some patients (50.5%) reported a digestive symptom, including lack of appetite, diarrhea, vomiting, and abdominal pain *(Pan et al, 2020).*

According to the "novel coronavirus infected pneumonia treatment scheme-Sixth edition" issued by the National Health Commission of the People"s Republic of China, the condition of the patients at the time of admission was**16** classified as the regular group (fever, respiratory symptoms, and radiographic evidence of pneumonia), the severe group [satisfy any of the following: (1) shortness of breath, a respiratory rate of more than 30 breaths per minute; (2) at a quiet rest, peripheral blood oxygen saturation is less than 93%; (3) PaO2/FiO2 of 300 mmHg or less; (4) pulmonary imaging indicated that the lesion progression was greater than 50% within 24–48 h] and the critically ill group [satisfy any of the following: (1) respiratory failure occurs and mechanical ventilation support is required; (2) shock; (3) complicated with vital organ failure requires ICU treatment] (Yuan *et al*, 2020).

A large percentage of infected patients are asymptomatic or develop mild to moderate flu-like symptoms, approximately 15% of patients progress to severe pneumonia associated with high fatality rates (Schiaffino *et al*, 2020).

Since being first reported in Wuhan, China, in December 8, 2019, the outbreak of the novel coronavirus, now known as COVID-19, has spread globally. The incidence of fever, cough, fatigue, and dyspnea symptoms were 85.6 %, 65.7 %, 42.4 % and 21.4 % respectively. The prevalence of diabetes was 7.7 %, hypertension was 15.6 %, cardiovascular disease was 4.7 %, and malignancy was 1.2 %. The complications, including ARDS risk, ranged from 5.6–13.2 %, with the pooled estimate of ARDS risk at 9.4 %, ACI at 5.8 %, AKI at 2.1 %, and shock at 4.7%. The risks of severity and mortality ranged from 12.6 to 23.5% and from 2.0 to 4.4 %, with pooled estimates at 18.0 and 3.2 %, respectively. The percentage of critical cases in diabetes and hypertension was 44.5 % and 41.7 %, respectively. Fever is the most common symptom in patients with COVID-19. (Hu *et al*, 2020).

The most prevalent comorbidities are hypertension and diabetes which are associated with the severity of COVID-19. ARDS and ACI may be the main obstacles for patients to treatment recovery. The case severe rate and mortality is lower than that of SARS and MERS (Hu *et al,* 2020).

2-3-8Risk groups

About one in five individuals worldwide could be at increased risk of severe COVID-19, should they become infected, due to underlying health conditions, but this risk varies considerably by age. Elderly and those with underlying clinical conditions shown a consistently higher risk of severe COVID-19 in China, Europe, and the USA. In USA the report show that underlying conditions were reported in 71% of individuals admitted to hospital with COVID-19 and in 94% of deaths. (Clark *et al,* 2020).

WHO, along with public health agencies in countries such as the UK and the USA, have issued guidelines on who is considered to be at increased risk of severe COVID-19 this includes individuals with diabetes, cardiovascular disease, chronic kidney disease, chronic respiratory disease, and a range of other chronic conditions. Such conditions increase the risk of needing hospital-based treatment such as oxygen supplementation. A large proportion of the additional health-care burden of COVID-19 epidemics is likely to result from infection of those with underlying conditions (Clark *et al*, 2020).

It is to be noted that the affinity of the S protein to ACE-2 is said to be exceedingly higher (at least 10–20 times) as compared to that of a similar protein on SARS-CoV-1, and the ACE-2 expression depends on the genetic factors, age, and sex. This explains a very low case fatality rate (CFR) in pediatric patients compared to patients beyond 80 years of age (CFR of 0% for individuals under 8 years of age vs. 21.9% for patients above 80 years). Unfortunately, the ACE- 2 expression also increases in the presence of comorbid conditions such as obesity, preexisting chronic cardiopulmonary disease, cancer, and use of immunosuppressive drugs, and such patients are prone to develop severe disease (Bal *et al*, 2020).

2-3-9Sample collection and diagnosis

Similar to other infectious diseases, appropriate specimen collection is the key step in the laboratory diagnosis of COVID-19. Currently, SARS-CoV-2 has**18** been detected in upper respiratory tract specimens, lower respiratory tract specimens, nasopharyngeal swabs, oropharyngeal swabs, throat swabs, sputum, bronchoalveolar lavage fluid (BALF), whole blood, serum, stool, urine, saliva, rectal swabs and conjunctival swabs, and the respiratory secretions are the most frequently samples for diagnosis (Li *et al*, 2020).

The real time reverse transcription–polymerase chain reaction (Real time RT-PCR) is one of the best and accurate laboratory methods for detecting, tracking, and studying the coronavirus. It is a method by which we can detect the presence of specific target genetic material. The real-time RT-PCR minimized the chance of false positive results because the amplification and analysis carried out in a closed system (Sethuraman *et al*, 2020).

Coronaviruses have a number of molecular targets within their positive-sense, single-stranded RNA genome that can be used for PCR assays. These include genes encoding structural proteins; such as helicase (Hel), nucleocapsid (N), transmembrane (M), envelope (E) and envelope glycoproteins spike (S).There are also species-specific accessory genes that are required for viral replication, these include hemagglutinin esterase (HE), open reading frames ORF1a and ORF1b and RNA-dependent RNA polymerase (RdRp) (Tang *et al*, 2020).

During infection, several types of antibodies are raised to the virus. IgM antibodies emerge first, after 5 days post-symptom onset. IgG antibodies are more tailored, and typically emerge after 10 days post-symptom onset. Many serology tests detect both IgG and IgM, which increases the specificity of the test. IgA antibodies may also increase during infection, and are typically found in mucous (Johns Hopkins, 2020).

The presence of antibodies only indicates previous SARS-CoV-2 infection. The results of serology tests can then be used to estimate the true spread of the virus through a population, even if individuals were asymptomatic or were never diagnosed (Johns Hopkins, 2020).

In real time –PCR assay the viral RNA is measured by the cycle threshold (Ct), which is defined as the number of cycles required for the fluorescent signal to cross the threshold and becomes detectable. The interpretation of result in real time-PCR is based on Ct values for specimen; a value less than 40 is clinically reported as PCR positive. RT-PCR is highly specific but false negative result may also occur due to sampling error or inappropriate timing of sampling (Sethuraman *et al*, 2020).

2-3- 10 Prognosis

The elderly and patients with underlying diseases are more likely to experience a severe progression of COVID- 19. It is recommended that timely antiviral treatment should be initiated to slow the disease progression and improve the prognosis (Wu *et al*, 2020).

Rapid blood tests, including platelet count, prothrombin time, D-dimer, and neutrophil to lymphocyte ratio can help clinicians to assess severity and prognosis of patients with

COVID-19. The sepsis-induced coagulopathy scoring system can be used for early assessment and management of patients with critical disease (Liao *et al*, 2020).

2-3-11Prevention

For the general population, at this moment there is no vaccine preventing COVID-19. The best prevention is to avoid being exposed to the virus. Airborne precautions and other protective measures have been discussed and proposed for prevention. Infection preventive and control (IPC) measures that may reduce the risk of exposure include the following: use of face masks; covering coughs and sneezes with tissues that are then safely disposed of (or, if no tissues are available, use a flexed elbow to cover the cough or sneeze); regular hand washing with soap or disinfection with hand sanitizer containing at least 60% alcohol (if soap and water are not available); avoidance of contact with infected people and maintaining an appropriate distance as much as possible; and refraining from touching eyes, nose, and mouth with unwashed hands(Adhikari *et al*,2020)

2-3-12Lung Pathologies associated with SARS CoV

Pneumonia

Acute pneumonia is an inflammation of the lung that can be caused by a variety of organisms, most commonly bacteria and viruses. Regardless of the cause, pneumonias tend to produce one of three basic radiographic patterns. *(Eisenberg, R.L. 2015).*

2-3-13Alveolar Pneumonia

Alveolar, or air-space, pneumonia, exemplified by pneumococcal pneumonia, is produced by an organism that causes an inflammatory exudate that replaces air in the alveoli so that the affected part of the lung is no longer air containing but rather appears solid, or radiopaque. The inflammation spreads from one alveolus to the next by way of communicating channels, and it may involve pulmonary segments or an entire lobe (lobar pneumonia). *(Eisenberg, R.L. 2015).*

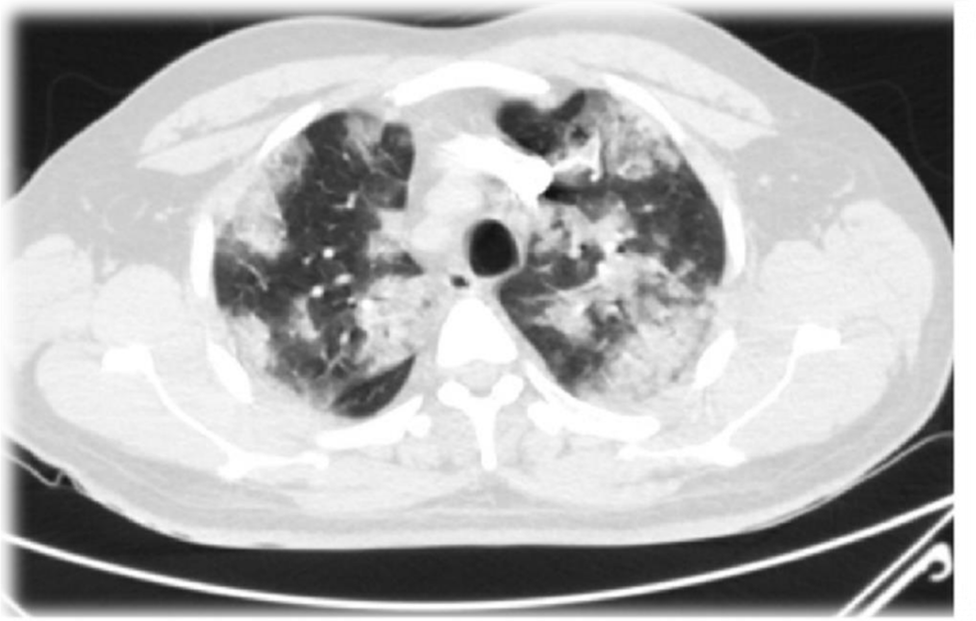

Figure 2-5:Axial ct show diffuse alveolar damage: thin section CT shows patchy areas of GGO and consolidation in the lung periphery in upper lobes(2008-2022 ResearchGate GmbH)

2-3-14Bronchopneumonia

Bronchopneumonia, typified by staphylococcal infection, is primarily an inflammation that originates in the bronchi or the bronchiolar mucosa and spreads to adjacent alveoli. Because alveolar spread of the infection in the peripheral air spaces is minimal, the inflammation tends to produce small patches of consolidation. Bronchial inflammation causing airway obstruction leads to atelectasis with loss of lung volume. *(Eisenberg, R.L. 2015).*

Figure 2-6: Axial ct bronchopneumonia in the middle lobe and in both lower lobes (radiologykey.com)

2-3-15Interstitial Pneumonia

Interstitial pneumonia is most commonly produced by viral and mycoplasma infections. In this type of pneumonia, the inflammatory process predominantly involves the walls and lining of the alveoli and the interstitial supporting structures of the lung, the alveoli septa. *(Eisenberg, R.L. 2015).*

Figure 2-7: axial ct show Interstitial Pneumonia diffuse, bilateral ground glass opacity (radiologykey.com)

2-3-16Consolidation

Consolidation of the lung is simply a "solidification" of the lung tissue due to accumulation of solid and liquid material in the air space that would have normally been filled by gas. It is also known as pulmonary consolidation. *(Kowalczyk, N., 2017)*

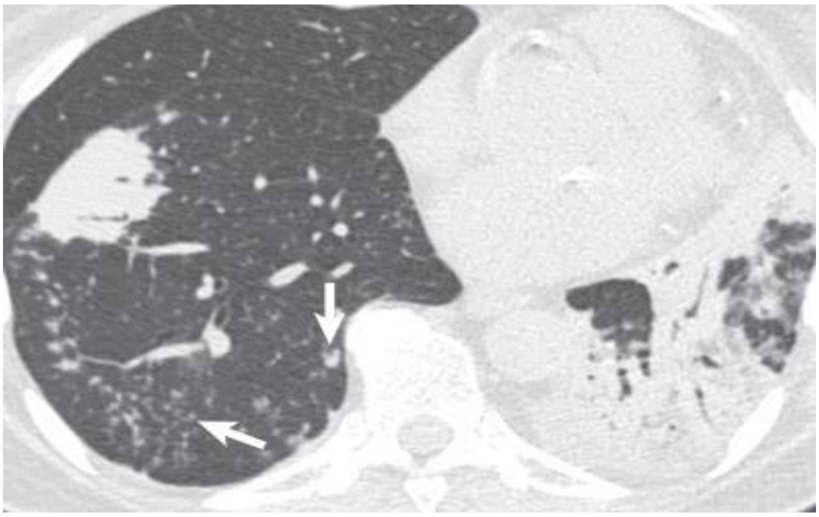

Figure 2-8:axial image from noncontract chest ct shows left greater than right multifocal lung consolidation with air bronchograms. Mild centrilobular and tree in bud nodularity (arrows)in the right lower lobe is consistent with aeogenous spread of cancer (radiology key.com)

2-3-17Pleural Effusion (PE)

A pleural effusion is an abnormal amount of fluid around the lung. In pleural effusion, fluid accumulates in the space between the layers of pleura. The fluid in pleural effusion also may result from inflammation. *(Kowalczyk, N., 2017).*

Figure 2-9:-displaced-crus sign in pleural effusion. Ct scan reveals anterior and lateral displacement of right hemidiaphragmatic crus by pleural fluid (black arrow) in a patient with bilateral effusions and ascites.

2-4Investigations done

2-4-1lab test

COVID-19 testing plays a critical role in the fight against the virus. Understanding COVID-19 tests, including the different types of tests and their uses, and the types of samples the tests use, is key to making an informed decision that meets your needs.

Types of Tests

There are different types of COVID-19 tests – **diagnostic tests** and **antibody tests**.

Diagnostic tests can show if you currently are infected with SARS-CoV-2, the virus that causes COVID-19. There are two types of COVID-19 diagnostic tests:

- Molecular tests, such as polymerase chain reaction (PCR) tests
- Antigen tests, often referred to as rapid tests

Samples for COVID-19 diagnostic tests are typically collected using an anterior nares (nasal) swab sample. Some diagnostic tests use mid-turbinate, nasopharyngeal, oropharyngeal, or saliva samples. COVID-19 diagnostic tests can be performed at a laboratory, a standalone testing site, a doctor’s office or health clinic, or at home. For some COVID-19 diagnostic tests, you go to a testing site to have your sample collected and for others you can collect your own sample at home using a home collection kit and mail it to a laboratory for testing. Other tests can be performed completely at home, giving you results within minutes, without needing to send your sample to a laboratory.

If you think you need a COVID-19 diagnostic test, you can find a community testing site in your state. You can also use an FDA-authorized at-home COVID-19 diagnostic test which gives you the option of self-testing where it is convenient for you. Be aware that COVID-19 diagnostic tests are authorized for specific uses. For example, some tests can be used by people with and without symptoms and other tests are only for people with symptoms. Also, laboratory-based tests, such as PCR tests, are generally more accurate than at-home tests.

For details about each authorized COVID-19 diagnostic test, see the lists of authorized Molecular Diagnostic Tests and Antigen Diagnostic Tests, as well as the At-Home COVID-19 Diagnostic Tests webpage. Using the search box in the EUA tables, you can use keywords to search and filter the type of test or collection kit you are looking for. As new tests are authorized for use, they are added to these tables so that anyone can access up-to-date information on all authorized tests and collection kits.

Antibody (or serology) tests look for antibodies in your blood that your immune system produced in response to SARS-CoV-2, the virus that causes COVID-19. **Antibody tests should not be used to diagnose a current SARS-CoV-2 infection or COVID-19** and, at this time, should also not be used to check for immunity. More research is needed to determine what, if anything, antibody tests can tell us about a person's immunity.

Samples for antibody tests are typically collected by a doctor or other medical professional by taking blood from a finger stick or your vein. For more information about antibody testing, visit Antibody (Serology) Testing for COVID-19: Information for Patients and Consumers.

Types of Samples

Different tests are authorized to be used with different types of samples. The most common sample types.

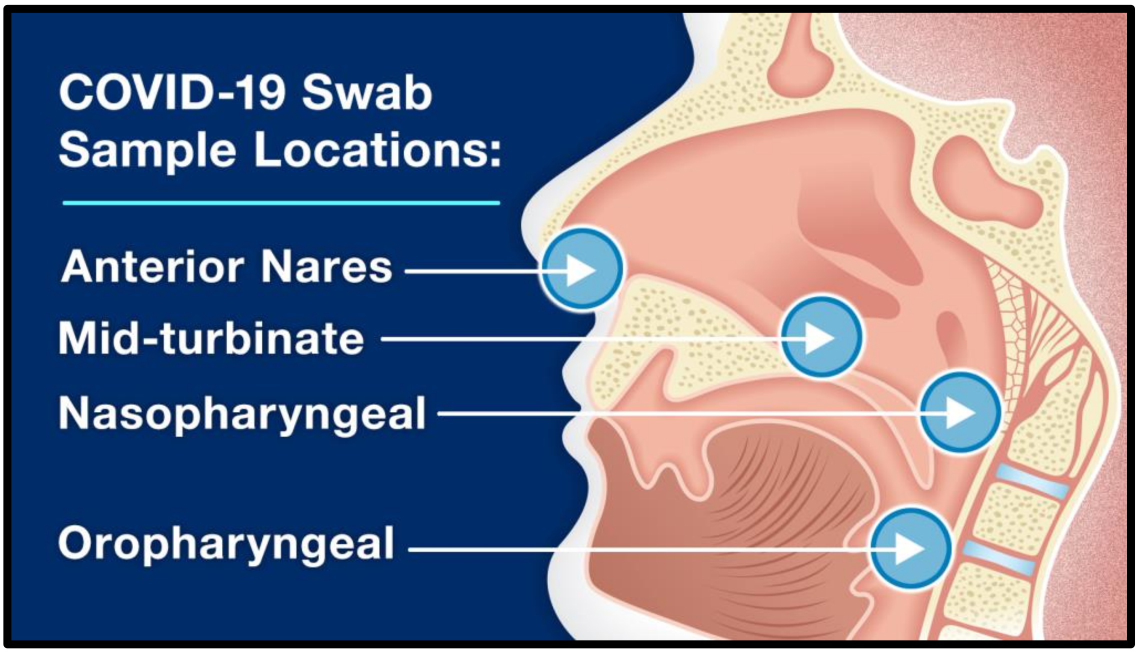

Figure (2-10) Swab samples use a swab (similar to a long Q-Tip) to collect a sample from the nose or throat.

The types of samples include:

Anterior Nares (Nasal) – takes a sample from just inside the nostrils

Mid-turbinate – takes a sample from further up inside the nose

Nasopharyngeal – takes a sample from deep inside the nose, reaching the back of the throat, and should only be collected by a trained health care provider

Oropharyngeal – takes a sample from the middle part of the throat (pharynx) just beyond the mouth, and should only be collected by a trained health care provider

Saliva samples are collected by spitting into a tube rather than using a nose or throat swab.

Blood samples are only used to test for antibodies and not to diagnose COVID-19. Venous blood samples are typically collected at a doctor's office or clinic. Some antibody tests use blood samples from a finger stick.

2-4-2Computed Tomography (CT)

CT is a medical imaging method employing tomography and digital geometry processing it use constant three dimensional image of the inside of an object from a large series of two dimensional x-ray images taken around a single axis of rotation (serum(*(Lois E. Romans, 2010*).

The primary purpose of CT is to produce a two- dimensional representation of the linear x-ray attenuation coefficient distribution through a narrow planner cross section of the human body, the resultant image delineates various structures within the body, showing the relative anatomic relationship *(Lois E. Romans, 2010*).

The physical principle of the CT includes the three processes referred to as Data acquisition, Data processing, and Image display. Data acquisition Refer to systemic collection of information from the patient to produce the CT image. The two method of data acquisition is slice-by-slice data acquisition and volume data acquisition *(Lois E. Romans,2010).*

In conventional slice-by-slice data acquisition, data are collected through different beam geometries to scan the patient. Essentially, the x-ray tube rotates round the patient and collects data from the first slice. The tube stops and the patient moves into position to scan next slice. The process continues until all slices have been individually scanned *(Lois E.Romans,2010)*

In volume data acquisition, special beam geometry referred to as spiral or helical geometry is used to scan a volume of tissue rather than one slice at a time. In spiral or helical CT, the x-ray tube rotates around the patient and traces a spiral\helical path scan an entire volume tissue while the patient holds a single slice per one revolution of x-ray tube. More recently, multi-slice spiral \helical CT has become available for faster imaging patients. It generates multiple slices per one revolution of the x ray tube *(Lois E. Romans,2010).*

Essentially constitutes the mathematical principles involved in ct. data processing in a three-step process. First, the raw data undergo some form of pre-processing, in which correction are made and some reformatting of data occurs *(Lois E. Romans, 2010*).

This is necessary to facilitate the next step in data processing, image reconstruction. In this step, the scan data, which represent attenuation readings converted into a digital image characterized by CT numbers. The final step is image storage of the reconstructed digital image. This image is held in a disk memory is a short-term storage *(Lois E. Romans, 2010)*.

Image display it is final process. After the CT image has been reconstructed, it exits the computer in digital form. The must be converted to a form that is suitable for viewing and meaningful to the observer. In CT the digital reconstructed image is converted into a gray scale image for interpretation by the radiologist. Because a diagnosis is made from is image, it is important to present this image in a way that facilitates diagnosis *(Lois E. Romans,2010).*

The grayscale image is display on a cathode ray tube (CRT), or television monitor, which is an essential component of the control or viewing console. In some scanner there are two monitors, one for text information and one for images *(Lois E. Romans,2010).*

The instrumentation : a modern CT facility consist of a scanning gantry that include the collimated x-ray source, the detectors, the computer for data acquisition ,the image reconstruction system, motorized patient – handling table and the CT viewing console *(Lois E. Romans, 2010).*

The major technical difference between various commercial scanner lies in the gantry design and the number and type of x-ray detectors used *(Lois E. Romans,2010).*

2-4-2-1Computed Tomography of Lungs

For this scan, the table moves continuously through the tunnel-like hole as the x-ray tube rotates around the individual. This allows the x-ray beam to follow a spiral path. The machines computer can process the many slices into a very detailed, three dimension (3D) pictures of the lungs and other structures in the chest *(Abdulraheem, 2020).*

2-4-2-2 High Resolution Computed Tomography of Lung (HRCT)

HRCT of the lungs is an established imaging technique for the diagnosis and management of interstitial lung disease, emphysema, and small airway disease. In addition to having a high degree of specificity for diagnosing conditions *(Sundaran, et al,2010).*

The anatomic detail provided by HRCT imaging sections allows more detailed analysis of pathologic processes affecting the small airways, airspaces or alveolar walls, and interstitial. HRCT has become established as a useful technique for the detection and characterization of diffuse lung disease (DLD). Standard HRCT scanning with single slice CT allows assessment of the lung at the scanned levels only and cannot exclude abnormalities in the lungs between these sections HRCT may also play an important role in detecting early morphologic changes in patients with suspected pulmonary disorders such as interstitial lung disease (ILD), emphysema, asbestosis, and bronchiectasis. *(Keith, et al. 2009).*

2-4-2-3Clinical indication for HRCT

When describing the indications for HRCT, it is important to note the plain chest radiograph is an indispensable part of the diagnostic evaluation of patients with suspected lung disease. However, because of the described limitations of plain film, the use of HRCT is indicated in the following instances; detection of lung disease, characterization and specification of diffuse infiltrative lung disease, evaluation of disease activity, evaluation before biopsy and assessment of focal lung disease. *(Keith, et al. 2009)*

2-5 Literature Review (Previous Studies):

Ai, T. et al. (2020) have studied the correlation of chest CT and RT-PCR Testing for Coronavirus Disease 2019 (COVID-19) in Wuhan, China, for who underwent both chest CT and RT-PCR tests between January 6 and February 6, 2020. With using of RT-PCR as the reference standard, the performance of chest CT in the diagnosis of COVID19 was assessed. In addition, for patients with multiple RT-PCR assays. Their results were analyzed as compared with serial chest CT scans for those with a time interval between RT-PCR tests of 4 days or more. They improved that chest CT has a high sensitivity for diagnosis of coronavirus disease (COVID-19) and chest CT may be considered as a primary tool for the current COVID-19 detection in epidemic areas.

Zhao, Wei et al. (2020) aimed to investigate the relation between chest CT findings and clinical conditions of coronavirus disease (COVID-19) pneumonia as a multicenter study, were the data on 101 cases of COVID 19 collected retrospectively from four institutions in Hunan, China. Where Patients with confirmed COVID-19 pneumonia have typical imaging features that can be helpful in early screening of highly suspected cases and in evaluation of the severity and extent of disease. Most patients with COVID-19 pneumonia have GGO or mixed GGO and consolidation and vascular enlargement in the lesion. Lesions are more likely to have peripheral distribution and bilateral involvement and be lower lung predominant and multifocal. CT involvement score can help in evaluation of the severity and extent of the disease.

Sarfraz Saleemi, et al. (2020) have studied the radiology features of chest imaging and its correlation to clinical severity in patients with COVID-19, using CT chest data of 29 patients who were admitted with confirmed diagnosis of COVID-19 by (RT-PCR) categorized based upon the patterns and distribution**26** of COVID-19, collected by reviewing the electronic medical record. They found that focal ground glass (GG) opacity was present in 5 (17%) patients, mixed GG and consolidation in 13 (45%), bilateral GGOs in 21 (72%), and nodular/reticular/band like opacities in 8 (28%) patients. Bilateral ground glass opacities were the most common CT scan feature in patients with COVID-19 (76%). Opacities were dominant in the lower zone (72%) and frequently distributed peripherally (48%). Severe disease was most likely to have bilateral opacities compared with mild ($p = 0.001$) and it was correlated with rise of inflammatory markers *Ran Yan, et al. (2020*) aimed to evaluate the value of chest CT severity score (CT-SS) in differentiating clinical forms of coronavirus disease 2019 (COVID-19), defining by summing up individual scores from 20 lung regions; scores of 0, 1, and 2 were respectively assigned for each region if parenchymal opacifications involved 0%, less than 50%, or equal to or more than 50% of each region (theoretic range of CT-SS from 0 to 40). They found Lung opacifications mainly involved the lower lobes, in comparison with middle-upper lobes. No significant differences in distribution of the disease were seen between right and left lungs. The individual scores in each lung and the total CT-SS were higher in severe COVID-19 when compared with mild cases (P>05). They have concluded that the CT-SS could be used to evaluate the severity of pulmonary involvement quickly and objectively in patients with COVID-19. *Na Zhu et al. (2020)* aimed to characterize coronavirus (Covid-19) pneumonia in adults using chest computed tomography, the diagnostic accuracy of chest computed tomography (CT) and RT-PCR for COVID-19 pneumonia in the early and progressive stages. Where data collected prospectively. The study population was divided into two groups; early stage of COVID-19 (number = 50 patients, with positive RT-PCR but mild symptoms) and progressive COVID-19 stage (number = 53, positive and severe RT-PCR symptoms such as fever> 37 ° C, cough and shortness of breath). All patients underwent CT imaging. The first**27** stage including the typical category; 34% (17 of 50 cases), 6% indeterminate category (3 cases), 10% atypical category (5 cases) and 50% (25 cases) were normal CT images. The progressive stage included a typical category that was further divided into five subgroups; (i) ground-glass opacity of the peripheral bilateral lower lobe (GGO) in (37.7%), (ii) peripheral bilateral lower lobes GGO with peribronchovascular consolidation and bronchiolar dilation in (18.8%), (iii) peripheral bilateral lower lobes GGO with appearance of crazy pavement in (15%), (iv) diffuse bilateral GGO in (18.8%) and (v) bilateral peripheral GGO with enlargement of the mediastinal lymph nodes (9.4%). They concluded that chest CT is very effective in detect lung parenchymal abnormalities in progressive stage of COVID-19 patients in 100*%.*

Dawoud, Mohammed.M, et al. (2020) have correlated the lung abnormalities with duration and severity of symptoms prospectively. CT lung abnormalities were progressed on follow-up CT studies. They found that a high total lung severity score in many patients with mild symptoms and a low total lung severity score in many patients with moderate to severe symptoms. The study's conclusion identified that chest CT should be used as a routine examination for diagnosing COVID-19 pneumonia and follow-up of disease advance and the progression of lung abnormalities was related to the duration more than the severity of symptoms**.**

Chapter Three

(Martials And Methods)

Materials and Methods

3-1Materials

3-1-1Study Design

This study is prospective and analytic study.

3-1-2Study Duration:-

The study begun on 20 September, 2021 and submitted in 19th may, 2022

3-1-3Study Sampling: -

A sample of 100patients who undergoes HRCT in different Computed Tomography departments in Khartoum State and Isolation Center

3-1-4Study area

The study will be carried out in Khartoum State and Isolation Center.

3-1-5Study population

A total of 100 patients with a final diagnosis of COVID-19 who had undergone chestHR CT were randomly selected from a group of patients and with confirmed RT-PCR.

3-1-6**Data Collection Methods**

Data collection sheets (appendix I) were filled out with the clinical Presentations and clinical data for all patients. Final Radiographic imaging diagnose of HRCT chest radiographic Images also were filled out in data collection sheets.

3-1-7**Data Statistical Analysis**

All statistical analyses were performed by Statistical Product and Service Software (SPSS Statistics, version 26.0, Chicago, IL, USA). *P*-value < 0.05 was considered statistically significant.

3-1-8Ethical consideration:

No identification or individual details will be published no information or patent details will be discovered or used for other reasons than the study purpose.

3-1-9Sampling

3-1-9-1Inclusion criteria

All patients with underwent HRCT scan and confirmed COVID-19 infection by RT-PCR

3-1-9-2Exclusion criteria:-

Patients with lung malignancy, a history of lobectomy, tuberculosis, or atelectasis were excluded from this study.

3-1-10Study Variables:-

Demographic characteristics as (age, gender), medical history, clinical symptoms in patients with COVID-19, lab test values and radiographic HRCT chest findings.

3-1-11Equipment:-

Study was performed using helical computed tomography scanner (TOSHIBA Aquilion CT machine).

3-2Methods

3-2-1CT Imaging acquisition

Chest high-resolution CT (HRCT) was performed for all patients. All patients in the supine position were scanned with breath holding at the end of inhalation. with the scanning parameters as follows: tube voltage 120 kV, tube current 110 mA, pitch 1.0, rotation time ranging from 0.5s to 0.75s, slice thickness 5 mm, with section thickness of 1 mm or 1.5 mm for axial, coronal and sagittal reconstructions.

3-2-2CT image analysis and quantification:-

HRCT radiographic images were independently reviewed by two radiologists with over 3-year experience that was blinded to the clinical data of the patients. Images were reviewed independently, and final decisions were reached by consensus. Quantitative evaluation was made on the abnormal manifestations of chest HRCT imaging.

The abnormal imaging signs including (Single, Multiple, Uni-lateral, Bi-lateral, Localized, Diffused, Patchy, Nodular, Peripheral Ground Glass Opacities (GGOs), Consolidation, interlobular septal thickening and Sub-plural band) were quantified by two radiologists. Lymphadenopathy, Pulmonary fibrosis, Pleural effusion and Emphysema pula not related to COVID-19 was ruled out. The radiologists estimated the lesion areas on each lung lobe as a percentage of the whole lung lobe, and the percentages in each lung lobe were scored using a semi-quantitative visual scoring system (CT-SS) was used to identify the severity of COVID-19 disease, where the lung divided into six zones by the level of tracheal carina and the level of inferior pulmonary vein bilaterally on CT images. Ground-glass opacities (GGOs) were rated by Likert scale of 0–4. (0= absent; 1= 1 – 25 %; 2= 26 – 50%; 3= 51 -75%; 4= 76 – 100%). Global severity score for each targeted pattern was calculated as total score of six zones (24). Whereas 1 to 12 scores of overall total categorized as mild cases and from 13 to 24 scores considered as severe cases.

3-3Strengths and Limitations

3-3-1Strengths

This study was achieved during the crucial time of COVID-19 pandemic where there are urgent needs for these researches.

3-3-2Limitations

There were several limitations in our study. First, the study was cross sectional study with only 50 patients enrolled. The relatively small sample size was inadequate to disclose further potential mechanism or to include other predictive factors for prognosis. An insufficient time made the data collection mechanisms difficult to be accomplished.

3-3-3Confidentiality

The data was collected with ensuring by hiding the medical record names of patients from data handlers

3-3-4Conflict of Interest:

No conflict of interest exits in the submission of this thesis.

CHAPTER FOUR

(RESULTS)

Results

Table (4.1): Distribution of study sample according to gender (n= 100)

Gender				
Variables	**Frequency**	**Percent %**	**Valid Percent**	**Cumulative Percent**
Male	44	44.0	44.0	44.0
Female	56	56.0	56.0	100.0

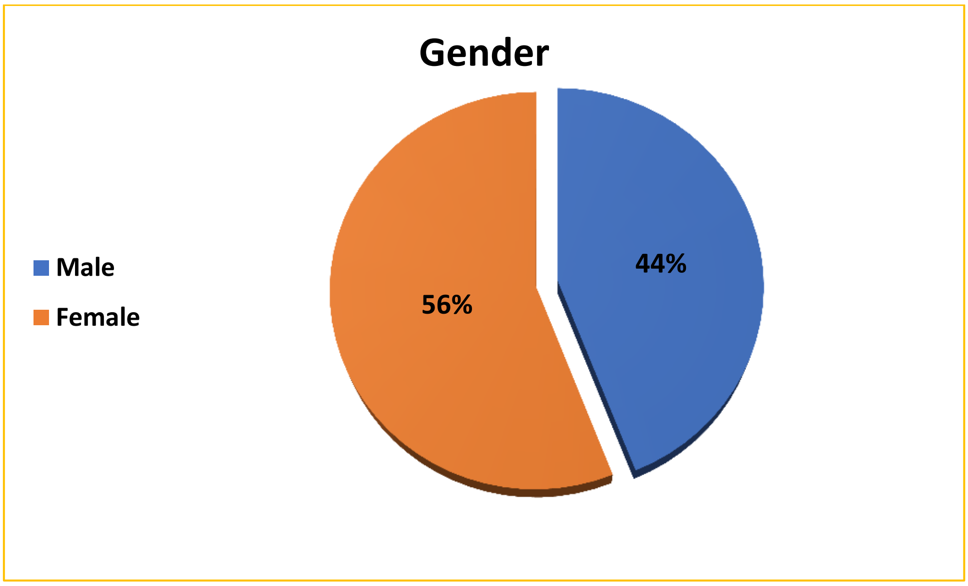

Figure (4.1): Distribution of study sample according to gender (n= 100).

Table (4.2): Distribution of study sample according to age (n= 100):

Age Groups				
Variables	**Frequency**	**Percent**	**Valid Percent**	**Cumulative Percent**
30 – 49 years old	10	10.0	10.0	10.0
50 – 60 years old	47	47.0	47.0	57.0
More than 70 years old	43	43.0	43.0	100.0

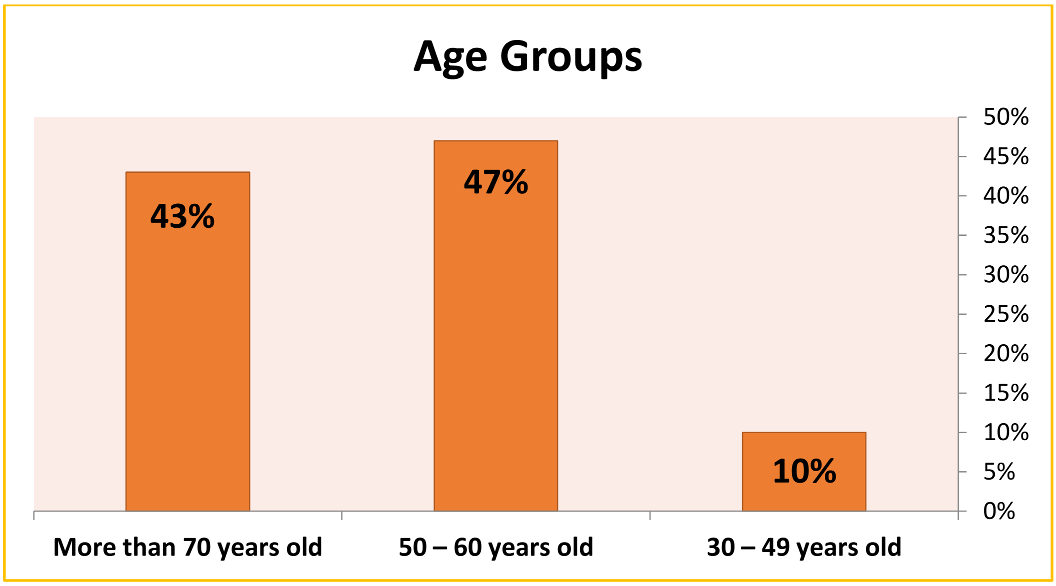

Figure (4.2): Distribution of study sample according to age (n= 100).

Table (4.3): Distribution of study sample according to medical history (n= 100)

Medical History				
Variables	**Frequency**	**Percent**	**Valid Percent**	**Cumulative Percent**
Diabetes	24	24.0	24.0	24.0
Hypertension	25	25.0	25.0	49.00
Diabetes and Hypertension	51	51.0	51.0	100.0

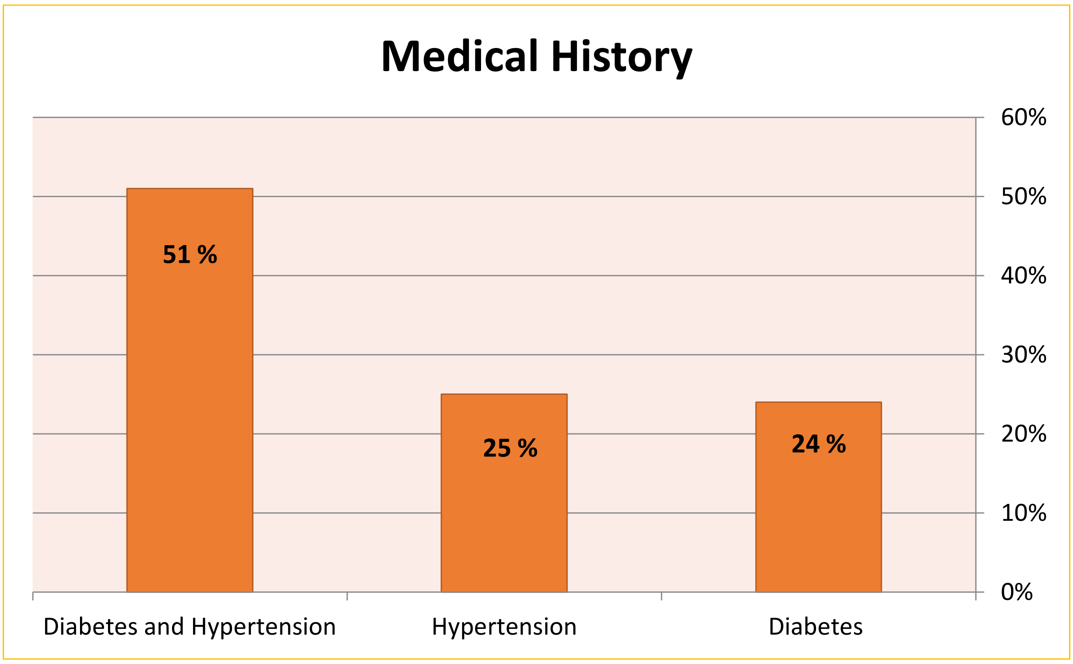

Figure (4.3): Distribution of study sample according to medical history (n= 100).

Table (4.4): Distribution of study sample according to clinical symptoms (n= 100):

Clinical Symptoms				
Variables	**Frequency**	**Percent**	**Valid Percent**	**Cumulative Percent**
Mild	00	00.0	00.0	00.0
Moderate	43	43.0	43.0	43.0
Severe	57	57.0	57.0	100.0

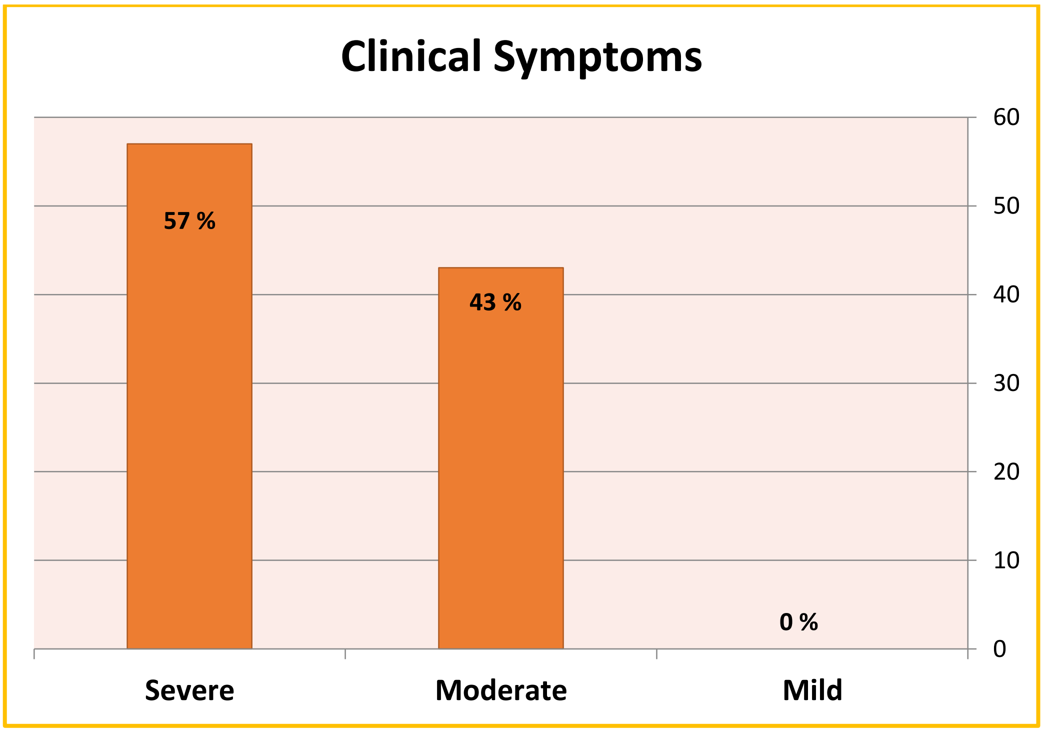

Figure (4.4): Distribution of study sample according to clinical symptoms (n= 100).

Table (4.5): Distribution of study sample according to CT findings (n= 100):

CT Findings				
Variables	**Frequency**	**Percent**	**Valid Percent**	**Cumulative Percent**
GGOs and consolidation with a surrounding halo sign	17	17.0	17.0	17.0
GGOs, consolidation with a surrounding halo sign and Bilateral or local patchy shadowing	27	27.0	27.0	44.0
GGOs, consolidation with a surrounding halo sign, Bilateral or local patchy shadowing and Interstitial abnormalities	56	56.0	56.0	100.0

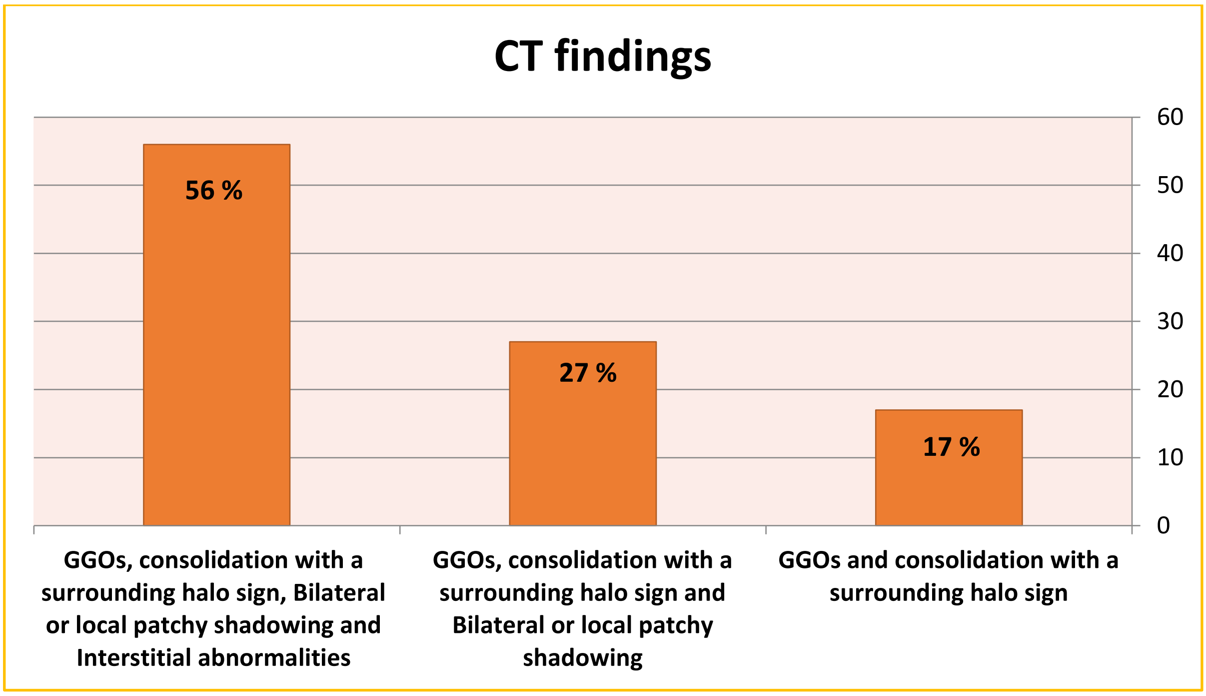

Figure (4.5): Distribution of study sample according to CT findings (n= 100):

Table (4.6): Correlation between gender and age with medical history (n=100).

Chi-Square Tests					
		Medical History			Asymptotic Significance (2-sided)
		Diabetes	Hypertension	Diabetes and Hypertension	
Gender	Male	10	10	23	0.691
	Female	14	14	28	
Total		24	25	51	
Age Groups	30 – 49 years old	6	2	2	0.000
	50 – 60 years old	19	20	7	
	More than 70 years old	0	1	42	
Total		25	23	51	

Table (4.7): Correlation between gender and age with clinical symptoms (n=100).

Chi-Square Tests				
		Medical History		Asymptotic Significance (2-sided)
		Moderate	**Severe**	
Gender	Male	19	25	.884
	Female	24	32	
Total		43	57	
Age Groups	30 – 49 years old	9	2	0.000
	50 – 60 years old	33	13	
	More than 70 years old	1	42	
Total		43	57	

Table (4.8): Correlation between gender and age with CT Findings (n=100).

Chi-Square Tests					
		CT Findings			Asymptotic Significance (2-sided)
		GGOs and consolidation with a surrounding halo sign	GGOs, consolidation with a surrounding halo sign and Bilateral or local patchy shadowing	GGOs, consolidation with a surrounding halo sign, Bilateral or local patchy shadowing and Interstitial abnormalities	
Gender	Male	6	12	26	.719
	Female	11	15	30	
Total		17	27	56	
Age Groups	30 – 49 years old	6	3	1	0.000
	50 – 60 years old	11	24	12	
	More than 70 years old	0	0	43	
Total		17	27	56	

CHAPTER FIVE

(DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS)

(DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS)

5.1 Discussion

This study aimed to evaluate of COVID 19 by using computed tomography. A total of 50 patients who had Chest (HRCT) and confirmed positively with COVID-19 using real time polymerase chain reaction RT-PCR were included in this study. the demographic data were as follows: 44 (44 %) were males and 56 (56 %) were females as shown in table and fig (4-1). The age was categorized into three groups, the majority of patients infected with COVID-19 were aged 50 – 60 years old 47 (47 %) and 43 (43 %) have age More than 70 years old aged between 40 to 59 years as shown in table and fig (4-2). This result was agreed with Centers for Disease Control and Prevention (CDC) states that older people are more likely to get very sick from COVID-19. Being seriously ill means that elderly people with COVID19 may need hospitalization, intensive care or a ventilator to help them breathe, or they may even die. The risk increases for people in their 50s and increases in their 60s, 70s, and 80s. People 85 and older are more likely to become seriously ill *(CDC platform, 2022).*

The incident of hypertension and diabetes in our patient was high (51; 51%) as shown in table (4.3) and fig (4.4). These results similar to previous study that assumed that might the results related to relatively senior age. Association of cardiovascular comorbidities with clinical severity and prognosis in hospitalized patients remains to be further investigated and would have profound impact on patient management *(Shu Li, et al. 2021).*

According to the distribution of study sample according to clinical symptoms: 43 % of total patients have moderate where 57 % of them have severe symptoms as shown in table (4.5) and fig (4.5). these findings in the same line with previous study *(Wang, Z., et al.2020)* who stated that the overall proportion of clinical symptoms was about 10% to 15% higher in severe patients.

Study found that COVID-19 distributed as GGOs, consolidation with a surrounding halo sign, Bilateral or local patchy shadowing and Interstitial abnormalities in 56 % of patients with covid-19, and GGOs, consolidation with a surrounding halo sign and Bilateral or local patchy shadowing in 27 % of total patients. These results in the same line with study reported by *(Sarfraz Saleemi, et al. 2020)* who stated that the dominant radiology feature in their cohort study was ground glass opacity which, in most patients, was bilateral with peripheral distribution and mixed GG with consolidation in 13 (45%) cases.

When we made a correlation by using Chi-Square Test between gender and age with both medical history and clinical symptoms of patients who infected with COVID-19 there was no significant difference (*p value* = 0.691 and 0.884 > 0.05, respectively). where there is a statistical difference in comparing with age groups *(p value* = 0.000 < 0.05). as well as there was not significant difference within gender with CT Findings *(p value* = 0.719 > 0.05) and there is a statistical difference in correlation between CT findings and age groups *(p value* = 0.000 < 0.05). some of these results were not in consistent with previous study that stated that males are more likely than females to be infected with COVID-19, whether in mild or severe cases. These findings are in line with recent research, which suggests that higher levels of ACE2 and TMPRSS2 in males, hormonal influences on the immunological response, and gender variations in behavior may all have a role in the greater severity and fatality of COVID-19 seen in men *(Mukherjee S, et al. 2021).*

5.2 Conclusion

Chest CT played an important role in the diagnosis and follow up of COVID-19.

Most patients with COVID-19 disease who have abnormal CT scan of chest show as GGOs, consolidation with a surrounding halo sign, Bilateral or local patchy shadowing and Interstitial abnormalities.

There is a statistical difference in correlation between age groups with medical history, clinical symptoms and CT findings.

This comprehensive characterization of COVID-19 will inform healthcare providers and public health policy makers in their efforts to treat and control the current outbreak.

5.3 Recommendations

Future studies should use the RT-PCR results as the standard reference in conjunction with the final CT diagnose in order to determine the specificity and sensitivity (accuracy) as predictors for measuring disease severity.

Since the clinical characteristics of COVID-19 change with the duration of the infection, we recommend future researchers to carefully consider the duration of disease as a fundamental factor in their studies.

Further studies are needed with larger sample size and external validation in different provinces in Sudan to establish local reference values and to determine variations among Sudanese population.

Numerous procedural requirements are mandatory, including end-inspiration scan, scanner calibration, unified section thickness and reconstruction protocol, manual segmentation adjustment, lung volume correction and so on. The systemic error is also concerning. Furthermore, software analysis mainly focused on small airway diseases such as COPD and is less applied to the evaluation of GGO or other respiratory diseases.

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APPENDICES

Appendix A

Data sheet

NO	AGE	GENDER	CHRONIC DISEASES			Clinical symptom			CRP	CT FINDING
			DM	HTN	DM And HTN	Mild	Moderate	Severe		

- **CT FINDING :-**

1. Ground-glass opcities
2. Consoldation with a surrounding halo sign
3. Bilateral or local patchy shadowing
4. Interstitial abnormalities

Appendix B

CT Images

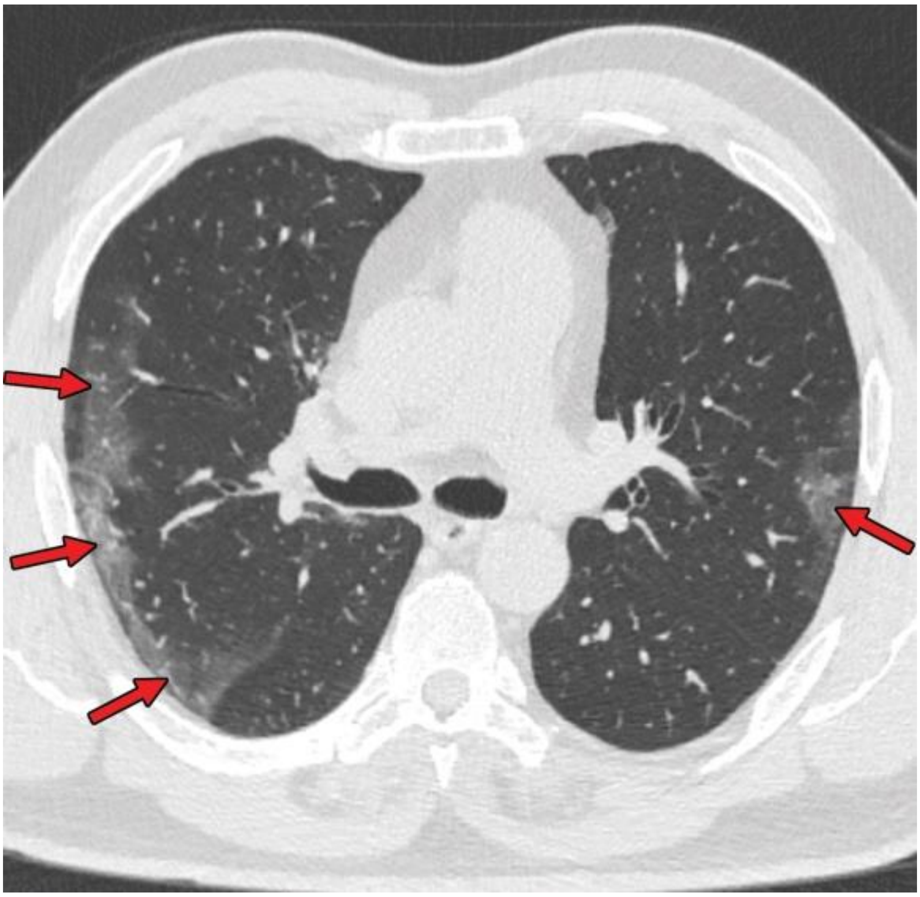

Image 1: COVID-19 pneumonia with typical imaging features according to the Radiological Society of North America (RSNA) chest CT classification system . Axial nonenhanced chest CT images (lung window) in a 59-year-old man with positive RT-PCR test results for SARS-CoV-2, show bilateral areas of ground-glass opacities (arrows) in a peripheral distribution.

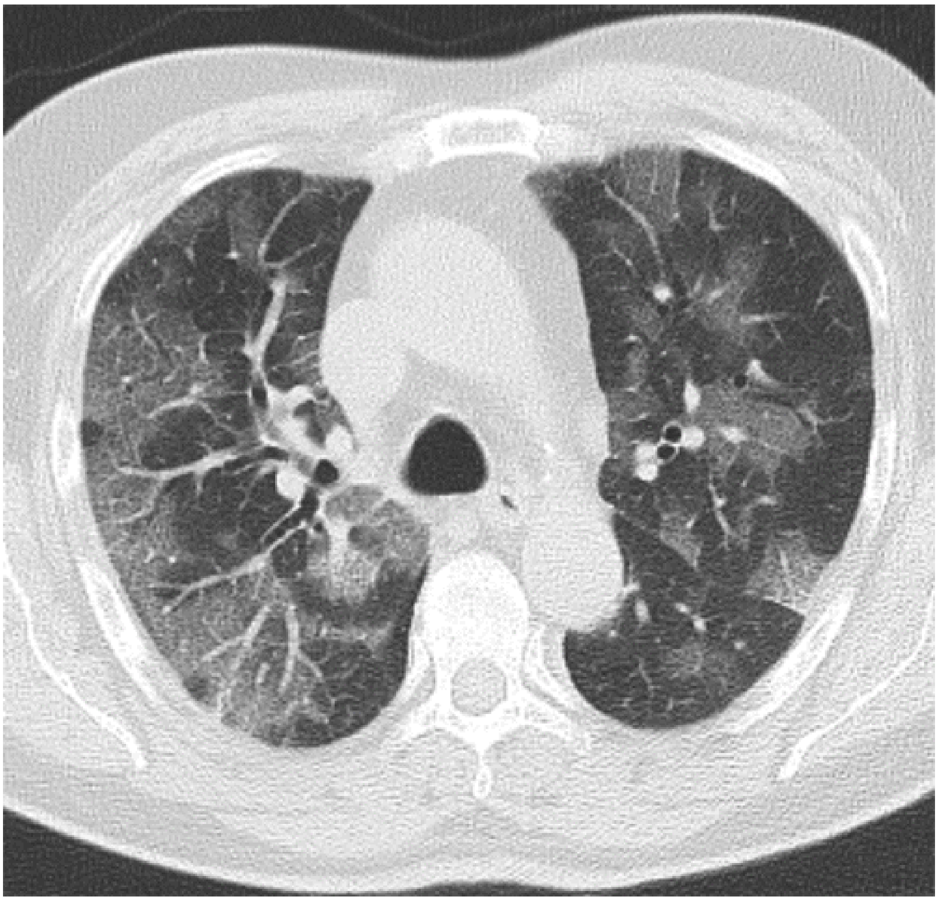

Image 2: Chest CT abnormalities of relatively high prevalence in COVID-19. Axial nonenhanced chest CT image (lung window) shows bilateral ground-glass opacities and dilated segmental and subsegmental vessels, mainly on the right, in a 70-year-old man with positive RT-PCR test results for SARS-CoV-2.

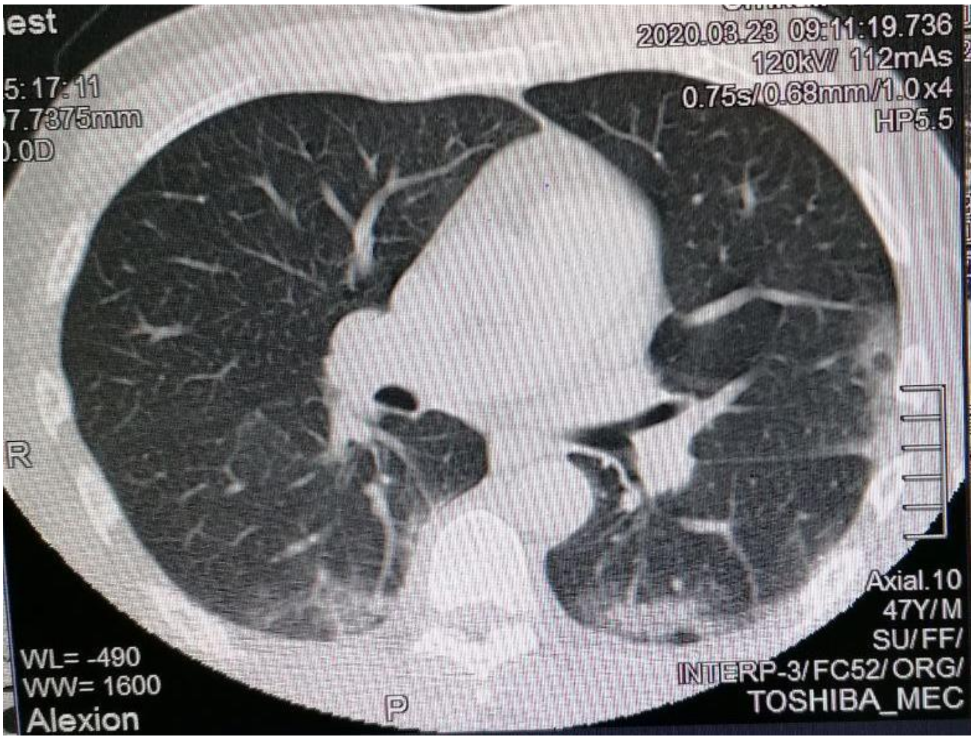

Image 3: HRCT chest for male 47 years old show the first case recover from COVID-19

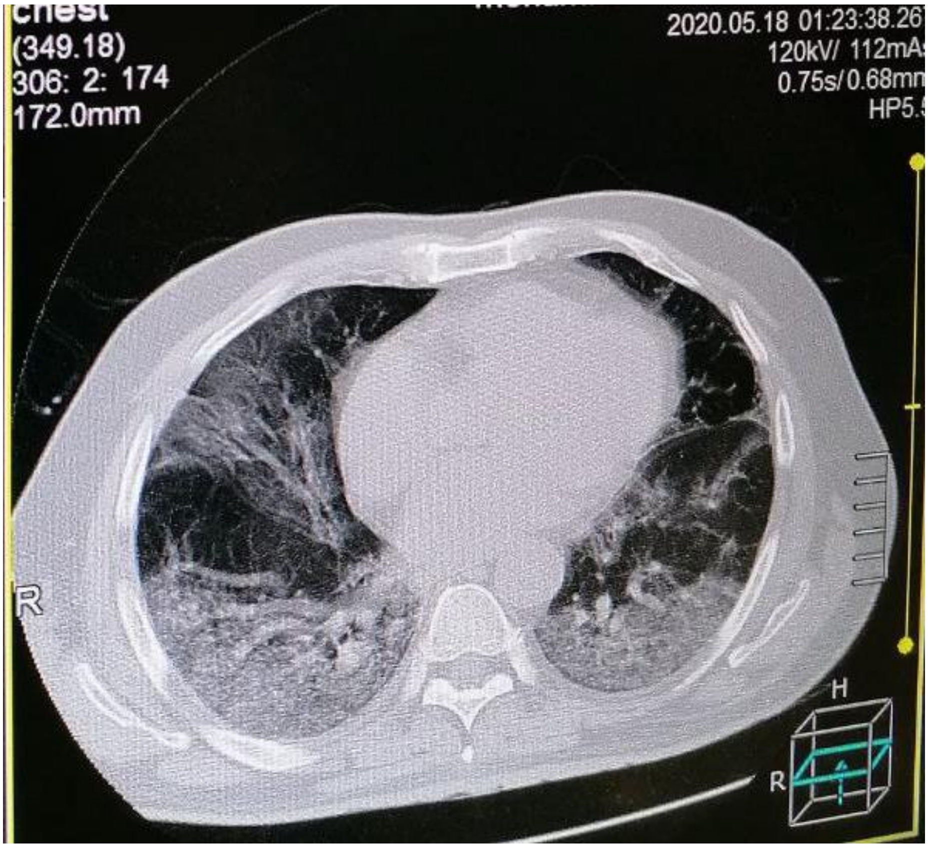

Image 4: chest HRCT images in a 55-year-old woman with severe COVID-19

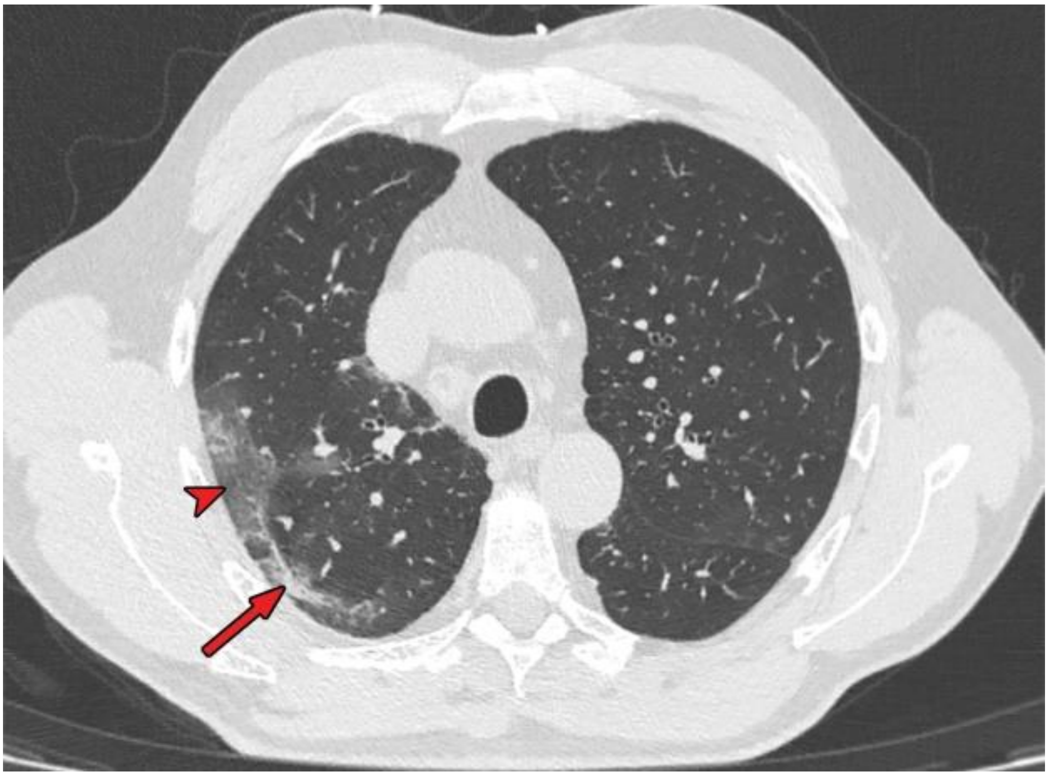

Image 5: Chest CT abnormalities of relatively intermediate prevalence in COVID-19, shown in a 63-year-old man with positive RT-PCR test results for SARS-CoV-2. Axial nonenhanced chest CT image shows a subpleural curvilinear opacity (arrow) and an area of ground-glass opacity (arrowhead) in the right upper lobe

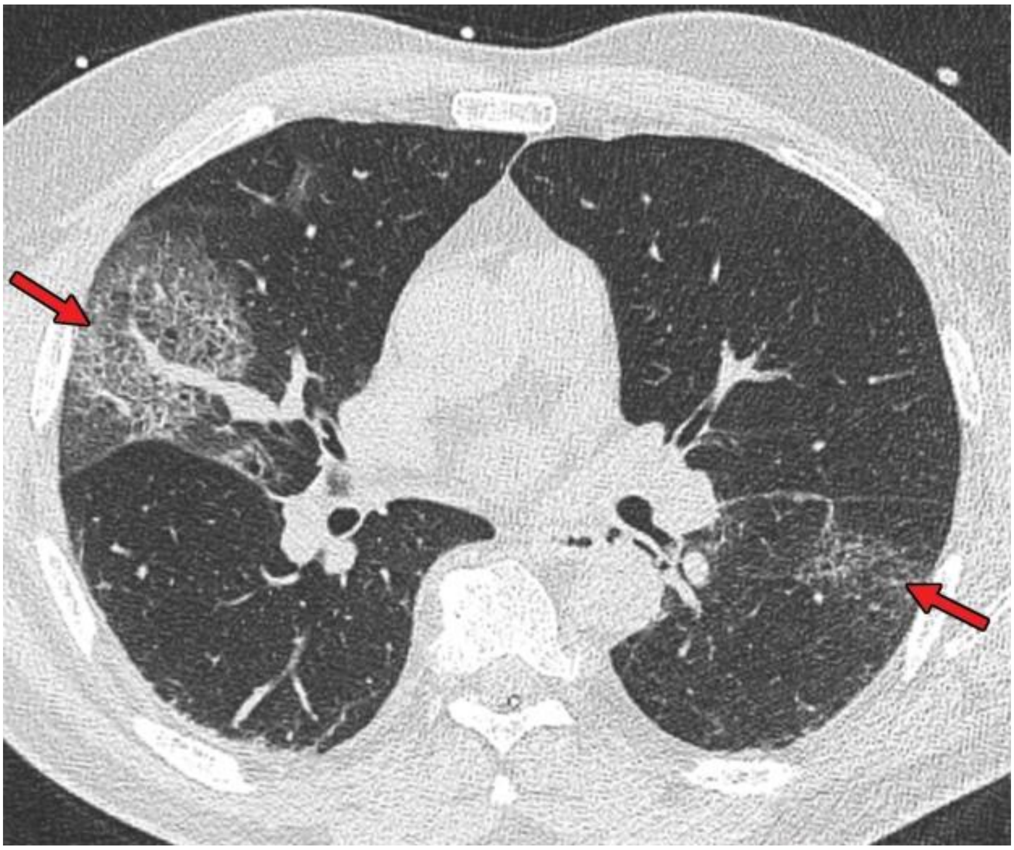

Image 6: Crazy-paving pattern in a 66-year-old man with COVID-19. Axial nonenhanced chest CT image shows ground-glass opacities, with superimposed septal thickening (arrows) in the middle lobe and left lower lobe

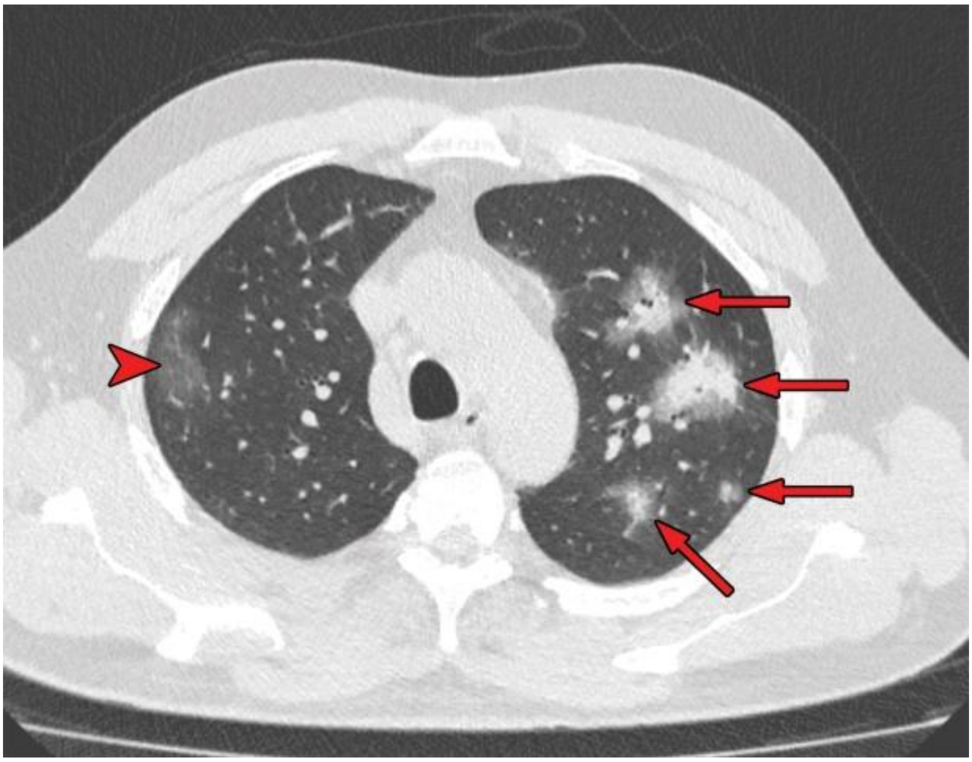

Image 7:Halo sign in a 55-year-old man with RT-PCR-test–proven COVID-19. Axial nonenhanced chest CT images show consolidations surrounded by ground-glass opacities (arrows) in both upper lobes, findings consistent with the halo sign.