The Research of Medical Science Review
ISSN: 3007-1208 & 3007-1216 Volume 3, Issue 7, 2025

PREVALENCE OF NEPHROPATHY AMONG DIABETIC PATIENTS WITH VARIOUS LEVELS OF VISCERAL ADIPOSITY INDEX

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DOI: https://doi.org/10.5281/zenodo.16885795

Keywords
Diabetes mellitus, Visceral Adiposity Index (VAI), Type 2 diabetes, Chronic kidney disease, Metabolic dysfunction.

Article History
Received on 01 June 2025
Accepted on 04 July 2025
Published on 09 July 2025

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Abstract

Diabetic nephropathy (DN) is a predominant consequence of type 2 diabetes mellitus (T2DM), with visceral obesity contributing to its development through metabolic dysfunction. The Visceral Adiposity Index (VAI), an indicator of visceral fat, may assist in predicting diabetic nephropathy risk; however, local data is limited.

OBJECTIVE: *To determine the frequency of nephropathy among diabetic patients presenting with various levels of visceral adiposity index (VAI) to the tertiary care hospital of Rawalpindi.*

SUBJECTS AND METHODS: *This cross-sectional study was performed at Fauji Foundation Hospital, Rawalpindi. 173 patients having Type 2 Diabetes Mellitus (HbA1c >6.5%) from one year or more were enrolled. VAI was computed with sex-specific formulas that included waist circumference, BMI, triglycerides, and HDL-C, categorizing patients into three levels: VAI <1.45 (Level 1), 1.45–2.65 (Level 2), and >2.65 (Level 3). Diabetic nephropathy was diagnosed using eGFR (<60 mL/min/1.73m²) or albuminuria (UACR ≥30 mg/g). Gathered data was analyzed utilizing SPSS v20. Stratification was done for study confounders. Chi-square test was applied to evaluate relationships and p≤0.05 considered significant.*

RESULTS: *The incidence of diabetic nephropathy escalated with elevated VAI levels. At VAI level 1, merely 19.1% of patients exhibited diabetic nephropathy, in contrast to 53.5% at level 2 and 64.7% at level 3. In total, 42.2% of patients received a diagnosis of diabetic nephropathy. Females had elevated DN rates at all VAI levels (p=0.001). Age stratification indicated substantial diabetic nephropathy in older patients (>55 years) with elevated VAI (p=0.001), whereas extended diabetes duration (≥27 months) and inadequate glycemic control (HbA1c ≥10.0%) reinforced the correlation (p≤0.001 and p=0.009, respectively).*

CONCLUSION: *Increased VAI is significantly associated with the incidence of DN, especially in females, individuals with poorly managed diabetes, and those with an extended course of the disease. VAI, an uncomplicated and economical*

instrument, has the potential to improve early diabetic nephropathy risk categorization in resource-constrained environments, facilitating targeted therapies to alleviate renal consequences. Future investigations are required to confirm causality and refine VAI levels.

INTRODUCTION

Type II diabetes mellitus (T2DM) has become a significant global public health issue, characterized by several complications and a rising prevalence. Individuals with diabetes mellitus are susceptible to several complications, rendering the condition a significant hazard to human health. [i] Visceral adipose tissue, conversely, has been identified as a significant factor in the pathogenesis of T2DM. Obesity is generally a chronic, recurrent, and complex condition that impacts all organ systems and frequently results in metabolic abnormalities or other associated comorbidities that influence both physical and mental health. [ii] Research indicates that diabetic kidney disease (DKD) constitutes 44.5% of end-stage renal disease. Diabetic nephropathy is identified as the most prevalent cause of chronic kidney disease (CKD) in Pakistan, accounting for 27.1% of cases. [iii]

Elevated visceral fat tissues in the body may contribute to the pathophysiology of DKD through mechanisms such as insulin resistance, inflammation, endothelial dysfunction, fibrinolysis, and thrombosis.[iv,v] Several studies have indicated that the distribution of adipose tissue, rather than its total volume, is more critical in the onset of vascular problems. [vi] Despite significant advancements in current treatment protocols for DKD that have successfully delaying disease progression, the incidence of DKD continues to rise, and associated mortality rates remain unchanged. A thorough examination of the risk factors associated with the advancement of DKD, particularly visceral fat accumulation, is essential for developing effective preventive and therapeutic strategies to mitigate the onset and development of DKD in clinical settings.[vii,viii]

The Visceral Adiposity Index (VAI), commonly referred to as visceral fat grade, has demonstrated reliability as an indication of visceral fat accumulation and adipose tissue dysfunction. A higher index value correlates with an increased level of visceral fat content. In contrast to conventional body assessment metrics such as BMI, waist circumference (WC), and waist-to-height ratio (WHtR), the visceral adiposity index (VAI) can precisely differentiate visceral fat from subcutaneous fat. Magnetic Resonance Imaging (MRI) and Computed Tomography (CT) are accurate and dependable methods for identifying visceral fat; nevertheless, these imaging techniques can be expensive and challenging to perform for certain individuals. [ix, x] Consequently, employing VAI, a mathematical model that incorporates both anthropometric and metabolic characteristics to quantify adipose distribution, may serve as a superior instrument for evaluating the effects of visceral adiposity on clinical outcomes.[xi] Concluded that VAI may be a simple and cost-effective index to predict the occurrence of DKD as with increasing the VAI the incidence of DKD also increases and they emphasized that further prospective investigations to be conducted on various population.

Despite its clinical relevance, studies investigating the prevalence of diabetic nephropathy among patients with high VAI are limited, especially in local contexts. This study aims to fill this gap by examining the prevalence of diabetic nephropathy among patients with elevated VAI in a specific geographic and ethnic population, where such research is scarcely conducted. Given the significant role of visceral adiposity in the pathogenesis of DN, assessing VAI in diabetic patients can serve as a valuable tool for early detection and intervention. If our study shows a higher prevalence of DKD among patients with increased VAI, this index would routinely be investigated among all the patients at very early stages of their presentation with diabetes. By determining the prevalence of diabetic nephropathy among patients with high VAI, this study aims to provide critical insights that can inform clinical practices and public health strategies to devise the guidelines for the prevention and management of diabetic nephropathy especially in the local context that would eventually help to reduce the overall morbidity and mortality associated with diabetic nephropathy.

MATERIAL AND METHODS

This cross-sectional study was conducted at the Department of Medicine, Fauji Foundation Hospital, Rawalpindi, over six months from December 2024 to May 2025. A sample size of 173 diabetic patients was calculated using the WHO sample size calculator, assuming a 95% confidence level, 7% absolute precision, and an anticipated nephropathy prevalence of 67.02% as described by Li C et al.[12] in their study. Ethical approval was taken from ethical review board through letter number 883/RC/FFH/RWP and informed consent (written in Urdu/English) were obtained prior to enrollment from every patient. Consecutive non-probability sampling was employed to enroll patients aged 20–70 years with type 2 diabetes (HbA1c >6.5% and ≥1 year of confirmed diagnosis). Exclusion criteria included pre-existing chronic kidney disease, pregnancy, incomplete records, and nephrotoxic drug use. Visceral adiposity index (VAI) was calculated using sex-specific formulas incorporating waist circumference (WC), BMI, triglycerides (TG), and HDL-C. Patients were stratified into three VAI levels: Level 1 (VAI <1.45), Level 2 (VAI 1.45–2.65), and Level 3 (VAI >2.65). Diabetic nephropathy was diagnosed if eGFR (calculated via MDRD equation) was <60 mL/min/1.73m² or urinary albumin-to-creatinine ratio (UACR) was ≥30 mg/g. Data collection involved anthropometric (height, weight, WC) and biochemical (lipid profile, HbA1c, serum creatinine, UACR) measurements. SPSS v20 was used for analysis of quantitative variables such as age, BMI, HbA1c, eGFR and were expressed as mean ± SD, while qualitative variables like sex, smoking status, hypertension status and diabetic nephropathy were reported as frequencies/percentages. Stratification on the basis of age, sex, diabetes duration, HbA1c, and hypertension was performed. Chi-square test was applied and p value ≤0.05 considered significant.

RESULTS

The study comprised 173 patients with type II diabetes, with a mean age of 48.03±11.86 years (range: 28–70) and a mean duration of diabetes of 38.03±13.53 months. Females constituted 51.4% of the study, and males accounted for 48.6%. More than half of the participants were smokers, and 38.7% were hypertensive. The average HbA1c was 9.22±1.62%, with 38.7% of patients exhibiting levels ≥10.0%. The average BMI was 26.38±6.21 kg/m². The average eGFR was 76.35±19.29 ml/min. The average visceral adiposity index was 1.93±1.07, with 39.3% of patients in VAI level 1, 41.0% in level 2, and 19.7% in level 3. In terms of diabetes management, 38.2% utilized insulin followed by oral medications and lifestyle modifications. A comprehensive analysis containing all the studied quantitative and qualitative demographic and clinical factors is included in Table 1, Table 2, Figure 1 and Figure 2.

The incidence of diabetic nephropathy escalated with elevated VAI levels. At VAI level 1, merely 19.1% of patients exhibited diabetic nephropathy, in contrast to 53.5% at level 2 and 64.7% at level 3. In total, 42.2% of patients received a diagnosis of diabetic nephropathy (see figure 3).

Sex-stratified analysis indicated that females exhibited a consistently greater prevalence of nephropathy throughout all VAI levels compared to males (p=0.001), whereas males demonstrated a similar trend but with fewer instances in the highest VAI category. Age-based stratification indicated that younger patients (upto 40 years) displayed significant nephropathy rates even at low VAI (31.8%), though not statistically significant (p=0.081), while older patients (>55 years) exhibited the lowest rates at low VAI but a pronounced increase at elevated levels (p = 0.001). The examination of diabetes duration revealed no significant trend in those with a shorter illness duration (15–26 years; p=0.664), whereas a robust link was observed in those with a longer duration (≥27 years; p≤0.001). Glycemic control stratification indicated that inadequate control (HbA1c ≥ 10.0%) exhibited the highest rates of nephropathy across VAI levels (p=0.009), but intermediate control (8.0–9.9%) also demonstrated significance (p=0.015). Patterns of antidiabetic care indicated that lifestyle modifications and oral medications were associated with the most robust VAI–nephropathy correlation (p<0.005), whereas insulin-treated individuals exhibited questionable significance (p=0.050). The study of hypertension interactions revealed a robust connection in non-hypertensive individuals (p<0.001), but a non-significant trend was observed in hypertensive persons (p=0.064), indicating that hypertension may obscure the effect of VAI.

Table 1: Profile of quantitative demographic and clinical variables of the study population (n = 173)

Variable	Minimum	Maximum	Mean	± Std. Deviation
Age (Years)	28.00	70.00	48.03	11.86
Duration of Diabetes (months)	15.00	60.00	38.03	13.53
HbA1c Levels (%)	6.61	11.99	9.22	1.62
Height (m)	1.50	1.90	1.71	0.12
Weight (kg)	50.60	99.80	76.12	14.08
BMI (kg/m²)	14.20	42.60	26.38	6.21
Waist Circumference (cm)	70.00	108.70	88.70	10.54
Triglyceride (mmol/L)	0.82	2.46	1.58	0.49
HDL (mmol/L)	0.80	1.99	1.41	0.36
eGFR (ml/min)	45.50	110.00	76.35	19.29
Albuminuria (mg/g)	14.30	199.90	105.46	52.87
Visceral Adiposity Index (VAI)	0.49	6.54	1.93	1.07

Table 2: Profile of qualitative demographic and clinical variables of the study population (n = 173)

Variable	Category	Frequency	Percent
Sex	Female	89	51.4
	Male	84	48.6
Age Group (Years)	Upto 40	53	30.6
	41–55	67	38.7
	>55	53	30.6
Duration Group (Months)	Upto 24	40	23.1
	25–44	65	37.6
	≥45	68	39.3
Smoker	No	74	42.8
	Yes	99	57.2
Hypertensive	No	106	61.3
	Yes	67	38.7
HbA1c Group (%)	6.5–7.9	47	27.2
	8.0–9.9	59	34.1
	≥10.0	67	38.7

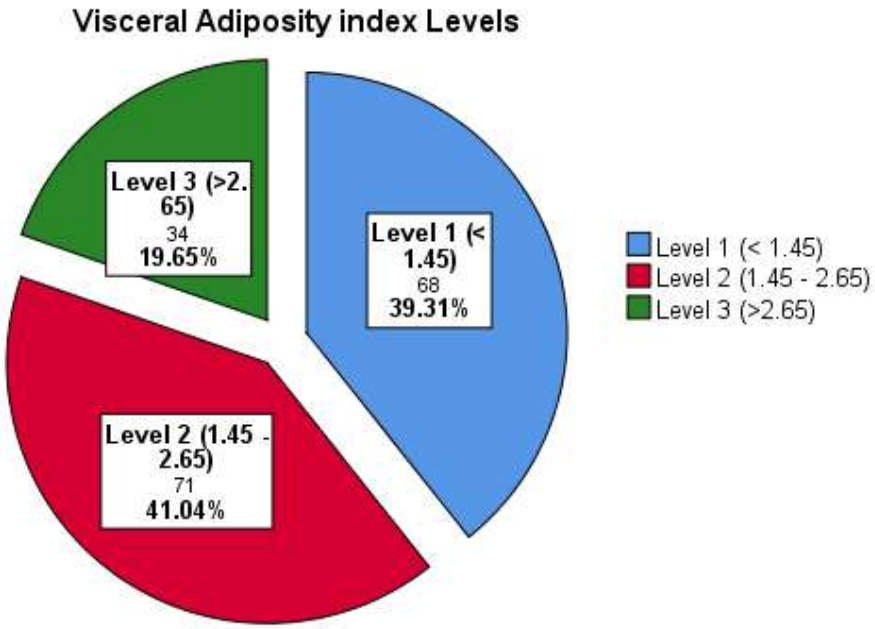

Figure 1: Distribution of total study population on the basis of VAI Levels

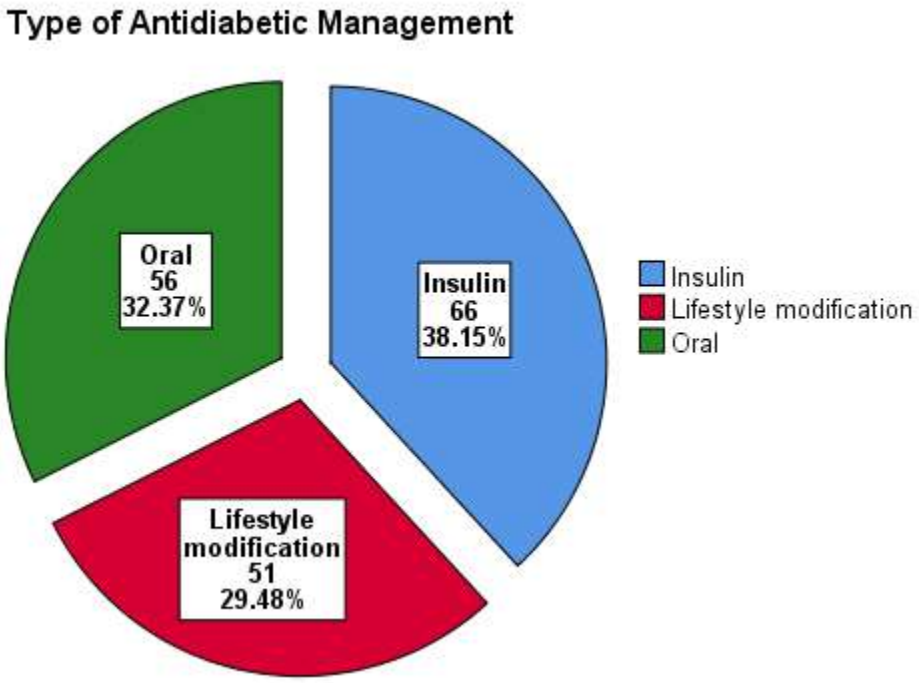

Figure 2: Distribution of total study population on the basis of diabetic management

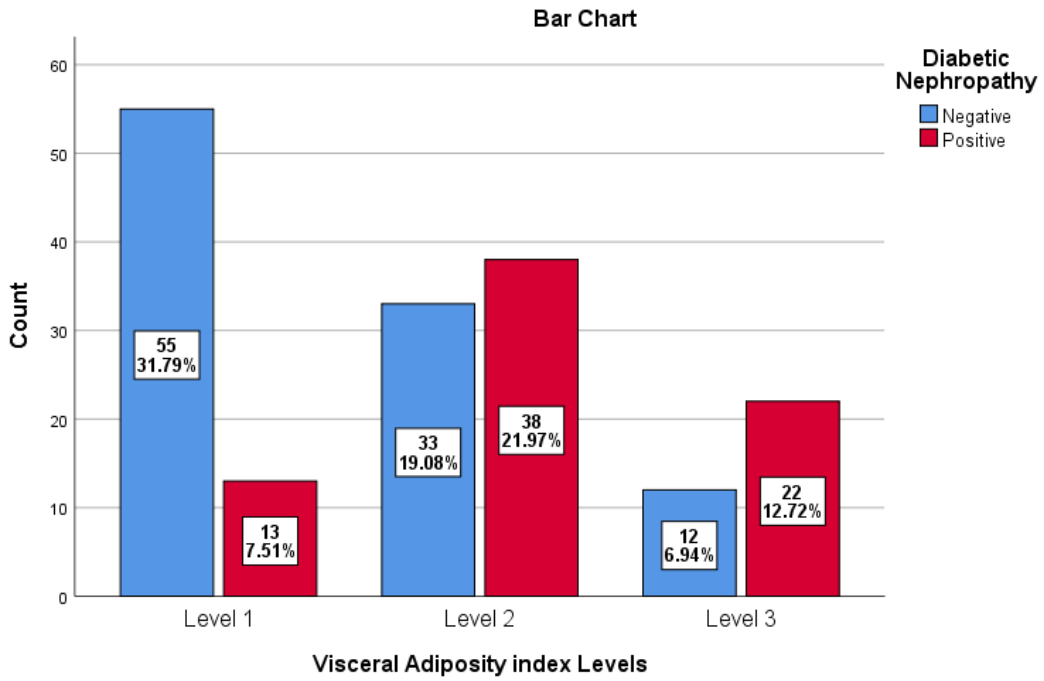

Figure 3: Incidence of diabetic kidney disease among patients with various VAI levels

Table 3: Stratified analysis of diabetic kidney disease by visceral adiposity index levels (n=173)

Stratification Variable		VAI Level	Diabetic Kidney Disease n (%)	p-value
Sex	Female	Level 1 (VAI < 1.45)	4/24 (16.7%)	0.001
		Level 2 (VAI 1.45 – 2.65)	21/37 (56.8%)	
		Level 3 (VAI > 2.65)	18/28 (64.3%)	
	Male	Level 1 (VAI < 1.45)	9/44 (20.5%)	0.007
		Level 2 (VAI 1.45 – 2.65)	17/34 (50.0%)	
		Level 3 (VAI > 2.65)	4/6 (66.7%)	
Age Groups (Years)	Upto 40	Level 1 (VAI < 1.45)	7/22 (31.8%)	0.081
		Level 2 (VAI 1.45 – 2.65)	10/18 (55.6%)	

Stratification Variable		VAI Level	Diabetic Kidney Disease n (%)	p-value
		Level 3 (VAI > 2.65)	9/13 (69.2%)	
	41–55	Level 1 (VAI < 1.45)	5/25 (20.0%)	0.012
		Level 2 (VAI 1.45 – 2.65)	17/30 (56.7%)	
		Level 3 (VAI > 2.65)	7/12 (58.3%)	
	>55	Level 1 (VAI < 1.45)	1/21 (4.8%)	0.001
		Level 2 (VAI 1.45 – 2.65)	11/23 (47.8%)	
		Level 3 (VAI > 2.65)	6/9 (66.7%)	
Duration of Diabetes (Months)	Upto 24	Level 1 (VAI < 1.45)	5/12 (41.7%)	0.664
		Level 2 (VAI 1.45 – 2.65)	11/19 (57.9%)	
		Level 3 (VAI > 2.65)	5/9 (55.6%)	
	25–44	Level 1 (VAI < 1.45)	5/29 (17.2%)	0.001
		Level 2 (VAI 1.45 – 2.65)	15/27 (55.6%)	
		Level 3 (VAI > 2.65)	7/9 (77.8%)	
	≥45	Level 1 (VAI < 1.45)	3/27 (11.1%)	0.001
		Level 2 (VAI 1.45 – 2.65)	12/25 (48.0%)	
		Level 3 (VAI > 2.65)	10/16 (62.5%)	
HbA1c Levels	≥10.0%	Level 1 (VAI < 1.45)	5/22 (22.7%)	0.009
		Level 2 (VAI 1.45 – 2.65)	20/33 (60.6%)	
		Level 3 (VAI > 2.65)	8/12 (66.7%)	

Stratification Variable		VAI Level	Diabetic Kidney Disease n (%)	p-value
	6.5–7.0%	Level 1 (VAI < 1.45)	4/21 (19.0%)	0.019
		Level 2 (VAI 1.45 – 2.65)	10/19 (52.6%)	
		Level 3 (VAI > 2.65)	5/7 (71.4%)	
	8.0–9.9%	Level 1 (VAI < 1.45)	4/25 (16.0%)	0.015
		Level 2 (VAI 1.45 – 2.65)	8/19 (42.1%)	
		Level 3 (VAI > 2.65)	9/15 (60.0%)	
Antidiabetic Management	Insulin	Level 1 (VAI < 1.45)	7/24 (29.2%)	0.050
		Level 2 (VAI 1.45 – 2.65)	17/30 (56.7%)	
		Level 3 (VAI > 2.65)	8/12 (66.7%)	
	Lifestyle Modification	Level 1 (VAI < 1.45)	4/25 (16.0%)	0.004
		Level 2 (VAI 1.45 – 2.65)	11/18 (61.1%)	
		Level 3 (VAI > 2.65)	5/8 (62.5%)	
	Oral Agents	Level 1 (VAI < 1.45)	2/19 (10.5%)	0.005
		Level 2 (VAI 1.45 – 2.65)	10/23 (43.5%)	
		Level 3 (VAI > 2.65)	9/14 (64.3%)	
Hypertension Status	Non-Hypertensive	Level 1 (VAI < 1.45)	6/44 (13.6%)	<0.001
		Level 2 (VAI 1.45 – 2.65)	22/42 (52.4%)	
		Level 3 (VAI > 2.65)	13/20 (65.0%)	
	Hypertensive	Level 1 (VAI < 1.45)	7/24 (29.2%)	0.064

Stratification Variable	VAI Level	Diabetic Kidney Disease n (%)	p-value
	Level 2 (VAI 1.45 – 2.65)	16/29 (55.2%)	
	Level 3 (VAI > 2.65)	9/14 (64.3%)	

DISCUSSION

This study examined the prevalence of diabetic nephropathy in individuals with T2DM at different VAI levels in a tertiary care facility in Rawalpindi, Pakistan. Our findings indicate a significant increase in nephropathy prevalence corresponding to elevated VAI levels, escalating from 19.1% at level 1 to 64.7% at level 3, with an aggregate prevalence of 42.2%. This link remained consistent across many stratifications, including sex, age, duration of diabetes, glycemic control, antidiabetic treatment, and hypertension status, although with differing levels of statistical significance. These findings highlight the potential significance of visceral adiposity as a modifiable risk factor in the advancement of DKD, consistent with growing information about the relationship between metabolic dysfunction and renal outcomes in T2DM.

The identified positive link between VAI and DKD prevalence aligns with previous studies indicating that visceral fat accumulation plays a significant role in insulin resistance, inflammation, and endothelial dysfunction, all of which are crucial in the pathogenesis of DKD. In a recent study, Li C and colleagues investigated the correlation between the visceral adiposity index (VAI) and the incidence of kidney disease in adults with diabetes, categorized by varying levels of VAI. They discovered that among a total of 2508 patients, 32.6% (n=241/740) of those with VAI <1.45, 65.2% (n=330/506) with VAI 1.45 - 2.65, and 67.02% (n=374/558) with VAI >2.65 exhibited diabetic nephropathy. [xii, xiii] Our study's nephropathy rate of 42.2% aligns with global estimates in T2DM populations, which vary from 20% to 50% according on disease duration and management.[xiv,xv]

Our finding of a graded increase in diabetic nephropathy prevalence with rising VAI levels (19.1% at level 1 to 64.7% at level 3) aligns with multiple studies. A Chinese cohort reported a 12.7% higher nephropathy risk per one-SD VAI increase (HR 1.127),[xvi] while another found a 4% and 3% increased prevalence per VAI unit in Chinese and US cohorts, respectively.[xvii] An Indian study showed superiority of VAI over BMI in predicting nephropathy (AUC 0.826),[xviii] and a Romanian study linked elevated VAI to lipid alterations in T2DM. [xix] Chinese data confirmed association of VAI with albuminuria and reduced eGFR (OR 2.31 for highest quartile),[xx] and an Indian cohort noted 68% nephropathy prevalence in T2DM with comorbidities. [xxi] Korean research validated VAI variants for CKD risk (OR up to 6.47),[xxii] while a meta-analysis reported a 12% CKD risk increase, stronger in women (OR 1.22). [xxiii] A recent study in elderly Chinese T2DM patients found a 29% higher DKD risk in the top VAI tertile, especially with longer diabetes duration, [xxiv] corroborating our stratified findings and supporting global relevance of VAI as a nephropathy risk marker.

Sex-stratified analysis revealed a greater nephropathy burden in females at all VAI levels (p=0.001), likely due to hormonal effects on fat distribution and renal vulnerability. This gender gap reflects findings indicating that VAI had more robust correlations with DKD in women, potentially attributable to the exacerbation of visceral adiposity following postmenopausal estrogen reduction. Conversely, males demonstrated a plateau in the highest VAI group, indicating distinct metabolic thresholds. [xxv,xxvi]

Age-related trends indicated that younger patients (≤40 years) exhibited significant nephropathy even at low VAI (31.8%), though not statistically significant (p=0.081), suggesting the presence of early-onset aggressive disease phenotypes in South Asian populations. Patients over 55 years exhibited a more pronounced increase in VAI elevation (p=0.001),

consistent with age-related reductions in renal reserve exacerbated by obesity.[xxvii,xxviii]

The duration of diabetes further influenced this relationship, demonstrating higher associations in instances lasting 27 months or more ($p \leq 0.001$), so reinforcing the idea that persistent hyperglycemia exacerbates the nephrotoxic effects of visceral fat via advanced glycation end-products and oxidative stress. Glycemic control proved to be a significant modulator, with inadequate control (HbA1c ≥10.0%) resulting in the greatest rates of nephropathy across varying VAI levels ($p=0.009$). This aligns with data that hyperglycemia synergistically interacts with dyslipidemia, fundamental elements of VAI, to exacerbate glomerular injury. Intermediate control (HbA1c 8.0-9.9%) demonstrated importance ($p=0.015$), underscoring the necessity for rigorous objectives to reduce VAI-related risks.[xxix,xxx]

Antidiabetic management patterns demonstrated strong correlations between VAI and nephropathy in individuals undergoing lifestyle modifications or oral agents ($p<0.005$), whereas insulin users exhibited borderline significance ($p=0.050$), potentially attributable to advanced disease stage or the anti-inflammatory effects of insulin diminishing the association.[xxxi]

The role of hypertension in exacerbating DKD concerning VAI levels was noteworthy: non-hypertensive individuals exhibited a significant correlation ($p<0.001$), whereas hypertensive individuals did not ($p=0.064$). This implies that elevated blood pressure may overshadow or obscure the independent effect of VAI, as evidenced in studies where comorbid hypertension complicates adiposity assessments.[xxxii]

These findings have substantial implications for risk classification and therapy in T2DM. VAI, an uncomplicated, non-invasive metric that includes waist circumference, triglycerides, and HDL cholesterol, outperforms BMI in forecasting cardiometabolic risks and may function as an effective instrument for identifying people at high risk for nephropathy screening. In resource-constrained environments such as Pakistan, where obesity and T2DM are prevalent, incorporating VAI into standard evaluations may enable early therapies, including lifestyle adjustments, GLP-1 receptor agonists, or SGLT2 inhibitors, aimed at visceral fat reduction and kidney protection. The increased occurrence among females and younger patients highlights the necessity for customized screening techniques, which may mitigate DKD progression and alleviate healthcare burdens.

Strengths and Limitations of Study

The strength of our study includes complete stratification across demographic and clinical characteristics, yielding nuanced insights into the role of VAI. The sample size, sourced from a tertiary facility, guaranteed representation of varied T2DM characteristics, with comprehensive quantitative data augmenting generalizability within analogous groups. The utilization of standardized markers such as eGFR and albuminuria enhances diagnostic precision for nephropathy, while statistical studies reinforce dependability. However, limitations of this study must be recognized. The cross-sectional design prohibits causal inferences; observed relationships may indicate reverse causality, wherein nephropathy affects metabolic parameters. The recruitment from a single institution restricts external validity, potentially leading to selection bias favoring severe patients, as indicated by elevated mean HbA1c levels and smoking prevalence. Unmeasured confounders, including food habits, physical activity, or genetic variables common among South Asians, may affect the results, which is missing. The VAI categorization was particular to the study and lacked universal thresholds, potentially impeding comparisons. Reduced power for several analyses due to small subgroup sizes in stratifications resulted in non-significant p-values. Clinically, these limitations necessitate careful interpretation: although VAI demonstrates potential as a marker, prospective validation is required to establish its prognostic value.

CONCLUSION

This study reveals a notable correlation between the VAI and the occurrence of diabetic nephropathy in our local population, with nephropathy rates increasing from 19.1% at VAI level 1 to 64.7% at level 3. The strong correlation, consistent across sex, age, diabetes duration, glycemic control, and hypertension status, highlights potential of VAI as a non-invasive, cost-effective method for identifying high-risk patients in resource-limited environments. The pronounced

association observed in females, younger patients, and individuals with inadequate glycemic control and longer diabetes duration underscores the necessity for focused screening and proactive intervention strategies. Future prospective, multicenter studies are essential to confirm causality, establish population-specific VAI cutoffs, and evaluate interventions like lifestyle modifications or renoprotective therapies to mitigate nephropathy risk. Integrating VAI into routine T2DM management could facilitate personalized care, reduce disease progression, and alleviate the healthcare burden in high-prevalence regions like Pakistan.

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