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Association of Atherogenic Lipid Index with Kidney Dysfunction in Patients with Type 2 Diabetes

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ABSTRACT:

Background: Diabetic kidney disease is a major complication of type 2 diabetes mellitus (T2DM), commonly assessed using estimated glomerular filtration rate (eGFR) and urinary albumin-to-creatinine ratio (UACR). Dyslipidemia may contribute to kidney injury, and the Atherogenic Lipid Index (ALI), derived from triglyceride and high-density lipoprotein cholesterol levels, may provide a simple marker of atherogenic lipid abnormalities. Association of atherogenic lipid index with kidney dysfunction in patients with T2DM.

Methods: This cross-sectional analytical study included 294 adults with T2DM. ALI was calculated as $\log_{10}$(triglyceride/HDL-C), with both concentrations expressed in mmol/L. Participants were categorized according to tertiles of ALI distribution, with the lower two tertiles (ALI ≤0.59) compared with the highest tertile (ALI >0.59).

Results: Reduced kidney function was more prevalent in the highest ALI tertile than in the lower two tertiles (30.5% vs. 14.1%; p=0.001), corresponding to higher odds of reduced kidney function (OR 2.68; 95% CI 1.48–4.85). ALI showed modest discrimination for reduced kidney function (AUC 0.647; 95% CI 0.568–0.727), with 56% sensitivity and 59% specificity at a cut-off of 0.52. Albuminuria prevalence did not differ significantly between groups (43.2% vs. 40.2%; OR 1.13; 95% CI 0.69–1.85; p=0.630), and ALI showed no discriminatory ability for albuminuria (AUC 0.489; 95% CI 0.420–0.558).

Conclusions: Higher ALI was associated with reduced kidney function but not albuminuria in patients with T2DM. However, its modest discriminatory performance suggests that ALI should not be considered a stand-alone marker of kidney involvement

1. INTRODUCTION

Type 2 diabetes mellitus (T2DM) is a major global health concern, with a steadily increasing prevalence and a substantial burden of microvascular and macrovascular complications. Diabetic kidney disease (DKD) is among the most clinically significant microvascular complications of T2DM and remains a leading cause of chronic kidney disease and kidney failure, while substantially increasing the risk of cardiovascular morbidity and mortality. Kidney involvement in patients with T2DM is primarily assessed using two complementary markers: the estimated glomerular filtration rate (eGFR), which reflects kidney filtration function, and the urinary albumin-to-creatinine ratio (UACR), which reflects glomerular injury and increased urinary albumin excretion. Importantly, albuminuria may develop while eGFR remains preserved, whereas a subset of patients may

experience a decline in eGFR without substantial albuminuria. Therefore, concurrent assessment of eGFR and UACR is essential for the detection, risk stratification, and monitoring of kidney disease in patients with diabetes (de Boer et al., 2022; Rossing et al., 2022; Stevens et al., 2024).

Beyond hyperglycemia and hypertension, abnormalities in lipid metabolism are increasingly recognized as potential contributors to the development and progression of DKD. Diabetic dyslipidemia is typically characterized by elevated triglyceride (TG) levels, reduced high-density lipoprotein cholesterol (HDL-C), and a predominance of small dense low-density lipoprotein particles. These lipid abnormalities may contribute to kidney injury through several interconnected mechanisms, including renal lipid accumulation and lipotoxicity, oxidative stress, chronic inflammation, endothelial dysfunction, podocyte injury, and progressive renal fibrosis. The Atherogenic Lipid Index (ALI), calculated as $\log_{10}$(TG/HDL-C), with both lipid concentrations expressed in mmol/L, integrates atherogenic and protective lipid components into a single readily obtainable measure. Higher ALI values reflect a more atherogenic lipid profile and may therefore represent the metabolic milieu associated with both vascular and kidney injury. Because TG and HDL-C are routinely measured in clinical practice, ALI may provide a simple and potentially useful marker for identifying metabolic disturbances associated with kidney dysfunction in patients with T2DM (Harkin et al., 2023; Li et al., 2025; B. Wang et al., 2024).

Although ALI has been extensively investigated as a marker of atherosclerotic and cardiovascular risk, evidence regarding its association with kidney involvement in patients with T2DM remains comparatively limited, particularly when reduced eGFR and albuminuria are evaluated as distinct renal manifestations. Previous studies have reported associations between atherogenic lipid indices and DKD, impaired kidney function, or albuminuria; however, the extent to which ALI reflects these two complementary dimensions of kidney involvement remains incompletely characterized. Furthermore, evidence from Indonesian populations is scarce. Given that ALI can be readily calculated from routinely available lipid measurements without additional laboratory testing, determining its relationship with both eGFR and albuminuria may provide clinically relevant information regarding its potential role in kidney risk assessment. Therefore, this study aimed to investigate the association of ALI with reduced eGFR and albuminuria in patients with T2DM and to evaluate its discriminatory ability to identify these two manifestations of kidney involvement (Xu et al., 2022; Yan et al., 2024; Zhang et al., 2025).

2. MATERIALS AND METHODS

2.1 Study design and subjects

This cross-sectional analytical study was conducted to investigate the association of the ALI with reduced estimated eGFR and albuminuria in patients with T2DM. The study was conducted at FINARI Medical Center, Makassar, Indonesia, from January to July 2026. All eligible patients presenting during the study period were included using a total sampling approach.

Adult patients aged ≥18 years with a confirmed diagnosis of T2DM documented in their medical records were eligible for inclusion. Participants were required to have available TG, (HDL-C, serum creatinine, and UACR measurements. Patients with non-diabetic kidney diseases, including glomerulonephritis, lupus nephritis, polycystic kidney disease, or obstructive nephropathy, were excluded. Patients receiving kidney replacement therapy, including hemodialysis or peritoneal dialysis, and those with conditions potentially causing transient albuminuria at the time of examination, such as urinary tract infection, fever, or pregnancy, were also excluded.

2.2 Clinical and Laboratory Assessment

Demographic characteristics, clinical data, and laboratory results were obtained from the patients' medical records. Clinical variables included age, sex, body mass index (BMI), systolic and diastolic blood pressure, and glycated hemoglobin (HbA1c). BMI was calculated as body weight in kilograms divided by the square of height in meters (kg/m^2). Blood pressure measurements recorded during the corresponding clinical visit were used for the analysis.

Venous blood samples were collected under non-fasting conditions and processed according to standard laboratory procedures. Serum total cholesterol, TG, and HDL-C concentrations were measured using enzymatic colorimetric methods on an Erba XL 640 automated clinical chemistry analyzer (Erba Mannheim). Serum creatinine was determined using the kinetic Jaffé method on the same platform. HbA1c was measured using the boronate affinity method with the NycoCard HbA1c point-of-care testing system. The ALI was calculated as $\log_{10}$(TG/HDL-C), with TG and HDL-C concentrations expressed in mmol/L. Kidney function was assessed using the eGFR, calculated from serum creatinine, age, and sex using the 2021 Chronic Kidney

Disease Epidemiology Collaboration (CKD-EPI) equation. Reduced kidney function was defined as an eGFR <60 mL/min/1.73 m².

Urinary albumin excretion was assessed using a random spot urine sample. Urinary albumin was measured using an immunoturbidimetric assay, whereas urinary creatinine was determined using the kinetic Jaffé method. The UACR was calculated and expressed as milligrams of albumin per gram of creatinine (mg/g). According to the Kidney Disease: Improving Global Outcomes (KDIGO) classification, UACR was categorized as A1 (<30 mg/g), A2 (30–300 mg/g), and A3 (>300 mg/g). For binary analyses, albuminuria was defined as UACR ≥30 mg/g.

2.3 Data collection

Data were collected from the medical records and laboratory database of patients with type 2 diabetes mellitus who attended FINARI Medical Center, Makassar, Indonesia, between January and July 2026. All patients who fulfilled the predefined inclusion and exclusion criteria during the study period were included using a total sampling approach. Demographic and clinical variables included age, sex, BMI, systolic and diastolic blood pressure, HbA1c, and medication history. Laboratory variables included total cholesterol, TG, high-density lipoprotein cholesterol (HDL-C), serum creatinine, urinary albumin, and urinary creatinine.

The Atherogenic Lipid Index was calculated as $\log_{10}$(TG/HDL-C), with TG and HDL-C concentrations expressed in mmol/L. The eGFR was calculated from serum creatinine, age, and sex using the 2021 CKD-EPI creatinine equation and expressed as mL/min/1.73 m². The UACR was calculated from urinary albumin and creatinine concentrations and expressed as mg/g. Reduced kidney function was defined as an eGFR <60 mL/min/1.73 m², while albuminuria was defined as UACR ≥30 mg/g. UACR was further categorized as A1 (<30 mg/g), A2 (30–300 mg/g), and A3 (>300 mg/g).

Prior to statistical analysis, the collected data underwent systematic editing, coding, data entry, and cleaning to ensure completeness and internal consistency. Records were reviewed for eligibility and availability of the variables required to calculate ALI and assess kidney outcomes. Data were subsequently screened for incomplete entries and implausible or extreme values before inclusion in the analytical dataset. After application of the eligibility criteria and data-quality procedures, 294 patients with T2DM were included in the final analysis

2.4 Definitions and Outcomes

The primary exposure of interest was the Atherogenic Lipid Index (ALI), calculated as $\log_{10}$(TG/HDL-C), with TG and HDL-C concentrations expressed in mmol/L. Because no universally established clinical cut-off for ALI has been validated for identifying kidney dysfunction in patients with T2DM, participants were categorized according to the distribution of ALI values in the study population. The tertile boundaries were <0.36, 0.36–0.59, and >0.59, representing the lower, middle, and upper thirds of the ALI distribution, respectively. For the primary categorical analysis, the lower and middle tertiles were combined (ALI ≤0.59) and compared with the highest tertile (ALI >0.59) to specifically evaluate whether participants with the highest ALI levels differed in kidney outcomes from the remainder of the study population. This categorization was distribution-based and was not intended to represent an established clinical risk threshold. ALI was also evaluated as a continuous variable in ROC analyses.

The primary outcomes were reduced kidney function and albuminuria. Kidney function was assessed using the eGFR, calculated using the 2021 CKD-EPI creatinine equation and expressed as mL/min/1.73 m². Reduced kidney function was defined as eGFR <60 mL/min/1.73 m², whereas eGFR ≥60 mL/min/1.73 m² was classified as preserved kidney function. For descriptive purposes, eGFR was further categorized according to KDIGO GFR categories as G1 (≥90 mL/min/1.73 m²), G2 (60–89 mL/min/1.73 m²), G3a (45–59 mL/min/1.73 m²), G3b (30–44 mL/min/1.73 m²), G4 (15–29 mL/min/1.73 m²), and G5 (<15 mL/min/1.73 m²).

Albuminuria was assessed using the UACR obtained from a random spot urine sample and expressed as mg/g. Albuminuria was defined as UACR ≥30 mg/g, whereas UACR <30 mg/g was classified as no albuminuria. For descriptive and categorical analyses, albuminuria was further classified according to KDIGO categories as A1 (<30 mg/g), A2 (30–300 mg/g), and A3 (>300 mg/g). The primary analyses evaluated the associations between ALI risk groups and the presence of reduced kidney function and albuminuria. In addition, receiver operating characteristic (ROC) curve analyses were performed to assess the

discriminatory ability of ALI for identifying reduced kidney function and albuminuria, with the area under the curve (AUC), sensitivity, specificity, and optimal cut-off values reported.

2.5 Statistical Analysis

Statistical analyses were performed using IBM SPSS Statistics for Windows, version 26.0 (IBM Corp., Armonk, NY, USA). The distribution of continuous variables was assessed using the Shapiro–Wilk test. Normally distributed continuous variables were summarized as mean ± standard deviation, whereas non-normally distributed variables were presented as median with the corresponding dispersion measure. Categorical variables were summarized as frequencies and percentages.

Associations between ALI categories and kidney outcomes were evaluated using Pearson's chi-square test. For the primary categorical analysis, participants in the lower and middle ALI tertiles were combined (ALI ≤0.59) and compared with participants in the highest tertile (ALI >0.59), with the former serving as the reference group. Reduced kidney function was defined as eGFR <60 mL/min/1.73 m², and albuminuria was defined as UACR ≥30 mg/g. Associations were expressed as crude odds ratios (ORs) with 95% confidence intervals (CIs). Because multivariable logistic regression was not performed, these estimates represent unadjusted associations and may be affected by residual confounding from factors such as age, sex, blood pressure, glycemic control, obesity, diabetes duration, and medication use. Accordingly, the findings were interpreted as associations rather than independent or causal effects.

Receiver operating characteristic (ROC) curve analysis was performed using ALI as a continuous variable to evaluate its ability to discriminate participants with and without reduced kidney function and albuminuria. Discriminatory performance was quantified using the area under the ROC curve (AUC) with 95% CIs. An AUC of 0.5 indicates discrimination no better than chance, whereas progressively higher values indicate greater discriminatory ability. The reported ALI cut-off values were derived from the ROC analysis and were presented together with the corresponding sensitivity and specificity. These ROC-derived cut-offs were exploratory and were not considered validated clinical thresholds. All statistical tests were two-sided, and a p-value <0.05 was considered statistically significant.

3. RESULTS AND DISCUSSION

3.1 Baseline Characteristics

A total of 294 patients with type 2 diabetes mellitus were included in the analysis. The median age was 62 years (range, 35–79), and 150 participants (51.0%) were female. The median body mass index was 25.30 kg/m² (range, 16.10–65.80), while the median systolic and diastolic blood pressures were 130 mmHg (range, 100–190) and 80 mmHg (range, 55–110), respectively. The median HbA1c level was 8.30% (range, 5.80–14.80).

The median total cholesterol, triglyceride, and HDL-C levels were 199 mg/dL (range, 105–399), 137 mg/dL (range, 59–1412), and 46 mg/dL (range, 21–107), respectively. The median ALI was 0.47 (range, 0.02–1.67). Regarding kidney parameters, the median serum creatinine level was 0.83 mg/dL (range, 0.08–2.84), the median eGFR was 83.4 mL/min/1.73 m² (range, 6.9–219), and the median UACR was 25.32 mg/g (range, 0.65–5650). Based on UACR categories, 173 participants (58.8%) were classified as A1, 105 (35.7%) as A2, and 16 (5.4%) as A3 (Table 1).

Table 1. Clinical and laboratory characteristics of the study participants (n = 294)

Characteristics	Overall (n = 294)
Demographic and clinical characteristics	
Age, years	62 (35–79)
Sex, n (%)	
Male	144 (49.0)
Female	150 (51.0)
Body mass index, kg/m²	25.30 (16.10–65.80)

Systolic blood pressure, mmHg	130 (100–190)
Diastolic blood pressure, mmHg	80 (55–110)
HbA1c, %	8.30 (5.80–14.80)
Lipid parameters	
Total cholesterol, mg/dL	199 (105–399)
Triglycerides, mg/dL	137 (59–1412)
HDL-C, mg/dL	46 (21–107)
Atherogenic Lipid Index	0.47 (0.02–1.67)
Kidney parameters	
Serum creatinine, mg/dL	0.83 (0.08–2.84)
eGFR, mL/min/1.73 m²	83.4 (6.9–219)
UACR, mg/g	25.32 (0.65–5650)
Albuminuria category, n (%)	
A1 (<30 mg/g)	173 (58.8)
A2 (30–300 mg/g)	105 (35.7)
A3 (>300 mg/g)	16 (5.4)
Data are presented as median (range) for continuous variables and n (%) for categorical variables. **Abbreviations**: eGFR, estimated glomerular filtration rate; HbA1c, glycated hemoglobin; HDL-C, high-density lipoprotein cholesterol; UACR, urinary albumin-to-creatinine ratio.	

3.2 Association between ALI and Reduced Kidney Function

The distribution of eGFR categories differed significantly between the ALI risk groups. Reduced kidney function (eGFR <60 mL/min/1.73 m²) was observed in 28 (14.1%) participants in the low-risk ALI group and 29 (30.5%) participants in the high-risk ALI group. Conversely, an eGFR ≥60 mL/min/1.73 m² was observed in 171 (85.9%) and 66 (69.5%) participants in the low- and high-risk ALI groups, respectively. The association between ALI risk category and reduced kidney function was statistically significant (p=0.001). Compared with participants in the low-risk ALI group, those in the high-risk group had 2.68-fold higher odds of reduced kidney function (OR 2.68; 95% CI, 1.48–4.85) (Table 2)

Table 2. Association of Atherogenic Lipid Index Risk with Kidney Outcomes

Kidney outcome	Atherogenic Lipid Index		OR (95% CI)	p value
	Low-risk (n=199)	High-risk (n=95)		
UACR category, n (%)				
A1 (<30 mg/g)	119 (59.8)	54 (56.8)	—	0.298
A2 (30–300 mg/g)	72 (36.2)	33 (34.7)	—	
A3 (>300 mg/g)	8 (4.0)	8 (8.4)	—	

Kidney function, n (%)				
eGFR ≥60 mL/min/1.73 m²	171 (85.9)	66 (69.5)	Reference	0.001
eGFR <60 mL/min/1.73 m²	28 (14.1)	29 (30.5)	2.68 (1.48–4.85)	
Albuminuria, n (%)				
No (UACR <30 mg/g)	119 (59.8)	54 (56.8)	Reference	0.630
Yes (UACR ≥30 mg/g)	80 (40.2)	41 (43.2)	1.13 (0.69–1.85)	

Data are presented as n (%), with percentages calculated within each ALI risk category. Associations were assessed using Pearson's chi-square test. Low-risk ALI was defined as ALI ≤0.59 and high-risk ALI as ALI >0.59. Odds ratios are presented with the low-risk ALI group as the reference category. Abbreviations: ALI, Atherogenic Lipid Index; CI, confidence interval; eGFR, estimated glomerular filtration rate; OR, odds ratio; UACR, urinary albumin-to-creatinine ratio.

3.3 Discriminatory Performance of ALI for Kidney Outcomes

Receiver operating characteristic curve analysis showed that ALI had modest discriminatory ability for reduced kidney function. The area under the curve (AUC) was 0.647 (95% CI, 0.568–0.727; p=0.013). At an ALI cut-off value of 0.52, the sensitivity and specificity for identifying participants with an eGFR <60 mL/min/1.73 m² were 56% and 59%, respectively (Table 3; Figure 1A). The ROC curve was positioned above the reference diagonal, indicating discriminatory ability greater than chance, although the overall performance remained modest.

In contrast, ALI showed no meaningful discriminatory ability for albuminuria, with an AUC of 0.489 (95% CI, 0.420–0.558; p=0.262). At an ALI cut-off value of 0.47, the sensitivity and specificity for identifying albuminuria (UACR ≥30 mg/g) were 46% and 48%, respectively (Table III; Figure 1B). Consistent with the AUC estimate, the ROC curve closely followed the reference diagonal, indicating discrimination approximately equivalent to chance.

Table 3. Discriminatory Performance of the Atherogenic Lipid Index for Reduced Kidney Function and Albuminuria

Outcome	ALI cut-off	Sensitivity (%)	Specificity %	AUC (95% CI)	p value
Reduced kidney function (eGFR <60 mL/min/1.73 m²)	0.52	56	59	0.647 (0.568–0.727)	0.013
Albuminuria (UACR ≥30 mg/g)	0.47	46	48	0.489 (0.420–0.558)	0.262

Receiver operating characteristic curve analysis was used to evaluate the discriminatory performance of ALI for reduced kidney function and albuminuria. Reduced kidney function was defined as eGFR <60 mL/min/1.73 m², and albuminuria was defined as UACR ≥30 mg/g. Abbreviations: ALI, Atherogenic Lipid Index; AUC, area under the receiver operating characteristic curve; CI, confidence interval; eGFR, estimated glomerular filtration rate; UACR, urinary albumin-to-creatinine ratio.

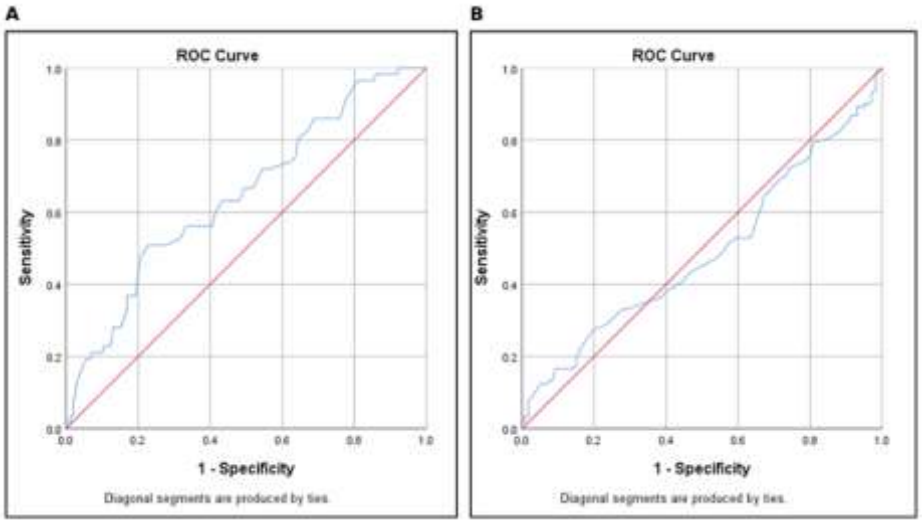

Figure 1. Receiver operating characteristic curves of the Atherogenic Lipid Index for kidney outcomes. (A) ROC curve of ALI for identifying reduced kidney function (eGFR <60 mL/min/1.73 m²), with an AUC of 0.647 (95% CI, 0.568–0.727; p=0.013). (B) ROC curve of ALI for identifying albuminuria (UACR ≥30 mg/g), with an AUC of 0.489 (95% CI, 0.420–0.558; p=0.262). ALI, Atherogenic Lipid Index; AUC, area under the receiver operating characteristic curve; CI, confidence interval; eGFR, estimated glomerular filtration rate; ROC, receiver operating characteristic; UACR, urinary albumin-to-creatinine ratio.

3.4 Discussion

In this cross-sectional study of 294 patients with T2DM, the principal finding was a significant association between the ALI and reduced kidney function, whereas no significant association was observed between ALI and albuminuria. Reduced kidney function (eGFR <60 mL/min/1.73 m²) was more frequent in the high-risk than in the low-risk ALI group (30.5% vs. 14.1%), with participants in the high-risk group having approximately 2.68-fold higher odds of reduced kidney function. In contrast, albuminuria was observed in 43.2% and 40.2% of the high- and low-risk ALI groups, respectively, with no significant difference between groups. These findings suggest a differential relationship between atherogenic lipid abnormalities and kidney manifestations in T2DM, with ALI being more strongly associated with reduced filtration function than with urinary albumin excretion. This distinction is clinically relevant because eGFR and UACR represent complementary but not necessarily parallel manifestations of DKD.

The significant association between higher ALI and reduced eGFR is consistent with previous evidence linking atherogenic lipid abnormalities to impaired kidney function. Huang et al. (2021) reported that increased atherogenic lipid indices and triglyceride concentrations were associated with a greater risk of kidney function decline, while Yuan et al. (2020) demonstrated an association between the atherogenic index and subclinical renal damage during long-term follow-up. Biologically, a high ALI reflects a lipid profile characterized by increased triglyceride-rich lipoproteins relative to HDL-C. Such abnormalities may promote renal lipid accumulation and lipotoxicity, leading to oxidative stress, endothelial dysfunction, inflammation, podocyte injury, glomerulosclerosis, and tubulointerstitial fibrosis, which may ultimately impair filtration capacity. Nevertheless, because the present study was cross-sectional, the observed association cannot establish temporality or causality between elevated ALI and reduced kidney function (Huang et al., 2021; Yuan et al., 2020; Zhang et al., 2025)

Despite this significant association, ALI demonstrated only modest discriminatory ability for reduced kidney function, with an AUC of 0.647 (95% CI, 0.568–0.727; p=0.013), and sensitivity and specificity of 56% and 59%, respectively, at a cut-off of 0.52. This finding highlights an important distinction between statistical association and clinical discrimination: although high-risk ALI was associated with reduced eGFR at the group level, its ability to distinguish individual patients with and without reduced kidney function was limited. Therefore, ALI should not be considered a stand-alone marker of kidney dysfunction. Rather, because it can be readily derived from routinely measured triglyceride and HDL-C concentrations, ALI may provide

complementary metabolic information when interpreted alongside established kidney markers and conventional clinical risk factors (Hirano et al., 2022; Li et al., 2025; B. Wang et al., 2024)

In contrast, ALI was not significantly associated with albuminuria, either when UACR was evaluated categorically (A1–A3; p=0.298) or as a binary outcome (UACR ≥30 mg/g; OR 1.129; 95% CI, 0.688–1.853; p=0.630). Furthermore, ALI showed no meaningful discriminatory ability for albuminuria (AUC 0.489; 95% CI, 0.420–0.558; p=0.262). These findings differ from previous studies reporting associations between atherogenic lipid parameters and urinary albumin excretion. Xue et al. (2021) reported a positive association between the TG/HDL-C ratio and UACR, while Wang et al. (2019) found that elevated triglyceride concentrations were associated with increased UACR. The discrepancy may reflect the multifactorial nature of albuminuria, which is influenced by glycemic control, blood pressure, diabetes duration, obesity, inflammation, kidney function, and renoprotective therapies in addition to lipid abnormalities. Moreover, albuminuria primarily reflects glomerular barrier and podocyte injury, whereas eGFR reflects overall filtration capacity, potentially explaining why ALI showed different relationships with these two kidney manifestations (Lee et al., 2016; Y.-X. Wang et al., 2019; Xue et al., 2021)

These findings should be interpreted in light of several limitations. The cross-sectional design precludes causal or temporal inference and therefore does not establish ALI as a predictor of subsequent kidney function decline. UACR was assessed using a single spot urine measurement, which may be affected by biological variability and cannot establish persistent albuminuria. The single-center setting may also limit generalizability, while potentially important confounders—including age, sex, blood pressure, glycemic control, obesity, diabetes duration, lipid-lowering therapy, and renoprotective treatment were not comprehensively adjusted for; consequently, the reported ORs represent unadjusted associations. Nevertheless, the simultaneous evaluation of eGFR and albuminuria provides insight into potentially different relationships between atherogenic dyslipidemia and distinct kidney manifestations in T2DM. Future prospective, multicenter studies incorporating serial ALI, eGFR, and UACR measurements and multivariable adjustment are warranted to determine whether ALI is independently associated with longitudinal kidney outcomes (American Diabetes Association, 2025; de Boer et al., 2022; Rossing et al., 2022)

4. CONCLUSION

In patients with type 2 diabetes mellitus, a higher Atherogenic Lipid Index (ALI) was significantly associated with reduced kidney function but not with albuminuria. Although ALI demonstrated some ability to discriminate reduced kidney function, its overall discriminatory performance was limited, while no meaningful discrimination was observed for albuminuria. These findings suggest that ALI may serve as a complementary metabolic indicator of impaired kidney filtration but should not be used as a stand-alone marker of kidney involvement. Further prospective studies with longitudinal follow-up and appropriate adjustment for potential confounders are needed to clarify the independent and prognostic value of ALI for kidney outcomes in patients with T2DM.

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AUTHOR CONTRIBUTIONS

Abdul Qayyum Irfan: Conceptualization, Methodology, Investigation, Data Curation, Formal Analysis, Writing – Original Draft, Visualization.

Fabiola MS Adam: Conceptualization, Methodology, Supervision, Validation, Writing – Review & Editing.

Haerani Rasyid: Conceptualization, Methodology, Supervision, Validation, Writing – Review & Editing. Syakib Bakri: Methodology, Validation, Writing – Review & Editing.

Andi Makbul Aman: Methodology, Validation, Writing – Review & Editing.

Andi Nabilla Ramadhani Putri Makhfi Ghalib: Data Curation, Writing – Original Draft, Visualization

Andi Alfian Zainuddin: Methodology, Formal Analysis, Validation, Writing – Review & Editing. All authors reviewed and approved the final version of the manuscript and agreed to be accountable for the work.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

ETHICS STATEMENT

The study protocol was reviewed and approved by the Human Biomedical Research Ethics Committee, Faculty of Medicine, Universitas Hasanuddin, Makassar, Indonesia (ethical approval No. 689/UN.4.6.4.5.31/PP36/2026). The requirement for informed consent was waived by the ethics committee because of the retrospective nature of the study and the use of routinely collected clinical data. All patient data were anonymized prior to analysis and handled confidentially to protect participant privacy.

DATA AVAILABILITY STATEMENT

The datasets generated and/or analyzed during the current study are available from the corresponding author upon reasonable request.

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