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Diagnostic Efficacy of Ultrasonography in the Evaluation of Haematuria Compared With Multidetector Computed Tomography Urography

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Abstract

Introduction: Haematuria is a common clinical presentation that may result from a wide range of urinary tract disorders. Ultrasonography (USG) is frequently used as an initial imaging modality because it is non-invasive and free from ionising radiation, whereas multidetector computed tomography urography (MDCTU) provides comprehensive evaluation of the urinary tract. This study evaluated the diagnostic performance of USG in patients with haematuria in comparison with MDCTU.

Materials and methods: A prospective observational study was conducted in the Department of Radiodiagnosis, Vydehi Institute of Medical Sciences and Research Centre, Bengaluru, from June 2024 to December 2025. Eighty-five patients with haematuria underwent both USG and MDCTU within 24 hours. The two imaging modalities were interpreted independently by different radiologists who were blinded to the findings of the other modality. Imaging findings were categorised as benign renal lesion, bladder/urothelial mass, calculus, obstructive findings, or renal mass. MDCTU was considered the imaging reference standard. Diagnostic performance of USG for identifying lesions classified as suspicious for malignancy on MDCTU was assessed using sensitivity, specificity, positive predictive value, and negative predictive value.

Results: The study included 85 patients, with a mean age of 39.86 ± 14.89 years; 50 (58.80%) were males, and 35 (41.20%) were females. Microscopic haematuria was present in 66 (77.60%) patients and gross haematuria in 19 (22.40%). On MDCTU, calculus was the most frequent finding, identified in 69 (81.18%) patients, followed by renal mass in 10 (11.76%), bladder/urothelial mass in 5 (5.88%), and benign renal lesion in 1 (1.18%). USG identified calculus in 52 (61.18%), obstructive findings in 17 (20.00%), renal mass in 10 (11.76%), and bladder/urothelial mass in 6 (7.06%). The association between USG and MDCTU findings was statistically significant ($p<0.001$). For identifying lesions classified as suspicious for malignancy on MDCTU, USG demonstrated a sensitivity of 80.00% (95% CI: 54.81-92.95%), specificity of 94.29% (95% CI: 86.21-97.76%), positive predictive value of 75.00% (95% CI: 50.50-89.82%), and negative predictive value of 95.65% (95% CI: 87.98-98.51%).

Conclusion: USG demonstrated good diagnostic utility in the evaluation of haematuria, particularly for identifying renal masses and showed good agreement with MDCTU in the imaging-based classification of lesions suspicious for malignancy. It may serve as a useful initial imaging modality, while MDCTU provides a more comprehensive assessment when further evaluation or characterisation of urinary tract abnormalities is required. Further multicentre studies with larger sample sizes and histopathological correlation are warranted to validate these findings.

Categories: Radiology
Keywords: diagnostic accuracy, haematuria, mdct urography, ultrasonography, urinary tract malignancy

Introduction

Haematuria, defined as the presence of blood in the urine, is a common clinical presentation that may result from a wide spectrum of urinary tract disorders, ranging from benign conditions such as urinary tract infection and urolithiasis to clinically significant conditions, including renal masses and urothelial malignancies [1]. Because haematuria may be the initial manifestation of serious underlying disease, appropriate and timely imaging is essential for identifying the cause and guiding further management [2]. The choice of imaging modality should balance diagnostic accuracy with patient safety, availability, and cost [3].

Ultrasonography (USG) is commonly used as an initial imaging modality in patients with haematuria because it is non-invasive, readily available, relatively inexpensive, and free from ionising radiation [4]. It can effectively demonstrate renal calculi, hydronephrosis, cysts, renal masses, and bladder abnormalities [5]. However, its diagnostic performance may be limited by operator dependency, bowel gas, patient habitus, and difficulty in visualising the entire ureter. Small calculi, subtle urothelial lesions, and early neoplasms may therefore be missed on USG, particularly when the findings are equivocal or clinical suspicion remains high

[6].

Multidetector computed tomography urography (MDCTU) provides comprehensive evaluation of the urinary tract with high spatial resolution and multiphasic imaging of the kidneys, ureters, and urinary bladder [7]. It enables detection and characterisation of urinary calculi, renal masses, urothelial lesions, and other structural abnormalities and is particularly useful when significant pathology is suspected [8]. However, MDCTU involves ionising radiation and, when contrast-enhanced imaging is performed, exposure to iodinated contrast media. Its higher cost and relatively lower accessibility than USG may limit its use as a universal first-line investigation [9]. Therefore, comparison of USG with MDCTU is clinically relevant for determining the diagnostic capability of USG in the evaluation of haematuria [10].

Despite the established roles of both modalities, differences in their ability to identify specific causes of haematuria remain clinically relevant. A direct comparison of their findings and diagnostic performance can help determine the diagnostic utility of USG and identify its strengths and limitations in comparison with MDCTU. Further evaluation of the diagnostic performance of USG against MDCTU may help clarify its role as an initial imaging modality in patients presenting with haematuria.

Therefore, the present study aimed to compare ultrasonographic findings with MDCTU findings in patients presenting with haematuria and to evaluate the diagnostic performance of USG using MDCTU as the imaging reference standard.

Materials And Methods

A prospective observational study was conducted in the Department of Radiodiagnosis, Vydehi Institute of Medical Sciences and Research Centre, Bengaluru, Karnataka, India, from June 2024 to December 2025. The study was approved by the Research and Human Ethical Committee of Vydehi Institute of Medical Sciences and Research Centre (IEC No. VIEC/2023/APP/PG/26; approval date: 13 February 2024). Written informed consent was obtained from all participants, and the study was conducted in accordance with the principles of the Declaration of Helsinki.

Sample size

The sample size was calculated using a reported prevalence of malignancy of 28% among patients with haematuria by Kumar et al. [11]. At a 95% confidence level and 10% absolute precision, the sample size was calculated using the formula:

$$n = \frac{Z^2 pq}{d^2}$$

where Z = 1.96, p = 0.28, q = 1-p = 0.72, and d = 0.10. The minimum required sample size was 78 patients, and 85 patients were ultimately included in the study.

Inclusion and exclusion criteria

Patients with haematuria, including those with persistent microscopic haematuria and relevant risk factors for urological disease, were eligible for inclusion. Patients with previously diagnosed urinary tract malignancy, previous urinary tract surgery, iatrogenic ureteric or bladder injury, severe renal failure, pregnancy, or contrast allergy were excluded. Demographic details, type of haematuria, clinical history, and serum creatinine levels were recorded prospectively using a structured data collection form.

A total of 101 patients were screened for eligibility during the study period. Of these, 85 patients fulfilled the eligibility criteria and were included in the final analysis, while 16 patients were excluded. The participant selection process is illustrated in Figure *1*.

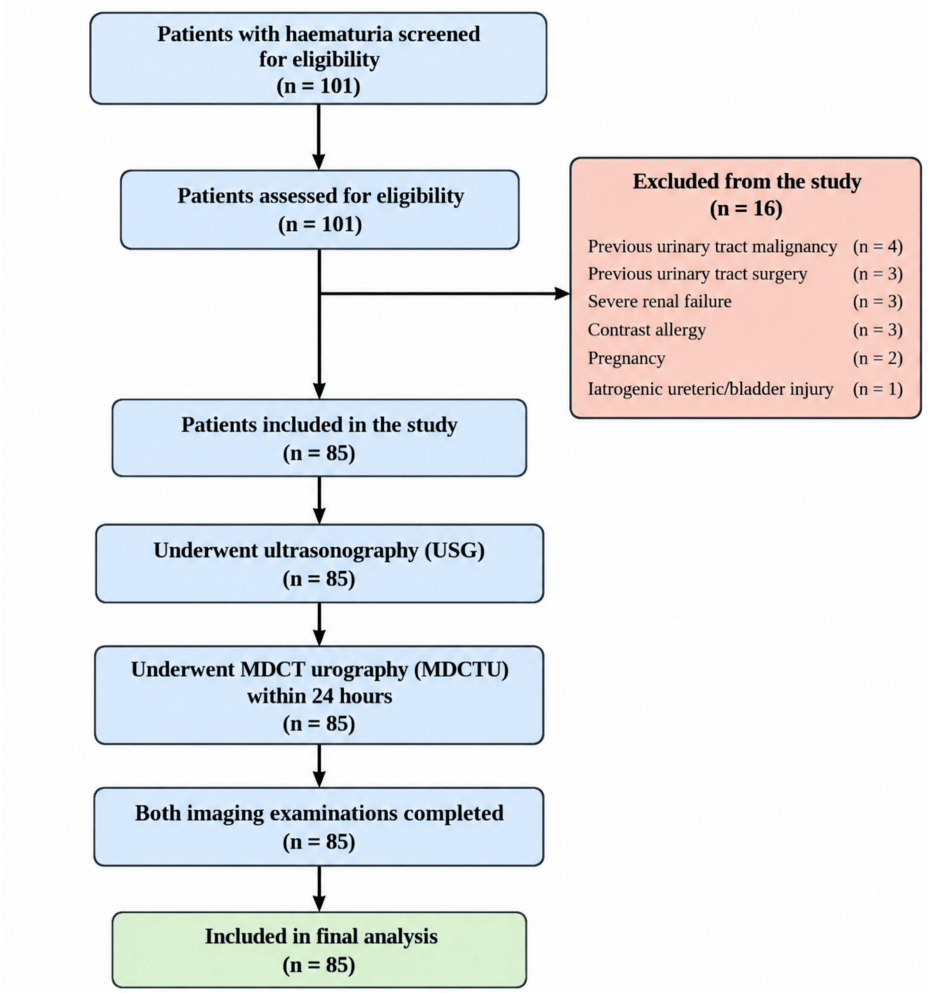


FIGURE 1: Participant flow chart

MDCTU, multidetector computed tomography urography.

Imaging protocol

All patients underwent both USG and MDCTU, with a maximum interval of 24 hours between the two examinations. USG was performed using a Samsung V6 Premium ultrasound system (Samsung Medison Co., Ltd., Seoul, South Korea) with a 3-7 MHz curvilinear probe. The abdomen and pelvis were systematically evaluated for renal and bladder abnormalities, including calculi, masses, and obstructive findings.

MDCTU was performed using a 128-slice Siemens CT scanner (Siemens Healthineers, Erlangen, Germany) with unenhanced, corticomedullary, nephrographic, and excretory phase imaging. Following unenhanced imaging, 80 mL of non-ionic low-osmolar iohexol contrast was administered intravenously at 3.5 mL/s. The excretory phase was obtained approximately 8-10 minutes after contrast administration for assessment of the collecting system and ureters [12,13].

Imaging interpretation and blinding

Ultrasonographic and MDCTU examinations were interpreted independently by different radiologists. The radiologists interpreting each imaging modality were blinded to the findings of the other imaging modality to minimise interpretation bias. Both examinations were performed within a maximum interval of 24 hours, and the findings were recorded independently for subsequent comparison.

Imaging classification

MDCTU was considered the imaging reference standard for comparison with ultrasonographic findings. Imaging abnormalities were classified into five categories: benign renal lesion, bladder/urothelial mass, calculus, obstructive findings, and renal mass [12,13]. The corresponding ultrasonographic and MDCTU findings were compared to assess the ability of USG to identify different urinary tract abnormalities.

For the imaging-based assessment of suspected malignant lesions, renal and bladder/urothelial masses classified as suspicious on MDCTU were considered positive findings, while lesions classified as benign were considered negative findings. This classification was based on the MDCTU interpretation alone. MDCTU served as an imaging reference standard and not as a histopathological gold standard. As histopathological confirmation was not available for all lesions, the malignancy-related diagnostic parameters were interpreted as measures of agreement with MDCTU-based imaging classification rather than definitive confirmation of malignancy.

Statistical analysis

Statistical analysis was performed using SPSS version 21.0 (IBM Corp., Armonk, NY). Continuous variables were summarised as mean ± standard deviation. Categorical variables were expressed as n (%) and analysed using Fisher's exact test. Diagnostic performance was assessed by calculating sensitivity, specificity, positive predictive value, and negative predictive value for detection of malignant causes. A p-value <0.05 was considered statistically significant.

Results

The study included 85 patients with haematuria, with a mean age of 39.86 ± 14.89 years. Males constituted 50 (58.80%) patients and females 35 (41.20%). Microscopic haematuria was the predominant presentation, occurring in 66 (77.60%) patients, while 19 (22.40%) had gross haematuria. The mean serum creatinine level was 0.98 ± 0.18 mg/dL (Table *1*).

Variable	Category	Value
Age (years)	Mean ± SD	39.86 ± 14.89
Sex	Male	50 (58.80%)
	Female	35 (41.20%)
Type of haematuria	Microscopic	66 (77.60%)
	Gross	19 (22.40%)
Serum creatinine (mg/dL)	Mean ± SD	0.98 ± 0.18

TABLE 1: Demographic and baseline characteristics of patients with haematuria

Data are presented as mean ± standard deviation (SD) for continuous variables and frequency with percentage, n (%), for categorical variables.

SD, standard deviation.

MDCTU identified calculus as the most frequent imaging finding, observed in 69 (81.18%) patients, followed by renal mass in 10 (11.76%), bladder/urothelial mass in 5 (5.88%), and benign renal lesion in 1 (1.18%). On USG, calculus was detected in 52 (61.18%) patients, followed by obstructive findings in 17 (20.00%), renal mass in 10 (11.76%), and bladder/urothelial mass in 6 (7.06%) (Table *2*).

Imaging finding	Ultrasonography	MDCT urography
Benign renal lesion	0 (0.00%)	1 (1.18%)
Bladder/urothelial mass	6 (7.06%)	5 (5.88%)
Calculus	52 (61.18%)	69 (81.18%)
Obstructive findings	17 (20.00%)	0 (0.00%)
Renal mass	10 (11.76%)	10 (11.76%)

TABLE 2: Comparison of ultrasonography and MDCT urography findings in patients with haematuria

Data are presented as frequency with percentage, n (%).

MDCT, multidetector computed tomography.

Using MDCTU as the imaging reference standard, among the 69 patients classified as having calculus on MDCTU, USG identified 48 (69.57%) as calculus, while 17 (24.64%) were classified as having obstructive findings and 3 (4.35%) as bladder/urothelial mass. Of the 10 patients with a renal mass on MDCTU, USG correctly identified 9 (90.00%), while 1 (10.00%) was classified as having calculus. Among the five patients with bladder/urothelial mass on MDCTU, USG correctly identified 3 (60.00%), whereas 2 (40.00%) were classified as having calculus. The single benign renal lesion identified on MDCTU was classified as calculus on USG. The association between ultrasonographic and MDCTU classifications was statistically significant ($p<0.001$) (Table *3*).

Ultrasonography finding	Benign renal lesion (n=1)	Bladder/urothelial mass (n=5)	Calculus (n=69)	Renal mass (n=10)	Statistical test	p-value
Bladder/urothelial mass	0 (0.00%)	3 (60.00%)	3 (4.35%)	0 (0.00%)	Fisher's exact test	<0.001
Calculus	1 (100.00%)	2 (40.00%)	48 (69.57%)	1 (10.00%)		
Obstructive causes	0 (0.00%)	0 (0.00%)	17 (24.64%)	0 (0.00%)		
Renal mass	0 (0.00%)	0 (0.00%)	1 (1.45%)	9 (90.00%)		
Total	1 (100%)	5 (100%)	69 (100%)	10 (100%)		

TABLE 3: Cross-tabulation of ultrasonography findings according to MDCT urography findings

Data are presented as frequency with percentage, n (%), with percentages calculated within each MDCT urography category. The association between ultrasonography and MDCT urography findings was assessed using Fisher's exact test. A p-value <0.05 was considered statistically significant.

MDCT, multidetector computed tomography.

For the imaging-based assessment of lesions suspicious for malignancy, MDCTU classified 15 (17.65%) patients as having suspected malignant lesions and 70 (82.35%) as having benign findings. USG classified 12 (80.00%) of the 15 MDCTU-suspected malignant cases as malignant and 3 (20.00%) as benign. Among the 70 cases classified as benign on MDCTU, USG classified 66 (94.29%) as benign and 4 (5.71%) as malignant (Table *4*).

Ultrasonography	MDCT: Malignant	MDCT: Benign	Total	Statistical test	p-value
Malignant	12 (80.00%)	4 (5.71%)	16 (18.82%)		
Benign	3 (20.00%)	66 (94.29%)	69 (81.18%)	Fisher's exact test	<0.0001
Total	15 (100%)	70 (100%)	85 (100%)		

TABLE 4: Diagnostic accuracy of ultrasonography for detection of malignant causes of haematuria using MDCT urography as the reference standard

Data are presented as frequency with percentage, n (%). Diagnostic classifications on ultrasonography were cross-tabulated against MDCT urography as the reference standard. Fisher's exact test was used to assess the association between ultrasonography classification and MDCT urography findings. A p-value <0.05 was considered statistically significant.

MDCT, multidetector computed tomography.

When MDCTU was used as the imaging reference standard, USG demonstrated a sensitivity of 80.00% (95% CI: 54.81-92.95%) and specificity of 94.29% (95% CI: 86.21-97.76%) for identifying lesions classified as suspicious for malignancy. The positive predictive value was 75.00% (95% CI: 50.50-89.82%), while the negative predictive value was 95.65% (95% CI: 87.98-98.51%). These findings indicate good agreement between USG and MDCTU for the imaging-based classification of suspected malignant lesions (Table *5*).

Diagnostic measure	Value
Sensitivity	80.00% (54.81-92.95%)
Specificity	94.29% (86.21-97.76%)
Positive predictive value	75.00% (50.50-89.82%)
Negative predictive value	95.65% (87.98-98.51%)

TABLE 5: Diagnostic performance of ultrasonography for identifying malignant causes of haematuria (MDCT urography as reference standard)

Data are presented as percentages with 95% confidence intervals.

MDCT, multidetector computed tomography.

Discussion

The present study included 85 patients with haematuria, with a mean age of 39.86 ± 14.89 years and a male predominance (58.80%). Microscopic haematuria was the predominant presentation, occurring in 66 (77.60%) patients, while 19 (22.40%) had gross haematuria. The relatively younger age and predominance of microscopic haematuria in the present cohort differ from those reported in previous haematuria studies, which have generally included older patient populations. Bretlau et al., in a cohort of 771 patients undergoing CT urography, reported a broader age distribution with a greater representation of older patients, while studies evaluating high-risk haematuria cohorts have also predominantly included older individuals [14]. The male predominance observed in the present study is consistent with the sex distribution reported in several haematuria imaging cohorts.

On MDCTU, calculus was the predominant finding in the present study, identified in 69 (81.18%) patients, followed by renal mass in 10 (11.76%), bladder/urothelial mass in 5 (5.88%), and benign renal lesion in 1 (1.18%). This distribution was more strongly dominated by calculi than that reported in other CT-based haematuria studies. Bretlau et al. reported calculi in approximately 68 (9%) patients undergoing CT urography, while Parate et al. reported urolithiasis in 28 (35.8%) of their cohort [14,15]. Kumar et al. reported calculi in 10 (20%) patients and a higher proportion of malignant lesions, including renal and bladder/urothelial malignancies [11]. These differences may reflect variations in patient selection, referral patterns, and the clinical characteristics of the study populations. The higher proportion of calculi in the present study may also be attributable to the clinical and referral characteristics of patients attending the participating tertiary care centre. Overall, the findings demonstrated a predominantly stone-related pattern of haematuria on MDCTU.

On USG, calculus was also the most frequent finding, detected in 52 (61.18%) patients, followed by obstructive findings in 17 (20.00%), renal mass in 10 (11.76%), and bladder/urothelial mass in 6 (7.06%). Comparison of USG findings with MDCTU demonstrated a statistically significant association ($p<0.001$). Among the 69 patients with calculus identified on MDCTU, USG identified 48 (69.57%) as having calculi, while 17 (24.64%) were classified as having obstructive findings. Of the 10 renal masses identified on MDCT, USG correctly identified 9 (90.00%). Among the five bladder/urothelial masses, USG correctly classified 3 (60.00%), while 2 (40.00%) were classified as calculi. These findings are consistent with Unsal et al., who demonstrated that an ultrasound-based diagnostic pathway could identify many patients requiring further evaluation, although CT urography detected additional ureteric calculi and urothelial lesions that were not identified on ultrasound [16]. Koterazawa et al. reported a sensitivity of 45.6% for USG in detecting upper tract urothelial carcinoma, with hydronephrosis or other ultrasound abnormalities present in 99 (72.8%) cases [17]. These findings support the observation that USG may identify secondary obstructive changes even when the underlying lesion is not directly visualised.

An important distinction in interpreting the present findings is that detection of a renal mass does not necessarily establish its malignant nature. In the present study, USG identified 9 of the 10 renal masses classified on MDCTU, indicating good agreement between the two modalities for renal mass detection. However, this finding should not be interpreted as confirmation of the ability of USG to differentiate benign from malignant renal lesions. Such characterisation requires assessment of lesion-specific imaging features and, where indicated, further diagnostic evaluation.

Using MDCTU as the imaging reference standard, the present study identified 15 lesions classified as suspicious for malignancy and 70 cases with benign imaging findings. USG correctly identified 12 (80.00%) suspicious cases and 66 (94.29%) benign cases, with 4 (5.71%) false-positive and 3 (20.00%) false-negative classifications. Accordingly, USG demonstrated a sensitivity of 80.00%, specificity of 94.29%, positive predictive value of 75.00%, and negative predictive value of 95.65% for identifying lesions classified as suspicious for malignancy on MDCTU. These parameters represent agreement with the MDCTU-based imaging classification and should not be interpreted as diagnostic accuracy against histopathologically confirmed malignancy. The relatively high specificity and negative predictive value indicate good agreement with MDCTU for identifying cases without suspicious imaging findings in this cohort. Nevertheless, the three false-negative cases highlight that suspicious lesions identified on MDCTU may not always be detected or similarly classified on USG. Rhéaume-Lanoie et al. reported a substantially lower sensitivity of 35.3% for USG in detecting urinary tract neoplasms among patients with macroscopic haematuria, with a specificity of 89.9%, whereas Koterazawa et al. reported a sensitivity of 45.6% for detecting upper tract urothelial carcinoma [10,17]. Differences in diagnostic performance may be attributable to variations in patient populations, the types of urinary tract lesions evaluated, and the reference standards employed. Furthermore, the negative predictive value is influenced by the prevalence of suspicious lesions in the study population and should therefore be interpreted in the context of the present cohort.

Strengths and limitations

The strengths of the present study include its prospective design, independent interpretation of USG and MDCTU by different radiologists who were blinded to the findings of the other modality, inclusion of all patients undergoing both imaging examinations within a short interval, and direct comparison of ultrasonographic findings with MDCTU as the imaging reference standard. These methodological features allowed a structured comparison of modality-specific findings while minimising potential interpretation bias.

However, the study was conducted at a single tertiary care centre with a relatively small sample size of 85 patients, which may limit the generalisability of the findings. The relatively high proportion of calculi in the study population may also reflect the referral pattern and patient selection at the study centre. In addition, the study evaluated diagnostic performance against MDCTU and did not include histopathological confirmation for all lesions; therefore, the classification of suspected malignant lesions was based on imaging appearances rather than definitive pathological diagnosis. The study also assessed renal mass detection rather than the ability of USG to characterise renal masses according to histological subtype or malignant potential. Therefore, the findings should be interpreted within the context of the imaging-based reference standard.

Conclusions

USG demonstrated good diagnostic utility in the evaluation of patients with haematuria, with good agreement with MDCTU for the identification of several urinary tract abnormalities, particularly renal masses. Although USG showed limitations in identifying calculi and certain bladder/urothelial lesions, it demonstrated high specificity for identifying lesions classified as suspicious for malignancy on MDCTU. These findings suggest that USG may serve as a useful initial imaging modality in the evaluation of haematuria, while MDCTU provides a more comprehensive assessment for further evaluation and characterisation of urinary tract abnormalities. However, the findings should be interpreted in the context of the imaging-based reference standard, as histopathological confirmation was not available for all lesions. Further multicentre studies with larger sample sizes and histopathological correlation are warranted to

validate these findings and better define the role of USG in the evaluation of haematuria.

Additional Information

Author Contributions

All authors have reviewed the final version to be published and agreed to be accountable for all aspects of the work.

Concept and design: Thummala Srimadhav, Suresh A, Sudhanva N, Mohit E

Acquisition, analysis, or interpretation of data: Thummala Srimadhav, Suresh A, Sudhanva N, Mohit E

Drafting of the manuscript: Thummala Srimadhav, Suresh A, Sudhanva N, Mohit E

Critical review of the manuscript for important intellectual content: Thummala Srimadhav, Suresh A, Sudhanva N, Mohit E

Disclosures

Human subjects: Informed consent for treatment and open access publication was obtained or waived by all participants in this study. Institutional Ethics Committee, Vydehi Institute of Medical Sciences and Research Centre, Bengaluru issued approval VIEC/2023/APP/PG/26. **Animal subjects:** All authors have confirmed that this study did not involve animal subjects or tissue. **Conflicts of interest:** In compliance with the ICMJE uniform disclosure form, all authors declare the following: **Payment/services info:** All authors have declared that no financial support was received from any organization for the submitted work. **Financial relationships:** All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work. **Other relationships:** All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.

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