Platinum Priority – Brief Correspondence
Editorial by Valeria Panebianco, Yoshi Narumi, Giovanni Barchetti, Rodolfo Montironi and James W.F. Catto on pp. 57–58 of this issue

Diagnostic Accuracy and Interobserver Agreement for the Vesical Imaging-Reporting and Data System for Muscle-invasive Bladder Cancer: A Multireader Validation Study

Yoshiko Ueno [a,*], Mitsuru Takeuchi [a,b], Tsutomu Tamada [a,c], Keitaro Sofue [a], Satoru Takahashi [a,d], Yuki Kamishima [a,e], Nobuyuki Hinata [f], Kenichi Harada [f], Masato Fujisawa [f], Takamichi Murakami [a]

[a] Department of Radiology, Kobe University Graduate School of Medicine, Kobe, Japan.; [b] Department of Radiology, Radiolonet Tokai, Nagoya, Japan.; [c] Department of Radiology, Kawasaki Medical School, Kurashiki, Japan.; [d] Imaging Research Center, Takatsuki General Hospital, Takatsuki, Japan.; [e] Department of Radiology, Nagoya City West Medical Center, Nagoya, Japan; [f] Department of Urology, Kobe University Graduate School of Medicine, Kobe, Japan.

Article info

Abstract

A Vesical Imaging-Reporting and Data System (VI-RADS) based on multiparametric magnetic resonance imaging (mp-MRI) was developed to provide accurate information for the diagnosis of muscle-invasive bladder cancers (MIBCs). In this study we evaluated the interobserver agreement and diagnostic performance of VI-RADS. We retrospectively evaluated data for 74 consecutive patients with bladder cancer who had undergone mp-MRI before transurethral resection in a single institution from January 2010 to August 2018. Five readers assessed the probability of the presence of MIBC using VI-RADS scores. The interobserver agreement was assessed by measuring intraclass correlation coefficients (ICCs). Receiver operating characteristic (ROC) analysis was used to evaluate the MIBC diagnostic performance. The area under the ROC curve (AUC) was estimated for ordinal score assessments. Our study demonstrated that interobserver agreement was excellent among five readers (ICC 0.85, 95% confidence interval 0.80–0.89) and the diagnostic performance of VI-RADS was represented as a pooled AUC of 0.90 (95% confidence interval 0.87–0.93).
Patient summary: We evaluated the interobserver agreement and diagnostic performance of a new scoring system based on magnetic resonance imaging called a Vesical Imaging-Reporting and Data System (VI-RADS) for muscle-invasive bladder cancer. Our results indicate that VI-RADS is suitable as a comprehensive tool for appropriate treatment planning for patients with bladder cancer.

* Corresponding author. Department of Radiology, Kobe University Graduate School of Medicine, 7-5-2 Kusunoki-cho, Chuo-ku, Kobe, Japan. Tel. +81 78 3826104.
E-mail address: yoshiu0121@gmail.com (Y. Ueno).

The first step of the diagnostic algorithm for bladder cancer (BC) is evaluating the presence of muscle invasion, which can be performed by analysing histopathological samples obtained via transurethral resection of bladder tumour (TURBT) [1]. However, because TURBT can show false-negative results or cannot confirm invasion depth in

multiple cases, repeat TURBT is often performed. Owing to recent developments in magnetic resonance imaging (MRI) [2–6], multiparametric MRI (mp-MRI) is being considered as a complementary tool for TURBT, if not as a replacement. The Vesical Imaging Reporting and Data System (VI-RADS) was released in May 2018 as a standard imaging and diagnostic method for BC [7]. VI-RADS classifies the probability of muscle invasion suggested by mp-MRI findings into five stages. However, a major challenge for mp-MRI has been the lack of reporting on reproducibility and diagnostic performance. Thus, the aim of this study was to evaluate the interobserver agreement and diagnostic performance of VI-RADS for muscle-invasive BC (MIBC).

Between January 2010 and August 2018, 168 consecutive patients who had undergone bladder mp-MRI including T2-weighted imaging (T2WI), diffusion-weighted imaging (DWI), and dynamic contrast-enhanced (DCE) imaging before TURBT at our institution were eligible for this study. Patients were excluded according to the following criteria: (1) prior treatment within 6 mo before mp-MRI ($n = 62$); (2) high-grade pTa tumours if there was no muscularis propria in the specimen at initial TURBT and no repeat TURBT was performed ($n = 5$); (3) any pT1 tumours at initial TURBT for which no repeat TURBT was performed ($n = 11$); (4) tumours with unknown pT stage ($n = 6$); and (5) non-muscle-invasive BC (NMIBC) at initial TURBT diagnosis but tumour remained on repeat TURBT ($n = 10$). The final study population comprised 74 patients. All MRI examinations were performed using a 1.5-T or 3.0-T system (Achieva; Philips Medical Systems, Best, The Netherlands) with body array coils. The MRI parameters are shown in Supplementary Table 1.

A study coordinator chose the targeted lesion on the basis of the extent of invasion, that is, the tumour with the highest invasion was targeted first. However, if tumours showed an equal extent of invasion, the largest lesion was targeted first. MR images were interpreted independently by five board-certified radiologists who specialize in urogenital radiology. All readers were provided with information regarding the location of the targeted lesion, but were blinded to clinical outcome and histopathology results. The readers were instructed to score each tumour on T2WI, DWI, and DCE images individually according to the VI-RADS criteria [7] (Supplementary Table 2), and a VI-RADS score between 1 and 5 was assigned to suggest the probability of muscle invasion (where 1 denotes presence highly unlikely and 5 indicates presence highly likely) according to the scoring flowchart in Supplementary Fig. 1. In brief, in this system the final score is first based on T2WI for morphology because of its high spatial resolution in evaluating the integrity of the muscularis propria. Then the presence of definitive muscular invasion is evaluated using DWI and DCE MRI. The dominant sequences for risk estimates are DWI first and then DCE second when DWI is suboptimal [7]. An example case is shown in Fig. 1.

The interobserver agreement of VI-RADS scores was assessed by measuring intraclass correlation coefficients (ICCs). Receiver operating characteristic (ROC) analysis and the area under the ROC curve (AUC) were used to evaluate the MIBC diagnostic performance.

Post-treatment histological assessment revealed that 37/74 patients (50.0%) had MIBC and 37/74 (50.0%) had NMIBC. The patient and tumour characteristics are summarized in Supplementary Table 3. For the 74 patients, the ICC for interobserver agreement was 0.85 (95% confidence interval 0.80–0.89). The pooled number and proportion of cases in the data set scored by five readers according to VI-RADS are shown in Table 1. The diagnostic performance of each reader using scores of 3 and 4 as cutoff points is shown in Supplementary Table 4. The pooled AUC was 0.90 (95% confidence interval 0.87–0.93). A cutoff point of 4 resulted in pooled sensitivity of 76% and pooled specificity of 93%, compared to 88% and 77%, respectively, with a cutoff point of 3.

According to the VI-RADS guideline [7], the final score is first based on T2WI because of its high spatial resolution in evaluating the integrity of the muscularis propria. However, the presence of definitive muscular invasion is decided by DWI and DCE MRI. Tekes et al. [2] reported that 81% of bladder tumours showed a similar signal intensity to that of muscle on T2WI. Our retrospective review of images after interpretation revealed that MIBCs that slightly protruded from the mucous membrane but substantially invaded the muscle layer could be underestimated on T2WI, but correctly evaluated on DWI and DCE images (Supplementary Fig. 2). Takeuchi et al. [3] reported that bladder tumour contours could be accurately evaluated using DWI because microvessels or reactive tissue adjacent to the tumour could be enhanced to a level similar to that of cancer components on contrast-enhanced images but could be distinguished
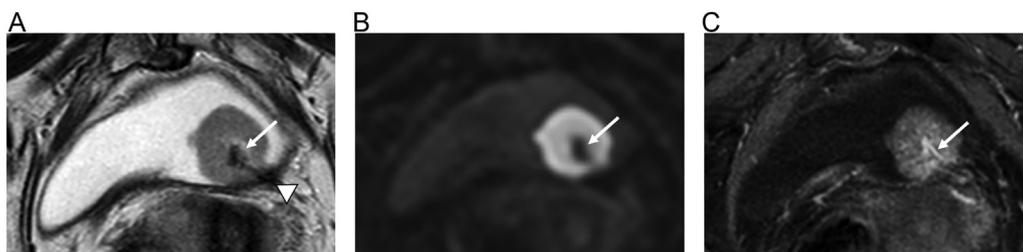

Fig. 1 – Example case of an 85-yr-old woman with pT1 urothelial carcinoma. (A) T2-weighted image shows tumour with a stalk (arrow) on the left posterior side of the bladder. The SI is lower for the muscle layer at the base of the tumour than for the tumour (arrowhead), which can be rated as category 2. (B) Axial DW image showing a C-shaped area of high SI with a low-SI stalk connecting to the left side of bladder wall (arrow) that can be rated as category 2. (C) T1-weighted axial gadolinium-enhanced image showing the tumour at the left posterior wall with uninterrupted submucosal enhancement (arrow). This can also be rated as category 2. The final VI-RADS score is 2. DW = diffusion-weighted; SI = signal intensity; VI-RADS = Vesical Imaging-Reporting and Data System.

Table 1 – Pooled number and proportion of cases in the data set scored by five readers according to VI-RADS

	VI-RADS score				
	1	2	3	4	5
Pooled number of cases (n)	10	23	11	16	14
Muscle-invasive bladder cancer cases, n (%)	0 (0)	4 (17)	5 (45)	15 (94)	13 (93)
Non-muscle-invasive bladder cancer cases, n (%)	10 (100)	19 (83)	6 (55)	1 (6)	1 (7)

VI-RADS = Vesical Imaging-Reporting and Data System.

from tumours with the contrast of DWI. However, artefacts can be caused by eddy currents and body motion in DWI, and image quality can be highly dependent on machine configuration [8]. Although the use of contrast media can be restricted by the patient's condition, DCE images can potentially be a substitute for DWI [7,9].

In our study, 93–94% of the cases scored as VI-RADS 4 or 5 had MIBC, while none of the cases scored as VI-RADS 1 had MIBC. Therefore, we contend that the main aim of TURBT should be accurate pathological diagnosis of tumours rather than focusing on complete resection for lesions with a VI-RADS score of 4 or 5, and vice versa for lesions with a VI-RADS score of 1. However, some cases that were scored as VI-RADS 2 or 3 had MIBC (17% for VI-RADS 2, 45% for VI-RADS 3). For such cases, even if the pathological result at initial TURBT is NMIBC, repeat TURBT may still be needed for accurate pathological diagnosis or complete resection of tumour [1]. We believe that applying VI-RADS in the performance of TURBT assists in appropriate determination of the depth and range of the excision site, which can reduce the risk of bladder perforation and enhance the accuracy of pathological diagnosis.

Several limitations of our study warrant mention. First, the study was retrospective and our data were based on reinterpretation by five radiologists. It is possible that the performance of mp-MRI could differ when evaluated prospectively. Second, the sample size was relatively small, with 74 patients at a single institution. Further multicentre validation studies are desirable.

In conclusion, this study showed that the ICC among five radiologists was 0.85 and the pooled AUC was 0.90 for diagnosis of MIBC. With further efforts to refine its applications and standardization, VI-RADS may become an important comprehensive tool for appropriate treatment planning for patients with BC.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.eururo.2019.03.012.

References

[1] Babjuk M, Bohle A, Burger M, et al. EAU guidelines on non-muscle-invasive urothelial carcinoma of the bladder: update 2016. Eur Urol 2017;71:447–61.

[2] Tekes A, Kamel I, Imam K, et al. Dynamic MRI of bladder cancer: evaluation of staging accuracy. Am J Roentgenol 2005;184:121–7.

[3] Takeuchi M, Sasaki S, Ito M, et al. Urinary bladder cancer: diffusion-weighted MR imaging—accuracy for diagnosing T stage and estimating histologic grade. Radiology 2009;251:112–21.

[4] Panebianco V, De Berardinis E, Barchetti G, et al. An evaluation of morphological and functional multi-parametric MRI sequences in classifying non-muscle and muscle invasive bladder cancer. Eur Radiol 2017;27:3759–66.

[5] Panebianco V, Barchetti F, de Haas RJ, et al. Improving staging in bladder cancer: the increasing role of multiparametric magnetic resonance imaging. Eur Urol Focus 2016;2:113–21.

[6] Huang L, Kong Q, Liu Z, Wang J, Kang Z, Zhu Y. The diagnostic value of MR imaging in differentiating T staging of BC: a meta-analysis. Radiology 2018;286:502–11.

[7] Panebianco V, Narumi Y, Altun E, et al. Multiparametric magnetic resonance imaging for bladder cancer: development of VI-RADS (Vesical Imaging-Reporting and Data System). Eur Urol 2018;74:294–306.

[8] Shen SH, Chiou YY, Wang JH, et al. Diffusion-weighted single-shot echo-planar imaging with parallel technique in assessment of endometrial cancer. Am J Roentgenol 2008;190:481–8.

[9] Gupta N, Sureka B, Kumar MM, Malik A, Bhushan TB, Mohanty NK. Comparison of dynamic contrast-enhanced and diffusion weighted magnetic resonance image in staging and grading of carcinoma bladder with histopathological correlation. Urol Ann 2015;7:199–204.