

Diagnostic Accuracy of Computed Tomography and Magnetic Resonance Urography in Detection of Bladder Tumors taking Histopathology as Gold Standard in Patients Presenting with Hematuria at Tertiary Care Hospital Karachi

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ABSTRACT

Objective: To compare the computed tomography urography and magnetic resonance urography in the diagnosis of bladder tumors in patients who present with hematuria using the histopathology as reference standard.

Study Design: Cross sectional diagnostic accuracy study

Place and Duration of Study: This study was conducted at the Department of Radiology, Sindh Institute of Urology and Transplantation, Karachi from 1st February 2022 to 1st 31st July 2022.

Methods: 356 patients presented to the with hematuria were enrolled. Eligible patients were subjected to a computed tomography ureography and magnetic resonance ureography and the findings compared to the histopathological diagnosis. Sensitivity, specificity, positive predictive value and negative predictive value and overall diagnostic accuracy of both imaging modalities were calculated.

Results: The mean age was 59.23 ± 8.41 years and the mean duration of symptoms was 2.14 ± 0.89 weeks. One hundred and eighty seven (52.5%) were males and 169 (47.5%) were females. Magnetic resonance urography sensitivity was 80.0%, specificity 99.0%, positive predictive value 93.6%, negative predictive value 96.4% and diagnostic accuracy 96.0%. By contrast, computed tomography urography had a sensitivity of 63.6%, specificity of 95.0%, positive predictive value of 70.0%, negative predictive value of 93.4% and diagnostic accuracy of 90.1%. Magnetic resonance urography was thus more sensitive and was overall more accurate to detect bladder tumors than computed tomography urography.

Conclusion: Computed tomography urography was good for detecting bladder tumors in patients with hematuria compared to magnetic resonance urography. Magnetic resonance urography however was more sensitive, specific and had a higher overall diagnostic accuracy than magnetic resonance urography when compared with histopathology as a reference standard.

Key Words: Bladder tumor, Hematuria, Computed tomography urography, Magnetic resonance urography, Diagnostic accuracy, Histopathology

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INTRODUCTION

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Bladder cancer is a substantial tumour of the urinary tract and it is still a challenge in urology. Not only its clinical importance is associated with the disease burden, but it is also a recurrent disease and can be timely detected and managed. Hematuria (gross or microscopic) is the most common symptom of bladder cancer. Painless hematuria is of special importance and is often the initial presentation of a bladder tumour, and urinary frequency, urgency and dysuria may be present, notably in patients with carcinoma in situ, or when the disease is invasive.^{1,2}

There are a number of different ways to diagnose a suspected bladder tumor. Cystoscopy remains a useful tool for bladder evaluation, as well as for direct

visualization of the bladder mucosa and to obtain specimens for a histopathologic diagnosis.³ Cystoscopy, however, is invasive, can be uncomfortable for the patient and can sometimes be technically challenging especially in the presence of gross haematuria, blood clot or poor anatomy.^{3,4}

Computed tomography urography (CTU) is a valuable imaging tool for the evaluation of hematuria due to its ability to evaluate the upper and lower urinary tract, as well as, to characterize urothelial changes and associated urinary tract pathology.^{5,6} CTU will also incorporate cross sectional imaging with contrast enhanced evaluation of the collecting system and will give helpful anatomical information regarding suspected urothelial lesions. It is however not very accurate in diagnosis of bladder tumors, particularly in the case of small and superficial tumors.⁷ In selected patients, the exposure to the ionizing radiation and the use of iodinated contrast material are additional factors that need to be taken into account, and may therefore restrict the use of CTU.⁵

Magnetic resonance urography is an alternative method of imaging the urinary tract, and is important because of its lack of ionizing radiation.⁸ It is a useful modality for situations where CTU is unavailable or not a good choice, and has very good soft-tissue contrast. MR based imaging can also provide additional data about the surrounding soft tissues and bladder wall.^{8,9} In the past, some difference in the diagnostic effectiveness of these modalities. Woo S et al¹⁰ found sensitivity and specificity of 61.5% and 94.9% respectively for CTU as opposed to 76.9% and 93.4% for MRU in the detection of bladder tumors.

Therefore, it will be useful to have the ability to make a precise comparison between CTU and MRU particularly when a patient is referred with hematuria for which bladder malignancy needs to be excluded. Both these modalities are increasingly being used for urinary tract imaging, but there is still a limited amount of locally generated evidence of their comparative diagnostic performance. Hence, the purpose was to assess and compare the diagnostic accuracy of CT urography and MR urography in patients with hematuria for the detection of bladder tumors using the histopathology as the reference standard.

METHODS

This cross-sectional diagnostic accuracy study was conducted at the Department of Radiology, Sindh Institute of Urology and Transplantation Karachi from 1st February 2022 to 31st July 2022 letter No.CPSP/REU/RAD-2017-198-2446 Dated 13.01.2022. Hematuria patients who were referred to the Department of Radiology were targeted for recruitment. The sample size was determined based on a previously reported magnetic resonance urography (MRU) sensitivity of 76.9%, a specificity of 93.4%, the

expected prevalence of bladder tumor of 20.7%, the margin of error of 10% for sensitivity and 7% for specificity, and a 95% confidence interval. The calculated sample size was 356 patients which were obtained using non-probability consecutive sampling.

All patients of either gender, aged between 30–80 years, who presented with a positive urine dipstick for blood and defined operationally as hematuria were included. Patients who were not consenting, and those who had warfarin use, as well as renal and bladder trauma, previous history of malignancy, uncontrolled hypertension, type II diabetes mellitus, pregnant patients, previous stroke, renal impairment, chronic obstructive pulmonary disease, asthma and congestive cardiac failure were excluded. Demographic and clinical data were collected. Computed tomography urography and MRU were performed for evaluation of bladder tumors. Patients were then subjected to flexible cystoscopy and biopsy of suspicious areas were taken and sent for histopathological examination. Histopathological assessment was carried out by a pathologist with extensive experience in bladder pathology for over 10 years, and pathology was deemed as a reference standard to define the presence or absence of bladder tumor.

The data was analysed through SPSS-20. Diagnostic performance measures were computed separately for CTU and MRU. True-positive results were considered to be positive imaging result and positive histopathology, and true-negative results were considered to be negative imaging result and negative histopathology. A false-positive result was defined as positive imaging and negative histopathology and a false-negative result was defined as negative imaging and positive histopathology. The sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and diagnostic accuracy of both CTU and MRU were determined based upon the histopathology reference standard.

RESULTS

The mean age was 59.23±8.41 years, and the mean duration of symptoms was 2.14±0.89 weeks. There were 187 (52.5%) males and 169 (47.5%) females. Histopathological examination confirmed bladder tumor in 55 (15.4%) patients, while 301 (84.6%) had negative histopathological findings (Table 1).

MRU correctly identified 44 of the 55 histopathologically confirmed tumors, with 11 false-negative findings. Among the 301 histopathology-negative patients, MRU correctly classified 298 as negative, with only three false-positive findings. CTU correctly identified 35 of the 55 histopathologically confirmed tumors but missed 20 cases. Among patients without tumor on histopathology, CTU correctly classified 286, while 15 were false positive (Table 2).

Table No. 1: Baseline and histopathological characteristics of study participants (n=356)

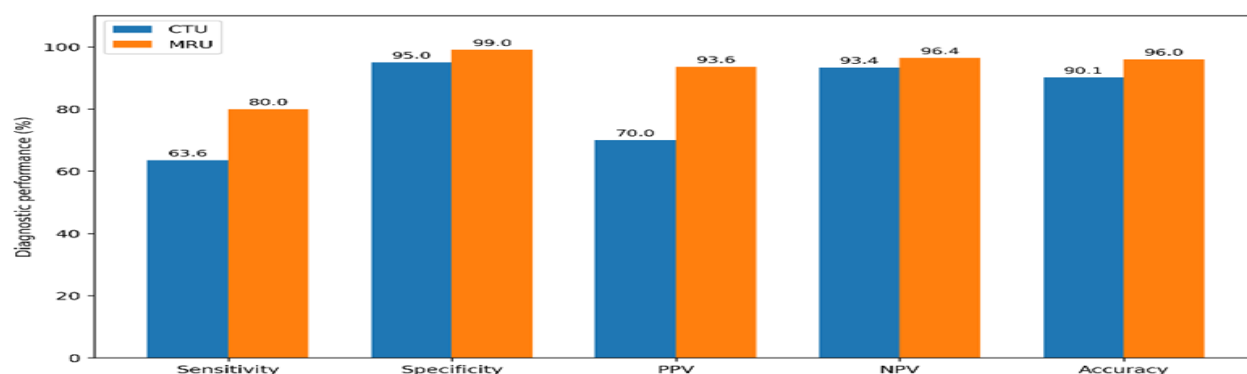
Characteristic	Mean±SD/No.(%)
Age (years)	59.23±8.41
Duration of symptoms (weeks)	2.14±0.89
Male	187 (52.5%)
Female	169 (47.5%)
Histopathology positive	55 (15.4%)
Histopathology negative	301 (84.6%)

These findings translated into a sensitivity of 80.0% for MRU compared with 63.6% for CTU. MRU also demonstrated higher specificity (99.0% vs. 95.0%), PPV (93.6% vs. 70.0%), NPV (96.4% vs. 93.4%), and overall diagnostic accuracy (96.0% vs. 90.1%). The largest difference between the modalities was observed for PPV, followed by sensitivity (Table 3).

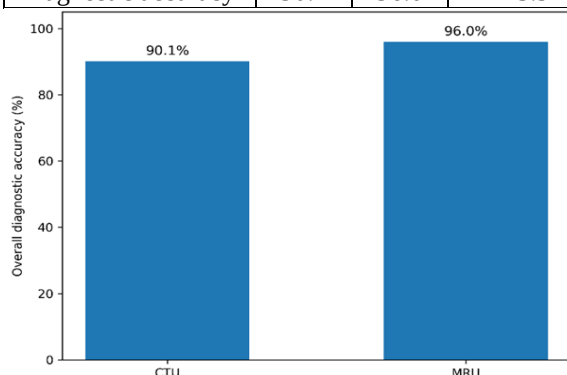
Overall, MRU demonstrated consistently better diagnostic performance than CTU. The improvement was particularly notable for tumor detection, with MRU correctly identifying 44/55 histopathologically positive cases compared with 35/55 using CTU.

Table No. 2: CTU and MRU findings against histopathology

Imaging modality	True positive	False positive	False negative	True negative	Total
CTU	35	15	20	286	356
MRU	44	3	11	298	356

**Figure No. 1: Diagnostic performance of CTU and MRU for bladder tumor detection****Table No. 3: Comparative diagnostic performance of CTU and MRU**

Diagnostic parameter	CTU (%)	MRU (%)	Difference
Sensitivity	63.6	80.0	+16.4
Specificity	95.0	99.0	+4.0
Positive predictive value	70.0	93.6	+23.6
Negative predictive value	93.4	96.4	+3.0
Diagnostic accuracy	90.1	96.0	+5.9

**Figure No. 2: Overall diagnostic accuracy of CTU and MRU**

Furthermore, MRU generated only 3 false-positive results compared with 15 with CTU and reduced false-negative findings from 20 with CTU to 11 with MRU. Thus, MRU demonstrated superior sensitivity and overall diagnostic accuracy while maintaining very high specificity for bladder tumor detection (Figs. 1-2).

DISCUSSION

In the present study, both modalities showed good diagnostic performance with MRU always outperforming CTU. MRU had a sensitivity of 80.0%, specificity of 99.0%, PPV of 93.6%, NPV of 96.4% and overall diagnostic accuracy of 96.0%. By comparison, the sensitivity of CTU was 63.6%, specificity was 95.0%, PPV was 70.0%, NPV was 93.4%, and accuracy was 90.1%. The main advantage of MRU therefore was its high sensitivity and high PPV showing good discrimination of bladder tumors in the population.

The ability to detect blood in the urine (hematuria) is one of the most important presenting signs of bladder malignancy and can often trigger the investigation of the urinary tract.^{1,2} The spectrum of causes of hematuria is from urinary tract disorders with a benign course to urothelial malignancy, clinically significant or not, and current clinical recommendations include risk-based

evaluation.¹¹ Early diagnosis of bladder tumors is especially critical as this may allow the disease to advance and have a negative impact on the management of the disease.^{12,13}

Even with the development of imaging techniques, cystoscopy with histological evaluation is still the cornerstone of the final diagnosis of bladder cancer.^{4,14} Current EAU guidelines would still advocate for cystoscopic evaluation in cases of patients who present with clinical symptoms of bladder cancer and highlight that non-invasive tests are not entirely a substitute for cystoscopy.¹⁴ However, imaging is also useful as an adjunctive test and could detect tumors, upper urinary tract abnormalities, and other candidates for hematuria before invasive investigations.^{5,11} Renal imaging (including CT urography) is therefore currently recommended as part of the investigations of patients with haematuria who are appropriately selected for such investigations.¹⁴

Because of its high spatial resolution, the assessment of the renal parenchyma, collecting systems, ureters and bladder, CTU has emerged as a valuable imaging modality for urinary tract evaluation. In the present study, CTU showed a specificity of 95.0% and a NPV of 93.4% which means that it was good to identify patients without bladder tumors.^{7,15} However, it had a lower sensitivity of 63.6%. Of 55 histopathology proven tumors, CTU correctly diagnosed 35 but not 20. This is a relatively high false-negative rate, as the missed malignant lesion could impede further evaluation and treatment.

There has been a wide range of sensitivity in the ability of CTU to detect bladder cancer as seen in previous investigations.^{15,16} Trinh et al¹⁵ assessed the performance of CT urography in the evaluation of patients with hematuria and in surveillance of patients with bladder cancer, and found an overall accuracy of 91.5%, sensitivity of 86.3%, specificity of 92.4%, PPV of 63.6%, and NPV of 97.8%. Their study also showed that false negative results were often imaging technique related, while false positive results might be due to benign prostatic enlargement, bladder trabeculation, changes caused by treatments, blood clot or inflammatory changes.¹⁵

The previous studies have found a sensitivity of about 79%, specificity of 94%, accuracy of 91%, and a high negative predictive value of 95%, especially in patients investigated due to hematuria.^{15,16} Thus, the overall CTU accuracy in our study (90.1%) is comparable to the previously published results, although the sensitivity is less. Variation between studies may be partly explained by differences in imaging protocols, bladder distention, morphology of the tumor, and size of the lesion as well as patient characteristics and interpretation criteria.¹⁷

The present study showed that MRU had a good diagnostic performance. It correctly identified 44 of the

55 tumours that were histopathologically confirmed, reducing the number of false negative examinations from 20 to 11, compared with CTU. MRU thus realized a sensitivity of 80.0%, which is an absolute improvement of 16.4 percentage points compared to CTU. MRU also made only three false positive examinations, versus 15 with the use of CTU. This led to a specificity of 99.0% and PPV of 93.6% showing the good diagnostic value of MRU.

Biologically and technically, the superiority of MRU is reasonable. MRI has a high soft-tissue contrast and allows multiplanar imaging of the bladder wall and adjacent tissues without the use of ionizing radiation.^{17,18} Multiparametric MRI methods have improved further the characterization of bladder lesions and the evaluation of the local extent of the tumor, with diffusion-weighted MRI and dynamic MRI being the most promising. Vesical Imaging-Reporting and Data System (VI-RADS) has also been developed which offers a structured system of MRI acquisition and interpretation/reporting in the setting of bladder cancer.¹⁹

Multiparametric MRI has recently been shown to have good diagnostic accuracy in bladder tumors and prediction of muscle invasion.²⁰ The current European guidelines are aware of the possibility of multiparametric MRI for local staging, and they also highlight that in the scenario in which MRI is performed for local staging, it should be ideally done before transurethral resection.¹⁹ The present study assessed MR urography for diagnosis of tumor and not for local staging with VI-RADS; however, the cumulative findings in favor of MRI add support to the clinical importance of the better performance of MRU in our population.

The results of present study also agree with Woo S, et al¹⁰ achieved sensitivities and specificities of around 61.5% for CTU and 76.9% for MRU, and 94.9% and 93.4%, respectively. In our study, the sensitivities were 63.6% and 80.0%, respectively. This similarity is remarkable and suggests that, in some clinical and technical scenarios, MR-based assessment might be able to identify a higher percentage of bladder tumors than CTU.

The most marked of the present study was the difference in PPV. The PPV for MRU was 93.6% while that of CTU was 70.0%. The reasons for this difference were the significantly lower number of false positive examinations with MRU. Clinically, better PPV equates to a more positive imaging result being more likely to be histologically-confirmed disease. However, the prevalence of the disease is a factor that affects PPV and NPV and should be considered along with the population.^{20,21}

The NPV was high for both the modalities: 93.4% for CTU and 96.4% for MRU. This finding has application in the assessment of a patient with hematuria because

the higher the NPV, the lower the chance of disease after a negative examination. Nonetheless, there was less than 100% sensitivity in both modalities, and 11 histopathologically confirmed tumors were not detected by MRU. Thus, negative imaging studies should not be used as a substitute for a high suspicion of bladder malignancy. This interpretation is in line with the interpretation of current guidelines, which still consider cystoscopy and histological evaluation as main pillars of bladder cancer diagnosis.^{14,22}

MRU had an overall diagnostic accuracy of 96.0%, while that for CTU was 90.1%. The absolute difference in accuracy was 5.9 percentage points, but when the prevalence of disease is relatively low, there may be clinically important differences that are not reflected in the absolute difference in accuracy. In this study, we were able to confirm the diagnosis by histopathology in only 55 of 356 patients. In such situations, a large number of true negative cases have a significant impact on overall accuracy. As a result, sensitivity, specificity, PPV and NPV offer some extra and clinically beneficial information apart from the overall accuracy estimate.^{20,21}

Another possible benefit of MRU is the lack of ionizing radiation.²² Patients undergo radiation exposure with CTU and typically receive iodinated contrast dye, which is important in patients who need repeat imaging or those who are at risk for iodinated contrast.^{5,22} MR urography is specifically mentioned as an alternative for microhematuria in the updated AUA/SUFU guideline for microhematuria, in which the use of contrast-enhanced CT is contraindicated.¹¹ MRU, however, also has a number of drawbacks, such as longer acquisition times, higher costs, limited availability, and artifacts and contraindications in some patients.²³ Thus, the selection of these two approaches, CTU or MRU, should be personalized and not only determined by their diagnostic accuracy.

The results of this study should therefore not be interpreted as an argument for universally replacing the CTU with the MRU. The fact that CTU is generally abundant, speedy and very useful for extensive evaluation of the urinary tract is still maintained to the present day, and contemporary guidelines continue to give it a strong place in the assessment of hematuria.^{14,22} Our results suggest that MRU might have some extra diagnostic value in the right patient, however, especially when radiation or iodinated contrast are contraindicated or when more soft-tissue characterization is needed.

CONCLUSION

MRU outperformed CTU in detecting bladder tumors in hematuria patients, as evidenced by increased sensitivity, specificity, predictive values and overall diagnostic accuracy. MRU can thus serve as an alternative or a complementary imaging technique in

selected cases, and histopathology will still play a crucial role in diagnosis.

Author's Contribution:

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Final Approval of version:	All the above authors
Agreement to accountable for all aspects of work:	All the above authors

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REFERENCES

1. Sung H, Ferlay J, Siegel RL, Laversanne M, et al. Global cancer statistics 2020: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. *CA Cancer J Clin* 2021;71(3):209-49.
2. Teoh JYC, Huang J, Ko WY, Lok V, et al. Global trends of bladder cancer incidence and mortality, and their associations with tobacco use and gross domestic product per capita. *Eur Urol* 2020;78(6):893-906.
3. Barocas DA, Boorjian SA, Alvarez RD, Downs TM, et al. Microhematuria: AUA/SUFU guideline. *J Urol* 2020;204(4):778-86.
4. Barocas DA, Lotan Y, Matulewicz RS, Raman JD, et al. Updates to microhematuria: AUA/SUFU guideline 2025. *J Urol* 2025;213(5):547-57.
5. Waisbrod S, Natsos A, Wettstein MS, Saba K, et al. Assessment of diagnostic yield of cystoscopy and computed tomographic urography for urinary tract cancers in patients evaluated for microhematuria: a systematic review and meta-analysis. *JAMA Netw Open* 2021;4(5):e218409.
6. Sadow CA, Silverman SG, O'Leary MP, et al. Bladder cancer detection with CT urography in an academic medical center. *Radiol* 2008;249(1):195-202.
7. Trinh TW, Glazer DI, Sadow CA, Sahni VA, et al. Bladder cancer diagnosis with CT urography: test characteristics and reasons for false-positive and false-negative results. *AbdomRadiol (NY)*. 2018;43(3):663-71.
8. Helenius M, Brekkan E, Dahlman P, Lönnemark M, et al. Bladder cancer detection in patients with gross haematuria: computed tomography urography with enhancement-triggered scan

- versus flexible cystoscopy. *Scand J Urol* 2015;49(5):377-81.
9. Panebianco V, Narumi Y, Altun E, Bochner BH, et al. Multiparametric magnetic resonance imaging for bladder cancer: development of VI-RADS (Vesical Imaging-Reporting And Data System). *Eur Urol* 2018;74(3):294-306.
 10. Woo S, Panebianco V, Narumi Y, Del Giudice F, et al. Diagnostic performance of Vesical Imaging Reporting and Data System for the prediction of muscle-invasive bladder cancer: a systematic review and meta-analysis. *Eur Urol Oncol* 2020;3(3):306-15.
 11. Luo C, Huang B, Wu Y, Chen J, Chen L. Use of Vesical Imaging-Reporting and Data System (VI-RADS) for detecting the muscle invasion of bladder cancer: a diagnostic meta-analysis. *Eur Radiol* 2020;30(8):4606-14.
 12. Del Giudice F, Pecoraro M, Vargas HA, Cipollari S, et al. Systematic review and meta-analysis of Vesical Imaging-Reporting and Data System (VI-RADS) inter-observer reliability: an added value for muscle invasive bladder cancer detection. *Cancers (Basel)* 2020;12(10):2994.
 13. Yuan B, Cai L, Cao Q, Wu Q, et al. Role of Vesical Imaging-Reporting and Data System in predicting muscle-invasive bladder cancer: a diagnostic meta-analysis. *Int J Urol* 2022;29(3):186-95.
 14. Jazayeri SB, Dehghanbanadaki H, Hosseini M, Taghipour P, et al. Diagnostic accuracy of Vesical Imaging-Reporting and Data System (VI-RADS) in suspected muscle invasive bladder cancer: a systematic review and diagnostic meta-analysis. *Urol Oncol* 2022;40(2):45-55.
 15. Feng Y, Zhong K, Chen R, Zhou W. Diagnostic accuracy of Vesical Imaging-Reporting and Data System (VI-RADS) for the detection of muscle-invasive bladder cancer: a meta-analysis. *Abdom Radiol (NY)* 2022;47(4):1396-1405.
 16. Jazayeri SB, Dehghanbanadaki H, Hosseini M, Taghipour P, et al. Can magnetic resonance imaging differentiate muscle invasion (T2) and lamina propria invasion (T1) urothelial carcinoma of the bladder? A systematic review and meta-analysis of Vesical Imaging-Reporting and Data System accuracy. *Curr Urol* 2023;17(4):262-7.
 17. Witjes JA, Bruins HM, Cathomas R, Compérat EM, et al. European Association of Urology guidelines on muscle-invasive and metastatic bladder cancer: summary of the 2020 guidelines. *Eur Urol* 2021;79(1):82-104.
 18. Babjuk M, Burger M, Capoun O, Cohen D, et al. European Association of Urology guidelines on non-muscle-invasive bladder cancer (Ta, T1, and carcinoma in situ). *Eur Urol* 2022;81(1):75-94.
 19. Richters A, Aben KKH, Kiemeny LALM. The global burden of urinary bladder cancer: an update. *World J Urol* 2020;38(8):1895-1904.
 20. Murad MH, Lin L, Chu H, Hasan B, et al. The association of sensitivity and specificity with disease prevalence: analysis of 6909 studies of diagnostic test accuracy. *CMAJ* 2023; 195(27):E925-31.
 21. Trevethan R. Sensitivity, specificity, and predictive values: foundations, pliability, and pitfalls in research and practice. *Front Public Health* 2017;5:307.
 22. Akobeng AK. Understanding diagnostic tests 1: sensitivity, specificity and predictive values. *Acta Paediatr* 2007;96(3):338-41.
 23. Jubber I, Ong S, Bukavina L, Black PC, et al. Epidemiology of bladder cancer in 2023: a systematic review of risk factors. *Eur Urol* 2023;84(2):176-90.