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Evaluation of NGASL Biomarkers and Some Biochemical Parameters in Patients with Renal Disorders in Ramadi City, Iraq

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Authors' contributions

This work was carried out in collaboration among all authors. The final manuscript draft was reviewed by all authors, who also gave their approval. All authors read and approved the final manuscript.

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ABSTRACT

This study was designed to determine the effect or the relationship between neutrophil gelatinase-associated lipocalin (NGASL) and some kidney function parameters in kidney disorder patients to detect the level of serum markers in kidney disorder patients (acute glomerular nephritis, renal calculi, and acute renal failure) in Ramadi City. 120 male and female samples participated; the present study was divided into three groups of 90 patients (30 acute glomerular nephritis, 30 renal calculi, and 30 acute renal failure) and 30 healthy control individuals. The serum NGASL was measured using an ELISA technique. Kidney function tests (serum creatinine and serum urea, HB, and WBC)) were also measured by the quantitative method. The result showed low significant ($p > 0.001$) differences in hemoglobin and WBC percent in the acute renal failure group compared with other groups, and when compared between the studied groups, the results showed high significant ($p< 0.001$) differences in urea and creatinine concentration in the acute renal failure group compared with the AGN and RC groups. On the other hand, the result showed high significant($p<0.001$) differences in level of NGASL in Acute Renal Failure group compare with others groups. The correlation between parameters showed a higher negative correlation between Hb with urea, creatinine, and NGASL ($r = -0.571, -0.508$, and -0.463), respectively. In addition to the higher correlation between urea and creatinine with NGASL ($r = 0.670, 0.406$),. So can be considered NGASL a biomarker for kidney injury or kidney disorder. That may indicate the NGASL effect of renal disease and may be used as predictive parameters for kidney diseases.

Keywords: Renal disorder; NGASL; urea; creatinine.

LIST OF ABBREVIATIONS

NGASL :Neutrophil Gelatinase-associated Lipocalin
AGN : Acute Glomerular Nephritis
RC : Renal Calculi
ARF : Acute Renal Failure

1. INTRODUCTION

“Kidney disorders are considered one of the very common problems in Iraq and are considered a chronic disease that may sometimes lead to death in some people. There are routine tests used in medical laboratories to determine kidney disease problems, but these tests may not be very suitable for identifying kidney problems, so in this research we used tests that are new and very accurate; they are used in the initial diagnosis of kidney problems and determining their functions very accurately” (Cai et al., 2010). “Kidney disease often starts slowly and develops without symptoms over a number of years, so CKD may not be detected until it has progressed to the point where your kidney function is quite low. Fortunately, most people do not progress to end-stage kidney disease, especially if they are diagnosed early and are able to take steps to preserve their remaining kidney function” (Flo et al., 2004). Neutrophil gelatinase-associated lipocalin NGASL is a 25 kDa protein of the lipocalin family. “Lipocalin proteins are composed of 8 βstrands that form a β-barrel enclosing a calyx (Flower et al., 2000). This NGASL structure was illustrated by crystallography” (Goetz et al., 2002). “The calyx binds and transports small molecules. NGASL was originally identified in neutrophils, but it is also expressed in kidney, liver, and epithelial cells in response to various pathologic states, such as inflammation, infection, intoxication, ischemia, acute kidney injury, and neoplastic transformation. The kidneys are two bean-shaped organs. Each kidney is about the size of a fist. Your kidneys filter extra water and waste out of your blood and make urine. Kidney disease means your kidneys are damaged and can’t filter blood the way they should” (Perry et al., 2010). “Kidney diseases can affect your body’s ability to clean your blood, filter extra water out of your blood, and help control your blood pressure. It can also affect red blood cell production and vitamin D3 metabolism needed for bone health. You’re born with two kidneys. They’re on either side of your spine, just above your waist” (Kashani et al., 2013). “Chronic kidney disease (CKD) is a clinical syndrome secondary to the definitive change in function and/or structure of the kidney and is characterized by its irreversibility and slow and progressive evolution. Another important aspect is that the pathology represents a higher risk of complications and mortality, especially cardiovascular-related” (National Kidney Foundation, 2002). “In addition to being highly prevalent, CKD is associated with a higher risk of cardiovascular disease, severity, and death. In fact, global data from 2013 showed

that the reduction in GFR was associated with 4% of deaths worldwide, i.e., 2.2 million deaths. More than half of those deaths were due to cardiovascular causes, while 0.96 million were related to end-stage renal disease" (Thomas et al., 2017). "The aforementioned SBN census found a gross annual mortality rate of 19.9% on dialysis. Glomerulonephritis (gloe-MER-u-loe-nuh-FRY-tis) is inflammation of the tiny filters in the kidneys (glomeruli)" (Marinho et al., 2017). "The excess fluid and waste that glomeruli (gloe-MER-u-lie) remove from the bloodstream exit the body as urine. Glomerulonephritis can come on suddenly (acute) or gradually (chronic)" (Coresh et al., 2007). "Severe or prolonged inflammation associated with glomerulonephritis can damage the kidneys. Treatment depends on the type of glomerulonephritis you have" (Vassalotti et al., 2016). "Polycystic kidney disease (PKD) is an inherited disorder in which clusters of cysts develop primarily within your kidneys, causing your kidneys to enlarge and lose function over time. Cysts are noncancerous round sacs containing fluid" (Mattix HJ et al., 2002). The cysts vary in size, and they can grow very large. Having many cysts or large cysts can damage your kidneys (Johnson et al., 2004). "Acute kidney injury (AKI) is a sudden and recent reduction in the level of kidney function. Doctors usually say AKI is severe when the kidney function, measured by blood tests" (Khwaja, A. KDIGO. 2012), has dropped by one half (50%). Acute kidney injury often gets better in a few days or weeks. It is often caused by'stress' on the kidney from problems elsewhere in the body (Soni et al. 2010) rather than diseases starting in the kidney. However, if you are identified as at risk, then it is important you seek specialist assessment and treatment to ensure the issue does not progress (Venge, 2018). "Kidney stones (also called renal calculi, nephrolithiasis, or urolithiasis) and the prevention of renal stone recurrence remain a serious problem in human health" (Mikawlrawng et al., 2014). "Prevention of stone recurrence requires a better understanding of the mechanisms involved in stone formation" (Khan et al., 2016). Kidney stones have been associated with an increased risk of chronic kidney diseases (Sigurjonsdottir et al., 2015), end-stage renal failure (Mikawlrawng et al., 2014, El-Zoghby et al., 2012), cardiovascular diseases [Rule et al., 2010; Worcester and Coe, 2008], diabetes, and hypertension (Marinho et al., 2017). It has been suggested that kidney stone may be a systemic disorder linked to the metabolic syndrome. Nephrolithiasis is responsible for 2 to 3% of end-stage renal cases if it is associated with nephrocalcinosis (Courbebaisse et al., 2017). "A kidney stone usually will not cause symptoms until it moves around within the kidney or passes into one of the ureters" (Moro et al., 2010). Neutrophil gelatinase-associated lipocalin (NGASL), a 25 kDa protein produced by injured nephron epithelia, is one of the most promising new markers of renal epithelial injury (Bouchard et al., 2016). "In contrast to serum creatinine and urinary output, which are the measures of kidney function, NGASL is specifically induced in the damaged nephron and then released into blood and urine, where it can be readily measured" (Independent Hospital Pricing Authority (AU). 2015). "Clinical studies indicate that NGASL, unlike creatinine, is a marker responsive to tissue stress and nephron injury but less so to adaptive hemodynamic responses. In certain clinical settings, NGASL is an earlier marker compared with serum creatinine" (Park, et al., 2005). "Neutrophil gelatinase-associated lipocalin (NGASL) is protein bound to gelatinase, and it was first described in neutrophils. Circulating NGASL is normally reabsorbed at the level of the proximal tubule, and, after ischemia, NGASL is secreted in the thick ascending limb and found in the urine" (National Institute for Health and Clinical Excellence, 2008). "NGASL may be increased in patients with infections. Thus, its value for diagnosing early ARF in complicated, septic patients may be limited. Urinary NGASL measurement has recently become commercially available" (KDIGO clinical practice guideline for the diagnosis, 2009). Neutrophil gelatinase-associated lipocalin (NGASL) is an independent biologic marker able to detect earlier AKI than serum creatinine. In serum creatinine is a marker of kidney function, whereas NGASL is a marker of kidney injury. Moreover, NGASL levels are useful to quantify the degree of tubular damage to establish the stratification of AKI (National Institute for Health and Care Excellence 2013). The limitations of using NGASL in ED seem to be related to the false-positive levels in septic patients or in chronic kidney diseases (Australian Commission on Safety and Quality in Health Care. 2017). The study was aimed to investigate the role of plasma NGASL as an early biomarker of renal kidney injury patient in Ramadi city /Iraq.

2. MATERIALS AND METHODS

2.1 Sample Study

Blood samples were collected from 120 patients in hospitals in the Ramadi city suffering from kidney problems. The samples were distributed as follows: 30 samples for healthy people (15 men

and 15 women), 30 samples for people who're suffering from acute nephronitis, and 30 samples for people with kidney stones. And 30 samples for people with acute kidney failure; the samples were collected for the period from January 1 to February 25, 2024.

2.2 Blood Collection

A venous blood sample was collected, a total of blood (3-5 ml) from each patient with kidney problems, and it was divided into two tubes (2 ml). The whole blood sample was dispensed into a tube containing ethylene diamine tetraacetic acid (an EDTA-tube) and used for estimation of CBC. The second sample part of blood (2 ml) was put into a gel tube. Allow serum to clot for 10-20 minutes at room temperature. to measure the concentration of the NGASL biomarker and the concentration of serum urea, creatinine, hemoglobin and WBC.

2.3 Measurements

Regarding the measurements related to the current study, urea and creatinine were measured by using standard methods with reagents from BioMaghreb Company – Tunisia. NGASL ELISA kits are a solid phase direct sandwich method. The assay was performed according to the steps described by the manufacturer (SUNLONG, China).

2.4 Statistical Analysis

SAS (2012) version 9 was used for the statistical analysis. Pprogram was used to investigate the effect of data differences between groups. All results have been expressed as mean ± standard error (M ± SD). Differences between groups have analyzed using an analysis of variance (ANOVA), Least significant difference (LSD) test. Pearson correlation coefficient (r) was calculated to check the interdependence of variables, and chi-square has been used to test the significant difference between groups. ($P<0.05$) has been regarded as statistically significant. Chi-square test was used to significant compare between percentage (0.05 and 0.01 probability in this study (Abdul et al., 2023).

3. RESULTS AND DISCUSSION

Comparative between Study Groups to Determine the Effect of NGASL and Some Parameter: Table 2 and Figs. (2, 3) clarify the mean ± SD between all study groups (AGN, RC, ARF, and controls group) using the ANOVA test. The results showed low significant ($p > 0.001$) differences in hemoglobin percent between all study groups (AGN, RC, and ARF) compared with the control group, and when compared between study groups, the result showed low significant ($p > 0.001$) differences in hemoglobin percent and WBC percent in the acute renal failure group compared with other groups. And when compare between study groups, the result showed high significant ($p<0.001$) differences in urea and creatinine concentration in all study groups compared with the control group, and when compare between the study groups, the results showed high significant ($p<0.001$) differences in urea and creatinine concentration in the acute renal failure group compared with (AGN and RC). On the other hand, the result showed high significant ($p<0.001$) differences in the level of NGASL in all study groups, and when compared between the three study groups, the result showed high significant ($p<0.001$) differences in the acute renal failure group compared with other groups. That may indicate the NGASL effect of renal disease and may be used as predictive parameters for kidney diseases.

Discussion: The present study assessed the hematological parameters and comorbidities among hospitalized CKD patients. We observed some blood parameters altered in CKD patients. Among the parameters, we found a decreased Hb, RBC, and WBC. Also, we noticed the degree of alterations directly associated with the severity of CKD patients. This study agrees with Alemu et al. (2021), who reported that a cross-sectional study among 251 CKD patients in Northwest Ethiopia reported that the prevalence of anemia was 64%, which varies from 44.8% to 93.8% with increasing stages of CKD. Another study showed that 19.5% of CKD patients developed severe anemia, and 25% of anemia-affected CKD patients developed anemia even after receiving therapy. (Adera et al., 2019) Also, a study by George et al. (2018) showed that a cross-sectional study among 1564 mixed-ancestry South African patients showed lowered RBC and Hb levels in the case of CKD participants. “A prevalence of anemia ranged from 37.2% (stage 3) to 82.4% (stages 4-5). There is also the prevalence of anemia even after hemodialysis in the case of a patient with CKD. The reduced Hb levels may be due to iron-deficiency anemia caused by CKD” (Batchelor et al., 2020) “Another potential mechanism of developing anemia in CKD patients is the reduced RBC lifespan as the

Table 1. Compare between study groups to determine the Effect of NGASL and some parameter

Variables	Mean ± SD				LSD valve	P value
	Controls	Acute Renal failure	Renal calculi	Acute glomerulonephritis		
Hemoglobin (%)	14.2 ±1.4 a	9.1 ± 1.3 b	11.9 ± 2.7 b	10.2 ± 1.8 b	1.794 **	0.001
WBC (cell/mm^3)	7.96 ±2.14 c	5.95 ± 2.66 c	14.1 ± 3.3 a	11.2 ± 4.4 b	1.802 **	0.001
Urea (mg/dl)	32.1±7.3 d	101.5 ± 48.6 a	51.9 ± 15.9 c	75.2 ± 33.8 b	17.54 **	0.001
Creatinine (mg/dl)	0.9 ±0.16 b	3.65 ± 1.22 a	1.35 ± 0.53 b	1.69 ± 0.93 b	0.891 **	0.001
NGASL (ng/ml)	112.4±65.5 d	912.5 ± 239.3 a	665.8 ± 119.1 b	289.8 ± 86.8 c	106.45 **	0.001

*Means having with the different letters in same row differed significantly ** (P≤0.01).*

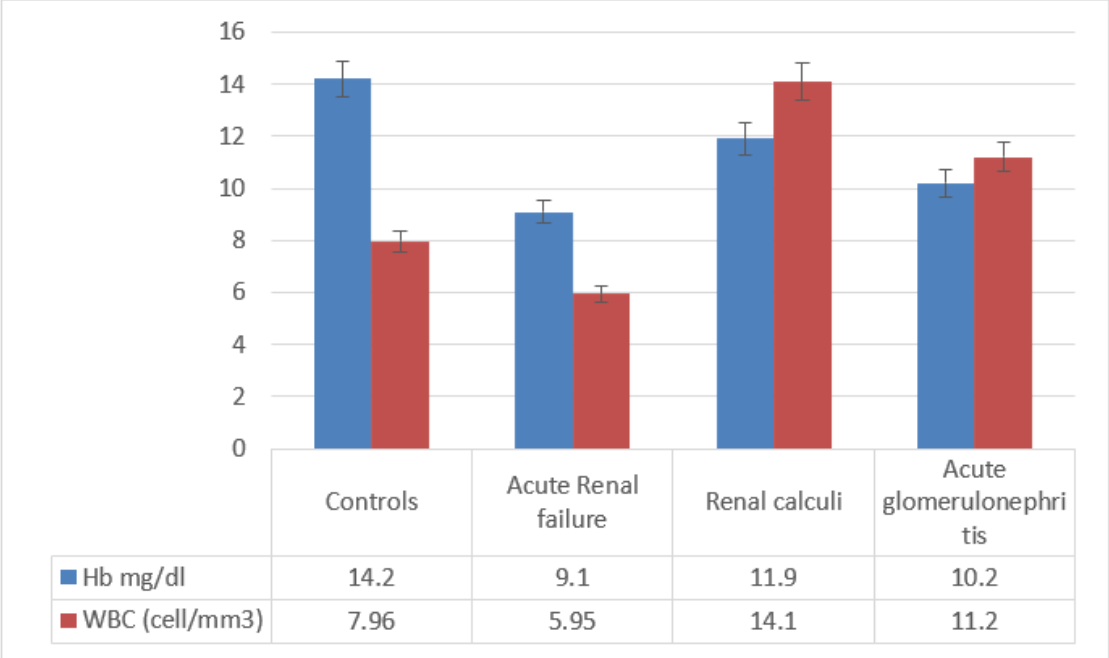

Fig. 1. The levels of some hematological parameters in studied groups

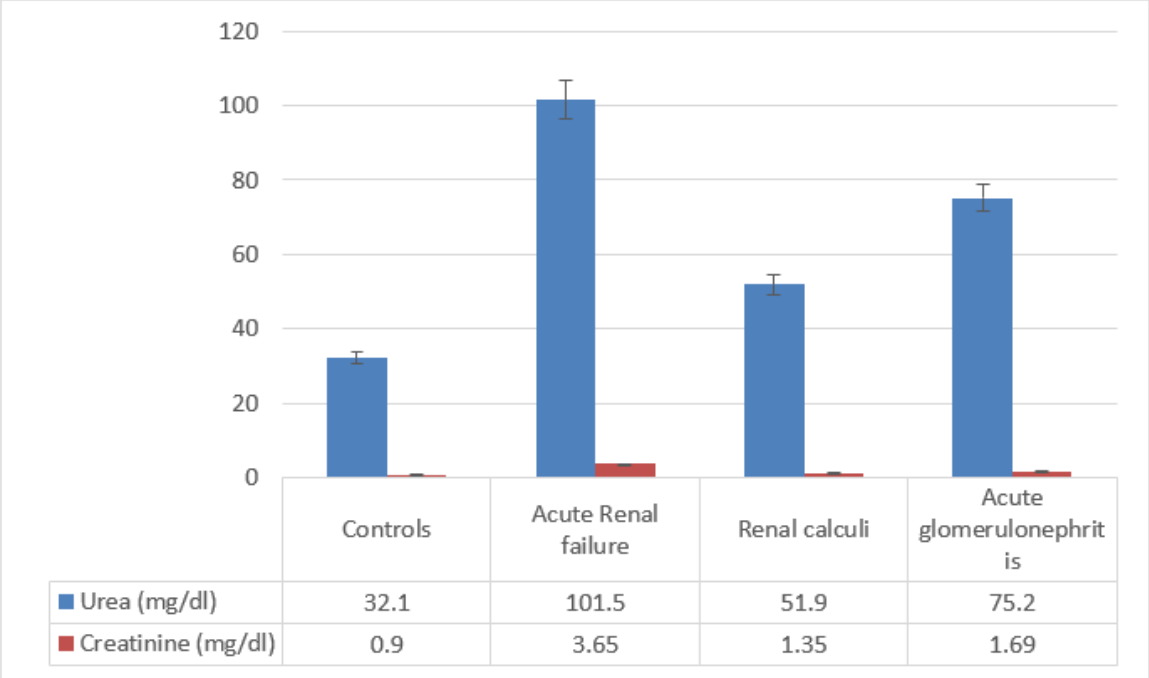

Fig. 2. The levels of some kidney function parameters in studied groups

production of erythropoietin reduces in CKD with the progression of the staging" (Babitt et al., 2012). And when compare between study groups, the result showed high significant ($p<0.001$) differences in urea and creatinine concentration in all study groups compared with the control group, and when compare between the study groups, the results showed high significant ($p<0.001$) differences in urea and creatinine concentration in the acute renal failure group compared with (AGN and RC). This study agrees with Al-Sabah et al. (2024), who showed creatinine among AKI

patients stages, and the control group found highly significant differences (P≤0.001) between stage 3 and control, stage 3 and stage 1, and stage 3 and stage 2. Also, a high significant difference in P≤0.001 between all patients and the control group related to that developed AKI is defined as an increase in serum creatinine, and this is because of creatinine elimination by the kidney and when the kidney damage causes an increase in serum creatinine. Nevertheless, serum creatinine levels are used to diagnose and stratify AKI, which agrees with the Nehomar 2020, and urea among AKI patient stages, and the control group found highly significant differences (P≤0.001) among stage 1, stage 2, and stage 3 with control, between stage 1 and stage 3, and between stage 2 and stage 3. Also, a high significant difference in P≤0.001 between all patients and the control group related to urea is a product of proteins and nitrogen metabolism. Urea is the most abundant substance in the blood of uremic people (Noman Salman, 2022). In patients with heart failure, decreased cardiac output and insufficient arterial filling lead to the release of the sympathetic nervous system (SNS) and renin-angiotensin-aldosterone system (RAAS), and increased sodium reabsorption in proximal renal tubules, resulting in increased urea concentration. The current result shows a trend increasing in level of NGASL in all study groups, and when compared between the three study groups, the result showed high significant (p<0.001) differences in the acute renal failure group compared with other groups. This study agrees with Al-Sabah et al.'s (2024) showing NGASL among AKI patients' stages 1 and the control group found highly significant differences (P≤0.01) among all stages with control. Also, a high significant difference in P≤0.01 between all patients and the control group. NGASL was first identified in neutrophil granules; it is nearly entirely reabsorbed in the proximal tubule, and increased levels can be a sign of proximal tubular damage (Srisawat and Kellum, 2020). This pro-inflammatory mediator is generated as a result of tissue damage and acts as a biomarker for the early detection of kidney injury. All nephron segments have the potential to be harmed after an ischemia event; however, the proximal tubular cells are typically the most injured. When AKI is present, the distal tubule and Henle's loop can produce 1000 times more NGASL, and this agrees with Menez and Parikh (2019) and disagrees with Capelli et al. (2020), which demonstrated that NGASL showed a slight increase in their study of kidney injury. On the basis of these unique properties, recent studies have validated the reliability of NGASL as a specific, sensible, and early predictor of AKI after cardiac surgery, contrast administration, septic shock, and even renal transplantation (Ling et al., 2008). In the current study, NGASL was measured in a cohort of patients affected by non-advanced CKD with stable renal function. Interestingly, apart from the already cited predictive value, a strict, independent, and inverse correlation with estimated GFR was described for both sNGASL and uNGASL, suggesting that under these particular conditions this protein may also represent a surrogate index of residual renal function, similar to what has previously been described elsewhere (Bolignano et al., 2008).

Correlation between Parameters of all Study Groups: Table 2 shows the correlation between all study groups (acute glomerular nephritis AGN, acute renal failure ARF, renal calculi RC) in some studied parameters (Hb, WBC, urea, creatinine, and NGASL). The result showed a high (r = -0.571, p≤0.001) negative correlation between urea and hemoglobin. Also, the result of the correlation test showed a high (rr = -0.508, -0.463, p≤0.001) negative correlation between hemoglobin percent with creatinine and NGASL, respectively. On the other hand, the result found a high (rr = -0.253, p≤0.001) negative correlation between WBC and creatinine concentration with The result showed a high (rr = 0.670, 0.406, p≤0.05) positive correlation between urea with creatinine and NGASL, respectively. Creatinine concentration also showed a high (rr = 0.573, p≤0.0001) positive correlation with NGASL.

This result indicates that a decrease in hemoglobin percent leads to an increase in (urea, creatinine, and NGASL), and this study approaches the study of (Segal et al., 2014), who showed patients with CKD might suffer from different types of cardiac diseases; decreased Hb and RBC levels might cause anemia in CKD patients. Also, I noticed negative associations between Hb and RBC levels with the staging of CKD patients. Reduced renal function results in decreased erythropoietin production, which results in decreased Hb synthesis and a decrease in the total number of RBCs (Kutuby et al., 2015). The patient develops anemia because of this significant decrease in RBC. 40 Iron and erythropoietin produce RBC in the bone marrow. (Batchelor et al., 2020). This result indicates that increasing in urea concentration leads to an increase in creatinine and NGASL concentration. Nevertheless, serum creatinine levels are used to diagnose and stratify AKI. This study, which

agrees with the Nehomar 2020) and urea among AKI patient stages and the control group, found highly significant differences (P≤0.001) among stage 1, stage 2, and stage 3 with control, between stage 1 and stage 3, and between stage 2 and stage 3. Also, a high significant difference in P≤0.001 between all patients and the control group related to urea is it product of proteins and nitrogen metabolism; urea is the most abundant substance in the blood of uremic people (Noman Salman et al., 2022). The results indicate that creatinine and NGASL may be used together as ideal biomarkers for identifying renal disease. This pro-inflammatory mediator is generated as a result of tissue damage and acts as a biomarker for the early detection of kidney injury. All nephron segments have the potential to be harmed after an ischemia event; however, the proximal tubular cells are typically the most injured. When AKI is present, the distal tubule and Henle's loop can produce 1000 times more NGASL, and this disagrees with Capelli et al. (2020), which demonstrated that NGASL showed a slight increase in their study of kidney injury.

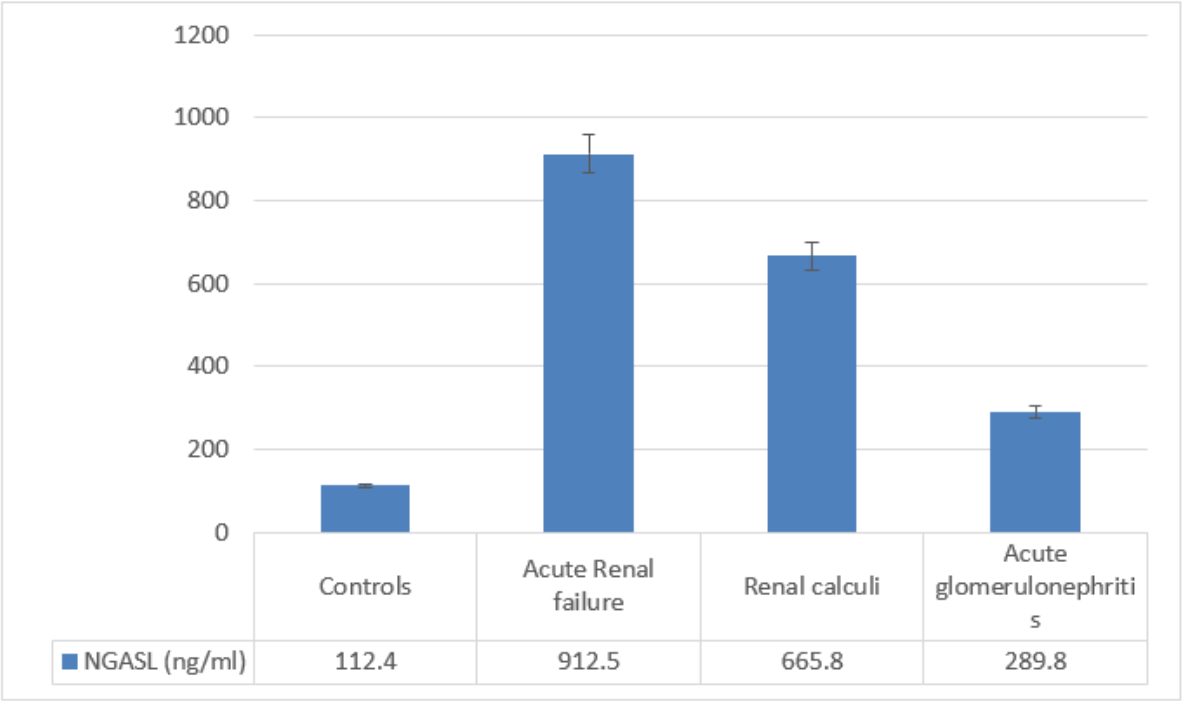

Fig. 3. The levels of NGASL in studied groups

Table 2. Correlation between parameters of all study groups

Variables	Correlation	Hb	WBC	Urea	Creatinine	NGASL
Hb	R	1	0.105	-0.571**	-0.508**	-0.463**
	Sig.		0.176	0.0001	0.0001	0.0001
WBC	R		1	-0.131	-0.253*	-0.104
	Sig.			0.123	0.012	0.179
Urea	R			1	0.670**	0.406**
	Sig.				0.0001	0.0001
Creatinine	R				1	0.573**
	Sig.					0.0001
NGASL	R					1
	Sig.					

***Correlation is significant at the 0.01 level (1-tailed)*
**Correlation is significant at the 0.05 level (1-tailed)*

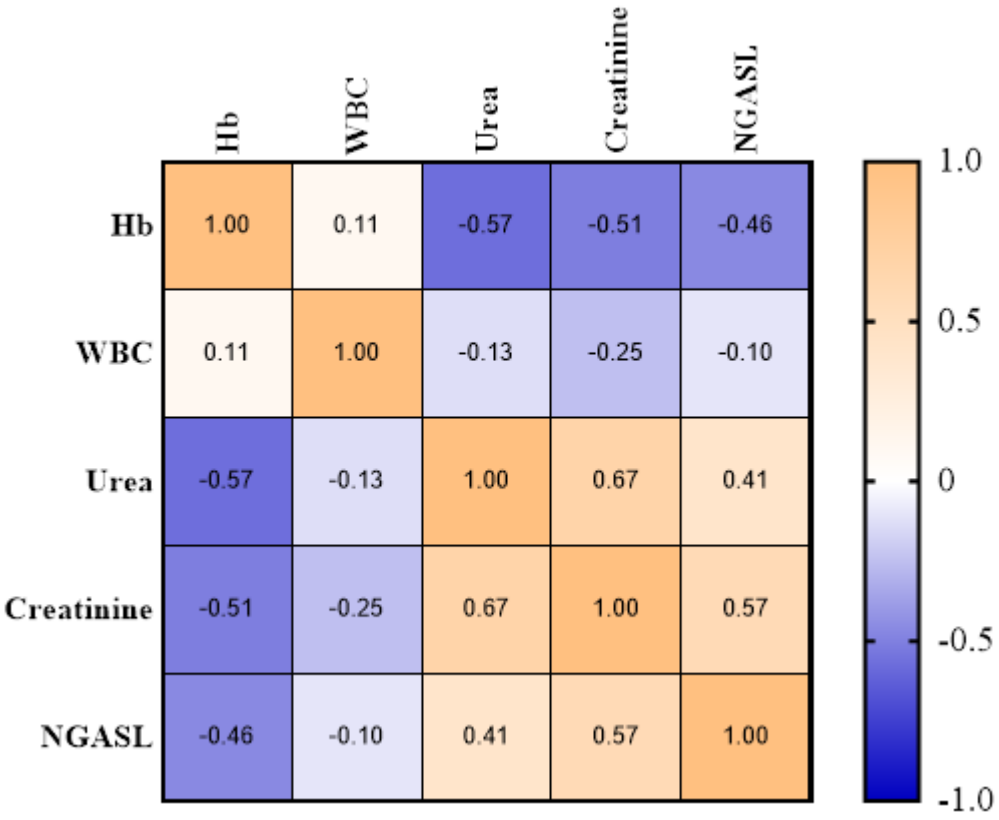

Fig. 4. Correlation map between parameters of all study groups

4. CONCLUSION

An increase in the protein Neutrophil gelatinase-associated lipocalin was observed in renal failure patients compared to acute nephritis patients and renal calculi patients. A decrease in the level of hemoglobin and red blood cells was observed in patients with kidney failure compared to other groups. The study summary proved that the protein neutrophil gelatinase associated lipocalin (NGASL) is more specific in diagnosing kidney problems than the urea and creatinine tests for all groups.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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