VI-RADS

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Interobserver agreement for the Vesical Imaging-Reporting and Data System (VI-RADS) in differentiating non-muscle-invasive and muscle-invasive urinary bladder tumors

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Abstract

Background Bladder cancer is the most common tumor of the genitourinary tract. Transitional cell carcinoma is divided into two categories: non-muscle-invasive bladder cancer (NMIBC) and muscle-invasive bladder cancer (MIBC). In spite of the high recurrence rate, NMIBC has good prognosis, while MIBC has poor prognosis due to local organ invasion and metastases. Mp-MRI shows better tumor detection and staging. The aim of this study is to validate VI-RADS in detecting MIBC and assessing interobserver agreement and impact of reader's experience.

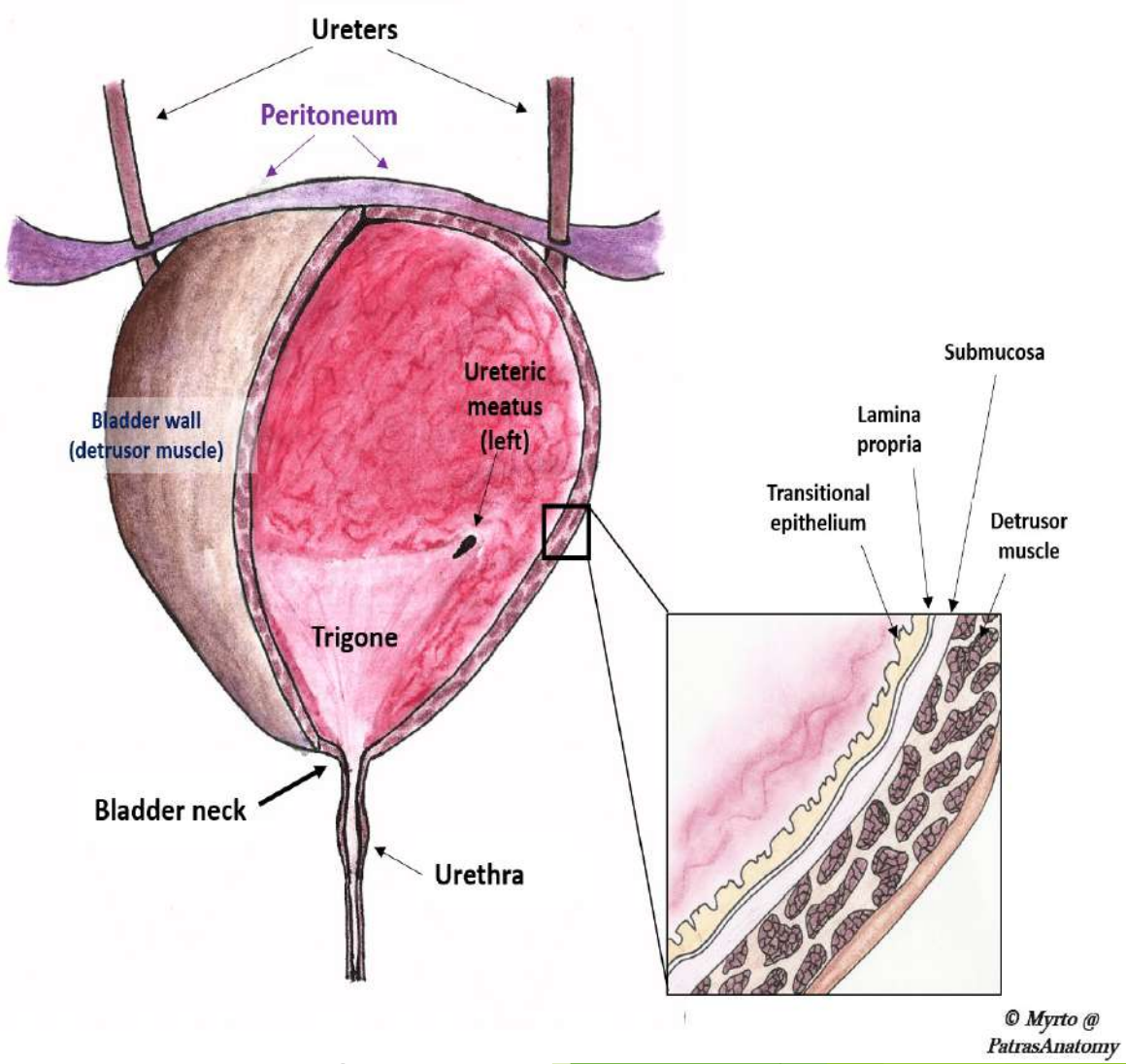
Results At cutoff value of VI-RADS score ≥ 3, the VI-RADS showed sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and accuracy of 96.8%,83.3%, 93.8%, 90.9%, and 93%, respectively, for reader 1, 93.5%, 91.7%, 84.6%, and 93% for reader 2, and 96.8%,83.3%, 93.8%, 90.9%, and 93% for reader 3. The interobserver agreement between individual readers was excellent among the three readers.

Conclusions Vesical imaging-reporting and data system (VI-RADS) is a good method showing satisfactory sensitivity, specificity, and diagnostic value for detecting detrusor muscle invasion.

Keywords NMIBC, MIBC, Mp-MRI, VI-RADS

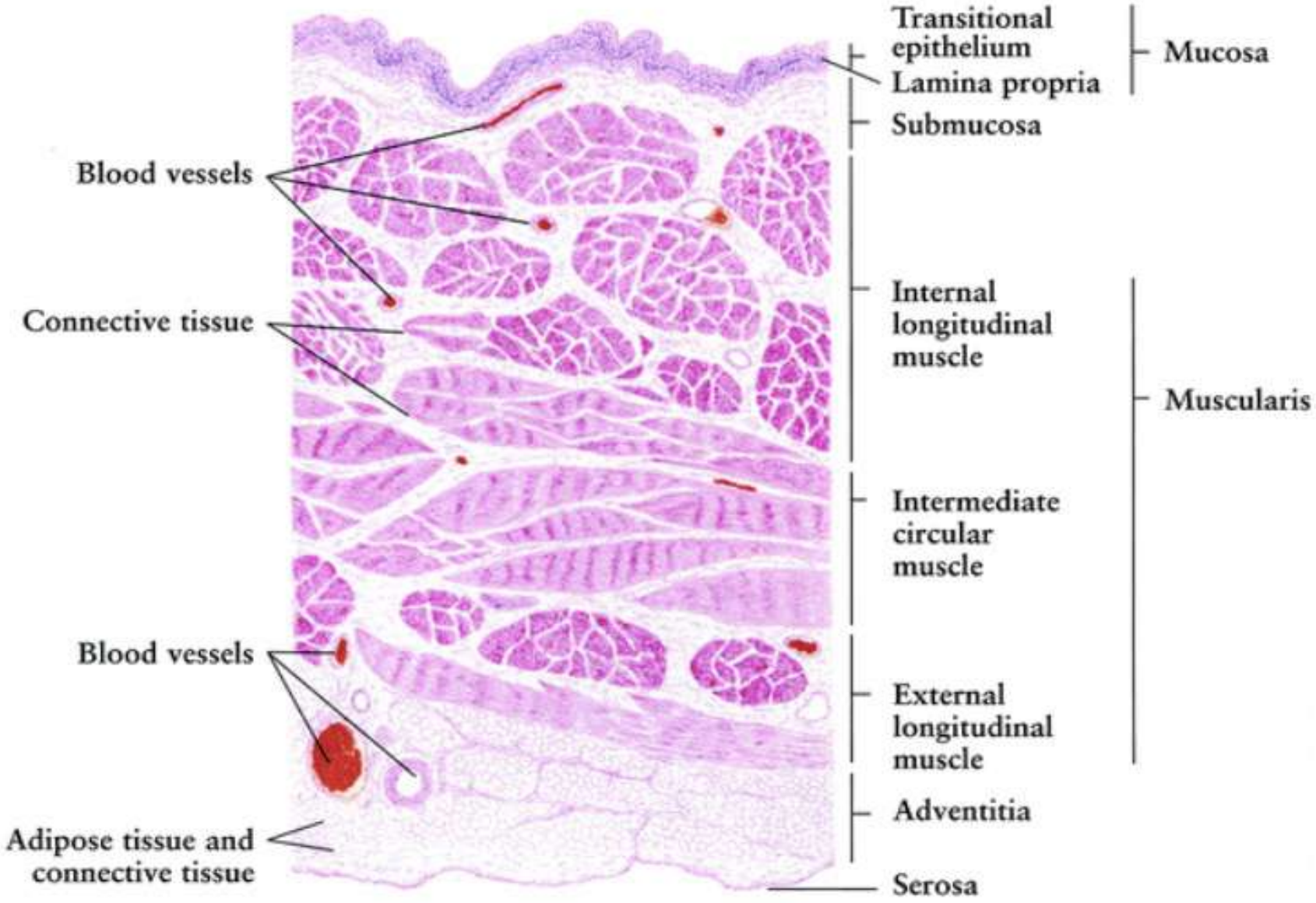
Urinary Bladder: Anatomy

- The urinary bladder is a musculomembranous sac, predominantly extraperitoneal, its size position and relations varying according to the amount of fluid it contains.
- Peritoneum covers the superior surface, or dome of the bladder.
- The bladder receives both ureters posterolaterally, whereas inferiorly, the bladder neck is continuous with the urethra.
- The orifices of the ureters at the ureterovesical junction are joined by an elevated ridge covered by mucosa (the interureteric ridge).
- The trigone describes a triangular region on the internal face of the bladder on the inferior wall, marked at its corners by the ureterovesical junction and the urethra.



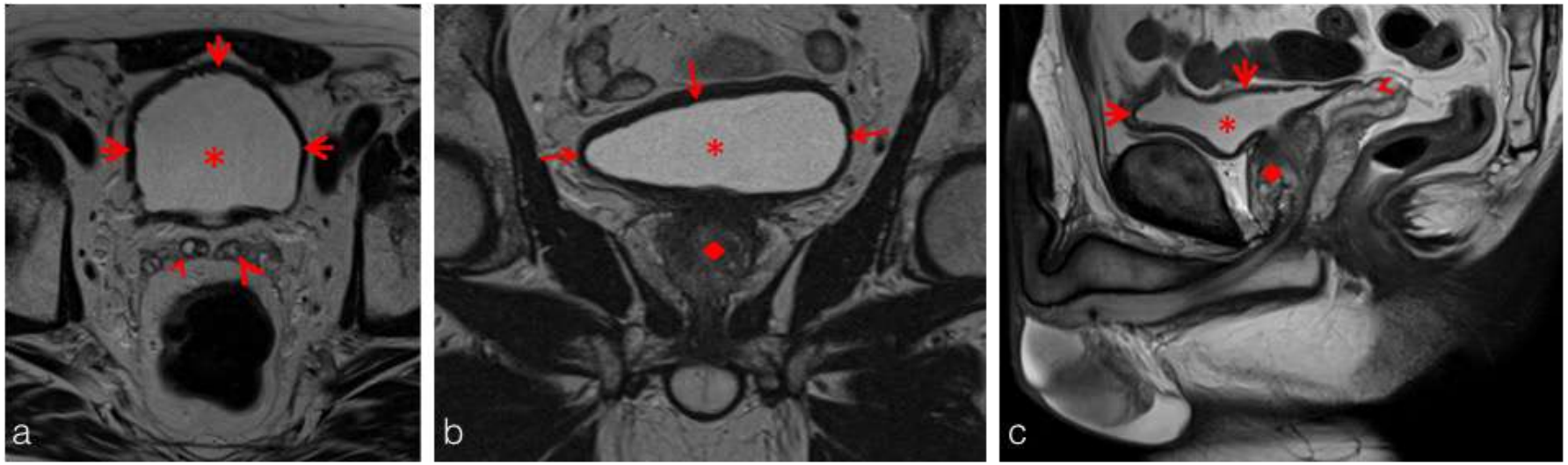
Urinary Bladder: Histology

- The 3 layers of urinary bladder
  - Mucosa
    - Urothelium
    - Subepithelial connective tissue (lamina propria)
  - Muscularis propria
  - Perivesical fat
- Normal urothelium is seven or fewer cells thick, hyperplastic and dysplastic lesions can be thicker, and in carcinoma in situ cells lose adhesion.
- The subepithelial connective tissue depth is similar for the anterior, posterior, and lateral walls (0.72–2.55 mm), but thinner at the trigone (ie, 0.46–1.58 mm) and thicker at the dome (0.98–3.07 mm). The subepithelial connective tissue contains a muscularis mucosae. This consists of wavy, thin, smooth muscle fascicles often associated with large, thin-walled blood vessels.
- The connective tissue be- tween the muscularis mucosae and the muscularis propria is occasionally called “submucosa” by radiologists.
- The muscularis propria is composed of inner and outer smooth muscles with different orientations.
- The boundary between the muscularis propria and perivesical tissue is not well defined. Aggregates of adipose tissue are often seen in muscularis propria, and in 61% are abundant in deep muscularis propria. The muscularis propria adipose tissue merges with perivesical adipose tissue without a clear line of demarcation

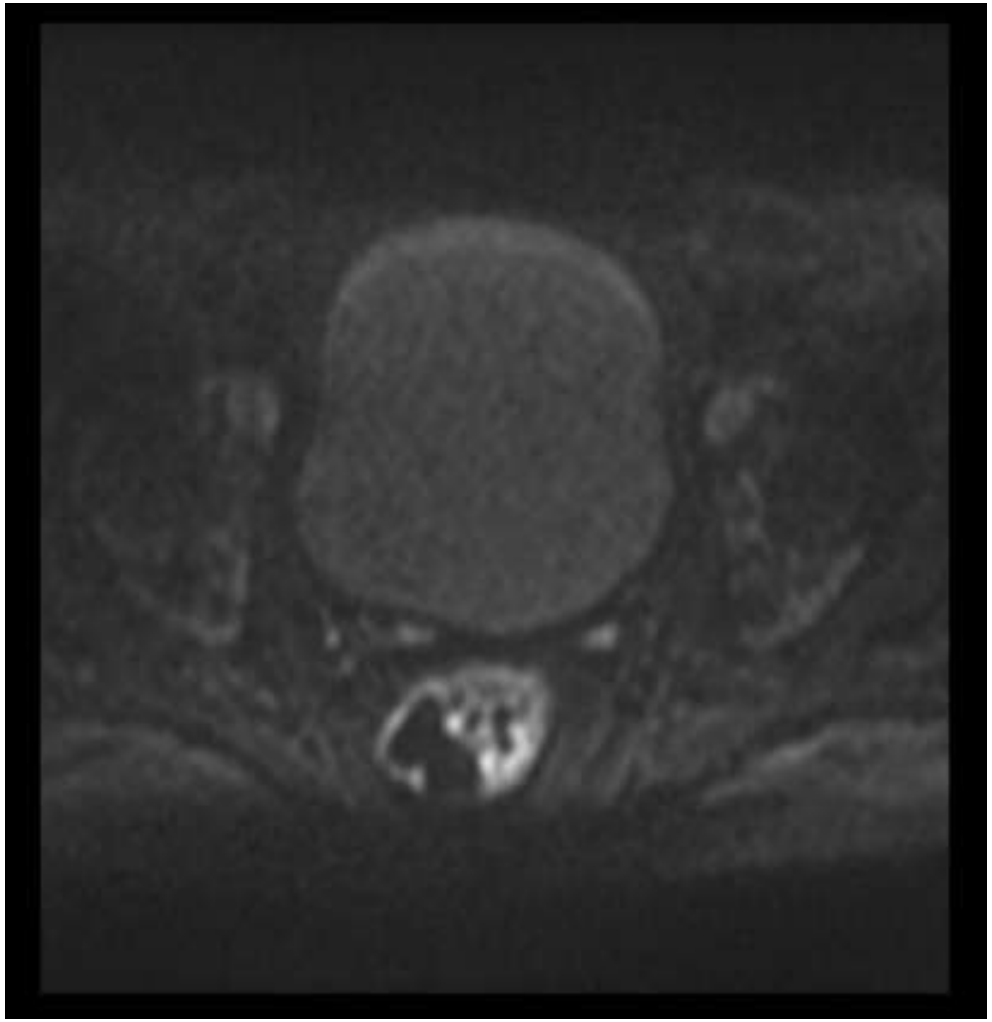

Transitional epithelium
Lamina propria
Submucosa
Mucosa
Blood vessels
Connective tissue
Internal longitudinal muscle
Muscularis
Intermediate circular muscle
Blood vessels
External longitudinal muscle
Adventitia
Adipose tissue and connective tissue
Serosa

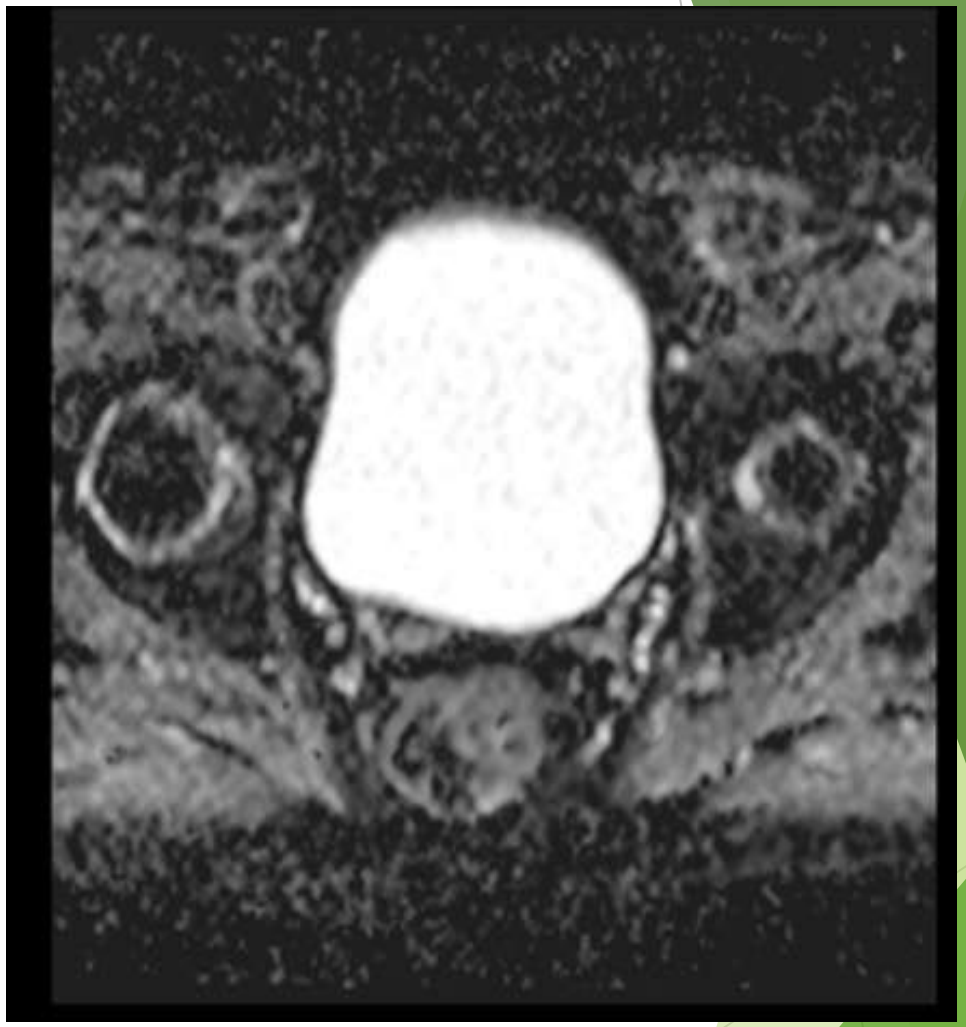
Urinary bladder: MRI

- Muscularis propria (detrusor) appears as a low signal intensity (SI) line on T2W images, while the inner layer composed of urothelium and lamina propria is not seen.
- At DWI, the inner layer is not visualized, while muscularis propria appears as an intermediate SI line.
- With ADC maps, urine appears hyperintense and bladder wall is of intermediate SI.
- With DCE, the inner layer presents early enhancement, and it appears as a high SI line, while muscularis propria presents as a low SI line that enhances slowly and progressively
- Several conditions can cause inflammation of urothelium and lamina propria, resulting in thickening and edema. In such cases, T2W images may show a thickened hyperintense line (ie, the edematous inner layer) that overlays the hypointense muscular layer. DWI may show a thickened hypointense line representing edematous mucosa.

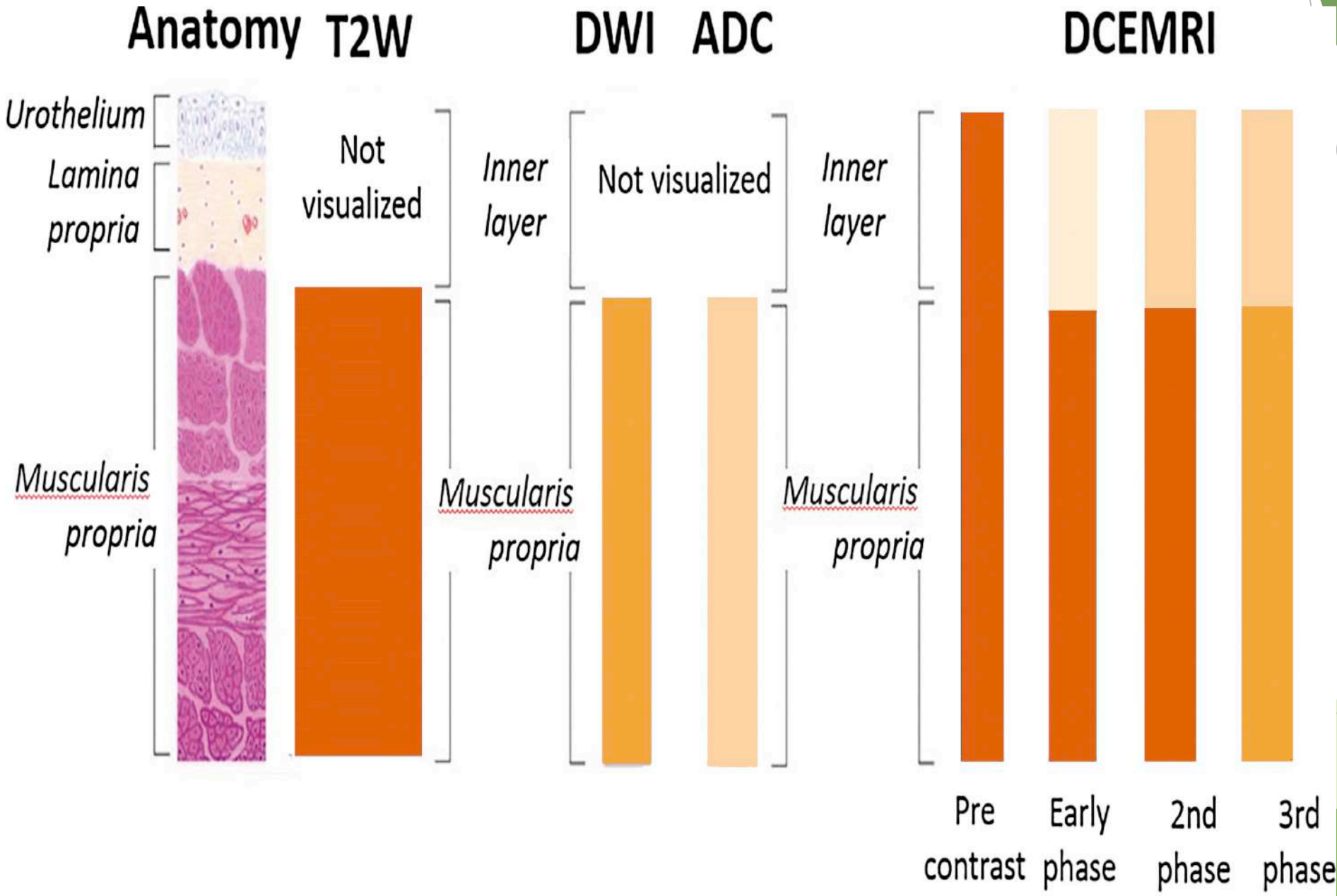


Normal T2W of the urinary bladder





At DWI, the inner layer is not visualized, while muscularis propria appears as an inter- mediate SI line.
With ADC maps, urine appears hyperintense and bladder wall is of intermediate SI.


Anatomy
T2W
DWI
ADC
DCEMRI
Urothelium
Lamina propria
Muscularis propria
Not visualized
Inner layer
Not visualized
Muscularis propria
Inner layer
Muscularis propria
Pre contrast
Early phase
2nd phase
3rd phase

Vesical Imaging- Reporting and Data Sytem (VI-RADS)

- A structured reporting scheme for multiparametric bladder MRI in the evaluation of bladder cancer.
- A systematic approach to bladder lesion based on multiparametric MRI (mpMRI) was proposed by the European Association of Urology in 2018 [1].
- Multi-parametric magnetic resonance imaging (mpMRI) offers an opportunity to reduce staging errors through better anatomical visualization

Assessment categories

- A combination of imaging findings –
  - T2WI (SC-category),
  - DWI (DW-category), and
  - Dynamic contrast enhancement (CE-category) –
- Each lesion is assigned a score from 1 to 5 indicating the likelihood of clinically significant cancer:

Preparation:

- Motion and susceptibility artifacts from bowel peristalsis can be minimized by the administration of an intramuscular antispasmodic agent
- Adequate bladder distension allows correct visualization of the wall and identification of the muscularis propria (detrusor) without any folds (
- Adequate bladder distention is vital and can be achieved by instructing the patient to void 1–2 h before imaging or by instructing the patient to start drinking 500–1000 ml of water in the 30 min before the examination, depending on the patient's tolerance level.
- Without distention, the bladder wall will appear thick and uneven, leading to either a misdiagnosis of BC or overstaging of tumors that are present.
- Overdistension of the bladder may cause a motion artifact due to discomfort, and the extent of BC will be indistinct. I
- In patients with a history of incomplete bladder emptying, a residual volume ultrasound scan prior to MRI can be useful to judge when the bladder is optimally full (around 300 ml).
- Real-time MRI images can also be used to determine adequate bladder filling. For an underfilled bladder, the scan should be repeated in 30–60 min after the patient has drunk more fluid. In case of an overfilled bladder, the patient should partly empty their bladder before the scan is repeated.

Image acquisition

- T2-weighted (T2W) image, DWI, and dynamic contrast-enhanced image (DCE MRI) are key components of mpMRI examination.
- All images should include:
  - whole bladder
  - proximal urethra
  - pelvic nodes
  - prostate if the patient is a male. In females, adjacent pelvic viscera (uterus, ovaries, fallopian tubes, and vagina) should also be included. Spin-echo T1-weighted (T1W) image is used to identify hemorrhage and clot in the bladder, and bone metastasis.

Multiparametric MRI (mpMRI) protocol

- T2W
  - At least two planes of multiplanar (axial, coronal, and sagittal) T2W images without fat suppression are usually obtained with two-dimensional (2D) fast-spin-echo (FSE) or turbo-spin-echo sequences.
  - Three-dimensional spin-echo acquisitions (eg, SPACE, CUBE, VISTA) may be used as an adjunct to 2D acquisitions.

- DWI/ADC
  - DWI is computed by quantifying the diffusion of water molecules in tissues, and it plays a significant role in the bladder mpMRI examination.
  - Axial and sagittal/coronal breathing-free spin-echo EPI sequence combined with spectral fat saturation is recommended.
  - It is essential to obtain DWI with good image quality, maintaining a balance between high spatial resolution and signal-to-noise ratio.

- Dynamic CE
  - Although either a 2D or a 3D T1 gradient echo (GRE) sequence with fat suppression may be used, 3D acquisition (eg VIBE, LAVA, THRIVE) is preferred to obtain higher spatial resolution.
  - Pre-contrast image is also acquired.
  - A gadolinium- based contrast agent is administered using a power-injector system at a dose of 0.1 mmol/kg of body weight at a rate of 1.5–2.0ml/s if standard relaxivity agent is used and followed by saline flush.
  - Initial contrast image is acquired at 30 s after the beginning of injection and followed by the same sequences four to six times every 30 s to depict the early enhancement of inner layer followed by tumor enhancement.
  - If 3D- GRE is acquired with isotropic voxels, an arbitrary plane perpendicular to tumor base can be reformatted.
  - Late phase is not useful for T staging because signal contrast among the inner and outer layers and tumor decreases.

VI-RADS-
Structural Category (SC)

Muscle appears hypointense on T2W images. This should be the first MR appearance to search in the examination. Interruption of the low SI muscular line may suggest muscle invasion. Different scenarios may be present:

- SC1: uninterrupted low SI line representing the integrity of muscularis propria (lesion <1 cm; exophytic tumor with or without stalk and/or thickened inner layer)
- SC2:uninterruptedlowSIlinerepresentingtheintegrity of muscularis propria (lesion >1 cm; exophytic tumor with stalk and/or high SI thickened inner layer, when present, or sessile/broad-based tumor with high SI thickened inner layer, when present)
- SC3:lackofcategory2findingswithassociatedpresenceof an exophytic tumor without stalk, or sessile/broad-based tumor without high SI thickened inner layer but with no clear disruption of low SI muscularis propria
- SC 4: interruption of low SI line suggesting extension of the intermediate SI tumor tissue to muscularis propria
- SC 5: extension of intermediate SI tumor to extravesical fat, representing the invasion of the entire bladder wall and extravesical tissues

VI-RADS
DW category

The tumor is hyperintense on DWI and hypointense on ADC map. Muscularis propria may present intermediate SI, while the stalk and inner layer have low SI on DWI

- DW category 1: muscularis propria with intermediate continuous SI on DWI (lesion <1 cm, hyperintense on DWI and hypointense on ADC, with or without stalk and/ or low SI thickened inner layer on DWI)
- DW category 2: muscularis propria with continuous intermediate SI on DWI (lesion >1 cm, hyperintense on DWI and hypointense on ADC, with low SI stalk and/or low SI thickened inner layer on DWI, or broad-based/ sessile tumor with low/intermediate SI thickened inner layer on DWI)
- DW category 3: lack of category 2 findings (lesions corresponding to T2 category 3 findings) but with no clear disruption of low SI muscularis propria.
- DW category 4: High SI tumor on DWI and low SI tumor on ADC extending focally to muscularis propria.
- DW category 5: High SI tumor on DWI and low SI tumor on ADC extending to the entire bladder wall and extravesical fat.

VI-RADS
DCE category

As for DCE MRI, tumor and inner layer enhance early and may enhance at the same time and grade. Muscularis propria should maintain no enhancement in the early phase, and it is recognizable as a low SI line under the tumor. Contrast-enhanced (CE) categories are as follows:

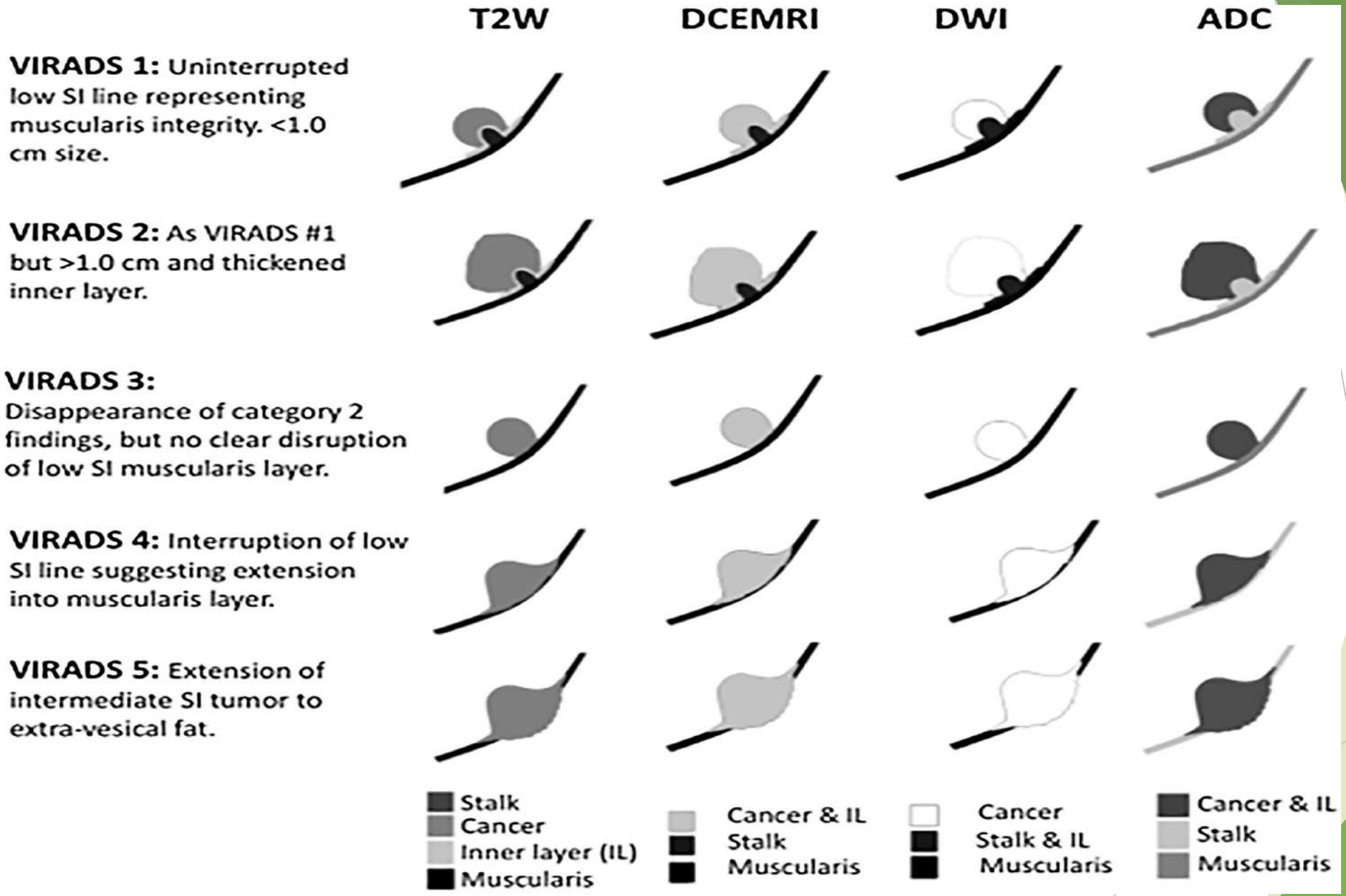
- CE category 1: No early enhancement of the muscularis propria (lesions corresponding to SC 1 findings)
- CE category 2: no early enhancement of muscularis propria with early enhancement of inner layer (lesions corresponding to SC 2 findings)
- CE category 3: lack of category 2 findings (lesions corresponding to SC category 3 findings) but with no clear disruption of low SI muscularis propria
- CE category 4: tumor early enhancement extends focally to muscularis propria
- CE category 5: tumor early enhancement extends to the entire bladder wall and to extravesical fat

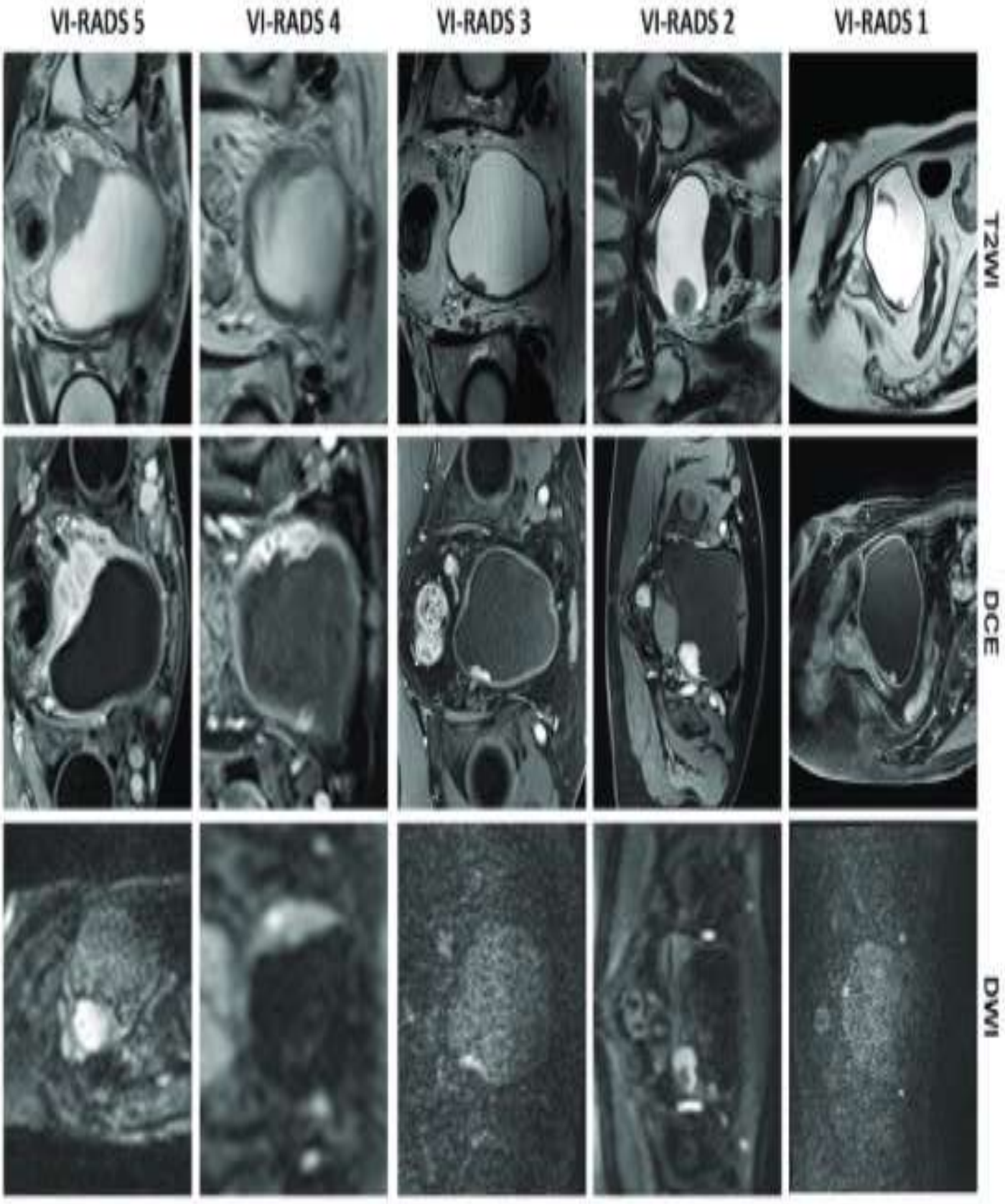
Scoring

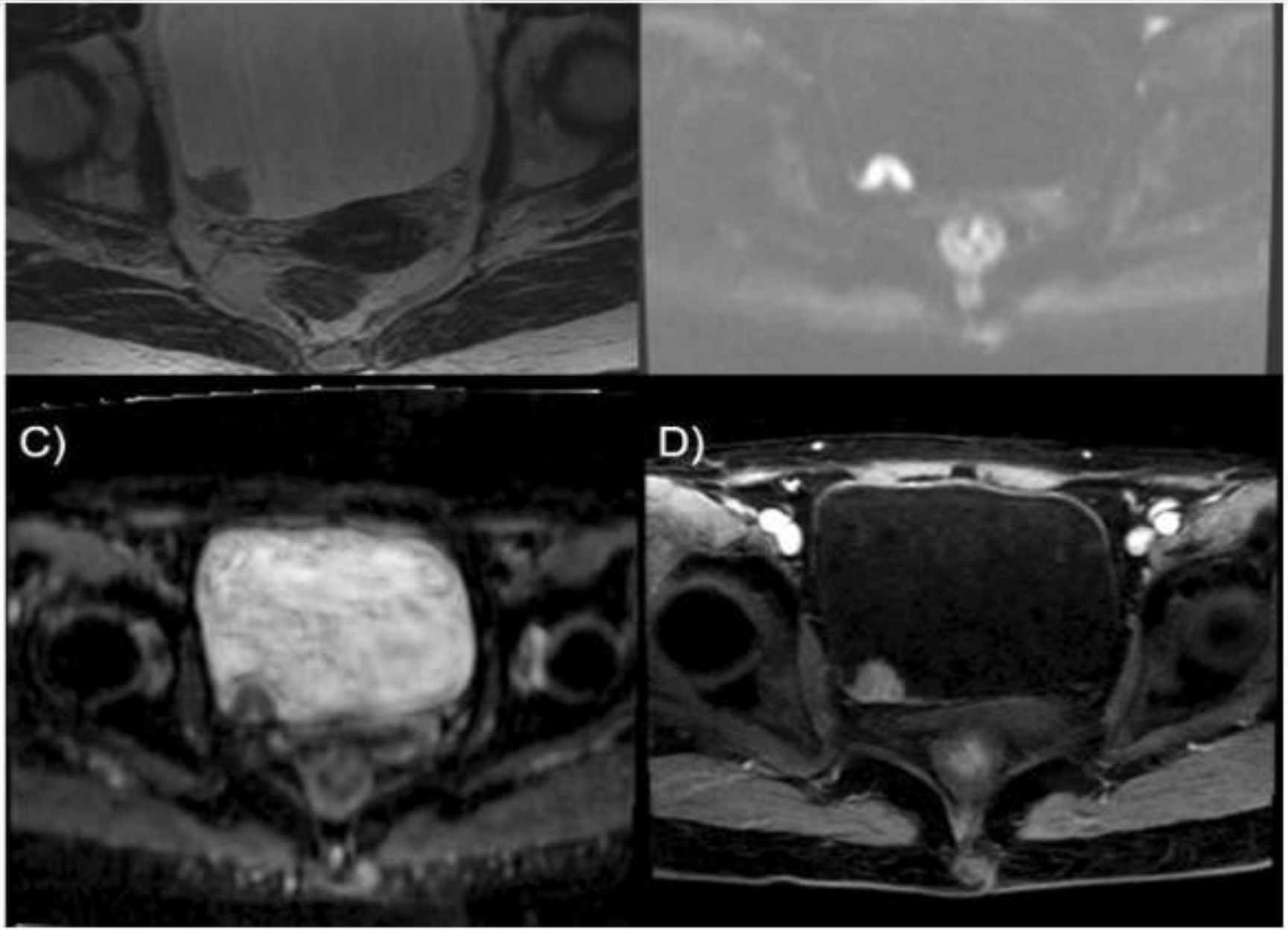
- The final score is firstly based on T2W imaging for the morphology, because of their high spatial resolution in the evaluation of the integrity of muscularis propria.
- The presence of definitive muscular invasion is decided by DWI and DCE MRI. If there is any discordance between T2W and DCE sequences (a deviation of two categories between T2W and DCE MRI), DWI improves the accuracy when the image quality of DWI sequence is optimal.

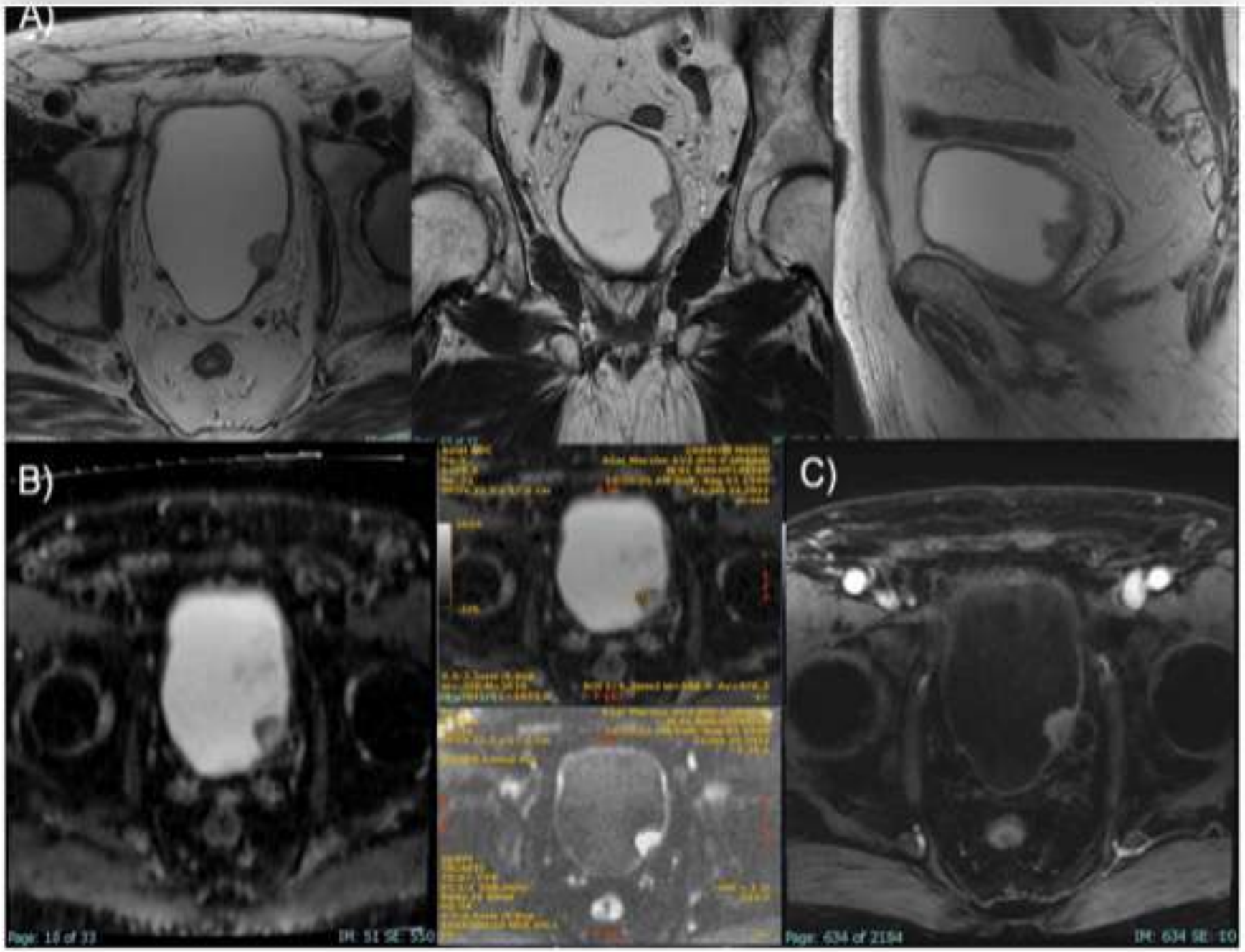
VI-RADS

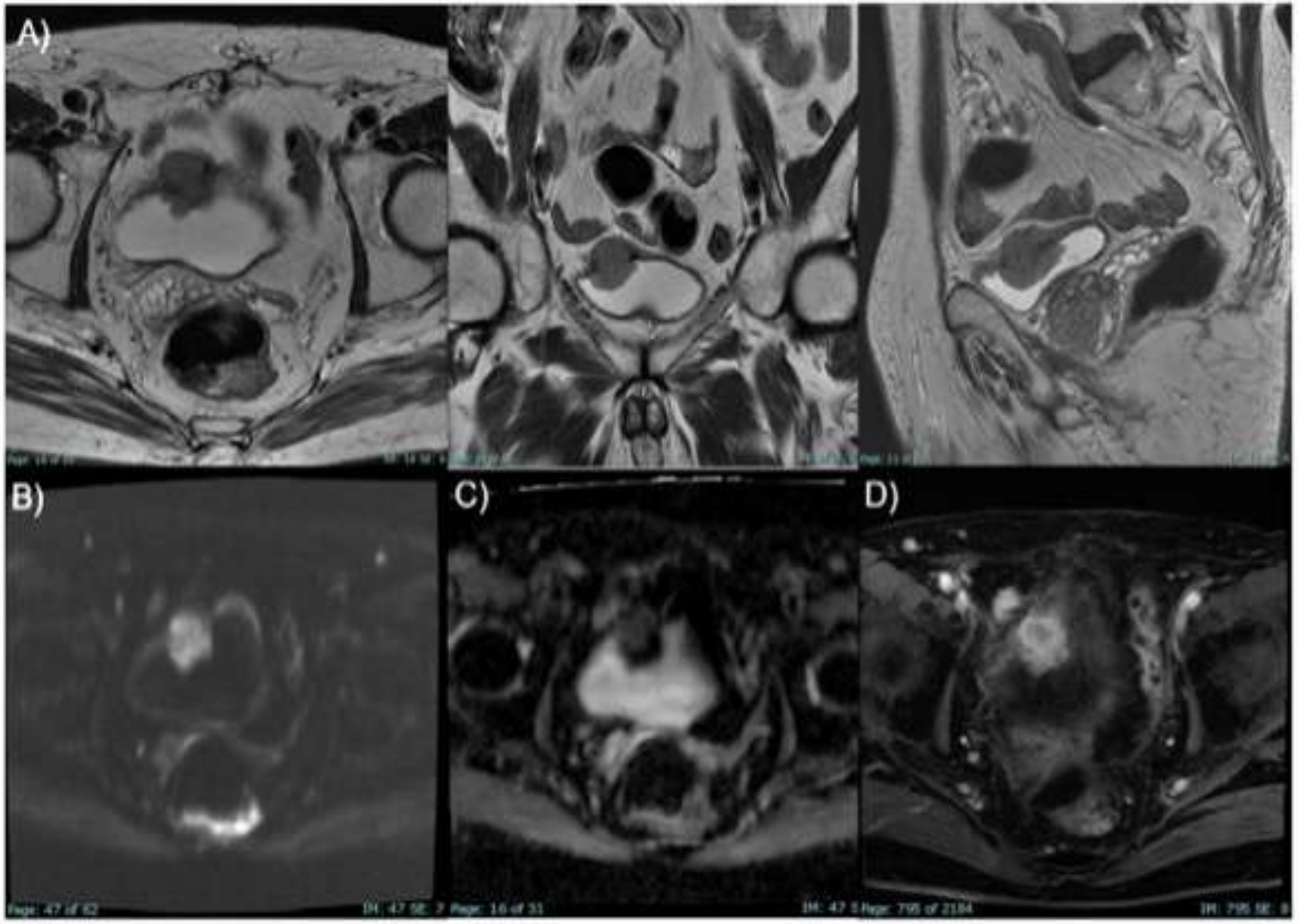
- VI-RADS 1 (muscle invasion is highly unlikely): SC, CE, and DW category 1
- VI-RADS 2 (muscle invasion is unlikely to be present): SC, CE, and DW category 2; both CE and DW category 2 with SC category 3
- VI-RADS 3 (the presence of muscle invasion is equivocal): SC, CE, and DW category 3; SC category 3, CE or DW category 3, the remaining sequence category 2
- VI-RADS 4 (muscle invasion is likely): at least SC and/or DW and CE category 4; the remaining category 3 or 4; SC category 3 plus DW and/or CE category 4; SC category 5 plus DW and/or CE category 4
- VI-RADS 5 (invasion of muscle and beyond the bladder is very likely): at least SC plus DW and/or CE category 5; the remaining category 4 or 5

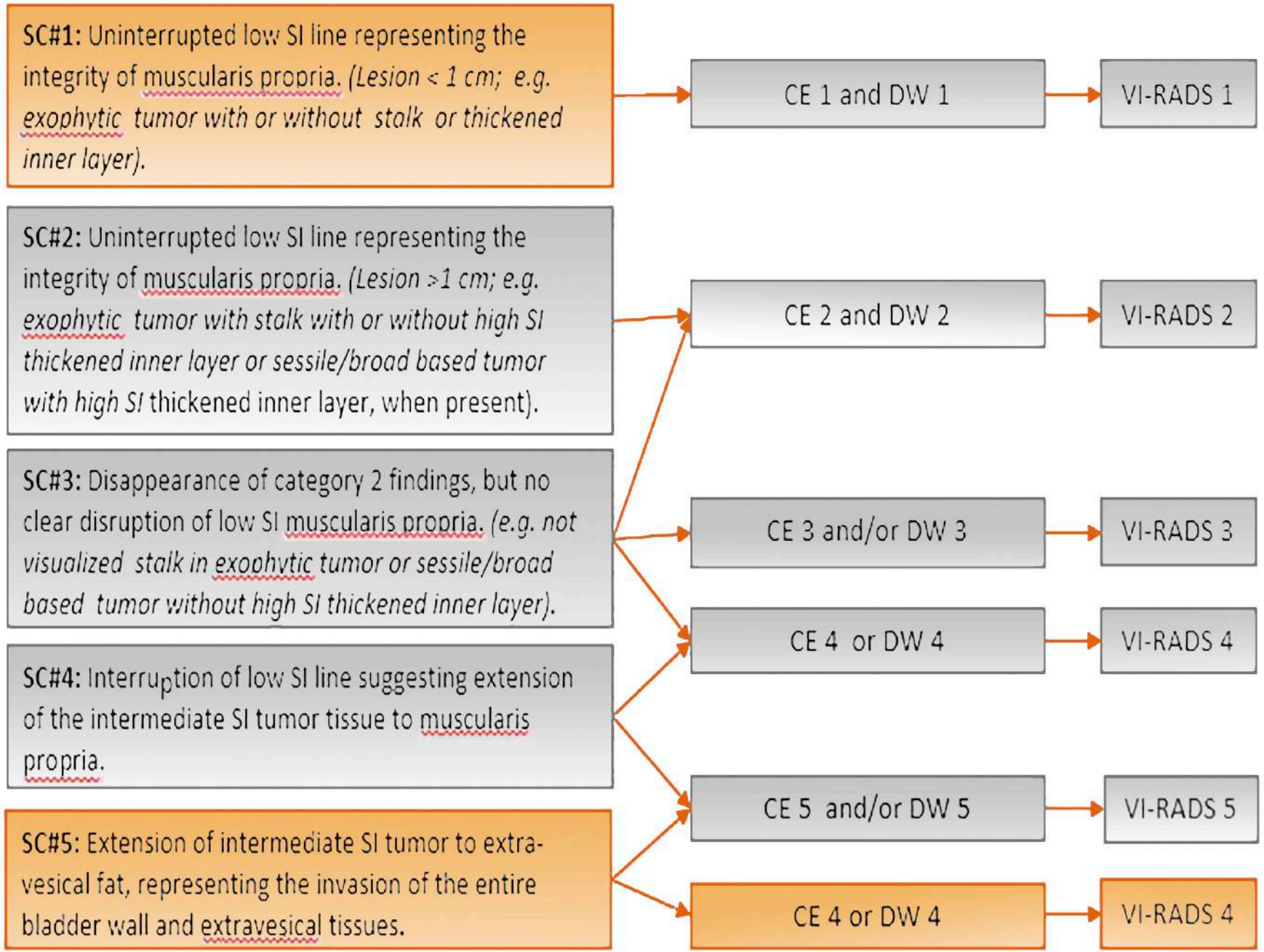

T2W
DCEMRI
DWI
ADC
VIRADS 1: Uninterrupted low SI line representing muscularis integrity. <1.0 cm size.
VIRADS 2: As VIRADS #1 but >1.0 cm and thickened inner layer.
VIRADS 3: Disappearance of category 2 findings, but no clear disruption of low SI muscularis layer.
VIRADS 4: Interruption of low SI line suggesting extension into muscularis layer.
VIRADS 5: Extension of intermediate SI tumor to extra-vesical fat.
Stalk
Cancer
Inner layer (IL)
Muscularis
Cancer & IL
Stalk
Muscularis
Cancer
Stalk & IL
Muscularis
Cancer & IL
Stalk
Muscularis


VI-RADS 5
VI-RADS 4
VI-RADS 3
VI-RADS 2
VI-RADS 1
T2WI
DCE
DWI


C)
D)


A)
B)
C)

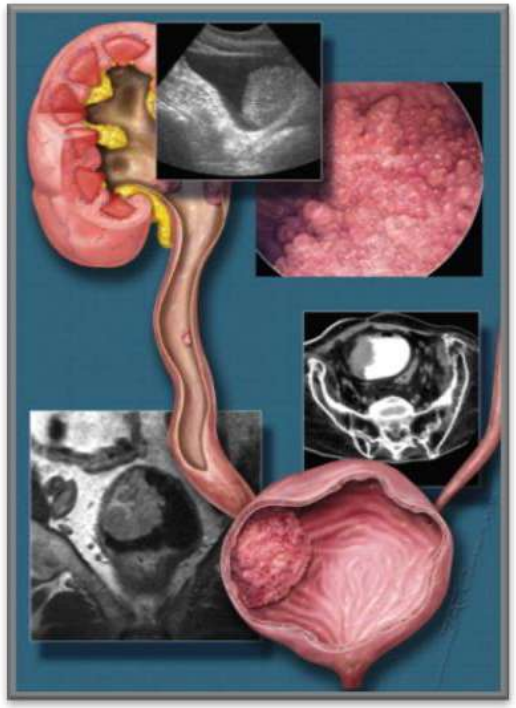

A)
B)
C)
D)


SC#1: Uninterrupted low SI line representing the integrity of muscularis propria. (Lesion < 1 cm; e.g. exophytic tumor with or without stalk or thickened inner layer).
SC#2: Uninterrupted low SI line representing the integrity of muscularis propria. (Lesion >1 cm; e.g. exophytic tumor with stalk with or without high SI thickened inner layer or sessile/broad based tumor with high SI thickened inner layer, when present).
SC#3: Disappearance of category 2 findings, but no clear disruption of low SI muscularis propria. (e.g. not visualized stalk in exophytic tumor or sessile/broad based tumor without high SI thickened inner layer).
SC#4: Interruption of low SI line suggesting extension of the intermediate SI tumor tissue to muscularis propria.
SC#5: Extension of intermediate SI tumor to extra-vesical fat, representing the invasion of the entire bladder wall and extravesical tissues.
CE 1 and DW 1
VI-RADS 1
CE 2 and DW 2
VI-RADS 2
CE 3 and/or DW 3
VI-RADS 3
CE 4 or DW 4
VI-RADS 4
CE 5 and/or DW 5
VI-RADS 5
CE 4 or DW 4
VI-RADS 4

Interobserver agreement for the Vesical Imaging-Reporting and Data System (VI-RADS) in differentiating non-muscle-invasive and muscle-invasive urinary bladder tumors

Lecturer in-charge : Dr Shafora Bibi Samri
Registrar : Dr Tasnim
Mmed Phase II : Dr Elfira Isma
Mmed Phase I : Dr Fatin Farhana

Transitional cell carcinoma (TCC) = urothelial carcinoma



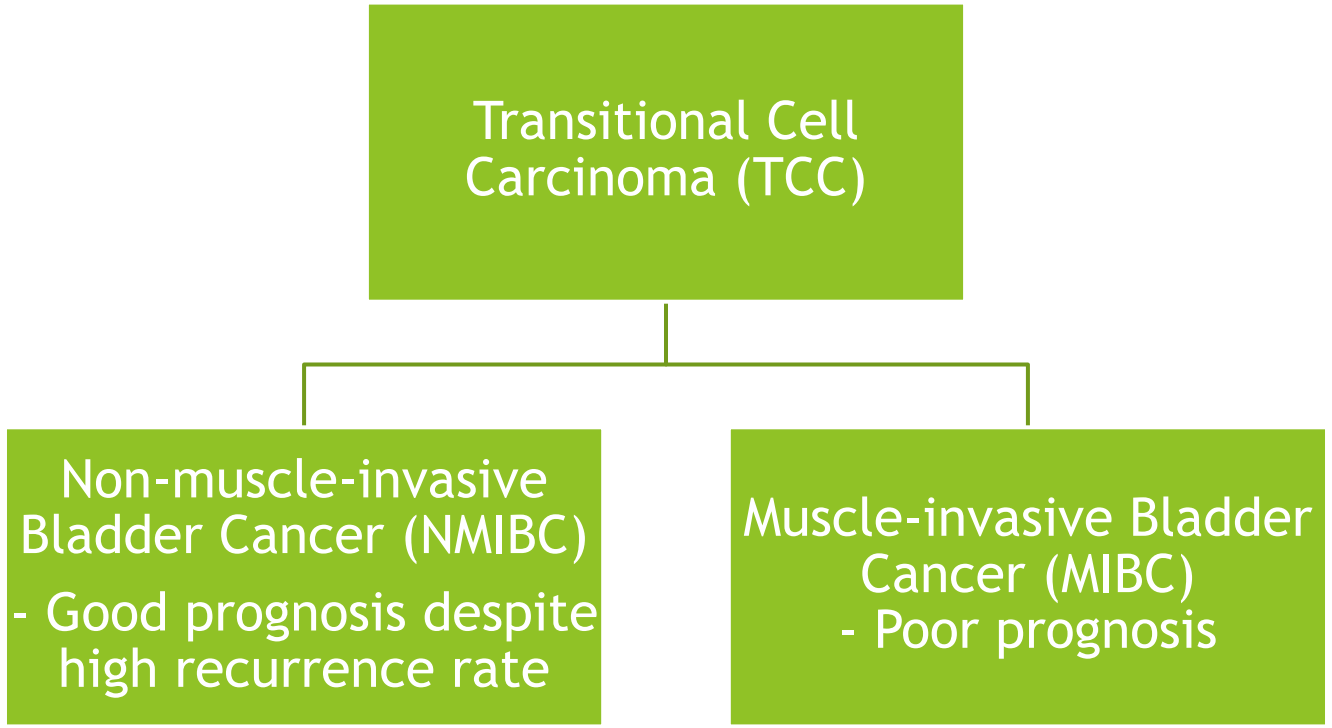
- Most common primary **malignancy of the urinary tract** and may be found along its entire length, from the renal pelvis to the bladder.
- Distribution:

  - renal pelvis: uncommon ~2-3%

  - ureter: least common ~1%

  bladder: by far the most common ~97%

Bladder Cancer



Radiology Imaging Shift

Excretory Urography (IVP @ IVU)

Cross Sectional modalities : USG, CT, MRI

Multiparametric MRI (mp MRI) = DWI, DCE, T2W

Why? To improve tumor detection, staging, assessment of treatment response and detect recurrence.

GOLD STANDARD : Cystoscopy and biopsy to diagnose urothelial tumor

VI-RADS
*Panebianco et al. (2018)

- It is a standardized mp-MRI protocol to evaluate the risk of muscle invasion by bladder cancer using T2-WI structural categorization, DWI, and DCE-MRI

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European Association of Urology

Platinum Priority – Review – Bladder Cancer
Editorial by XXX on pp. x–y of this issue

Multiparametric Magnetic Resonance Imaging for Bladder Cancer: Development of VI-RADS (Vesical Imaging-Reporting And Data System)

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Abstract

Context: Management of bladder cancer (BC) is primarily driven by stage, grade, and biological potential. Knowledge of each is derived using clinical, histopathological, and radiological investigations. This multimodal approach reduces the risk of error from one particular test, but may present a staging dilemma when results conflict. Multiparametric magnetic resonance imaging (mpMRI) may improve patient care through imaging of the bladder with better resolution of the tissue planes than computed tomography and without radiation exposure.
Objective: To define a standardized approach to imaging and reporting mpMRI for BC, by developing a VI-RADS score.
Evidence acquisition: We created VI-RADS (Vesical Imaging-Reporting And Data System) through consensus using existing literature.
Evidence synthesis: We describe standard imaging protocols and reporting criteria (including size, location, multiplicity, and morphology) for bladder mpMRI. We propose a five-point VI-RADS score, derived using T2-weighted MRI, diffusion-weighted imaging, and dynamic contrast enhancement, which suggests the risks of muscle invasion. We include sample images used to understand VI-RADS.
Conclusions: We hope that VI-RADS will standardize reporting, facilitate comparisons between patients, and in future years, will be tested and refined if necessary. While we do not advocate mpMRI for all patients with BC, this imaging may compliment pathology or reduce radiation-based imaging. Bladder mpMRI may be most useful in patients with non–muscle-invasive cancers, in expediting radical treatment or for determining response to bladder-sparing approaches.
Patient summary: Magnetic resonance imaging (MRI) scans for bladder cancer are becoming more common and may provide accurate information that helps improve patient care. Here, we describe a standardized reporting criterion for bladder MRI. This should improve communication between doctors and allow better comparisons between patients.

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E-mail address: valeria.panebianco@uniroma1.it (V. Panebianco).

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METHODS : Patients Selection

- 38 patients (31 male + 7 female) with mean age of 62.26 ± 8.18 years were recruited from April 2021 until January 2022.

Diagnosed with urinary bladder cancer by cystoscopy or any previous radiologic examination with no age or sex predilection

(HPE proven)

- Contraindications to IV MRI contrast media
- Renal impairment
- Unfit for transurethral resection of bladder tumour (TURBT)
- Recent biopsy 1-2 days prior to MRI
- Non-TCC bladder cancer pathologically

METHODS : Technique of mp-MRI

MRI :

1.5T (Philips Achieva scanner, Healthcare, Netherlands) with an eight-channel phased-array coil

Sequences :
3 planes - T2W TSE
Axial - DWI/ADC, DCE, T1 fat suppressed three-dimensional-gradient echo sequence (THRIVE) pre and post contrast

Contrast :
0.1 mmol/kg of body weight of gadolinium-based contrast agent (gadoteric acid) at a rate of 2 ml/sec saline flush initial post-contrast acquisition after 15 s and five consecutive sequences taken every 15 s (Table 1).

Table 1 Multiparametric MRI protocol

	Axial T2-WI	Coronal T2-WI	Sagittal T2-WI	Axial DWI
TR	4385	7645	3000	2200
TE	100–115	100–115	100–115	63
FOV	27–32 cm	28–32 cm	16 cm	28–32 cm
Matrix	272 × 272	232 × 135	160 × 160	96 × 96
Slice thickness	3–4 mm	3–4 mm	3–4 mm	3 mm
Gap	0–0.5 mm	0–0.5 mm	0–0.5 mm	0.5–1 mm
Flip angle	90	90	90	90
Acquisition time	180 s	30 s	48 s	4:35 min
B value				0,400,800 s/mm^2

METHOD : Statistical Analysis

- Data were collected, revised, coded, and entered to the Statistical Package for Social Science (IBM SPSS) version 23.
- **Quantitative data** with parametric distribution were presented as mean, standard deviations, and ranges.
- **Qualitative variables** were presented as numbers and percentages.

METHODS : Mp-MRI analysis and interpretation

- MR images were interpreted independently by **three radiologists** from the same institution with diferent levels of expertise:
  - **Reader 1** : consultant of more than 5 years
  - **Reader 2** : resident of 2.5 years
  - **Reader 3** : consultant of more than 10 years
- All readers were blinded to histopathology results

- The assessments for T2W structural category (SC), diffusion weighted imaging category (DW), dynamic contrast enhanced imaging category (CE), and VI-RADS scores were assigned to each lesion as follows:

VI-RADS 1 (muscle invasion is highly unlikely)	VI-RADS 2 (muscle invasion is unlikely to be present)	VI-RADS 3 (the presence of muscle invasion is equivocal)	VI-RADS 4 (muscle invasion is likely)	VI-RADS 5 (invasion of muscle and beyond the bladder is very likely)
Category 1 • SC • CE • DW	Category 2 • SC • CE • DW OR • CE + DW (category 2) • SC (category 3)	Category 3 • SC • CE • DW OR • SC (category 3) • CE / DW (category 3) • Remaining sequence is category 2	Category 4 • SC or/and DW • CE • Remaining category 3 or 4 OR • SC (category 3) + DW and/or CE (category 4) OR • SC (category 5) + DW and/or CE (category 4)	Category 5 • SC • DW and/or CE • Remaining category 4 or 5

REVISION…

STRUCTURAL CATEGORIES (SC)

CATEGORY	
SC 1	• uninterrupted low SI line representing the integrity of muscularis propria • lesion <1cm • exophytic tumor with stalk and/or high SI thickened inner layer
SC 2	• uninterrupted low SI line representing the integrity of muscularis propria • lesion >1 cm • exophytic tumor with stalk and/or high SI thickened inner layer, when present, or sessile/broad-based tumor with high SI thickened inner layer, when present
SC 3	• lack of category 2 findings with associated presence of an exophytic tumor without stalk; OR • or sessile/broad-based tumor without high SI thickened inner layer but with no clear disruption of low SI muscularis propria
SC 4	• interruption of low SI line suggesting extension of the intermediate SI tumor tissue to muscularis propria
SC 5	• extension of intermediate SI tumor to extravesical fat, representing the invasion of the entire bladder wall and extravesical tissues

CONTRAST-ENHANCED (CE) CATEGORIES

CATEGORY	
CE 1	No early enhancement of the muscularis propria (lesions corresponding to SC 1 findings)
CE 2	No early enhancement of muscularis propria with early enhancement of inner layer (lesions corresponding to SC 2 findings)
CE 3	Lack of category 2 findings (lesions corresponding to SC category 3 findings) but with no clear disruption of low SI muscularis propria
CE 4	Tumor early enhancement extends focally to muscularis propria
CE 5	Tumor early enhancement extends to the entire bladder wall and to extravesical fat

DIFFUSION WEIGHTED (DW) CATEGORIES

CATEGORY	
DW 1	• muscularis propria with intermediate continuous SI on DWI • lesion <1 cm • hyperintense on DWI • hypointense on ADC • with or without stalk and/or low SI thickened inner layer on DWI
DW 2	• muscularis propria with continuous intermediate SI on DWI • lesion >1 cm • hyperintense on DWI • hypointense on ADC • with low SI stalk and/or low SI thickened inner layer on DWI, or broad-based/ sessile tumor with low/intermediate SI thickened inner layer on DWI
DW 3	• lack of category 2 findings (lesions corresponding to T2 category 3 findings) but with no clear disruption of low SI muscularis propria.
DW 4	• High SI tumor on DWI and low SI tumor on ADC extending focally to muscularis propria.
DW 5	• High SI tumor on DWI and low SI tumor on ADC extending to the entire bladder wall and extravesical fat

Examples…

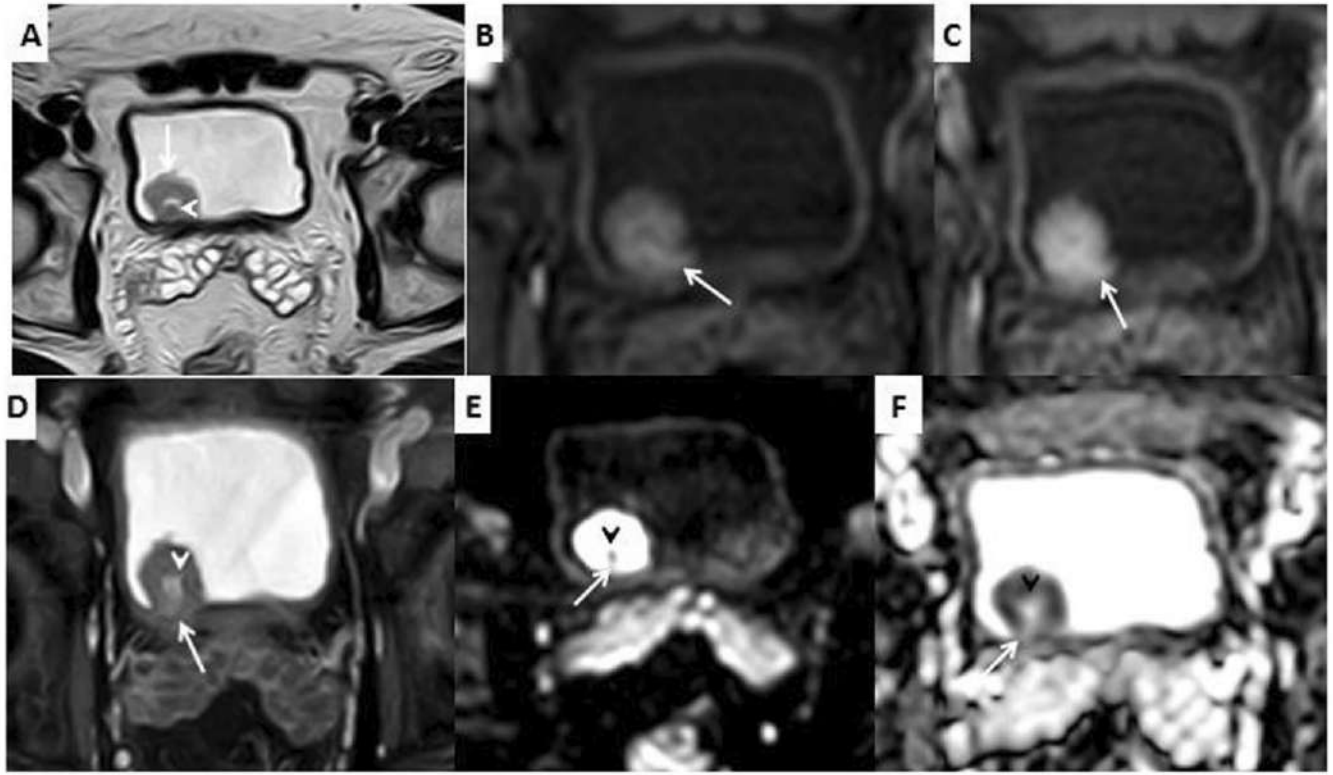


Fig. 1 **A** T2-WI shows a tumor at right posterior urinary bladder wall (arrow) with a stalk (arrowhead). The VI-RADS score for SC category was 2. **B–D** Axial DCE with early and delayed phases shows early enhancement of the submucosa and uninterrupted muscle layer (arrows) and enhancing stalk (arrow heads). The VI-RADS score for CE category was 2. **E**, **F** Axial DWI and ADC map show restricted diffusion of the tumor with ADC value 0.994×10^{-3} mm^2/s with a stalk connecting to the posterior bladder wall (arrows). The VI-RADS score for DW category was 2. Final VI-RADS score is 2, denoting that muscle invasion is unlikely to be present. Pathology proved low-grade papillary TCC with no invasion of the muscularis propria

VIRADS 2

VIRADS 4

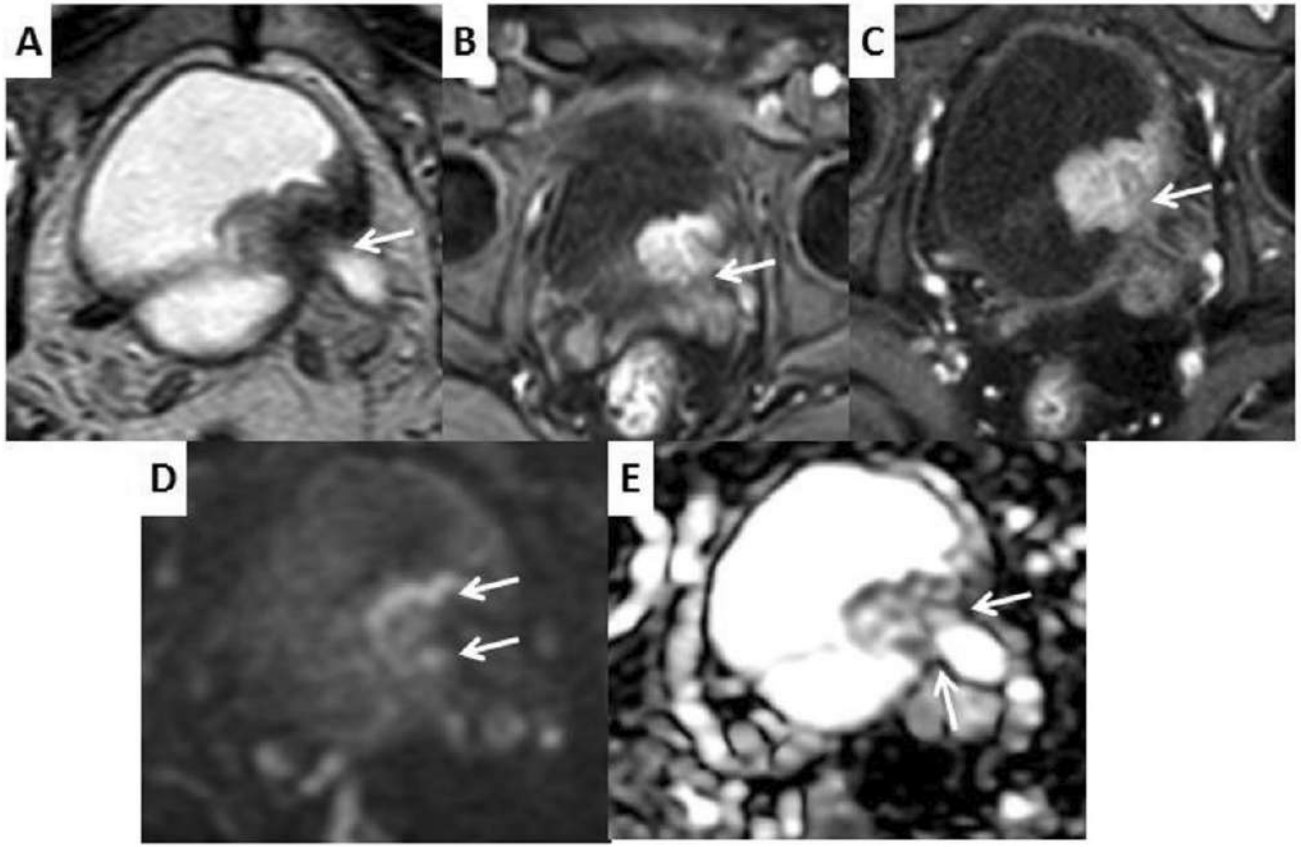


Fig. 4 **A** T2-WI shows a tumor at the left lateral wall of the bladder near the vesicoureteric junction with interruption of the low SI muscularis propria and mild ureteric dilatation (arrow). The VI-RADS score for SC category was 4. **B**, **C** Axial DCE with early and delayed phases shows tumor at left lateral wall with no early enhancement of the muscularis propria (arrow). The VI-RADS score for CE category was 3. **D**, **E** Axial DW image and ADC map show minimal restricted diffusion, no clear interruption of the muscle layer (arrows). The VI-RADS score for DW category was 3. Final VI-RADS score is 3, denoting that the presence of muscle invasion is equivocal. Pathology proved high TCC with invasion of the muscularis propria

VIRADS 5

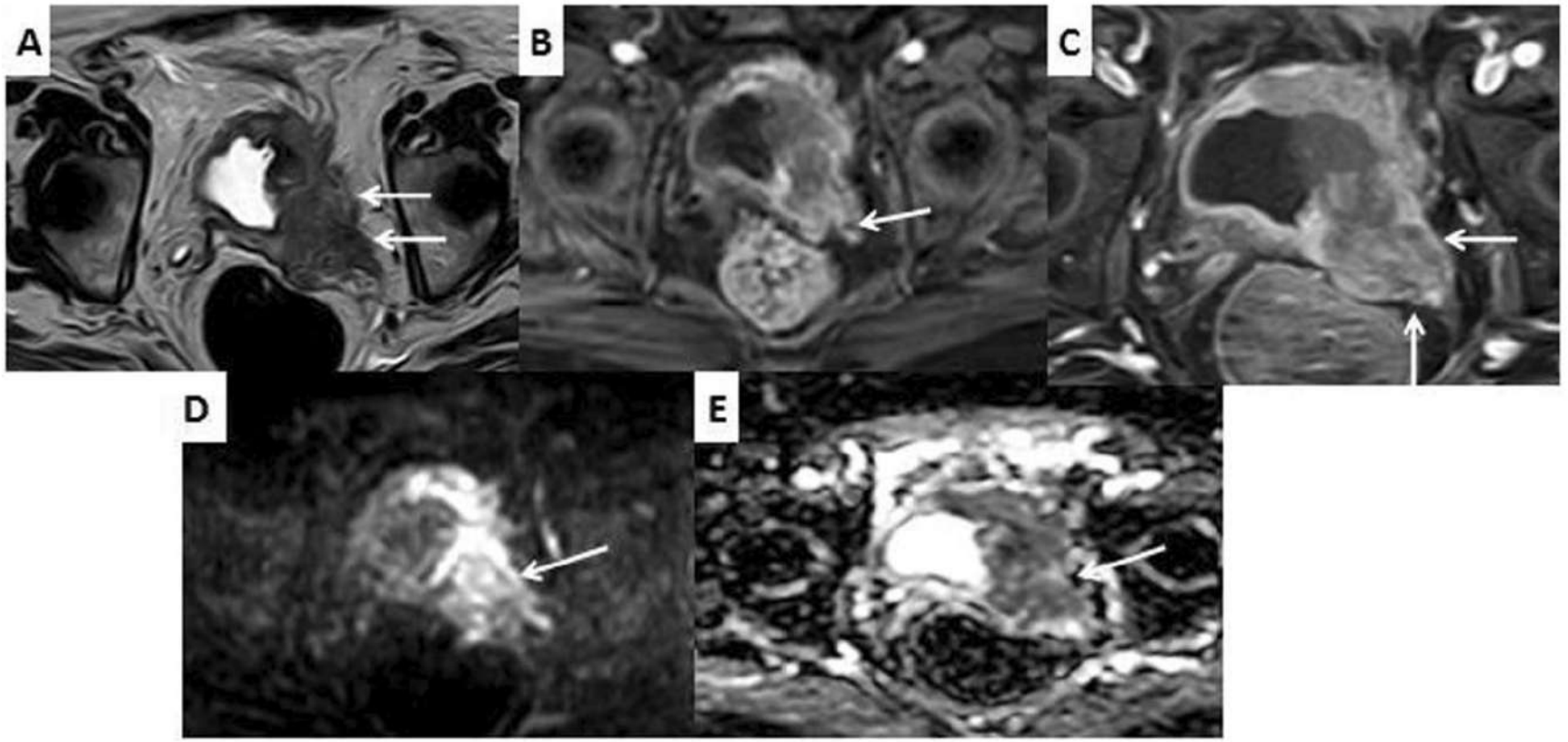
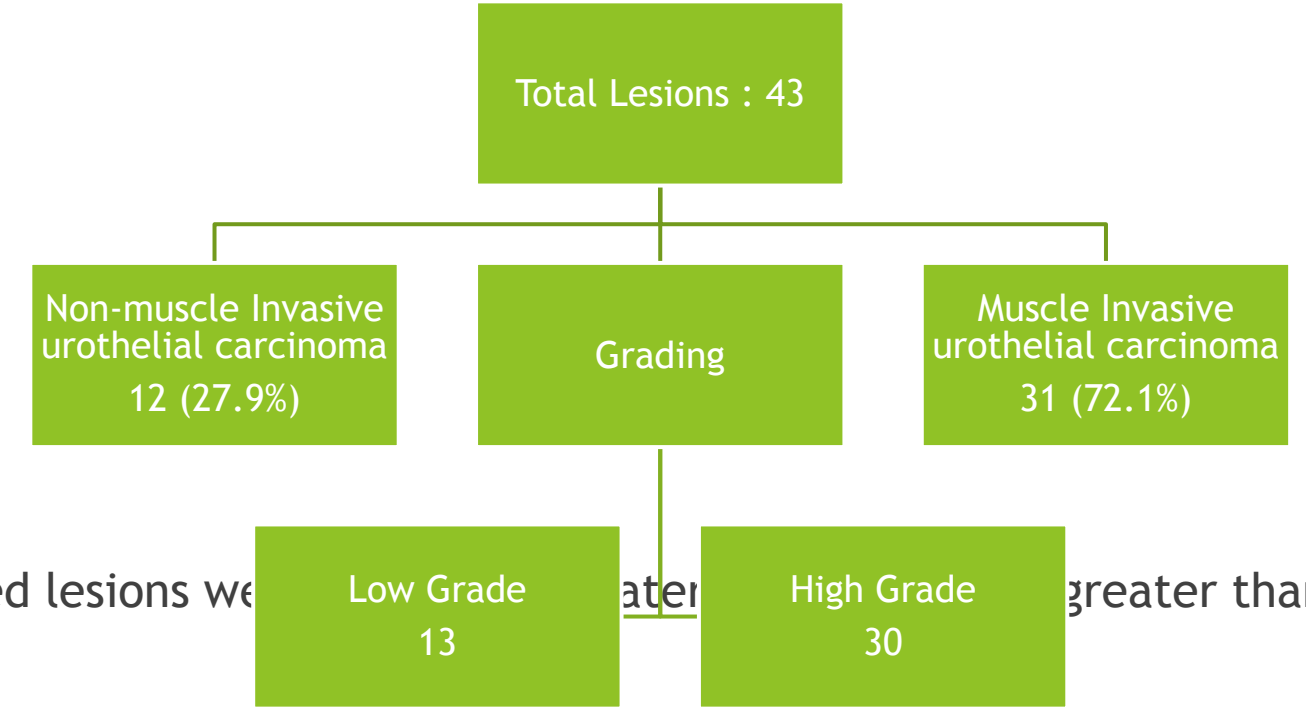


Fig. 3 **A** T2-WI shows tumor at the anterior and left posterolateral sides of the bladder with extravesical tumor mass (arrows), SC category 5. **B**, **C** Axial DCE with early and delayed phases shows enhancement of the tumor at the anterior and left posterolateral walls with extravesical mass (arrows), CE category 5. **D**, **E** Axial DWI and ADC map show restricted diffusion of the tumor with ADC value 0.694×10^{-3} mm^2/s at the anterior and left posterolateral walls with extravesical mass (arrow), DW category 5. Final VI-RADS score is 5, meaning that invasion of muscle and beyond the bladder is very likely. Pathology proved high-grade TCC with invasion of the muscularis propria

RESULTS

Total Patients : 38 (31 male + 7 female)



Most of the studied lesions we ater greater than 3 cm in size and showed no stalk.

Highly significant correlation

- Regarding the tumor contact length (TCL) and the presence of stalk with the presence or absence of muscle invasion

Significant correlation

- Regarding the tumor size and pathologic result at cut of value≥3 cm

Nonsignificant

- ADC value statistic

All parameters individually and collectively showed highly significant correlation with the histopathological results for all readers.

Table 2 Relation between pathology with lesions' characteristics

	Pathology		Test value	*P* value	Sig.
	Non-muscle invasive	Muscle invasive			
	No. = 12	No. = 31			
Location of lesions					
Neck	0 (0.0%)	2 (6.5%)	0.812*	0.368	NS
Trigone	1 (8.3%)	3 (9.7%)	0.019*	0.892	NS
Dome	1 (8.3%)	5 (16.1%)	0.438*	0.508	NS
Anterior wall	1 (8.3%)	4 (12.9%)	0.176*	0.675	NS
Posterior wall	3 (25.0%)	1 (3.2%)	4.862*	0.027	S
Lateral walls	4 (33.3%)	16 (51.6%)	1.162*	0.281	NS
Circumferential	0 (0.0%)	5 (16.1%)	2.190*	0.139	NS
Ureteral orifice	1 (8.3%)	3 (9.7%)	0.019*	0.892	NS
Size					
< 3 cm	6 (50.0%)	5 (16.1%)	5.213*	0.022	S
≥ 3 cm	6 (50.0%)	26 (83.9%)			
Tumor contact length (TCL) (cm)					
Median (IQR)	2.9 (1.65–3.75)	5 (3.8–7.6)	−2.682≠	0.007	HS
Range	1.4–8.2	1.1–16			
Stalk					
No	2 (16.7%)	30 (96.8%)	29.162*	0.000	HS
Yes	10 (83.3%)	1 (3.2%)			
ADC value ($\times 10^{-3}$ mm^2/s)					
Mean ± SD	1.03 ± 0.28	1.03 ± 0.23	0.028•	0.978	NS
Range	0.68–1.7	0.59–1.5			
T stage					
< T3	12 (100.0%)	1 (3.2%)	38.412*	0.000	HS
≥ T3	0 (0.0%)	30 (96.8%)			

P value > 0.05: Nonsignificant; *P* value < 0.05: Significant; *P* value < 0.01: Highly significant

*Chi-square test; •: Independent t test; ≠: Mann–Whitney test

- At cutoff value of VI-RADS score≥3

	Sensitivity	Specificity	Positive Predictive Value (PPV)	Negative Predictive Value (NPV)	Accuracy
Reader 1	96.8%	83.3%	93.8%	90.9%	93%
Reader 2	93.5%	91.7%	84.6%	93%	90%
Reader 3	96.8%	83.3%	93.8%	90.9%	93%

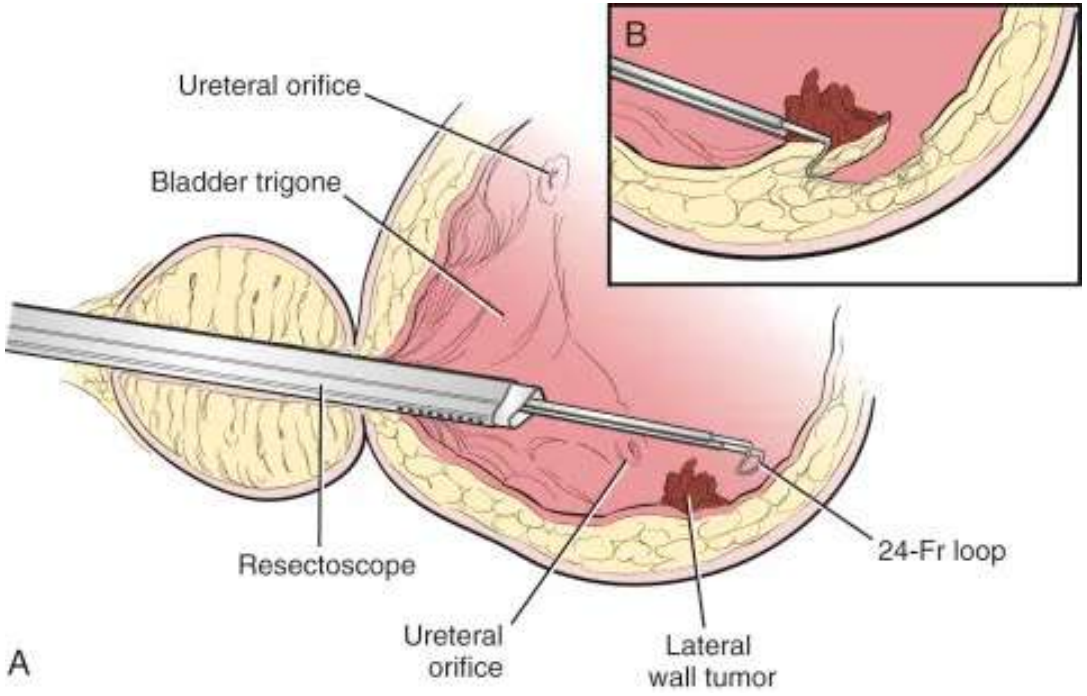
- The interobserver agreement between individual readers was excellent among all three readers (0.81–1.00)
- Kappa agreement was used to assess the agreement between each reader and the histopathological results and the readers with each other.
- Kappa result is interpreted as follows:

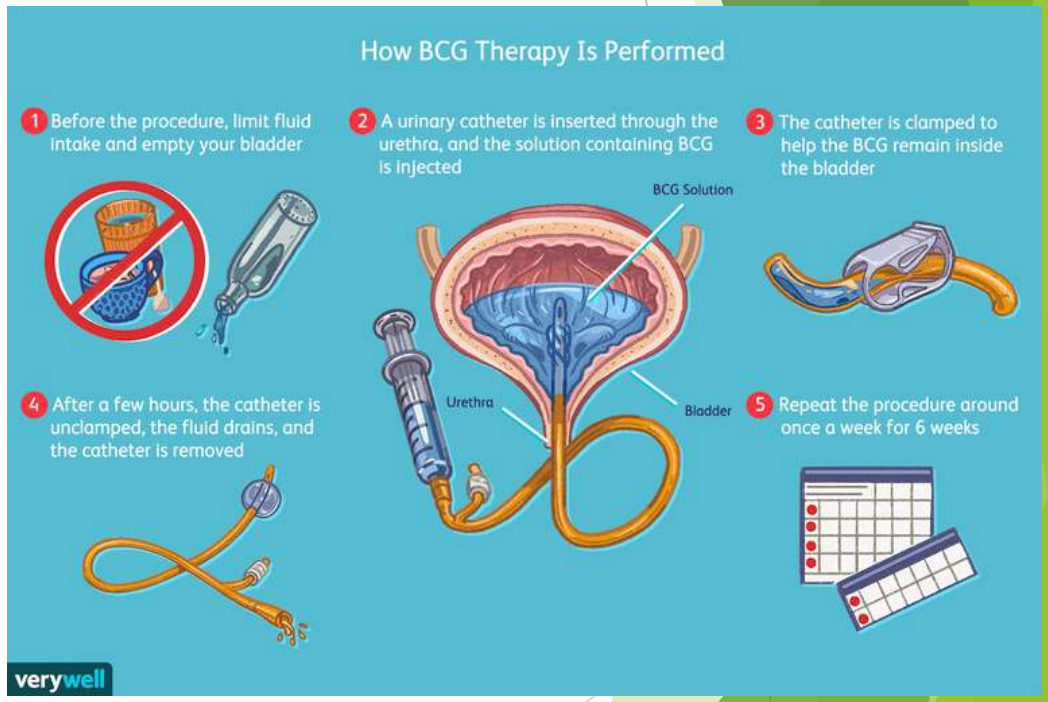
Values	
≤0	no agreement
0.01–0.20	none to slight
0.21–0.40	fair
0.41–0.60	moderate
0.61–0.80	substantial
0.81–1.00	excellent or almost perfect agreement

DISCUSSIONS

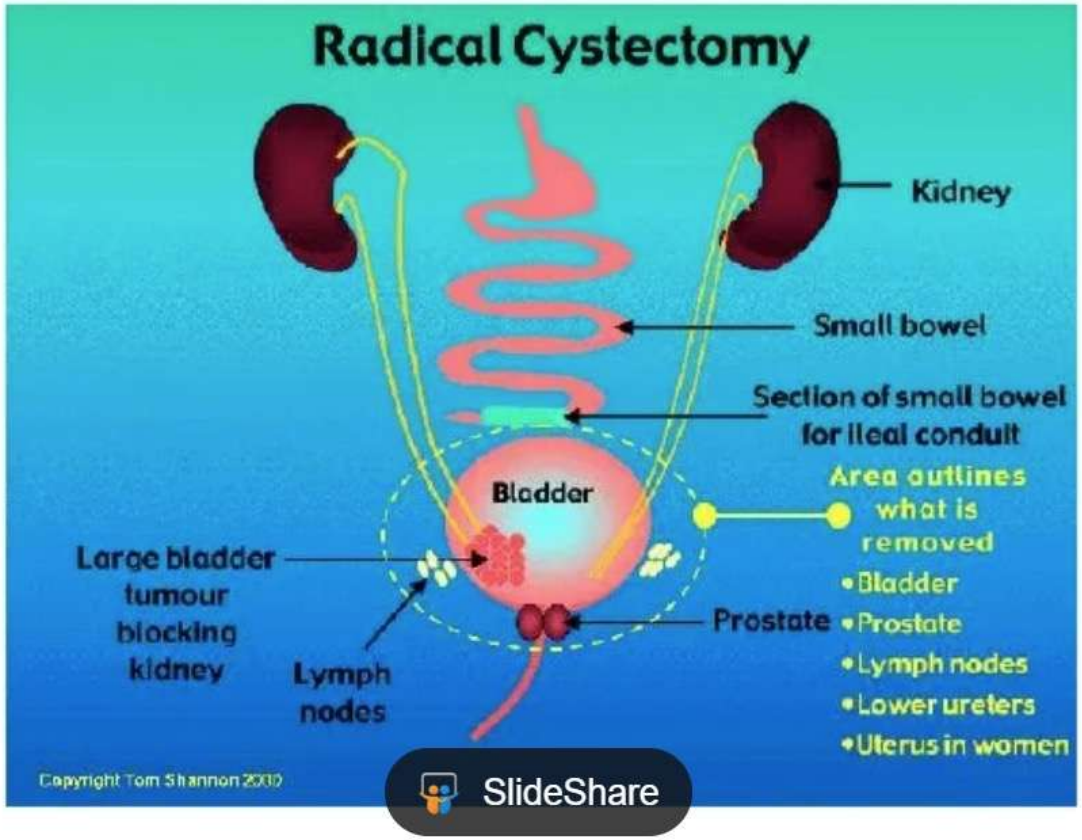
- Evaluation of muscle invasion is essential in staging and treatment planning for urinary bladder (UB) cancer.
- NMIBC : transurethral resection with or without intravesical Bacillus Calmette–Guerin (BCG) instillations is recommended.
- MIBC : undergo radical cystectomy with or without neoadjuvant chemotherapy.
- VI-RADS to standardize MRI acquisition and interpretation for UB cancer.
- Preliminary results indicate that the performance of the VI-RADS is satisfactory regarding sensitivity, specifcity, and overall accuracy was high

NMIBC : TURBT WITH @ WITHOUT BCG





Mibc : Radical cystectomy with @ without neoadjuvant chemotherapy



- Tumors scored as VI-RADS 4 and 5 were proved to be muscle-invasive cancer based on pathologic examination (n=29, 67.4%).
- Tumors scored as VI-RADS 2 by the more experienced readers (reader 1 and 3) (n=11, 25.6%) all of them were correctly staged except one and verified as nonmuscle invasive (90.9%).
- Tumors scored as VI-RADS 2 by the less experienced reader (reader 2) (n=13, 30.2%), 3 of them were incorrectly staged and were proven to be muscle invasive (23.07%).
- Tumors scored as VI-RADS 3 (equivocal for muscle invasion) by the more experienced readers (n=3, 7%), all were confirmed to be muscle-invasive cancer.
- No lesions were scored as VI-RADS 1 attributed to the late presentation.

Quantitative indicators for predicting muscle layer invasion of bladder cancer

- tumor size at cutof≥3 cm : bigger tumors are more likely to be muscle invasive
- tumor contact length (TCL) : highly signifcant results for detection of MIBC (further studies are needed)
- ADC values : statistically nonsignifcant to assess muscle invasion to predict the tumor grade. Likely attributed to the small number of studied lesions and high grades of most of the lesions.

VI-RADS can detect muscle invasion when the VI-RADS score is 3 or greater.

- Our study suggests that most of the lesions with fibrovascular stalk (10 out of 12 lesions) were proved to be NMIBC.
- Results showed that for tumors scored as VI-RADS 4 and 5, the VI-RADS system achieved an accuracy of 100% in predicting muscle invasion.

When to perform MRI?

- Due to the absence of reliable method to avoid or measure reactive change in the bladder wall after TURBT, bladder biopsy, or intravesical treatment, MRI examination is best performed before or at least 2 weeks post to intervention.
- 2–3-day interval between cystoscopy and removal of Foley catheter as air in the bladder, from cystoscopy or indwelling catheter, can cause distortion of DWI due to susceptibility artifact.

Limitations

- Most of the cases were MIBC due to their late presentation which might have caused a bias in the resulting statistics.
- VI-RADS is still unfamiliar to many physicians and is still under modifcation.

Conclusions

- VI-RADS is an effective comprehensive method showing satisfactory sensitivity, specificity, and diagnostic value for detecting MIBC.
- VI-RADS shows excellent interobserver agreement regardless the reader's experience.

THANK YOU

Critical appraisal

overview

Not stating date received, accepted and published online

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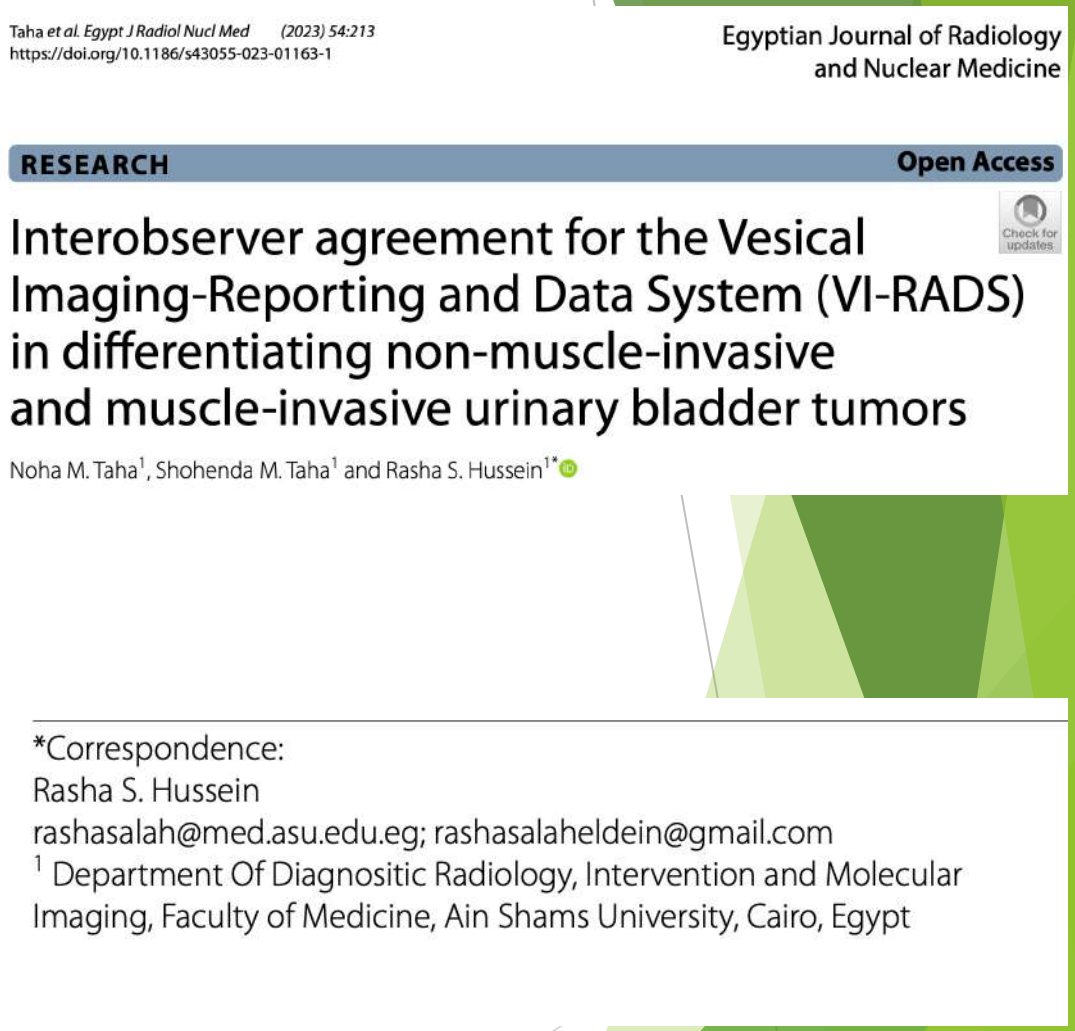
Author and institution clearly stated

Clearly described title



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RESEARCH Open Access

Interobserver agreement for the Vesical Imaging-Reporting and Data System (VI-RADS) in differentiating non-muscle-invasive and muscle-invasive urinary bladder tumors

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Abstract

- Concise explanation on the background, objectives, results and conclusion of the study

Abstract

Background Bladder cancer is the most common tumor of the genitourinary tract. Transitional cell carcinoma is divided into two categories: non-muscle-invasive bladder cancer (NMIBC) and muscle-invasive bladder cancer (MIBC). In spite of the high recurrence rate, NMIBC has good prognosis, while MIBC has poor prognosis due to local organ invasion and metastases. Mp-MRI shows better tumor detection and staging. The aim of this study is to validate VI-RADS in detecting MIBC and assessing interobserver agreement and impact of reader's experience.

Results At cutoff value of VI-RADS score ≥ 3, the VI-RADS showed sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and accuracy of 96.8%,83.3%, 93.8%, 90.9%, and 93%, respectively, for reader 1, 93.5%, 91.7%, 84.6%, and 93% for reader 2, and 96.8%,83.3%, 93.8%, 90.9%, and 93% for reader 3. The interobserver agreement between individual readers was excellent among the three readers.

Conclusions Vesical imaging-reporting and data system (VI-RADS) is a good method showing satisfactory sensitivity, specificity, and diagnostic value for detecting detrusor muscle invasion.

Keywords NMIBC, MIBC, Mp-MRI, VI-RADS

Introduction

Background

Transitional cell carcinoma (TCC) is divided into two categories: non-muscle-invasive bladder cancer (NMIBC) and muscle-invasive bladder cancer (MIBC) [1]. In spite of the high recurrence rate, NMIBC has good prognosis, while MIBC has poor prognosis due to local organ invasion and metastases [2].

Previously, excretory urography was used to investigate gross hematuria and suspected urothelial tumor. Now, imaging was shifted to ultrasonography (US) and cross-sectional modalities such as computed tomography (CT) and magnetic resonance (MR) imaging. Cystoscopy and biopsy are the gold standard for diagnosis of urothelial tumor. Imaging is mandatory for proper staging and treatment planning [3].

Multiparametric MRI (mp-MRI) is recently introduced and it combines functional sequences as diffusion-weighted imaging (DWI) and dynamic contrast-enhanced MRI (DCE-MR) with anatomic T2-weighted images (T2-WI). This improves tumor detection, staging, assessment of treatment response, and detects recurrence [4].

The interpretation of the presence of muscle invasion may vary between radiologists. Therefore, standardized and systematic reporting increases interobserver agreement, and improves communication between different specialists. Panebianco et al. proposed the vesical imaging-reporting and data system (VI-RADS). It is a standardized mp-MRI protocol to evaluate the risk of muscle invasion by bladder cancer using T2-WI structural categorization, DWI, and DCE-MRI [5, 6].

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- Explained the need of mpMRI to stage patient into NMIBC or MIBC for treatment planning
- Introduction of VIRADS scoring via T2W structural category, DWI and DCE-MRI

Methods and analysis

- Single center study
- Data obtained in short interval between April 2021 to January 2022
- Sample size adequate and clearly written
- Inclusion and exclusion criteria clearly stated

Methods

Patients

Thirty-eight patient, with a mean age of 62.26 ± 8.18 years, were included in this study. Patients were recruited from urology clinics in our hospitals from April 2021 to January 2022.

Inclusion criteria were patients diagnosed with urinary bladder cancer by cystoscopy or by any previous radiologic investigations with no age or sex predilection. Exclusion criteria were any contraindications to intravenous MRI contrast administration, e.g., allergy to IV contrast, high serum creatinine, low GFR or severe renal impairment; patients who were unfit for transurethral resection of bladder tumor (TURBT), e.g., as those unfit for anesthesia or with urethral stricture; patients who underwent recent biopsy within 1–2 days before MRI; and pathology was non-TCC bladder cancer. The study was done after the approval of our ethical committee which waived the requirement for written consent.

Technique of Multiparametric-MRI examination

The MRI examination was done using 1.5 T MRI (Philips Achieva scanner, Healthcare, Netherlands) with an eight-channel phased-array coil. A respiratory belt was placed around patient abdomen for synchronization of patient breath. T2-weighted turbo spin-echo images were acquired in three orthogonal planes (axial, sagittal, and coronal). Axial DWI with ADC was done. Axial dynamic contrast-enhanced imaging (DCE) axial T1 fat suppressed three-dimensional-gradient echo sequence (THRIVE) before and after IV injection of 0.1 mmol/kg of body weight of gadolinium-based

MRI scanning parameters stated

Technique of Multiparametric-MRI examination

The MRI examination was done using 1.5 T MRI (Philips Achieva scanner, Healthcare, Netherlands) with an eight-channel phased-array coil. A respiratory belt was placed around patient abdomen for synchronization of patient breath. T2-weighted turbo spin-echo images were acquired in three orthogonal planes (axial, sagittal, and coronal). Axial DWI with ADC was done. Axial dynamic contrast-enhanced imaging (DCE) axial T1 fat suppressed three-dimensional-gradient echo sequence (THRIVE) before and after IV injection of 0.1 mmol/kg of body weight of gadolinium-based contrast agent (gadoteric acid) at a rate of 2 ml/sec. followed by saline flush. An initial post-contrast acquisition was done 15 s after contrast injection, followed by five consecutive sequences taken every 15 s (Table 1).

Table 1 Multiparametric MRI protocol

	Axial T2-WI	Coronal T2-WI	Sagittal T2-WI	Axial DWI
TR	4385	7645	3000	2200
TE	100–115	100–115	100–115	63
FOV	27–32 cm	28–32 cm	16 cm	28–32 cm
Matrix	272×272	232×135	160×160	96×96
Slice thickness	3–4 mm	3–4 mm	3–4 mm	3 mm
Gap	0–0.5 mm	0–0.5 mm	0–0.5 mm	0.5–1 mm
Flip angle	90	90	90	90
Acquisition time	180 s	30 s	48 s	4:35 min
B value				0,400,800 s/mm^2

Data analysis

Analysis of data

Mp-MRI analysis and interpretation

- The MR images were interpreted independently by three radiologists from the same institution with different levels of expertise: two consultants of more than 5 and more than 10 years (readers 1 and 3) and a resident of 2.5 years (reader 2). All readers were blinded to histopathology results. The assessments for T2-WI structural category (SC), diffusion-weighted imaging category (DW), dynamic contrast-enhanced imaging category (DCE), and VI-RADS scores were assigned to each lesion as follows: (Panebianco et al. [4]).
- *VI-RADS 1 (muscle invasion is highly unlikely)* SC, CE, and DW category 1.
- *VI-RADS 2 (muscle invasion is unlikely to be present)* SC, CE, and DW category 2; both CE and DW category 2 with SC category 3.
- *VI-RADS 3 (the presence of muscle invasion is equivocal)* SC, CE, and DW category 3; SC category 3, CE or DW category 3, the remaining sequence category 2.
- *VI-RADS 4 (muscle invasion is likely)* at least SC and/or DW and CE category 4; the remaining category 3 or 4; SC category 3 plus DW and/or CE category 4; SC category 5 plus DW and/or CE category 4.
- *VI-RADS 5 (invasion of muscle and beyond the bladder is very likely)* at least SC plus DW and/or CE category 5; the remaining category 4 or 5.

Statistical analysis

Statistical analysis

- Data were collected, revised, coded, and entered to the Statistical Package for Social Science (IBM SPSS) version 23. The quantitative data with parametric distribution were presented as mean, standard deviations, and ranges. Also, qualitative variables were presented as numbers and percentages.

The following tests were done:

- Student *t* test was applied to compare parametric quantitative variables between two groups.
- Mann–Whitney test was applied for comparison of nonparametric quantitative variables between two groups
- Independent-samples *t* test of significance was used when comparing between two means.
- Chi-square (X2) test of significance was used in order to compare proportions between two qualitative parameters.
- Pearson's correlation coefficient (*r*) test was used for correlating data.
- Probability (*P* value)
  - *P* value < 0.05 was considered significant.
  - *P* value < 0.001 was considered as highly significant.
  - *P* value > 0.05 was considered insignificant.

- Kappa agreement was used to assess the agreement between each reader and the histopathological results and the readers with each other.
- Kappa result is interpreted as follows: values ≤ 0 as indicating no agreement and 0.01–0.20 as none to slight, 0.21–0.40 as fair, 0.41–0.60 as moderate, 0.61–0.80 as substantial, and 0.81–1.00 as excellent or almost perfect agreement.

Results

- The interobserver agreement between individual read ers was excellent among all three readers (0.81–1.00)
- Highly significant correlation was obtained regarding the tumor contact length (TCL) and the presence of stalk with the presence or absence of muscle invasion. Significant correlation was obtained regarding the tumor size and pathologic result at cutoff value≥3 cm. The ADC value was statistically nonsignificant in this studied group

Discussion

Comparison with other studies – agrees to other studies

1. meta-analysis by Huang et al. [14] which reported that multiparametric MRI has a good diagnostic performance for predicting MIBC.
2. Wang et al. [9] used cutoff value above VI-RADS 3 with sensitivity, specificity, and accuracy of 82.3%, 95.3%, and 88.64%, respectively.
3. Barchetti et al. [5] found sensitivity, specificity, and accuracy of 85–91%, 89–94%, and 77–82%, respectively, for predicting muscle invasion for ≥ VI-RADS 3.
4. Del Giudice [15] and Makboul et al. [16] establishes VI-RADS≥2 as a highly prognostic cut- off value for muscle invasion with sensitivity, specific- ity, and accuracy ranged between 78 and 91.9%, 88 and 96.5%, and 84 and 87.9%, respectively.
5. Ueno [13] pin- pointed sensitivity, specificity, accuracy, PPV, and NPV of 74.1%, 94.1%, 83.7%, 93.1%, and 78.7%, respectively, for≥VI-RADS 3, and 83.4%, 77.3%, 80.4%, 80.3%, and 79.7%, respectively, for ≥ VI-RADS 2
6. Luo et al. [17] ascertained that VI-RADS score provides a good predic- tive ability for detecting MIBC with VI-RADS 3 or 4 as the cutoff value.
7. Metwally et al. [18] found that the optimal cutoff value for predicting MIBC after the first TURBT was VI-RADS 3 or more with 84.1% sensitiv- ity, 92.3% specificity, and 87.9% accuracy. However, after the second TURBT, the cutoff value was VI-RADS 2 or more with 89.9% sensitivity, 90.1% specificity, and 90% accuracy.

- consistency between the three readers in VIRADS scoring was excellent (kappa 0.81–1.00)
- high reproducibility of VI-RADS

Limitation

- Late presentation of patient renders patient VIRADS with MIBC this study
- VI-RADS is still unfamiliar to many physicians and is still under modification.

Suggestion:

Further studies, possibly including multiple institutions and more readers

Conclusion

VI-RADS is an effective comprehensive method showing satisfactory sensitivity, specificity, and diagnostic value for detecting MIBC.

VI-RADS shows excellent interobserver agreement regardless the reader’s experience.

Summary

- VIRADS is effective in determining NMIBC/MIBC for further treatment plan
- If were to implement in our center
  - Requires input from Urology team
  - Very limited MRI slots in our center which might delay treatment

Thank you.