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Estimation of Urinary Monocyte-Chemoattractant Protein-1 level in Patients with Lupus Nephritis and its Relation to Disease Activity

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ABSTRACT

Background: Augmented levels of Monocyte-Chemoattractant Protein-1 (MCP-1) have been accompanied by enhanced renal inflammation and fibrosis, demonstrating its viability as a clinical marker of disease progression in Lupus Nephritis (LN).

Objective: This study designed to assess urinary MCP-1 concentrations in individuals with systemic lupus erythematosus (SLE) and to examine its linkage to overall disorder severity, with particular emphasis on active nephritis.

Methods: The current research utilized a cross-sectional approach to examine 90 participants aged 18 years and older, of both sexes with confirmed diagnosis of SLE in accordance with the 2019 ACR/EULAR criteria. The participants were stratified into three groups: Group I comprised participants with SLE without nephritis; Group II encompassed participants with SLE presenting with active nephritis; and Group III functioned as the control group and composed of healthy subjects matched by age and sex.

Results: A notable positive linkage was observed among MCP-1 and various renal manifestations, including hematuria, proteinuria, ESR at the first hour, CRP, blood urea, serum creatinine, albumin/creatinine ratio, red blood cells in urine, urinary protein levels, and anti-dsDNA titres ($P < 0.05$). Conversely, no linkage was found among MCP-1 levels and extrarenal manifestations such as serositis, neurological symptoms, photosensitivity and oral ulcers. Furthermore, MCP-1 exhibited a significant negative linkage with Hb, platelet count, and complement components C3 and C4 ($P < 0.001$). Specifically, the linkage coefficients for MCP-1 with C3 and C4 were $r = -0.545$ and $r = -0.367$, respectively, with $P < 0.001$ and 0.004.

Conclusions: Urinary MCP-1 levels were augmented in participants with active LN and demonstrated a strong linkage with disease activity when compared to participants without renal manifestations and healthy controls. Therefore, urinary MCP-1 may serve as a reliable indicator for surveillance of LN activity.

Keywords: Urinary monocyte-chemoattractant protein-1, Lupus nephritis, Disease activity, Systemic lupus erythematosus.

INTRODUCTION

SLE is a persistent autoimmune disorder marked by chronic inflammation and characterized by multisystem involvement. Its clinical manifestations frequently result from immune complex accumulation within the capillaries of various visceral organs or from the direct destruction of host cells mediated by autoantibodies [1].

LN represents a serious and prevalent adverse consequence of SLE, a persistent autoimmune disorder characterized by multisystem inflammation, including renal involvement. The kidneys are commonly affected in SLE, and the development of renal injury in LN may culminate in end-stage renal disease (ESRD) if not appropriately managed. Therefore, early detection and continuous monitoring of disease activity are essential to optimize treatment outcomes and prevent irreversible renal damage [2].

Several biomarkers have been investigated for their potential in assessing disease activity and guiding therapeutic interventions. One such biomarker is MCP-1, a chemokine critically facilitates immune cell recruitment, especially monocytes, to sites of inflammation. Augmented levels of MCP-1 have been linked to enhanced renal inflammation and fibrosis indicating that MCP-1 may function as a reliable marker for assessing disease severity in LN [3].

Numerous immune indicators and numerous proteins produced by human peripheral blood mononuclear cells have been identified, including a range of cytokines, chemokines, growth factors, soluble receptors, adhesion molecules, and markers of endothelial cell activation. These factors have been proposed as potential indicators for the timely identification of the disease. These biomarkers are anticipated to assist in predicting disease progression and monitoring therapeutic responses [4-7]. Despite extensive research efforts, no definitive indicators have yet been identified that reliably indicate the status of disease activity [8]. Urinary indicators are considered outperformed serum measures for detecting LN, likely as they represent immediate products and consequences of renal inflammation or injury [9-11]. Among these biomarkers, MCP-1 has emerged as a prominent and novel parameter of LN [6, 12, 13]. MCP-1 is a chemokine responsible for recruiting monocytes and macrophages to inflammation [14].

MCP-1 is synthesized by mesangial cells, podocytes, and monocytes due to exposure to multiple inflammation-inducing factors, such as tumor necrosis factor alpha (TNF-α). It initiates the migration of

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inflammatory cells and mediators, which thereafter exacerbate tissue damage and lead to the progression of renal dysfunction. Furthermore, MCP-1 interaction has been observed to decrease nephrin levels, a critical protein involved in maintaining kidney cell integrity and function [15]. While antagonists of MCP-1 have been shown to inhibit the progression of renal disorder, the presence of MCP-1 within the glomerulus has been linked to poorer renal function and may serve as an indicator of severe pathological classes of lupus nephritis [16]. Therefore, this research aimed to measure urinary MCP-1 levels in patients with SLE and to explore their relationship with the presence of active nephritis.

PATIENTS AND METHODS

Study individuals in this cross-sectional analysis comprised 90 participants aged 18 years and older of both sexes who were diagnosed with SLE in accordance to 2019 classification criteria established by the ACR/EULAR. The study period extended from June 2022 to December 2024.

Exclusion criteria: Participants diagnosed with rheumatoid arthritis and other autoimmune disorder, diabetes mellitus, cardiac disease, chronic liver disease, patients having malignant tumors or mental illness and pregnancy.

Participants were stratified into three equal groups: Groups I included participants with SLE without nephritis, groups II comprised participants with SLE with active nephritis and groups III, which contained age- & sex-matched healthy persons as controlled group.

All participants underwent comprehensive history taking and general physical examination, followed by laboratory investigations that included simple urine analysis, 24-hour urinary protein measurement or protein-to-creatinine ratio, complete blood count (CBC) assessing hemoglobin, white blood cells, and platelets, erythrocyte sedimentation rate (ESR), C-reactive protein (CRP), antinuclear antibodies (ANA), anti–double stranded DNA (anti-dsDNA) titers, kidney function tests (blood urea and serum creatinine), and complement components C3 and C4.

Diagnosis of LN: The study population was assessed for lupus disease severity using the Systemic Lupus Erythematosus Disease Activity Index (SLEDAI), alongside standard lab tests evaluations. Serological indicators of disease severity, such as complement components C3 and C4 and ESR ≥ 100 mm/hr, were evaluated. Indicators of renal flare, including urinary sediment analysis (proteinuria and hematuria), albumin-to-creatinine ratio, and quantitative assessment of proteinuria over 24 hours, were also measured. Renal impairment was assessed through elevated blood urea and serum creatinine levels.

Detection of MCP-1 in urine: Early morning urine samples were drawn from participants in both the study and control groups. Specimens were maintained at 4 °C and promptly delivered to the laboratory, where they underwent centrifugation to eliminate cellular debris. The supernatant was subsequently separated and preserved at –80 °C pending further examination. Urinary MCP-1 concentrations were measured using an ELISA kit obtained commercially, as per the manufacturer's recommendations.

Human MCP-1 ELISA kit:

Principle and material: The assay kit utilized was ELISA specifically designed for Human MCP-1 detection. Quantification of urinary MCP-1 utilized a sandwich ELISA format for quantification. Microplate wells were pre-coated with monoclonal antibodies selective for human MCP-1. Upon the addition of urine samples, MCP-1 present in the specimens captured by immobilized antibodies. A biotinylated secondary antibody selective for human MCP-1 was thereafter introduced to form a sandwich immune complex. Subsequently, streptavidin linked to horseradish peroxidase (HRP) was introduced, which binds to the biotinylated antibody. Following incubation, free streptavidin HRP was eliminated through multiple washing steps. A colorimetric substrate was subsequently added, inducing a colorimetric response that correlated linearly with the concentration of MCP-1 present in the sample. To terminate the enzymatic activity, an acidic stop solution was added, followed by absorbance measurement at 450 nm using a microplate reader. MCP-1 measured values were then read by reference to a standard curve generated from known MCP-1 measured values.

Specimen collection: Sterile tubes were used to collect urine samples, which were then centrifuged at 2000–3000 rpm for 20 minutes. The upper layer was carefully aspirated, ensuring exclusion of the sediment, and retained for subsequent analysis.

Reagent preparation: Reagents were pre-incubated at room temperature to ensure thermal equilibrium prior to experimentation. The standard preparation involved reconstituting 120 µL of the standard solution (1920 ng/L) with 120 µL of standard diluent to obtain a 960 ng/L stock solution. This stock was allowed to incubate for 15 minutes with gentle agitation before serial dilutions were performed. Duplicate standards were formulated through progressive dilution of the 960 ng/L stock solution 1:2 with standard diluent, resulting in concentrations of 480 ng/L, 240 ng/L, 120 ng/L, and 60 ng/L. The standard diluent served as the zero standard (0 ng/L).

For the wash buffer, 20 mL of 25× Wash Buffer Concentrate was diluted with deionized or distilled water to a final volume of 500 mL of 1× Wash Buffer.

To calculate results, a standard curve was generated y plotting the average OD values of the standards on the Y-axis against their respective concentrations on the X-axis. A best-fit curve was then drawn through the plotted points to interpolate sample concentrations (Figure 1).

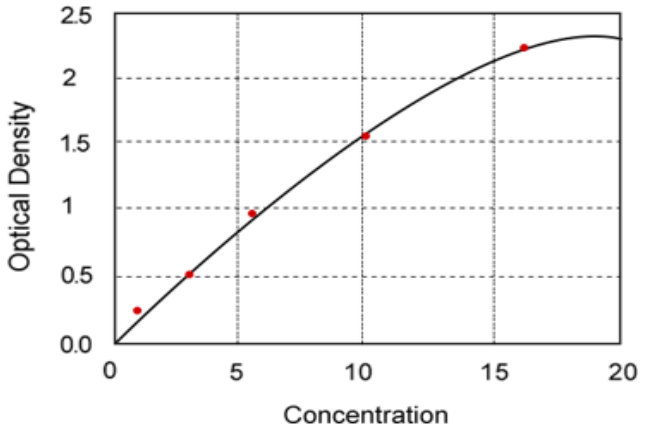

Figure (1): Standard curve**.**

Ethical approval: Ethical clearance was originated from the Ethics Committee of Tanta University, Egypt, and documented informed consents were provided by all subjects or their authorized representatives prior to participation. The study adhered to the Helsinki Declaration throughout its execution.

Statistical analysis

All statistical computations were carried out using IBM SPSS Statistics for Windows, version 27.0 (IBM Corporation, Armonk, NY, USA). The distribution of numerical variables was assessed for normality using the Shapiro–Wilk test and visual examination of histograms. Parametric quantitative data were represented as mean ± SD and relative to among groups using one-way analysis of variance (ANOVA), followed by Tukey's post hoc test for pairwise comparisons. Categorical data were expressed as frequencies and percentages, with intergroup differences calculated using the Chi-square (χ^2) test. A two-tailed *P*-value ≤ 0.05 was considered notably significant.

RESULTS

Thrombocytopenia (Plt<150000) and renal manifestation (hematuria and proteinuria) measurements in group II were notably higher than in groups I and III (P < 0.001). No meaningful variations were detected among the three study groups regarding age, sex, malar rash, discoid rash, oral ulcers, photosensitivity, arthritis, serositis (pleural and pericardial effusions), or neurological manifestations. Female patients exhibited a greater susceptibility compared to male participants (Table 1)

Table (1): Demographic and Clinical Profile of Participant Groups

		Group 1 (n=30)	Group II (n=30)	Group III (n=30)	P
Age (Years)		45.3 ± 8.06	43.8 ± 9.3	40.7 ± 10.73	0.167
Sex	**Male**	13 (43.33%)	8 (26.67%)	10 (33.33%)	0.393
	Female	17 (56.67%)	22 (73.33%)	20 (66.67%)	
Extra renal manifestation					
Malar rash		2 (6.67%)	3 (10%)	0 (0%)	0.227
Discoid rash		1 (3.33%)	3 (10%)	0 (0%)	0.160
Oral ulcers		2 (6.67%)	4 (13.33%)	0 (0%)	0.117
Photo sensitivity		0 (0%)	2 (6.67%)	0 (0%)	0.129
Arthritis		1 (3.33%)	2 (6.67%)	0 (0%)	0.355
Serositis (pleural effusion)		0 (0%)	1 (3.33%)	0 (0%)	0.364
Serositis (pericardial effusion)		0 (0%)	1 (3.33%)	0 (0%)	0.364
Neurological manifestations		0 (0%)	1 (3.33%)	0 (0%)	0.364
Thrombocytopenia (Plt<150000)		9 (30%)	18 (60%)	0 (0%)	**<0.001***
Renal manifestation					
Hematuria		0 (0%)	11 (36.67%)	0 (0%)	**<0.001***
Proteinuria		0 (0%)	9 (30%)	0 (0%)	**<0.001***

Results are shown as mean ± SD or frequency (%).

Hemoglobin (Hb) levels were markedly reduced in group II relative to groups I and III (P < 0.001), with no marked variation observed among groups I and III. White blood cell counts differed markedly among the three groups. Platelet counts were markedly reduced in groups I and II relative to group III (P < 0.001), while no marked difference was found among groups I and II. Both ESR at the first hour and CRP levels were markedly elevated in group II against groups I and III (P < 0.05), and were also markedly increased in group I against group III (P < 0.001). Serum creatinine, blood urea, albumin-to-creatinine ratio, urinary red blood cells, and urinary protein levels were markedly increased in group II relative to groups I and III (P < 0.05), without marked differences among groups I and III (Table 2).

Table (2): Laboratory profile, activity markers of lupus and MCP-1 of the participant groups

	Group I (n=30)	Group II (n=30)	Group III (n=30)	P value	Post hoc
CBC					
Hb (g/dL)	11.6 ± 0.77	10.5 ± 1.26	12.1 ± 0.64	**<0.001***	**P1 < 0.001*P2 = 0.119P3 < 0.001***
WBC (10^9/L)	5.9 ± 1.04	6.1 ± 1.5	6.8 ± 1.48	0.121	
Platelet (10^9/L)	188.9 ± 47.10	168.6 ± 41.98	294.2 ± 73.21	**<0.001***	**P1 = 0.454P2 < 0.001*P3 < 0.001***
Serological markers					
ESR at first hour (mm/hr)	38.8 ± 9.61	47.6 ± 11.62	6.6 ± 1.42	**<0.001***	**P1 = 0.025*P2 < 0.001*P3 < 0.001***
CRP (mg/ml)	26.6 ± 6.51	33.1 ± 8.14	5.1 ± 1.14	**<0.001***	**P1 = 0.012*P2 < 0.001*P3 < 0.001***
Kidney function					
Serum creatinine (mg/dl)	0.9 ± 0.21	1.6 ± 0.40	0.7 ± 0.11	**<0.001***	**P1 < 0.001*P2 = 0.074P3 < 0.001***
Blood urea (mg/dl)	28.7 ± 6.95	41.2 ± 8.92	22.9 ± 5.66	**<0.001***	**P1 < 0.001*P2 = 0.129P3 < 0.001***
Albumin / creatinine ratio (mg/g)	11 ± 2.71	66.7 ± 6.52	6.8 ± 1.61	**<0.001***	**P1 = 0.003*P2 = 0.943P3 < 0.001***
RBCs cells in urine	2.9 ± 0.68	19.4 ± 3.33	2.2 ± 0.50	**<0.001***	**P1 < 0.001*P2 = 0.329P3 < 0.001***
Protein in urine	0.2 ± 0.04	2.6 ± 0.62	0 ± 0	**<0.001***	**P1 < 0.001*P2 = 0.857P3 < 0.001***
C3 (mg/dL)	99.8 ± 24.92	88.8 ± 19.12	121.9 ± 7.35	**<0.001***	**P1 = 0.092P2 < 0.001*P3 < 0.001***
C4 (mg/dL)	24.8 ± 5.74	22.9 ± 5.62	28.5 ± 3.93	**<0.001***	**P1 = 0.437P2 = 0.046*P3 = 0.001***
Albumin / creatinine ratio (mg/g)	11 ± 2.12	66.7 ± 16.44	6.8 ± 1.60	**<0.001***	**P1 = 0.003*P2 = 0.943P3 < 0.001***
RBCs cells in urine	2.9 ± 0.41	19.4 ± 3.33	2.2 ± 0.48	**<0.001***	**P1 < 0.001*P2 = 0.329P3 < 0.001***
Protein in urine	0.2 ± 0.04	2.6 ± 0.64	0 ± 0	**<0.001***	**P1 < 0.001*P2 = 0.857P3 < 0.001***
Serum creatinine (mg/dl)	0.9 ± 0.21	1.6 ± 0.40	0.7 ± 0.11	**<0.001***	**P1 < 0.001*P2 = 0.074P3 < 0.001***
Blood urea (mg/dl)	28.7 ± 6.80	41.2 ± 8.92	22.9 ± 5.66	**<0.001***	**P1 < 0.001*P2 = 0.129P3 < 0.001***
ANA titer	1.3 ± 0.31	2.2 ± 0.48	0.7 ± 0.16	**<0.001***	**P1 = 0.004*P2 < 0.034*P3 < 0.001***
Anti-dsDNA titer	149.4 ± 56.91	285.9 ± 36.18	13.2 ± 1.68	**0.002***	**P1 = 0.049*P2 = 0.047*P3 < 0.001***
Monocyte chemoattractant protein 1 (pg/ml)	317.6 ± 41.25	457.8 ± 91.09	158.3 ± 38.74	**<0.001***	**P1<0.001* P2<0.001* P3<0.001***

Results are shown as mean ± SD or frequency (%). *p value <0.05, P1: P value among group I and group II, P2: P value among group I and group III, P3: P value among group II and group III. HB: Haemoglobin, CRP: C-reactive protein, WBC: white blood cell, RBCs: red blood cell, ANA: Antinuclear antibodies, Anti-dsDNA: anti-double stranded DNA antibodies.

Mild (SLEDAI score >4–8) and moderate (SLEDAI score >8–12) disease activity scores didn't differ markedly among the two groups. However, inactive disease (SLEDAI score 0–4) was markedly more prevalent in group I against group II ($P < 0.001$), whereas severe disease activity (SLEDAI score >12) was markedly less frequent in group I against group II ($P < 0.001$) (Table 3).

Table (3): SLEDAI score in group I and group II

		Group I (n=30)	Group II (n=30)	P
SLEDAI score	**Inactive (0–4)**	19 (63.33%)	0 (0%)	**<0.001***
	Mild (>4–8)	7 (23.33%)	5 (16.67%)	0.519
	Moderate (>8–12)	4 (13.33%)	6 (20%)	0.731
	Severe (>12)	0 (0%)	19 (63.33%)	**<0.001***

*: Significant.

There was a positive linkage among monocyte chemoattractant protein 1 and renal manifestation (hematuria and proteinuria), ESR at first hour, CRP, blood urea, serum creatinine, albumin/ creatinine ratio, RBCs cells, urinary proteins and anti dsDNA titer) (P value <0.05). No linkage was observed among MCP-1 levels and extrarenal manifestations (serositis, neurological, photo sensitivities & oral ulcers). A marked negative linkage was found among MCP-1 levels and Hb, platelet count, and complement components C3 and C4 (P < 0.001). Specifically, MCP-1 exhibited negative linkage with C3 (r = -0.545, P < 0.001) and C4 (r = -0.367, P = 0.004) (**Table 4**).

Table (4): Linkage between MCP-1 and (clinical data, laboratory data

	MCP-1	
	r	P value
Malar rash	0.171	0.107
Discoid rash	0.174	0.102
Oral ulcers	0.205	0.052
Photo sensitivity	0.132	0.214
Arthritis	0.164	0.124
Serositis (pleural effusion)	0.172	0.106
Serositis (cardiac effusion)	0.172	0.106
Neurological (epilepsy)	0.132	0.212
Thrombocytopenia	0.194	0.067
Hematuria	0.429	<0.001*
Proteinuria	0.369	0.003*
Laboratory data	**MCP-1**	
ESR at first hour (mm/hr)	0.727	**<0.001***
CRP (mg/ml)	0.714	**<0.001***
HB (g/dL)	-0.497	**<0.001***
WBC (10^9/L)	-0.183	0.085
Platelet (10^9/L)	-0.618	**<0.001***
Blood urea (mg/dl)	0.602	**<0.001***
Serum creatinine (mg/dl)	0.612	**<0.001***
Activity markers of lupus	**MCP-1**	
C3 (mg/dL)	-0.545	**<0.001***
C4 (mg/dL)	-0.367	**0.004***
Albumin / creatinine ratio (mg/g)	0.316	**0.002***
RBCs cells in urine	0.595	**<0.001***
Protein in urine	0.589	**<0.001***
ANA titer	0.443	**<0.001***
Anti dsDNA titer	0.405	**<0.001***

*: Significant, P1: P value among group I and group II, P2: P value among group I and group III, P3: P value among group II and group III.

MCP-1 was markedly reduced in participants with SLEDAI score<12 than in participants with SLEDAI score>12 (P value=0.047) (Table 5).

Table (5): Relation among MCP-1 and SLEDAI score in group II

	SLEDAI score<12 (n=11)	SLEDAI score>12 (n=19)	P
MCP- 1 (pg/ml)	414.45 ± 36.22	438.63 ± 27.2	**0.047***

*: Significant.

DISCUSSION

SLE is a long-standing autoimmune state distinguished by widespread inflammations that can implicate a range of tissue and organs, with symptoms varying from mild to severe and the condition often follows an unpredictable pattern, alternating between periods of remission and flare-ups [17].

In the present study, ESR at first hour was markedly elevated in group II than in group I and group III and were markedly elevated in group I than in group III. Likewise, **Zedan *et al.*** [18] reported that ESR at first hour was notably increased in LN group than (SLE group and control group) and was notably increased in SLE group relative to control group. **Taha *et al.*** [19] reported similar findings. Contrarily, **Aldakhakhny *et al.*** [20] found that there were no notable difference in ESR observed among LN group and SLE group.

This research showed that, CRP was notably higher in group II than in group I and group III and were notably higher in group I than in group III. **Zedan *et al.*** [18] agrees with our findings, as they reported that CRP was notably increased in LN group relative to SLE group and control group and notably increased in SLE group relative to control group. **Taha *et al.*** [19] reported similar findings. In contrast, **Aldakhakhny *et al.*** [20] found that no notable difference in CRP was observed among LN group and SLE group.

In our study, serum creatinine and blood urea were notably increased in group II relative to group I and group III. Besides, albumin/creatinine ratio and protein in urine were markedly elevated in group II against group I and group III. In line with our results, **Zedan *et al.*** [18] found that protein in urine was notably raised in LN group than in SLE group and control group. **El-Shehaby *et al.*** [13] and **Taha *et al.*** [19] reported similar findings regarding protein in urine. Additionally, **Najla *et al.*** [21] reported that albumin/creatinine ratio was notably higher in LN group versus SLE group.

In the present study, C3 and C4 were notably reduced in group I and group II relative to group III. In line with our data, **Soliman *et al.*** [22] documented that C3 and C4 were notably reduced in LN group and SLE

group versus control group. However, a previous study contradicted the previous findings. The authors found that C3 and C4 were notably reduced in LN group than SLE group [19].

In our study, anti dsDNA titer was markedly elevated in group II relative to group I and group III and was markedly elevated in group I than in group III. **Zedan *et al.*** [18] confirmed our findings as they reported that anti dsDNA was notably increased in LN group than in SLE group and control group and was more in SLE group relative to control group. **Taha *et al.*** [19] reported similar findings regarding anti dsDNA. However, **Mirfeizi *et al.*** [23] found that anti dsDNA titer showed no meaningful difference among SLE group and LN group.

In the present research, MCP-1 was markedly elevated in group II than in group I and group III and was markedly elevated in group I than in group III. In agreement with our results, **Zedan *et al.*** [18] found that MCP-1 was notably raised in LN group than in SLE group and control group and was notably increased in SLE group versus control group. **Tawfik *et al.*** [24] and **El-Shehaby *et al.*** [13] reported similar findings. Contrarily, **Živković *et al.*** [25] reported that median values of MCP-1 showed no meaningful difference between both participants with active LN and those with inactive LN. This variation may be due to the different sample sizes in both studies.

In our study, the inactive (0–4) SLEDAI score was notably increased in group I relative to group II. Severe (>12) SLEDAI score was markedly reduced in group I relative to group II. As our results, **Najla *et al.*** [21] found that SLEDAI score was markedly reduced in SLE group than in LN group. Also, **Taha *et al.*** [19] reported similar findings. Besides, **Alzawawy *et al.*** [10] reported that inactive (0–4) SLEDAI score was markedly elevated in participants without renal involvement than participants with renal involvement. Severe (>12) SLEDAI score was markedly reduced in participants without renal involvement than patients with renal involvement.

In our study, a positive linkage was identified among MCP-1 levels and the presence of hematuria. As our results, **Kiani *et al.*** [26] documented that there was a positive linkage among MCP-1 and hematuria. In contrast, **El-Shehaby *et al.*** [13] reported that there was no meaningful linkage among MCP-1 and hematuria.

In our study, there was a positive linkage among MCP-1 and proteinuria. As our results, **Zedan *et al.*** [18] found that there was a positive linkage among MCP-1 and proteinuria. Also, **Živković *et al.*** [25], **Taha *et al.*** [19] and **El-Shehaby *et al.*** [13] reported similar findings. However, **Noris *et al.*** [27] failed to demonstrate a linkage among urinary MCP-1 and proteinuria.

In our research, there was a linear linkage among MCP-1 and ESR at first hour. Similarly, **Zedan *et al.*** [18] reported that there was a linear linkage among MCP-1 and ESR in participants with LN. In contrast, **Ellingsen *et al.*** [28] observed that no meaningful relationship existed among plasma MCP-1 levels and ESR.

In our research, there was a linear linkage among MCP-1 and CRP. Similarly, **Liou *et al.*** [29] found that there was a positive linkage among MCP-1 and CRP. However, **Ellingsen *et al.*** [28] reported that no meaningful relationship existed among plasma MCP-1 levels and CRP levels.

In our research, there was a positive linkage among MCP-1 and blood urea and serum creatinine. As our results, **Zedan *et al.*** [18] documented that there was a positive linkage among MCP-1 and blood urea in participants with active LN. Also, **El-Shehaby *et al.*** [13] observed similar findings regarding serum creatinine. Contrarily, **Zedan *et al.*** [18] reported that no linkage was found among MCP-1 and serum creatinine in LN groups.

In the present study, there was a negative linkage among MCP-1 and Hb and platelet. **Alzawawy *et al.*** [10] agrees with our findings, as they reported that there was a negative linkage among MCP-1 and Hb. Opposing to the previous results, **Panasiuk *et al.*** [30] found that no linkage was observed among MCP-1 concentration and platelet.

In our study, there was a negative linkage among MCP-1 and C3 and C4. As our results, **Zedan *et al.*** [18] found that there was a negative linkage among MCP-1 and (C3 and C4). Also, **El-Shehaby *et al.*** [13] and **Živković *et al.*** [25] reported similar findings. In contrast, **Hassan *et al.*** [31] found that there was no meaningful relationship existed among MCP-1 and (C3 and C4) in participants with LN.

In the current research, there was a positive linkage among MCP-1 and albumin/creatinine ratio and urinary proteins. In line with our research, **Tawfik *et al.*** [24] found that urinary MCP-1 shows a significantly positive linkage with albumin/creatinine ratio. Besides, **El-Shehaby *et al.*** [13] found that there was a positive linkage among MCP-1 and urinary proteins.

Nevertheless, contrary to previous findings, the earlier study conducted by **Dai *et al.*** [32] was unable to detect any linkage among urinary MCP-1 and proteinuria in LN participants and the same finding was documented in subsequent research by **Mirfeizi *et al.*** [23].

In our study, there was a positive linkage among MCP-1 and anti dsDNA titer. As our results, **Taha *et al.*** [19] documented that there was a linear linkage among MCP-1 and anti dsDNA in participants with active LN. Also, **Zedan *et al.*** [18] reported similar findings. However, **Alharazy *et al.*** [33] documented that there were no meaningful relationship existed among uMCP-1 levels and anti-dsDNA Ab titres.

In the current study, MCP-1 was markedly reduced in participants with SLEDAI score<12 than in participants with SLEDAI score>12. As our results, **Zedan *et al.*** [18] documented that there was a meaningful linear linkage among urinary MCP-1 and renal SLEDAI. **El-Shehaby *et al.*** [13], **Barbado *et al.***

[34], and Taha *et al.* [19] observed similar results. In contrast, Živković *et al.* [25] documented that median values of urinary MCP-1 were insignificantly different among those with SLEDAI from 0 to 10 and those with SLEDAI ≥11.

LIMITATIONS

Primary limitation of this research was its one-center design, which may limit the applicability of the findings. Additionally, dimensioned sample size may decrease the statistical power of the analysis. The research did not include a comparative evaluation of MCP-1 against other established biomarkers, nor did it assess the effects of LN treatment on renal function parameters in participants with SLE.

CONCLUSION

Our findings documented that urinary MCP-1 levels were high and showed a strong linkage with disease activity in participants with active LN in contrast to participants without renal involvement and healthy controls. MCP-1 was positively linked with renal manifestations, ESR at the first hour, CRP, blood urea, serum creatinine, albumin/creatinine ratio, urinary red blood cells, urinary protein levels, and anti-dsDNA titers. Conversely, it was negatively correlated with hemoglobin levels, platelet count, and complement components C3 and C4. Based on these observations, we concluded that urinary MCP-1 may serve as a reliable indicator for evaluation of LN activity.

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