

Prognostic Utility of Plasma Neutrophil Gelatinase Associated Lipocalin in Acute Myocardial Infarction Patients Undergoing Percutaneous Coronary Intervention

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Abstract

Background: Acute myocardial infarction (AMI), including ST-segment elevation myocardial infarction (STEMI) and non-ST-segment elevation myocardial infarction (NSTEMI), remains a major cause of global morbidity and mortality. Early identification of patients at higher risk of adverse outcomes is essential for optimizing clinical management and improving prognosis. This study aimed to evaluate the prognostic utility of plasma neutrophil gelatinase-associated lipocalin (NGAL) as a biomarker for predicting short-term outcomes in patients with acute myocardial infarction undergoing percutaneous coronary intervention (PCI).

Materials and Methods: This prospective cohort study was conducted among patients admitted to the Department of General Medicine and Cardiology Unit, AIMS General Hospital, Apollo Health City, Jubilee Hills, Hyderabad. Patients aged ≥ 18 years who presented with clinical features suggestive of acute myocardial infarction, ST-T changes in two contiguous electrocardiographic leads or newly developed left bundle branch block, elevated cardiac troponin I levels, and undergoing PCI were included after obtaining informed consent. Patients with a history of previous coronary artery bypass grafting, acute or chronic kidney disease, cerebrovascular disease, sepsis, or malignancy were excluded. Plasma NGAL levels were assessed before and after PCI, and their association with short-term clinical outcomes was evaluated.

Results: A total of 100 patients with a mean age of 57.79 ± 7.49 years were included in the study. Of these, 82% were males and 18% were females, indicating male predominance. Receiver operating characteristic (ROC) curve analysis demonstrated that troponin I levels, pre-PCI NGAL, post-PCI NGAL, and change in NGAL levels (Δ NGAL) were significant predictors of in-hospital outcomes and left ventricular ejection fraction (LVEF) assessed at the 1-month and 3-months follow-up after PCI ($p < 0.05$).

Conclusion: Plasma NGAL demonstrated promising prognostic potential as an independent biomarker for predicting short-term outcomes in patients with acute myocardial infarction undergoing percutaneous coronary intervention. Measurement of NGAL may aid in early risk stratification and clinical decision-making in this patient population.

Keywords: Acute Myocardial Infarction; Neutrophil Gelatinase-Associated Lipocalin; NGAL; Percutaneous Coronary Intervention; Prognostic Biomarker; Left Ventricular Ejection Fraction.

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Introduction

Acute myocardial infarction (AMI), comprising ST-segment elevation myocardial infarction (STEMI) and non-ST-segment elevation myocardial infarction (NSTEMI), remains a major cause of global morbidity and mortality. Despite advances in reperfusion strategies, pharmacological therapy, and interventional cardiology, patients with AMI continue to experience significant short-

term and long-term adverse outcomes. Early identification of patients at higher risk of complications is essential for optimizing treatment strategies and improving prognosis [1]. Several biomarkers, including cardiac troponins, natriuretic peptides, C-reactive protein, and matrix metalloproteinases, along with established risk prediction models such as the GRACE, TIMI, and

SYNTAX scores, have improved risk stratification in patients with AMI. However, accurate prediction of clinical outcomes, particularly after percutaneous coronary intervention (PCI), remains challenging despite contemporary risk prediction models [2]. Neutrophil gelatinase-associated lipocalin (NGAL), a member of the lipocalin family, has emerged as a potential biomarker of cardiovascular injury due to its role in inflammation, extracellular matrix remodeling, and renal dysfunction. NGAL exists in plasma as a free molecule and as a complex with matrix metalloproteinase-9 (NGAL/MMP-9). Increased expression of NGAL/MMP-9 complexes has been observed in vascular inflammatory conditions, suggesting its involvement in atherosclerotic plaque instability and myocardial injury. Following ischemic injury and reperfusion, inflammatory activation and myocardial damage may contribute to elevated circulating plasma NGAL concentrations [3].

Therefore, plasma NGAL may serve as an indicator of myocardial injury and inflammatory response, providing additional prognostic information beyond conventional biomarkers. The present study aimed to evaluate the association between plasma NGAL levels, myocardial injury following reperfusion, and short-term outcomes in patients with acute myocardial infarction undergoing percutaneous coronary intervention.

Aim and Objectives

Aim: To evaluate the prognostic utility of plasma neutrophil gelatinase-associated lipocalin (NGAL) in predicting short-term outcomes in patients with acute myocardial infarction undergoing percutaneous coronary intervention.

Objectives

1. To assess plasma NGAL levels before and after percutaneous coronary intervention in patients with acute myocardial infarction.
2. To evaluate the association between plasma NGAL levels and short-term clinical outcomes following percutaneous coronary intervention.
3. To determine the correlation of plasma NGAL with conventional cardiac biomarkers and other prognostic parameters in patients with acute myocardial infarction.

Material and Methods

A total of 100 patients were enrolled in this prospective study. The study was conducted among patients presenting with acute myocardial infarction and admitted to the Departments of General Medicine and Cardiology at AIMSR General Hospital & Apollo Hospital, Apollo Health City, Jubilee Hills, Hyderabad, India, from April 2024 to March 2026.

Inclusion Criteria

- Age ≥ 18 years.
- Clinical signs and symptoms suggestive of acute myocardial infarction.
- Electrocardiographic evidence of ischemia, including ST-T segment changes in two contiguous leads or newly developed left bundle branch block.
- Elevated cardiac troponin I levels.
- Undergoing percutaneous coronary intervention.
- Provided written informed consent for participation.

Exclusion Criteria

- Previous or planned coronary artery bypass grafting.
- History of significant prior cardiac disease.
- Acute kidney injury.
- Chronic kidney disease.
- Cerebrovascular disease.
- Chronic inflammatory disorders.
- Active infection or sepsis.
- Malignancy.

Statistical Analysis: Data were entered into Microsoft Excel and analyzed using SPSS software (Version 26.0, IBM Corp., and Armonk, NY, USA). Continuous variables were assessed for normality using the Shapiro–Wilk test and are presented as mean $\pm$ standard deviation (SD), whereas categorical variables are expressed as frequency and percentage.

Baseline demographic and clinical characteristics of the study population were summarized using descriptive statistics. Comparisons of continuous variables between two independent groups (discharged vs. death, preserved vs. reduced left ventricular ejection fraction [LVEF]) were performed using the Independent Samples Student's t-test, as the variables were normally distributed. Categorical variables were expressed as proportions.

The association between biomarkers (Troponin I, Pre-PCI NGAL, Post-PCI NGAL, and Δ NGAL) and clinical outcomes, including in-hospital mortality and LVEF status at 1-month and 3-month follow-up, was evaluated using the independent t-test. The diagnostic performance of each biomarker for predicting hospital outcome and reduced LVEF was assessed by Receiver Operating Characteristic (ROC) curve analysis. The Area under the Curve (AUC) with 95% Confidence Interval (CI) was calculated to determine the discriminative ability of each biomarker.

A two-tailed p-value <0.05 was considered statistically significant.

Study Procedure: Clinical, demographic, and laboratory data were collected from all enrolled patients. Plasma NGAL levels were measured before and after PCI, and their association with

short-term clinical outcomes was evaluated along with conventional cardiac biomarkers and echocardiographic parameters.

Table 1: Baseline Demographic and Clinical Characteristics of Study Participants (n=100)

Characteristics	n (%) / Mean $\pm$ SD
Age (years)	57.79 $\pm$ 7.49
Minimum–Maximum age (years)	46–81
Gender	
Male	82 (82.0)
Female	18 (18.0)
Diabetes mellitus	
Present	43 (43.0)
Absent	57 (57.0)
Hypertension	
Present	89 (89.0)
Absent	11 (11.0)
Smoking history	
Present	54 (54.0)
Absent	46 (46.0)
Alcohol history	
Present	27 (27.0)
Absent	73 (73.0)

Table 2: Clinical and Biomarker Characteristics of Study Participants

Parameters	Minimum	Maximum	Mean $\pm$ SD
Systolic blood pressure (mmHg)	122	156	135.34 $\pm$ 8.81
Diastolic blood pressure (mmHg)	80	102	90.32 $\pm$ 7.15
Troponin I (ng/ml)	3.6	16.4	9.39 $\pm$ 4.52
Pre-PCI NGAL (ng/ml)	62	180	107.76 $\pm$ 33.22
Post-PCI NGAL (ng/ml)	62	166	100.40 $\pm$ 34.28
Δ NGAL	-10	34	7.36 $\pm$ 10.62

Table 3: Clinical Outcomes and Left Ventricular Function During Follow-up

Outcome	n (%)
Hospital outcome (n=100)	
Discharged	85 (85.0)
Death	15 (15.0)
LVEF at 1-month follow-up (n=85)	
Preserved LVEF	63 (74.1)
Reduced LVEF	22 (25.9)
LVEF at 3-month follow-up (n=85)	
Preserved LVEF	56 (65.9)
Reduced LVEF	29 (34.1)

Table 4: Association of Troponin I and NGAL Levels with In-Hospital Outcomes

Biomarker	Discharged Mean $\pm$ SD	Death Mean $\pm$ SD	p-value
Troponin I (ng/ml)	8.9 $\pm$ 4.2	12.1 $\pm$ 5.3	0.01*
Pre-PCI NGAL (ng/ml)	106 $\pm$ 32	119 $\pm$ 39	0.01*
Post-PCI NGAL (ng/ml)	97 $\pm$ 32	120 $\pm$ 41	0.01*
Δ NGAL	8.82 $\pm$ 10.73	-0.93 $\pm$ 4.4	0.01*

Table 5: Association of Troponin I and NGAL Levels with LVEF at 1-Month Follow-up

Biomarker	Preserved LVEF Mean $\pm$ SD	Reduced LVEF Mean $\pm$ SD	p-value
Troponin I (ng/ml)	8.1 $\pm$ 4.0	12.6 $\pm$ 4.2	0.01*
Pre-PCI NGAL (ng/ml)	96 $\pm$ 26	138 $\pm$ 31	0.01*
Post-PCI NGAL (ng/ml)	87 $\pm$ 24	136 $\pm$ 31	0.01*
Δ NGAL	9.44 $\pm$ 7.51	2.0 $\pm$ 14.96	0.01*

Table 6: Association of Troponin I and NGAL Levels with LVEF at 3-Month Follow-up

Biomarker	Preserved LVEF Mean $\pm$ SD	Reduced LVEF Mean $\pm$ SD	p-value
Troponin I (ng/ml)	6.8 $\pm$ 2.9	13.3 $\pm$ 3.6	0.01*
Pre-PCI NGAL (ng/ml)	88 $\pm$ 20	137 $\pm$ 27	0.01*
Post-PCI NGAL (ng/ml)	80 $\pm$ 21	131 $\pm$ 27	0.01*
Δ NGAL	8.33 $\pm$ 5.98	5.90 $\pm$ 15.12	0.01*

Table 7: Receiver Operating Characteristic Curve Analysis of NGAL and Troponin I for Prediction of Clinical Outcomes

Outcome	Biomarker	95% CI	p-value
Hospital outcome	Troponin I	0.425–0.800	0.001
	Pre-PCI NGAL	0.403–0.797	0.001
	Post-PCI NGAL	0.435–0.822	0.001
	Δ NGAL	0.715–0.882	0.01
1-month LVEF	Troponin I	0.769–0.946	0.001
	Pre-PCI NGAL	0.822–0.951	0.001
	Post-PCI NGAL	0.853–0.968	0.001
	Δ NGAL	0.589–0.875	0.01
3-month LVEF	Troponin I	0.857–0.973	0.001
	Pre-PCI NGAL	0.913–0.987	0.001
	Post-PCI NGAL	0.900–0.990	0.001
	Δ NGAL	0.488–0.752	0.04

Discussion

Acute myocardial infarction (AMI) remains one of the leading causes of morbidity and mortality worldwide. AMI is broadly classified into ST-segment elevation myocardial infarction (STEMI) and non-ST-segment elevation myocardial infarction (NSTEMI), based on electrocardiographic findings and clinical characteristics. Despite significant advances in reperfusion strategies, pharmacological therapy, and percutaneous coronary intervention (PCI), early identification of patients at high risk of adverse outcomes remains a major clinical challenge.

Neutrophil gelatinase-associated lipocalin (NGAL) has emerged as a potential cardiovascular biomarker due to its involvement in inflammation, extracellular matrix remodeling, and renal injury pathways. NGAL is expressed in plasma both as a free molecule and as a complex with matrix metalloproteinase-9 (MMP-9). Increased NGAL expression has been demonstrated in conditions associated with vascular injury, myocardial ischemia, and heart failure. It is suggested that myocardial injury and inflammatory activation following ischemia and reperfusion contribute to increased circulating NGAL levels.

NGAL is produced by cardiomyocytes, neutrophils, and renal tubular epithelial cells. Increased NGAL gene expression has been observed in various pathological cardiac conditions, including chronic heart failure, myocarditis, coronary artery disease, and acute myocardial infarction. Elevated plasma NGAL levels in AMI may reflect an inflammatory response associated with myocardial injury and

may provide additional prognostic information beyond conventional biomarkers. The present study aimed to evaluate the prognostic utility of plasma NGAL in predicting short-term outcomes among patients with acute myocardial infarction undergoing percutaneous coronary intervention.

In the present study, a total of 100 patients fulfilling the inclusion criteria were enrolled after obtaining informed consent. The mean age of the study population was 57.79 $\pm$ 7.49 years. Among the participants, 82% were males and 18% were females, indicating a male predominance. Similar findings were reported by Avci et al [4], who observed a mean age of 61.51 $\pm$ 14.72 years, with males comprising 82.4% and females 17.6% of the study population, indicating a comparable gender distribution among patients with acute myocardial infarction.

Regarding cardiovascular risk factors, diabetes mellitus was present in 43% of patients, hypertension in 89%, and smoking history in 54% and alcohol consumption in 27% of participants. Bajramovic et al [5] evaluated the association between serum NGAL levels and clinical parameters in patients with acute myocardial infarction and reported that patients with higher NGAL levels had increased blood pressure values and greater evidence of cardiac dysfunction, suggesting a possible association between NGAL elevation and cardiovascular risk burden.

In the present study, the mean admission troponin I level was 9.39 $\pm$ 4.52 ng/ml, while the mean pre-PCI and post-PCI NGAL levels were 107.76 $\pm$ 33.22 ng/ml and 100.40 $\pm$ 34.28 ng/ml, respectively. In-hospital mortality occurred in 15%

of patients, whereas 85% were discharged. Left ventricular ejection fraction (LVEF) was preserved in 74.1% of patients at 1-month follow-up and in 65.9% at 3-month follow-up.

A significant association was observed between elevated troponin I, pre-PCI NGAL, and post-PCI NGAL levels and adverse in-hospital outcomes. Patients who died had significantly higher levels of these biomarkers compared with patients who were discharged ($p < 0.05$). Similarly, patients with reduced LVEF at 1-month and 3-month follow-up had significantly higher troponin I and NGAL levels compared with patients with preserved ventricular function ($p < 0.05$).

These findings are consistent with the observations of Zahler et al [6], who demonstrated that elevated NGAL levels were independently associated with poor in-hospital outcomes among STEMI patients. Their study suggested that increased NGAL reflects inflammatory activation and may serve as a marker of adverse cardiovascular and renal outcomes following primary PCI. The relationship between cardiac injury and renal dysfunction is complex and bidirectional. In acute coronary syndromes, particularly STEMI, cardiorenal interactions likely contribute to worsening cardiac and renal dysfunction. NGAL is considered an early marker of renal tubular injury and is also involved in neutrophil-mediated inflammatory responses. Therefore, increased NGAL levels may represent both myocardial inflammatory injury and early cardiorenal stress.

Previous studies have demonstrated an association between NGAL levels and ventricular dysfunction. Avci et al. reported higher plasma NGAL concentrations among patients with reduced LVEF, although the difference did not reach statistical significance. Nymo et al [7] demonstrated that circulating NGAL levels in acute coronary syndrome patients were associated with long-term prognosis and may help identify individuals requiring closer clinical monitoring. Similarly, Kirbis et al [8] reported an association between urinary NGAL levels and NT-proBNP concentrations following myocardial infarction, suggesting a relationship between NGAL and heart failure development.

Inflammation plays a central role in the development and progression of atherosclerosis and acute myocardial infarction. Neutrophils contribute significantly to plaque instability and rupture through the release of inflammatory mediators and matrix metalloproteinases. MMP-9 promotes extracellular matrix degradation, plaque rupture, and intraplaque hemorrhage. NGAL binds with MMP-9 and prevents its degradation, thereby enhancing MMP-9 activity and potentially contributing to vascular remodeling and plaque

instability. In the present study, receiver operating characteristic (ROC) curve analysis demonstrated that troponin I, pre-PCI NGAL, post-PCI NGAL, and Δ NGAL were significant predictors of in-hospital outcomes and LVEF at 1-month and 3-month follow-up after PCI ($p < 0.05$). These findings suggest that NGAL may provide additional prognostic information in patients undergoing reperfusion therapy.

Frydland et al [9] reported that elevated admission plasma NGAL levels were independently associated with the development of cardiogenic shock and 30-day mortality in patients with STEMI. Similarly, Avci et al. demonstrated significantly higher plasma NGAL levels in non-survivors than survivors and suggested that NGAL may predict cardiovascular mortality in STEMI patients.

Lindberg et al [10] reported that elevated NGAL levels were associated with increased risk of all-cause mortality and major adverse cardiovascular events (MACE) among STEMI patients undergoing primary PCI. High plasma NGAL levels remained an independent predictor of adverse outcomes even after adjustment for conventional risk factors.

Similarly, Lahiri et al [11] demonstrated that plasma NGAL was an independent predictor of in-hospital mortality in patients with acute coronary syndrome, with NGAL showing potential utility as a novel risk stratification biomarker.

The present study demonstrates that plasma NGAL has potential prognostic utility as an independent biomarker for predicting short-term outcomes in patients with acute myocardial infarction undergoing percutaneous coronary intervention. The significant association between NGAL levels, mortality, and left ventricular dysfunction suggests that NGAL may complement existing clinical and biochemical risk stratification tools. Further large-scale studies are required to validate its role in predicting long-term cardiovascular outcomes.

Conclusion

- Plasma neutrophil gelatinase-associated lipocalin (NGAL) demonstrated potential utility as an independent prognostic biomarker for predicting short-term outcomes in patients with acute myocardial infarction undergoing percutaneous coronary intervention.
- Plasma NGAL showed a significant association with conventional cardiac biomarkers, particularly troponin I, suggesting its potential role as an adjunctive marker for risk stratification.
- Elevated pre-PCI and post-PCI levels were significantly associated with adverse in-hospital outcomes and reduced left ventricular ejection fraction during follow-up.

- ROC curve analysis demonstrated modest predictive performance for short-term clinical outcomes and left ventricular function following PCI
- Plasma NGAL may provide additional prognostic information beyond conventional biomarkers and could aid in early identification of high-risk patients with acute myocardial infarction.
- Further large-scale prospective studies are required to validate the role of NGAL in predicting long-term cardiovascular outcomes and to establish its clinical applicability.

References

1. Bu D, Hemdahl A-L, Gabrielsen A, Fuxe J, Zhu C, Eriksson P, et al. Induction of neutrophil gelatinase-associated lipocalin in vascular injury via activation of nuclear factor-kappaB. *Am J Pathol.* 2006;169(6):2245–53.
2. Bolignano D, Coppolino G, Lacquaniti A, Buemi M. From kidney to cardiovascular diseases: NGAL as a biomarker beyond the confines of nephrology. *Eur J Clin Invest.* 2010;40(3):273–6.
3. Sreenivas Kumar A, Sinha N. Cardiovascular disease in India: A 360 degree overview. *Medical journal, Armed Forces India.* 2020;76(1):1–3
4. Avci A, Ozturk B, Demir K, Akyürek F, Altunkeser BB. The prognostic utility of plasma NGAL levels in ST segment elevation in myocardial infarction patients. *Adv Prev Med.* 2020;2020:4637043. doi: 10.1155/2020/4637043.
5. Buonafina M, Martinez-Martinez E, Jaisser F. More than a simple biomarker: the role of NGAL in cardiovascular and renal diseases. *Clin Sci (Lond).* 2018;132(9):909-923. doi: 10.1042/CS20171592
6. Zahler D, Merdler I, Banai A, Shusterman E, Feder O, Itach T, et al. Predictive value of elevated neutrophil gelatinase-associated lipocalin (NGAL) levels for assessment of cardio–renal interactions among ST-segment elevation myocardial infarction patients. *J Clin Med.* 2022;11(8):2162. doi:10.3390/jcm11082162
7. Nymo SH, Hartford M, Ueland T, Yndestad A, Lorentzen E, Truvé K, et al. Serum neutrophil gelatinase-associated lipocalin (NGAL) concentration is independently associated with mortality in patients with acute coronary syndrome. *Int J Cardiol.* 2018;262:79-84. doi:10.1016/j.ijcard.2018.03.028
8. Kirbiš S, Gorenjak M, Sinkovič A. The role of urine neutrophil gelatinase-associated lipocalin (NGAL) in acute heart failure in patients with ST-elevation myocardial infarction. *BMC Cardiovasc Disord.* 2015;15:177. doi:10.1186/s12872-015-0167-6
9. Frydland M, Møgelvang R, Møller JE, Møller-Helgestad O, Holmvang L, Mark PD, et al. Neutrophil gelatinase-associated lipocalin (NGAL) measured at admission is associated with development of late cardiogenic shock and mortality in patients with ST-segment elevation myocardial infarction. *Eur Heart J Acute Cardiovasc Care.* 2021;10(Suppl 1):zua b020.169. doi:10.1093/ehjacc/zuab020.169.
10. Lindberg S, Pedersen SH, Møgelvang R, Jensen JS, Flyvbjerg A, Galatius S, et al. Prognostic utility of neutrophil gelatinase-associated lipocalin in predicting mortality and cardiovascular events in patients with ST-segment elevation myocardial infarction treated with primary percutaneous coronary intervention. *J Am Coll Cardiol.* 2012;60(4):339-345. doi:10.1016/j.jacc.2012.04.017
11. Lahiri A, Alex AG, George PV. Estimating the prevalence of elevated plasma neutrophil gelatinase-associated lipocalin level in patients with acute coronary syndromes and its association with outcomes. *Indian Heart J.* 2018;70(2):220-224. doi:10.1016/j.ihj.2017.06.005.