International Journal of Reproduction, Contraception, Obstetrics and Gynecology
Sirsam S et al. Int J Reprod Contracept Obstet Gynecol. 2025 Nov;14(11):3766-3775
www.ijrcog.org
pISSN 2320-1770 | eISSN 2320-1789

DOI: https://dx.doi.org/10.18203/2320-1770.ijrcog20253517

Original Research Article

Evaluation of spot urine albumin creatinine ratio as a screening tool for prediction of preeclampsia

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Received: 07 October 2025
Revised: 23 October 2025
Accepted: 24 October 2025

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ABSTRACT

Background: Preeclampsia is the second leading cause of maternal mortality, accounting for approximately 12-18% of pregnancy-related deaths. Spot urine albumin creatinine ratio (UACR) underscores its significance as a practical tool for earlier detection and effective management thereby enhancing clinical outcomes for both mother and their infants.
Methods: Singleton pregnant women between 16 and 20 weeks of gestation attending the antenatal care (ANC) outpatient department (OPD) of GMC Akola were enrolled in this prospective study. The spot urinary albumin-to-creatinine ratio (UACR) was calculated for each case. All patients were placed under regular follow-up at 24 weeks, 28 weeks, 32 weeks, 34 weeks, 36 weeks, and subsequently on a weekly basis until delivery. Special attention was given to identifying the development of preeclampsia during the antenatal period and/or at the time of delivery.
Results: A UACR cutoff of 35.5 mg/mmol was identified as predictive of preeclampsia, with a significant association noted ($p<0.0001$). Diagnostic performance measures revealed a sensitivity of 85.1%, specificity of 91.4%, PPV of 82.6%, and NPV of 92.8%, suggesting high diagnostic accuracy.
Conclusions: The present study establishes that spot UACR, when measured between 16-20 weeks of gestation in asymptomatic pregnant women, serves as a highly sensitive and specific early screening tool for predicting the subsequent development of preeclampsia.

Keywords: Preeclampsia, UACR, Spot urine albumin creatinine ratio

INTRODUCTION

Preeclampsia (PE) is a complex syndrome that affects approximately 3-5% of pregnancies. It is primarily characterized by the emergence of hypertension after the 20th week of gestation.[1,2] This condition is often associated with dysfunction in various organ systems, including the kidneys, liver, hematologic system, central nervous system, and placenta.[3,4]

PE is the second leading cause of maternal mortality, accounting for approximately 12-18% of pregnancy-related deaths.[5] The incidence of this syndrome in developing nations has been reported to range from 4% to 18%. Globally, the prevalence of preeclampsia varies between 2% and 8% of all pregnancies.[6] Notably, the WHO estimates that the incidence of this potentially fatal disorder is significantly higher, up to seven times greater in developing countries compared to their developed counterparts.[7] In India, the National Institute of Health and Family Welfare (NIHFW) reports that the incidence of preeclampsia among pregnant women is between 8% and 10%. This highlights the pressing need for improved prenatal care and monitoring, particularly in regions with higher incidence rates.[8,9]

The clinical manifestations of PE exhibit considerable variability, ranging from mild to severe forms, with the latter potentially resulting in life-threatening complications for both the mother and the fetus.[10] Women

with a history of preeclampsia are at an increased risk of developing chronic health conditions, including chronic hypertension, cardiovascular disease, stroke, metabolic syndrome, cognitive impairment, and end-stage renal disease.[11,12] Furthermore, preeclampsia poses significant risks to the fetus and newborn, with infants born to mothers affected by PE being at a heightened risk for both immediate and long-term health complications.[13,14]

According to the criteria established by the American College of obstetrics and gynecology (ACOG), preeclampsia is diagnosed when a pregnant individual's blood pressure exceeds 140/90 mmHg, accompanied by proteinuria greater than 300 mg over 24 hours. These measurements must be observed on at least two separate occasions, with the assessments taking place more than six hours apart and occurring after the 20th week of gestation. In cases where the blood pressure is recorded at higher than 160/100 mmHg, along with proteinuria exceeding 500 mg in a 24-hour collection and the presence of imminent symptoms, the condition is classified as severe preeclampsia.[15]

The available screening tools for preeclampsia include a combination of maternal risk factors, uterine artery Doppler assessments, mean arterial pressure measurements, maternal serum levels of pregnancy-associated plasma protein-A, and placental growth factor. This multifaceted approach can identify approximately 95% of cases of early-onset preeclampsia, albeit with a false positive rate of 10%.[16,17]

However, a significant challenge remains in the development of a universally accepted screening test that can accurately predict preeclampsia before its clinical onset.[18] Numerous studies have been conducted to identify such a predictive tool; however, the effectiveness of individual tests varies considerably, and none have proven capable of reliably forecasting the disease before the emergence of clinical symptoms. This underscores the ongoing need for research in this area to improve early detection strategies for preeclampsia.[18,19]

To facilitate earlier prediction and diagnosis, especially since micro albuminuria is a marker of endothelial dysfunction. However, micro albuminuria is currently defined as urinary albumin excretion (UAE) ranging from 30 to 300 mg over 24 hours when assessed via a 24-hour urine collection. Alternatively, it can be measured using the urinary albumin-to-creatinine ratio (UACR) in a spot urine sample, with a corresponding range of 30 to 300 mg/g.

The random albumin-to-creatinine ratio from a single urine sample is increasingly recommended.[20] This approach not only streamlines the assessment process but has also demonstrated a robust correlation with 24-hour protein excretion levels. The stability of urinary creatinine excretion in individuals with a consistent glomerular filtration rate further supports its use as a reliable internal reference.

The validity of the UPCR method for evaluating proteinuria is well-supported in the literature, especially in non-pregnant populations, and has been endorsed by the International Society for the Study of Hypertension in Pregnancy. This recognition underscores its significance as a practical tool for the early detection and effective management of preeclampsia, thereby enhancing clinical outcomes for both mothers and their infants.[21]

Despite significant advancements in the field of obstetrics and gynecology, there remains a paucity of comprehensive data regarding the optimal management of preeclampsia. The most effective therapeutic approaches continue to be a subject of ongoing debate and controversy. Ultimately, this contributes to an increased incidence of both maternal and fetal morbidity and mortality, further exacerbating the adverse outcomes associated with preeclampsia.[21] Thus, our present analysis aims to investigate whether spot urine albumin: creatinine ratio measures between 16-20 weeks of gestation can predict preeclampsia in asymptomatic pregnant women.

METHODS

Study type

This was a prospective study.

Study setting

This was conducted in a tertiary care Centre Government Medical College, Akola.

Study population

ANC visiting OPD from 16-20 weeks by last menstrual period (LMP) and verified by ultrasound was the study population.

Study period

The study duration was from July 2023 to January 2025.

Inclusion criteria

Patients with ANC visiting OPD from 16-20 weeks of the last menstrual period (LMP) and verified by ultrasound who give consent for study; singleton pregnancy; 16-20 weeks of gestation; or nil dipstick proteinuria.

Exclusion criteria

People with high risk pregnancy; twin gestation; positive on urine dipstick; previous bad obstetrics outcome; and women with hematuria, ongoing urinary tract infection, acute renal failure, chronic kidney disease.

Ethical considerations

Women included in the study were informed of the study, and written consent was obtained from them. No patient was financially burdened during the study.

Study method

Singleton pregnant women between 16 and 20 weeks of gestation attending the ANC OPD were enrolled in the study. Prior to participation, appropriate written, informed, and valid consent was obtained from each participant. The demographic characteristics, medical history, and obstetric details of all enrolled women were meticulously documented. A comprehensive general and obstetric examination was performed, and only those who tested negative for urine albumin via the urine dipstick method were subsequently subjected to a spot urine albumin-to-creatinine ratio (UACR) test. Each participant was provided with a sterile urine container without preservatives, and after receiving standardized instructions, a midstream urine sample was collected. The spot urinary albumin-to-creatinine ratio (UACR) was calculated for each case. Urine albumin levels were quantified using the immunoturbidimetric method with a commercially available kit (Beckman Coulter) and analyzed via the Beckman AU 480 fully automated biochemistry analyzer. Urine creatinine levels were determined using the modified kinetic Jaffe reaction, which was performed without deproteinization. The UACR values for each participant were meticulously recorded. All patients were placed under regular follow-up at 24 weeks, 28 weeks, 32 weeks, 34 weeks, 36 weeks, and subsequently on a weekly basis until delivery. Special attention was given to identifying the development of preeclampsia during the antenatal period and/or at the time of delivery. For the prediction of preeclampsia, a UACR cutoff value of 35.5 mg/mmol was used as the diagnostic threshold.

Data management and analysis

All collected data were entered into Microsoft Excel (version 17) and analyzed using Statistical Package for the Social Sciences (SPSS) software.

Data analysis plan and methods

Descriptive statistics and diagrammatic representations, including bar diagrams and pie charts, were used as appropriate. Descriptive analysis included the calculation of mean, standard deviation, ratio, and proportion with percentages. Quantitative data were analyzed using Student's unpaired t-test, with a $p<0.0001$ considered statistically significant.

RESULTS

Among them, 54 participants were under the age of 20, with 37 (25%) being normotensive and 17 (11%) diagnosed with preeclampsia. In the 21-25 age group, 25 (16%) were normotensive and 12 (8%) had preeclampsia, making a total of 37 participants. The 26-30 age group comprised 30 participants, including 18 (12%) normotensive and 12 (8%) preeclamptic cases. For those over 30 years of age, 22 (15%) were normotensive and 7 (5%) had preeclampsia, totalling 29 participants. Statistical analysis showed no significant association between age group and the occurrence of preeclampsia, with a p value of 0.598.

Table 1: Distribution according to age group.

Age group (in years)	Normotensive	Preeclampsia	Total
	N (%)	N (%)	
<20	37 (25)	17 (11)	54
21-25	25 (16)	12 (8)	37
26-30	18 (12)	12 (8)	30
>30	22 (15)	7 (5)	29
Total	102	48	150
P value	0.598		

Table 2: Distribution according to gravida status.

Gravida status	Normotensive	Preeclampsia
	N (%)	N (%)
Primi	68 (45)	22 (15)
G2	23 (15)	14 (9)
G3	11 (7)	12 (8)
Total	102	48
P value	0.005	

Table 3: Distribution according to gestational age.

GA range (weeks)	Normotensive	Preeclampsia
	N (%)	N (%)
< 20	19 (13)	14 (9)
20 – 21.9	46 (30)	18 (13)
≥ 22	37 (25)	16 (11)
Total	102	48
p-value	0.277	

Table 4: Association of UACR with preeclampsia.

UACR	Pre-eclampsia (positive)	Normotensive (negative)	Total
	N (%)	N (%)	
Test positive	41 (28)	9 (6)	50
Test negative	7 (5)	93 (62)	100
Total	48	102	150

Table 5: Distribution according to blood pressure and spot UACR.

Parameters	Normotensive	Preeclampsia	P value
SBP (mm Hg)	109.78±11.55	117.6±8.01	<0.0001
DBP (mm Hg)	68.93±7.68	72.4±7.6	0.0026
Spot UACR (mg/mmol)	26.84±4.69	44.12±9.43	<0.0001

Table 6: Association of spot urinary ACR with preeclampsia.

Spot UACR (mg/mmol)	Normotensive	Preeclampsia	Total
	N (%)	N (%)	
<35.5	77 (51)	7 (4)	84
≥35.5	25 (16)	41 (28)	66
Total	102	48	150

Table 7: Association of spot UACR with onset of preeclampsia.

Spot UACR (mg/mmol)	Preeclampsia		Total	P value
	< 34 weeks	**≥ 34 weeks**		
	N (%)	N (%)		
<35.5	4 (7)	6 (13)	10	0.520
≥35.5	17 (36)	21 (43)	38	
Total	21	27	48	

Table 8: Diagnostic accuracy of spot UACR in predicting preeclampsia.

Parameters	Values (%)
Sensitivity	85.10
Specificity	91.40
Positive predictive value	82.60
Negative predictive value	92.80

Among the 150 participants, primigravida women formed the largest group, with 68 (45%) being normotensive and 22 (15%) developing preeclampsia. In the gravida 2 (G2) group, 23 (15%) were normotensive and 14 (9%) had preeclampsia. Interestingly, in the gravida 3 (G3) group, a smaller proportion of women were normotensive 11 (7%), while a comparable number 12(8%) had preeclampsia. Statistical analysis revealed a significant association between gravida status and the development of preeclampsia, with a p value of 0.005. Among those with gestational age less than 20 weeks, 19 (13%) were normotensive and 14 (9%) had preeclampsia. In the 20-

21.9 weeks range, 46 (30%) were normotensive and 18 (13%) were preeclamptic. For gestational age ≥22 weeks, 37 (25%) were normotensive and 16 (11%) had preeclampsia. Although the number of preeclampsia cases varied across gestational age groups, statistical analysis showed no significant association, with a p value of 0.277.

The diagnostic performance of spot UACR in predicting preeclampsia was assessed using a defined cut-off. Among the 50 participants who tested positive based on UACR, 41 (28%) were confirmed cases of preeclampsia, while 9 (6%) were normotensive, representing false positives. Of the 100 participants with a negative UACR test, 7 (5%) had preeclampsia (false negatives), and 93 (62%) were normotensive (true negatives). These findings indicate that UACR has a strong association with preeclampsia and supports its utility as a potential screening tool.

The study compared systolic and diastolic blood pressure, along with spot UACR, between normotensive and preeclamptic participants. The mean SBP in the normotensive group was 109.78±11.55 mm Hg, whereas it was significantly higher at 117.6±8.01 mm Hg in the preeclampsia group ($p<0.0001$). Similarly, the mean diastolic blood pressure (DBP) was 68.93±7.68 mm Hg in normotensive individuals compared to 72.4±7.6 mm Hg in those with preeclampsia, showing a statistically significant difference ($p=0.0026$). Furthermore, the mean spot UACR was substantially elevated in the preeclamptic group (44.12±9.43 mg/mmol) compared to the normotensive group (26.84±4.69 mg/mmol), with the difference being highly significant ($p<0.0001$). These findings indicate a strong association between elevated UACR and increased blood pressure in preeclampsia.

The association between spot UACR and preeclampsia was analyzed using a cut-off value of 35.5 mg/mmol. Among the 84 participants with UACR levels below 35.5 mg/mmol, 77 (51%) were normotensive, while only 7 (4%) developed preeclampsia. In contrast, of the 66 participants with UACR levels ≥35.5 mg/mmol, 25 (16%) were normotensive, whereas a significantly higher number, 41 (28%), had preeclampsia. These findings suggest a strong association between elevated spot UACR and the presence of preeclampsia, indicating that UACR may serve as a useful predictive marker for early detection.

The association between spot UACR and the onset of preeclampsia was evaluated based on gestational age at diagnosis (<34 weeks vs. ≥34 weeks). Among the 48 women with preeclampsia, 10 had UACR levels <35.5 mg/mmol, with 4 (7%) experiencing early-onset (<34 weeks) and 6 (13%) having late-onset (≥34 weeks) preeclampsia. In comparison, 38 women had UACR levels ≥35.5 mg/mmol, of whom 17 (36%) had early-onset and 21 (43%) had late-onset preeclampsia. Although a higher UACR appeared more frequently associated with both early and late-onset preeclampsia, the difference was not statistically significant ($p=0.520$).

The diagnostic accuracy of spot UACR in predicting preeclampsia was evaluated using sensitivity, specificity, and predictive values. The test demonstrated a sensitivity of 85.10%, indicating its ability to correctly identify a high proportion of true preeclampsia cases. The specificity was 91.40%, reflecting its effectiveness in correctly identifying normotensive individuals. The positive predictive value (PPV) was 82.60%, suggesting a strong probability that individuals with a positive UACR result had preeclampsia. Similarly, the negative predictive value (NPV) was 92.80%, indicating that a negative UACR result reliably excluded preeclampsia. These results supported the utility of spot UACR as a reliable screening tool for early identification of preeclampsia

DISCUSSION

Preeclampsia remains one of the foremost contributors to maternal and perinatal morbidity and mortality worldwide. The pathophysiological basis of this complex multisystem disorder is rooted in widespread endothelial dysfunction, inadequate trophoblastic invasion leading to impaired placentation, and dysregulated maternal immunological responses, all of which may be influenced by underlying genetic predisposition. These disturbances contribute to the characteristic clinical spectrum of preeclampsia, ranging from mild hypertension to severe end-organ damage, with significant implications for both maternal and fetal outcomes.[22,23]

Thus, our current analysis to establish whether spot urine albumin: creatinine ratio can predict the development of preeclampsia in 16-20 weeks of gestation asymptomatic pregnant women. In the current study, demographic, clinical and biochemical parameters had been discussed.

Distribution according to age and gravida status

In the present analysis, the distribution of participants based on age revealed that out of the total cohort, 54 individuals were under the age of 20 years. Among them, 37 participants (25%) were found to be normotensive, while 17 individuals (11%) were diagnosed with preeclampsia. In the 21-25-year age group, 25 participants (16%) were normotensive and 12 (8%) presented with preeclampsia, resulting in a total of 37 subjects. The age group of 26-30 years comprised 30 participants, among whom 18 (12%) were normotensive and 12 (8%) developed preeclampsia. In participants aged above 30 years, a total of 29 cases were recorded, of which 23 (15%) were normotensive and 7 (5%) were preeclamptic. Despite the distribution of cases across age categories, statistical analysis demonstrated no significant correlation between maternal age and the incidence of preeclampsia, as indicated by a p value of 0.598.

With respect to gravida status, among the total 150 study participants, primigravida women represented the most substantial subgroup. Out of these, 68 (45%) remained normotensive, whereas 22 (15%) developed preeclampsia.

In women with gravida 2 (G2) status, 23 individuals (15%) were normotensive and 14 (9%) experienced preeclampsia. Notably, in the gravida 3 (G3) subgroup, a smaller proportion of participants, 11 (7%), were normotensive, yet a comparable number, 12 (8%), were diagnosed with preeclampsia. This pattern reflects a significant association between increasing gravida status and the development of preeclampsia, supported by statistical significance (p=0.005).

When compared to existing literature, the findings from the present study are partially consistent with the observations reported by Mishra et al where the mean age of the study population was 27.79±4.79 years. In their analysis, 35 women (56.45%) were primiparous, and 27 (43.54%) were multiparous. Their data suggested a predominance of primipara among the study population, aligning with our findings wherein primigravidas constituted a higher proportion of preeclamptic cases.

Similarly, Mahajan et al. reported a mean maternal age of 24.71±4.50 years in their COHORT. Their results further emphasized that the incidence of preeclampsia was more prevalent in primigravida women, with 16 cases (57.2%) occurring in this group compared to 12 cases (42.8%) in multigravida women. This again corroborates the trend observed in the present analysis, suggesting a higher susceptibility to preeclampsia in first pregnancies.

Additionally, in the study conducted by Modak et al the reported mean maternal age was 23±3.42 years, with a mean BMI of 24±2.46 kg/m² in the unaffected (normotensive) group. Although their study focused on unaffected individuals, the demographic characteristics remain relevant for contextual comparison, highlighting the relatively young age profile and moderate BMI of the studied population.[22]

Distribution according to blood pressure and UACR

In the present analysis, a comparative evaluation was conducted between normotensive and preeclamptic participants with respect to systolic blood pressure (SBP), diastolic blood pressure (DBP), and spot urine albumin-creatinine ratio (UACR). The findings revealed that the mean SBP in the normotensive group was 109.78±11.55 mm Hg, while a significantly higher mean SBP of 117.6± 8.01 mm Hg was observed in the preeclampsia group. This difference was found to be highly statistically significant (p<0.0001), indicating a clear association between elevated systolic blood pressure and preeclampsia. Similarly, the mean DBP in the normotensive cohort was 68.93±7.68 mm Hg, which was significantly lower compared to 72.4±7.6 mm Hg recorded in the preeclamptic group (p=0.0026), further supporting the hypertensive profile characteristic of preeclampsia.

In addition to blood pressure measurements, the mean spot UACR was analyzed as a marker of proteinuria and renal involvement in preeclampsia. The normotensive group had a mean UACR of 26.84±4.69 mg/mmol, whereas a markedly elevated mean UACR of 44.12±9.43 mg/mmol was noted among preeclamptic participants. This elevation was found to be highly significant (p<0.0001), underscoring the strong pathophysiological association between renal impairment and the clinical manifestation of preeclampsia.

These findings are consistent with those reported in the study by Baweja et al., where the mean systolic blood pressure among preeclamptic women was significantly elevated at 116 mm Hg compared to 109 mm Hg in the unaffected group (p=0.001). Comparable results were also observed in the study conducted by Modak et al wherein the mean SBP in the preeclamptic group was 117 mm Hg, while it was 109 mm Hg in the normotensive group, with the difference being statistically significant (p=0.013). These data reinforce the observation that elevated systolic blood pressure is a consistent hemodynamic alteration in preeclamptic individuals and aligns well with other independent investigations.[22]

Furthermore, the diastolic blood pressure data in the present study correlate with the findings of Modak et al which in turn were consistent with the results reported by Gupta et al indicating a similar trend of elevated DBP in the preeclamptic population.[24]

With respect to renal parameters, the current study's findings on UACR are in strong concordance with those of Modak et al who reported a median spot urine protein-creatinine ratio (UPCR) of 44.8 mg/mmol among women who subsequently developed preeclampsia, in contrast to a median value of 26.6 mg/mmol in unaffected women. The cut-off value of UPCR (≥35.5 mg/mmol) used in their study closely aligns with the threshold employed in the present analysis, and the statistical significance of these findings suggests robust predictive value of spot UPCR or UACR in identifying women at risk for preeclampsia. Similarly, Baweja et al also identified ≥35.5 mg/mmol as a meaningful cut-off, lending further support to the reliability of this biomarker in the clinical setting.[9,23]

However, it is important to note that some divergence in findings has been reported across the literature, primarily due to variations in the cut-off values for spot UPCR. For instance, studies cited in references 25 and 26 reported lower thresholds of ≥32.2 mg/g and ≥9.85 mg/g, respectively, which may be attributed to differences in population characteristics, sample processing techniques, or unit conversions (mg/mmol vs mg/g). Despite these discrepancies, the overall trend strongly favors the role of elevated UACR or UPCR as a significant biochemical indicator in the early identification and monitoring of preeclampsia.

Distribution according to gestational age

In the present analysis, participants were categorized based on their gestational age at the time of evaluation to assess

its association with the occurrence of preeclampsia. Among those with a gestational age of less than 20 weeks, 19 participants (13%) were normotensive, whereas 14 individuals (9%) were diagnosed with preeclampsia. In the gestational age range of 20 to 21.9 weeks, 46 women (30%) were normotensive and 18 (13%) developed preeclampsia. Among those with gestational age ≥22 weeks, 37 participants (25%) remained normotensive while 16 (11%) exhibited features of preeclampsia. Although a numerical trend of increasing cases of preeclampsia was observed as gestational age progressed, statistical analysis revealed no significant association between gestational age at the time of assessment and the development of preeclampsia (p=0.277). This suggests that while gestational age may influence the timing of clinical manifestation, it may not serve as a direct predictive factor for the development of the condition during the early to mid-trimesters.

These findings may be interpreted in conjunction with those reported by Mahajan et al where the gestational age at delivery was evaluated in preeclamptic versus unaffected patients. In their study, out of the total preeclampsia COHORT, 13 women (46.4%) delivered before 37 weeks of gestation, while 15 women (53.6%) delivered at or beyond 37 weeks. Importantly, the mean gestational age at delivery was found to be significantly lower in preeclamptic women as compared to normotensive controls, emphasizing the impact of preeclampsia on pregnancy duration and its association with preterm birth.

Moreover, comparative data from the study conducted by Rajeshwari et al offer additional insights into gestational age differences in hypertensive versus normotensive pregnancies. In their analysis, the mean gestational age among healthy normotensive women (Group A, n=42) was 22.26±2.69 weeks, whereas hypertensive women (Group B, n=8) had a significantly higher mean gestational age of 26.5±1.94 weeks at the time of evaluation. This finding may reflect delayed onset or diagnosis of hypertensive complications in certain populations, although the smaller sample size of the hypertensive group in that study warrants cautious interpretation.[27-29]

Taken together, while the present analysis did not establish a statistically significant correlation between gestational age and preeclampsia incidence at the time of presentation, findings from Mahajan et al and Rajeshwari et al underscore that preeclampsia frequently influences the timing of delivery and may be associated with altered gestational trajectories, particularly resulting in earlier deliveries. Therefore, although gestational age alone may not be a definitive risk factor for the development of preeclampsia, it remains a critical parameter in understanding the clinical course and perinatal outcomes associated with the disorder.

Distribution according to association of UACR and pre-eclampsia

In the present analysis, the clinical utility of the spot UACR as a predictive marker for preeclampsia was evaluated using a diagnostic cut-off value of ≥35.5 mg/mmol. Among the 84 participants whose UACR values were below this threshold, a predominant majority, 77 individuals (51%), were normotensive, while only 7 participants (4%) developed preeclampsia. Conversely, among the 66 participants with elevated UACR levels (≥35.5 mg/mmol), 25 individuals (16%) remained normotensive, whereas a significantly higher proportion, 41 participants (28%), were diagnosed with preeclampsia. The stark contrast in preeclampsia incidence between the low and high UACR groups was found to be statistically significant, indicating a strong and meaningful association between elevated UACR and the occurrence of preeclampsia. These findings underscore the potential of spot UACR as a valuable non-invasive biochemical marker for the early detection and risk stratification of preeclampsia in antenatal settings.

The current findings are well supported by the study conducted by Mahajan et al which also demonstrated a robust association between elevated UACR and the development of preeclampsia. In their analysis, out of 28 patients (18.7%) who were categorized as UACR positive (i.e., UACR ≥35.5 mg/mmol), 25 individuals (89.3%) developed preeclampsia, while only 3 participants (2.4%) remained unaffected despite having elevated UACR levels. In contrast, among the 122 patients (81.3%) with negative UACR results (below the threshold), only 3 participants (10.7%) went on to develop preeclampsia, representing false-negative cases. The diagnostic performance metrics reported in their study were noteworthy, with a sensitivity of 89.29%, specificity of 97.54%, positive predictive value (PPV) of 89.29%, and negative predictive value (NPV) of 97.54%. These high values for both sensitivity and specificity suggest that spot UACR is a reliable early indicator with strong discriminative power for identifying women at risk of preeclampsia.

Similarly, the study by Modak et al further substantiates the predictive validity of proteinuria assessment via the urinary protein-creatinine ratio, which is conceptually and diagnostically analogous to UACR. In their study, out of a total of 18 women (15.52%) who tested positive for UPCR (≥35.5 mg/mmol), 12 individuals (10.34%) subsequently developed preeclampsia, whereas 6 women (5.17%) represented false-positive cases, wherein the test was positive but the clinical condition did not manifest. Conversely, among the 98 women (84.48%) who tested negative for UPCR, only 3 developed preeclampsia later during pregnancy, thereby constituting the false-negative subgroup. The diagnostic performance of UPCR at the cut-off value of ≥35.5 mg/mmol was reported with a sensitivity of 80%, specificity of 94.06%, PPV of 66.67%, and an impressive NPV of 96.94%, indicating that a

negative UPCR test is highly predictive of the absence of preeclampsia.[29,30]

Collectively, these findings, including the current study and supporting evidence from Mahajan et al and Modak et al reinforce the clinical relevance of early proteinuria screening using UACR or UPCR as reliable surrogate markers for renal endothelial dysfunction and early preeclamptic changes. The high sensitivity and specificity values associated with the cut-off of ≥35.5 mg/mmol strongly support its implementation in routine antenatal surveillance to enable timely intervention and improve maternal and fetal outcomes.[29,30]

Distribution according to association of UACR and onset of preeclampsia

In the present analysis, the relationship between the spot UACR and the timing of preeclampsia onset was assessed by categorizing cases into early-onset (gestational age <34 weeks) and late-onset (≥34 weeks) groups. Among the 48 women diagnosed with preeclampsia, 10 had UACR levels below the established diagnostic threshold of 35.5 mg/mmol. Within this subgroup, 4 women (7%) experienced early-onset preeclampsia, while 6 (13%) developed late-onset disease. In contrast, 38 preeclamptic participants exhibited elevated UACR levels (≥35.5 mg/mmol), among whom 17 cases (36%) were classified as early-onset and 21 cases (43%) as late-onset preeclampsia. These data indicate a numerically higher occurrence of both early and late-onset preeclampsia in women with elevated UACR levels compared to those with lower values. However, statistical analysis did not demonstrate a significant association between UACR stratification and the timing of preeclampsia onset, as evidenced by a p value of 0.520.

These findings are comparable to those reported by Rupali Modak et al who evaluated the association between spot UPCR, an analogous renal biomarker, and the gestational age at onset of preeclampsia. In their COHORT, 15 women developed preeclampsia, of whom 3 (20%) had UPCR levels below 35.5 mg/mmol. All three cases in this subgroup were categorized as late-onset preeclampsia (≥34 weeks), with no instances of early-onset disease observed. Conversely, 12 participants (80%) exhibited UPCR values ≥35.5 mg/mmol. Within this elevated group, 2 women (13.33%) had early-onset and 10 (67.67%) had late-onset preeclampsia. Despite the apparent predominance of elevated UPCR levels among both early and late-onset cases, the association was not statistically significant in their study either (p=0.629).

The results of both the present analysis and that of Rupali Modak et al suggest that while elevated UACR or UPCR values are more commonly observed in preeclamptic patients, particularly those with late-onset disease, these biomarkers alone may not have sufficient discriminatory power to predict the precise timing of preeclampsia onset. The absence of a statistically significant association in both datasets indicates that, although renal dysfunction marked by elevated UACR or UPCR is a hallmark of preeclampsia, other pathophysiological factors are likely to play a more critical role in determining the gestational age at which the condition manifests.[22]

Therefore, while elevated UACR remains a valuable diagnostic and prognostic tool in identifying women at risk for preeclampsia, its predictive utility for distinguishing early-onset from late-onset cases appears limited. Future studies incorporating a combination of biochemical markers, Doppler studies, and maternal risk factors may provide a more comprehensive risk assessment model for stratifying the timing and severity of preeclampsia onset.

Distribution according to diagnostic accuracy and UACR positivity

In the present analysis, the diagnostic performance of the spot urine albumin-creatinine ratio (UACR) as a screening tool for preeclampsia was rigorously evaluated. Out of the 150 participants, 50 individuals tested positive for preeclampsia based on a UACR threshold of ≥35.5 mg/mmol. Among these, 41 participants (28%) were true positives, being confirmed cases of preeclampsia, while 9 participants (6%) were normotensive, representing false-positive results. In contrast, among the 100 individuals who tested negative (UACR <35.5 mg/mmol), 7 (5%) developed preeclampsia, classified as false negatives, whereas the remaining 93 participants (62%) were normotensive, constituting true negatives.

Based on this distribution, the sensitivity of UACR in detecting preeclampsia was calculated to be 85.10%, indicating a high capacity to identify true cases of the condition. The specificity was 91.40%, demonstrating strong performance in accurately ruling out preeclampsia in normotensive individuals. The PPV was 82.60%, suggesting that individuals with a positive UACR test had a high likelihood of having preeclampsia. Likewise, the NPV was 92.80%, reflecting the reliability of a negative test result in excluding the disease. These findings collectively support the utility of spot UACR as a valuable, non-invasive, and reliable screening tool for early identification and risk assessment of preeclampsia in antenatal clinical practice.

Comparable findings have been reported in several previous studies. In the study by Mahajan et al the incidence of preeclampsia was 18.7%, and a significant elevation in UACR levels was observed among patients with preeclampsia compared to unaffected individuals. The diagnostic threshold used was the same as in the current study (UACR ≥35.5 mg/mmol), with 18.7% of patients classified as test positive and 81.3% as test negative. Their reported sensitivity and specificity were 89.29% and 97.54%, respectively, with a PPV of 89.29% and an NPV of 97.54%. These performance indicators were highly consistent with the present analysis,

reinforcing the clinical validity of UACR as an effective predictive marker for preeclampsia.[28]

Further corroborative evidence comes from the studies by Mishra et al and Devi et al both of whom reported similar diagnostic accuracies using the same cut-off value. These studies collectively demonstrate that UACR possesses high sensitivity and specificity when appropriately thresholded, making it a dependable marker for both ruling in and ruling out preeclampsia.[30,31]

In contrast, the study conducted by Agarwal S et al. utilized a lower UACR cut-off value of 0.2 (units not standardized), and reported a sensitivity of 62%, which, although moderate, was comparable to the results reported by Fatema et al (50-68%) and Gupta et al (67%). Agarwal et al also noted a specificity of 84%, a PPV of 56%, and an NPV of 92%. While the PPV in this study was lower than in others, the high NPV underscores the test's strength in effectively excluding the disease in negative cases. Similar high NPVs were reported by Fatema K et al. (96.42%), Upadhyay and Dayal (97.5%), and Oya Demirci (91.2%), emphasizing the role of UACR in minimizing unnecessary interventions in low-risk women when the test is negative.[28]

The findings of the present analysis are in strong agreement with several previously published studies. The consistently high negative predictive value across multiple cohorts highlights the strength of UACR in reassuring the absence of disease, while its reasonably high sensitivity and specificity support its role as a first-line screening tool for preeclampsia. Although some variability in performance metrics across studies can be attributed to differences in cut-off values, population characteristics, and assay methodologies, the overarching evidence affirms that UACR is a clinically valuable and cost-effective biomarker for early identification and risk stratification of preeclampsia in antenatal care.

Limitations

The relatively small sample size of 150 participants, though adequate for preliminary analysis, may have limited the statistical power, especially for subgroup evaluations across various ethnic, socioeconomic, or regional backgrounds. Only a single spot UACR measurement was taken, whereas serial assessments throughout pregnancy could have offered better insights into progression and predictive value. The study also did not account for several potential confounding variables such as maternal BMI, dietary habits, smoking status, insulin resistance, or socioeconomic factors, which may have influenced outcomes.

CONCLUSION

The present study establishes that spot UACR, when measured between 16-20 weeks of gestation in asymptomatic pregnant women, serves as a highly sensitive and specific early screening tool for predicting the subsequent development of preeclampsia. A UACR cut-off value of ≥35.5 mg/mmol was significantly associated with the incidence of preeclampsia, demonstrating a sensitivity of 85.10% and specificity of 91.40%, with high positive and negative predictive values (82.6% and 92.8%, respectively).

This suggests that a single, non-invasive, cost-effective UACR test during the second trimester can reliably stratify risk and facilitate early surveillance or prophylactic interventions. Importantly, its strong predictive value holds even in the absence of clinical symptoms and proteinuria on dipstick, offering a valuable opportunity for timely obstetric management and potential reduction in maternal-fetal morbidity associated with preeclampsia.

Future directions

The strength of this study lies in its prospective design, strict inclusion criteria, and the use of widely accessible and low-cost diagnostic test, spot UACR, as a predictive biomarker. By excluding high-risk pregnancies and focusing solely on asymptomatic women with normal dipstick findings, the study highlights the utility of UACR as an early screening marker in the general obstetric population. The high sensitivity and specificity achieved reinforce its clinical applicability. Moving forward, larger, multicentric trials are warranted to validate these findings across diverse populations and healthcare settings. Additionally, integrating UACR screening into routine antenatal care protocols, possibly in combination with other biomarkers or Doppler studies, could further refine prediction models. Serial UACR assessments and correlation with pregnancy outcomes such as fetal growth restriction or adverse delivery outcomes may also provide more nuanced insights into the temporal evolution of preeclampsia and its early manifestations.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

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Cite this article as: Sirsam S, Chavan SS, Chavan R. Evaluation of spot urine albumin creatinine ratio as a screening tool for prediction of preeclampsia. Int J Reprod Contracept Obstet Gynecol 2025;14:3766-75.