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Correlation of thoracic CT scan on reverse transcription-polymerase chain reaction in COVID-19 patients with end-stage renal disease

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ABSTRACT

Background: Patients with end-stage renal disease (ESRD) regularly undergo hemodialysis and exhibit symptoms similar to those of COVID-19 infection. Therefore, it is necessary to carry out further exams, such as thoracic CT scans, using the COVID-19 Reporting and Data System (CO-RADS). The study aimed to analyze the correlation between thoracic CT scan imaging and reverse transcription-polymerase chain reaction (RT-PCR) in COVID-19 patients with ESRD.

Methods: This study employed a cross-sectional study design with total sampling. Participants in this study were patients with ESRD who underwent regular dialysis. The data were collected from March 2020-2021. The collected data included COVID-19 diagnosis with RT-PCR and radiographic imaging based on CO-RADS. The statistical tests consisted of chi-square and Spearman correlation with p <0.05.

Results: The findings from the chest x-rays of the participants revealed that 3.2% had no abnormalities, unilateral abnormalities of 14.3%, and bilateral abnormalities of 82.5%. Most participants had a CO-RADS 1-3 score of 63.5% and a negative RT-PCR of 63.5%. The study revealed that 82.5% of participants exhibited CO-RADS 1-3 and RT-PCR negative results, while 69.6% of participants showed CO-RADS 4-5 and positive RT-PCR (r = 0.462; p <0.001).

Conclusion: A significant correlation exists between CO-RADS and RT-PCR in patients with ESRD.

Keywords: *CO-RADS, COVID-19, end-stage renal disease, radiographic imaging, RT-PCR.*

1. INTRODUCTION

The COVID-19 pandemic has affected about 123 million individuals, resulting in more than 2 million fatalities in 230 nations. According to reports from Wuhan, hemodialysis centers are one of the areas most affected by COVID-19. It has been reported that 10% of patients undergoing routine hemodialysis had contracted COVID-19 [1]. Determining the diagnosis of COVID-19 in patients with stage 5 chronic kidney disease or end-stage renal disease (ESRD) who have undergone routine hemodialysis is challenging due to the similarity between their symptoms of shortness of breath and other signs of infection and the symptoms of COVID-19. The use of chest x-ray examinations for diagnosing COVID-19 in patients with end-stage renal disease (ESRD) is not specific. Therefore, the preferred and most accurate method for identifying the coronavirus remains the reverse transcription-polymerase chain reaction (RT-PCR) test [2].

Rapid and accurate identification of COVID-19 is crucial as it affects the implementation of isolation treatment for patients, which is a key measure in preventing the spread of COVID-19 [3, 4]. False negatives pose a challenge in RT-PCR tests, particularly during the initial phases of the illness [5]. During the early stages of the pandemic, the process of verifying a

COVID-19 diagnosis using RT-PCR was time-consuming. This resulted in delays in providing medication to patients, including making judgments regarding hemodialysis for individuals with end-stage renal disease (ESRD) who were suspected of being infected with COVID-19. In order to prevent the negative consequences of delayed hemodialysis therapy, it is imperative to explore other solutions. A thoracic computed tomography (CT) scan is a fast-screening method used to quickly identify individuals who are suspected of having COVID-19. This scan is likely to aid in the diagnosis of COVID-19 and can help prevent the spread of the virus, particularly in patients with end-stage renal disease (ESRD) [2].

Patients with ESRD are at a significantly elevated risk of infection. This heightened susceptibility can be attributed mostly to compromised immune response, malnutrition, chronic inflammation, heightened oxidative stress, accumulation of uremic toxins, and malfunction of the endothelium. Patients undergoing regular hemodialysis are at an increased risk of contracting the COVID-19 virus due to both a weakened immune response and frequent movement within the hospital as part of their treatment [6]. CO-RADS is a CT scan-based approach that evaluates the likelihood of pulmonary involvement in COVID-19 and has demonstrated practical utility in clinical settings [7]. Ground glass opacities (GGO) are common characteristics observed in COVID-19 patients, namely in those classified as CO-RADS 3, 4, and 5 [8]. While frequently observed in cases of COVID-19, GGO can also be attributed to many other causes such as pulmonary edema and lung infections caused by bacteria, fungi, and other viruses. Patients with ESRD frequently experience pulmonary edema and are at a heightened risk of developing pulmonary infections due to SARS-COV-2 or other microorganisms. Consequently, the thoracic CT scan images may exhibit a wider range of abnormalities, posing challenges in differentiating whether the pulmonary abnormalities are attributable to COVID-19 or not [9].

The RT-PCR test is highly specific for COVID-19, with a specificity of 98%. However, its sensitivity can vary between 60-70% and 95-97% [5]. Regarding the diagnosis of COVID-19, thoracic CT scans exhibit a high level of sensitivity (ranging from 67-100%), but their specificity is relatively lower (ranging from 25-80%) [10]. A study conducted in 2020 in Amsterdam found that 92.9% of patients with CT scans showing CO-RADS 4 and 5 had positive RT-PCR results [11]. Although not a conventional diagnostic method for COVID-19, a thoracic CT scan can be useful in guiding the decision to diagnosis COVID-19. This study aimed to establish a correlation between thoracic CT scan imaging and RT-PCR in COVID-19 patients with ESRD in Indonesia, considering the distinct clinical characteristics of ESRD patients in this country compared to those elsewhere.

2. METHODS

Study design

A cross-sectional design was conducted with a total sampling approach. The study included patients diagnosed with end-stage renal disease (ESRD) who obtain regular dialysis treatment. The process of gathering data took place between March 2021-2022. The study procedure involved the identification of participant criteria, the collection of data, and analysis. The identified data comprised of participant characteristics, COVID-19 diagnosis using RT-PCR, and radiographic imaging. Prior to data collection, participants were provided with a comprehensive explanation of the nature and purpose of the research. Participants must voluntarily participate in this study and complete a consent form.

Ethical approval

In accordance with the principles outlined in the Declaration of Helsinki, it is necessary that the rights of participants are upheld. Therefore, when collecting data, we operate under the supervision of the hospital's ethical committee.

Participants

The inclusion criteria for participants were as follows: being at least 18 years old, having a diagnosis of chronic kidney disease for a minimum of 5 years, being in the end-stage renal disease (stage 5), regularly performing hemodialysis twice a week, and having indications of being a COVID-19 patient. The diagnosis of chronic kidney disease was established according to the clinical practice guidelines for kidney injury or disease set out by the Kidney Disease: Improving Global Outcomes (KDIGO) organization. This diagnosis was made by a nephrologist with a minimum of 5 years of experience. The COVID-19 patients could be identified by employing a COVID-19 patient scoring system. Patients with scores of 20 or higher were classified as high risk, those with scores between 5 and 19 were considered medium risk, while patients with scores ranging from 0 to 4 were categorized as low risk (refer to Table 1) [12]. Meanwhile, exclusion criteria consisted of insufficient medical data and participant refusal.

Table and Legends

Table 1. COVID-19 Risk Scoring

No	Data	Criteria	Scoring
Major			

1	S/O	Previous exposure to confirmed COVID-19 patients without proper personal protective equipment (PPE), in addition to the presence of more than one minor observable symptom.	Assign score 20 if one or more of the criteria 1-3 are fulfilled
2	O	Chest x-ray: Bilateral basal ridges.	
3	O	Thoracic CT scan: bilateral ground glass opacities	
Minor			
4	S	Work/attend mass gatherings/places of worship/marriages/parties/markets or public facilities (airports, banks, etc)	Assign score 4 if one or more of the criteria 4-7 are fulfilled
5	S	Living or traveling in an infected area/community (within and outside the country)	
6	S	Family (1 household) working or traveling to a place with confirmed/at-risk cases	
7	S	Neighborhood with confirmed cases (residence or workplace)	
8	S/O	Fever/history of fever for the last 14 days (≥37.5°C)	Assign score 4 if one or more of the criteria 8-11 are fulfilled
9	S/O	Anosmia (reduced sense of smell)	
10	S/O	Gastrointestinal symptoms (Diarrhea/Nausea/Vomiting/Stomach Pain)	
11	S/O	Airway symptoms (Shortness/Cough/Cold)	
12	O	Comorbid factors (DM/ HT/ CKD/ Malignancy/ Autoimmune/ Cardiac abnormalities/Obesity/ Pregnancy)	1
13	O	Leukopenia (<5000)	1
14	O	NLR (Neutrophil Lymphocyte Ratio) >3.5	1
15	O	Absolute Lymphocyte Count <1100	1
16	O	Decreased thrombocyte (<150×10^3/µL)	1
17	O	CRP (>5x Normal) N = ±10mg/L	1
18	O	Chest x-ray: Bilateral ridge (Peripheral Basal)	1
19	O	Chest x-ray: Diffuse bilateral ridge	1
20	O	Chest x-ray: Unilateral ridge	1
21	O	Chest x-ray: Bilateral central ridge	1
22	S	Previous exposure to confirmed COVID-19 patients without proper personal protective equipment (PPE) without any additional symptoms or signs (isolated case).	1
Total Score			

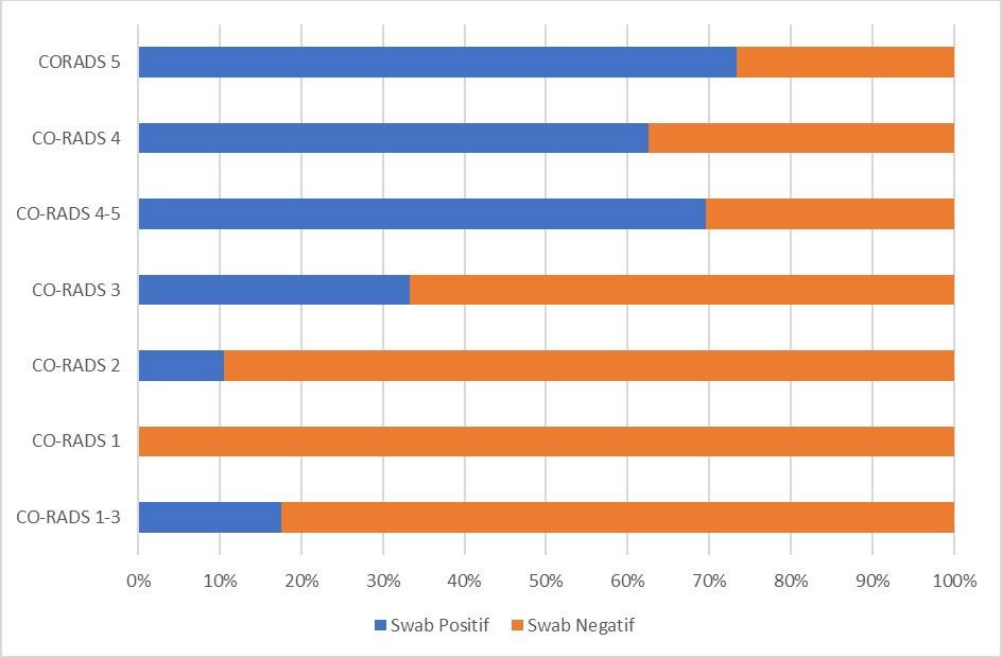
*Note: S=subjective; O=objective; score interpretation included 1-4=low risk, 5-19=medium risk, and ≥20=high risk.

COVID-19 Diagnosis

Diagnosis of COVID-19 in participants used the nasopharynx swab method with RT-PCR by Roche coas z-480 (Roche Diagnostics Intl, Ltd., Risch-Rotkreuz, Switzerland). The analysis of the swab examination data was conducted by a microbiology expert, and the results were positive and negative for COVID-19 infection [3, 4].

Radiographic imaging

The thoracic CT scan examination in this study used a Toshiba 128 slice CT scan type aquilion 7078D. The thoracic CT scan was performed in response to the participant's COVID-19 symptoms. Thoracic CT scans were interpreted by radiologists who possess a minimum of 5 years of expertise. The thoracic CT scan results were categorized into five groups based on the COVID-19 Reporting and Data System (CO-RADS) [7]. The study concluded that CORADS 1-3 did not result in COVID-19, and CORADS 4-5 resulted in COVID-19 [12]. Meanwhile, several thoracic CT scans showed a characteristic of COVID-19 infection in the lung fields (Figure 1).



Statistical analysis

The data for this study were analysed using the Statistical Package for the Social Sciences (SPSS) 23.0 version (IBM Corp., Armonk, NY, USA), where the data were presented in table form. Prior to analyzing the acquired data, a normality test was conducted using the Kolmogorov-Smirnov test. The statistical tests employed in this study encompassed the chi-square test and the Spearman correlation. The analysis results were deemed significant if the *p*-value was less than 0.05.

3. RESULT

Characteristic of participants

Most of the participants were male (52.4%), 55 years old (22-83), with the most age in the range of 51-60 years (42.9%). Participants have been on hemodialysis for 2 (1-96) months. There are several comorbid diseases in participants including hypertension (98.4%), diabetes mellitus (68.3%), kidney stone (1.6%), autoimmune (3.2%), and malignancy (4.8%). COVID-19 scoring values could be seen in Table 2.

Table 2. Characteristic of participants

Characteristic	RT-PCR			CO-RADS		
	Positive (n=40)	Negative (n=23)	*p*	1-3 (n=40)	4-5 (n=23)	*p*
Age	56 (22-83)	55 (23-66)	0.002*	55 (22-83)	57 (23-72)	0.881
18-30	2 (5)	3 (13.04)	0.056	2 (5)	3 (13.04)	0.262
31-40	0 (0)	1 (4.35)		0 (0)	1 (4.35)	
41-50	11 (27.5)	1 (4.35)		10 (25)	2 (8.69)	
51-60	14 (35)	13 (56.52)		16 (40)	11 (47.83)	
>60	13 (32.5)	5 (21.74)		12 (30)	6 (26.09)	

Sex						
Male	21 (52.5)	12 (52.2)	1.000	20 (50)	13 (56.5)	0.813
Female	19 (47.5)	11 (47.8)		20 (50)	10 (43.5)	
Comorbid						
Hypertension	39 (97.5)	23 (100)	1.000	39 (97.5)	23 (100)	1.000
DM	26 (65)	17 (73.9)	0.652	28 (70)	17 (65.2)	0.911
Kidney stone	1 (2.5)	0 (0)	1.000	1 (2.5)	0 (0)	1.000
Autoimmune	0 (0)	2 (8.7)	0.130	0 (0)	2 (8.7)	0.130
Malignancy	2 (5)	1 (4.3)	1.000	3 (7.5)	0 (0)	0.293
Hemodialysis period	1 (1-72)	4 (1-96)	0.004*	2 (1-96)	3 (1-36)	0.507
Scoring COVID-19	26 (9-33)	29 (12-29)	0.249	25 (9-33)	29 (12-29)	0.170

Note: DM=diabetes mellitus; RT-PCR= reverse transcription-polymerase chain reaction; CO-RADS=COVID-19 Reporting and Data System; *significant <0.05.

Clinical condition

There was a significant correlation between CO-RADS and the presence of Myalgia (p=0.014) as well as CO-RADS and diarrhea (p=0.041) in terms of clinical symptoms. However, there was no significant correlation between the clinical symptoms and the results of the RT-PCR test. The laboratory examinations showed a strong correlation with RT-PCR, except for lymphocytes and RT-PCR (p=0.200). Meanwhile, in the CO-RADS examination, there was a significant correlation between the findings of CRP and CORADS laboratories (p=0.028; Table 3).

Table 3. Clinical features of participants

Characteristic	RT-PCR			CO-RADS		
	Positive (n=40)	Negative (n=23)	*p*	1-3 (n=40)	4-5 (n=23)	*p*
Clinical onset	3 (1-7)	3 (1-7)	0.465	3 (1-7)	3 (1-7)	0.087
Clinical symptoms						
Fever	22 (55)	16 (69.6)	0.384	22 (55)	16 (69.6)	0.384
Cough	32 (80)	21 (91.3)	0.302	31 (77.5)	22 (95.7)	0.078
Swallowing pain	3 (7.5)	0 (0)	0.293	3 (7.5)	0 (0)	0.293
Shortness of breath	25 (62.5)	15 (65.2)	1.000	25 (62.5)	15 (65.2)	1.000
Easily tired	27 (67.5)	13 (56.5)	0.549	27 (67.5)	13 (56.5)	0.549
Myalgia	11 (27.5)	11 (47.8)	0.175	9 (22.5)	13 (56.5)	0.014*
Diarrhea	6 (15)	1 (4.3)	0.407	7 (17.5)	0 (0)	0.041*
Decreased appetite	21 (52.5)	14 (60.9)	0.704	22 (55)	13 (56.5)	1.000
Laboratories test						
SpO2	92 (83-99)	91 (86-98)	0.001*	92 (83-99)	91 (86-98)	0.397
Leucocyte	11.69 (4.35-45.09)	12.24 (5.43-42.49)	<0.001**	11.65 (4.35-45.09)	12.24 (5.43-42.49)	0.716
Neutrophile			<0.001**			0.994
Lymphocyte	10.58 (2.75-43.42)	10.02 (3.39-39.69)	0.200	10.53 (27.52-43.42)	9.78 (3.39-39.69)	0.386
NLR			<0.001**			0.436

CRP	0.88 (0.20-2.77)	1.00 (0.15-2.07)	<0.001**	0.87 (0.2-2.77)	1.00 (0.15-1.88)	0.028*
PCT	15 (2-88)	17 (2-77)	<0.001**	16.5 (2-88)	12 (2-77)	0.245
	4.8 (0.1-42.9)	5.8 (0.1-29.9)		2 (0.2-42.9)	8.4 (0.1-29.9)	
	1.0 (0.3-100)	2.11 (0.42-69.63)		1 (0.3-100)	2.1 (0.42-56.88)	

Note: SpO2=oxygen saturation; NLR=Neutrophil to Lymphocyte Ratio; CRP=C-reactive Protein; PCT=procalcitonin; RT-PCR=reverse transcription-polymerase chain reaction; CO-RADS=COVID-19 Reporting and Data System; *significant <0.05; **significant <0.001.

Correlation between thoracic CT scan imaging and RT-PCR describe

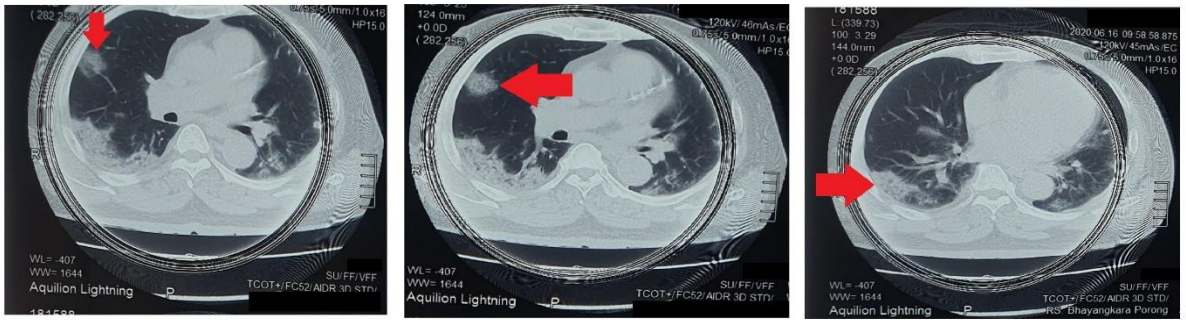
The chest x-ray findings revealed that 3.2% of the participants had no abnormalities, unilateral abnormalities of 14.3%, and bilateral abnormalities of 82.5%. These results are detailed as follows: (1) Among the participants, 5% had no abnormalities, with an equal distribution of CO-RADS 1-3 and negative RT-PCR results; (2) Unilateral abnormalities were observed in 10% of participants, with a breakdown of 12.5% having CO-RADS 1-3, 17.4% having positive RT-PCR results, and 21.7% having CO-RADS 4-5; (3) Bilateral abnormalities were found in 78.3% of participants, with 82.5% having negative RT-PCR results, 82.6% having positive RT-PCR results, and 85% having CO-RADS 1-3.

There was a significant difference observed between positive and negative RT-PCR results based on CO-RADS imaging. The majority of participants with positive RT-PCR (69.6%) had a CO-RADS interpretation of 4-5 (p<0.001), whereas the majority of people with negative RT-PCR (82.5%) had a CO-RADS interpretation of 1-3 (p<0.001; see Table 4). Figure 2 provides a detailed illustration of the association between CO-RADS imaging and RT-PCR, which showed a significant correlation.

Table 4. Comparison between CO-RADS and RT-PCR

CO-RADS	RT-PCR		p
	Negative (n=40)	Positive (n=23)	
1-3	33 (82.5)	7 (30.4)	<0.001**
4-5	7 (17.5)	16 (69.6)	<0.001**

Note: RT-PCR=reverse transcription-polymerase chain reaction; CO-RADS=COVID-19 Reporting and Data System; *significant <0.05; **significant <0.001.



4. DISCUSSION

Lung capillary permeability increases during lung infections, particularly COVID-19 pneumonia. The increased permeability of pulmonary capillaries is a result of alveolar injury and elevated levels of inflammatory cytokines. Severe damage to the alveoli can lead to the development of acute respiratory distress syndrome (ARDS). ARDS in COVID-19 is a result of fluid

leakage in the lungs and can be differentiated from other types of lung fluid buildup caused by heart problems or increased pressure. The widespread damage to the air sacs in ARDS can cause long-term scarring, including fibrosis near the outer layer of the lungs and widening of the bronchial tubes in certain patients with severe illness. [13].

GGO is frequently characterised as an atypical lung condition resembling a faintly illuminated or uniformly dispersed grey ridge [14]. GGO and consolidation are common characteristics observed in thoracic x-rays and CT scans of patients with COVID-19. Although cardiomegaly and pleural effusion are typically seen in hydrostatic pulmonary edema, they are rarely observed in COVID-19-induced ARDS. Therefore, the presence of these features can aid in distinguishing between the two etiologies [13].

CO-RADS is a scoring system utilized in COVID-19 reporting to evaluate thoracic CT scans in individuals with suspected COVID-19. It indicates the degree of suspicion for pulmonary damage caused by COVID-19. CO-RADS utilises the findings observed on a thoracic CT scan to determine the likelihood of pulmonary involvement in COVID-19. The level of suspicion ranges from very low (CO-RADS 1) to very high (CO-RADS 5). There are also two additional categories: a technically inadequate examination (CO-RADS 0) and a thoracic CT scan that supports a confirmed SARS-CoV-2 infection at the time of examination (CO-RADS 5) [7].

Thoracic radiography is a supplementary diagnostic test commonly employed to aid in the identification of COVID-19 pneumonia. However, in patients with ESRD, this test alone is inadequate for establishing a definitive diagnosis of COVID-19. This is due to the fact that routine thoracic radiographs in hemodialysis patients frequently reveal lung abnormalities resulting from pulmonary edema and non-COVID-19 infections. To provide a more precise description of non-specific thoracic pictures for diagnosing COVID-19 infection, a thoracic CT scan evaluation can be utilised [15]. A study conducted in Wuhan found that 60-70% of COVID-19 patients exhibited pure GGO on thoracic CT scans [14]. Thoracic CT scans in COVID-19 patients with a history of ESRD show similar characteristics to those without ESRD. In both groups, the majority of patients exhibit bilateral lung abnormalities and GGO on thoracic CT scans [16]. A study conducted by Goicoechea et al. in Spain found that up to 80% of COVID-19 patients having regular hemodialysis exhibited a thoracic radiographic picture showing GGO or typical lung shadowing in the outer regions of the lungs [17].

One of the characteristic characteristics of COVID-19 infection is the presence of bilateral GGO that is distributed peripherally and predominantly affects the lower lobes. GGO is a frequently observed imaging characteristic in the initial stages of the disease. It typically emerges within a timeframe of 0-4 days and may increase in size as the infection worsens [14]. The thoracic CT scan is a moderately sensitive imaging test for detecting COVID-19, with a reported sensitivity of up to 97%. CT scan data indicating COVID-19 infection can be detected earlier than PCR swab test results [12]. There was no significant difference between the positive and negative swab groups as indicated by the thoracic pictures. Specifically, the majority of participants in both groups exhibited abnormalities in both lungs. Research conducted by Weinstock et al. found that chest x-rays in COVID-19 patients were mostly bilateral abnormalities (20.9%), peripheral (35.4%) and dominance in the lower lung zone (33.8%) [18].

A study conducted in Amsterdam found that the percentage of cases with CO-RADS 1 and 2 (not indicative of COVID-19) and positive RT-PCR results was 2.7%. For CO-RADS 3 (COVID-19 indeterminate) cases with positive RT-PCR results, the percentage was 4.5%. In contrast, for CO-RADS 4 and 5 (indicative of COVID-19) cases with positive RT-PCR results, the rate was 92.9%. These findings align closely with the results of another study, which observed that patients with thoracic CT scans showing CO-RADS 4-5 predominantly had positive PCR swab results [11]. The sensitivity of a thoracic CT scan for diagnosing COVID-19 is 70%, with a specificity of 79%, PPV of 86%, and NPV of 76%. The most often observed characteristic in these scans is GGO accounting for more than 50% of the affected area, with a distribution that is primarily peripheral and perihilar [19]. A study conducted in India including 112 patients found that 76% of them tested positive for SARS-CoV-2 infection using RT-PCR, while 81% showed signs of infection on thoracic CT scans. The research concluded that there was a strong association between the results of thoracic CT scans and swab PCR tests [20].

Although thoracic CT scans exhibit a high level of sensitivity (67-100%), a comparatively lower level of specificity (25-80%) [10]. The thoracic CT scans reveal the signs of viral pneumonia, which are directly linked to the development of viral infections in the lungs. Consequently, pneumonia caused by viruses often exhibit comparable disease patterns and presentations. GGO and consolidation are radiographic patterns observed in CT scans of patients with COVID-19 pneumonia and other virus-induced pneumonias, such as influenza. These patterns are commonly found in the thoracic CT scans of patients with viral pneumonia, making them closely resemble COVID-19 pneumonia [21].

A previous study by Xie et al. showed that although five patients from 167 participants were initially tested negative for COVID-19 using RT-PCR swabs, their thoracic CT scans indicated infection. When these patients underwent repeat RT-PCR swabs, positive results were obtained within a range of 2-8 days after the initial swab [22]. The findings of PCR testing using nasopharyngeal swabs can be affected by several factors, including the time elapsed between the initial exposure to COVID-19 and the PCR sampling, the source or origin of the sample, the technique used for sample collection, and the quality of the diagnostic kit or tools employed [23, 24]. Nasopharyngeal swab samples have high sensitivity, particularly when symptoms manifest, and this sensitivity gradually diminishes within 2-3 weeks after infection [25].

Several studies have shown that patients who test negative for the presence of the virus in their nasopharyngeal swab PCR findings may nevertheless have false negatives. Since this is believed to occur, the quantity of the virus in the nasopharynx is insufficient to be detected by the PCR technique. PCR testing of samples obtained from the lower respiratory tract, such as bronchoalveolar lavage (BAL), is more sensitive than that of those taken from the upper respiratory tract. The specimens collected from BAL showed the greatest rate of positive results in SARS CoV-2 PCR testing, with a rate of 93%. This was followed by sputum specimens with a rate of 72%, nose swabs with a rate of 63%, and pharyngeal swabs with a rate of 32% [23, 24]. Another viewpoint suggests that the virus initially enters and reproduces in the lung parenchyma through the upper respiratory tract. As a result, even if the nasopharyngeal swab test shows negative results, the viral load in the lower respiratory tract may be higher, leading to inflammation and abnormalities in the lungs [26]. Although the expression of ACE2 is abundant in type I and type II alveolar epithelial cells, relatively little in the upper respiratory tract [27]. These considerations suggest that despite a negative result from a nasopharyngeal PCR swab, if the clinical and radiological characteristics indicate COVID-19, it is important to be cautious about the possibility of false negatives.

The sensitivity of nasopharyngeal PCR can vary and it may take up to 7 days for results, particularly in developing countries with limited COVID-19 diagnostic capabilities. For individuals who are clinically and radiologically suspected of having COVID-19, it is necessary to conduct a repeat swab PCR test within 1-2 days after the initial PCR test [28]. Thoracic CT scan is a valuable imaging tool for diagnosing COVID-19. It is particularly useful in cases when the patient's clinical condition is taken into account, there is a risk of false negatives from RT-PCR tests, or when quick RT-PCR testing is not feasible.

The study was limited by the small research sample size, indicating the necessity for future research with a bigger sample size. Furthermore, this research was a single centre, thus requiring the design of additional multicenter studies to validate the findings of this study.

5. CONCLUSION

Most of participants have CO-RADS scores ranging from 1 to 3, accounting for 63.5% of the total, and also tested negative for RT-PCR with the same percentage. A strong correlation exists between thoracic CT scan imaging and RT-PCR in COVID-19 patients with ESRD. The thoracic CT scan examination (CO-RADS) lacks sufficient strength to serve as a standalone diagnostic tool for COVID-19 in patients with ESRD. Therefore, additional support from PCR swab examination is still necessary.

REFERENCES

[1] Li J, Xu G. Lessons from the experience in Wuhan to reduce risk of COVID-19 infection in patients undergoing long-term hemodialysis. Clin J Am Soc Nephrol. 2020;15(5):717-719.

[2] Rahaman MM, Li C, Yao Y, et al. Identification of COVID-19 samples from chest x-ray images using deep learning: A comparison of transfer learning approaches. J Xray Sci Technol. 2020;28(5):821-839.

[3] Saputra GNR, Yudhawati R, Fitriah M. Association of soluble receptor for advanced glycation end-products (sRAGE) serum on COVID-19 severity: A cross-sectional study. Ann Med Surg. 2022;74:103303.

[4] Fitriah M, Putri AE, Semedi BP, et al. Immunomodulation effect of convalescent plasma therapy in severe - critical COVID-19 patients. Open Access Emerg Med. 2023;15:109-118.

[5] Kucirka LM, Lauer SA, Laeyendecker O, et al. Variation in false-negative rate of reverse transcriptase polymerase chain reaction-based SARS-CoV-2 tests by time since exposure. Ann Intern Med. 2020;173(4):262-267.

[6] Oyelade T, Alqahtani J, Canciani G. Prognosis of COVID-19 in patients with liver and kidney diseases: an early systematic review and meta-analysis. Trop Med Infect Dis. 2020;5(2):80.

[7] Prokop M, van Everdingen W, van Rees Vellinga T, et al. CO-RADS: a categorical CT assessment scheme for patients suspected of having COVID-19-definition and evaluation. Radiology. 2020;296(2):e97-e104.

[8] Abrishami A, Khalili N, Dalili N, et al. Clinical and radiologic characteristics of COVID-19 in patients with CKD. Iran J Kidney Dis. 2020;14(4):267-277.

[9] Duzgun SA, Durhan G, Demirkazik FB, et al. COVID-19 pneumonia: the great radiological mimicker. Insights Imaging. 2020;11(1):118.

[10] Kanne JP, Little BP, Chung JH, et al. Essentials for radiologists on covid-19: an update-radiology scientific expert panel. Radiology. 2020;296(2):e113-e4.

[11] Korevaar DA, Kootte RS, Smits LP, et al. Added value of chest computed tomography in suspected COVID-19: an analysis of 239 patients. Eur Respir J. 2020;56(2):2001377.

[12] Ai T, Yang Z, Hou H, et al. Correlation of chest CT and RT-PCR testing for coronavirus disease 2019 (COVID-

19) in China: a report of 1014 cases. Radiology. 2020;296(2):e32-e40.

[13] Barile M. Pulmonary edema: a pictorial review of imaging manifestations and current understanding of mechanisms of disease. Eur J Radiol Open. 2020;7:100274.

[14] Nagpal P, Narayanasamy S, Vidholia A, et al. Imaging of COVID-19 pneumonia: Patterns, pathogenesis, and advances. The British journal of radiology. 2020;93(1113):20200538.

[15] Wong HYF, Lam HYS, Fong AH, et al. Frequency and distribution of chest radiographic findings in patients positive for COVID-19. Radiology. 2020;296(2):e72-e78.

[16] Ahmadzadeh-Darinsoo M, Akbariqomi M, Ahmadzadeh-Darinsoo M, et al. Clinical features of covid-19 hospitalized patients with and without chronic kidney disease: a single-center, cross-sectional study. Electron J Gen Med. 2022;19(2):em345.

[17] Goicoechea M, Sánchez Cámara LA, Macías N, et al. COVID-19: clinical course and outcomes of 36 hemodialysis patients in Spain. Kidney Int. 2020;98(1):27-34.

[18] Weinstock MB, Echenique A, Russell JW, et al. Chest x-ray findings in 636 ambulatory patients with COVID-19 presenting to an urgent care center: a normal chest x-ray is no guarantee. J Urgent Care Med. 2020;14(7):13-18.

[19] Giannitto C, Sposta FM, Repici A, et al. Chest CT in patients with a moderate or high pretest probability of COVID-19 and negative swab. Radiol Med. 2020;125(12):1260-1270.

[20] Mehta V, Jyoti D, Guria RT, Sharma CB. Correlation between chest CT and RT-PCR testing in India's second COVID-19 wave: a retrospective cohort study. BMJ Evid Based Med. 2022;27(5):305-312.

[21] Nagaoka K, Kawasuji H, Takegoshi Y, et al. Association of subpleural ground-glass opacities with respiratory failure and RNAemia in COVID-19. Eur Radiol. 2023;33(7):4713-4722.

[22] Xie X, Zhong Z, Zhao W, et al. Chest CT for typical coronavirus disease 2019 (COVID-19) pneumonia: relationship to negative RT-PCR testing. Radiology. 2020;296(2):e41-e45.

[23] Amanat F, Stadlbauer D, Strohmeier S, et al. A serological assay to detect SARS-CoV-2 seroconversion in humans. Nat Med. 2020;26(7):1033-1036.

[24] Tu YF, Chien CS, Yarmishyn AA, et al. A Review of SARS-CoV-2 and the ongoing clinical trials. Int J Mol Sci. 2020;21(7):2657.

[25] Korevaar DA, Toubiana J, Chalumeau M, et al. Evaluating tests for diagnosing COVID-19 in the absence of a reliable reference standard: pitfalls and potential solutions. J Clin Epid. 2021;138:182-188.

[26] Seetulsingh P, Kannangara CI, Richman P. Undetectable SARS-CoV-2 in a nasopharyngeal swab but persistent viral RNA from deep lung swabs: findings from an autopsy. BMJ Case Rep. 2020;13(10):e237446.

[27] Korkmaz I, Dikmen N, Keleş FO, et al. Chest CT in COVID-19 pneumonia: correlations of imaging findings in clinically suspected but repeatedly RT-PCR test-negative patients. Egypt J Radiol Nucl Med. 2021;52(96):1-9.

[28] Ng QX, Liew MF, Yeo WS. Making sense of a negative COVID-19 swab test. Quant Imaging Med Surg. 2020;10(11):2212-2214.