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Original Research Article

Comparison of Symmetric Dimethylarginine (SDMA), Creatinine, and Cystatin C Level as Biomarkers of Chronic Kidney Disease in Diabetic Patients With and Without Microalbuminuria

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Abstract: *Diabetic kidney disease remains a major contributor to chronic kidney disease (CKD) morbidity. Earlier detection beyond serum creatinine alone is needed. Symmetric dimethylarginine (SDMA) and cystatin C have been proposed as sensitive markers of reduced glomerular filtration.* ***Objective:*** *To measure and compare the levels of symmetric dimethylarginine, creatinine and Cystatin C in diabetic patients with and without microalbuminuria as markers for diagnosis of chronic kidney disease* ***Methods:*** *This was a case-control study involving 110 diabetic patients with or without microalbuminuria who visited the Departments of Pathology at Nishtar Hospital, Multan Patients were divided into cases (diabetic patients with microalbuminuria) and controls (diabetic patients without microalbuminuria).5 mL blood sample was collected for random blood glucose level, HbA1C, renal function tests (urea & creatinine), SDMA and cystatin C.* ***Results:*** *Among cases (with microalbuminuria), the mean HbA1C (%), SDMA (µmol/L), serum creatinine (mg/dL), serum cystatin C (mg/L) and eGFR (ml/min/1.73m2) was 8.3± 2.1, 1.4 ±0.8, 0.9 ± 1.0, 0.02 ± 0.02 and 94.6 ± 41.2, receptively. Among controls (without microalbuminuria), the mean HbA1C (%), SDMA (µmol/L), serum creatinine (mg/dL), serum cystatin C (mg/L), and eGFR (ml/min/1.73m2) were 7.1 ± 2.4, 1.1 ± 0.9, 0.7 ± 0.4, 0.007± 0.005, and 108.0 ± 53.5, respectively.* ***Conclusion:*** *There were higher levels of SDMA, serum creatinine, and Cystatin C among diabetic patients with microalbuminuria than among patients without microalbuminuria.*

Keywords: Symmetric dimethylarginine, creatinine, cystatin C, chronic kidney disease, diabetic patients, microalbuminuria

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Introduction

The non-communicable diseases (NCDs), for example, diabetes mellitus (DM) and kidney disease, are the most important cause of global mortality and morbidity. DM is believed to be a rapidly expanding, persistent disease worldwide. Globally, about one in eleven adults suffers from DM, with Type 2 Diabetes Mellitus (T2DM) responsible for 90 percent of these cases (1). Both microvascular and macrovascular complications distinguish the DM disease. Among microvascular complications, it is notable that up to 25 to 40 percent of the CKD (chronic kidney disease), also referred to as diabetic kidney disease (DKD), is attributed to diabetes, making it the leading cause for kidney failure on a global level (2). Approximately one-third of the individuals with T1DM (Type 1 Diabetes Mellitus) and around 50 percent of those with T2DM will eventually develop CKD (3).

CKD is a leading health-related issue among all diseases. More than 100 million adults suffer from the disease in the high-income countries, while the disease burden is 387.5 million in countries with lower-middle income (4). The disease is more common among adults than among younger individuals. The CKD staging is dependent on the estimated rate of glomerular filtration, as well as albuminuria, in accordance with recommendations for improving kidney disease outcomes worldwide. If the disease is diagnosed at an early stage, it can help in preventing complications, especially cardiovascular complications, leading to mortality.

Albuminuria is categorized into three grades based on the ACR (albumin-to-creatinine ratio) observed in a spot urine sample. The 1st grade is identified as a normal to slightly enhanced albuminuria, indicated by an ACR (albumin-creatinine ratio) of below 30mg/g. The 2nd grade, A2, denotes moderately enhanced albuminuria along with ACR ranging from 30 to 300mg/g (referred to in novel terminology as what was once known as "microalbuminuria"). The A3, which is the third grade, indicates severely enhanced albuminuria (formerly referred to as macroalbuminuria/dipstick +ve proteinuria) along with ACR of above 300mg/g or albumin excretion ratio (AER) exceeding 300 mg/24 hour. The likelihood of over DKD development is linked to the albumin excretion levels (5). It is significant to highlight that albuminuria serves as an independent marker for CKD, even when the GFR (glomerular filtration rate) is above 60mL/min/1.73 m².

The serum levels of creatinine and urea are nowadays the most commonly used diagnostic tools for CKD. According to studies, an important relationship is found between eGFR (estimated glomerular filtration rate) and serum creatinine (SCr), which explains why the disease is only detected when 40-50 percent of the renal parenchyma is impaired (6). Metabolomics has played a crucial role in discovering novel biological markers for CKD, including dimethylarginines. Symmetric dimethylarginine (SDMA) was originally observed in the accumulation of kidney failure and could be a risk factor in deteriorating kidney function in T2DM.

The SDMA is an amino acid that is released during protein degradation from cells. It was initially isolated from human urine in 1970. Mostly, SDMA clearance is accomplished through glomerular filtration. SDMA is also linked to cardiovascular disease, according to a recent report, which found that higher levels of SDMA can lead to certain heart diseases among patients who have T2DM and a persistent urinary albumin excretion rate (UAER) >30 mg/24 h.

This research aims to gain a deeper understanding of the role of symmetrical dimethylarginine in patients being evaluated for renal

disease. This research may aid clinicians in the early detection of kidney diseases and the development of more effective care plans for patients. The cost of care would also be reduced if the illness is detected early.

This study was conducted to measure and compare the levels of symmetric dimethylarginine (SDMA), creatinine, and Cystatin C in diabetic patients with and without microalbuminuria as markers for the diagnosis of chronic kidney disease.

Methodology

A case-control study was conducted in the Department of Pathology at Nishtar Hospital, Multan, from January 2024 to January 2025. Patients aged 18 years or older, of either gender, diagnosed with T2DM with or without microalbuminuria, were included in the study. The sample size of 110 was calculated using Cochran's formula, with a power of 95% and a significance level of 5%. Patients with normal or non-persistent elevated urinary albumin excretion rate, on dialysis, a history of cardiac disease or CAD, physical or mental disability, malignancies, or inflammatory diseases, thyroid issues, uncontrolled hypertension, chronic inflammatory disease, and pregnant women were excluded.

After obtaining approval from the ethics review committee, informed consent was obtained. Patients were divided into cases (diabetic patients with microalbuminuria) and controls (diabetic patients without microalbuminuria). Age, medical history, and disease duration were recorded for every patient. The body mass index (BMI) was calculated based on the measurements of height and weight for all participants. A 5 mL blood sample was collected for random blood glucose level, HbA1C, renal function tests (urea & creatinine), SDMA, and cystatin C. Serum was separated by centrifugation at 5000 rpm for 5 minutes.

The collected data were entered into the computer software SPSS version 27. Frequency and percentages were calculated for qualitative/categorical variables. Quantitative variables, i.e., duration of disease, height, weight, BMI, HbA1C, serum urea, creatinine, SDMA, Cystatin C level, and eGFR, were presented as means and standard deviations. An independent sample t-test was used for comparison between the two groups—correlation of microalbuminuria with different biomarkers, such as SDMA, creatinine, and Cystatin C. The p-value of ≤0.05 was considered significant.

Results

A total of 110 patients were included in the study, with 55 patients in each group. Table I demonstrates that among cases, the duration of disease was <1 year for 2(3.6%) and 1-5 years for 25 (45.5%), while >5 years for 28 (50.9%) cases. Among controls, the duration of disease was <1 year for 16 (29.1%) and 1-5 years for 23 (41.8%), while >5 years for 16 (29.1%) controls. Table II shows that among the cases, 6 (10.9%) had a BMI <18.5, 21 (38.2%) had a BMI of 18.5-24.9, and 11 (20%) had a BMI of 25.0-29.9, while 17 (30.9%) cases had a BMI >30. Among the controls, 6 (10.9%) had a BMI <18.5, 19 (34.5%) had a BMI of 18.5-24.9, and 10 (18.2%) had a BMI of 25.0-29.9, while 20 (36.4%) controls had a BMI >30.

In cases, the meanduration of disease was 6.7±5.6 years, BMI was 26.5±6.7, HbA1c was 8.3±2.1%, serum urea was 37.8±24.9mg/dL, SDMA was 1.4±0.8µmol/L, serum creatinine was 0.9±1.0 mg/dL, serum cystatin C was 0.02±0.02mg/L and eGFR was 94.6 ±41.2 ml/min while among controls were 3.8±4.6 years, 26.2±6.4, 7.1±2.4%, 34.0±26.4 mg/dL, 1.1±0.9µmol/L, 0.7±0.4 mg/dL, 0.007±0.005 mg/L and 108.07±53.51 mg/min, respectively.

Table III shows that when an independent samples t-test was applied to both groups, significant results ($P < 0.05$) were found regarding the duration of disease ($p = 0.004$), HbA1c ($p = 0.008$), SDMA ($p = 0.032$), and serum cystatin C ($p = 0.000$). In contrast, insignificant results were observed regarding BMI ($p = 0.84$), serum urea ($p = 0.44$), serum creatinine ($p = 0.21$), and eGFR.

A strong positive relationship exists between serum urea and serum creatinine ($r = 0.804$, $p < 0.01$), consistent with impaired renal function (Table IV). Similarly, serum creatinine and SDMA showed a moderate positive correlation ($r = 0.487$, $p < 0.01$). On the other hand, a significant negative correlation was found between eGFR and serum creatinine ($r = -0.679$, $p < 0.01$). eGFR and serum urea also exhibited a moderate to strong inverse relationship ($r = -0.576$, $p < 0.01$), indicating reduced renal clearance. Higher SDMA levels were associated with lower eGFR($r = -0.381$, $p < 0.01$). HbA1c and Serum cystatin C show no significant relationships with other parameters.

Table 1: Duration of Disease between Both Groups

Duration of Disease	Cases (n=55)		Cases (n=55)	
	Frequency (n)	Percentage (%)	Frequency (n)	Percentage (%)
<1 year	2	3.6	16	29.1
1-5 years	25	45.5	23	41.8
>5 years	28	50.9	16	29.1

Table 2: Body Mass Index between Both Groups

BMI	Cases		Controls	
	Frequency (n)	Percentage (%)	Frequency (n)	Percentage (%)
<18.5	6	10.9	6	10.9
18.5-24.9	21	38.2	19	34.5
25.0-29.9	11	20.0	10	18.2
≥30	17	30.9	20	36.4

Table 3: Independent T-test between Both Groups

	Levene's Test for Equality of Variances		t-test for Equality of Means		
	F	Sig.	T	df	Sig. (2-tailed)
Duration of disease	0.998	0.320	2.925	108	0.004*
BMI	0.000	0.991	0.192	108	0.848
HbA1C	0.381	0.538	2.700	108	0.008*
Serum urea	0.268	0.606	0.775	108	0.440
SDMA	0.833	0.364	2.171	108	0.032*
Serum creatinine	4.373	0.039	1.262	108	0.210
Serum cystatin C	4.823	0.030	4.632	108	0.000*

eGFR	0.158	0.692	-1.474	108	0.143

Table 4: Pearson Correlation Coefficient among Cases (with Microalbuminuria)

Variables	1	2	3	4	5	6
1. HbA1C	-					
2. Serum urea (mmol/L)	-.110	-				
3. SDMA (µmol/L)	-.124	.410**	-			
4. Serum creatinine (mg/dL)	-.265	.804**	.487**	-		
5. Serum cystatin C (mg/L)	.158	-.041	-.122	-.066	-	
6. eGFR (ml/min/1.73m2)	.112	-.576**	-.381**	-.679**	.096	-

Discussion

CKD is a major health issue, especially prevalent in lower-middle-income countries. Early symptoms are minimal, as the kidneys function until the disease reaches its final stage. Biomarkers like SDMA and creatinine can diagnose early-stage CKD. In diabetic patients, elevated serum cystatin C levels can indicate diabetic nephropathy before significant albuminuria. Cystatin C is considered a more reliable marker than SCr since it is less influenced by muscle mass and protein intake. Therefore, the current study was carried out to measure and compare the levels of symmetric dimethylarginine (SDMA), creatinine, and cystatin C in diabetic patients with and without microalbuminuria as markers for the diagnosis of CKD.
The findings of this study showed that most patients had a disease duration of more than 5 years, while the controls had a duration of 1-5 years. The mean age of patients was 6.76±5.607 years, while that of controls was 3.8±4.6 years (p=0.004). Sapkota and coworkers reported in their study that the mean duration of diabetes among patients was 6±3.13 years, while among controls it was 4±1.8 years (p=0.27) (7). But a study undertaken by Abdel Wahid and associates reported mean duration of diseases among patients was 7.7±7.1 years, and among controls was 7.6±7.2 years (8).
Study revealed that among patients and controls, the majority were obese, followed by normal, overweight, and underweight. The mean BMI of the patients was 26.5±6.7 (overweight), while that of the controls was also 26.2±6.4 (overweight) (p = 0.84). The results of a study conducted by Amelia confirmed that the mean BMI of patients was 32.4±6.7 (classified as obese), while that of controls was 30.6±5.9 (also classified as obese) (9). However, the results of this study are comparable with a study undertaken by Colombo et al, who asserted that the mean BMI of patients was 26.6±5.3, while for controls it was 26.2±6.2 (p=0.68) (10).
Hemoglobin A1c (HbA1c) is a crucial measure in the management and diagnosis of diabetes. The results of this study highlighted that the mean HbA1c (%) of patients was 8.3±2.1, while for controls, it was 7.1±2.4 (p=0.008). Almost comparable results were reported by Li et al., which means the mean HbA1c of patients was 8.1±2.4, while for controls it was 7.3±1.8 (11). However, the results of a study performed by Pasternak et al are comparable with our study results, which means the HbA1c of patients was 7.8±1.9, while for controls it was 7.3±1.5 (12).
Serum urea, also known as blood urea nitrogen, is a blood test that measures the amount of nitrogen in the form of urea, a waste product of protein metabolism, providing insights into kidney function, fluid balance, and certain metabolic processes. A study revealed that a significant majority of patients and controls had elevated serum urea levels. The mean serum urea (mg/dL) levels among patients and controls were 37.8±24.9 and 34.0±26.4, respectively (p=0.440).
The SDMA serves as a biomarker for kidney function in human medicine. The mean SDMA levels among patients and controls were 1.4 ± 0.8 µmol/L and 1.1 ± 0.9 µmol/L, respectively (p = 0.032). Numerous studies conducted on patients with CKD showed comparable results regarding SDMA levels between cases and controls with normal kidney function (13, 14). Among individuals who have impaired kidney function, a robust association was observed between measured glomerular filtration rate and SDMA.
It is worth noting that most patients and controls had SCr concentrations within the normal range. The mean SCr (mg/dL) among patients was 0.9 ± 1.0, while among controls, it was 0.7 ± 0.4 (p = 0.210). The results of our study are comparable with a study carried out by Penno et al, who elucidated that both patients and controls had SCr concentration within the normal range (15The mean SCr (mg/dL) among patients was 0.8 ± 0.2, which was also the value among controls. Similar results were also reported by a study performed by Peralta et al, who stated that the mean SCr (mg/dL) among patients was 1.1 ±0.4, while among controls it was 0.9±0.2 (16).
Cystatin C is considered a more sensitive and specific marker for estimating glomerular filtration rate, a measure of kidney function, compared to traditional markers such as serum creatinine (SCr). The serum cystatin C concentration is unaffected by age, race, gender, muscle mass, and protein intake, unlike SCr. When GFR declines, the level of cystatin C begins to increase proportionally. It can identify mild reductions in kidney function, referred to as "preclinical kidney dysfunction." The study showed that the mean serum cystatin levels among patients were 0.022 ± 0.023 mg/L, while those among controls were 0.007 ± 0.005 mg/L (p = 0.000). However, a study performed by Liao et al highlighted that mean serum cystatin levels among patients were 1.0± 0.4 mg/L, and among controls were 0.9 ± 0 mg/L (17). A study done by Stankute et al also highlighted that mean serum cystatin levels among patients were 1.05±0.38 mg/L, and among controls were 0.91±0.26 mg/L (18).
The glomerular filtration rate is a crucial measure of kidney function used to assess how effectively the kidneys filter waste products from the blood. During the study, the estimated glomerular filtration rate was also assessed among both groups. The study revealed that the mean eGFR (ml/min/1.73 m²) among patients was 94.6 ± 41.2, while among controls it was 108 ± 3.5 (p = 0.143). Comparable results were also reported by a study conducted by Levey et al., who confirmed that both groups were within the normal range. The meaneGFR (ml/min/1.73m2) among patients was 94.1±22.9 while among controls was 102.2±21.3 (19). Another study carried out by Sukkar et al also showed similar findings that mean eGFR (ml/min/1.73m2) among patients was 77.2±27.2, while among controls was 86.2±22.0 (20).
This study is unique in the local setting as it is the first to investigate markers such as SDMA, creatinine, and Cystatin C in diabetic patients. It will provide valuable local evidence on the performance of these markers in diagnosing kidney disease in T2DM patients with and without microalbuminuria, thereby contributing to more accurate and effective clinical practices within our population.
The study's limitations include its confinement to the Departments of Nephrology and Pathology at Nishtar Hospital, Multan, which may limit the generalizability of the findings. Additionally, due to time constraints, the study included only 110 patients, which may affect the robustness and representativeness of the results.

Conclusion

The concentrations of SDMA, serum creatinine, and Cystatin C were higher among diabetic patients with microalbuminuria compared to those without microalbuminuria. Further studies are needed on a large scale regarding this topic.

Declarations

Data Availability statement

All data generated or analysed during the study are included in the manuscript.

Ethics approval and consent to participate

Approved by the department concerned. (IRBEC--24)

Consent for publication

Approved

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Conflict of interest

The authors declared the absence of a conflict of interest.

Author Contribution

AAS (Additional Principal)
Manuscript drafting, Study Design,
MH (Medicine Fellow)
Review of Literature and drafting an article.
SHG (Associate Professor)
Conception of Study, Development of Research Methodology Design,
HZ
Study Design, manuscript review, and critical input.
MAAJ
Data analysis and Data entry

All authors reviewed the results and approved the final version of the manuscript. They are also accountable for the integrity of the study.

References

1. Nazzal Z, Hamdan Z, Masri D, Abu-Kaf O, et al. Prevalence and risk factors of chronic kidney disease among Palestinian type 2 diabetic patients: a cross-sectional study. BMC Nephrol. 2020;21(1):484. https://doi.org/10.1186/s12882-020-02138-4
2. Sun H, Saeedi P, Karuranga S, Pinkepank M, et al. IDF Diabetes Atlas: Global, regional and country-level diabetes prevalence estimates for 2021 and projections for 2045. Diabetes Res Clin Pract. 2022;183:109119. https://doi.org/10.1016/j.diabres.2021.109119
3. Pelle MC, Provenzano M, Busutti M, Porcu CV, et al. Up-date on diabetic nephropathy. Life (Basel). 2022;12(8):1202. https://doi.org/10.3390/life12081202
4. Ammirati AL. Chronic kidney disease. Rev Assoc Med Bras (1992). 2020;66(Suppl 1):s03–s09. https://doi.org/10.1590/1806-9282.66.S1.3
5. Gremese E, Bruno D, Varriano V, Perniola S, et al. Serum albumin levels: a biomarker to be repurposed in different disease settings in clinical practice. J Clin Med. 2023;12(18):6017. https://doi.org/10.3390/jcm12186017
6. Farrington DK, Surapaneni A, Matsushita K, Seegmiller JC, et al. Discrepancies between cystatin C–based and creatinine-based eGFR. Clin J Am Soc Nephrol. 2023;18(9):1143–52. https://doi.org/10.2215/CJN.0000000000000217
7. Sapkota S, Khatiwada S, Shrestha S, Baral N, et al. Diagnostic accuracy of serum cystatin C for early recognition of nephropathy in type 2 diabetes mellitus. Int J Nephrol. 2021;2021:8884126. https://doi.org/10.1155/2021/8884126
8. Abdelwahid HA, Dahlan HM, Mojemamy GM, Darraj GH. Predictors of microalbuminuria and its relationship with glycemic control among type 2 diabetic patients of Jazan Armed Forces Hospital, southwestern Saudi Arabia. BMC Endocr Disord. 2022;22(1):307. https://doi.org/10.1186/s12902-022-01232-y
9. Amelia R, Sari DK, Muzasti RA, Wijaya H. Correlation of cystatin-C with albumin-creatinine ratio for the diagnosis of diabetic nephropathy in patients with type 2 diabetes: a cross-sectional study in Medan, Indonesia. Open Access Maced J Med Sci. 2022;10(T7):12–15. https://doi.org/10.3889/oamjms.2022.9249
10. Colombo M, McGurnaghan SJ, Blackbourn LA, Dalton RN, et al. Comparison of serum and urinary biomarker panels with albumin/creatinine ratio in the prediction of renal function decline in type 1 diabetes. Diabetologia. 2020;63(4):788–98. https://doi.org/10.1007/s00125-019-05081-8
11. Li Y, Ji X, Ni W, Luo Y, et al. Serum albumin and albuminuria predict the progression of chronic kidney disease in patients with newly diagnosed type 2 diabetes: a retrospective study. PeerJ. 2021;9:e11735. https://doi.org/10.7717/peerj.11735
12. Pasternak M, Liu P, Quinn R, Elliott M, et al. Association of albuminuria and regression of chronic kidney disease in adults with newly diagnosed moderate to severe chronic kidney disease. JAMA Netw Open. 2022;5(8):e2225821. https://doi.org/10.1001/jamanetworkopen.2022.25821
13. Asghar S, Asghar S, Mahmood T, Bukhari SMH, et al. Microalbuminuria as the tip of iceberg in type 2 diabetes mellitus: prevalence, risk factors, and associated diabetic complications. Cureus. 2023;15(8):e43190. https://doi.org/10.7759/cureus.43190
14. Poulsen CG, Rasmussen DG, Genovese F, Hansen TW, et al. Marker for kidney fibrosis is associated with inflammation and deterioration of kidney function in people with type 2 diabetes and microalbuminuria. PLoS One. 2023;18(3):e0283296. https://doi.org/10.1371/journal.pone.0283296
15. Penno G, Orsi E, Solini A, Bonora E, et al. Renal hyperfiltration is independently associated with increased all-cause mortality in individuals with type 2 diabetes: a prospective cohort study. BMJ Open Diabetes Res Care. 2020;8(1):e001481. https://doi.org/10.1136/bmjdrc-2020-001481
16. Peralta CA, Katz R, Sarnak MJ, Ix J, et al. Cystatin C identifies chronic kidney disease patients at higher risk for complications. J Am Soc Nephrol. 2011;22(1):147–55. https://doi.org/10.1681/ASN.2010050483
17. Liao X, Zhu Y, Xue C. Diagnostic value of serum cystatin C for diabetic nephropathy: a meta-analysis. BMC Endocr Disord. 2022;22(1):149. https://doi.org/10.1186/s12902-022-01052-0
18. Stankute I, Radzeviciene L, Monstaviciene A, Dobrovolskiene R, et al. Serum cystatin C as a biomarker for early diabetic kidney disease and dyslipidemia in young type 1 diabetes patients. Medicina (Kaunas). 2022;58(2):218. https://doi.org/10.3390/medicina58020218
19. Levey AS, Gansevoort RT, Coresh J, Inker LA, et al. Change in albuminuria and GFR as end points for clinical trials in early stages of CKD: a scientific workshop sponsored by the National Kidney Foundation in collaboration with the US Food and Drug Administration and European Medicines Agency. Am J Kidney Dis. 2020;75(1):84–104. https://doi.org/10.1053/j.ajkd.2019.06.009
20. Sukkar L, Kang A, Hockham C, Young T, et al. Incidence and associations of chronic kidney disease in community participants with diabetes: a 5-year prospective analysis of the EXTEND45 study. Diabetes Care. 2020;43(5):982–90. https://doi.org/10.2337/dc19-1803