Published in final edited form as:

Med Care. 2016 July ; 54(7): 719–724. doi:10.1097/MLR.0000000000000542.

Breast MRI in the Diagnostic and Preoperative Workup among Medicare Beneficiaries with Breast Cancer

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Conflict of Interest: All authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest (such as honoraria; educational grants; participation in speakers' bureaus; membership, employment, consultancies, stock ownership, or other equity interest; and expert testimony or patent-licensing arrangements), or non-financial interest (such as personal or professional relationships, affiliations, knowledge or beliefs) in the subject matter or materials discussed in this manuscript now or within the past three years.

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Abstract

Purpose—We compared the frequency and sequence of breast imaging and biopsy use for the diagnostic and preoperative workup of breast cancer according to breast MRI use among older women.

Methods—Using SEER-Medicare data from 2004–2010, we identified women with and without breast MRI as part of their diagnostic and preoperative breast cancer workup and measured the number and sequence of breast imaging and biopsy events per woman.

Results—10,766 (20%) women had an MRI in the diagnostic/preoperative period, 32,178 (60%) had mammogram and US, and 10,669 (20%) had mammography alone. MRI use increased across study years, tripling from 2005 to 2009 (9% to 29%). Women with MRI had higher rates of breast imaging and biopsy compared to those with mammogram and US or those with mammography alone (5.8 v 4.1 v 2.8; respectively). There were 4,254 unique sequences of breast events; the dominant patterns for women with MRI were an MRI occurring at the end of the care pathway. Among women receiving an MRI post-diagnosis, 26% had a subsequent biopsy compared to 51% receiving a subsequent biopsy in the sub-group without MRI.

Conclusions—Older women who receive breast MRI undergo additional breast imaging and biopsy events. There is much variability in the diagnostic/preoperative work-up in older women, demonstrating the opportunity to increase standardization to optimize care for all women.

Keywords

magnetic resonance imaging (MRI); breast cancer; preoperative; utilization

BACKGROUND

Diagnosis and preoperative workup for women with breast cancer can include evaluation using several imaging modalities and breast biopsy. Breast magnetic resonance imaging (MRI) is increasingly used as an adjunct imaging modality to determine extent of disease and for preoperative planning. [1–5] The potential benefits of preoperative MRI – such as lower reoperation rates, lower likelihood of recurrence, and improved mortality – have not been substantiated in the literature. [6, 7] Higher breast biopsy rates have been associated with preoperative MRI use [8, 9] and greater overall utilization of breast-related services has been

hypothesized in relation to breast MRI for women newly diagnosed with breast cancer. [10] With approximately 25% of older women and 58% of younger women with breast cancer receiving a preoperative MRI, [11, 12] it is important to fill gaps in the evidence-base for limitations and benefits of preoperative MRI.

Breast MRI has greater sensitivity than mammography and ultrasound; [13, 14] thus, detects additional lesions, both cancerous and non-cancerous. [9, 15, 16] Detection of additional lesions may lead to further workup before surgical treatment. Increased use of breast services results in additional costs, procedures,, and potentially, a delay in treatment. There have been no reports in the literature on differences in number or type of imaging and biopsies used with pre- and perioperative breast MRI for women with breast cancer. [12] Several studies, however, have shown that use of preoperative breast MRI is significantly associated with 1–3 week delays in treatment.[13, 17] While a delay in treatment may not impact survival, it can result in psychological burden for women. [13, 18, 19] Comparing mammography, ultrasound (US), and biopsy use during the diagnostic and preoperative workup in relation to preoperative MRI use for women with breast cancer will help elucidate whether there are additional burdens of care that should be considered in weighing the tradeoffs of MRI use.

We examined population-based patterns of breast care for older women with breast cancer who did and did not receive breast MRI in the diagnostic and preoperative periods. Using SEER-Medicare data, we estimated: 1) frequency of breast imaging and breast biopsy by receipt of advanced imaging, 2) imaging and biopsy use sequencing, and 3) time from the first breast imaging use to surgical treatment.

METHODS

Data and Study Population

SEER-Medicare data (2004–2010) were used for this study. [20, 21] The study cohort included women aged 66 years or older at the time of an incident breast cancer diagnosis in 2005–2009 with no prior breast cancer (N=71,193) and concurrent enrollment in Medicare parts A and B. Women were excluded if: they lacked a pathologic breast cancer diagnosis(i.e. without a histologic confirmation), were diagnosed in a nursing home, did not receive cancer-directed surgery, did not have at least one breast imaging claim (mammogram, US, or MRI) performed during the *diagnostic/preoperative* window (defined below; 2,332 women had surgery on or within days of diagnosis). Lastly, we excluded women who did not receive surgery, as a first course of treatment within six months of the diagnosis date (N=7,496), resulting in a final cohort of 53,653 women. The study was approved by the Committee for Protection of Human Subjects.

Main Variable Definitions

The *diagnostic/preoperative window* was defined as the period between the initial breast imaging or biopsy within 60 days prior to diagnosis and the primary surgical treatment. We refer to any breast imaging (both screening and diagnostic) or breast biopsy (including the biopsy associated with the initial cancer diagnosis (DXBX)), occurring during the diagnostic/preoperative window as a *breast event*. We assumed that multiple images

occurring on the same-day occurred in the following order: 1) mammogram, 2) US, and 3) MRI (i.e. MAM|US, MAM|MRI, US|MRI or MAM|US|MRI). If a biopsy was performed on the same day as imaging, we considered the imaging to occur first. For each woman, an imaging hierarchy was applied to describe the *most advanced imaging modality* in the diagnostic/preoperative window as follows: 1) MRI, 2) mammogram and US, and 3) mammogram alone. We classified women as receiving MRI if receipt of MRI occurred anytime during the diagnostic/preoperative window.

Patient and Tumor Characteristics

Women's characteristics included a) age at diagnosis, b) race, collapsed to white, black and other due to small cell sizes, c) rural or urban residence, d) SEER registry, e) ZIP-level median household income, f) diagnosis year, g) breast cancer characteristics including: stage, histology, grade, nodal status, hormone receptor status, and size. We categorized primary treatment into mastectomy, breast conserving surgery with radiation or breast conserving surgery without radiation. We measured comorbidities as defined by the Klabunde adaptation of the Charlson Index. [22]

Analysis

Frequency distributions of patient and tumor characteristics by the most advanced imaging modality used are presented. Unadjusted *per capita breast event rates* for the total number of breast events per woman, the number of each imaging breast event type per woman and the number of biopsy breast events per woman were examined by most advanced imaging modality used. For each group, the mean predicted per capita breast event rates and 95% confidence intervals (CI) were estimated using a Poisson model with standardization via predicted margins to adjust for all available patient and tumor characteristics.

Each woman's breast event sequence was chronologically ordered, noting her diagnostic biopsy. To compare the utilization of diagnostic and preoperative workup with and without MRI, women were grouped by number of breast events and we examined the five most common breast event sequences.

The women were classified into two imaging groups, with and without MRI. After identifying the first occurrence of an MRI or mammogram/US in each imaging group, we analyzed the sequence of breast events following the first imaging event. We dichotomized women according to whether a biopsy occurred after the first imaging event. We report the proportion of women with a subsequent biopsy following an image by image group. Analyses were conducted in SAS (SAS 9.4 System Options: Reference, Second Edition. Cary, NC: SAS Institute Inc.; 2011) and Stata/SE 12.1 (StataCorp. 2011. Stata 12 Base Reference Manual. College Station, TX: Stata Press).

RESULTS

Of the 53,653 women, 10,766 (20%) had an MRI, the majority had mammogram and US (32,178; 60%), and 10,669 (20%) had mammography alone. (Table 1) Two percent of women (729/32,178) had only US and were assigned to the mammogram and US group. MRI use tripled from 2005 to 2009 (9% to 29%). (Table 1) The overall median time from

initial breast event to surgical treatment was 46 days (IQR: 30–66) and by imaging: MRI, 54 days (IQR: 37–76); US, 43 days (IQR: 28–63); Mammogram, 47 days (IQR: 31–67).

On average, women in the MRI group had 5.8 breast events, while mammogram and US group had 4.1 and mammography alone, 2.8. The MRI group had a small increase in biopsies compared to the US and mammography alone groups (1.4 v. 1.2 and 1.2, respectively), but most of the additional breast events were imaging events. (Table 2) Adjusting the per capita breast event rate for woman and tumor characteristics, we found similar patterns to the unadjusted estimates. (Table 3) The per capita breast event rate for the mammogram and US group was slightly greater than the mammography alone group, which appears to account for the US exam itself.

There were 4,254 different breast event sequences among the women in the study cohort (2,692 among MRI users, 1,562 without MRI). Figure 1 depicts the 5 most common sequences by number of breast events for women with MRI (N=10,766) and without MRI (N=42,887). Each sequence is displayed by combination of events on different claim dates and events occurring on the same day (see Legend, Figure 1). Sixty-five percent of women (N=27,905) with no MRI had 3 (34%) or 4 (31%) breast events with the most common sequence being a mammogram/US on the same day followed by a diagnostic biopsy (N=6,897; 3 breast events). Among women in the MRI group, an MRI occurred post-diagnosis for 9,196 women (85%) with 7,146 (66%) having 4 (20%), 5 (26%), or 6 (20%) breast events. The most common breast event sequence was a mammogram/US on the same day, followed by a diagnostic biopsy and concluding with an MRI (N=714; 4 breast events). Among the subgroup of women who had any breast imaging post-diagnosis, a biopsy followed the imaging event for 51% of women without an MRI compared to 26% of women with an MRI ($p<0.001$).

DISCUSSION

Evidence of increasing overall imaging rates in the era of advanced imaging[11–13, 23] has led to concerns about the extent of imaging utilization in many clinical settings, including breast cancer diagnosis and workup. [24] Breslin et al. [12] reported a higher number of traditional and advanced imaging tests among women with preoperative MRI, which increased over time (2005–2008). In their large study population (N=52,202) of commercially-insured younger women (<65 years), they concluded that advanced imaging was additive rather than replacing traditional imaging in the diagnostic workup of breast cancer. Our study presents similar findings for the Medicare population noting up to 2.5 times compared to mammography alone and 1.5 times for mammography/US among women with breast MRI.

In a prospective multi-institutional study of 969 women with preoperative MRI, Lehman et al. reported that 13% underwent biopsy based on the MRI [15], while another study (N=141) found that 29% of preoperative evaluations led to biopsy. [25] In the present study, we found a modestly higher rate of biopsy among women with and without MRI in the diagnostic and preoperative period. By mapping the sequence of breast events in our study population, we found that MRI is usually among the last breast events prior to primary surgical treatment, so relatively few biopsies are likely to occur because of MRI among older women.

Furthermore, when we examined the subgroup of women with an imaging event post-diagnosis, we found a significantly smaller percent of the women had biopsies following an MRI, compared to women whose biopsy followed a mammogram and ultrasound. These findings are important when evaluating the potential risks and benefits of preoperative MRI. If relatively few additional biopsies result from MRI, then that may be a less likely potential harm, yet may afford the benefit of better determining extent of disease prior to the primary surgery.

Similar to other studies reporting longer periods between imaging and treatment [13, 18] we found the MRI group to be delayed by a week compared to the other groups. Although these delays are not likely to affect recurrence or mortality, women need this evidence to help them weigh any potential benefit against risks that may be important to them, such as anxiety due to longer time between initial imaging and their definitive treatment.

Our examination of entire care episodes associated with breast cancer diagnosis and initial surgical management in a large nationally representative sample is unique, but we note limitations, including age restriction to 66+, generalizability to fee-for-service delivery systems only, inability to account for women's preferences, or clinical rationale, such as monitoring neoadjuvent chemotherapy. Also, breast density is not available in SEER-Medicare data, therefore we were not able adjust for breast density in the model. Although we examined MRI use by year, there may be heterogeneity of patterns of care within episodes. These limitations were considered when interpreting our results.

Because studies in both older and younger women with breast cancer have shown an increased use of breast MRI during the preoperative period – with between 22% and 68% receiving MRI, [2628] generating evidence to weigh the factors likely to be involved in the tradeoffs of benefit and limitations, is important.

Our study demonstrates that older women receiving diagnostic/preoperative MRI undergo more breast events than those without MRI and is most often performed as the final test. Our finding of 4,000 different breast event combinations indicates there is much variability in the diagnostic/preoperative work-up in older women, demonstrating the opportunity to increase standardization as a means to optimize clinical care.

Acknowledgments

Funding: This study used the linked SEER-Medicare database. The interpretation and reporting of these data are the sole responsibility of the authors. The authors acknowledge the efforts of the Applied Research Program, NCI; the Office of Research, Development and Information, CMS; Information Management Services (IMS), Inc.; and the Surveillance, Epidemiology, and End Results (SEER) Program tumor registries in the creation of the SEER-Medicare database. This work was supported by funding from the National Institutes of Health, National Cancer Institute under grant R01 CA149365-01.

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Figure 1.

The number of women and sequence frequency for the five most common breast event sequences for each number of breast events during the diagnostic/preoperative window, by preoperative MRI groups, among women (N=53,653) who were enrolled in Medicare (2004–2010) with a diagnosis of breast cancer (2005–2009)

Table 1

Characteristics of women (N=53,653) diagnosed with breast cancer (2005–2009) who were enrolled in Medicare (2004–2010) by the most advanced imaging modality in the diagnostic/preoperative window

	Most Advanced Imaging Modality							
	MRI		Mammogram and US		Mammogram Only		Total	
Characteristics[1] of women	***N***	***Col %***	***N***	***Col %***	***N***	***Col %***	***N***	***Col %***
Total	10,776	20.0	32,178	60.0	10,699	20.0	53,653	100.0
Age at diagnosis (yrs.)								
66–69	3,230	30.0	5,728	17.8	2,172	20.3	11,130	20.7
70–74	3,344	31.0	7,843	24.4	2,762	25.8	13,949	26.0
75–79	2,379	22.1	7,672	23.8	2,662	24.9	12,712	23.7
80–84	1,296	12.0	6,395	19.9	1,942	18.2	9,633	18.0
85+	527	4.9	4,540	14.1	1,191	10.6	6,228	11.6
Race								
White	9,784	90.6	28,080	87.3	9,306	87.0	47,150	87.9
Black	479	4.4	2,396	7.4	857	8.0	3,732	7.0
Other[2]	526	4.9	1,684	5.2	531	5.0	2,741	5.1
Residential location								
Urban	10,193	94.6	28,908	89.8	9,231	86.3	48,332	90.1
Rural	577	5.4	3,268	10.2	1,466	13.7	5,311	9.9
Census Tract Median Income Quartiles								
1st (<=$36,000)	1,660	15.5	8,499	26.7	3,177	30.0	13,336	25.1
2nd ($36,001–$47,500)	2,325	21.7	8,247	25.9	2,773	26.2	13,345	25.1
3rd ($47,501–$64,600)	2,929	27.4	7,993	25.1	2,467	23.3	13,389	25.2
4th (>=$64,601)	3,792	35.4	7,120	22.3	2,173	20.5	13,085	24.6
Comorbidities								
0	7,671	71.2	19,533	60.7	6,538	61.1	33,742	62.9
1	2,206	20.5	7,969	24.8	2,714	25.4	12,889	24.0
2+	899	8.3	4,676	14.5	1,447	13.5	7,022	13.1
Year of Diagnosis								

Characteristics[1] of women	Most Advanced Imaging Modality							
	MRI		Mammogram and US		Mammogram Only		Total	
	N	*Col %*	*N*	*Col %*	*N*	*Col %*	*N*	*Col %*
2005	952	8.8	6,822	21.2	2,742	25.6	10,516	19.6
2006	1,506	14.0	6,924	21.5	2,433	22.7	10,863	20.3
2007	2,230	20.7	6,338	19.7	2,077	19.4	10,645	19.8
2008	2,972	27.6	6,012	18.6	1,793	16.8	10,777	20.1
2009	3,116	28.7	6,082	18.9	1,654	15.4	10,852	20.2
Stage								
0	1,591	14.8	2,726	8.5	4,216	39.4	8,533	15.9
I	5,142	47.7	16,258	50.5	3,746	35.0	24,146	46.9
II	2,954	27.4	9,565	29.7	1,809	16.9	14,328	26.7
III	792	7.3	2,467	7.7	579	5.4	3,838	7.1
IV	88	1.0	329	1.0	86	1.0	503	1.0
Unknown	209	1.9	833	2.6	263	2.5	1,305	2.4
Histology (invasive)								
Ductal	6,237	57.9	21,923	68.1	4,974	46.5	33,134	61.8
Lobular	1,470	13.6	2,927	9.1	608	5.7	5,005	9.3
Mixed	875	8.1	1,885	5.9	417	3.9	3,177	5.9
Other	603	5.6	2,717	8.4	484	4.5	3,804	7.1
Grade								
High	2,509	24.9	7,769	25.7	1,847	19.4	12,125	24.6
Intermediate	4,784	47.4	13,757	45.6	3,981	41.8	22,522	45.2
Low	2,793	27.7	8,644	28.7	3,696	38.8	15,133	30.4
Nodal Status								
Positive	2,374	25.1	7,110	25.9	1,525	21.7	11,009	25.0
Negative	7,102	74.9	20,349	74.1	5,501	78.3	32,952	75.0
ER Status								
Positive	8,562	84.6	24,935	84.1	7,502	81.4	40,999	83.7
Negative	1,554	15.4	4,709	15.9	1,715	18.6	7,978	16.3
Size								

Characteristics[1] of women	Most Advanced Imaging Modality							
	MRI		Mammogram and US		Mammogram Only		Total	
	N	*Col %*	*N*	*Col %*	*N*	*Col %*	*N*	*Col %*
<1 cm	2,546	25.2	6,871	22.3	3,038	35.1	12,455	25.2
1 to <2 cm	4,011	39.7	12,364	40.2	2,760	31.9	19,135	38.7
2 to <5 cm	2,983	29.5	9,900	32.2	2,398	27.8	15,281	30.9
5+ cm	568	5.6	1,608	5.2	444	5.1	2,620	5.3
Primary Treatment								
Mastectomy	3,778	35.1	12,005	37.3	3,867	36.1	19,650	36.6
BCS[3] without Radiation	2,297	21.3	7,720	24.0	2,955	27.6	12,972	24.2
BCS[3] with Radiation	4,701	43.6	12,453	38.7	3,877	36.2	21,031	39.2
Number of Days in the Diagnostic/Preoperative Window								
<= Median (46 days)	4,162	38.6	17,667	54.9	5,217	48.8	27,046	50.4
> Median (46 days)	6,614	61.4	14,511	45.1	5,482	51.2	26,607	49.6
	Median (IQR) Number of Days in the Diagnostic/Preoperative Window							
	54 (37–76)		43 (28–63)		47 (31–67)			

[1] Missing (N): Race (30), Residential location (10), Median income (498), Grade (3,873), Nodal status (9,692), ER status (4,676) and Size (4,162).

[2] Other includes Hispanic, Asian, Native American and Other.

[3] BCS: Breast Conserving Surgery.

Table 2

Per capita breast event rates[1] among women (N=53,653) enrolled in Medicare with a diagnosis of breast cancer (2005–2009) by most advanced imaging modality during the diagnostic/preoperative window.

	MRI (N=11,638 events)			Ultrasound (N=52,377 events)			Mammogram (N=92,943 events)			Biopsy (N=68,686 events)			Total (N=225,149 events)		
Most Advanced Imaging Modality	**# of Women**	**# of MRIs**	**Rate**	**# of Women**	**# of US**	**Rate**	**# of Women**	**# of MAM**	**Rate**	**# of Women**	**# of BX**	**Rate**	**# of Women**	**# of Breast Events**	**Rate**
MRI	10,766	11,638	1.08	9,016	13,425	1.49	10,260	20,997	2.05	10,766	15,323	1.42	10,776	61,383	5.70
Mammogram and US	NA	NA	NA	32,178	38,952	1.21	31,119	53,184	1.71	32,178	39,627	1.23	32,178	131,763	4.09
Mammogram only	NA	NA	NA	NA	NA	NA	10,699	18,762	1.75	10,699	13,241	1.24	10,699	32,003	2.99

[1] Per capita breast event rate = Number of (MRI, Ultrasound, Mammogram, Biopsy) per woman

Table 3

Adjusted[1] mean predicted per capita breast event rate[2] and 95% CIs[3] by most advanced imaging modality, among women (N=53,653) who were enrolled in Medicare (2004–2010) with a diagnosis of breast cancer (2005–2009) during the diagnostic/preoperative window

Most Advanced Imaging Modality	*Summary of Mean Predicted Per Capita Breast Event Rates*					
	Total		Imaging		Biopsy	
	Mean	95% CI	Mean	95% CI	Mean	95% CI
MRI	5.75	(5.74, 5.77)	4.34	(4.33, 4.35)	1.41	(1.41, 1.42)
Mammogram and US	4.09	(4.09, 4.10)	2.87	(2.87, 2.88)	1.22	(1.22, 1.22)
Mammogram only	2.84	(2.83, 2.85)	1.61	(1.60, 1.62)	1.23	(1.22, 1.23)
Total	4.27	(4.27, 4.29)	3.02	(3.01, 3.03)	1.26	(1.26, 1.27)

[1] Poisson models adjusted for patient and tumor characteristics

[2] Per Capita breast event rate = Number of (MRI, Ultrasound, Mammogram, Biopsy) per woman

[3] CIs = Confidence Intervals