Diagnostic performance of magnetic resonance imaging and targeted biopsy results in men with indwelling urinary catheters: A propensity score matched study

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ABSTRACT

Introduction: We sought to evaluate multiparametric magnetic resonance imaging (mpMRI) findings and biopsy results in men with an indwelling catheter undergoing prostate cancer screening. mpMRI is central to the evaluation of prostate cancer. Little is known as to the effect of an indwelling urinary catheter on prostate mpMRI findings and the results of subsequent biopsies.
Methods: We retrospectively reviewed 5820 mpMRI exams performed from 2017–2023. Forty-eight patients underwent mpMRI with indwelling urinary catheter. Using propensity score matching, patients were matched 1:1 for age, pre-biopsy prostate-specific antigen (PSA), and prostate volume. Clinical characteristics, mpMRI findings, and targeted biopsy results were compared between the groups.
Results: After propensity score matching, clinical characteristics of the study groups did not differ significantly. Prostate Imaging-Reporting & Data System (PI-RADS) distribution did not show a significant difference (p=0.51); PI-RADS ≥3 lesions were identified in 20/48 patients with indwelling catheters (42%) and in 18/50 patients without catheters (36%). Among patients with a PI-RADS score ≥3, clinically significant prostate cancer (CSPC) was identified in 5/20 patients carrying catheters and 6/18 patients without catheters (p=0.152). A higher rate of any cancer was identified in patients without a catheter (67% vs. 35%, p=0.049). PSA >9.79 ng/ml predicted the finding of CSPC in patients carrying urinary catheters with PI-RADS ≥3 lesions.

Conclusions: Our findings suggest no significant difference in mpMRI findings and CSPC rates for patients with and without indwelling urinary catheters. Patients carrying urinary catheters suspected to harbor CSPC based on an elevated PSA level should undergo further evaluation, including mpMRI and biopsies when necessary before benign prostatic hyperplasia treatment.

INTRODUCTION

Patients experiencing urinary retention, especially in the presence of obstructive uropathy, are required to carry a urinary catheter until the surgical treatment of their enlarged prostate. The presence of a urinary catheter significantly affects the quality of life, introducing discomfort, inconvenience, and potential complications such as infections [1,2]. One of the main concerns when treating patients with urinary obstruction in certain age groups is whether to screen for prostate cancer (PC) prior to treating the enlarged prostate[3]. This question becomes even more crucial when blood levels of prostate specific antigen (PSA) are obtained immediately after the insertion of the urethral catheter in the absence of documented pre-obstruction PSA levels. In these cases, elevated PSA levels may not truly represent a higher risk for prostate cancer, complicating the process of PC screening [4,5].

Multiparametric magnetic resonance imaging (mpMRI) has become an integral part of the diagnostic process for prostate cancer and is recommended before prostate biopsy [6]. Suspicious prostatic lesions on mpMRI are stratified according to the Prostate Imaging Reporting & Data System version 2 (PI-RADS v2), and targeted biopsies are recommended for lesions scored as PI-RADS≥3 [7]. Data are lacking regarding the effects of an indwelling catheter on the evaluation of prostate mpMRI and scoring of suspicious lesions. Furthermore, the association between mpMRI findings and biopsy results in the presence of a urinary catheter are unknown.

In this study, we sought to determine the effects of an indwelling urethral catheter on the interpretation of prostate mpMRI and on the detection rates of clinically significant prostate cancer (CSPC) using mpMRI-targeted and systematic biopsies.

METHODS

Patients

After obtaining Institutional Review Board approval, we conducted a retrospective study that included all consecutive patients who underwent mpMRI of the prostate for prostate cancer screening in our institute between January 2017 and June 2023. We identified 53 patients who performed the MRI while carrying a urinary catheter. Two patients with suspected pelvic lesions, 2 patients on active surveillance for low risk PC, and 1 patient who was lost to follow-up were excluded. Propensity score matching (PSM) was performed, and patients were matched 1:1 for the preoperative parameters: PSA, prostate volume and age. Matching tolerance was set at 0.0009, yielding a total of 98 propensity score-matched patients. Clinical

and demographic characteristics were compared between the groups, including PI-RADS score and targeted prostate biopsy results (Supplementary Figure 1).

mpMRI protocol and targeted biopsies
The mpMRI scans were performed on a 3Tesla scanner with a 16-channel surface coil. According to PI-RADS v.2 guidelines, all scans included T2 Echo sequences on three scan planes, T1 volumetric interpolated examination before and after administration of contrast medium and diffusion weight imaging sequences in axial plane with calculation of the relative apparent diffusion coefficient (ADC) map. According to the mpMRI characteristics, a PI-RADS score was assigned to each detected lesion. Biopsies were performed transperineally using a 5-mm grid and a spring-loaded biopsy gun with an 18G needle. All procedures were performed using the BioJet MRI/TRUS fusion biopsy system. After sampling all suspicious lesions, systematic biopsies were obtained.

Study outcomes
Primary outcomes were PI-RADS scores and identification of CSPC from the targeted prostate biopsies. The secondary outcome was identification of insignificant prostate cancer. CSPC was defined as international society of urological pathology (ISUP) grade ≥2.

Statistical analysis
Statistical comparisons between groups were performed by means of the Chi-square, Fisher-Exact and Mann-Whitney U tests. Univariate and multivariate logistic regressions were performed to evaluate the association between prostate biopsy results and predicting factors - PSA, prostate volume and age. A ROC curve was created to evaluate the identification of CSPC based on PSA levels in patients with indwelling catheters, and the PSA threshold was assessed using the Youden index. All analyses were 2-sided, and statistical significance was defined as $p<0.05$. The statistical analyses were done with SPSS v. 29 (IBM, USA), and graphical items were created using RAW Graphs v. 2.0 (DensityDesign, Calibro and Inmagik) and SPSS v.29.

RESULTS

Study population
The cohort comprised of 5820 MRI exams conducted on 4990 unique patients between January 2017 and June 2023. From this cohort, 48 patients who had indwelling urinary catheters and were not excluded from the study, formed the catheter group. Propensity score matching was conducted using PSA, prostate volume, and age as predictors. This process created a matched control group, allowing for a comparison of PI-RADS scores and biopsy outcomes between the original catheter group and the matched group (Supplementary Figure 1).

No significant differences were identified when comparing the clinical characteristics of the two groups, including age, PSA levels, PI-RADS score, and prostate volume (Table1). No significant differences were observed in all parameters included in the propensity score matching.

mpMRI suspicious findings
The distribution of PI-RADS scores did not show a significant difference between the groups (P=0.51). In patients with catheters, the distribution was as follows: PI-RADS 0/1 (15

(31%)), PI-RADS 2 (13 (27%)), PI-RADS 3 (6(12.5%)), PI-RADS 4 (8(16.7%)), and PI-RADS 5 (6(12.5%)). For patients without catheters, findings included: PI-RADS 0/1 (22(44%)), PI-RADS 2 (10(20%)), PI-RADS 3 (8(16%)), PI-RADS 4 (4(8%)), and PI-RADS 5 (6(12%)) (Table 1, Supplementary Figure 2). PI-RADS≥ 3 lesions were identified in 20 patients with indwelling catheters (41.6%) and in 18 patients without catheters (36%). There was no significant difference between the groups (P = 0.71), (Table 1).

Biopsy results

All patients with suspicious lesions on mpMRI (PI-RADS≥ 3) underwent MRI targeted fusion biopsies. Among the 20 patients with indwelling catheters and suspected lesions, biopsy results included: 2/20patients (10%) with ISUP1, 4/20 patients (20%) with ISUP2 and 1/20 patient (5%) with ISUP4. Among the 18 patients without catheters, findings included 6/18 patients (33%) with ISUP1, 3/18 patients (17%) with ISUP2, 1/18 patient (6%) with ISUP3 and 2/18 patients (11%) with ISUP4 (Table 2 a,b). Men without an indwelling catheter had a significantly higher rate of any cancer on biopsy (12/18, 67% vs. 7/20, 35%, p=0.049); however, rates of clinically significant prostate cancer did not differ significantly (6/18, 33% vs. 5/20, 25%, p=0.152) between the groups (Figure 1).

Among 11 patients with CSPC: average PSA levels were 26 ng/mL for the 5 patients within the catheter group and 16.25 ng/mL for the 6 patients within the non-catheter group (p=0.34). Average age was 68.5 years for the catheter group and 74.8 years for the non-catheter group (p=0.064). Average prostate volume was 126 cc for the catheter group and 53.8 cc for the non-catheter group (p=0.089). Average PSA density was 0.22 for the catheter group and 0.4 for the non-catheter group (p=0.34). Among patients diagnosed with any grade of prostate cancer: average PSA level was 23.57 ng/mL for the catheter group and 16.96 ng/mL for the non-catheter group (p=0.36). Average age was 68.39 years for the catheter group and 71.97 years for the non-catheter group (p=0.157). Average prostate size was 119.4cc for the catheter group and 90.89cc for the non-catheter group (p=0.33). Average PSA density was 0.2 for the catheter group and 0.27 for the non-catheter group (p=0.5).

It is important to note that the ISUP grade reported per patient reflects the highest grade identified in any of the sampled cores. In more than 80% of cases, this highest-grade tumor was found in the targeted biopsy cores.

Analysis of tumor location revealed that approximately 10% of the prostate cancer-positive samples were located in the transition zone (TZ), while the majority of lesions were identified in the peripheral zone (PZ).

Predicting factors for CSPC

When evaluating predicting factors for CSPC in patients with urinary catheters, higher PSA was found to be the only significant predictor of a positive biopsy (Supplementary Table 1).Using the Youden index we identified a PSA threshold of 9.79 ng/ml (specificity 0.488, sensitivity 1, PPV 0.185, NPV 1) for CSPC (AUC 0.77, p = 0.009, CI 0.549-0.99), under which no patient was diagnosed with clinically significant prostate cancer (Figure 2).

DISCUSSION

Screening for PC in patients carrying urinary catheters presents a unique challenge. In the current study we thought to evaluate the impact of the presence of an indwelling urinary catheter when performing mpMRI, its influence on PI-RADS scoring, and targeted biopsy results. Our findings suggest mpMRI maintains its accuracy in patients with a urinary catheter. We found no significant difference in the distribution of PI-RADS scores between patients with and without urinary catheter. Moreover, no significant difference was found in the rate of CSPC between the two groups. These findings support the use of mpMRI as a reliable diagnostic tool in patients with indwelling urinary catheters.

PC evaluation has evolved substantially with the advent of prostate mpMRI. Traditionally, PC diagnosis relied on PSA levels and digital rectal examinations (DRE), followed by trans-rectal ultrasound-guided biopsies (TRUS). TRUS guided systematic biopsy, has a diagnostic yield of 40-50%, but it may miss clinically significant cancers, especially in patients with persistent elevated PSA levels despite a negative initial biopsy [8,9]. In contrast, MRI fusion targeted biopsy uses mpMRI to identify suspicious lesions and guide targeted biopsies, enhancing the detection of clinically significant prostate cancers. Studies show that MRI fusion targeted biopsy has a higher accuracy and sensitivity for detecting significant prostate cancer, reducing the likelihood of missing aggressive cancers [8-11]. Studies have demonstrated that mpMRI not only enhances the detection of clinically significant prostate cancers but also reduces unnecessary biopsies and the diagnosis of indolent tumors [12,13].

Many patients with urinary catheters are eager to undergo BPH surgery as soon as possible to remove the catheter and alleviate their symptoms [2]. BPH surgeries such as transurethral resection of the prostate (TURP) and holmium laser enucleation of the prostate (HOLEP) target the transitional zone of the prostate. Prostate cancer isolated exclusively in the transitional zone (TZ) accounts for 20-25% of all prostate cancers [14-16]. Several studies have reported that cancer arising from the TZ have a more favorable prognosis than tumors that arise in the peripheral zone (PZ) [15,16]. Incidental prostate cancer (iPCa) is often detected during the microscopic evaluation of resected tissue from BPH surgeries. The likelihood of detecting prostate cancer pathology during BPH surgery varies, with incidental prostate cancer found in approximately 3-16% of cases. The detection rate of iPCa varies depending on the type of surgical procedure, with TURP has rate at approximately 1.4% and Robot-Assisted Simple Prostatectomy (RASP) the lowest at 1.18%. The most common pathological findings in these incidental cases include low-grade cancers, typically classified as Gleason score 6, which are often considered clinically insignificant [3]. Identifying clinically significant tumor before BPH surgery is important as it may alter the surgical treatment and justify performing robotic assisted radical prostatectomy which may treat both the cancer and the enlarged prostate. [17,18]

Patients with acute urinary retention often arrive to counseling with high PSA levels from a blood test obtained after the catheter insertion. Although studies demonstrate that PSA elevation after catheterization is minimal [19], this finding often leads to further evaluation, including performing an mpMRI of the prostate, aimed at identifying lesions suspicious for prostate cancer. Data regarding the accuracy of mpMRI in this scenario are scarce [20]. Our

results demonstrate that patients with urinary catheters are in a similar risk of harboring CSPC compared to those without, with higher PSA levels being a significant predictor of prostate cancer. Using the Youden index we identified a PSA threshold of 9.79, under which no patient with a PI-RADS score ≥3 prostate mpMRI lesion was diagnosed with clinically significant prostate cancer. Following further validation on additional, larger, cohorts this finding may suggest a benefit in using a higher PSA threshold when evaluating for the presence of prostate cancer in patients with an indwelling catheter and a prostate mpMRI finding.

Our study has several limitations that should be acknowledged. The retrospective nature of the study introduces inherent biases and limits the ability to establish causality. While propensity score matching was employed to balance preoperative parameters between the groups, residual confounding variables may still exist. Furthermore, the high prostate volume and PSA levels of patients in acute urinary retention with an indwelling catheter may have created a matched cohort with a higher risk of harboring prostate cancer; nevertheless, rates of CSPC did not differ significantly between the two groups. Additionally, the sample size, particularly of patients with urinary catheters, was relatively small, which may affect the generalizability of the findings.

Another limitation of our study is that only patients with PI-RADS ≥3 underwent prostate biopsy, limiting our ability to determine the false negative rate of mpMRI. However, in the catheter group, several patients with PI-RADS ≤2 lesions subsequently underwent BPH surgery aimed at catheter weaning. Histopathological examination of the resected tissue in these cases revealed only benign findings, suggesting a low likelihood of undetected clinically significant cancer in this subgroup.

Finally, the study focused on patients from a single institution, which may limit the external validity of the findings. Different institutions may have varying protocols and patient demographics, which could influence the outcomes. Future studies with larger cohorts are necessary to validate our results and provide more robust conclusions regarding the implications of urinary catheters on prostate cancer evaluation.

CONCLUSIONS

In the current study, mpMRI findings were similar between patients with elevated PSA levels with and without indwelling urinary catheters. Moreover, prostate biopsy results did not show a significantly different rate of CSPC when performing a biopsy on all patients with a PI-RADS ≥3 lesion.

Our findings suggest that patients carrying urinary catheters who present with elevated PSA levels prior to BPH surgery, should undergo further evaluation with a prostate mpMRI, and targeted biopsy when necessary.

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FIGURES AND TABLES

Figure 1. (A) Subgroup analysis of the prostate biopsy results into 0=benign, 1=clinically insignificant prostate cancer (ISUP1), and 2–4=clinically significant prostate cancer (CSPC) (ISUP2–4). (B) Subgroup analysis of the prostate biopsy results into 0=benign, 1(+)=clinically significant and insignificant prostate cancer (ISUP1–4).

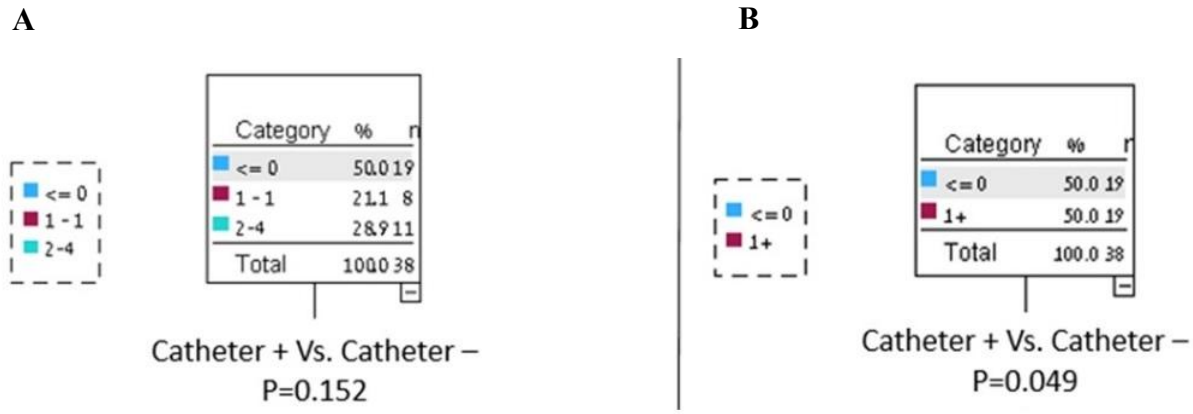

Figure 2. Receiver operating characteristics of PSA threshold for CSPC (clinically significant prostate cancer), in patients with urinary catheters. AUC - area under curve.

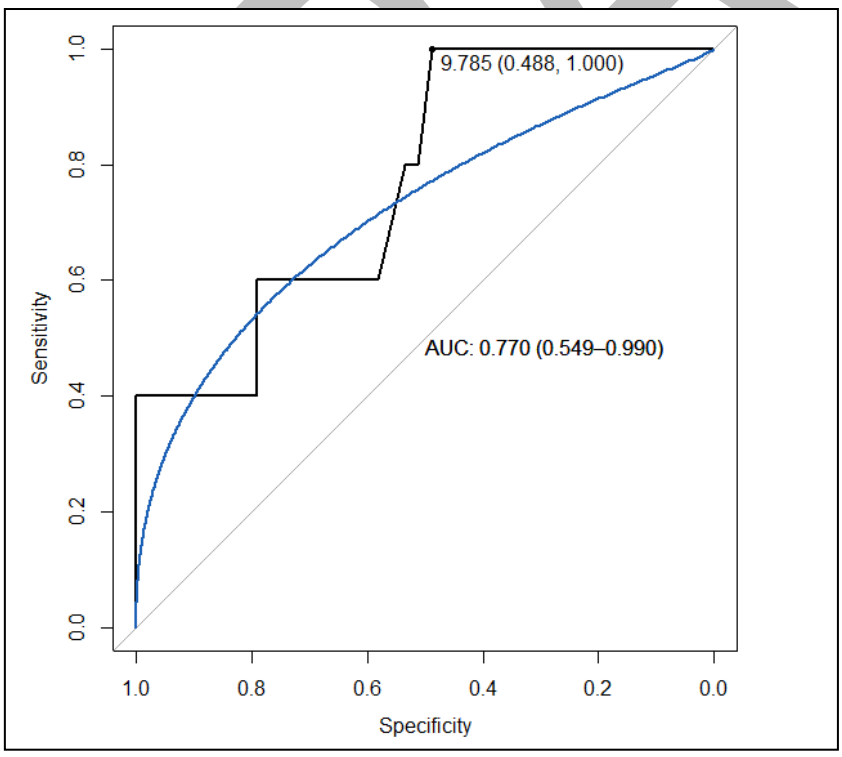

Table 1. Patient characteristics			
Variable	**Patients with urinary catheter (n=48)**	**Patients without urinary catheter (n=50)**	**p**
Age (years)	68.72 [64.64, 70.9]	68.52 [63.05, 72.63]	0.68
PSA (ng/ml)	10.85 [7, 17.42]	8.55 [5.72, 13.21]	0.63
Prostate volume (ml)	115.1 [83.8, 150]	92.3 [63.2, 159.5]	0.24
PI-RADS score			0.51
0/1	15 (31.2%)	22 (44%)	
2	13 (27.1%)	10 (20%)	
3	6 (12.5%)	8 (16%)	
4	8 (16.7%)	4 (8%)	
5	6 (12.5%)	6 (12%)	
PI-RADS distribution			0.71
PI-RADS 0/1+2	28 (58.3%)	32 (64%)	
PI-RADS 3+4+5	20 (41.6%)	18 (36%)	

PI-RADS: Prostate Imaging-Reporting & Data System; PSA: prostate-specific antigen.

Table 2A. MRI fusion prostate biopsy results based on the PI-RADS scores in patients with urinary catheters				
Variable	**PI-RADS 3 (n=6)**	**PI-RADS 4 (n=8)**	**PI-RADS 5 (n=6)**	**Suspicious lesions (N=20)**
Benign	5	5	3	(13/20) 65%
ISUP1	0	2	0	(2/20) 10%
ISUP2	1	1	2	(4/20) 20%
ISUP3	0	0	0	(0/20) 0%
ISUP4	0	0	1	(1/20) 5%
ISUP5	0	0	0	(0/20) 0%

ISUP: International Society of Urological Pathology. MRI: magnetic resonance imaging; PI-RADS: Prostate Imaging-Reporting & Data System.

Table 2B. MRI fusion prostate biopsy results based on the PI-RADS scores in patients without urinary catheters				
Variable	**PI-RADS 3 (n=8)**	**PI-RADS 4 (n=4)**	**PI-RADS 5 (n=6)**	**Suspicious lesions (N=18)**
Benign	5	1	0	(6/18) 33%
ISUP1	2	2	2	(6/18) 33%
ISUP2	1	0	2	(3/18) 17%
ISUP3	0	1	0	(1/18) 5.5%
ISUP4	0	0	2	(2/18) 11%
ISUP5	0	0	0	(0/20) 0%

ISUP: International Society of Urological Pathology. MRI: magnetic resonance imaging; PI-RADS: Prostate Imaging-Reporting & Data System.