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The Role of Endorectal Coil MRI in the management of patients with prostate cancer and in determining radical prostatectomy surgical margin status: A report of a single surgeon's practice

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Abstract

Objective—To evaluate the role of combination of endorectal coil and external multicoil array MRI in the management of prostate cancer and predicting the surgical margin status in a single surgical practice.

Materials and Methods—We reviewed all patients referred by a single surgeon from January 1993 to May 2002 for staging prostate MRI prior to selecting treatment. All MRI examinations were performed using 1.5T (Signa; GE Medical Systems) with a combination of endorectal and pelvic multi-coil array. The tumor size, stage and total gland volume on MR, PSA and Gleason grade were all compared with the pathological stage and diagnosis of positive surgical margin (PSM).

Result—A total of 232 patients were evaluated, of which 110 underwent radical prostatectomy all performed by one surgeon (Group 1), and 122 did not (Group 2). The results showed MRI stage, PSA and age, all significantly different ($P < 0.001$). In Group 1, the results showed a high specificity (99%) and accuracy (91%) of the MRI staging T3. Post-surgical follow up (median 4.5 years) showed 90% of men had PSA levels below 0.1ng/ml. The positive surgical margin (PSM) rate was 16%. There was no significant difference found on MR imaging between PSM group and non-PSM group. A single tumor length above 1.8cm was the cut point above which there was PSM ($P = 0.002$).

Conclusion—In conclusion, the combined use of clinical data and endorectal MR imaging can help optimize patient management and selection for surgery, and in a single surgeon's practice lead to successful outcomes.

Introduction

Accurate staging of prostate cancer remains a challenge. Approximately 40% of patients with clinically organ confined prostate cancer have extraprostatic disease at pathology¹. The incidence of positive surgical margin (PSM) is 16-46%, and associated with a 30-50% 10-year actuarial local failure rate^{1,2}.

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Few studies have assessed endorectal and multi-coil array MR imaging combined with clinical data for optimizing patient selection for surgery, post operative follow-up and assessed the factors contributing to post operative surgical margins status.

Materials and methods

Overview

Under an institutional review board protocol, we reviewed retrospectively all patients referred and treated by a single surgeon (K.R.L.) from January 1993 to May 2002 for staging prostate MRI examination prior to selecting treatment (n=232). Patients with prostate cancer, suspected of having extra-glandular disease, based upon either PSA, Gleason score or rectal exam were referred for endorectal coil MRI.

The original MRI, clinic and pathologic reports were reviewed. All MRI findings including the size/volume of the prostate, presence or absence of extracapsular extension (ECE), and seminal vesicle invasion (SVI) were compared with pathology. Post prostatectomy, patients were followed with PSA.

We assessed the correlation between the clinical and pre-operative MRI-findings, PSA, Gleason grade and pathological stage including the surgical margin status and recorded all PSM cases.

Pre-surgical PSA, Gleason sum, MRI findings and pathologic tumor size and stage were statistically evaluated to determine any influence on surgical margins status.

MRI protocol

All MR imaging was performed using 1.5T system (GE Healthcare, Milwaukee, WI) with an endorectal coil (Medrad Inc. PA) and an external pelvic coil. Multiplanar T2-weighted images were obtained with FSE technique: TR/TE 5000/104ms, 3-mm section thickness, 3.5-mm interleaved acquisition, 10-12 cm field of view, and 256 × 256 matrix. Axial T1-weighted (TR/TE 500/8 ms) images were also obtained. The retroperitoneum was imaged using T1-weighted imaging (TR/TE 500/8 ms) to assess lymph nodes and bones.

MR imaging interpretation

The MR exams were prospectively interpreted by one of nine experienced radiologists. Findings were classified into one of three categories: (1) MR stage T2: definitely organ-confined, (2) possible T3: possibly extracapsular. Examples were: "probable," "possible," and "suspicious" and (3) MR stage T3: definite extra-capsular extension.

Statistical Analysis

Patient's age, PSA, clinical and pathologic staging, MRI classification, surgical margin status, and Gleason score were recorded. The accuracy, sensitivity, specificity, and positive and negative predictive values were calculated for MRI. Statistical methods included two-sample Student's t-test, Fisher's exact test. Sensitivity and specificity analyses to compare (1) Surgery or no surgery groups and (2) the men with and without PSM.

Results

A total of 232 patients' records were reviewed. The endorectal coil MR exams were all performed with the same protocol and done 3-10 weeks after biopsy (median 7 weeks). The mean interval from MR to surgery was 6 weeks (range 1-18 weeks). None of the patients received preoperative hormones or radiation therapy. MR classified 151 men as stage T2, 13

possible and 68 definite stage T3. There were 4 MR cases with seminal vesicle and 4 with lymph node involvement. Based upon all MR findings pooled 151 were T2 and 81 stage T3 or greater.

Based on all pre-operative data, 110 patients underwent radical prostatectomy (Group 1), and 122 patients did not (Group 2). Group 1's mean age was 62.2 years versus 68 in group 2 (Table 1). The mean PSA values and Gleason sum were 8.1 and 6.4 versus 24.1 and 6.5. In group 1, 88% were MR stage T2, compared to 41% of group 2. Thus, the MRI stage ($p<0.001$), as well as PSA ($p=0.046$) and age ($p<0.001$), were significantly different between two groups.

Group 2 had a higher rate of T3 disease, on MR (59%) and were older than those in group 1 (Table 1). The PSA levels were much higher, mean 24ng/ml. Thus, the MRI was not the only deciding factor for selection of surgery. Other factors, such as overall medical health, co-morbid conditions and geographical and social choices were evaluated.

Endorectal coil MRI in selecting patient

In Group 1, 82% (90/110) of the patients had pathological organ-confined disease (Table 2). The MR correctly staged 83 men (88%), with an accuracy of 91% and specificity 99%, with 6 thought to be possible T3 and one patient with definite T3 disease. Twenty men (18%) had stage T3 at pathology, with 11 (true positives) identified on MRI and one case suspected. There were 8 men under-staged (false negatives) by MR as stage T2. There were 5 cases of SVI, always associated with ECE. No patient had SVI alone, and 2 cases of lymph node involvement were identified.

While 19 men's MR examinations showed stage T3 or greater disease, they did go to surgery (based upon favorable clinical features such as age and/or PSA), and 12 were found to have T3 or greater disease. Seven of this group were MR false positives and found to have T2 or organ confined disease.

The performance characteristics of the MRI to predict SVI, both ECE and SVI, and positive lymph nodes for patients with clinical localized disease at pathology, are shown in Table 3. There was 1 false negative and 9 false negative for *definite* MRI studies with respect to the end point of SVI, and both ECE and SVI, respectively. There was, however, only 1 false-positive MRI for definite ECE and SVI (specificity 99%). Thus if only the MRI stage of *definitely* T3 was used to prevent patients from consideration for radical prostatectomy then only 1 % of patients would have been excluded. Moreover, this would have raised the pathologic organ confinement rate in this group from 82% (90/110) to 91% (89/99), and would have reduced the percent of patients with ECE or/and SVI from 18% (20/110) to 8% (9/110) in Group 1.

Post-operative follow-up

In group 1, 85 men were followed up after surgery with PSA. Of those, 25 were lost to follow up. Median follow up time was 4.5 years (range 4 months to 7 years). The results showed 90% (77/85) of men had PSA levels below 0.1ng/ml and 98% (83/85) below 1ng/ml. Only 1 patient had a PSA level of more than 40ng/ml after 5 years follow up.

Associated with Positive Surgical Margins

In group 1, 84% of the men (92/110) had negative surgical margins, 16% (18/110) had at least 1 PSM and 5 of the 18 had more than one site of PSM. PSMs occurred at the apex ($n=10$, 56%), posterolaterally ($n=4$), inferiorly ($n=3$), and at the base ($n=1$) of the gland. Table 4 lists results of the possible predictors of PSM. The mean tumor was 1.79 cm in length in the positive margin cases versus 1.19 cm in negative margin cases. A single tumor length above 1.8cm was the cut point above which there was PSM ($P=0.002$). The larger tumor size at pathology was

significantly associated with PSM. There were no differences in MR stage or gland volumes. The PSM rate in the T2 MRI was 17%, and 15% in the T3 MRI group and the mean gland volume on MRI was 38.7cc in PSM versus 40.1cc in negative margins.

Discussion

This study was conducted to examine the retrospective findings of MRI and pathological correlates in staging and surgical margin status. In it, the same surgical approach for radical prostatectomy was used for all patients.

Endorectal MRI had a low sensitivity (55%) but an extremely high specificity (99%) to predict T3 disease. Confining the endorectal MR image analysis to the strictest category would have reduced the percentage of patients with established ECE or/and SVI from 18% to 8%, and increased the pathologic organ confinement rate from 82% to 91%. Only 1 of 110 patients would have been excluded from surgery on the basis of false-positive study.

The main benefit of prostate MRI is its ability to detect advanced disease missed by conventional clinical staging. Our results are comparable to previous reports with the endorectal coil (sensitivity 54%, specificity 95%)^{3,4,5}. A false-positive MR finding may deprive a man with localized disease of a potentially curative operation. Thus, when making an overall determination of MR stage radiologists should attempt to work at a high specificity that serves to minimize the chance of a false-positive finding^{6,7}.

Most errors reported in assessing ECE by MRI are false negative results that occur because microscopic penetration of the capsule is noted at pathology but cannot be detected by MRI. Fortunately, microscopic invasion of the capsule without SVI or positive margins may not change the disease-free survival rate from that associated with pathologically organ-confined disease treated with radical prostatectomy^{8,9}.

This study used pre-defined criteria for the diagnosis of T3 tumor to rank the probability of extra-glandular disease. In 7 patients, capsular thickening, bulging, and minimal irregularity were interpreted as “possible” capsular penetration; only 1 of them was identified as T3 tumor at pathology (sensitivity 14%). Obviously, the necessity for strict criteria (high specificity) precludes the use of MR imaging findings of “possible T3” to prevent a patient going to surgery.

Another aim of this study was to assess the risk of PSM with endorectal MRI and other clinical features in patients with clinically localized prostate cancer.

The PSM rate in our series (16%) was lower than most other published reports (16-46%)^{1, 2, 10}. In this series, using endorectal MRI, as well as preoperative PSA and patient age in the selection of candidates for radical prostatectomy all likely contributed to the decrease in the incidence of PSMs. In the PSM cases, the MR predicted T3 disease in 15% was not deemed significant enough to change surgical management.

In our series a preoperative finding of definite ECE and SVI on MRI to predict PSM was 11% (2/18) sensitivity, 88% (81/97) specificity, and 75% (83/110) accuracy.

Determining the relationship between PSM and the length of tumor in biopsy specimens was the best predictor in our series with increased PSM over 1.8 cm of tumor at pathology ($p=0.002$). However, tumor length on MRI was not significantly different between PSM and negative margins ($p=0.65$).

In conclusion, the combined use of clinical data and endorectal coil MR can optimize patient management and selection for surgery and, in a single surgeon's practice, lead to successful

outcomes. Based on our findings, the only predictor of PSMs was tumor length and PSMs occurred infrequently (16% rate), independent of all pre-operative data.

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TABLE 1
Pre-treatment variables in 232 men with prostate cancer

Variable	Group 1 Surgery (n=110) Mean Value	Group 2 Non-surgery (n=122) Mean Value	P-value
MRI stage	T2 (88%)	T3 (59%)	<0.001
Age	62.2	68.0	<0.001
PSA	8.1	24.1	0.046
Gleason sum	6.4	6.5	0.90

TABLE 2**Group 1: MRI staging with pathology, group 1**

Pathology	Cases	MRI		
		T2	Possible T3	Definite T3
T2	90 (82%)	83	6	1
T3	20 (18%)	8	1	11
Total	110	91 (83%)	7 (6%)	12 (11%)

TABLE 3
Accuracy of MRI to predict advanced prostate cancer, Group 1 patients

Parameter	Seminal Vesicle Invasion	Extra-capsular extension (ECE) or/ECE+SVI	Lymph Node metastases
Sensitivity	0.80 (4/5)	0.55 (11/20)	1.00 (2/2)
Specificity	1.00 (105/105)	0.99 (89/90)	0.98(106/108)
Positive predictive value	1.00 (4/4)	0.92 (11/12)	0.50 (2/4)
Negative predictive value	0.99 (105/106)	0.91 (89/98)	1.00 (106/106)
Accuracy	0.99 (109/110)	0.91 (100/110)	0.98 (108/110)

TABLE 4
Predictors for Positive Surgical Margins (PSM) vs. Negative Surgical Margins (NSM) in Group 1 (surgical) patients

Method	Variable	PSM	NSM	P-value
Pathology	Mean Size	1.79 cms	1.19 cms	0.002
	Stage	T3 (20%), T2 (16%)	T3 (80%), T2 (84%)	0.74
MRI	Size	1.31	1.20	0.65
	Stage	T3 (15%), T2 (17%)	T3 (85%), T2 (84%)	0.99
	Gland Volume	38.7(cc)	40.1(cc)	0.75
Gleason score		6.50	6.17	0.12
PSA		7.56	8.24	0.63