Neutrophil-to-Lymphocyte Ratio as a Predictor of COVID-19 Disease in Haemodialysis Patients

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ABSTRACT

Background: Worldwide coronavirus disease 2019 (COVID-19) is caused by a coronavirus, one of the newly recognized and quickly spreading primary causes of pneumonia and severe acute respiratory syndrome (SARS-CoV-2). Patients with ESRD are most susceptible to morbidity and death linked to COVID-19.

Objective: The purpose of this study was to evaluate the importance of the NLR in ESRD patients as an inflammatory marker of COVID-19.

Patients and Methods: Eighty-four ESRD patients on maintenance hemodialysis at Ain Shams University Hospitals from February 2021 to the end of July 2021 participated in this prospective cohort research.

Results: Our results showed a greater level of NLR in the COVID-19 group, with a cut-off value of 5.26. Among all hematological measures, NLR had the highest specificity (95.24%) and sensitivity (76.19%) for COVID-19. Furthermore, there is a substantial positive connection between NLR and COVID-19 mortality. In the COVID group, NLR alone had a higher correlation with CRP than lymphocyte and neutrophil numbers. Our findings revealed that COVID-19 ESRD patients had substantially higher D dimer, LDH, CRP, and ferritin levels than non-COVID-19 ESRD patients. The COVID group in our study showed severe hypoalbuminemia, anemia, and a lower urea reduction rate (URR).

Conclusion: In ESRD patients, NLR, neutrophilia, and lymphopenia are thought to be predictive of COVID-19 illness. On the other hand, NLR has the highest specificity and sensitivity. In ESRD patients with COVID-19 illness, greater NLR levels were linked to increased death rates. Our findings showed that the COVID-19 patients receiving continuous hemodialysis fared better when anticoagulation and antiviral medication were used.

Keywords: Neutrophil, Lymphocyte, COVID-19, Haemodialysis

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INTRODUCTION

The mortality and morbidity rates among hemodialysis patients are greater than in the general population [(1)]. Pneumonia affects 20% of hemodialysis patients, and infection is the main cause of mortality after cardiovascular illness in ESRD patients [(2)]. Coronavirus is one of the world's (COVID-19) developing and quickly spreading main causes of pneumonia and severe acute respiratory syndrome (SARS-CoV-2) [(3)].

Owing to ESRD patients are immunocompromised with a high comorbidity burden, and the impractical social distancing rules in-centre hemodialysis, make them more vulnerable to COVID-19 disease [(4)]. The retention of uremic toxins, malnutrition, especially in an antioxidant diet, and antioxidant loss during hemodialysis, with leukocyte activation increase oxidative stress factors and oxidative product accumulation. Important factors that determine oxidative stress in hemodialysis patients are the duration of dialysis therapy, anemia, hemodialysis catheter, and bio-incompatible dialyzers [(5)]. Thus, making them more susceptible to COVID-19 disease, which resulted in a cytokine release [(6)].

Inflammatory responses affect the adaptive immune system of hemodialysis so circulating inflammatory biomarkers represent immune status and are considered potential predictors for COVID-19 patients' prognosis. Indications and prognostic factors of systemic inflammatory response including viral pneumonia are leucocytic WBC count, NLR, PLR, and LMR [(7)].

NLR is considered a predictor of ARDS resulting in generalized inflammation in the lungs in a rapid onset, which is one of the most common clinical pictures of COVID-19 disease [(8)]. Early identification and intervention of pulmonary infection risk factors affect the prognosis of maintenance hemodialysis patients [(5)].

Our study aimed to determine the significance of NLR as an inflammatory marker of COVID-19 in ESRD patients and compared different laboratory and clinical outcomes between COVID-19 ESRD and non-COVID-19 ESRD patients on maintenance hemodialysis.

PATIENTS AND METHODS

Eighty-four ESRD patients on maintenance hemodialysis at Ain Shams University Hospitals from February 2021 to the end of July 2021 participated in this prospective cohort study.

Patients were considered eligible if they were a) Patients on prevalent adequate hemodialysis for more than 6 months b) aged more than 18 years old c) possessed a functional arteriovenous fistula or arteriovenous graft that could provide 300 millilitres of blood per minute.

Exclusion criteria: Any patient with clinical evidence of infection other than COVID 19 including malignancy, having a vascular access complication, undergoing dialysis from a temporary or permanent dialysis catheter.

Patients were randomly allocated into two groups: **Group (1):** included 42 ESRD patients who tested positive for SARS-CoV-2 using RT-PCR on nasopharyngeal swabs or by characteristic COVID-19 radiological images on a thoracic computed tomography scan, and **Group (2):** included 42 ESRD patients who tested negative for SARS-CoV-2 on nasopharyngeal swabs or had normal thoracic computed tomography scans.

Study design

All patients maintained four-hour dialysis sessions thrice weekly using bicarbonate dialysate solutions (composition: Na+ 140 mmol/l, Cl- 111 mmol/l, Ca2+ 1.5 mmol/l, Mg2+ 0.5 mmol/l, K+ 2 mmol/l, acetate 2 mmol/l, and bicarbonate 33 mmol/l) with a blood flow rate of 300ml/min and a dialysate flow rate of 500ml/min. Anticoagulation was achieved using unfractionated heparin. All patients were receiving high flux hemodialysis HFHD using FX80 polysulfone membrane (Fresenius Medical Care, Germany) with a surface area of 1.8 m^2, ultrafiltration coefficient of 59ml/h x mmHg, and urea clearance of 276ml/min at a blood flow rate of 300ml/min. The ultrafiltration goal was determined based on interdialytic weight gain.

Relevant demographic data for all patients were obtained, including age, gender, weight, and BMI, as well as a detailed history of symptoms during the observational period and a detailed drug history, including oxygen therapy, medications, and outcomes among the COVID-19 group.

The study's outcome included comparing the clinical and laboratory results of COVID-19 ESRD and non-COVID-19 ESRD patients receiving maintenance hemodialysis, as well as evaluating the importance of NLR as an inflammatory marker of COVID-19 in ESRD patients.

Biochemical analyses

Blood samples obtained from the study population were used to analyze the following: CBC with differential count, CRP, ferritin, BUN -pre- and post-dialysis- with measured urea reduction ratio, serum albumin, LDH, and D-dimer. To determine the NLR for the research population, divide the absolute neutrophil count by the absolute lymphocyte count from a CBC with differential.

Data regarding nasopharyngeal swabs for COVID-19 PCR were collected. High-resolution CT chest findings for the study population were also collected.

Statistical analysis

SPSS V. 20.0 was utilized for statistical analysis. As counts and percentages, categorical variables were displayed. However, for skewed data, the median and interquartile range were displayed, and for properly distributed data, the mean ± SD. Group comparisons were performed using the independent-sample t-test. Using Fisher's exact test where appropriate or the chi-square test when appropriate, associations between categorical variables were discovered. Pearson's correlation test was used to determine the associations in the research. For statistical significance, p-values < 0.05 on both sides were considered significant.

RESULTS

Table 1: Comparison between COVID-19 and non-COVID-19 groups among demographic data.

		COVID 19 group	Non-COVID-19 group	Test value	P-value	Sig.
Age(years)	Mean ± SD Range	55.90 ± 14.88 24 – 85	45.64 ± 16.72 17 – 74	-2.971•	0.004	HS
Sex	Female Male	21 (50.0%) 21 (50.0%)	17 (40.5%) 25 (59.5%)	0.769*	0.381	NS

P-value >0.05: Non-significant (NS); P-value <0.05: Significant (S); P-value< 0.01: highly significant (HS) *: Chi-square test •: Independent t-test ‡: Mann Whitney test •: Independent t-test

Table 2: Comparison between COVID-19 and non-COVID-19 groups' anthropometric measures.

		COVID 19 group	Non- COVID 19 group	Test value	P-value	Sig.
Height (meter)	Mean ± SD Range	1.65 ± 0.07 1.50 – 1.75	1.64 ± 0.08 1.40 – 1.76	-0.452	0.653	NS
Weight(kg)	Mean ± SD Range	74.76 ± 10.34 54 – 100	74.69 ± 16.76 40 – 125	-0.024	0.981	NS
BMI kg/m^2)	Mean ± SD Range	27.57 ± 3.98 21.26 – 40	26.91 ± 6.54 0 – 45.91	-0.554	0.581	NS
Dry weight(kg)	Mean ± SD Range	72.22 ± 10.79 47 – 96	73.10 ± 16.29 38 – 121	0.288	0.774	NS
Systolic Blood Pressure (mmHg)	Mean ± SD Range	134.29 ± 17.55 100 – 170	124.64 ± 18.29 90 – 170	-2.465	0.016	S
Diastolic Blood Pressure(mmHg)	Mean ± SD Range	82.38 ± 12.65 50 – 110	74.88 ± 10.50 50 – 90	-2.956	0.004	HS

There were no statistically significant differences according to the height, weight, BMI, and dry weight of the studied subjects. On the other hand, the COVID-19 group had considerably higher systolic and diastolic blood pressures compared to the non-COVID-19 group.

Table 3: Comparison between COVID-19 and non-COVID-19 groups as regards Co-morbidities.

Co-morbidity	COVID 19 group		Non-COVID-19 group		Test value	P-value	Sig.
	No.	%	No.	%			
Diabetes mellitus	20	47.6%	6	14.3%	10.918	0.001	HS
Hypertension	27	64.3%	28	66.7%	0.053	0.818	NS
Atrial Fibrillation	3	7.1%	3	7.1%	0.000	1.000	NS
Ischemic Heart Disease	9	21.4%	8	19.0%	0.074	0.786	NS
Chronic Obstructive Pulmonary Disease	9	21.4%	2	4.8%	5.126	0.024	S
Autoimmune Diseases	0	0%	2	4.8%	2.049	0.152	NS

Table 3 demonstrates that diabetes mellitus and COPD were substantially more prevalent in the COVID-19 group than in the non-COVID-19 group, with p-values of 0.01 and 0.024, respectively.

Table 4: Comparison between COVID-19 and non-COVID-19 groups as regards laboratory data:

		COVID 19 group	Non- COVID 19 group	Test value	P-value	Sig.
Hb (g/dl)	Mean ± SD Range	9.18 ± 1.61 6.6 – 13.7	10.18 ± 1.54 7.44 – 15.1	2.899•	0.005	HS
CRP (mg/l)	Median (IQR) Range	100 (78.5 – 158) 21 – 549.8	10 (6 – 13) 6 – 38	-7.686‡	0.000	HS
Ferritin (mcg/L)	Median (IQR) Range	1151 (566 – 1567) 75 – 10000	690 (345 – 1153) 8.7 – 4239	-2.157‡	0.031	S
D-dimer (micro/mlIFEU)	Median (IQR) Range	3 (1.7 – 5) 0.38 – 10.3	0.63 (0.45 – 1.49) 0.23 – 4.32	-5.606‡	0.000	HS
LDH (U/L)	Median (IQR) Range	278.5 (213 – 464) 33 – 1056	180 (167 – 230) 97 – 320	-5.389‡	0.000	HS
serum albumin (g/dl)	Mean ± SD Range	3.31 ± 0.53 2 – 4.3	3.69 ± 0.51 2 – 4.4	3.296•	0.001	HS
BUN pre-session (mg/dl)	Median (IQR) Range	81 (56 – 96) 40 – 163	54 (41 – 64) 19 – 110	-4.131‡	0.000	HS
BUN post-session (mg/dl)	Median (IQR) Range	45 (35 – 65) 9 – 100	20 (15 – 30) 1 – 94	-5.697‡	0.000	HS
URR	Mean ± SD Range	37.35 ± 16.16 12.5 – 91.89	61.64 ± 17.91 15 – 98.61	6.527	< 0.001	HS

*: Chi-square test •: Independent t-test ‡: Mann Whitney test •: Independent t-test

As regards laboratory data, CRP, ferritin, D-dimer, LDH, pre, and post-dialysis BUN were significantly higher in the COVID-19 group. Also, as regards hemoglobin (Hb), serum albumin and URR were significantly lower in the COVID-19 group in comparison to the non-Covid group.

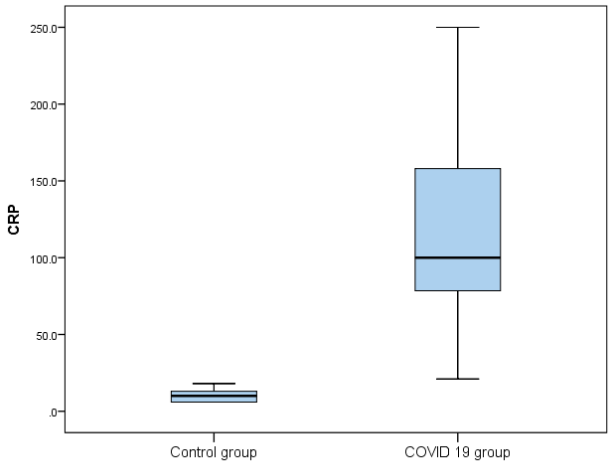

Figure (1): A box blot figure demonstrating the distribution of values (median, lower, and upper quartile) for CRP between both study groups.

Table 5: CT Chest findings, Oxygen therapy, Medications, and Outcomes among the COVID-19 group:

		COVID 19 group	
		No.	**%**
CORAD BY CT CHEST	1	2	4.8%
	2	1	2.4%
	3	6	14.3%
	4	8	19.0%
	5	25	59.5%
Oxygen Therapy	Nasal	20	47.6%
	Mask	14	33.3%
	CPAP	3	7.1%
	Non-breather mask	1	2.4%
	Ventilated	4	9.5%
Steroids	No	13	31.0%
	Yes	29	69.0%
Anticoagulation	No anticoagulation	1	2.4%
	Heparin	29	69.0%
	Oral new anticoagulant	11	26.2%
	Warfarin	1	2.4%
Anti-viral (Remdesivir)	Yes	27	64.3%
	No	15	35.7%
Outcome	Died	4	9.5%
	Alive	38	90.5%

Table 5 demonstrates outcomes among COVID-19 group patients, the most common CORAD score was CORAD 5(59.5%) taking into consideration that all our COVID group patients were hospitalized. Furthermore, all the patients needed oxygen therapy with different modalities ranging from nasal prong (47.6%) up to mechanical ventilation (9.5%). 69% of the patients received steroids in different forms during the hospitalization period. 97.6% of the patients received anticoagulation. A total of 27 patients (64.3%) received anti-viral (Remdesivir). 9.5% of patients died along the course of the disease.

Table 6: NLR, Neutrophils, and lymphocytes among both study groups:

		COVID 19 group	**Non- COVID 19 group**	**Test value ‡**	**P-value**	**Sig.**
Neutrophils ($(10^x$ 3/uL)	Median (IQR) Range	5.98 (3.6 – 8) 0.63 – 31.9	3.67 (2.93 – 4.74) 1.78 – 7.44	-3.463‡	0.001	HS
Lymphocytes (10^x 3/uL)	Median (IQR) Range	0.7 (0.47 – 1.07) 0.19 – 2.87	1.37 (1.14 – 1.75) 0.4 – 3.03	-4.728‡	0.000	HS
NLR	Median (IQR) Range	7.6 (5.59 – 11.18) 1.02 – 45.83	2.48 (2.13 – 3.9) 0.61 – 8.71	-5.931‡	0.000	HS

‡: Mann Whitney test •: Independent t-test

Table 6 shows that the median for NLR was [7.6 (5.59-11.18)] the COVID group had much greater rates than the non-COVID-19 group. Furthermore, the COVID-19 group had a considerably higher median neutrophil count than the non-COVID-19 group. The Lymphocyte median was substantially lower in the COVID group.

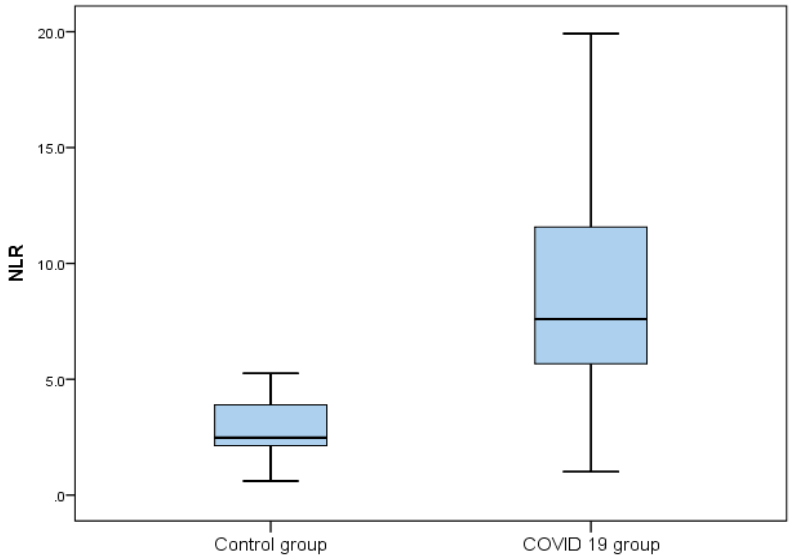

Figure (2): A box blot figure demonstrating the distribution of values (median, lower, and upper quartile) for NLR.

Table 7: Neutrophils, Lymphocytes, and NLR specificity and sensitivity in COVID-19 infection.

Parameter	AUC	Cut of Point	Sensitivity	Specificity	PPV	NPV
Neutrophils (10^x 3/uL)	0.719	>4.74	64.29	76.19	73.0	68.1
Lymphocytes((10^x 3/uL)	0.800	≤0.93	73.81	85.71	83.8	76.6
NLR	0.875	>5.26	76.19	95.24	94.1	80.0

Table 7 shows that NLR is more specific (95.24%) and sensitive (76.19%) in determining COVID-19 infection among ESRD patients compared to either lymphocytes or neutrophils alone.

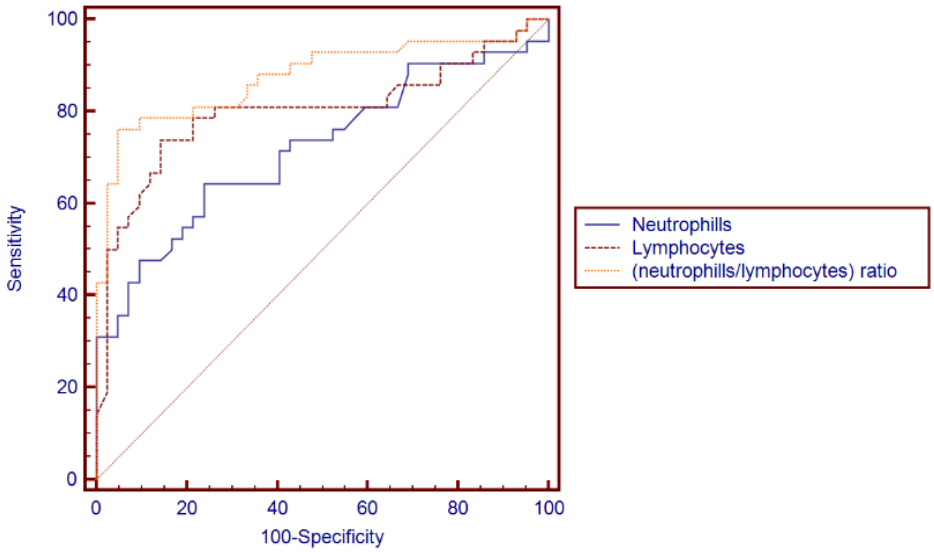

figure (3) ROC curve of neutrophils, lymphocytes, and NLR as a predictor of COVID 19

Table 8: Correlation of CORAD score, oxygen therapy, anticoagulation, antiviral, and outcome with NLR

		(Neutrophils/Lymphocytes) ratio		Test value	P-value	Sig.
		Median (IQR)	Range			
CORAD BY CT CHEST	1	1.26(1.26-1.26)	1.26-1.26	7.316‡‡	0.120	NS
	2	4.81(2.73-7.5)	2.18-8.17			
	3	8.6(5.83-14.75)	1.02-45.83			
	4	9.43(7.69-11.18)	7.69-11.18			
	5	9.9(6-21.27)	2.56 – 41.5			
Oxygen Therapy	Nasal	4.11(3.41-10.5)	3.41 – 10.5	5.215‡‡	0.266	NS
	Mask	6.9 (5.59 – 11.97)	2.56 – 31.19			
	CPAP	8.38(5.34-11.11)	1.02-41.5			
	Non-breather mask	7.33 (7.33 – 7.33)	7.33 – 7.33			
	Ventilated	19.38 (11.16 – 34.79)	7.33 – 45.83			
Anticoagulation	No anticoagulation	15 (15 – 15)	15 – 15	1.480‡‡	0.687	NS
	Heparin	8.6 (5.59 – 11.11)	1.02 – 31.42			
	Oral new anticoagulant	7.5 (4.69 – 14.75)	1.26 – 45.83			
	Warfarin	7.44 (7.44 – 7.44)	7.44 – 7.44			
Anti-viral (Remdesivir)	Yes	7.5 (4.69 – 11.11)	1.02 – 41.5	-0.932‡	0.351	NS
	No	10 (5.75 – 14.85)	3.41 – 45.83			
Outcome	Died	19.38 (11.16 – 34.79)	7.33 – 45.83	-2.057‡	0.040	S
	Alive	7.47 (4.69 – 11.11)	1.02 – 41.5			

‡: Mann Whitney test; ‡‡: Kruskal Wallis test

Table (8) shows that NLR was associated with poorer outcomes in the COVID-19 group (P 0.04).

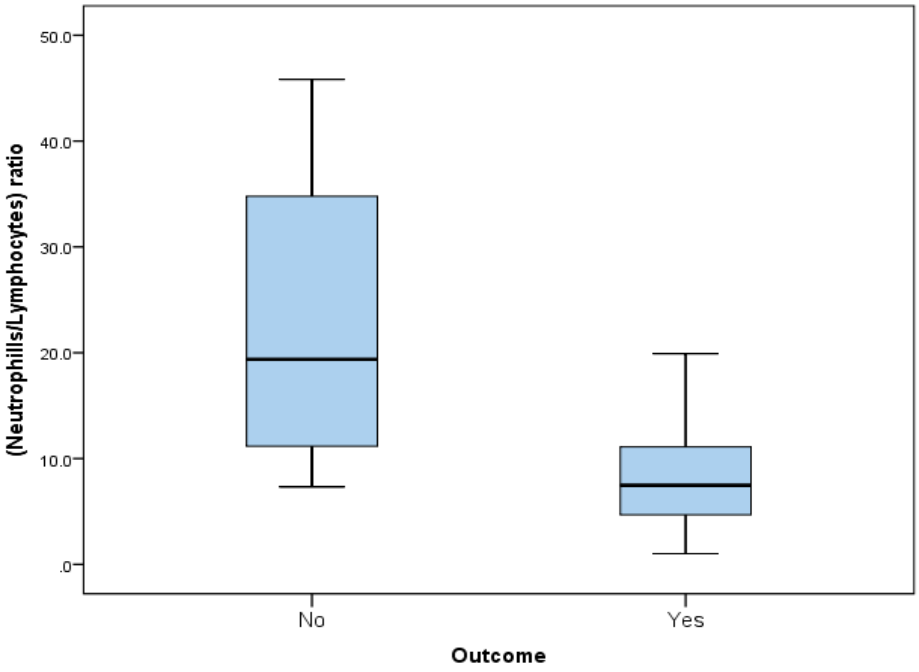

Figure (4) Correlation between NLR and the outcome.

Table 9: Correlation between neutrophils, lymphocytes, and NLR and other laboratory findings.

	Neutrophils		Lymphocytes		NLR	
	r	P-value	r	P-value	R	P-value
CRP	0.178	0.271	-0.308	0.053	0.403*	**0.010**
Ferritin	-0.142	0.369	-0.147	0.352	0.033	0.838
D-dimer(micro/mlIFEU)	0.180	0.254	-0.079	0.619	0.162	0.305
LDH (240-480)	-0.070	0.657	-0.083	0.603	0.022	0.891
serum albumin	-0.087	0.586	-0.411**	**0.007**	0.140	0.375

Table (9) shows that there was a substantial positive connection between the NLR and the CRP, with a p-value of 0.01. On the other hand, there was a negative correlation between lymphocytes and serum albumin with a p-value of 0.007. Apart from that, there are no other significant correlations.

DISCUSSION

In December 2019, the SARS-CoV-2 epidemic began in Wuhan, China. Three times a week, 4-hour restrictions in an indoor setting and the unavoidable interaction with medical personnel and other patients are factors that contribute to an elevated infection incidence in hemodialysis patients [(9)].

Dialysis patients were immunosuppressed and had several comorbidities. After cardiovascular disease, infection is the second most common reason for hospitalization and mortality among hemodialysis patients. Infection makes up 20% of cases of pneumonia. However, compared to non-dialysis patients, dialysis patients have a greater death rate and medical burden [(9)].

We included a population of 84 hemodialysis patients divided into two equal groups (the COVID group of which 50% were male and 50% were female and the non-COVID group of which 40.5% were female and 59.5% were male). The COVID group was identified using either typical COVID-19 radiological images from a thoracic CT scan or RT-PCR for SARS-CoV-2 on nasopharyngeal swabs.

In our study, diabetes was more commonly present in the COVID group 47.6% while the non-COVID group was only 14.3%. In agreement with our study, a previous study by **Özgür et al.** [(10)] demonstrated that COVID-19-infected ESRD patients had a statistically significant greater proportion of patients with diabetic nephropathy (p-value=0.03). Similarly, this result was supported by **De Meester et al.** [(11)] who demonstrated that diabetic ESRD patients had increasing odds of SARS-CoV-2 infection compared to other comorbidities. This can be explained by diabetic CKD patients treated with ACE Inhibitors and angiotensin II type 1 receptor blockers (ARBs) had increased ACE2 expression and increased risk of COVID-19 inhibition and fatality.

However, **Esposito et al.** [(12)] showed that the information gathered on DM between COVID-19 ESRD and non-COVID ESRD groups is negligible.

In our study, COPD was significantly more common in the COVID group than the non-COVID group with a p-value of 0.024.

This may be explained by COPD resulting in the impairment of innate and adaptive immunity and an increase of ACE2 enzyme in small airway epithelium and alveoli that facilitate SARS-COV-2 entry to cells. However, **Gerayeli et al.** [13] a systemic review that discussed general population studies on whether COPD patients were more susceptible to COVID-19. Because the data were collected from individuals who already had COVID-19, they were unable to determine if COPD enhanced the probability of contracting SARS-CoV-2 infection, the study stated that the odds of hospital admission increased in COPD patients. In agreement with our study, an explanation of why our study population (COVID-19-infected ESRD hospitalized patients) had COPD as a significant co-morbidity compared to the non-hospitalized non-COVID group.

The current study found that in comparison to the non-COVID group, the COVID-19 group had considerably reduced hemoglobin and serum albumin levels. According to prior research by **Pecly et al.** [14] that supported our findings, anemia was present in 77.3% of hemodialysis patients with COVID-19 during their hospital stay. This can be explained by the fact that COVID-19 patients produced more inflammatory cytokines, which impacted the longevity of erythrocytes and erythroid progenitor cells. **Izcovich et al.** [15] also demonstrated that the decrease in albumin in the COVID study group was associated with higher mortality and morbidity. In another research, done by **Kamel et al.** [16], COVID-19 hospitalized ESRD patients had lower serum albumin levels than non-ESRD patients.

CRP, ferritin, D-dimer, LDH, BUN pre, and BUN post were significantly higher in the COVID-19 group than in the non-COVID group as mentioned in our study. In agreement with our study, **Pecly et al.** [14] showed that most hospitalized hemodialysis ESRD patients with COVID-19 infection had higher CRP levels (52.3%), D-dimer (56.8%), and ferritin (70.5%). In another prospective randomized trial **Esposito et al.** [12] recruited maintenance hemodialysis patients infected with COVID-19, the results showed they had lymphopenia, and higher ferritin and LDH levels compared to non-COVID ESRD patients. This can be explained by chronic kidney disease patients had a higher prevalence of other co-morbid conditions such as DM, and uremic toxins associated with impairment of immunity, especially lymphocyte and granulocyte.

Our study found that neutrophils were significantly higher in the COVID ESRD group than in the non-COVID ESRD group, while the lymphocytic count was lower in the COVID group than in the non-COVID. Compatible with our results, lymphopenia was noticed in COVID-19 ESRD patients compared to non-infected ESRD patients, as shown in research done by **Esposito et al.** [12]. This was also proved by **Jianhong et al.** [17] who stated in their study that lymphocytopenia was noted in COVID-19 patients.

In the present study, NLR was considerably greater in the COVID group compared to the non-COVID-19 group. Our study showed that NLR is more specific

(95.24%) and sensitive (76.19%) in identifying COVID-19 infection among ESRD patients than either lymphocytes or neutrophils alone, with an NLR cut-off value of >5.26. NLR was also significantly correlated with the outcome of the patients, with non-survivors having a much higher NLR. This was proven by a multicentered retrospective study by **Oguz et al.** [18] that was conducted on 123 ESRD patients on hemodialysis hospitalized due to COVID-19 infection. NLR demonstrated a positive predictive value, indicating that NLR > 5.17 was substantially linked with ICU admission and mortality. An explanation could be that neutrophils an important for both innate and adaptive immunity components, and integration of NLR regarding two leucocyte subtypes gives a precise assessment of the immune system and clinical significance than other inflammatory markers.

In agreement with the current study, a multicentric observational study by **Mutinelli-Szymanski et al.** [19] included 62 hemodialysis patients with COVID-19 infection. The results indicated that NLR was >3.7 in severe COVID-19 patients. Also, **Reusch et al.** [20] demonstrated that NLR is higher in severe COVID infection. This highlights the importance of using simple and easy markers such as NLR to determine the poor prognosis and early supportive treatments to decrease mortality.

When correlating between neutrophils, lymphocytes, and NLR and other laboratory findings like CRP, ferritin, D-dimer, LDH, and serum albumin, we discovered a positive connection between NLR and CRP levels. Likewise, this data was supported by **Mousavi-Nasab et al.** [21] and **Sukrisman et al.** [22]. These results may indicate that a simple marker, such as NLR, can be utilized to distinguish between nonsevere and severe cases, particularly at a remote healthcare center.

In the present study, we correlated between NLR of the COVID-19 group and the CORAD score by CT chest, oxygen therapy, the use of anticoagulation, Remdesivir, and the outcome of the patients. There was a significant correlation was the NLR being associated with poorer outcomes in the COVID group. **Adina et al.** [23] showed a significant positive correlation between NLR, lymphopenia, and severity of CT chest.

In the current study, the most common CORAD score among the COVID group was CORAD 5(59.5%) while the least common CORAD score was CORAD 2(2.4%) Furthermore, all the COVID group patients needed oxygen therapy with different modalities ranging from nasal prong (47.6%) up to mechanical ventilation (9.5%). This was justified as our entire COVID group of patients were hospitalized with the main cause of admission being desaturation. Similar results were present in **Goicoechea et al.** [24]. A retrospective study done by **Tortonese et al.** [25] showed that 75 % of COVID-19 hemodialysis patients require oxygen therapy.

69% of the COVID group in the current study received steroids in different forms during the hospitalization period while 31% didn't. 97.6% of the COVID group patients received anticoagulation whether heparin (69%), oral new anticoagulant (26.2%), or

warfarin (2.4%). A total of 27 patients (64.3%) of the COVID group patients received anti-viral (Remdesivir). 9.5% of our COVID group died along the course of the disease while 90.5% survived. A study carried out by **Oguz et al.** [18] found that 23% died of COVID-19 among 123 hemodialysis patients. **Goicoechea et al.** [24] showed 30.5% of hemodialysis patients died of COVID-19 in a retrospective study. This difference in mortality rates might be attributed to different age groups and co-morbidities in different studies.

Limitations: This is a tiny population. Cytokines (IL-1β, IL-6, IL-12) were not measured. However, using a simple and not expensive marker as an NLR marker for COVID-19 hemodialysis patients and its correlation with patient outcome is considered a strength point in our study.

CONCLUSION

In ESRD patients, NLR, neutrophilia, and lymphopenia are thought to be predictive of COVID-19 illness. On the other hand, NLR has the highest specificity and sensitivity. In ESRD patients with COVID-19 illness, greater NLR levels were linked to increased fatality rates.

Ethical approval:

Ain Shams Medical Ethics Committee of the Faculty of Medicine gave its approval to this study (reference number: FMASU M S 17/ 2021 on 2/2/2021). After obtaining the necessary information, all participants provided verbal and written consent.

Data and material accessibility:

Although the study's datasets are confidential and not publicly accessible, they can be obtained from the appropriate author on justified request.

Contributions of the authors:

AOA contributed by acquiring data; MSA prepared the text; HAH, SMH, AOA, and MSA conceived the study and took part in its analysis and interpretation.

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