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Serum Uric Acid, Creatinine, and GFR in Pregnant Women: A Case-Control Study in Kosti Sudan

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Abstract:

Background: Pregnancy induces complex physiological adaptations that significantly alter renal hemodynamics and biochemical markers. Accurate interpretation of renal function parameters during pregnancy requires trimester-specific reference values.

Objective: This study aimed to assess serum uric acid (UA), creatinine, and glomerular filtration rate (GFR) among pregnant women across different trimesters and to establish trimester-specific reference intervals in comparison with non-pregnant controls.

Methods: A hospital-based case-control study was conducted at Kosti Teaching Hospital, Sudan, including 200 participants (100 apparently healthy pregnant women and 100 non-pregnant controls). Serum UA and creatinine were measured using standardized spectrophotometric methods, while GFR was estimated using a validated calculation approach. Comparative and stratified statistical analyses were performed to evaluate differences between groups and across trimesters.

Results: Pregnant women exhibited significantly lower serum UA and creatinine levels and significantly higher GFR compared to non-pregnant controls (all $p < 0.001$). Furthermore, both UA and creatinine demonstrated significant trimester-dependent variations ($p < 0.001$). Trimester-specific reference intervals for all studied parameters were established. No significant associations were observed between renal biomarkers and maternal age or body mass index (BMI).

Conclusion: This study highlights marked pregnancy-related alterations in renal function biomarkers and provides trimester-specific reference intervals for a Sudanese population. These findings offer clinically relevant benchmarks that may enhance early detection, risk stratification, and monitoring of renal dysfunction during pregnancy.

Keywords: Uric acid, creatinine, GFR, pregnancy, renal biomarkers, trimester-specific reference intervals, Sudan.

Introduction

Pregnancy is a physiological condition characterized by profound anatomical, hormonal, and metabolic changes that affect multiple organ systems, particularly the kidneys. These renal adaptations are essential to meet the increased metabolic demands of both the mother and the developing fetus. Early in pregnancy, renal plasma flow and glomerular filtration rate (GFR) increase by approximately 40–50%, leading to enhanced clearance of metabolic waste products and measurable alterations in biochemical markers of renal function[1], [2].

Serum creatinine is widely used as a clinical indicator of renal function. However, during pregnancy, physiological hemodilution and increased GFR lead to reduced serum creatinine levels, rendering standard reference ranges derived from non-pregnant populations inappropriate[3], [4]. Consequently, even slight elevations in creatinine during pregnancy may indicate underlying renal impairment[5].

Uric acid, the end product of purine metabolism, is also an important biomarker in obstetric practice. Its levels typically decrease in early pregnancy due to increased renal clearance and the uricosuric effect of estrogen, followed by a gradual increase toward term[6], [7]. Elevated uric acid levels in late pregnancy have

been associated with hypertensive disorders, particularly preeclampsia, and may serve as an early marker of placental dysfunction[8, 10].

Accurate interpretation of renal biomarkers during pregnancy is therefore essential to differentiate between normal physiological adaptations and pathological conditions. Despite this, many laboratories continue to rely on reference intervals established in non-pregnant populations, which may lead to misinterpretation of results, particularly in low- and middle-income settings. Furthermore, there is a notable lack of trimester-specific reference intervals for renal biomarkers in African populations, including Sudan[11, 13].

Therefore, this study aimed to evaluate serum uric acid, creatinine, and estimated GFR among healthy pregnant women across different trimesters and to establish trimester-specific reference intervals in White Nile State, Sudan.

Materials and Methods

Study population: A case-control hospital study was conducted in Kosti Teaching Hospital, Kosti City, White Nile, during the period from September to November 2024. Involving 200 women, 100 pregnant women with trimester intervals as the case group and 100 non-pregnant women as the control group.

Participants aged 18 years and above who consented to take part in the study and signed the informed consent form were included. Participants with human immunodeficiency virus infection, impaired liver function, and those with pre-existing renal disease and systemic diseases such as systemic lupus erythematosus (SLE) and diabetes mellitus were excluded.

Data collection and sampling: The primary data were collected by using structured questionnaires based on objectives of the study. The secondary data were collected from laboratory results, journals, scientific papers, and books. The independent variables include age, gender, weight, length, and body mass index (BMI), which was calculated by weight (kg) / length ($m^{2)}$. The dependent variable includes serum uric acid and creatinine and GFR (which was calculated by GFR (ml/min) = $\frac{(140-Age)xWeight(Kg)}{72xP.creatinine(\frac{mg}{dl})}$

Five milliliters (5 ml) of venous blood were collected from all patients after overnight fasting into a lithium heparin blood container, then labeled and separated by centrifugation at 3500 rpm for 5 minutes; the obtained serum was immediately tested for uric acid and creatinine levels using spectrophotometric methods (Mindray BS-200).

Ethical consideration: The study was approved by the research board of the faculty of medical laboratory sciences at the University of El Imam El Mahdi, permission was taken from the ethical committee of Kosti Teaching Hospital, and verbal informed consent was taken from all participants.

Statistical analysis: Continuous variables were presented as mean and standard deviation and analyzed with the Student's t-test. The age and pregnancy categories were classified, and the mean differences were determined using the one-way ANOVA test. Reference intervals were established utilizing the robust method following CLSI C28-A3 guidelines 13. Statistical analyses were performed using SPSS version 23.0 (SPSS, Chicago, IL). Linear regression was employed to establish a correlation between the evaluated parameters and both age and BMI. All tests were conducted as two-tailed, with a significant level set at a p-value < 0.05.

Results:

A total of 200 participants were included in this study (100 pregnant women as the case group and 100 non-pregnant women as controls), with ages ranging from 18 to 40 years. The majority of participants (73.5%) were aged between 20 and 29 years.

The mean age of pregnant and non-pregnant women was 25.23 ± 5.13 and 24.31 ± 4.42 years, respectively. The mean BMI was 23.47 ± 4.69 kg/m² in pregnant women and 24.04 ± 4.85 kg/m² in non-pregnant women. No statistically significant differences were observed between the two groups regarding age or BMI (Table 1).

Serum uric acid and creatinine levels were significantly lower in pregnant women compared to controls ($p < 0.001$ and $p = 0.004$, respectively). In contrast, estimated GFR was significantly higher in pregnant women ($p < 0.001$) (Table 1).

Across pregnancy trimesters, serum uric acid, creatinine, and GFR demonstrated statistically significant differences (all $p < 0.001$) (Table 2).

Correlation analysis showed no significant associations between serum uric acid or creatinine and age or BMI among pregnant women. However, GFR demonstrated a moderate positive correlation with BMI ($r = 0.309$, $p = 0.002$) and no significant correlation with age (Table 3).

Discussion:

The present study demonstrates significant trimester-specific variations in serum uric acid, creatinine, and estimated GFR among healthy pregnant women. These findings are consistent with

well-established physiological renal adaptations during pregnancy [1,2] and reinforce the importance of pregnancy-specific interpretation of renal biomarkers.

The observed reduction in serum creatinine levels among pregnant women reflects increased glomerular filtration and plasma volume expansion. This decline is a recognized feature of normal pregnancy physiology and has been widely reported in previous studies [3,5]. These findings further emphasize the limitation of applying standard adult reference ranges to pregnant populations, as even slight elevations in creatinine during pregnancy may indicate impaired renal function [4,5].

Serum uric acid levels exhibited a characteristic pattern, with lower concentrations during early and mid-pregnancy followed by an increase in the third trimester. This biphasic trend has been described in earlier studies [6,7], where increased renal clearance and estrogen-induced uricosuria dominate early pregnancy, followed by reduced clearance and increased oxidative stress in late gestation. The rise in uric acid during the third trimester, although within physiological limits, may have clinical relevance due to its association with endothelial dysfunction and hypertensive disorders such as preeclampsia [8, 10].

The significantly elevated GFR observed in pregnant women supports the concept of physiological hyperfiltration, which facilitates metabolic waste elimination and supports fetal development 1,2. Similar findings have been reported in previous studies, confirming the persistence of increased GFR across pregnancy and highlighting the importance of interpreting GFR within a pregnancy-specific context 14.

A key strength of this study is the establishment of trimester-specific reference intervals for uric acid, creatinine, and GFR in a Sudanese population. These locally derived values address a critical gap in clinical laboratory practice, particularly in resource-limited settings where non-pregnant reference ranges are still commonly used [11,13]. The availability of such reference intervals may improve early detection of renal dysfunction and contribute to better maternal outcomes.

However, several limitations should be considered. The single-center design and relatively small sample size may limit the generalizability of the findings. Additionally, GFR was estimated rather than directly measured; however, creatinine-based estimation methods remain widely used in routine clinical practice, particularly in low-resource settings, which enhances the practical applicability of the findings [14,15].

Conclusion

The study concludes that pregnant women demonstrate reduced uric acid and creatinine levels, alongside elevated GFR, in comparison to non-pregnant women, indicating a typical renal adaptation to gestation. The renal biomarkers exhibit variation dependent on the trimester, underscoring the inadequacy of utilizing standard adult reference ranges in the context of pregnancy. This study establishes trimester-specific reference intervals, providing practical and population-relevant laboratory benchmarks. The application of these reference values may improve the interpretation of laboratory results and enable the earlier detection of pregnancy-related renal abnormalities in routine clinical practice.

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Conflict of Interest: Authors declare no conflict of interest.

Data availability: Data are available upon reasonable request.

Author Contributions: Mohamed Osman Ali Mohamed contributed to the conception, design, data acquisition, analysis, and interpretation of the study. Majdi A. Awadallah and Malaz Hammad Zoalnon contributed to the conception, design, drafting of the manuscript, and revision. Abdelhakam G. Tamomh was responsible for proofreading. Rimaz Gurashi and Khalid Eltahir Khalid Kheiralla contributed to the revision of the manuscript. GadAllah Modawe contributed to the analysis. All authors read and approved the final version of the manuscript. All authors meet the ICMJE criteria for authorship and agree to be accountable for all aspects of the work

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Table 1. Characteristics of study participants

Parameters	Non-pregnant women (Mean±SD)	Pregnant women (Mean±SD)	*P-value*	*value Participants' age range*				*P-*
				18-23	**24-29**	**30-35**	**36-41**	
Participants	100	100		93	74	26	7	
Age (Years)	24.31±4.42	25.23±5.13	0.176	20.87±1.58	25.92±1.63	31.96±2.13	37.71±1.50	**0.000**
BMI (kg/m²)	24.05±4.85	23.47±4.69	0.396	23.30±4.55	23.45±4.70	26.29±5.54	23.91±2.75	**0.035**
Uric acid (mg/dl)	5.57±1.28	2.68±1.33	**0.000**	4.32±1.82	3.93±2.13	3.92±1.95	4.34±1.45	0.686
Creatinine (mg/dl)	0.83±0.22	0.43±0.29	**0.000**	0.64±0.33	0.64±0.31	0.57±0.36	0.51±0.21	0.693
GFR (ml/min)	144.59±37.36	238.18±167.24.36	**0.000**	179.84±83.81	197.06±175.82	204.69±121.30	233.97±82.95	0.633

Table 2. Data distribution of the parameters among pregnant women in different trimesters.

Analytes	Pregnant women (Mean±SD)			P-value
	First trimester N = 33	**Second trimester N = 33**	**Third trimester N = 34**	
Age (Years)	24.73±4.80	26.09±5.35	24.88±5.26	0.500
BMI (kg/m²)	22.33±3.33	23.45±5.33	24.61±5.00	0.138
Uric acid (mg/dl)	2.94±0.82	1.96±1.52	3.13±1.26	**0.000**
Creatinine (mg/dl)	0.49±0.27	0.52±0.33	0.27±0.18	**0.000**
GFR (ml/min)	236.80±122.61	219.54±118.48	257.34±234.49	0.656

Table 3. The analytes in different pregnancy trimesters.

Analytes	First Trimester N = 33	Second Trimester N = 33	Third Trimester N = 34
Uric acid (mg/dl)	2.65 (2.58–2.72)–3.23 (3.16–3.27)	1.42 (1.41–1.56)–2.50 (2.38–2.58)	2.69 (2.69–2.78)–3.56 (3.47–3.59)
Creatinine (mg/dl)	0.40 (0.39–0.41)–0.59 (0.58–0.59)	0.40 (0.40–0.43)–0.63 (0.58–0.64)	0.21 (0.21–0.22)–0.33 (0.30–0.34)
GFR (ml/min)	193.32 (190.86–200.94)–280.27 (258.65–283.14)	177.53 (174.63–186.45)–261.56 (243.04–263.01)	175.52 (193.93–206.53)–339.15 (282.44–346.28)

Table 4. Correlation of the parameters with age and BMI in study subjects.

Parameters	Variables	r	*P-value*
Uric acid (mg/dl)	Age	-0.074	0.697
	BMI	0.137	0.476
Creatinine (mg/dl)	Age	-0.569	0.655
	BMI	-0.088	0.945
GFR (ml/min)	Age	0.003	0.409
	BMI	0.005	0.119