applied sciences

MDPI

Review

Diagnostic Protocol, Outcomes and Future Perspectives of the Vesical Imaging-Reporting and Data Systems (VI-RADS), a Narrative Review

Luigi Napolitano [1,†], Simona Ippoliti [2,†], Peter Fletcher [3], Martina Caruso [4,*], Luigi Cirillo [1], Roberto Miano [5,6], Enrico Finazzi Agrò [5,6], Roberto La Rocca [1], Ferdinando Fusco [7], Davide Arcaniolo [7] and Luca Orecchia [5]

1 Unit of Urology, Department of Neurosciences, Reproductive Sciences and Odontostomatology, University of Naples "Federico II", 80131 Naples, Italy; dr.luiginapolitano@gmail.com (L.N.); cirilloluigi22@gmail.com (L.C.); robertolarocca87@gmail.com (R.L.R.)
2 Urology Department, Hull Teaching Hospitals NHS Trust, Hull HU3 2JZ, UK; ippoliti.simona@gmail.com
3 Radiology Department, East and North Hertfordshire NHS Trust, Stevenage SG1 4AB, UK; pfletcher308@gmail.com
4 Department of Advanced Biomedical Sciences, University of Naples "Federico II", 80131 Naples, Italy
5 Urology Unit, Policlinico Tor Vergata Foundation, 00133 Rome, Italy; mianor@virgilio.it (R.M.); finazzi.agro@med.uniroma2.it (E.F.A.); luca.orecchia@hotmail.com (L.O.)
6 Department of Surgical Sciences, University of Rome Tor Vergata, 00133 Rome, Italy
7 Unit of Urology, Department of Woman, Child and General and Specialized Surgery, University of Campania "Luigi Vanvitelli", 80138 Naples, Italy; ferdinando-fusco@libero.it (F.F.); davide.arcaniolo@gmail.com (D.A.)
* Correspondence: caruso.martina90@gmail.com
† These authors contributed equally to this work.

Abstract: Bladder cancer (BC) is common worldwide, and has aggressive features and high rates of relapse despite treatments. Approximately 30% of patients present with muscle invasive disease, and therefore, high risk of metastasis. This review provides an overview of the state of the art for the 'Vesical Imaging Reporting and Data System' (VI-RADS). This scoring system presents a tool for the local staging of BC and has been validated across several institutions. We discuss the current application and the potential future clinical implications of VI-RADS in BC diagnosis, management and follow-up.

Keywords: bladder cancer; multiparametric magnetic resonance imaging; VI-RADS

Citation: Napolitano, L.; Ippoliti, S.; Fletcher, P.; Caruso, M.; Cirillo, L.; Miano, R.; Finazzi Agrò, E.; La Rocca, R.; Fusco, F.; Arcaniolo, D.; et al. Diagnostic Protocol, Outcomes and Future Perspectives of the Vesical Imaging-Reporting and Data Systems (VI-RADS), a Narrative Review. *Appl. Sci.* **2023**, *13*, 7331. https://doi.org/10.3390/app13127331

Academic Editor: Francesco Cappello

Received: 28 May 2023
Revised: 11 June 2023
Accepted: 16 June 2023
Published: 20 June 2023

1. Introduction

Bladder cancer (BC) represents the 10th most common neoplasm accruing 549,000 new diagnosis and almost 200,000 deaths per year [1]. It is predominant in males and is characterized by high recurrence ratios [2]. Urothelial carcinoma (UC) accounts for 90% of cases and represents the most common histotype. Invasion into the muscle layer divides BC into non-muscle-invasive bladder cancers (NMIBC) and muscle-invasive bladder cancers (MIBC) [3]. This division, as well as the extension of loco-regional disease, determines appropriate clinical management strategies and prognosis. Transurethral resection of bladder tumours (TURBT) is indicated to appropriately stage and manage NMIBC, while radical cystectomy is the standard of care for MIBC.

Achieving a pre-TURBT prediction of muscle invasion could be an important asset in BC staging [4]. In this setting, magnetic resonance imaging (MRI) plays a crucial role thanks to its high-contrast resolution. Indeed, MRI allows one to discern the different layers of bladder wall, unlike ultrasound and computed tomography (CT), so it may be able to stage BC without requiring invasive procedures [4,5]. Recent publications have reported that MRI shows good diagnostic performance in the preoperative prediction of muscle-layer infiltration. This has resulted in the first version of the Vesical Imaging-Reporting and Data

System (VI-RADS) being introduced in 2018 [6]. VIRADS reports the probability of muscle-layer invasion on a five-point numeric scale. The scoring system achieved good preliminary results and optimistic prospects, therefore ongoing investigation is being performed to improve procedural standardization.

This scoring system may have an application in all phases of BC management, and this is reflected in the published studies which analyse different aspects of VI-RADS in diverse clinical settings. This review aims to provide a comprehensive assessment of published literature on VI-RADS, constituting an updated overview of current applications, limitations and future perspectives.

2. Materials and Methods

A bibliographic search was performed in the Scopus (Elsevier, Amsterdam, The Netherlands), MEDLINE (US National Library of Medicine, Bethesda, MD, USA) and Web of Science (Thomson Reuters, Toronto, ON, Canada) databases in March 2023. Combinations of the following descriptors were used according to a free-text protocol: "multiparametric magnetic resonance imaging" and "bladder cancer" or "Vesical Imaging Reporting and Data System". Only articles in English were included. Conference abstracts, case reports, case series and commentaries were not included. Results were narratively reported and no quantitative synthesis of data was performed. All records were screened by three authors (LN, MC, LO) for inclusion.

3. Diagnostic Protocol

In the clinical management of BC, the assessment of muscle invasion plays a crucial role in determining appropriate treatments. Currently, BC staging is based on clinical examination, TURBT specimens and radiological imaging findings. The evaluation of local bladder disease, nodal involvement, distant metastases and any concurrent upper tract disease utilises contrast-enhanced CT studies of the abdomen and pelvis. Suggested CT phases include pre-contrast, early arterial and delayed excretory phase [7,8]. Multiparametric MRI (mpMRI) plays a crucial role in assessing the detrusor muscle invasion due to its excellent contrast resolution [9]. It is strongly recommended that m mpMRI is performed before or at least two weeks after bladder intravesical treatment or procedures as reactive oedema or inflammation may result in local over-staging [6]. Furthermore, since free air in the bladder can cause distortion of diffusion weighted images (DWI) due to susceptibility artifacts, 2–3 days should elapse between the removal of a vesical catheter or cystoscopy and MRI exam. Before starting the MRI scan, the intramuscular administration of an antispasmodic agent is suggested to avoid motion artifacts from bowel peristalsis. Adequate bladder distension is necessary to accurately assess BC and the possible invasion of the detrusor muscle. Patients are therefore advised to empty their bladder one or two hours before the exam or drink 500–1000 mL of water in the 30 min preceding imaging. The assessment of bladder distension with ultrasound may be useful to evaluate that the bladder is optimally full, with an approximate volume of 300 mL. An MRI scanner of 1.5 or 3.0 T should be preferred to achieve high spatial resolution and a high signal-to-noise ratio. The field of view (FOV) of all images should include the whole bladder, proximal urethra, pelvic lymph nodes, prostate in male patients, uterus, ovaries, fallopian tubes, and vagina in female patients. The mpMRI examination includes T2w images, DWI, and dynamic contrast-enhanced images (DCE-MRI) [6]. In detail, T2w images are usually acquired in at least two planes, using 2D fast-spin-echo (FSE) or turbo-spin-echo sequences. The location of the tumour influences the most appropriate plane to accurately evaluate the extent of the BC and its relationship with the bladder wall and perivesical fat. Minimizing any partial voluming effect is key to this process [10]; therefore, planes orthogonal to the tumour may be utilised. Additionally, thin slices of 3–4 mm are preferred to maximize spatial resolution, whilst needing to balance this against the signal-to-noise ratio.

DWI, a functional MRI technique, measures the Brownian motion of water molecules within a voxel. This motion is dependent on tissue cellularity and therefore, in densely

cellular tumour tissues which are associated with necrosis, fibrosis, haemorrhage and neo-angiogenesis, there is reduced Brownian motion [11]. The apparent diffusion coefficient (ADC) could be calculated from DWI sequences and is inversely proportional to the cell density. Two breathing-free spin-echo echo-planar imaging (EPI) sequences are recommended for the accurate staging of BC, with spectral fat saturation and a high b-value (800–1000 s/mm^2). Regarding DCE images, a 3D T1w gradient echo (GRE) sequence with fat suppression is preferred due to its higher resolution than with 2D acquisition. Pre-contrast images are required and can be useful to identify haemorrhages and clots in the bladder. The gadolinium-based contrast agent is administered at a recommended dose of 0.1 mmol/kg at a rate of 1.5–2.0 mL/s followed by saline flush. Contrast images are acquired 30 s following the start of contrast injection and then followed by a series of four to six sequences every 30 s. This captures the enhancement pattern of tissues, with early enhancement of the inner layer of the bladder wall subsequently followed by the tumour. With time, the signal contrast between the tumour and bladder wall decreases, meaning late phases are of little value for local T staging [6].

4. MRI Appearance of Bladder Cancer and VI-RADS

Before discussing the MRI appearance of BC, an accurate description of the MRI appearance of the bladder wall is required. In detail, the bladder wall is composed of three strata: mucosa, muscularis propria, and serosa/adventitia [9]. The mucosa includes the surface urothelium and underlying subepithelial connective tissue, also known as lamina propria, which is thinner at the trigone and thicker at the dome. The muscularis propria (detrusor muscle) is made up of smooth muscle bundles organized into an inner and an outer layer with different orientations. Finally, the serosa, a part of the visceral peritoneum, covers the bladder dome, while a layer of adventitia, composed of connective tissue, covers the remaining areas of the bladder. Unfortunately, MRI does not allow the visualization of all the described layers. The inner layer is not seen on T2w images as well as on DWI/ADC, while it appears as a hyper-intense line on DCE-MRI because of its early enhancement. However, in the case of an inflamed urothelium and lamina propria, the inner layer appears as a thickened hyperintense line on T2w images and hypointense line on DWI, due to oedema. The detrusor muscle is seen in all MRI sequences and appears hypo-intense on T2w images, while it is characterized by intermediate signal intensity on DWI/ADC. After the contrast injection, it enhances slowly and progressively. Any intravesical lesion with a T2 signal intensity intermediate to urine and muscle, a high DWI signal associated with a low signal at ADC map, and which shows postcontrast early enhancement at DCE-MRI, should be considered as a suspicious lesion [6]. As mentioned above, in clinical practice, the differential diagnosis between MIBC and NMIBC is crucial. In this setting, mpMRI may be a very promising imaging tool in the accurate evaluation of BC and in its local staging thanks to morphological high-resolution T2w images and functional DWI images and DCE sequences. For that, Panebianco et al. proposed VI-RADS, an MRI-based scoring system assessing tumour appearance in T2w, DWI and DCE images to standardize the image acquisition reporting of bladder mpMRI [6]. VI-RADS is composed of a 5-point scale, which reflects the overall risk of muscle invasiveness: each bladder lesion is assigned a final score from 1 to 5: VI-RADS 1 represents very low likelihood of muscle invasiveness and VI-RADS 5 a very high likelihood of detrusor muscle invasion. This scoring could be applicable both to untreated patients and those who have received diagnostic TURBT before re-TURBT. The VI-RADS algorithm for the overall score assessment considers T2w images as the primary sequence for BC staging for a VI-RADS score from 1 to 3, and DWI and DCE as the dominant sequences for VI-RADS 4 and 5. In case of discordance between T2w images and DCE-MRI scores, DWI should be considered as the dominant sequence to maximise accuracy [9].

4.1. T2-Weighted Image Evaluation

On T2w images, the radiologist may assess the morphologic characteristics of the lesion, such as size, growth pattern, and morphology, as well as the location and degree of interruption of the hypointense muscle by the intermediate signal tumour. This is possible thanks to the high signal-to-noise ratio and excellent anatomical detail. BC may have different patterns of growth: intramural, endoluminal, flat and mixed. In the case of endoluminal growth, the tumour can be papillary broad-based or pedunculated. Regarding the location of bladder lesion, a schematic map was elaborated and identifies six bladder surfaces: the dome, the right and left lateral surfaces, the trigone and the posterior and anterior surfaces [10].

Table 1 shows the assessment of BC T2w appearance, which defines the structural category (SC).

Table 1. Structural categories and corresponding lesions.

Structural Category (SC)	Bladder Cancer (BC) Lesion
SC1	Non-invasion of muscularis propria; lesion < 1 cm; exophytic tumour with or without stalk and with or without thickened inner layer
SC2	Non-invasion of muscularis propria; lesion > 1 cm; exophytic tumour with stalk with or without hyper-intensity thickened inner layer, or sessile tumour with hyper-intensity thickened inner layer, when present
SC3	No clear detrusor-muscle invasion, associated with an exophytic tumour without stalk or sessile tumour without hyper-intensity thickened inner layer
SC4	Detrusor-muscle invasion
SC5	Extravesical fat invasion

4.2. DWI Image Evaluation

On DWI, the radiologist may evaluate the degree of extension of the DWI high-signal-intensity tumour into the DWI intermediate signal muscle, as shown in Table 2. Takeuchi et al. described the "inchworm sign", represented by the arch-shaped hyperintense appearance of the tumour over the hypointense submucosal stalk [12]. This finding is indicative of lower tumour and an imaging biomarker of tumour aggressiveness.

Table 2. DWI and corresponding lesions.

DWI Categories	Bladder Cancer (BC) Lesion
DWI category 1	No interruption of intermediate signal intensity of muscularis propria; lesion < 1 cm characterised by high signal intensity on DWI and low signal intensity on ADC map, with or without stalk, with or without hypo-intense thickened inner layer on DWI.
DWI category 2	No interruption of intermediate signal intensity of muscularis propria; lesion > 1 cm characterised by high signal intensity on DWI and low signal intensity on ADC map, with stalk, with or without hypo-intense thickened inner layer on DWI, or sessile tumour with low- or intermediate-signal-intensity thickened inner layer on DWI.
DWI category 3	Absence of DWI category 2 findings without evidence of clear disruption of muscularis propria.
DWI category 4	High-signal-intensity tumour on DWI extending focally to muscularis propria.
DWI category 5	Extravesical fat invasion.

4.3. DCE-MRI Image Evaluation

The DCE-MRI images accurately assess the extension of the tumour, which enhances early, into the muscle, which enhances late, as shown in Table 3.

Table 3. Contrast-enhanced (CE) categories and corresponding lesions.

Contrast-Enhanced (CE) Category	Bladder Cancer (BC) Lesion
CE category 1	No early enhancement of the muscularis propria.
CE category 2	No early enhancement of the muscularis propria, but early enhancement of the inner layer.
CE category 3	Absence of category 2 findings, without any evidence of clear disruption of hypo-intensity of muscularis propria.
CE category 4	Focal extent of tumour early enhancement in the muscularis propria.
CE category 5	Extent of the tumour early enhancement in the entire bladder wall and extravesical fat.

The final VI-RADS score is obtained using the T2w, DWI and DCE-MRI categories, as shown in Table 4.

Table 4. VI-RADS scoring system.

VI-RADS	DWI/CE Categories	Structural Category (SC)
VI-RADS 1 (muscle invasion highly unlikely)	DWI and CE 1	SC 1
VI-RADS 2 (muscle invasion unlikely)	DWI and/or CE 2	SC 2, SC 3
VI-RADS 3 (muscle invasion equivocal)	DWI and CE 3	SC 3
VI-RADS 4 (muscle invasion likely)	DWI and/or CE 4	SC 3, SC 4, SC 5
VI-RADS 5 (muscle invasion highly likely)	DWI and/or CE 5	SC 4, SC 5

5. Diagnostic Performance of VI-RADS

Since its introduction in 2018 [6], the VI-RADS reporting scheme for mpMRI has shown excellent results in differentiating MIBC from NMIBC. The most important factors in determining the diagnostic performance of VI-RADS were accuracy—measured as area under the curve (AUC) of hierarchical summary receiver operating characteristic (HSROC) curve—sensitivity, specificity, and inter-reader agreement. Even though the vast majority of published studies are single-institution and retrospective in nature, consistent data has recently been gained from prospective multicentre studies and systematic reviews. Five different meta-analyses on VI-RADS unanimously reported high sensitivity and specificity for predicting muscle invasion as well as a high diagnostic accuracy [13–17]. As summarised in Table 5, sensitivity, specificity and AUC ranged between 0.83–0.92, 0.82–0.90 and 0.93–0.94, respectively, when a cut-off score of VI-RADS $\geq$ 3 was used, and 0.77–0.78, 0.94–0.97 and 0.91–0.94, respectively, when a cut-off score of VI-RADS $\geq$ 4 was used.

Table 5. VI-RADS diagnostic performance: pooled results reported from meta-analyses.

Author	# Studies	# Participants	Cutoff VI-RADS 3				Cutoff VI-RADS 4			
			Sensitivity (%)	Specificity (%)	Inter-Observer Agreement (κ)	Accuracy (AUC)	Sensitivity (%)	Specificity (%)	Inter-Observer Agreement (κ)	Accuracy (AUC)
Luo et al., 2020 [13]	6	1064	0.9	0.86	-	0.93	0.77	0.97	-	0.92
Woo et al., 2020 [14]	6	1770	0.83	0.9		0.94	-	-	-	-
Del Giudice et al., 2020 [18]	8	1016	-	-	0.83	-	-	-	-	-
Jazayeri et al., 2021 [17]	22	2576	0.89	0.84	-	0.93	-	-	-	0.93
Jazayeri et al., 2022 [19]	19	2439	-	-	0.76	-	-	-	-	-
Feng et al., 2022 [15]	19	2900	0.92	0.82	-	0.94	0.78	0.96	-	0.94
Del Giudice et al., 2022 [16]	20	2477	0.87	0.86	-	0.93	0.78	0.94	-	0.91

AUC = area under the curve; K = Cohen's kappa coefficient; # = number of.

Jazayeri et al. [19] and Del Giudice et al. [18] performed two meta-analyses to determine the inter-reader reliability, reporting their pooled Cohen's kappa (*k*) coefficient. These were found to be high to very high, ranging from 0.76 to 0.83 (Table 5). Similarly, a more recent prospective multi-centre study [20] showed that reporting bladder MRI according to the VI-RADS score provided a substantial inter-reader agreement (k = 0.81) among radiologists of different levels of expertise, with overall VI-RADS showing the highest AUC (0.95) compared to individual bladder MRI sequences (T2WI: 0.94; DWI: 0.93; DCE: 0.94). Arita et al. in a retrospective cohort of 66 patients obtained high to very-high interobserver agreement and accuracy for local staging, with a high diagnostic performance of the overall VI-RADS score for radiologists and also urologists [21]. Furthermore, VI-RADS was highly accurate for the diagnosis of different variants of MIBC, other than pure urothelial carcinoma [22]. An important point raised by Luo et at [13] was that a cut-off VI-RADS ≥ 4 should be applied when using imaging only to predict muscle invasion and not operating TURBT prior to radical cystectomy, whilst a cut-off of VI-RADS ≥ 3 would perform better in sensitivity and negative likelihood ratio, therefore decreasing the misdiagnosis of MIBC. This should be then used to evaluate patients who will receive TURBT for confirmation of muscle invasiveness via histopathology. A multicentre prospective study published by Metwally et al. in 2021 [23] reported a combined positive predictive value (PPV) and a negative predictive value (NPV) of 92.5% and 83.6% in VI-RADS ≥ 4, respectively, among different readers. Additionally, Bicchetti et al. in their multicentre prospective study published in 2022 [20] showed that reporting bladder MRI using VI-RADS provided a sensitivity ranging 83–93%, specificity 80–92%, PPV 67–81%, NPV 93–96%, and accuracy of 84–89% for more experienced readers; whilst a sensitivity ranging 83–95%, specificity 73–86%, PPV 60–71%, NPV 92–97%, and accuracy 80–85% for the less experienced readers. The AUC was 0.95 for the more experienced readers and 0.93 for the less experienced readers. Different factors, including the number of patients, magnetic field strength (3 T vs. 1.5 T), T2-weighted image slice thickness (3 mm vs. 4 mm), VI-RADS cut-off score ($\geq$3 vs. $\geq$4) [14] and study design and radiological characteristics [16] were commonly considered to be significant factors affecting the heterogeneity of the studies reported in the literature. Another strength of VI-RADS is represented by the good performance in staging patients after BC treatment [24] and it is also good at identifying patients who need to undergo re-resection TURBT [25]. Some anatomical and technical radiological factors can affect the accuracy of this scoring system, among these the flat appearance of the tumour should be mentioned [26].

6. MRI vs. Other Imaging Modalities and Diagnostic Cystoscopy

As mentioned above, the staging of BC traditionally relies on TURBT integrated with cross-sectional imaging (CT and MRI) to assess for nodal involvement and distant metastases. mpMRI plays a crucial role in the local staging of BC, whilst additionally assessing extravesical spread of the tumour to lymph nodes, bones and the upper urinary tract, through the use of functional sequences and its high contrast resolution [27–29]. However, other imaging modalities preserve an additional role in MIBC patients: bone scintigraphy is recommended in cases of suspected bone metastases and PET/CT shows higher sensitivity than CT in the assessment of nodal staging. Furthermore, PET/CT is highly recommended for restaging and the assessment of therapy response. PET/MRI is a novel imaging technique in BC imaging and its role is promising [30]. A small retrospective cohort study compared the local tumour staging in BC using mpMRI with VI-RADS scoring system and dual-phase contrast-enhanced CT. It reported that muscle invasion was overestimated in MRI and underestimated with CT [31]. Kufukihara et al. compared the diagnostic accuracy of VI-RADS with diagnostic cystoscopy, proving the superiority of VI-RADS, particularly for tumours located on the bladder neck, trigone, dome, posterior and anterior walls [32]. However, different concerns have been raised regarding the inability of the MRI to diagnose carcinoma in situ (CIS) [33], which incidence ranges between 5–19% [34] among patients with NMIBC, making diagnostic cystoscopy still an incontrovertible option in the bladder-cancer diagnostic pathway.

7. bpMRI vs. mpMRI Accuracy in VI-RADS

As the MRI is gaining a dominant role in BC staging, several studies have focused on the best combination of anatomic sequences and the possibility to omit DCE sequences. During the past decade, commonly used bladder MRI protocols included anatomic sequences of T1w- and T2-w imaging, and functional sequences of DCE and DWI. Comparative, multi-reader studies [35,36] have been published to assess the accuracy of the mpMRI and the biparametric (bp) MRI protocols in detecting MIBC using the VI-RADS criteria, with no significant differences shown in diagnostic performance between the two protocols and excellent agreement among the readers as well as high diagnostic accuracy, sensitivity and specificity. Furthermore, in both MRI protocols, diagnostic performance did not appear to be significantly affected by the reader's experience when using the VI-RADS criteria [35], regardless of the use of DCE sequences [37]. According to Gmeiner et al., only the T2w-imaging independently contributed to the diagnosis of high-grade and MIBC upon multivariate logistic regression [38], accurately showing the characteristics of BC without the necessity of a full multiparametric approach. Similarly, DWI-based VI-RADS scoring had the highest sensitivity (90.3–90.3%), specificity (99.1–95.8%), accuracy (97.3–94%), and AUC (0.947–0.914) in estimating MIBC for readers in the study of Aslan et al. [35]. Moreover, Watanabe et al. [39] developed a modified VI-RADS without DCE imaging, defined "non-contrast-enhanced VI-RADS (NCE-VI-RADS), which achieved a predictive accuracy for muscle invasion comparable to that of standard VI-RADS reporting. On the other hand, some authors underline the importance of DCE MRI, when disparities between sequences are found [9,12]. In a small-cohort multi-reader prospective study, Delli Pizzi et al. advocated carefulness when interpreting DCE sequences by less experienced readers, as a confounding factor such as inflammatory changes could potentially lead to an overestimation of the tumour stage [40]; however, most importantly, the non-contrast MRI protocol had the same diagnostic accuracy as the standard mpMRI in detecting muscle invasion, whatever the reader's experience [41].

8. Complementary Strategies

Wang et al. [42] proposed an additional strategy to accurately evaluate invasion depth of a tumour via the tumour contact length, proving the enhancement of the PPV of VI-RADS (90.91–91.59% compared to 82.46–87.72% found in VI-RADS score alone). Other complementary strategies have been proposed to improve the prediction of muscle invasiveness, including neoadjuvant chemotherapy (nac) VI-RADS (nacVI-RADS) for the radiologic assessment of the response to treatment among patients with MIBC [43]; volumetric ADC histogram analysis in differentiating MIBC from NMIBC [44]; the tumour-wall interface, defined as the "curvilinear contact length between the tumour and the bladder wall", used as a quantitative indicator in adjunct to VIRADS, a qualitative indicator, as independent predictors of muscle invasion [45].

9. Radiologist Learning Curve

Literature on the learning curve for VI-RADS is sparse, which reflects that it is yet to become the standard for reporting radiologists. As with comparable scoring systems such as PI-RADS, some authors suggest that VI-RADS could increase the performance of less experienced readers [14]. Papers reporting on the learning curve in inexperienced trainees suggest there is an early improvement in VI-RADS reader concordance, diagnostic accuracy, confidence and the time taken to evaluate the images. However, after 50–100 cases the initial improvement slows, which may represent a general improvement and experience in the reading of bladder MRI [46]. There are a number of pitfalls to reporting bladder MRI [47] and those experienced in bladder MRI are likely to use this knowledge to improve their sensitivity and specificity [48]. Studies which analyse the performance using VI-RADS of experienced readers of bladder MRI demonstrate that they achieve good sensitivity, specificity and overall inter-reader concordance [18]. However, studies with greater numbers of patients show significant improvements in sensitivity. Separating the influence of

the learning curve of VIRADS from exposure and familiarity with interpretation of bladder mpMRI is a challenge. With further use of VI-RADS, additional investigations examining the learning curve to achieving proficiency are also needed.

10. Future Perspectives of VI-RADS

The role of VI-RADS in the management of BC is still being extensively investigated. In view of its versatility, the reporting system could potentially support disease management at every disease stage. One major line of research is represented by the possibility of mpMRI to revisit the role of extensive TURBT in clearly muscle-invasive BC [49], with preliminary reports confirming the feasibility of such a strategy [20]. Patients with a VI-RADS score 5 disease might potentially avoid the morbidity of extensive primary resections in favour of sampling-TURBT for histology [50]. Concurrently, VI-RADS have also shown high concordance to conventional re-TURBT results in high-risk NMIBC, and a VI-RADS score 2 was identified as a clinical predictor of non-invasive disease at the second resection while VI-RADS cut-off of 3 as a predictor of understaged MIBC at TURBT [51]. These results hint at a possible practice-changing implementation of VI-RADS as a preoperative stratification test in the management of a highly prevalent disease such as NMIBC, granting a considerable reduction in patient morbidity and a reduction in treatment delay in patients harbouring MIBC. Further refinement of mpMRI performance/quality and validation of VI-RADS in this specific scenario has been advocated. MRI also appears to be promising in detecting therapeutic response to chemotherapy or radiotherapy. Preliminary reports have shown the feasibility of reporting vesical mpMRI in patients completing nac for MIBC according to the nacVI-RADS scoring system. nacVI-RADS were successfully used to assess radiological response to nac, the presence of residual disease and the infiltration of the muscolaris propria in a pilot cohort of patients undergoing radical cystectomy [43]. DWI, and ADC value quantification was also used to predict tumour aggressiveness and sensitivity of chemoradiotherapy, while DCE value quantification adequately supported the detection of residual disease from post-nac effects [52–54]. Overall possible implementation of diffusion- and contrast-based cut-off values in standardised mpMRI reporting systems could further enhance the versatility of the tool in the setting of neoadjuvant chemotherapy. However, prospective large-cohort studies are still needed to validate their clinical use prior to neoadjuvant chemotherapy and selection of appropriate bladder-cancer treatment strategies. Biparametric MRI carries the promising advantages of a contrast-free imaging protocol, consisting in shorter image acquisition and the elimination of possible adverse events related to the administration of intravenous contrast medium. Multivariate logistic regression analysis showed that only T2w VI-RADS scores were independent predictors of detrusor muscle invasion in a series of 57 patients receiving an mpMRI for BC, proving that contrast medium may not be necessary for the local staging of BC [38]. Feng et al. presented a diffusion-based fractional-order calculus diffusion model and combined it to a simplified biparametric VI-RADS to achieve high diagnostic performance in MIBC detection [55], providing further evidence that contrast-free MRI protocols may provide comparable diagnostic accuracy to mpMRI for MIBC detection [40]. The prospective head-to-head assessment of bp- vs. mpMRI in BC diagnostics may provide definitive answers on the added value of intravenous contrast medium administration.

Despite VI-RADS score promises to be very useful in clinical practice, there are some limitations at the present development state which should be considered. Primarily, VI-RADS score was initially developed in untreated patients to differentiate NMIBC from MIBC, hence its application in treated patients should be investigated further. VI-RADS score does not include some radiologically independent predictors of muscle invasion, such as number and location of the lesions or urethral infiltration. MRI currently does not allow one to accurately diagnose carcinoma in situ, lymphovascular invasion, and variant cancer histology. These factors are important in patient risk stratification and can currently be diagnosed only through the pathological examination of resected cancerous tissue. Moreover, while MRI and VI-RADS score have been proposed for the surveillance and follow-up

of patients with NMIBC, the economic implications and possible benefit for healthcare spending of this change in practice remain to be assessed. Indeed, serial MRI acquisitions may be associated with higher costs compared to standard-of-care outpatient diagnostic cystoscopy. Moreover, repeated administration of intravenous contrast medium during follow-up could be associated with side effects. Finally, the reliability and reproducibility of this scoring system among non-specialized radiologists is yet to be accurately established.

11. Conclusions

The recently developed VI-RADS may potentially play a significant role in the staging and management of BC as a non-invasive, comprehensive, and effective diagnostic tool providing accurate information for the differentiation of NMIBC from MIBC. If adequately validated in clinical practice, the inclusion of this scoring system may revolutionize the management of BC, allowing precise and faster management with a possible positive effect on prognosis. Several clinical trials investigating the different applications of VI-RADS are ongoing and large-cohort prospective studies should be conducted to provide validation and assess the scalability of the system.

Author Contributions: Conceptualization, L.N., L.O. and S.I.; methodology, M.C, L.N. and L.O.; validation, L.C. and L.N.; data curation, R.L.R. and D.A.; writing—original draft preparation, L.N., S.I., M.C., P.F. and L.O.; writing—review and editing, M.C. and D.A.; visualization R.M.; supervision, F.F., R.M. and E.F.A. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: No new data were created or analysed in this study. Data sharing is not applicable to this article.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Bray, F.; Ferlay, J.; Soerjomataram, I.; Siegel, R.L.; Torre, L.A.; Jemal, A. Global cancer statistics 2018: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. *CA Cancer J. Clin.* **2018**, *68*, 394–424. [CrossRef]
2. Zhu, C.-Z.; Ting, H.-N.; Ng, K.-H.; Ong, T.-A. A review on the accuracy of bladder cancer detection methods. *J. Cancer* **2019**, *10*, 4038–4044. [CrossRef]
3. Barone, B.; Napolitano, L.; Reccia, P.; De Luca, L.; Morra, S.; Turco, C.; Melchionna, A.; Caputo, V.F.; Cirillo, L.; Fusco, G.M.; et al. Preoperative Fibrinogen-to-Albumin Ratio as Potential Predictor of Bladder Cancer: A Monocentric Retrospective Study. *Medicina* **2022**, *58*, 1490. [CrossRef] [PubMed]
4. Hussain, S.; Mubeen, I.; Ullah, N.; Shah, S.S.U.D.; Khan, B.A.; Zahoor, M.; Ullah, R.; Khan, F.A.; Sultan, M.A. Modern Diagnostic Imaging Technique Applications and Risk Factors in the Medical Field: A Review. *Biomed. Res. Int.* **2022**, *2022*, 5164970. [CrossRef] [PubMed]
5. Nicola, R.; Pecoraro, M.; Lucciola, S.; dos Reis, R.B.; Narumi, Y.; Panebianco, V.; Muglia, V.F. VI-RADS score system—A primer for urologists. *Int. Braz. J. Urol.* **2022**, *48*, 609–622. [CrossRef] [PubMed]
6. Panebianco, V.; Narumi, Y.; Altun, E.; Bochner, B.H.; Efstathiou, J.A.; Hafeez, S.; Huddart, R.; Kennish, S.; Lerner, S.; Montironi, R.; 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. [CrossRef] [PubMed]
7. Flaig, T.W.; Spiess, P.E.; Agarwal, N.; Bangs, R.; Boorjian, S.A.; Buyyounouski, M.K.; Chang, S.; Downs, T.M.; Efstathiou, J.A.; Friedlander, T.; et al. Bladder Cancer, Version 3.2020, NCCN Clinical Practice Guidelines in Oncology. *J. Natl. Compr. Cancer Netw.* **2020**, *18*, 329–354. [CrossRef]
8. Caruso, M.; Romeo, V.; Stanzione, A.; Buonerba, C.; Di Lorenzo, G.; Maurea, S. Current Imaging Evaluation of Tumor Response to Advanced Medical Treatment in Metastatic Renal-Cell Carcinoma: Clinical Implications. *Appl. Sci.* **2021**, *11*, 6930. [CrossRef]
9. Panebianco, V.; De Berardinis, E.; Barchetti, G.; Simone, G.; Leonardo, C.; Grompone, M.D.; Del Monte, M.; Carano, D.; Gallucci, M.; Catto, J.; 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*, 3759–3766. [CrossRef]
10. Pecoraro, M.; Takeuchi, M.; Vargas, H.A.; Muglia, V.F.; Cipollari, S.; Catalano, C.; Panebianco, V. Overview of VI-RADS in Bladder Cancer. *Am. J. Roentgenol.* **2020**, *214*, 1259–1268. [CrossRef]

11. Caruso, M.; Stanzione, A.; Prinster, A.; Pizzuti, L.M.; Brunetti, A.; Maurea, S.; Mainenti, P.P. Role of advanced imaging techniques in the evaluation of oncological therapies in patients with colorectal liver metastases. *World J. Gastroenterol.* **2023**, *29*, 521–535. [CrossRef] [PubMed]
12. Takeuchi, M.; Sasaki, S.; Ito, M.; Okada, S.; Takahashi, S.; Kawai, T.; Suzuki, K.; Oshima, H.; Hara, M.; Shibamoto, Y. Urinary Bladder Cancer: Diffusion-weighted MR Imaging—Accuracy for Diagnosing T Stage and Estimating Histologic Grade. *Radiology* **2009**, *251*, 112–121. [CrossRef] [PubMed]
13. Luo, C.; Huang, B.; Wu, Y.; Chen, J.; Chen, L. Use of Vesical Imaging-Reporting and Data System (VI-RADS) for detecting the muscle invasion of bladder cancer: A diagnostic meta-analysis. *Eur. Radiol.* **2020**, *30*, 4606–4614. [CrossRef] [PubMed]
14. Woo, S.; Panebianco, V.; Narumi, Y.; Del Giudice, F.; Muglia, V.F.; Takeuchi, M.; Ghafoor, S.; Bochner, B.H.; Goh, A.C.; Hricak, H.; et al. Diagnostic Performance of Vesical Imaging Reporting and Data System for the Prediction of Muscle-invasive Bladder Cancer: A Systematic Review and Meta-analysis. *Eur. Urol. Oncol.* **2020**, *3*, 306–315. [CrossRef] [PubMed]
15. Feng, Y.; Zhong, K.; Chen, R.; Zhou, W. Diagnostic accuracy of vesical imaging-reporting and data system (VI-RADS) for the detection of muscle-invasive bladder cancer: A meta-analysis. *Abdom. Radiol.* **2022**, *47*, 1396–1405. [CrossRef]
16. Del Giudice, F.; Flammia, R.S.; Pecoraro, M.; Moschini, M.; D'Andrea, D.; Messina, E.; Pisciotti, L.M.; De Berardinis, E.; Sciarra, A.; Panebianco, V. The accuracy of Vesical Imaging-Reporting and Data System (VI-RADS): An updated comprehensive multi-institutional, multi-readers systematic review and meta-analysis from diagnostic evidence into future clinical recommendations. *World J. Urol.* **2022**, *40*, 1617–1628. [CrossRef]
17. Jazayeri, S.B.; Dehghanbanadaki, H.; Hosseini, M.; Taghipour, P.; Alam, M.U.; Balaji, K.C.; Bandyk, M. Diagnostic accuracy of vesical imaging-reporting and data system (VI-RADS) in suspected muscle invasive bladder cancer: A systematic review and diagnostic meta-analysis. *Urol. Oncol. Semin. Orig. Investig.* **2022**, *40*, 45–55. [CrossRef]
18. Jazayeri, S.B.; Dehghanbanadaki, H.; Hosseini, M.; Taghipour, P.; Bazargani, S.; Thomas, D.; Feibus, A.; Sarabchian, E.; Bacchus, M.W.; Di Valerio, E.A.; et al. Inter-reader reliability of the vesical imaging-reporting and data system (VI-RADS) for muscle-invasive bladder cancer: A systematic review and meta-analysis. *Abdom. Radiol.* **2022**, *47*, 4173–4185. [CrossRef]
19. Del Giudice, F.; Pecoraro, M.; Vargas, H.A.; Cipollari, S.; De Berardinis, E.; Bicchetti, M.; Chung, B.I.; Catalano, C.; Narumi, Y.; Catto, J.W.F.; et al. Systematic Review and Meta-Analysis of Vesical Imaging-Reporting and Data System (VI-RADS) Inter-Observer Reliability: An Added Value for Muscle Invasive Bladder Cancer Detection. *Cancers* **2020**, *12*, 2994. [CrossRef]
20. Bicchetti, M.; Simone, G.; Giannarini, G.; Girometti, R.; Briganti, A.; Brunocilla, E.; Cardone, G.; De Cobelli, F.; Gaudiano, C.; Del Giudice, F.; et al. A novel pathway to detect muscle-invasive bladder cancer based on integrated clinical features and VI-RADS score on MRI: Results of a prospective multicenter study. *Radiol. Med.* **2022**, *127*, 881–890. [CrossRef]
21. Arita, Y.; Shigeta, K.; Akita, H.; Suzuki, T.; Kufukihara, R.; Kwee, T.C.; Ishii, R.; Mikami, S.; Okuda, S.; Kikuchi, E.; et al. Clinical utility of the Vesical Imaging-Reporting and Data System for muscle-invasive bladder cancer between radiologists and urologists based on multiparametric MRI including 3D FSE T2-weighted acquisitions. *Eur. Radiol.* **2021**, *31*, 875–883. [CrossRef] [PubMed]
22. Arita, Y.; Yoshida, S.; Shigeta, K.; Kwee, T.C.; Edo, H.; Okawara, N.; Hashimoto, M.; Ishii, R.; Ueda, R.; Mikami, S.; et al. Diagnostic Value of the Vesical Imaging-Reporting and Data System in Bladder Urothelial Carcinoma with Variant Histology. *Eur. Urol. Oncol.* **2023**, *6*, 99–102. [CrossRef] [PubMed]
23. Metwally, M.I.; Zeed, N.A.; Hamed, E.M.; Elshetry, A.S.F.; Elfwakhry, R.M.; Alaa Eldin, A.M.; Sakr, A.; Aly, S.A.; Mosallam, W.; Ziada, Y.M.A.; et al. The validity, reliability, and reviewer acceptance of VI-RADS in assessing muscle invasion by bladder cancer: A multicenter prospective study. *Eur. Radiol.* **2021**, *31*, 6949–6961. [CrossRef] [PubMed]
24. Lewis, S.; Galsky, M. Editorial for "Preliminary Exploration of the Application of Vesical Imaging-Reporting and Data System (VI-RADS) in Post-Treatment Patients with Bladder Cancer: A Prospective Single-Center Study". *J. Magn. Reson. Imaging* **2022**, *55*, 287–288. [CrossRef] [PubMed]
25. Erkoc, M.; Otunctemur, A.; Bozkurt, M.; Can, O.; Atalay, H.A.; Besiroglu, H.; Danis, E.; Degirmentepe, R.B. The efficacy and reliability of VI-RADS in determining candidates for repeated transurethral resection in patients with high-risk non-muscle invasive bladder cancer. *Int. J. Clin. Pract.* **2021**, *75*, e14584. [CrossRef] [PubMed]
26. Oguz, U.; Bekci, T.; Ogreden, E.; Aslan, S.; Duman, A.; Demirelli, E.; Sengul, D.; Tok, D.S.; Ciftci, O.C.; Tosun, A. Prospective assessment of VI-RADS score in multiparametric MRI in bladder cancer: Accuracy and the factors affecting the results. *Diagn. Interv. Radiol.* **2022**, *28*, 396–402. [CrossRef]
27. Caglic, I.; Panebianco, V.; Vargas, H.A.; Bura, V.; Woo, S.; Pecoraro, M.; Cipollari, S.; Sala, E.; Barrett, T. MRI of Bladder Cancer: Local and Nodal Staging. *J. Magn. Reson. Imaging* **2020**, *52*, 649–667. [CrossRef]
28. Van der Pol, C.B.; Sahni, V.A.; Eberhardt, S.C.; Oto, A.; Akin, O.; Alexander, L.F.; Allen, B.C.; Coakley, F.V.; Froemming, A.T.; Fulgham, P.F.; et al. ACR Appropriateness Criteria® Pretreatment Staging of Muscle-Invasive Bladder Cancer. *J. Am. Coll. Radiol.* **2018**, *15*, S150–S159. [CrossRef]
29. Crozier, J.; Papa, N.; Perera, M.; Ngo, B.; Bolton, D.; Sengupta, S.; Lawrentschuk, N. Comparative sensitivity and specificity of imaging modalities in staging bladder cancer prior to radical cystectomy: A systematic review and meta-analysis. *World J. Urol.* **2019**, *37*, 667–690. [CrossRef]
30. Abouelkheir, R.T.; Abdelhamid, A.; Abou El-Ghar, M.; El-Diasty, T. Imaging of Bladder Cancer: Standard Applications and Future Trends. *Medicina* **2021**, *57*, 220. [CrossRef]

31. Hagen, F.; Norz, V.; Thaiss, W.M.; Mair, A.; Rausch, S.; Bedke, J.; Nikolaou, K.; Stenzl, A.; Kruck, S.; Hepp, T.; et al. Diagnostic benefit of multiparametric MRI over contrast-enhanced CT in patients with bladder cancer: A single-center 1-year experience. *Eur. J. Radiol.* **2022**, *146*, 110059. [CrossRef] [PubMed]
32. Kufukihara, R.; Kikuchi, E.; Shigeta, K.; Ogihara, K.; Arita, Y.; Akita, H.; Suzuki, T.; Abe, T.; Mizuno, R.; Jinzaki, M.; et al. Diagnostic performance of the vesical imaging-reporting and data system for detecting muscle-invasive bladder cancer in real clinical settings: Comparison with diagnostic cystoscopy. *Urol. Oncol. Semin. Orig. Investig.* **2022**, *40*, 61.e1–61.e8. [CrossRef] [PubMed]
33. Fragkoulis, C.; Papadopoulos, G.; Ntoumas, K. Re: Francesco Del Giudice, Giovanni Barchetti, Ettore De Berardinis; et al. Prospective Assessment of Vesical Imaging Reporting and Data System (VI-RADS) and Its Clinical Impact on the Management of High-risk Non–muscle-invasive Bladder Cancer Patients Candidate for Repeated Transurethral Resection. Eur Urol 2020;77:101–9. *Eur. Urol.* **2020**, *77*, e93. [CrossRef] [PubMed]
34. Sylvester, R.J.; van der Meijden, A.; Witjes, J.A.; Jakse, G.; Nonomura, N.; Cheng, C.; Torres, A.; Watson, R.; Kurth, K.H. High-grade Ta urothelial carcinoma and carcinoma in situ of the bladder. *Urology* **2005**, *66*, 90–107. [CrossRef]
35. Aslan, S.; Cakir, I.M.; Oguz, U.; Bekci, T.; Demirelli, E. Comparison of the diagnostic accuracy and validity of biparametric MRI and multiparametric MRI-based VI-RADS scoring in bladder cancer; is contrast material really necessary in detecting muscle invasion? *Abdom. Radiol.* **2022**, *47*, 771–780. [CrossRef]
36. Noh, T.I.; Shim, J.S.; Kang, S.G.; Sung, D.J.; Cheon, J.; Sim, K.C.; Kang, S.H. Comparison between biparametric and multiparametric MRI in predicting muscle invasion by bladder cancer based on the VI-RADS. *Sci. Rep.* **2022**, *12*, 20689. [CrossRef]
37. Bricio, T.G.M.; Gouvea, G.L.; Barros, R.V.; Chahud, F.; Elias, J.; Reis, R.B.; Muglia, V.F. What is the impact of dynamic contrast-enhancement sequence in the Vesical Imaging, Reporting and Data System (VI-RADS)? A subgroup analysis. *Cancer Imaging* **2022**, *22*, 20. [CrossRef]
38. Gmeiner, J.; Garstka, N.; Helbich, T.H.; Shariat, S.F.; Baltzer, P.A. Vesical Imaging Reporting and Data System (VI-RADS): Are the individual MRI sequences equivalent in diagnostic performance of high grade NMIBC and MIBC? *Eur. J. Radiol.* **2021**, *142*, 109829. [CrossRef]
39. Watanabe, M.; Taguchi, S.; Machida, H.; Tambo, M.; Takeshita, Y.; Kariyasu, T.; Fukushima, K.; Shimizu, Y.; Okegawa, T.; Fukuhara, H.; et al. Clinical validity of non-contrast-enhanced VI-RADS: Prospective study using 3-T MRI with high-gradient magnetic field. *Eur. Radiol.* **2022**, *32*, 7513–7521. [CrossRef]
40. Delli Pizzi, A.; Mastrodicasa, D.; Marchioni, M.; Primiceri, G.; Di Fabio, F.; Cianci, R.; Seccia, B.; Sessa, B.; Mincuzzi, E.; Romanelli, M.; et al. Bladder cancer: Do we need contrast injection for MRI assessment of muscle invasion? A prospective multi-reader VI-RADS approach. *Eur. Radiol.* **2021**, *31*, 3874–3883. [CrossRef]
41. Delli Pizzi, A.; Mastrodicasa, D.; Taraschi, A.; Civitareale, N.; Mincuzzi, E.; Censi, S.; Marchioni, M.; Primiceri, G.; Castellan, P.; Castellucci, R.; et al. Conspicuity and muscle-invasiveness assessment for bladder cancer using VI-RADS: A multi-reader, contrast-free MRI study to determine optimal b-values for diffusion-weighted imaging. *Abdom. Radiol.* **2022**, *47*, 1862–1872. [CrossRef]
42. Wang, X.; Tu, N.; Sun, F.; Wen, Z.; Lan, X.; Lei, Y.; Cui, E.; Lin, F. Detecting Muscle Invasion of Bladder Cancer Using a Proposed Magnetic Resonance Imaging Strategy. *J. Magn. Reson. Imaging* **2021**, *54*, 1212–1221. [CrossRef]
43. Pecoraro, M.; Del Giudice, F.; Magliocca, F.; Simone, G.; Flammia, S.; Leonardo, C.; Messina, E.; De Berardinis, E.; Cortesi, E.; Panebianco, V. Vesical Imaging-Reporting and Data System (VI-RADS) for assessment of response to systemic therapy for bladder cancer: Preliminary report. *Abdom. Radiol.* **2022**, *47*, 763–770. [CrossRef]
44. Li, S.; Liang, P.; Wang, Y.; Feng, C.; Shen, Y.; Hu, X.; Hu, D.; Meng, X.; Li, Z. Combining volumetric apparent diffusion coefficient histogram analysis with vesical imaging reporting and data system to predict the muscle invasion of bladder cancer. *Abdom. Radiol.* **2021**, *46*, 4301–4310. [CrossRef] [PubMed]
45. Lee, S.J.; Kim, Y.-H.; Lee, M.-Y.; Ko, H.S.; Oh, S.; Seol, H.-J.; Kim, J.W.; Ahn, K.H.; Na, S.; Seong, W.J.; et al. Ultrasonographic evaluation of ovarian mass for predicting malignancy in pregnant women. *Gynecol. Oncol.* **2021**, *163*, 385–391. [CrossRef] [PubMed]
46. Da Silva, M.C.; Pecoraro, M.; Pisciotti, M.L.; Dehghanpour, A.; Forookhi, A.; Lucciola, S.; Bicchetti, M.; Messina, E.; Catalano, C.; Panebianco, V. The learning curve in bladder MRI using VI-RADS assessment score during an interactive dedicated training program. *Eur. Radiol.* **2022**, *32*, 7494–7503. [CrossRef] [PubMed]
47. Lai, A.L.; Law, Y.M. VI-RADS in bladder cancer: Overview, pearls and pitfalls. *Eur. J. Radiol.* **2023**, *160*, 110666. [CrossRef]
48. Huang, S.; Bain, J.; Yiu, T.W.; Gilbourd, D.; Haxhimolla, H.Z.; Jain, T.; Jyoti, R. Accuracy of the Vesical Imaging–Reporting and Data System (VIRADS) for pre-treatment staging of bladder cancer in an Australian cohort. *J. Med. Imaging Radiat. Oncol.* **2022**, *66*, 370–376. [CrossRef]
49. Rysankova, K.; Hanzlikova, P.; Zidlik, V.; Vrtkova, A.; Slisarenko, M.; Skarda, J.; Grepl, M.; Krhut, J. Is high accuracy of Vesical Imaging-Reporting and Data System (VI-RADS) sufficient for its implementation in the urological practice? *Biomed. Pap.* **2023**, *167*, 85–90. [CrossRef]
50. Del Giudice, F.; Leonardo, C.; Simone, G.; Pecoraro, M.; De Berardinis, E.; Cipollari, S.; Flammia, S.; Bicchetti, M.; Busetto, G.M.; Chung, B.I.; et al. Preoperative detection of Vesical Imaging-Reporting and Data System (VI-RADS) score 5 reliably identifies extravesical extension of urothelial carcinoma of the urinary bladder and predicts significant delayed time to cystectomy: Time to reconsider the nee. *BJU Int.* **2020**, *126*, 610–619. [CrossRef]

51. Del Giudice, F.; Barchetti, G.; De Berardinis, E.; Pecoraro, M.; Salvo, V.; Simone, G.; Sciarra, A.; Leonardo, C.; Gallucci, M.; Catalano, C.; et al. Prospective Assessment of Vesical Imaging Reporting and Data System (VI-RADS) and Its Clinical Impact on the Management of High-risk Non–muscle-invasive Bladder Cancer Patients Candidate for Repeated Transurethral Resection. *Eur. Urol.* **2020**, *77*, 101–109. [CrossRef] [PubMed]
52. Kobayashi, S.; Koga, F.; Kajino, K.; Yoshita, S.; Ishii, C.; Tanaka, H.; Saito, K.; Masuda, H.; Fujii, Y.; Yamada, T.; et al. Apparent diffusion coefficient value reflects invasive and proliferative potential of bladder cancer. *J. Magn. Reson. Imaging* **2014**, *39*, 172–178. [CrossRef] [PubMed]
53. Yoshida, S.; Koga, F.; Kobayashi, S.; Ishii, C.; Tanaka, H.; Tanaka, H.; Komai, Y.; Saito, K.; Masuda, H.; Fujii, Y.; et al. Role of Diffusion-Weighted Magnetic Resonance Imaging in Predicting Sensitivity to Chemoradiotherapy in Muscle-Invasive Bladder Cancer. *Int. J. Radiat. Oncol.* **2012**, *83*, e21–e27. [CrossRef] [PubMed]
54. Donaldson, S.B.; Bonington, S.C.; Kershaw, L.E.; Cowan, R.; Lyons, J.; Elliott, T.; Carrington, B.M. Dynamic contrast-enhanced MRI in patients with muscle-invasive transitional cell carcinoma of the bladder can distinguish between residual tumour and post-chemotherapy effect. *Eur. J. Radiol.* **2013**, *82*, 2161–2168. [CrossRef]
55. Feng, C.; Wang, Y.; Dan, G.; Zhong, Z.; Karaman, M.M.; Li, Z.; Hu, D.; Zhou, X.J. Evaluation of a fractional-order calculus diffusion model and bi-parametric VI-RADS for staging and grading bladder urothelial carcinoma. *Eur. Radiol.* **2022**, *32*, 890–900. [CrossRef]