Original

Kidney Function in Normotensive and Preeclamptic Pregnancies: A Comparative Cross-Sectional Study in Abeokuta, Nigeria

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Abstract

Background: Preeclampsia is a significant obstetric complication in Nigeria, associated with acute and long-term renal outcomes. This study compared renal function parameters in normotensive and preeclamptic pregnancies attending the antenatal clinic of the federal medical centre (FMC), Abeokuta, Nigeria.

Method: This was a comparative cross-sectional study involving 180 pregnant women (90 with preeclampsia and 90 normotensive controls) attending the antenatal clinic at FMC. Serum creatinine, cystatin C, uric acid, phosphate, calcium, and FBS were measured using standard automated spectrophotometry. Cystatin C was measured using a particle-enhanced nephelometric immunoassay. eGFR was calculated using the CKD-EPI equation and staged according to the KDOQI guideline. Statistical analysis was performed using SPSS version 25.0. Student's t-test, Chi-square test, and Fisher's exact test were used as appropriate, with $p < 0.05$ considered statistically significant.

Results: The mean eGFR was significantly lower in preeclamptic ($p = 0.011$). Serum cystatin C was significantly higher in the preeclamptic group (1.09 ± 0.62 mg/L vs. 0.80 ± 0.22 mg/L; $p < 0.001$). Kidney dysfunction (eGFR ≤ 60 mL/min) was identified in 11.1% of preeclamptic participants, and none in the control group ($p < 0.001$). Generalized edema, leg swelling, etc were significantly associated with kidney dysfunction among preeclamptic women ($p = 0.010$, 0.029, and <0.001, respectively).

Conclusion: Preeclampsia significantly increases the risk of kidney dysfunction in pregnancy. Symptoms like headache, leg swelling, and generalized edema may serve as early indicators. Routine renal function screening using cystatin C may aid in early detection and better outcomes, especially in low-resource settings.

Keywords: Renal, preeclampsia, kidney dysfunction, Cystatin C, antenatal clinic, Federal Medical Centre, FMC, Abeokuta

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Introduction

Preeclampsia is a multisystem disorder unique to human pregnancy, defined by new-onset hypertension and proteinuria after 20 weeks of gestation. It complicates approximately 5–8% of pregnancies worldwide and contributes significantly to maternal and fetal morbidity and mortality, particularly in low- and middle-income countries (LMICs) where access to comprehensive antenatal care may be limited. [1–3] In Nigeria, preeclampsia and eclampsia account for a considerable proportion of direct obstetric deaths. [4–5]

The renal system is particularly affected during preeclampsia due to widespread endothelial dysfunction. In healthy pregnancies, physiologic vasodilation leads to a 50% increase in renal plasma flow and glomerular filtration rate (GFR), which in turn lowers serum creatinine and urea levels.[7–9] However, in preeclampsia, these adaptations are impaired, and glomerular endotheliosis a characteristic lesion leads to reduced renal perfusion, decreased GFR, and proteinuria.[10–12] The renal implications of preeclampsia can extend beyond pregnancy and contribute to long-term renal disease in affected women.[13]

Traditionally, serum creatinine has been used as a primary marker to estimate renal function in pregnancy. Yet, it is known to be insensitive in detecting mild or early renal impairment during pregnancy due to increased GFR and volume expansion.[14] Cystatin C, a 13-kDa cysteine protease inhibitor produced by all nucleated cells, is freely filtered by the glomeruli and reabsorbed and catabolized by proximal tubule cells, making it a promising alternative for estimating GFR.[15–17] Its levels are not affected by muscle mass, diet, or inflammatory conditions, enhancing its reliability in pregnancy.[18]

Globally, several studies have highlighted the clinical utility of cystatin C in detecting subtle renal dysfunction in pregnancy and its correlation with adverse obstetric outcomes. [19–21] However, its use in African clinical settings remains limited due to cost and lack of standardization. In Nigeria, where maternal healthcare systems face logistical and infrastructural challenges, studies exploring the value of cystatin C in antenatal care are rare but urgently needed. [22–23]

This study was therefore designed to evaluate and compare kidney function in normotensive and preeclamptic pregnant women in Abeokuta, Nigeria. In addition, it aims to assess the diagnostic value of serum cystatin C in detecting kidney dysfunction relative to serum creatinine, and to identify clinical characteristics associated with renal compromise in preeclamptic pregnancies. By addressing this gap, we hope to contribute toward evidence-based strategies to enhance antenatal nephrology screening in Nigeria and similar LMIC contexts.

Materials and Methods

This hospital-based comparative cross-sectional study was conducted at the Federal Medical Centre (FMC) in Abeokuta, Ogun State, Nigeria. The hospital is a tertiary-level healthcare facility and a major referral center that offers specialized care in various fields, including obstetrics and nephrology. The study aimed to assess and compare kidney function between pregnant women diagnosed with preeclampsia and those with normotensive pregnancies.

The study population consisted of 180 pregnant women aged between 18 and 45 years, attending antenatal clinics at FMC Abeokuta. Ninety participants were clinically diagnosed with preeclampsia, while the remaining ninety were normotensive controls matched by gestational age. Preeclampsia was diagnosed based on criteria established by the American College of Obstetricians and Gynecologists (ACOG), which include a systolic blood pressure of at least 140 mmHg and/or diastolic pressure of at least 90 mmHg, measured on two occasions at least four hours apart after 20 weeks of gestation, in combination with significant proteinuria of 300 mg or more in a 24-hour urine sample or a dipstick reading of +2 or more.

Participants were included if they had a singleton pregnancy and a gestational age of at least 20 weeks. Those with a known history of chronic kidney disease, preexisting hypertension, diabetes mellitus, multiple pregnancies, or a urinary tract infection at the time of recruitment were excluded. Eligible participants were recruited consecutively through purposive sampling. For every preeclamptic woman recruited, a normotensive control was selected to match gestational age as closely as possible, ensuring comparability between groups.

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The sample size was calculated using the formula for comparing two independent means, assuming a significance level of 5%, a statistical power of 80%, and an expected difference in estimated glomerular filtration rate (eGFR) values based on previously published studies. A total of 90 participants per group was considered adequate, accounting for potential attrition or incomplete data.

Data were collected through interviewer-administered structured questionnaires, physical examinations, and a review of clinical records. Information obtained included sociodemographic characteristics, obstetric and medical histories, clinical symptoms such as generalized edema, headache, and leg swelling, and biochemical markers of renal function. Venous blood samples were collected under aseptic conditions. Serum creatinine, uric acid, calcium, phosphate, and fasting blood sugar were measured using standard automated spectrophotometric techniques. Serum cystatin C levels were measured using a particle-enhanced nephelometric immunoassay. Midstream urine samples were analyzed for proteinuria and screened for urinary tract infections. The eGFR was calculated using the Chronic Kidney Disease Epidemiology Collaboration (CKD-EPI) equation and interpreted according to the Kidney Disease Outcomes Quality Initiative (KDOQI) staging system.

Data analysis was performed using IBM SPSS version 22.0. Continuous variables were summarized as means and standard deviations, or medians and interquartile ranges depending on data distribution, while categorical variables were summarized as frequencies and percentages. Group comparisons were conducted using independent sample t-tests for continuous variables and Chi-square or Fisher's exact tests for categorical variables. A p-value of less than 0.05 was considered statistically significant.

Ethical approval for the study was obtained from the Health Research Ethics Committee of the Federal Medical Centre, Abeokuta, with reference number HREC/03/05/2010 and protocol number FMCA/470/HREC/14/2014. All participants provided written informed consent before enrollment. Confidentiality of personal information was strictly maintained throughout the course of the study.

Results

Participant Characteristics

A total of 180 pregnant women were enrolled in the study, comprising 90 with preeclampsia and 90 normotensive controls. The mean age was 30.3 ± 6.6 years in the preeclamptic group and 30.2 ± 5.0 years in the control group ($p = 0.056$). Most participants were married (96.1%) and of Yoruba ethnicity (89.4%). No significant difference was found between the two groups in terms of educational status, occupation, or type of residence.

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Table 1: Sociodemographic characteristics of respondents

Characteristics	Pre-Eclampsia		Total	Test statistics	p-value
	Yes	***No***	***N (%)***		
Mean Age	30.3±6.6	30.2±5.0		t=0.254	0.056
	N (%)	*N (%)*		X^2	
Age					
15-24	22(24.4)	11(12.2)	*33(18.3)*	6.16	0.046
25-34	46(51.1)	61(67.8)	107(59.5)		
35-44	22(24.4)	18(20.0)	40(22.2)		
Marital Status					
Never Married	6(6.7)	1(1.1)	7(3.9)	3.42	0.118
Married	84(93.3)	89(98.9)	173(96.1)		
Level of Education					
No formal Education	3(3.3)	2(2.2)	5(2.8)	2.00	0.581*
Primary	11(12.2)	12(13.3)	23(12.8)		
Secondary	42(46.7)	34(37.8)	76(42.2)		
Post-secondary	34(37.8)	42(46.7	76(42.2)		
Occupation					
Self Employed	28(31.1)	14(15.6)	42(23.3)	11.2	0.061
Civil servant	23(25.6)	18(20.0)	41(22.8)		
Business/Trader	28(31.1)	49(54.4)	77(42.8)		
Unemployed	11(12.2)	9(10.0)	20(11.1)		
Area of Residence					
Urban	87(96.7)	88(97.8)	175(97.2)	0.20	0.650*
Rural	3(3.3)	2(2.2)	5(2.8)		
Total	**90(50.0)**	**90(50.0)**	**180(100.0)**		

Biochemical Findings

Biochemical analysis showed significantly higher serum cystatin C levels in preeclamptic women (1.09 ± 0.62 mg/L) compared to normotensive controls (0.80 ± 0.22 mg/L, $p < 0.001$). Similarly, serum phosphate and fasting blood sugar were significantly elevated in the preeclampsia group. Mean serum creatinine was slightly higher in preeclamptic women but not statistically significant. Notably, the mean eGFR was significantly lower in preeclamptic participants (100.8 ± 33.1 mL/min) versus controls (125.0 ± 23.9 mL/min, $p = 0.011$).

Table 2: Mean biochemical parameters of participants

Biochemical Parameter	Pre-eclampsia Mean ± SD		t	p-value
	Yes	**No**		
Serum Calcium(mmol/L)	2.27±0.27	2.33±0.18	1.709	0.004
Serum Phosphorus (inorganic) (mmol/L)	1.11±0.28	0.96±0.17	4.266	0.000
Cystatin C(mg/dL)	1.09±0.62	0.80±0.22	4.178	0.000
Serum creatinine(µmol/L)	89.4±52.5	86.9±47.5	0.342	0.168
Uric Acid(mmol/L)	1.60±0.49	1.29±0.20	5.543	0.135
Fasting Blood Sugar(mmol/L)	96.3±21.5	93.4±12.0	1.123	0.000
eGFR	100.8±33.1	125.0±23.9	5.601	0.011

Prevalence and Staging of Kidney Dysfunction

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Kidney dysfunction (eGFR ≤ 60 mL/min) was observed in 10 out of 90 women (11.1%) with preeclampsia, compared to none among the normotensive group ($p < 0.001$). According to KDOQI staging, 61.1% of preeclamptic women had normal renal function (Stage 1), 27.8% were in Stage 2, and 11.1% were in Stages 3–4. In contrast, 94.4% of normotensive women were in Stage 1, and only 5.6% were in Stage 2.

Table 3: Pattern of kidney dysfunction among participants

Biochemical Parameter	Preeclamptic	Non-Preeclamptic	Total	*F*	p-value
	N=90	N=90	N=180		
CKD Staging	N (%)	N (%)	N (%)		
Normal/asymptomatic(>90ml/min)	55(61.1)	85(94.4)	140(77.8)	29.762	<0.001
Stage2 CKD(60-89ml/min)	25(27.8)	5(5.6)	30(16.7)		
Stage 3a CKD(45-59ml/min)	1(1.1)	0(0)	1(0.6)		
Stage 3b CKD(30-44ml/min)	7(7.8)	0(0)	7(3.9)		
Stage 4/Advanced(15-29ml/min)	2(2.2)	0(0)	2(100.0)		
Stage 5 ESKD (< 15ml/min)	0(0)	0(0)	0(0)		

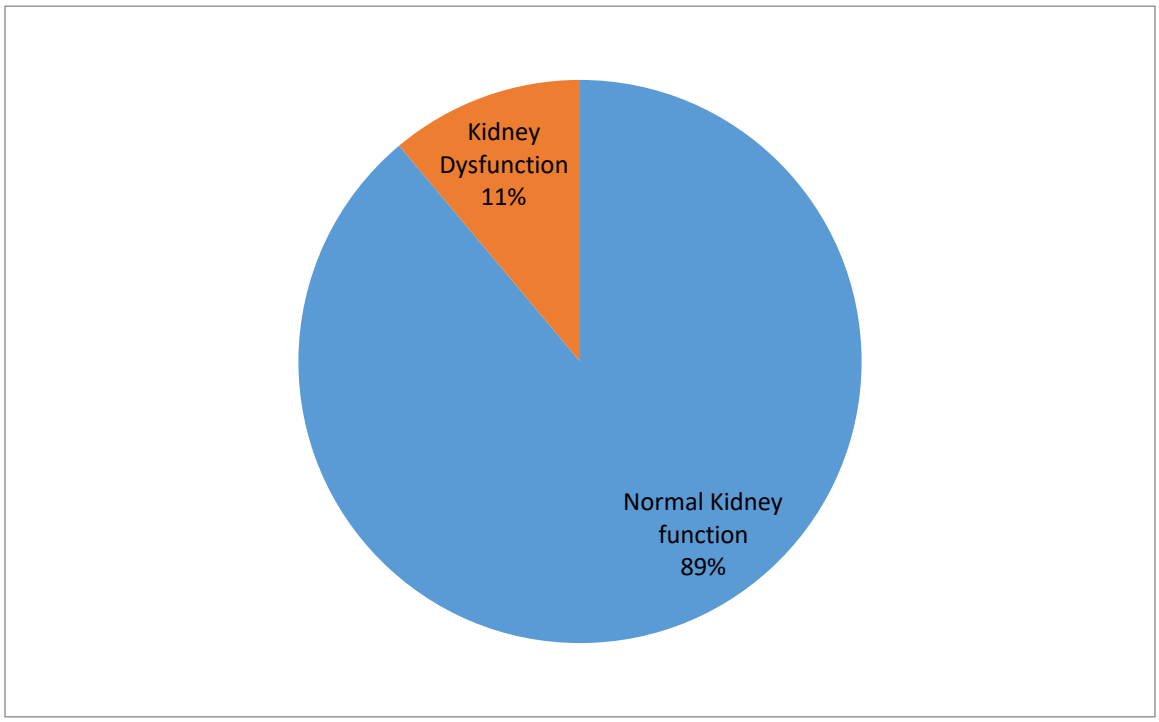

Fig 1: Profile of Women with Kidney dysfunction

Among the 10 women with kidney dysfunction (all in the preeclamptic group), clinical markers such as generalized edema (80%), severe headache (90%), and leg swelling (90%) were significantly more prevalent. Proteinuria of +++ grade was present in 70%, and 80% had glucosuria. Additionally, 80% of these women had abnormal renal ultrasound findings.

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Biochemically, they had significantly higher serum cystatin C levels (mean 2.45 ± 0.98 mg/L) and lower eGFR (mean 38.6 ± 9.2 mL/min).

Table 4: Clinical and Biochemical Profile of Women with Kidney Dysfunction (n = 10)

Parameter	Distribution
Generalized edema - **Frequency (%)**	8 (80.0%)
Severe headache - **Frequency (%)**	9 (90.0%)
Leg swelling - **Frequency (%)**	9 (90.0%)
Proteinuria (+++) - **Frequency (%)**	7 (70.0%)
Glucosuria - **Frequency (%)**	8 (80.0%)
Abnormal renal ultrasound - **Frequency (%)**	8 (80.0%)
Serum cystatin C (mg/L) - **Mean ± SD**	2.45 ± 0.98
Estimated GFR (mL/min) - **Mean ± SD**	38.6 ± 9.2

Table 5: Clinical and laboratory parameters of women with preeclampsia

Parameter	Normal	Kidney dysfunction	Total	χ^2	p-value
Characteristic					
Glucose					
Negative	55(68.8)	2(20.0)	57(63.3)		
Positive	25(31.3)	8(80.0)	33(36.7)	9.097	0.004*
Protein					
+	10(12.5)	0(0.0)	10(11.1)		
++	45(56.3)	3(30.0)	48(53.3	7.148	0.051*
+++	19(23.8)	7(70.0)	26(100.0)		
Negative	6(7.5)	0(0.0)	6(6.7)		
Urine MCS					
Normal	78(97.5)	8(80.0)	86(95.6)		
UTI	2(2.5)	2(20.0)	4(4.4)	6.410	0.059*
Lipid profile					
Dyslipidemia	22(27.5)	6(60.0)	28(31.1)		
Normal	58(72.5)	4(40.0)	62(68.9)	4.381	0.064
Total	**80(100.0)**	**10(100.0)**	**90(100.0)**		

Discussion

The prevalence of kidney dysfunction (defined as eGFR ≤ 60 mL/min) was 11.1% among the preeclamptic women in our cohort. This rate is higher than values reported in most Western studies, where rates typically range between 2–7%, but consistent with similar findings in LMICs.[20] This discrepancy may reflect differences in access to care, awareness, and timing of antenatal enrollment, reinforcing the need for improved screening in high-risk pregnancies in Nigeria and other LMICs. The findings of this study confirm a significantly higher risk of renal impairment among women with preeclampsia compared to normotensive controls, consistent with existing literature from both developed and resource-limited settings.[4–7] The observed reduction in eGFR among preeclamptic participants underscores the renal burden of this condition, aligning with previous studies that documented impaired glomerular function and elevated renal biomarkers in preeclamptic cohorts.[10, 18]

One of the key outcomes of this study is the superior performance of cystatin C, over serum creatinine in detecting early kidney dysfunction. While mean serum creatinine levels were slightly higher in the preeclamptic group, they did not differ significantly. In contrast, cystatin C showed a marked and statistically significant elevation, highlighting its diagnostic sensitivity. These findings are corroborated by previous studies, including those by Dharnidharka et al. and Laterza et al., [14,15] who reported that cystatin C outperforms creatinine in

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estimating GFR, particularly in special populations such as pregnant women.[21]

In East Africa, a study by Muli et al. in Kenya found that cystatin C outperformed creatinine in identifying early renal changes during pregnancy, particularly among preeclamptic patients.[22]This finding aligns with broader observations across sub-Saharan Africa, where few studies have rigorously evaluated cystatin C. Supporting this, a recent Nigerian study by Ayoola et al. reported a strong correlation between elevated cystatin C levels and poor renal outcomes in preeclamptic women, thereby validating our current results.[23]

Our subgroup analysis revealed that clinical symptoms such as generalized edema, leg swelling, and headache were more frequent in women with reduced kidney function. These clinical signs, while non-specific, should prompt early renal evaluation. The correlation between abnormal urinalysis findings particularly significant proteinuria and glucosuria and kidney dysfunction further supports routine dipstick screening during antenatal visits. Additionally, 80% of women with impaired renal function had abnormal renal ultrasound findings, supporting the utility of imaging in select cases. This study highlights the potential of cystatin C to augment current antenatal renal screening protocols. Its use could enable earlier detection of renal compromise, improve maternal monitoring, and guide referral decisions. However, barriers such as test availability, cost, and training must be addressed before implementation can be scaled. Evidence from larger multicenter African cohorts and cost-benefit analyses would be instrumental in supporting policy-level decisions.

Limitations of this study include its cross-sectional design, which precludes longitudinal outcome tracking, and the lack of gold-standard GFR measurement (e.g., inulin clearance). Additionally, while cystatin C demonstrated excellent diagnostic performance, its routine clinical use remains constrained by lack of availability in many public healthcare institutions.

Limitations

This study is limited by its cross-sectional design, which does not allow for follow-up on renal outcomes postpartum. Kidney function was assessed using eGFR rather than direct measurement methods. Additionally, data were collected from a single center, which may affect generalizability.

Implications of the findings

The findings of this study underscore the importance of recognizing preeclampsia as a condition with significant renal implications. The observed reductions in eGFR and elevations in cystatin C among preeclamptic women suggest early kidney dysfunction, even in the absence of prior renal disease. Clinically, this supports the need to incorporate routine renal function assessment including cystatin C and eGFR estimation into antenatal care for women with hypertensive disorders of pregnancy. Symptoms such as leg swelling, headache, and generalized edema, which were significantly associated with renal dysfunction, should prompt further evaluation rather than be dismissed as normal pregnancy-related discomforts. These findings also call for policy-level adjustments, particularly in low-resource settings, to integrate affordable renal screening tools into maternal health programs. Additionally, they highlight the need for further longitudinal research to understand the long-term renal outcomes of women affected by preeclampsia and to validate cystatin C as a reliable screening tool in pregnancy.

Conclusion

In conclusion, our findings suggest that, barring cost and logistics, cystatin C is a more sensitive marker for kidney dysfunction in preeclamptic pregnancies than serum creatinine. Given its strong correlation with reduced eGFR and renal symptoms, it should be considered for inclusion in antenatal testing panels for high-risk pregnancies in Nigeria. Early identification and intervention may help mitigate long-term maternal renal complications.

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