Association of Retrospective Peer Review and Positive Predictive Value of Magnetic Resonance Imaging-Guided Vacuum-Assisted Needle Biopsies of Breast

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ABSTRACT

Objective: To evaluate the association between retrospective peer review of breast magnetic resonance imaging-guided vacuum-assisted needle biopsies and positive predictive value of subsequent magnetic resonance imaging-guided biopsies

Materials and Methods: In January, 2015, a weekly conference was initiated in our institution to evaluate all breast magnetic resonance imaging-guided vacuum-assisted needle biopsies performed over January 1, 2014-December 31, 2015. During this weekly conferences, breast dynamic contrast-enhanced magnetic resonance imaging findings of 6 anonymized cases were discussed and then the faculty voted on whether they agree with the biopsy indication, accurate sampling and radiology-pathology correlation. We retrospectively reviewed and compared the magnetic resonance imaging indication, benign or malignant pathology rates, lesion types and the positive predictive value of magnetic resonance imaging-guided vacuum-assisted needle biopsy in the years before and after initiating this group peer review.

Results: The number of dynamic contrast-enhanced magnetic resonance imaging and magnetic resonance imaging-guided vacuum-assisted needle biopsies before and after initiating the review were 1447 vs 1596 ($p=0.0002$), and 253 (17.5%) vs 203 (12.7%) ($p=0.04$), respectively. There was a significant decrease in the number of benign biopsies in 2015 ($n=104$) compared to 2014 ($n=154$, $p=0.04$). The positive predictive value of magnetic resonance imaging-guided biopsy significantly increased after group review was implemented (Positive predictive value in 2014= $\%39.1$ and positive predictive value in 2015= $\%48.8$) ($p=0.03$), although the indications ($p=0.49$), history of breast cancer ($p=0.14$), biopsied magnetic resonance imaging lesion types ($p=0.53$) were not different. Less surgical excision was performed on magnetic resonance imaging-guided vacuum-assisted needle biopsy identified high-risk lesions in 2015 ($p=0.25$).

Conclusion: Our study showed an association between retrospective peer review of past biopsies and increased positive predictive value of magnetic resonance imaging-guided vacuum-assisted needle biopsies in our institution.

Keywords: Breast, dynamic contrast-enhanced magnetic resonance imaging, magnetic resonance imaging-guided vacuum-assisted needle biopsy, positive predictive value

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Introduction

With rising health care costs, recent initiatives have focused on appropriate ordering of tests by physicians, to minimize waste and to improve quality of care (1-7). National campaigns such as 'Choosing Wisely' have gained significant following to improve the utilization of high-cost imaging. Dynamic contrast-enhanced magnetic resonance imaging (MRI) of breast is an important tool for screening high-risk women and for the diagnosis, staging, and evaluation of breast malignancies (8-21). While MRI is highly sensitive (range, 89-100%), it has moderate to low specificity (range, 37-70%) (22-34), resulting in a significant increase in unnecessary needle biopsies (35-37). More than half of MRI detected abnormalities cannot be identified with an MRI directed, or "second-look" ultrasound (38-52), leading to an increased need for MRI-guided biopsies. MRI-guided vacuum-assisted needle biopsy is a costly and time-consuming procedure with a moderate yield of malignancy (range, 14-35%) and can be stressful procedure for patients due to claustrophobia and positioning, even occasionally requiring sedation.

In an effort to educate and inform our dedicated breast radiology group, a retrospective peer review system was initiated at our institution to evaluate the indication, technical adequacy, and radiology-pathology correlation of previously performed MRI-guided vacuum-assisted needle biopsies and their outcomes. In this study, we present the outcomes of MRI guided biopsies in our tertiary healthcare institution before and after the implementation of our MRI-guided vacuum-assisted needle biopsy peer-review process.

Materials and Methods

This was an institutional review board approved, Health Insurance Portability and Accountability Act (HIPAA) compliant, retrospective case review in which the requirement for patient informed consent was waived. We searched our tertiary imaging center's MRI database for patients who underwent breast MRI-guided vacuum-assisted needle biopsy between January 1, 2014 and December 31, 2014, before initiating the peer review, and between January 1, 2015 and December 31, 2015, after its implementation.

Dynamic contrast-enhanced MRI Technique and MRI-guided vacuum-assisted needle biopsy

All MR imaging studies were performed using a wide bore 3-Tesla MRI unit. (Discovery MR750 GE Healthcare, Waukesha, WI) The protocol consisted of T1-weighted sequence, followed by dynamic contrast-enhanced sequence, T2 weighted sequence and a diffusion weighted imaging sequence. Pulse sequence parameters are outlined in Table 1. Depending on patient size and scanned area, average scan time ranges from 38 minutes to 60 minutes. There is no change in protocol between January 1, 2014 and December 31, 2015. The standard protocol is applied to all patients with a clinical indication to undergo breast MRI for further evaluation between aforementioned dates. MRI-guided vacuum-assisted needle biopsy is recommended for 401 patients.

All MRI-guided vacuum-assisted needle biopsies were performed in a dedicated prone table (*Invivo* Gainesville FL) using a 9-gauge vacuum-assisted needle (ATEC; Hologic, Bedford, Mass). Some of the patients in our study had more than one biopsy performed and each biopsy was considered as a separate entity.

Peer Review Process

In January, 2015, a weekly conference was initiated to evaluate all MRI-guided vacuum-assisted needle biopsies performed over January 1, 2014-December 31, 2015. During each weekly conference, 6 ano-

nymized cases were presented by a breast imaging faculty member of 5-16 years of experience with breast MRI interpretation to an audience of breast imaging faculty comprising our entire group and the breast imaging fellows. The MRI findings and the biopsy indications of the lesions were discussed and then the breast imaging faculty voted on whether they agree with (a) the biopsy indication (b) appropriate sampling (c) radiology-pathology correlation (d) final recommendation.

Below data was collected from the electronic health record of each patient (a) patient age at the time of biopsy, (b) the indication for the study, (c) whether the patient had a new breast cancer or was treated for breast cancer in the past, and if so, whether the cancer was ipsilateral or contralateral to the biopsy site, (d) lesion type (mass or non-mass) and size. The pathology results were reviewed and categorized into benign, high-risk [atypical ductal hyperplasia, atypical lobular hyperplasia, lobular carcinoma in situ, atypical papilloma, and radial scar (including complex sclerosing lesion, complex sclerosing adenosis, and radial sclerosing lesion)] or malignant. Cancers were further classified into invasive or pure ductal carcinoma in situ based on their final surgical histopathology. In our institution, short-term MRI follow up or excision is not performed for lesions revealing benign and concordant results, in line with recent literature (53). Lesions revealing atypia are routinely reviewed in a multidisciplinary Clinical Management Conference, comprised of representatives from breast radiology, pathology, surgery departments and primary care providers who make a consensus management recommendation.

To control for possible radiologist interpretation differences between the two years, MRI-guided vacuum-assisted needle biopsy recommendations of radiologists who joined our group in 2014 and 2015 were excluded, and only the readings and recommendations by the same group of radiologists (n=12) at our institution were included in the analysis.

Statistical Analysis

Total number of MR imaging performed, number of biopsies, patient and tumor characteristics were summarized using frequencies and percentages. Biopsy rate was estimated along with 95% confidence interval (CI) for 2014 and 2015. Fisher's exact test was used to compare MRI-guided vacuum-assisted needle biopsy rates and patient characteristics of biopsied cases between these years. All tests were two-sided and p-values of 0.05 or less were considered statistically significant. Statistical analysis was carried out using SAS version 9 (SAS Institute, Cary, NC).

Table 1. Dynamic contrast-enhanced breast MRI protocol

Pulse Sequence Parameters	Protocol Pulse Sequences				
	Pre-contrast T1-Weighted	DCE (1 pre+5 post contrast)	T1-Weighted Sagittal	T2-Weighted	DWI
Average scan time (min)	5	10	7	10	6
TR/TE	5.4/2.1ms	5.4/2.2ms	7.5/2.1ms	~5000/100ms	~5000/60ms
Flip Angle	10°	10°	10°	90°	90°
Slice	1.8/-0.9mm	1.8/-0.9mm	2.4/-1.2mm	5/1mm	4/0mm
FOV	~30cm	~30cm	~22cm	~30cm	~36cm
Matrix	384x384	480x384	384x320	384x224	170x224

TR: Repetition Time; TE: Echo Time; FOV: field of view

Results

Of 459 MRI-guided vacuum-assisted needle biopsy procedures performed in the defined two-year time frame, 253 occurred between January 1, 2014-Jan 1, 2015 and 203 between Jan 1, 2015 and December 31, 2015. A single lesion was biopsied in each patient.

In the defined timeframe, significantly more dynamic contrast-enhanced MRIs were performed in 2014 compared to 2015 (1447 vs 1596, $p=0.0002$) while a lower biopsy rate was observed (17.5% vs 12.7% $p=0.04$).

There were no significant differences between patient age [median 50 vs 51 years, ($p=0.8$)], MRI indication ($p=0.49$), history of ipsilateral or contralateral breast cancer ($p=0.14$) or MRI lesion types (mass vs non-mass like enhancement, $p=0.53$) between the two groups. In 2014 there was a significantly higher benign biopsy rate (154 of 253, 60.9%) compared to 2015 (104 of 203, 51.2%) ($p=0.04$). The malignancy rates were similar (26.09% in 2014 and 26.11% in 2015), there was

a higher rate of high-risk lesions identified in 2015 (21.7% vs 12.7%) ($p=0.03$). There was a slight but significant increase in the positive predictive value of MRI-guided vacuum-assisted needle biopsies in 2015 [48.8% (97/203)] compared to those in 2014 [39.1% (98/253) ($p=0.04$)] (Table 2).

Clinical parameters including breast MRI indication, lesion type on MRI (mass vs non-mass), were not significantly different (Table 3).

Discussion and Conclusion

Magnetic resonance imaging is an important diagnostic tool for breast cancer and for screening high-risk patients. MRI has a high sensitivity for the detection of breast lesions however its specificity is low (22-34), increasing the false positive results and leading to costly, time and resource consuming interventions like MRI-guided vacuum-assisted needle biopsy. MRI-guided vacuum-assisted needle biopsy can be done in an outpatient office for half of a surgical biopsy cost without the need for anesthesia and hospitalization (54). However, this cost is approximately twice as much as an ultrasound image-guided biopsy or a stereotactic image-guided biopsy (55).

In our study, despite an increase (10.3%, $p=0.0002$) in the overall number of dynamic contrast-enhanced breast MRIs between pre-PRS and post-PRS periods, there was a significant decrease ($p=0.0002$) in the overall number of MRI-guided vacuum-assisted needle biopsies recommended by the same group of radiologists, without significant differences in the MRI indication ($p=0.49$) or MRI lesion type ($p=0.53$). Less benign biopsies occurred in 2015 compared to 2014 ($p=0.0002$). There was a statistically significant increase in positive predictive value of MRI-guided vacuum-assisted needle biopsy after the initiation of PRS in January 1, 2015 ($p=0.046$), although the same group of radiologists made the decision of biopsy.

The overall malignancy rate of breast lesions underwent MRI-guided vacuum-assisted needle biopsy was 26.1% in 2014 and 26.1% in 2015. Our results are similar to the malignancy rates of previous reports, which range between 20-43% (22, 24, 56-60). Our malignancy rate is at the lower end of the spectrum, because all suspicious mass-like enhancements –which are more likely to yield malignancy (48)–undergo MRI-directed ultrasound in our institution.

The upgrade rate for high-risk breast lesions identified at MRI-guided vacuum-assisted needle biopsy ranges between 3-21.5% (28, 61-62). In our study, 62.5% (20/32) of high-risk lesions were excised in 2014, this ratio was 45.5% (20/44) in 2015 ($p=0.17$). None of these high-risk lesions were upgraded into malignancy upon surgical excision. Surgical excision rate of high-risk lesions decreased in 2015, although the difference was not statistically significant ($p=0.25$).

Our study has some limitations. First, this is retrospective study performed in a single institution. The small number of patients included decreases the power of the statistical results. Further, for mass-like MR enhancement, we start our work up with MRI-directed ultrasound, and if a correlate is identified, perform ultrasound-guided needle biopsy. Non-mass like enhancement and masses with no ultrasound correlate are subjected to MRI-guided biopsy. MRI-directed ultrasound, and ultrasound guided biopsy rates are not included in this study. However, our primary goal was to investigate the rate of MRI-guided biopsies since ultrasound guided biopsy does not involve contrast or require magnet time, is much better tolerated and less costly compared to MRI-guided vacuum-assisted needle biopsy.

Table 2. Pathology results of the biopsied lesions in 2014 and 2015

	MRI Year				*p
	2014		2015		
	n	%	n	%	
Benign	154	60.87	104	51.23	0.046
Cancer	66	26.09	53	26.11	
High Risk	32	12.65	44	21.67	0.03
All	253	100.00	203	100.00	
Positive predictive value	39.13%		48.77%		0.046

Table 3. Breast MRI indications and findings of the biopsied lesions in 2014 and 2015

	MRI Year				*p
	2014		2015		
	n	%	n	%	
Breast Cancer					
Extent of Disease	131	51.78	115	56.65	0.49
High-risk screening	53	20.95	39	19.21	
Other	15	5.93	12	5.91	
Breast Cancer					
Surveillance	18	7.11	7	3.45	
*Problem solving	36	14.23	30	14.78	
MRI finding					
Asymmetry	1	0.40	0	0	0.53
Mass enhancement	107	42.29	94	46.31	

*p-values by Fisher's exact test

*Problem solving: further evaluation due to abnormal mammography, ultrasonography, nipple retraction

Our weekly all-radiologist review of MRI-guided vacuum-assisted needle biopsies was associated with an increase in positive predictive value of biopsies over time independent of lesion type, indication or history of breast cancer. Peer-review was associated with significantly less surgical excisions for high-risk lesions identified on MRI-guided vacuum-assisted needle biopsy.

Ethics Committee Approval: Ethics committee approval was received for this study from the Ethics Committee of MD Anderson Cancer Center.

Informed Consent: Informed consent was not taken due to retrospective design of the study.

Peer-review: Externally peer-reviewed.

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