Original Article - Urological Oncology

Investig Clin Urol 2025;66:207-214.
https://doi.org/10.4111/icu.20250068
pISSN 2466-0493 • eISSN 2466-054X

INVESTIGATIVE AND CLINICAL UROLOGY
ICUROLOGY

Correlation of shear wave elastography with histopathological grade, tumor stage, and microvessel density in bladder cancer

Gokhan Sahin[1], Hakan Gemalmaz[2], Mustafa Gok[3]

[1]Department of Urology, Aydin State Hospital, Aydin, [2]Department of Urology, Aydin Adnan Menderes University Hospital, Aydin, [3]Department of Radiology, Section of Interventional Radiology, Aydin Adnan Menderes University Hospital, Aydin, Türkiye

Purpose: To evaluate the pathological correlation and prognostic significance of tissue stiffness measured by shear wave elastography (SWE) in bladder cancer.

Materials and Methods: Patients with microscopic or macroscopic hematuria diagnosed with bladder tumors were included. SWE measurements were performed using a Samsung Medison RS80A Prestige ultrasonography device, with ten valid measurements taken for each tumor. Tumor specimens were collected via transurethral resection (transurethral resection of the bladder tumor) for histopathological analysis. Microvessel density (MVD) was assessed by immunohistochemical staining with anti-CD34 antibody using the hot-spot method. Correlations between tissue stiffness, MVD and tumor stage and grade were analyzed, and receiver operating characteristic (ROC) analysis determined the optimal SWE cutoff for differentiating tumor characteristics.

Results: A total of 65 bladder urothelial carcinoma patients were included in the study (43 high-grade, 22 low-grade). SWE and MVD were significantly higher in the high-grade group (p=0.001, p=0.002, respectively). ROC analysis showed SWE could differentiate tumor grades (area under ROC curve=0.837, p<0.001), with a cut-off of 4.25 kPa (74% sensitivity, 86% specificity). Stiffness was also higher in recurrence (p=0.007). A strong positive correlation between SWE and MVD was found (rho=0.767, p<0.001). SWE may be a reliable, non-invasive tool for assessing tumor grade and recurrence risk.

Conclusions: SWE may be a reliable, non-invasive preoperative marker for bladder cancer, aiding in tumor characterization and clinical decision-making.

Keywords: Bladder cancer; Microvessel density; Sonoelastography

INTRODUCTION

Bladder cancer is one of the most common malignancies worldwide [1]. Painless macroscopic hematuria is the initial symptom in approximately 85% of newly diagnosed cases [2,3]. Additionally, the majority of patients present with organ-confined disease at the time of diagnosis [4].

Bladder tumors are typically diagnosed using ultrasonography (USG) or computed tomography (CT). CT provides cross-sectional imaging, making it valuable for assessing hy-

Received: February 18, 2025 • **Revised:** March 8, 2025 • **Accepted:** March 17, 2025 • **Published online:** April 17, 2025
Corresponding Author: Mustafa Gok https://orcid.org/0000-0001-7021-0984
Department of Radiology, Section of Interventional Radiology, Aydin Adnan Menderes University Hospital, Zafer Mah, Aydin Adnan Menderes University Rad. Efeler, Aydin 09100, Türkiye
TEL: +90-532-420-46-16, E-mail: mustafagok@yahoo.com

dronephrosis, lymph node involvement, and the relationship between the tumor and surrounding tissues [5]. While USG is useful for detecting intravesical tumors, characterizing renal tumors, and identifying hydronephrosis, it has limitations in diagnosing upper urinary tract carcinoma [6].

In patients with a radiological diagnosis of a bladder tumor, transurethral resection of the bladder tumor (TUR-BT) should be performed following cystoscopic examination, and the obtained specimens should undergo histopathological evaluation [7,8].

In recent years, research has focused on whether imaging techniques used for tumor detection can differentiate between malignant and benign lesions. Studies on various tissues have demonstrated that malignant tissues are generally stiffer than benign ones. Consequently, the impact of tissue stiffness, as measured by elastography, on the prognosis of malignant tumors has become an area of investigation [9-11].

Elasticity refers to a tissue's ability to deform in response to an external force and subsequently return to its original state. Harder tissues typically take longer to regain their original shape. There are two primary ultrasonographic elastography techniques used to assess tissue elasticity: strain elastography (SE) and shear wave elastography (SWE). In SE, an external force is applied to measure tissue elasticity, whereas in SWE, tissue stiffness is assessed using acoustic radiation force [12].

Ultrasonographic elastography is widely used in the evaluation of tissues such as the thyroid, breast, and liver; however, its application in assessing bladder tumors remains limited [13]. To our knowledge, only one study has explored the histopathological correlation between SWE and bladder urothelial carcinoma [14]. Therefore, our study aims to contribute to this underexplored area of the literature.

Neoplastic tissues exhibit enhanced vascularization compared to normal tissues, a process that is essential for tumor growth and survival [15]. The angiogenic activity within tumors, as reflected by microvessel density (MVD), has emerged as a significant prognostic marker, with studies in bladder and renal pelvis cancers showing a strong correlation between MVD, tumor grade, stage and prognosis [16,17].

The aim of our study was to investigate the differences in tissue stiffness between pathological subgroups of bladder cancer, to assess the correlation between SWE and MVD and to determine the predictive value of tissue stiffness in bladder cancer prognosis.

MATERIALS AND METHODS

1. Patients and study design

Between June 2021 and September 2022, a total of 72 patients who presented with hematuria and diagnosed with bladder tumors at the Urology Outpatient Clinic of Aydın Adnan Menderes University Hospital were prospectively evaluated for inclusion in this study.

The inclusion criteria were the presence of a bladder mass detectable by USG, a successful elastography measurement, and a confirmed diagnosis of bladder urothelial carcinoma following TUR-BT and pathological sampling. Three patients were excluded from the study due to unsuccessful elastography measurements (interquartile range/median ratio [IQR/M] >25%), three patients declined surgery and one patient was excluded after pathological examination revealed no malignancy. Consequently, 65 patients who met the inclusion criteria were prospectively enrolled in the study.

SWE measurements were obtained from all patients with a partially filled bladder during the preoperative conventional USG procedure. All patients subsequently underwent TUR-BT for both diagnosis and treatment. Pathological evaluations were conducted to assess tumor grade, stage and MVD.

Following pathological examination, patients were categorized into groups based on tumor grade (high-grade and low-grade) and tumor stage (pTa, pT1, pT2). These groups were then compared in terms of tissue stiffness measured by SWE, MVD, and relevant radiological and clinical tumor characteristics. Informed consent was obtained from all patients, and the study was approved by the Aydın Adnan Menderes University Ethics Committee (approval number: 2021/95).

2. Protocol for USG and SWE measurements

Ultrasonographic evaluation of the patients was conducted using a Samsung Medison RS80A Prestige USG system (Samsung Medison Co., Ltd.). Both ultrasonographic and elastographic measurements were performed by a radiologist with 10 years of experience in radiology and 5 years of expertise in elastography. Conventional B-mode imaging and SWE measurements were carried out with an abdominal convex probe. In conventional B-mode USG, tumor characteristics such as size, location, blood supply, and number were assessed.

SWE measurements were performed using the ARFI (acoustic radiation force impulse) elastography-based technique. During the procedure, patients were instructed to

https://doi.org/10.4111/icu.20250068

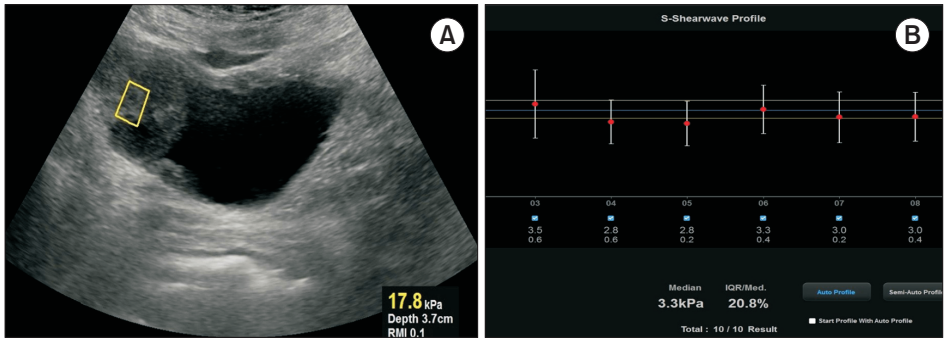

Fig. 1. (A, B) Shear wave elastography measurement and median value determination.

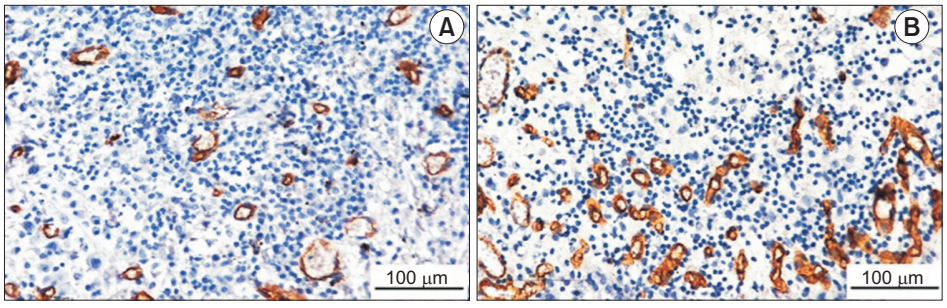

Fig. 2. Immunohistochemical staining of CD34 (200× magnification). (A) Low CD34 intensity. (B) High CD34 intensity.

remain as still as possible and hold their breath. Care was taken to avoid compressing the tumor with the probe. Once the shear wave application was activated, a 0.5 cm×0.5 cm region of interest was placed at the center of the tumor lesion. Ten valid SWE measurements were obtained for each lesion, with median values used for statistical analysis. Measurements were recorded in kilopascals (kPa), and the IQR/M was maintained below 25% for all lesions (Fig. 1).

3. Assessment of MVD

Pathological specimens were obtained from all patients via TUR-BT. Following histopathological evaluation of tumor stage and grade, immunohistochemical staining was performed using the anti-CD34 antibody kit, and MVD was assessed using the 'Hot-Spot' method [18].

The anti–CD34-stained sections were initially examined under a light microscope (Olympus BX53; Olympus Co.) at 40× magnification to identify the five most vascularized hotspots. Subsequently, vascular structures in each region were quantified at 200× magnification (Fig. 2). Vessels or vascular complexes that were distinctly separable from the surrounding tissue were counted as individual vessels. The mean vessel count from the five selected regions was then calculated and recorded.

4. Statistical analysis

Statistical analysis was performed using IBM SPSS software version 25.0 (IBM Corp.). The Mann–Whitney U test or Student's t-test was used to compare quantitative variables based on their distribution normality, while the chi-square test or Fisher's exact test was applied for categorical variables. For comparisons involving more than two groups, one-way ANOVA or Kruskal–Wallis test was used. Receiver operating characteristic (ROC) analysis was conducted to determine the optimal cutoff value. Multivariate logistic regression analysis was performed to determine the independent risk factors for tumoral recurrence and high-grade urothelial carcinoma. Data were presented as mean±standard deviation. A 95% confidence interval (CI) was applied, and p-value <0.05 was considered statistically significant.

RESULTS

The mean age of the 65 patients included in the study was 67.9±8.85 years. The mean age was 70.3±9.3 years in the high-grade group (HG group) and 63.1±5.4 years in the low-grade group (LG group). Patients in the HG group were significantly older than those in the LG group (p<0.001). Of the total cohort, 54 patients (83.1%) were male and 11 patients (16.9%) were female. The mean tumor size was 34.7±15.0 mm in the HG group and 22.8±9.0 mm in the LG group, with tumor size being significantly larger in the HG group (p=0.001). The demographic characteristics of the groups are summarized in Table 1.

Of the 65 patients included in the study, 43 were diagnosed with high-grade and 22 with low-grade urothelial

Table 1. Demographic characteristics of groups classified according to tumour stage and grade (n=65)

	LG (n=22)	HG (n=43)	p-value	pTa LG (n=11)	pT1 LG (n=11)	pT1 HG (n=28)	pT2 HG (n=15)	p-value
Age (y)	63.1±5.4	70.3±9.3	<0.001	63.2±5.5	63.1±5.5	69.1±9.9	72.6±7.8	0.009
Sex								
Female	4 (18.1)	7 (16.3)		2 (18.2)	2 (18.2)	5 (17.9)	2 (13.3)	
Male	18 (81.9)	36 (83.7)		9 (81.8)	9 (81.8)	23 (82.1)	13 (86.7)	
Tumor size (mm)	22.8±9.0	34.7±15.0	0.001	18.0±5.3	28.6±9.3	34.1±17.4	35.7±9.8	0.001

Values are presented as mean±standard deviation or number (%).
LG, low-grade; HG, high-grade.

Table 2. Comparison of SWE and MVD by tumor stage, histopathological grade, and recurrence status

	SWE (kPa)			MVD
	Minimum	Mean±SD	Maximum	
Tumor stage				
pTa LG	1.4	2.2±0.3	2.8	30.9±8.2
pT1 LG	2.7	3.0±0.5	4.8	38.8±8.9
pT1 HG	1.4	7.6±2.3	23.5	43.3±13.2
pT2 HG	1.4	5.7±1.6	11.9	52.8±12.5
p-value		0.001[a]		0.001[b]
Histopathological grade				
Low	1.4	2.9±0.5	8.8	34.5±9.2
High	1.4	7.0±2.4	23.5	45.8±13.5
p-value		0.001		0.002
Recurrence				
Yes (n=9)	2.3	9.8±1.9	18.3	43.3±2.9
No (n=13)	1.4	3.7±0.5	8.8	38.6±2.4
p-value		0.007		0.16

SWE, shear wave elastography; MVD, microvessel density; SD, standard deviation; LG, low-grade; HG, high-grade.
[a]:Based on Kruskal–Wallis test. [b]:Based on one-way ANOVA test.

carcinoma. Regarding tumor stage, 11 patients had pTa low-grade, 11 had pT1 low-grade, 28 had pT1 high-grade and 15 had pT2 high-grade urothelial carcinoma. Three patients with pT1 high-grade urothelial carcinoma were found to have concurrent carcinoma *in situ* (CIS).

The mean SWE value was 2.9±0.5 kPa in the LG group and 7.0±2.4 kPa in the HG group. Tissue stiffness was significantly higher in the HG group compared to the LG group (p=0.001). Similarly, the MVD was 34.5±9.2 in the LG group and 45.8±13.5 in the HG group, with MVD being significantly higher in the HG group (p=0.002) (Table 2).

The mean SWE values were 2.2±0.3 kPa in the pTa LG group, 3.0±0.5 kPa in the pT1 LG group, 7.6±2.3 kPa in the pT1 HG group, and 5.7±1.6 kPa in the pT2 HG group. Tissue stiffness was significantly lower in the pTa LG group compared to the pT1 HG and pT2 HG groups (p=0.001).

The MWD was 30.9±8.2 in the pTa LG urothelial carcinoma group, 38.8±8.9 in the pT1 LG group, 43.3±13.2 in the pT1 HG group, and 52.8±12.5 in the pT2 HG group. These findings indicate that MVD increased with advancing tumor stage and grade. Similar to SWE values, MVD in the pTa LG group was significantly lower than in the pT1 HG and pT2 HG groups (p=0.001) (Table 2).

Tumor number, tumor size, and the presence or absence of blood supply on Doppler USG showed no significant correlation with SWE values (p>0.05).

Papillary tumors were identified in 55 patients, while sessile tumors were present in 10 patients. The mean SWE values were 5.3±3.4 in the papillary tumor group and 7.9±7.6 in the sessile tumor group. The difference between the groups was not statistically significant (p=0.31).

ROC curve analysis demonstrated that SWE values can be used to differentiate between low- and high-grade bladder urothelial carcinoma (area under ROC curve [AUC] 0.837, p<0.001, 95% CI 0.737–0.937). Based on the Youden index, the optimal cut-off value for SWE was determined to be 4.25 kPa, with a sensitivity of 74% and a specificity of 86%.

Similarly, ROC curve analysis indicated that MVD val-

https://doi.org/10.4111/icu.20250068

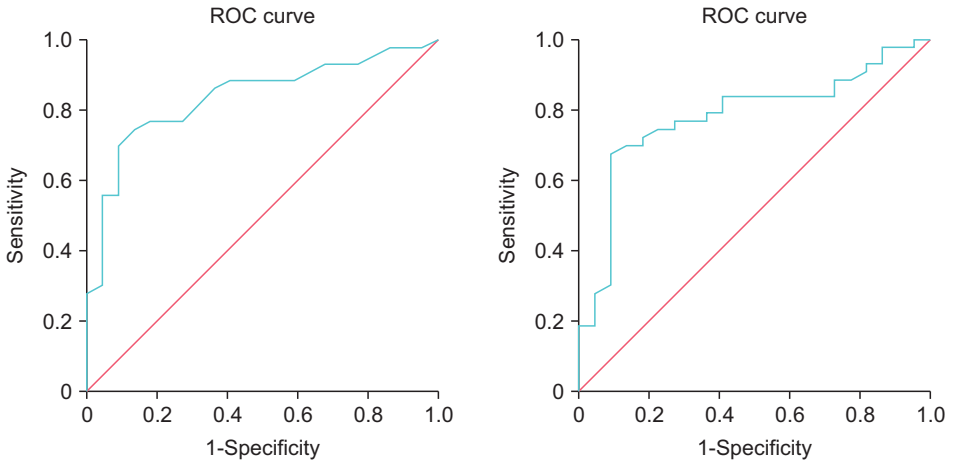

Fig. 3. Receiver operating characteristic (ROC) curves for differentiation of low- and high-grade bladder cancer with mean elasticity (left) and mean microvessel density (right).

Table 3. Multivariate logistic regression analysis of risk factors for recurrence and high-grade urothelial carcinoma

	Recurrence			High-grade urothelial carcinoma		
	OR	95% CI	p-value	OR	95% CI	p-value
SWE	0.654	0.444–0.963	0.032	1.431	1.018–2.011	0.039
MVD	0.977	0.836–1.143	0.773	1.144	1.039–1.260	0.006
Tumor number	0.201	0.004–10.969	0.432	1.838	0.321–10.535	0.495
Tumor size	1.025	0.940–1.119	0.576	1.088	1.017–1.163	0.014

OR, odds ratio; CI, confidence interval; SWE, shear wave elastography; MVD, mivrovessel density.

ues can also differentiate between low- and high-grade bladder urothelial carcinoma (AUC 0.781, p<0.001, 95% CI 0.663–0.899). The Youden index identified an optimal MVD cut-off value of 42.7, yielding a sensitivity of 67% and a specificity of 91% (Fig. 3).

Recurrent tumors were observed in 9 of the 22 patients who completed the 12-month follow-up period, while no tumor recurrence was detected in 13 patients. All patients with tumor recurrence were in the pT1 HG urothelial carcinoma group. Among the patients without recurrence, 5 had pT1 HG, 3 had pT1 LG, and 5 had pTa LG pathology. The mean SWE value was 9.8±1.9 kPa in the recurrence group and 3.7±0.5 kPa in the non-recurrence group. Tissue stiffness was significantly higher in the recurrence group compared to the non-recurrence group (p=0.007).

The mean MVD in the recurrence group was 43.3±2.9, while it was 38.6±2.4 in the non-recurrence group. Although the mean MVD was lower in the non-recurrence group, the difference was not statistically significant (p=0.16) (Table 2).

In the multivariate logistic regression analysis that included SWE, MVD, tumor number (solitary vs. multiple), and tumor size, SWE value was identified as an independent risk factor for tumoral recurrence. Tumor grade and stage were not included in the model, as all recurrent patients were in the pT1 HG group (odds ratio [OR] 0.654, 95% CI 0.444–0.963, p=0.032) (Table 3). Furthermore, SWE, MWD, and tumor size were found to be independent risk factors for high-grade tumors (OR 1.431, 95% CI 1.018–2.011; OR 1.144, 95% CI 1.039–1.260; OR 1.088, 95% CI 1.017–1.163; p=0.039, 0.006, 0.014, respectively) (Table 3).

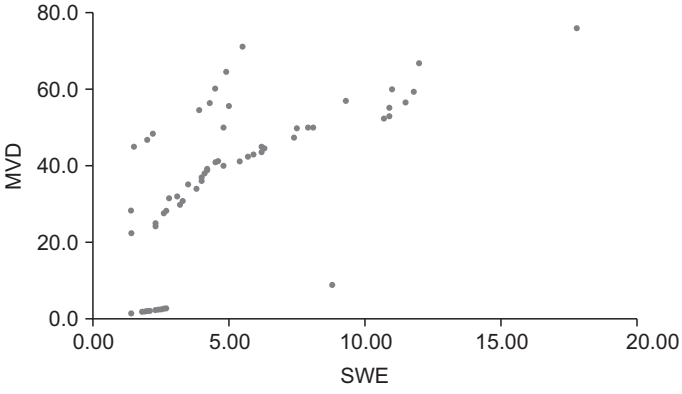

Fig. 4. Linear correlation graph between shear wave elastography (SWE) and microvessel density (MVD).

Our study demonstrated that MVD was higher in tumors with increased tissue stiffness. Linear correlation graph revealed a positive correlation between SWE and MVD (rho=0.767, p<0.001) (Fig. 4).

DISCUSSION

The follow-up and management of bladder cancer remain challenging for urologists due to the heterogeneous disease prognosis, the more aggressive nature of high-grade tumors, and the high risk of recurrence and metastasis [19-21]. Non-muscle invasive bladder cancer (NMIBC) is characterized by a high recurrence rate, with approximately 20% of cases progressing to muscle-invasive disease. NMIBC patients should be stratified into low-, intermediate-, and high-risk groups, with all patients undergoing evaluation for adjuvant treatment. While a single dose of intravesical chemotherapy is generally sufficient for low-risk patients, those in the intermediate- and high-risk groups are recommended to receive a six-week induction course of intravesical BCG (Bacillus Calmette-Guérin) therapy, followed by one to three years of maintenance therapy [22,23]. Individualized risk assessment for treatment planning can enhance patient outcomes by reducing morbidity and healthcare costs while improving quality of life.

Given the limited number of studies evaluating the relationship between bladder cancer and elastography, our study contributes to filling this gap in the literature. Elastographic assessment is more commonly utilized for superficial organs such as the thyroid, liver and breast due to its ease of application and ability to provide more precise measurements [24]. In the urogenital system, elastography has been primarily used for evaluating the kidney, prostate, and testis. However, assessing bladder masses with elastography presents challenges due to the bladder's pelvic location, its positioning behind the symphysis pubis when empty and the increased skin-to-mass distance in posterior wall tumors [25].

To date, only one study in the literature has investigated the pathological correlation of elastography in patients diagnosed with bladder urothelial carcinoma. In the study by Huang et al. [14], elastography measurements were performed transrectally or transvaginally, similar to our study they revelaed that tumor tissue stiffness was significantly higher in the HG urothelial carcinoma group compared to the LG group. Using a threshold value of 10.07 kPa, the study reported a sensitivity of 77% and a specificity of 78% for differentiating high- and low-grade tumors [14].

DEDE et al. [26] evaluated tissue stiffness in malignant and benign bladder tumors and as expected, found that malignant lesions had significantly higher tissue stiffness than benign lesions.

To the best of our knowledge, only these two studies in the literature have examined the relationship between bladder masses and elastography. In our study, tumor tissue stiffness was also compared according to pathological stage, revealing that the stiffness of pTa LG tumors was significantly lower than that of pT1 HG and pT2 HG tumors. Another key aspect that differentiates our study from previous research is our focus on predicting tumor recurrence. Our findings demonstrated that recurrent tumors within 12 months exhibited significantly higher tissue stiffness compared to those without recurrence.

With the increasing use of elastography, the underlying causes of increased tissue stiffness have become a topic of interest. Tumor tissue stiffness is believed to result from factors such as high mitotic activity leading to cell proliferation, fibrosis, angiogenesis, and hypoxia [10]. Consistent with our findings, Canoğlu et al. [17] concluded that MVD was higher in muscle-invasive bladder tumors and was associated with an increased risk of clinical progression. Similarly, a meta-analysis by Huang et al. [27], which examined MVD as a prognostic factor in bladder cancer, found that high MVD was correlated with reduced survival, suggesting that it could serve as a prognostic marker in bladder cancer.

Our study has contributed to the literature by providing findings that can aid in predicting the prognosis of bladder cancer. This approach allows for the personalization of intravesical treatment duration and type based on the aggressiveness and recurrence potential of the disease. Consequently, treatment-related side effects and healthcare costs may be minimized.

CONCLUSIONS

This study demonstrated that tissue elasticity is an independent risk factor for both tumor grade and tumoral recurrence. Additionally, MVD was identified as an independent risk factor for high-grade tumors. We believe that tissue elasticity and MVD may serve as prognostic markers for bladder cancer. Future large-scale studies incorporating SWE and MVD analysis will further elucidate their prognostic value in bladder cancer.

CONFLICTS OF INTEREST

The authors have nothing to disclose.

FUNDING

This study was financially supported by the Scientific Research Project of Aydin Adnan Menderes University (TPF-21054).

https://doi.org/10.4111/icu.20250068

ACKNOWLEDGMENTS

Thank you to Dr. Michael Huang Bsc (Bioinf Hon I), PhD (Med) (Honorary Senior Research Fellow, Baker Department of Cardiometabolic Health, University of Melbourne, Victoria, Australia) for his contribution with academic English editing.

AUTHORS' CONTRIBUTIONS

Research conception and design: Gokhan Sahin. Data acquisition: Mustafa Gok and Gokhan Sahin. Statistical analysis: Gokhan Sahin. Data analysis and interpretation: all authors. Drafting of the manuscript: Gokhan Sahin and Mustafa Gok. Critical revision of the manuscript: all authors. Administrative, technical, or material support: Mustafa Gok. Supervision: Hakan Gemalmaz. Approval of the final manuscript: all authors.

REFERENCES

1. Sung H, Ferlay J, Siegel RL, Laversanne M, Soerjomataram I, Jemal A, et al. Global cancer statistics 2020: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. CA Cancer J Clin 2021;71:209-49.
2. Compérat E, Larré S, Roupret M, Neuzillet Y, Pignot G, Quintens H, et al. Clinicopathological characteristics of urothelial bladder cancer in patients less than 40 years old. Virchows Arch 2015;466:589-94.
3. Kim K, Byun YJ, Zheng CM, Moon S, Jo SJ, Kang HW, et al. COL6A1 expression as a potential prognostic biomarker for risk stratification of T1 high grade bladder cancer: unveiling the aggressive nature of a distinct non-muscle invasive subtype. Investig Clin Urol 2024;65:94-103.
4. Olsson H, Hultman P, Rosell J, Jahnson S. Population-based study on prognostic factors for recurrence and progression in primary stage T1 bladder tumours. Scand J Urol 2013;47:188-95.
5. Trinh TW, Glazer DI, Sadow CA, Sahni VA, Geller NL, Silverman SG. Bladder cancer diagnosis with CT urography: test characteristics and reasons for false-positive and false-negative results. Abdom Radiol (NY) 2018;43:663-71.
6. Choyke PL. Radiologic evaluation of hematuria: guidelines from the American College of Radiology's appropriateness criteria. Am Fam Physician 2008;78:347-52.
7. Brausi M, Collette L, Kurth K, van der Meijden AP, Oosterlinck W, Witjes JA, et al.; EORTC Genito-Urinary Tract Cancer Collaborative Group. Variability in the recurrence rate at first follow-up cystoscopy after TUR in stage Ta T1 transitional cell carcinoma of the bladder: a combined analysis of seven EORTC studies. Eur Urol 2002;41:523-31.
8. Jeong SH, Ku JH. Treatment strategies for the Bacillus Calmette-Guérin-unresponsive non-muscle invasive bladder cancer. Investig Clin Urol 2023;64:103-6.
9. Simon V, Dudea SM, Crisan N, Stanca VD, Dudea-Simon M, Andras I, et al. Elastography in the urological practice: urinary and male genital tract, prostate excluded-review. Diagnostics (Basel) 2022;12:1727.
10. Yoo J, Seo BK, Park EK, Kwon M, Jeong H, Cho KR, et al. Tumor stiffness measured by shear wave elastography correlates with tumor hypoxia as well as histologic biomarkers in breast cancer. Cancer Imaging 2020;20:85.
11. Tyloch DJ, Tyloch JF, Adamowicz J, Juszczak K, Ostrowski A, Warsiński P, et al. Elastography in prostate gland imaging and prostate cancer detection. Med Ultrason 2018;20:515-23.
12. Balleyguier C, Ciolovan L, Ammari S, Canale S, Sethom S, Al Rouhbane R, et al. Breast elastography: the technical process and its applications. Diagn Interv Imaging 2013;94:503-13.
13. Zhi H, Ou B, Luo BM, Feng X, Wen YL, Yang HY. Comparison of ultrasound elastography, mammography, and sonography in the diagnosis of solid breast lesions. J Ultrasound Med 2007;26:807-15.
14. Huang XZ, Zhou AY, Liu MW, Zhang Y, Xu P. Shear wave elasticity differentiation between low- and high-grade bladder urothelial carcinoma and correlation with collagen fiber content. J Ultrasound Med 2021;40:113-22.
15. Ribatti D, Pezzella F. Overview on the different patterns of tumor vascularization. Cells 2021;10:639.
16. Zhang B, Li J, Wu Z, Li C, Sun T, Zhuo N, et al. Contrast-enhanced ultrasound characteristics of renal pelvis urothelial carcinoma and its relationship with microvessel density. Ultrasound Med Biol 2021;47:236-43.
17. Canoğlu A, Göğüş C, Bedük Y, Orhan D, Tulunay O, Baltaci S. Microvessel density as a prognostic marker in bladder carcinoma: correlation with tumor grade, stage and prognosis. Int Urol Nephrol 2004;36:401-5.
18. Bochner BH, Cote RJ, Weidner N, Groshen S, Chen SC, Skinner DG, et al. Angiogenesis in bladder cancer: relationship between microvessel density and tumor prognosis. J Natl Cancer Inst 1995;87:1603-12.
19. Moschini M, D'Andrea D, Korn S, Irmak Y, Soria F, Compérat E, et al. Characteristics and clinical significance of histological variants of bladder cancer. Nat Rev Urol 2017;14:651-68.
20. Soave A, Schmidt S, Dahlem R, Minner S, Engel O, Kluth LA, et al. Does the extent of variant histology affect oncological outcomes in patients with urothelial carcinoma of the bladder treated with radical cystectomy? Urol Oncol 2015;33:21.e1-9.
21. Kim DH, Choi MS, Choi JH, Lee C, Jeh SU, Kam SC, et al.

Correlation between urine cytology results on the day after overnight continuous saline irrigation following transurethral resection of bladder tumor and bladder tumor recurrence. Investig Clin Urol 2024;65:279-85.

22. Kim GK, Jo YH, Lee J, Han HH, Ham WS, Jang WS, et al. Short-term outcomes of intravesical gemcitabine for non-muscle-invasive bladder cancer after recent approval for use in Korea. Investig Clin Urol 2024;65:435-41.
23. Oddens J, Brausi M, Sylvester R, Bono A, van de Beek C, van Andel G, et al. Final results of an EORTC-GU cancers group randomized study of maintenance bacillus Calmette-Guérin in intermediate- and high-risk Ta, T1 papillary carcinoma of the urinary bladder: one-third dose versus full dose and 1 year versus 3 years of maintenance. Eur Urol 2013;63:462-72.
24. Frulio N, Trillaud H. Ultrasound elastography in liver. Diagn Interv Imaging 2013;94:515-34.
25. Sigrist RMS, Liau J, Kaffas AE, Chammas MC, Willmann JK. Ultrasound elastography: review of techniques and clinical applications. Theranostics 2017;7:1303-29.
26. DEDE O, TEKE M, Daggulli M, Penbegül N. Use of acoustic radiation force impulse elastography to discrimination benign and malignant masses for bladder. Int J Radiol Imaging Technol 2018;4:039.
27. Huang J, Ma X, Chen X, Liu X, Zhang B, Minmin L, et al. Microvessel density as a prognostic factor in bladder cancer: a systematic review of literature and meta-analysis. Cancer Biomark 2014;14:505-14.

https://doi.org/10.4111/icu.20250068