Original Article

Preoperative prostate magnetic resonance imaging does not impact surgical outcomes of radical prostatectomy

Christopher K. Bozorgmehr[1], Johnny Wang[1], James T. Gross[1], Nicholas A. Pickersgill[1,2*], Joel M. Vetter[1], Joseph E. Ippolito[3], Eric H. Kim[4,5]

[1]Division of Urologic Surgery, Department of Surgery, Washington University School of Medicine, St. Louis, MO, [2]Urology Service, Department of Surgery, Memorial Sloan-Kettering Cancer Center, New York, NY, [3]Mallinckrodt Institute of Radiology, Washington University School of Medicine, St. Louis, MO, [4]Division of Urology, Department of Surgery, University of Nevada Reno School of Medicine, Reno, Nevada, [5]Department of Physiology and Cell Biology, University of Nevada Reno School of Medicine, Reno, Nevada, USA

*E-mail: pickern1@mskcc.org

ABSTRACT

Objective: We reviewed our institutional experience of radical prostatectomy with and without preoperative multiparametric magnetic resonance imaging (mpMRI) to assess the impact of preoperative prostate mpMRI on surgical outcomes of radical prostatectomy.

Methods: We identified patients at our institution who underwent radical prostatectomy for prostate cancer (PCa) between January 2012 and December 2017 (n = 1044). Using propensity scoring analysis, patients who underwent preoperative mpMRI (n = 285) were matched 1:1 to patients who did not receive preoperative mpMRI (n = 285). Multivariable regression analysis was performed to identify factors predictive of operative time, estimated blood loss (EBL), lymph node yield, rates of complications within 30 days, and positive surgical margin (PSM).

Results: There were no significant differences in operative time, EBL, PSM, lymph node yield, or complication rates between the two cohorts. Multivariable analysis demonstrated that preoperative mpMRI was not predictive of the measured perioperative outcomes. Significant comorbidity (Charlson Comorbidity Index ≥3) was the sole predictor of perioperative complications (P = 0.015). Increasing biopsy Gleason score predicted increased lymph node yield (P < 0.001). The probability of PSM was associated with increasing preoperative prostate-specific antigen (odds ratio 1.036, P = 0.009). Body mass index was a predictor of operative time (P = 0.016) and EBL (P = 0.001).

Conclusions: Although preoperative mpMRI has an important role in the diagnosis and staging of PCa, it does not impact perioperative radical prostatectomy outcomes. Our findings do not support the routine use of preoperative mpMRI for surgical planning in patients already diagnosed with clinically localized PCa.

INTRODUCTION

Multiparametric magnetic resonance imaging (mpMRI) of the prostate has been increasingly used for the diagnosis and staging of prostate cancer (PCa). The popularity of prostate mpMRI is supported by evidence of improved detection of clinically significant PCa and mitigation of the overdiagnosis and overtreatment of indolent disease.[1,2] Although the primary indication for mpMRI is screening for prostate biopsy, studies have shown that up to 17% of men with a negative magnetic resonance imaging (MRI) will miss a diagnosis of clinically significant PCa if they do not proceed to biopsy.[3,4] The ongoing discussion regarding its utility as a screening tool, coupled with the burdensome costs it imposes on the health-care system,[5] demonstrates that the current

Access this article online	
Quick Response Code:	Website: www.indianjurol.com
	DOI: 10.4103/iju.iju_115_24

Received: 23.03.2024, **Revised:** 18.07.2024,

Accepted: 02.09.2024, **Published:** 01.10.2024

Financial support and sponsorship: This study was supported by an educational grant from the Midwest Stone Institute (MSI) to JTG.

Conflicts of interest: There are no conflicts of interest.

utilization of mpMRI is imperfect, and its value in clinical practice may be further maximized.

One potential avenue for improvement is preoperative surgical planning. In this context, the use of mpMRI has been limited due to conflicting results regarding its utility in improving the prediction of extraprostatic extension (EPE).[6-8] Currently, both the National Comprehensive Cancer Network and the American Urological Association recommend the use of mpMRI in the management of patients on active surveillance for targeted rebiopsy and monitoring of known lesions.[9,10] The current guidelines do not address the use of prostate mpMRI for patients who already have a diagnosis of localized PCa and are proceeding to radical prostatectomy.

The advantages of using mpMRI in preoperative planning have been suggested but not well defined. Previous studies have focused on the impact of mpMRI on positive surgical margins (PSMs) with conflicting results, with one randomized control trial showing no effect of preoperative mpMRI on PSM, while a more recent observational cohort study showed a reduction in PSM in those who had preoperative mpMRI.[11,12] Furthermore, little is known of the impact of prostate mpMRI on other surgical outcomes including operative time, estimated blood loss (EBL), and complication rates.[13-16] We sought to determine the ability of preoperative mpMRI to predict these perioperative outcomes, as additional information on prostate size, tumor location, and presumptive stage may aid surgical planning. While the benefits of prebiopsy prostate mpMRI are well studied, there remain questions about its value in enhancing outcomes for patients with a diagnosis of PCa who are planned for radical prostatectomy.

To investigate the clinical value of mpMRI in the preoperative setting, we reviewed our institutional experience of radical prostatectomy with and without preoperative mpMRI in propensity-matched cohorts to account for patient- and disease-specific factors.

MATERIALS AND METHODS

Subjects

This study was approved by the Institutional Review Board at the Washington University in St. Louis on May 1, 2014 (reference number: 201304085). We reviewed our prospectively maintained database of patients who underwent radical prostatectomy for clinically localized PCa at our institution between January 2012 and December 2017. A total of 1044 patients who underwent open, laparoscopic, and robotic radical prostatectomy during this period were identified. Patients undergoing radical prostatectomy had histologically confirmed PCa on biopsy, which was indicated after consideration of clinical and diagnostic data. During the study, mpMRI was often considered but was not required as part of the diagnostic workup, as it had not become the standard of care.[17] Surgeons integrated clinical and histopathological data to evaluate the utility of preoperative mpMRI and assess local staging for each patient on an individualized basis. In cases of high clinical suspicion, cross-sectional imaging, such as prostate-specific membrane antigen positron emission tomography-computed tomography, was also utilized to evaluate clinical staging. Informed consent was provided by all patients before undergoing radical prostatectomy. The medical care and procedures provided fell within the ethical considerations delineated by the Declaration of Helsinki and its amendments. The data that support the findings of this study are not openly available due to reasons of sensitivity and are available from the corresponding author on reasonable request. The data are in a controlled access data storage at our institution.

Propensity matching

To reduce the impact of known predictors of adverse outcomes, we used nearest neighbor (1:1) propensity score matching to pair patients who had a preoperative mpMRI with those who did not. Matching was based on age, race, body mass index (BMI), Charlson Comorbidity Index (CCI), prostate-specific antigen (PSA), biopsy Gleason score, and the operating surgeon.[18] The matched cohort included 285 patients who had a preoperative prostate mpMRI and 285 who did not.

Multiparametric magnetic resonance imaging technique and interpretation

All imaging studies were performed according to our previously described institutional mpMRI protocol.[19,20] Briefly, all patients underwent 3-T mpMRI using a pelvic phased-array coil on Siemens Trio and Skyra platforms (Siemens Healthcare, Erlangen, Germany). Small field of view (160 mm) axial T2-weighted turbo spin echo images consisted of a 512 × 512 matrix with 3-mm slice thickness. Images were interpreted based on the standard workflows at our institution.[19] In brief, mpMRI was interpreted by 9 radiologists in the abdominal imaging section. On average, these radiologists had 11 years of clinical experience after training during which they interpreted 80 studies per year. Radiologists had access to all clinical information, including prior imaging and biopsy results, available in the patient's medical record during the interpretation of these studies. Radiologists interpreted mpMRI using prostate imaging reporting and data system (PI-RADS) version 1 before February 2015. Studies performed from February 2015 onward were interpreted using PI-RADS version 2.[21] Three-dimensional (3D) renderings of the prostate and all suspicious lesions were routinely produced using the semiautomated 3D segmentation feature of DynaCAD (*in vivo* Corporation, Gainesville, FL). In addition, radiologists provided an overall risk for EPE based on the following characteristics: lesion

contact length with prostate margin, prostate margin bulge or irregularity, rectoprostatic angle obliteration, neurovascular bundle asymmetry, and gross EPE. In cases where EPE was suspected, surgeons and radiologists reviewed the mpMRI together.

Perioperative outcome measures

Assessed perioperative outcomes included lymph node yield, operative time, EBL, PSM rate, and postoperative complication rate. PSM was defined as any length PSM noted in the postoperative pathology report. Patients were classified as having complications if they experienced Clavien Grade II or higher complication within 30 days of surgery.[22]

Multivariable regression analysis

Multivariable regression analyses were performed to assess the impact of preoperative mpMRI on the following perioperative outcomes: operative time, EBL, lymph node yield, rates of complications within 30 days of surgery, and PSM. These analyses controlled for the following variables: age, PSA, CCI, Gleason score, surgeon, and BMI. In addition, the model assessing PSM included the presence of EPE on the final pathologic specimen. Logistic, Poisson, linear, and log-linear multiple regression modeling were used where appropriate. A *post hoc* power analysis was conducted for each of these models with the intention of determining the potential magnitude of difference that could have been detected with the sample size using the observed rates and standard deviations. Statistical analysis was performed using R, version 3.5.2 (R Foundation for Statistical Computing, Vienna, Austria). All statistical tests were two sided. Statistical significance was defined by $P < 0.05$.

Table 1: Clinical characteristics and patient demographics

Clinical characteristics	No mpMRI (*n*=285)	mpMRI (*n*=285)	*P*
Age (years), mean (SD)	63.1 (6.5)	62.3 (7.0)	0.290
Race, *n* (%)			
Black or African American	61 (21.4)	55 (19.3)	0.532
Other	224 (78.6)	230 (80.7)	
PSA (ng/mL), mean (SD)	8.0 (10.2)	8.3 (6.8)	0.276
BMI (kg/m^2), mean (SD)	28.7 (4.8)	28.6 (4.7)	0.600
CCI, *n* (%)			
0	187 (65.6)	185 (64.9)	0.861
1	46 (16.1)	48 (16.8)	
2	33 (11.6)	37 (13)	
≥3	19 (6.7)	15 (5.3)	
Biopsy Gleason, *n* (%)			
6	74 (26)	74 (26)	0.890
7	152 (53.3)	145 (50.9)	
8	38 (13.3)	41 (14.4)	
9	21 (7.4)	25 (8.8)	
Pathological T-stage, *n* (%)			
T2	182 (63.9)	189 (66.3)	0.539
T3	103 (36.1)	96 (33.7)	

BMI=Body mass index, PSA=Prostate-specific antigen, SD=Standard deviation, CCI=Charlson comorbidity index, mpMRI=Multiparametric magnetic resonance imaging

Table 2: Univariable comparison of perioperative outcomes between patients with and without multiparametric magnetic resonance imaging before radical prostatectomy

Perioperative outcomes	No mpMRI (*n*=285)	mpMRI (*n*=285)	*P*
Lymph node yield, mean (SD)	7.8 (5.8)	8 (5.5)	0.417
EBL (mL), mean (SD)	299.8 (448.2)	268.7 (329.4)	0.906
Operative time (min), mean (SD)	175.8 (71.9)	176.5 (65.8)	0.579
Complication within 30 days, *n* (%)	40 (14)	29 (10.2)	0.199
Positive margins, *n* (%)	101 (35.4)	95 (33.3)	0.659

mpMRI=Multiparametric magnetic resonance imaging, SD=Standard deviation, EBL=Estimated blood loss

RESULTS

Clinicopathological data for propensity-matched patients are summarized in Table 1. No baseline clinical characteristics were significantly different between the two groups. No perioperative outcomes were significantly different between the two groups [Table 2].

The multivariable analysis results for modeling probability of PSM, probability of complications within 30 days of surgery, number of lymph nodes examined, length of operating time, and EBL are summarized in Table 3. Of note, having a preoperative mpMRI was not associated with decreased or increased odds of having complications within 30 days of surgery (odds ratio [OR] 0.69, 95% confidence interval [CI] 0.41, 1.16, $P = 0.17$) or PSM (OR 0.90, 95% CI 0.62, 1.29, $P = 0.56$). Undergoing preoperative mpMRI was also not predictive of lymph node yield (rate ratio 1.00, 95% CI 0.96, 1.08, $P = 0.52$), operative time in minutes (1.4, 95% CI – 5.2, 8.0, $P = 0.68$), or EBL (percentage change 3.6%, 95% CI – 8.0%, 17.4%, $P = 0.57$). For each of these models, our sample size was found to be sufficient for detecting the following differences between each group: complications within 30 days of surgery – 8%, positive margins – 8%, lymph node number – 1.3 nodes, EBL – 90 mL, and operative time of 16 min.

Several associations were identified between various clinical characteristics and surgical outcomes in our multivariable analysis. Notably, patients with significant comorbidities (CCI ≥3) were found to have a higher likelihood of perioperative complications within 30 days of surgery ($P = 0.015$). Increased lymph node yield was associated with a higher biopsy Gleason score ($P < 0.001$). The probability of PSM was significantly associated with increasing preoperative PSA (OR 1.04, $P = 0.009$) and EPE on final pathology (OR 3.67, $P < 0.001$). In addition, operative time and EBL were positively correlated with BMI ($P = 0.016$ and $P = 0.001$, respectively).

DISCUSSION

Our institutional experience suggests that in patients undergoing radical prostatectomy for PCa, perioperative surgical outcomes including PSMs, complications within

Table 3: Multivariable logistics regression analysis of clinical factors predictive of perioperative outcomes

Variables	OR (95% CI)	*P*
Logistic regression modeling the probability of complication within 30 days of surgery		
Preoperative mpMRI	0.69 (0.41–1.16)	0.165
Age	1.00 (0.96–1.04)	0.951
BMI	1.04 (0.98–1.10)	0.172
PSA	1.01 (0.99–1.04)	0.335
CCI≥3 versus CCI=0	2.96 (1.24–7.06)	0.015*
Gleason 7 versus Gleason 6 at biopsy	0.70 (0.36–1.35)	0.289
Gleason 8 versus Gleason 6 at biopsy	0.90 (0.37–2.14)	0.804
Gleason 9 versus Gleason 6 at biopsy	0.56 (0.17–1.86)	0.342
Logistic regression modeling the probability of positive surgical margin		
Preoperative mpMRI	0.95 (0.65–1.38)	0.777
Age	1.01 (0.98–1.04)	0.454
BMI	1.00 (0.96–1.04)	0.909
PSA	1.04 (1.01–1.07)	0.009*
CCI ≥3 vs. CCI=0	0.77 (0.35–1.70)	0.800
Gleason 7 versus Gleason 6 at biopsy	1.07 (0.64–1.78)	0.682
Gleason 8 versus Gleason 6 at biopsy	0.87 (0.44–1.72)	0.898
Gleason 9 versus Gleason 6 at biopsy	0.95 (0.42–2.12)	0.800
Presence of EPE on final pathology	3.67 (2.44–5.53)	<0.001*
Variables	**Estimate (95% CI)**	***P***
Linear regression modeling of operative time		
Preoperative mpMRI	1.40 (−5.17–7.97)	0.676
Age	0.05 (−0.46–0.55)	0.854
BMI	0.86 (0.16–1.57)	0.016*
PSA	0.38 (−0.01–0.76)	0.056
CCI ≥3 versus CCI=0	13.9 (−0.66–28.47)	0.062
Gleason 7 versus Gleason 6 at biopsy	3.97 (−4.61–12.55)	0.364
Gleason 8 versus Gleason 6 at biopsy	−1.66 (−13.42–10.09)	0.782
Gleason 9 versus Gleason 6 at biopsy	−4.47 (−18.38–9.43)	0.529
Log-linear regression modeling of estimated blood loss		
Preoperative mpMRI	1.04 (0.92–1.17)	0.573
Age	1.00 (0.99–1.01)	0.394
BMI	1.02 (1.01–1.04)	0.001*
PSA	1.00 (1.00–1.01)	0.496
CCI ≥3 versus CCI=0	0.88 (0.68–1.15)	0.366
Gleason 7 versus Gleason 6 at biopsy	0.94 (0.80–1.11)	0.476
Gleason 8 versus Gleason 6 at biopsy	0.88 (0.71–1.10)	0.271
Gleason 9 versus Gleason 6 at biopsy	0.79 (0.61–1.04)	0.094
Poisson regression modeling the lymph node yield		
Preoperative mpMRI	1.02 (0.96–1.08)	0.516
Age	1.00 (1.00–1.01)	0.195
BMI	1.02 (1.01–1.03)	<0.001*
PSA	1.00 (1.00–1.01)	0.275
CCI ≥3 versus CCI=0	1.13 (1.01–1.27)	0.036*
Gleason 7 versus Gleason 6 at biopsy	1.26 (1.17–1.37)	<0.001*
Gleason 8 versus Gleason 6 at biopsy	1.49 (1.35–1.66)	<0.001*
Gleason 9 versus Gleason 6 at biopsy	1.61 (1.42–1.81)	<0.001*

OR=Odds ratio, CI=Confidence interval, EBL=Estimated blood loss, mpMRI=Multiparametric magnetic resonance imaging, CCI=Charlson comorbidity index, BMI=Body mass index, PSA=Prostate-specific antigen, *$P < 0.05$

30 days of surgery, length of operating time, and EBL are not impacted by the availability of a preoperative prostate mpMRI. Rather, these outcomes are predicted instead by the patient's comorbidities, PSA, BMI, and biopsy Gleason score. These findings suggest that patients with previously diagnosed PCa should not undergo mpMRI before radical prostatectomy solely for the purposes of improving surgical outcomes.

Within our study, mpMRI has a role in the management of patients with PCa that could potentially impact operative plans as well as patient perioperative outcomes. Prior reports have suggested that mpMRI may impact surgical planning and potentially improve decisions regarding nerve sparing and bladder neck dissection in patients with high-risk PCa.[23] At our institution, like many others, surgeons are trained to incorporate mpMRI into their practice in an active and collaborative way. Surgeons read and review prostate mpMRI independently while incorporating the data from their radiology colleagues which include the PI-RADS and internal EPE scoring system described in the methods section on mpMRI interpretation. Furthermore, surgeons and radiologists collaborate directly to interpret the findings in complex cases including those with high suspicion of EPE. These workflows provide the clearest way in which mpMRI is expected to impact the perioperative outcomes we examined in this study.

Despite this potential for impact, the availability of preoperative mpMRI did not influence the rates of PSMs for the patients in our cohort. Previous studies investigating the use of preoperative mpMRI have focused on its impact on PSMs alone. A randomized controlled trial by Rud *et al*. showed no difference in the likelihood of PSM between those who had preoperative mpMRI and those who did not.[12] Conversely, a more recent nonrandomized prospective study by Jäderling *et al*. showed a reduction in PSMs associated with the use of preoperative mpMRI.[11] This effect was demonstrated both when PSM was defined as >3 mm or any PSM present. The results of the present study align with Rud *et al*.; this negative finding is further supported by the results of our power analysis indicating that any clinically significant difference in PSMs should have been detected. Still, there are key differences between study methods that could account for the conflicting results with Jäderling *et al*. Specifically, Rud *et al*.'s method of communicating mpMRI findings involved the operating surgeon receiving a diagram of the mpMRI findings, whereas the study by Jäderling *et al*. involved a conference with a radiologist present for every patient who had an mpMRI.[11,12] The former method is more consistent with routine clinical practice, and in our opinion, better represents the way in which mpMRI interpretation is typically incorporated into surgical planning. These methods are also each susceptible to the interobserver variability in mpMRI interpretation, which we have previously shown can range from poor agreement to substantial agreement.[24] Together, these studies suggest that the value of preoperative mpMRI is not realized in the current practice but may be improved through changes to the collaborations between the radiologist and operating surgeon.

In contrast to PSM, the impact of preoperative mpMRI on EBL, postoperative complications, and length of operating time has not been examined in previous studies. Intuitively, these outcomes would be improved through the availability of imaging, as mpMRI provides detailed anatomy, tumor volume, prostate volume, and potential areas of EPE. However, these outcomes appear unchanged using mpMRI preoperatively in the study population. For EBL and complication rates, this indicates that preoperative mpMRI does not impact perioperative morbidity. In addition, mpMRI does not reduce the overall operative time, which is the most significant modifiable cost incurred to both the patient and the provider.[14,15,25] Previous results evaluating the use of mpMRI for the prediction of the final prostatectomy stage have been mixed, with one study failing to find any advantage compared to readily available clinical nomograms.[6-8] Given these negative results, our data do not support obtaining a prostate mpMRI before prostatectomy in patients with an established diagnosis of localized PCa.

Increasing BMI was a predictor of increasing operative time with a regression coefficient of 0.86 (CI 0.16, 1.57). This is similar to a previous study that demonstrated a regression coefficient of 0.93 (CI – 0.24, 2.11) which was suggestive of the effect demonstrated in the study cohort.[13] Increased BMI was also associated with increased EBL in our regression model. This relationship was demonstrated by Boorjian *et al*. using categorical weight groups rather than a regression model, making it unclear if the effect size is similar.[26] PSM was predicted by an increasing preoperative PSA similarly to other studies including Pooli *et al*., which showed an OR of 1.6 for patients with a PSA of ≥10.[27-29] Intuitively, the presence of EPE on final pathology was also strongly predictive of a PSM. While not noted in prior literature, the Gleason score being positively correlated with lymph node yield in this cohort is likely an effect of surgeons conducting extended lymph node dissections in the setting of a patient with higher risk disease.

The present study is limited by its retrospective design. Specifically, we have not controlled for the indications for mpMRI before surgery. However, propensity matching, and multivariable analysis controlled for factors including operating surgeon and likely limited any bias introduced by these variations. In addition, we recognize that in the years following our cohort's treatment, MRI technology has advanced, and its usage has become the standard of care when selecting patients for prostate biopsy. Future studies should focus on prospective analysis of mpMRI obtained specifically in the postbiopsy and preprostatectomy setting, as well as long-term outcomes including cancer-specific survival and patients' self-reported outcomes, such as erectile function and urinary continence.

CONCLUSIONS

Prostate mpMRI has an important role in PCa diagnosis and staging. Preoperative mpMRI did not impact perioperative outcomes after radical prostatectomy in this matched cohort. Our findings do not demonstrate a clinical benefit of mpMRI as a tool for preoperative surgical planning for patients with clinically localized PCa, but further research is needed.

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How to cite this article: Bozorgmehr CK, Wang J, Gross JT, Pickersgill NA, Vetter JM, Ippolito JE, *et al*. Preoperative prostate magnetic resonance imaging does not impact surgical outcomes of radical prostatectomy. Indian J Urol 2024;40:266-71.