

Utility of Urinary Neutrophil Gelatinase-Associated Lipocalin (NGAL) as a Non-Invasive Marker for Renal Pathology & Treatment Outcomes in Lupus Nephritis

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Abstract:

Introduction: Young women are primarily affected by lupus nephritis, which is linked to systemic lupus erythematosus and can seriously harm the kidneys if left untreated. Urine neutrophil gelatinase-associated lipocalin (NGAL) has become a viable non-invasive biomarker due to the invasiveness of renal biopsy. NGAL levels provide crucial information about kidney damage and the efficacy of therapy by indicating the severity of the disease and the response to treatment.

Materials & Methods: A prospective observational study was conducted at BSMMU, Dhaka, between March 2023 and August 2024. Fifty-two adults with biopsy-proven lupus nephritis were enrolled. Clinical characteristics, urinary NGAL levels, biochemical parameters, and renal histopathology were recorded at baseline and reassessed after six months of therapy.

Results: The study predominantly involved young females (92.3%), with 69.2% under the age of 30 and 67.3% having a normal weight. A majority were married (80.8%) and resided in urban areas (57.7%). Histologically, 57.7% of participants had class IV lupus nephritis. All patients were treated with Hydroxychloroquine, while 61.5% also received Cyclophosphamide plus Corticosteroids, 23.1% received MMF plus Corticosteroids, and 15.4% were treated with only Corticosteroids. A complete response was achieved by 67.3% of the patients. Urinary NGAL levels, a marker of renal inflammation, were highest in patients with class IV lupus nephritis, both at baseline (2.14 ± 1.01 ng/mL) and at 6 months (1.20 ± 0.59 ng/mL), with a significant correlation to disease severity ($p < 0.05$). Patients with proliferative lupus nephritis had higher urinary NGAL, elevated serum creatinine, and lower serum albumin levels compared to those with non-proliferative lupus nephritis. Those who experienced a complete response exhibited lower NGAL levels at both baseline (1.39 ± 0.48 ng/mL) and 6 months (0.80 ± 0.25 ng/mL).

Conclusion: The study highlights the potential of urine NGAL as a valuable biomarker for evaluating disease severity and treatment outcomes in lupus nephritis, suggesting that it could enhance clinical management and inform therapeutic decisions. However, further large-scale, multi-center studies are required to validate its use in routine clinical practice.

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Introduction:

Lupus nephritis is a major contributor to morbidity in systemic lupus erythematosus (SLE), an immune-mediated disorder that disproportionately affects women of reproductive age.¹⁻⁴ Renal involvement

occurs in a substantial proportion of patients, and the associated inflammation may lead to progressive scarring, chronic kidney disease, or renal failure if prompt management is not initiated.^{5,6}

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The wide spectrum of clinical presentations—from asymptomatic urinary abnormalities to rapidly progressive glomerulonephritis—creates diagnostic and therapeutic challenges.⁷⁻⁹ Early identification of active disease and reliable monitoring of treatment efficacy are therefore essential to optimize long-term outcomes.¹⁰

Renal biopsy provides crucial information for diagnosis, classification, and prognosis.^{11,12} Yet its invasive nature, procedure-related risks, and limitations for repeated monitoring have stimulated interest in alternative tools. Urinary neutrophil gelatinase-associated lipocalin (NGAL) is one such biomarker under active investigation.^{13,14} NGAL is released from renal tubular epithelial cells in response to injury and inflammation, making it a potential indicator of renal involvement in lupus nephritis.¹⁵⁻¹⁷ Numerous studies have shown the effectiveness of urine NGAL in Growing evidence suggests that urinary NGAL correlates with disease activity, histopathological severity, & response to treatment.¹⁸⁻²²

The current study evaluates urinary NGAL as a marker of renal inflammation and treatment response in patients with lupus nephritis, aiming to determine its clinical utility alongside conventional biochemical and histopathological indicators.

Materials and Methods:

This prospective observational study took place at the Nephrology Department of BSMMU, Dhaka, from

March 2023 to August 2024, and included 52 adult patients (≥ 18 years) diagnosed with biopsy-confirmed lupus nephritis. Patients with malignancies, infections, other autoimmune disorders, or insufficient biopsy samples were excluded.

After obtaining ethical approval and informed consent, participants underwent renal biopsy, urine collection for NGAL measurement, and various biochemical tests. Urine NGAL levels were assessed using a commercial ELISA kit, and treatment followed KDIGO guidelines.

All patients received Hydroxychloroquine, with immunosuppressive therapy adjusted according to the severity of the disease. Patients were monitored for six months, and their treatment response was classified as complete, partial, or no response.

Data analysis was conducted using SPSS v25, with statistical significance set at $p < 0.05$.

Results:

The majority of the 52 patients were female (92.3%) and under 30 years old (69.2%). Most of them were married (80.8%), resided in cities (57.7%), and had a normal BMI (67.3%). 94.3% had no to mild tubular atrophy and 92.3% had no to mild interstitial fibrosis at admission, but 51.9% had substantial tubulointerstitial inflammation.

Table-I:
Descriptive statistics of the study population. (n = 52)

Characteristics	Data	
Age group (in years)	<30	36 (69.2%)
	30 - 45	15 (28.8%)
	>45	1 (1.9%)
Gender	Male	4 (7.7%)
	Female	48 (92.3%)
BMI classification	Normal weight (18.5 - 24.9 kg/m ²)	35 (67.3%)
	Overweight (25 - 29.9 kg/m ²)	16 (30.8%)
	Obese (>30.0 kg/m ²)	1 (1.9%)
Marital status	Married	42 (80.8%)
	Unmarried	10 (19.2%)
Residence	Rural	22 (42.3%)
	Urban	30 (57.7%)
Tubulointerstitial inflammation	No inflammation	0
	Minimal	3 (5.8%)
	Mild	22 (42.3%)
	Moderate	27 (51.9%)
	Severe	0
Tubular atrophy	No to mild	49 (94.3%)
	Moderate to severe	3 (5.8%)
Interstitial fibrosis	No to mild	48 (92.3%)
	Moderate to severe	4 (7.7%)

Data presented as n (%).

Class IV lupus nephritis accounted for the majority of patients (57.7%), followed by class III (17.3%) and class II (15.4%), according to histological examination. There were no class I or VI cases found.

Multiple treatment protocols were administered to the study population (Table II). All respondents (100%) were given hydroxychloroquine, 61.5% were given cyclophosphamide plus corticosteroid, 23.1% were given MMF plus corticosteroid, and 15.4% were given corticosteroid alone. 67.3% of respondents gave a complete response, 28.8% gave a partial response, and 3.8% gave no response at all.

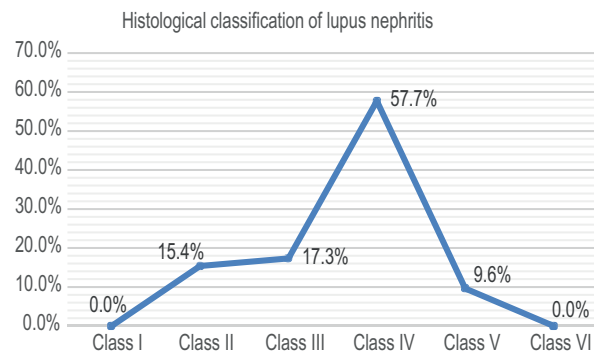


Figure 1: Distribution of study population according to histological classification of lupus nephritis. (n = 52)

Table-II:

Distribution of study population according to treatment. (n = 52)

Characteristics	Data
Treatment protocol	MMF + Corticosteroid 12 (23.1%)
	Cyclophosphamide + Corticosteroid 32 (61.5%)
	Corticosteroid (only) 8 (15.4%)
	Hydroxychloroquine 52 (100.0%)
Treatment response	Complete response 35 (67.3%)
	Partial response 15 (28.8%)
	No response 2 (3.8%)

Data presented as n (%).

At baseline (2.14 ± 1.01 ng/mL) and at 6 months (1.20 ± 0.59 ng/mL), class IV lupus nephritis had the highest urine NGAL levels, followed by class III. Histological class differences showed a substantial connection with disease severity and were statistically significant ($p < 0.05$).

Urinary NGAL levels were significantly higher in proliferative nephritis at both time points. Urinary PCR did not significantly change at any time point.

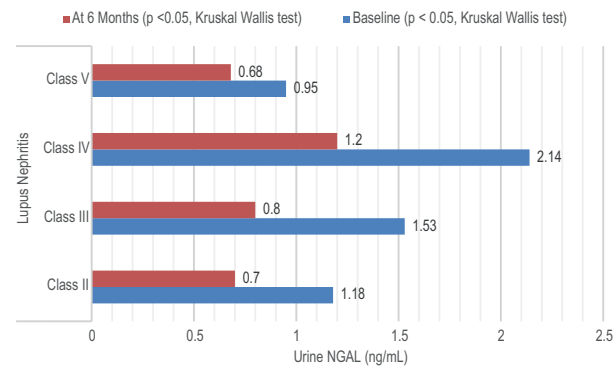


Figure 2: Urine NGAL levels at different stages of lupus nephritis.

Table-III:

Comparison of biochemical profile between proliferative and non-proliferative groups. (n = 52)

Characteristics		Lupus Nephritis		P value
		Proliferative	Non-Proliferative	
Baseline	Urine NGAL (ng/mL)	2.00 ± 0.96	1.12 ± 0.29	$< 0.05^a$
	Urinary PCR (mg/mmol)	3.22 ± 2.08	3.07 ± 3.59	0.852^a
At 6 Months	Urine NGAL (ng/mL)	1.11 ± 0.56	0.70 ± 0.15	$< 0.05^a$
	Urinary PCR (mg/mmol)	0.69 ± 0.94	0.21 ± 0.21	0.073^a

Data presented as mean $\pm$ SD.

^a Unpaired t-test was done. $P < 0.05$ was considered statistically significant.

Patients with moderate tubulointerstitial inflammation had the highest urine NGAL levels (2.34 ± 0.90 ng/mL), followed by mild (1.16 ± 0.14 ng/mL) and minimal (0.81 ± 0.16 ng/mL) inflammation. There were statistically significant differences between the groups ($p < 0.05$).

At baseline and six months, the proliferative group's median NGAL levels were higher than those of the non-proliferative lupus nephritis patients (Figure 3). Individuals with elevated urine NGAL levels were more prevalent in the proliferative group.

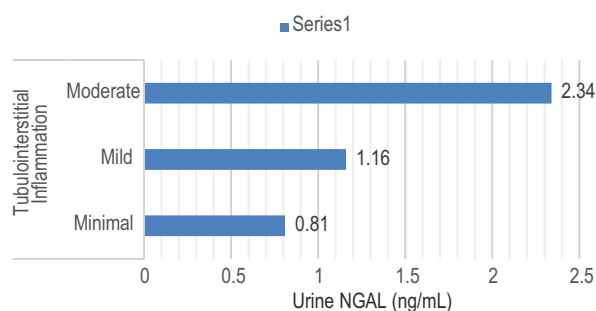


Figure 3: Urine NGAL levels at different severity groups for tubulointerstitial inflammation.

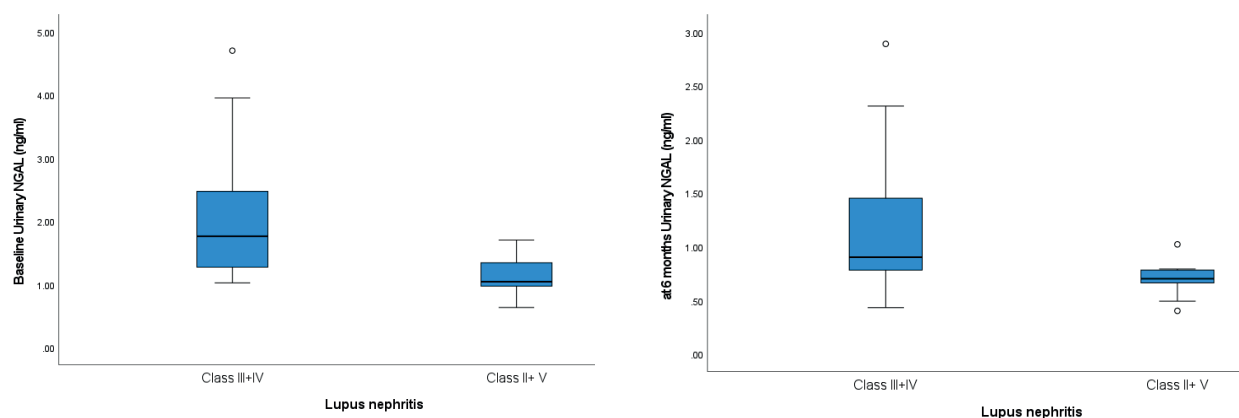


Figure 4: Box plot showing central tendency of the Urinary NGAL.

Table-IV : Relation of biochemical profile with treatment response. (n = 52)					
Characteristics		Treatment Response			P value
		Complete response (n=35)	Partial response (n=15)	Non-Response (n=2)	
Baseline	Urine NGAL (ng/mL)	1.39 ± 0.48	2.43 ± 0.99	3.80 ± 1.27	$< 0.05^b$
	Urinary PCR (mg/mmol)	3.12 ± 2.88	3.06 ± 1.38	5.10 ± 1.41	0.428^b
At 6 Months	Urine NGAL (ng/mL)	0.80 ± 0.25	1.37 ± 0.66	1.90 ± 0.57	$< 0.05^b$
	Urinary PCR (mg/mmol)	0.25 ± 0.30	0.90 ± 0.74	3.75 ± 0.21	$< 0.05^b$

Data presented as mean $\pm$ SD. ANOVA was done.

^b P value < 0.05 was considered statistically significant.

Patients exhibiting a complete treatment response demonstrated markedly reduced urine NGAL levels at both baseline (1.39 ± 0.48 ng/mL) and at 6 months (0.80 ± 0.25 ng/mL) in comparison to the partial and non-response cohorts.

Discussion:

This study assessed urinary NGAL as an indicator of renal inflammation, histopathological severity, and treatment response in lupus nephritis. The demographic distribution — with a predominance of

young females—is consistent with global epidemiological patterns of SLE.^{24–26} Similarly, the presence of overweight and obesity in a subset of participants reflects findings from earlier research suggesting that altered body composition may affect disease activity.²⁷ More than half of the cohort exhibited moderate tubulointerstitial inflammation, reinforcing prior observations that interstitial lesions strongly influence renal prognosis.^{28,29}

The low prevalence of significant tubular atrophy and fibrosis suggests limited chronic damage at presentation, possibly contributing to the favorable treatment outcomes observed.

Class IV nephritis was the dominant histological subtype, aligning with previous studies reporting its high frequency and association with aggressive clinical behavior.³⁰ The absence of class I and class VI nephritis may relate to referral patterns or patient selection characteristics.^{31,32} Treatment outcomes in the present study were comparable to those reported in the literature, with the majority achieving complete or partial response following standardized immunosuppressive regimens.^{33–37} The most notable finding was the strong correlation between urinary NGAL and markers of disease severity. Patients with class IV lupus nephritis and those categorized within the proliferative group exhibited the highest NGAL levels at baseline. These results are consistent with previous studies demonstrating that NGAL rises sharply in response to acute tubular injury and immune-mediated inflammation.^{21,38,39} The biochemical differences between proliferative and non-proliferative groups—such as elevated serum creatinine and lower serum albumin in the former—reinforce the association between NGAL and renal dysfunction.^{31,44–47}

Hypoalbuminemia in proliferative nephritis is commonly linked to heavy proteinuria and impaired renal function, although this difference diminished after treatment initiation, reflecting clinical improvement. NGAL's close relationship with tubulointerstitial inflammation is particularly important. Patients with moderate inflammation exhibited the highest levels, supporting the concept that NGAL originates from injured tubular epithelial cells. Because interstitial lesions strongly influence long-term renal prognosis, NGAL could help identify patients at higher risk.

Individuals who achieved complete therapeutic response demonstrated lower NGAL levels at both baseline and follow-up, consistent with findings from recent biomarker-based studies.^{48,49}

This suggests that NGAL may be useful both for initial risk stratification and for monitoring treatment response.

Overall, the results support urinary NGAL as a promising biomarker for disease activity, renal injury, and therapeutic response in lupus nephritis.

Conclusions:

Urinary NGAL showed strong associations with histopathological severity, biochemical markers, and clinical response in lupus nephritis. Higher baseline levels were linked to proliferative disease and greater interstitial inflammation, whereas declining levels corresponded with favorable therapeutic outcomes. Given its non-invasive nature and demonstrated sensitivity, urinary NGAL may serve as a valuable adjunct to conventional markers for disease monitoring. Further multi-center studies with larger sample sizes are needed to validate these findings and determine its optimal role in clinical practice.

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