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Relationship Between Preoperative Breast MRI and Surgical Treatment of Non-Metastatic Breast Cancer

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Abstract

Background and Objectives—More extensive surgical treatments for early stage breast cancer are increasing. The patterns of preoperative MRI overall and by stage for this trend has not been well established.

Methods—Using Breast Cancer Surveillance Consortium registry data from 2010 through 2014, we identified women with an incident non-metastatic breast cancer and determined use of preoperative MRI and initial surgical treatment (mastectomy, with or without contralateral prophylactic mastectomy (CPM), reconstruction, and breast conserving surgery +/− radiation). Clinical and sociodemographic covariates were included in multivariable logistic regression models to estimate adjusted odds ratios and 95% confidence intervals.

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Results—Of the 13,097 women, 2,217 (16.9%) had a preoperative MRI. Among the women with MRI, results indicated 32% higher odds of unilateral mastectomy compared to breast conserving surgery and of mastectomy with CPM compared to unilateral mastectomy. Women with preoperative MRI also had 56% higher odds of reconstruction.

Conclusion—Preoperative MRI in women with DCIS and early stage invasive breast cancer is associated with more frequent mastectomy, CPM, and reconstruction surgical treatment. Use of more extensive surgical treatment and reconstruction among women with DCIS and early stage invasive cancer whom undergo MRI warrants further investigation.

Keywords

Breast cancer surgery; preoperative breast MRI; breast reconstruction

Introduction

The trend away from radical mastectomy to breast conserving surgery (BCS) for treatment of breast cancer in the 1990s [1] has recently been shown to be shifting back towards more extensive surgical treatment in the last decade including for ductal carcinoma in situ (DCIS) and early stage invasive breast cancer. (1) MRI may be employed in the preoperative setting due to its high sensitivity for detecting otherwise occult disease not identified by mammography, (2–4).

Prior studies report that more extensive surgeries are performed after preoperative MRI, including an extensive meta-analysis of surgical outcomes by Houssami et al in 2013, which focused on studies that integrated a control group. (5–7) Such reports raise concerns that women may be undergoing more aggressive surgery related to MRI examinations, the benefit of which is uncertain because evidence has indicated that mastectomy is not always the superior treatment strategy. (8) At the same time, some reports suggest with the greater sensitivity and negative predictive value of MRI compared with mammography, an MRI can confirm whether BCS is feasible and better define extent of disease to increase the likelihood of clear margins. (9)

In addition to mastectomy rates increasing from between 10–20% [1,15,19], women are increasingly opting for bilateral surgeries including women without risk factors that indicate a clear survival benefit to contralateral prophylactic mastectomy (CPM). (10, 11) A number of patient and cancer characteristics have been associated with selection of CPM, including younger age [4,6,13–16], Caucasian race [4,14,15], family history of breast cancer [4,13,15–17], private health insurance [14], DCIS histology [4], and lobular tumor histology. [15,16,18] Recent studies have suggested CPM may coincide with the use of preoperative MRI (12, 13) with one study indicating that women who underwent MRI were twice as likely to have a CPM, (14) while other studies report CPM is associated with breast reconstruction at the time of mastectomy. (15, 16) There are very few studies that include breast reconstruction when examining the influence of preoperative breast MRI on surgical management including CPM.

Although many studies examining the outcomes and associations of preoperative MRI are published [3,6,13,22,23], very few have reported the proportion of women receiving mastectomy versus BCS for Stage 0 (DCIS) and Stage I–III (invasive) cancer in relation to MRI. While either surgical approach may be appropriate, and will generally reflect women's preferences, it is important to understand how the patterns of therapy in non-metastatic breast cancer may relate to the use of pre-operative MRI. The objective of this study was to assess the surgical management, including breast reconstruction, of Stage 0 (DCIS) and Stage I–III breast cancer with and without preoperative breast MRI in relation to clinical and women characteristics.

Materials and Methods

Data Source

The Breast Cancer Surveillance Consortium (BCSC) comprises regional breast imaging registries across the U.S., each consisting of multiple facilities. (17) Data from the registries are pooled at the BCSC Statistical Coordinating Center and include longitudinal data on breast imaging use and assessments, benign and malignant breast pathology, and linkage to state or regional Surveillance Epidemiology and End Results (SEER) cancer registries. Breast MRI data for this study were available from four BCSC registries: Group Health Cooperative (western Washington State), San Francisco, Vermont, and North Carolina. Each registry received approval for active or passive consenting processes or a waiver of consent by their respective institutional review boards. Data used for analysis were submitted to the BCSC from the four sites in March 2015 and included breast cancer diagnoses from January, 2010 through January, 2014. All procedures were HIPAA compliant and all sites hold U.S. Public Health Service Certificates of Confidentiality, which provide the highest degree of identity protection for participating women and health care providers. (18)

Study Population

The study cohort included women diagnosed with an incident non-metastatic unilateral breast cancer (stage 0 – III) and who received their initial surgical treatment within 6 months of their cancer diagnosis. Women who reported a personal history of breast cancer were excluded.

Definitions

Initial surgical treatments for Stage 0 (DCIS) and early stage invasive breast cancer included mastectomy, CPM, BCS with and without radiation therapy (RT) and breast reconstruction (19). We defined the preoperative window as the time interval between the diagnosis and the initial surgical treatment. Preoperative MRI was the primary exposure of interest; the comparison group had no MRI after diagnosis and before surgery, but may have had other breast imaging. Mode of detection was defined as screen detected (a cancer preceded by a positive [BI-RADS 0,3,4, or 5] screening mammogram within 12 months prior to diagnosis), interval detected (a cancer preceded by a negative screening mammogram within 12 months of diagnosis or a negative diagnostic mammogram between 6–42 months prior to diagnosis) or clinically detected (a cancer with a prior mammogram >42 months or first mammogram or unknown prior mammogram).

Patient and Tumor Characteristics

Women's age at diagnosis was categorized as (years): <40, 40–49, 50–59, 60–69, 70+. Women who reported at least one or more first-degree relative with a breast cancer diagnosis were considered as having a family history. Tumor characteristics included: invasive histology (ductal, lobular, or both), estrogen and progesterone receptor status (positive or negative), tumor size in cm (<1, 1 to <2, 2 to <5, 5+), grade (0, I, II, III), and nodal status (no positive nodes or positive nodes).

Statistical Analysis

We computed frequency distributions for MRI use and patient and tumor characteristics stratified by surgical treatments of mastectomy with and without CPM and BCS with and without RT. We compared frequency distributions for surgical treatments between women with and without MRI stratified by breast cancer stage and investigated the impact of MRI use on a stepwise progression across mastectomy, mastectomy plus CPM and mastectomy plus CPM and reconstruction. For the stepwise progression, we began by computing the proportion of women receiving mastectomy without CPM. Then among women with mastectomy, we computed the additional proportion of receiving CPM, and finally among women with CPM, the proportion of women with reconstruction.

For each of the 4 surgical treatment types we estimated separate unadjusted and multivariable adjusted logistic regression models to obtain odds ratios in relation to receipt of MRI. These models examined: 1) mastectomy vs. BCS estimated in the full study sample, 2) CPM vs. no CPM estimated among those with mastectomy, 3) reconstruction vs. no reconstruction estimated among women with mastectomy, and 4) RT vs. no RT among women with BCS. Model results are reported as crude and adjusted odds ratios (OR) with 95% confidence intervals (95% CI). Models were adjusted for patient and tumor characteristics including age at diagnosis, race, urban/rural status, family history of breast cancer, year of diagnosis, mode of detection, stage, histology, tumor size, grade, estrogen receptor (ER)/progesterone receptor (PR), nodal status and BCSC site. With regards to missing data, we performed sensitivity analyses, which resulted in the final models containing 71% of the non-missing data. For all analyses, we used SAS 9.4 SAS (SAS Institute Inc. 2015. SAS® 9.4 System Options: Reference, Fourth Edition. Cary, NC: SAS Institute Inc.). Statistical significance was determined based on a two-sided $\alpha = 0.05$.

Results

Among the 13,097 women with stage 0–III breast cancer, 2,217 (16.9%) of women had preoperative MRI. (Table 1) For surgical treatment, 24.9% of women received a mastectomy without CPM; 8.9% received mastectomy with CPM and 66.2% received BCS. Of the women receiving BCS, 72.1% had BCS with RT and 27.9% had BCS without RT. Of women with a mastectomy, 30.4% underwent breast reconstruction. (Table 1).

Overall, women's median age at diagnosis (IQR) was 62 (53 – 69) years and 20.7 % of women had a first-degree family history of breast cancer (Table 1). A family history was more common among women with CPM (28.5%). A higher proportion of women diagnosed

with an interval cancer received a mastectomy or mastectomy with CPM (19.8% and 19.1%, respectively) compared to those who received BCS with or without RT (14.6% and 13.4%, respectively). The overall distributions of tumor characteristics for the cohort were 83.9% ER positive, 73.3% PR positive, 37.8% tumor size > 2 cm, 25.3% grade I and 78.5% no positive nodes. Among women with invasive breast cancer, 16.8% had lobular or lobular and ductal carcinoma.

We compared surgical treatments stratified by preoperative MRI use. Among women with MRI, 27.8% underwent mastectomy without CPM, versus 24.3% of women without MRI. (Figure 1) Mastectomy with CPM was almost twice as frequent in women who received a MRI (14.5% v. 7.8%). The proportion of women receiving BCS with RT was lower among those with an MRI compared to those without an MRI (42.8% and 48.7%, respectively). The proportion of women with mastectomy who received reconstruction was higher among women receiving MRI (29.9% v. 20.9%); however, there was only a small difference between groups in the frequency of reconstruction among women with CPM (55.3% in the MRI group, 51.4% in the no MRI group (Figure 1).

Mastectomy with CPM was nearly double for all stages among women with MRI compared vs. without MRI (stage 0: 14.1% vs. 7.4%; stage I: 9.8% vs. 5.9%; stage II: 18.4% vs.9.3%; and stage III: 22.9% v 14.6%; respectively) (Table 2). Mastectomies without CPM for women who received MRI compared to women without MRI were also more frequent for stage 0 – II.

Comparison of surgical treatments by stage showed higher frequency at all stages of the stepwise progression from mastectomy to mastectomy plus CPM to mastectomy plus CPM and reconstruction for women with preoperative MRI. The differential in frequencies at all stages of the stepwise progression from mastectomy to mastectomy plus CPM to mastectomy plus CPM and reconstruction for women with MRI compared to those without MRI was greatest for those with stage 0 disease (MRI: 22.0% to 36.1% to 76.0% vs. No MRI: 19.1% to 26.5% to 69.9%). Similar but attenuated differences were found for stage I and II (Figure 2). Women with stage III cancer and MRI had a lower proportion of mastectomy than women without MRI. However, mastectomy plus CPM, and mastectomy plus CPM and reconstruction was higher for women with MRI. (Figure 2).

We examined the odds of each surgical treatment in relation to preoperative MRI. In adjusted logistic regression models, women with MRI were more likely to have a mastectomy (OR = 1.32; 95% CI 1.16–1.50) compared to women without MRI. Among women receiving mastectomy, women with MRI were also more likely to receive CPM (OR = 1.32 95% CI 1.05–1.65) and have breast reconstruction (OR = 1.56; 95% CI 1.24–1.97). Among women treated with BCS, MRI was not associated with use of radiation therapy (OR = 0.84; 95% CI 0.70–1.00) (Table 3).

Discussion

These national community-based data provide contemporary evidence on the association between preoperative MRI and surgical treatment for breast cancer in the U.S. MRI receipt

was associated with a greater likelihood of mastectomy and of CPM and of reconstruction, compared to women with no MRI. Even after adjusting for important clinical and sociodemographic characteristics, MRI was associated with 32% increased odds of mastectomy alone, and 32% increased odds of CPM, and 56% higher odds of reconstruction. These effects were most notable for the earliest stages – particularly DCIS and stage I and II invasive breast cancers. These findings add to the growing evidence that the observed national trends towards more aggressive surgical treatment of early stage breast cancer are associated with preoperative MRI. However, it remains unknown whether this relationship between MRI and more extensive surgery is due to MRI findings or instead patient and/or provider preferences.

National trends away from BCS have been noted since the early-mid-2000s in the U.S., despite the randomized-controlled-trial evidence showing equivalent recurrence and survival rates between BCS and mastectomy, and some morbidity benefits with BCS (20–23). A study of 1.2 million women (mean age in years: 59.6 for mastectomy, 61.6 for BCS) using the National Cancer Database showed a 34% increase in the adjusted odds of having a mastectomy among BCS-eligible women from 2004–2011, but more than a two-fold increase among women with DCIS. (16) At the same time, they found that rates of CPM rose from about 2% to 11%. (16) Within a National Comprehensive Cancer Network (NCCN) study of 10,249 women, no differences were seen in mastectomy relative to BCS from 2000–2009, but there was a significant increase in bilateral mastectomy (from 13% to 30%) among women with mastectomy (23%). (24) A similar increase in CPM was reported in an analysis of SEER data between 2002 and 2012, with a tripling in use of CPM (3.9% to 12.7%) during that time. (11) A rise in reconstruction rates mirrors these trends, and is thought that greater reconstruction options and availability contributory to the increase in use of CPM. (10, 11, 16, 24, 25) These consistent trends from very large, population-based data sources support a pattern of more extensive surgical treatment of breast cancer in the U.S. Our distribution of surgical treatments in our study is consistent with these recent reports.

Over the past decade, there has been a well-documented increase in use of preoperative MRI, (26) which may be a potential influence on surgical treatment trends. (7, 26) There is limited and conflicting evidence on the potential role of MRI in increasing mastectomy rates. A 2002–2009 study of 414 women with stages 0–III breast cancer found an 80% increase in odds of mastectomy compared to BCS for women with MRI (median age 51 years) (OR 1.8; 95% CI 1.1–3.2) (27). However a meta-analysis of 9 studies, focused only on DCIS did not find a significant difference in mastectomy in relation to MRI, which may be due to measuring all mastectomies, rather than mastectomy as the index surgical treatment. (28) Our results in a national sample of over 13,000 women show a 32% increase in the adjusted odds of mastectomy compared with BCS with MRI. Only a few small, single-institution studies have explicitly examined the potential association of preoperative breast MRI in CPM use. These studies have shown between a 70–82% increase from the approximately 3% CPM rate, with MRI use. (13, 29, 30) We report a lower increase in CPM, but significantly increased among women who receive a MRI. The prior studies were based on several hundred women, but included both academic (13, 30) and community-based (29) hospitals, and covered a similar time period to our study and women of similar ages (with

CPM: 48.8–50.4 years and without CPM: 56.8–58.9 years). One of these studies (30) examined the association of breast MRI with reconstruction, from a single institution with 446 breast cancer patients from 2002–2012. They found that a significantly higher proportion of women who had undergone mastectomy and preoperative MRI vs. no MRI also underwent reconstruction (83.9% v. 63.6%). Our results add to this evidence given our national sample and large study size and our estimates adjusted for clinical and sociodemographic characteristics that could impact choice of reconstruction.

We were able to examine the association between preoperative MRI and surgical treatment by stage. Given that risk of second ipsilateral cancer events, subsequent contralateral breast cancer, and death are all related to stage, (19) in addition to other factors, the clinical rationale for the most aggressive surgical course is expected to vary by stage. DCIS poses a particular challenge, given the very low risk of breast cancer mortality (via subsequent invasive cancer), and the concomitant greater likelihood of harm from possible overtreatment. (31) We found the greatest relative increase in CPM frequency, comparing the MRI group to the no MRI group among those diagnosed with DCIS. A retrospective chart review of 214 patients with DCIS at an academic medical center found that preoperative MRI did not lead to *change* in the planned surgical management, but that it was associated with increased mastectomy and CPM. (32) Costs, complications, reoperation, and morbidity have also been noted as concerns with aggressive surgery for DCIS. (1, 12)

In addition to the strength of our large, national sample comprised mostly of community-based settings, recent years of data, and BCSC data which includes women characteristics, this study also has limitations. We were unable to include MRI outcomes in this study, and thus could not determine whether MRI was causative in surgical management plans. We also did not have information on eligibility for BCS, margin status, or insurance information. Although we included many covariates, we could not identify women who were not clinical candidates for a particular surgical approach. We accounted for some established breast cancer risk factors, but did not have *BRCA* status. Finally, and importantly – we could not account for women's or providers' preferences in use of MRI or in use of surgical treatments.

Conclusion

Overall, our study reinforces previously reported trends of increasing mastectomy, CPM and reconstruction in relation to preoperative MRI, and provides new evidence related to the relationship of MRI and stage on surgical treatment and reconstruction for breast cancer. Given that more aggressive treatment of early stage breast cancer, is occurring, some component may be "overtreatment" relative to impact on medical outcomes including survival.

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Synopsis

Extensive surgical treatment for early stage breast cancer has been increasing however, patterns of preoperative MRI in relation to this trend have not been well established. Our study found that preoperative MRI in women with DCIS and early stage invasive breast cancer is associated with more frequent mastectomy, CPM, and reconstruction.

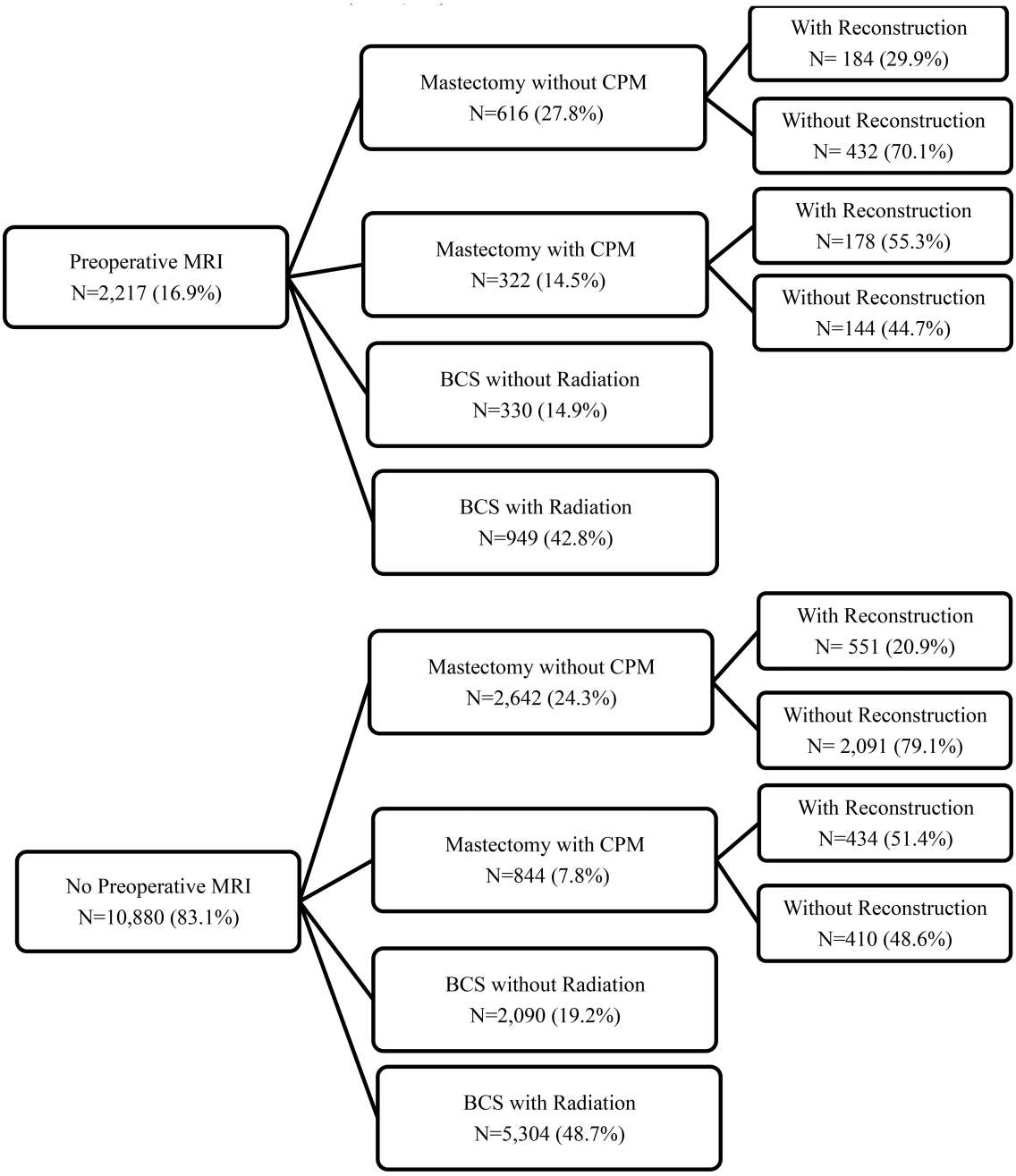

Figure 1.

Distribution of surgery type, radiation and reconstruction by receipt of preoperative MRI among women with non-metastatic breast cancer (N=13,097)

Abbreviations: MRI = magnetic resonance imaging; CPM = contralateral prophylactic mastectomy; BCS = breast conserving surgery.

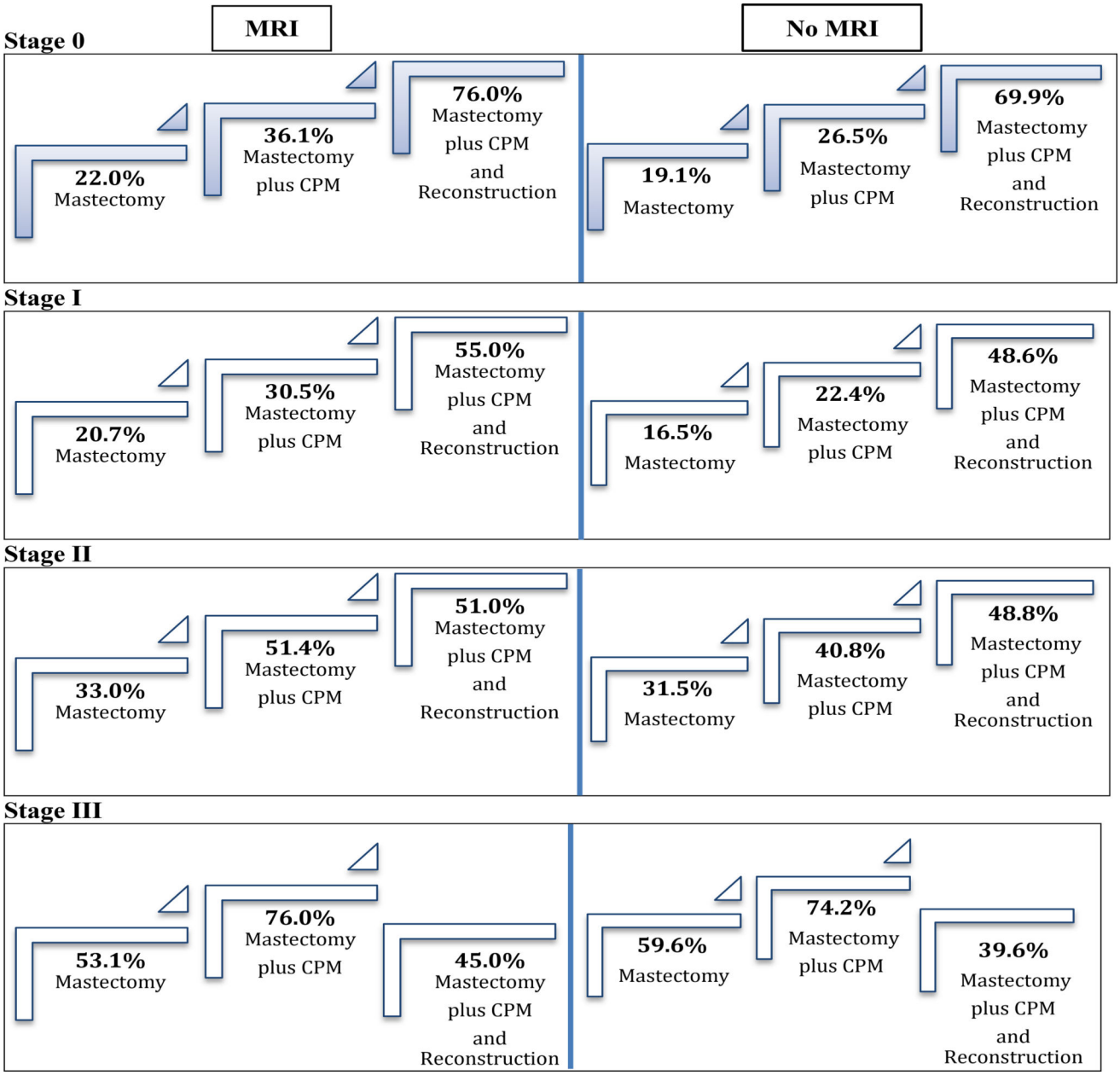

Figure 2.

Stepwise progression of women receiving mastectomy and among those mastectomy plus CPM, and among those mastectomy plus CPM and reconstruction with and without MRI by breast cancer stage (N=4,424)

Abbreviations: MRI = magnetic resonance imaging; CPM = contralateral prophylactic mastectomy.

Table 1

Preoperative MRI, year of diagnosis, mode of detection, patient and tumor characteristics by surgical treatment among women diagnosed with non-metastatic breast cancer (N=13,097)

	Total (N=13,097)		Mastectomy without CPM (N=3,258; 24.9%)		Mastectomy with CPM (N=1,166; 8.9%)		BCS without RT (N=2,420; 18.5%)		BCS with RT (N=6,253; 47.7%)	
Characteristics*	**N**	**(Col %)**	**N**	**(Col %)**	**N**	**(Col %)**	**N**	**(Col %)**	**N**	**(Col %)**
Preoperative MRI										
No	10,880	83.1	2,642	81.1	844	72.4	2,090	86.4	5,304	84.8
Yes	2,217	16.9	616	18.9	322	27.6	330	13.6	949	15.2
Mode of Detection										
Screen Detected	4,976	38.0	948	29.1	361	31.0	1,087	44.9	2,580	41.3
Interval Detected	2,060	15.7	644	19.8	223	19.1	354	14.6	839	13.4
Clinically Detected	834	6.4	302	9.3	104	8.9	174	7.2	254	4.1
Unknown	5,227	39.9	1,364	41.9	478	41.0	805	33.3	2,580	41.3
Age										
<40	312	2.4	78	2.4	101	8.7	41	1.7	92	1.5
40–49	1,994	15.2	509	15.6	358	30.7	284	11.7	843	13.5
50–59	3,424	26.1	809	24.8	364	31.2	536	22.1	1,715	27.4
60–69	4,108	31.4	970	29.8	253	21.7	654	27.0	2,231	35.7
70+	3,259	24.9	892	27.4	90	7.7	905	37.4	1,372	21.9
First-degree Family History of breast cancer										
No	9,465	79.3	2,370	80.4	752	71.5	1,767	79.0	4,576	80.2
Yes	2,477	20.7	579	19.6	300	28.5	470	21.0	1,128	19.8
Year of diagnosis										
2010	3,023	23.1	838	25.7	258	22.1	429	17.7	1,498	24.0
2011	3,191	24.4	826	25.4	263	22.6	487	20.1	1,615	25.8
2012	3,212	24.5	759	23.3	321	27.5	581	24.0	1,551	24.8
2013	3,324	25.4	750	23.0	280	24.0	761	31.4	1,533	24.5
2014**	347	2.7	85	2.6	44	3.8	162	6.7	56	0.9

Characteristics*	Total (N=13,097)		Mastectomy without CPM (N=3,258; 24.9%)		Mastectomy with CPM (N=1,166; 8.9%)		BCS without RT (N=2,420; 18.5%)		BCS with RT (N=6,253; 47.7%)	
	N	(Col %)	N	(Col %)	N	(Col %)	N	(Col %)	N	(Col %)
Stage* **										
0	2,437	18.6	475	14.6	203	17.4	561	23.2	1,198	19.2
I	5,780	44.1	993	30.5	375	32.2	1,094	45.2	3,318	53.1
II	3,979	30.4	1,264	38.8	442	37.9	668	27.6	1,605	25.7
III	901	6.9	526	16.1	146	12.5	97	4.0	132	2.1
Invasive Histology										
Invasive Ductal	8,124	83.2	1,993	78.0	691	76.9	1,417	85.1	4,023	86.6
Invasive Lobular	1,032	10.6	367	14.4	150	16.7	139	8.3	376	8.1
Invasive Lobular and Ductal	605	6.2	194	7.6	57	6.3	110	6.6	244	5.3
ER										
Positive	10,746	83.9	2,575	80.7	927	80.8	1,933	83.0	5,311	86.5
Negative	2,060	16.1	616	19.3	220	19.2	397	17.0	827	13.5
PR										
Positive	9,321	73.3	2,186	69.0	818	71.8	1,690	72.9	4,627	76.1
Negative	3,391	26.7	984	31.0	321	28.2	629	27.1	1,457	23.9
Tumor Size										
< 1cm	3,146	24.5	494	15.4	194	16.9	710	30.2	1,748	28.4
1 to <2cm	4,851	37.7	905	28.2	364	31.8	922	39.2	2,660	43.2
2 to <5cm	4,054	31.5	1,307	40.7	453	39.5	656	27.9	1,638	26.6
5+ cm	815	6.3	502	15.6	135	11.8	63	2.7	115	1.9
Tumor Grade										
Grade I	3,245	25.3	613	19.2	217	18.9	628	26.5	1,787	29.1
Grade II	5,591	43.5	1,441	45.0	504	43.9	1,018	42.9	2,628	42.8
Grade III	4,018	31.3	1,146	35.8	426	37.1	726	30.6	1,720	28.0
Nodal Status										

Characteristics*	Total (N=13,097)		Mastectomy without CPM (N=3,258; 24.9%)		Mastectomy with CPM (N=1,166; 8.9%)		BCS without RT (N=2,420; 18.5%)		BCS with RT (N=6,253; 47.7%)	
	N	(Col %)	N	(Col %)	N	(Col %)	N	(Col %)	N	(Col %)
No positive nodes	10,278	78.5	2,106	64.6	805	69.0	1,994	82.4	5,373	85.9
Positive nodes	2,819	21.5	1,152	35.4	361	31.0	426	17.6	880	14.1

*Missing (N): family history (1,155), invasive histology (899), ER status (291), PR status (385), tumor size (231) and grade (243).

**Breast cancers from January 2014 included.

***Derived AJCC stage group, 7th edition (2004+).

Table 2

Frequency of surgical treatment by preoperative MRI use, stratified by cancer stage (N = 13,097)

	MRI (N=2,217)				No MRI (N=10,880)			
	Mastectomy without CPM N = 616	**Mastectomy with CPM N = 332**	**BCS without RT N = 330**	**BCS with RT N = 949**	**Mastectomy without CPM N = 2,642**	**Mastectomy with CPM N = 844**	**BCS without RT N = 2,090**	**BCS with RT N = 5,304**
Cancer Stage	**N (row %)**	**N (row %)**	**N (row %)**	**N (row %)**	**N (row %)**	**N (row %)**	**N (row %)**	**N (row %)**
Stage 0 N = 2,437	78 (22.0)	50 (14.1)	60 (17.0)	166 (46.9)	397 (19.1)	153 (7.4)	501 (24.0)	1,032 (49.5)
Stage 1 N =5,780	189 (20.7)	89 (9.8)	141 (15.5)	492 (54.0)	804 (16.5)	286 (5.9)	953 (19.6)	2,826 (58.0)
Stage II N =3,979	256 (33.0)	143 (18.4)	113 (14.5)	265 (34.1)	1,008 (31.5)	299 (9.3)	555 (17.3)	1,340 (41.9)
Stage III N =901	93 (53.1)	40 (22.9)	16 (9.1)	26 (14.9)	433 (59.6)	106 (14.6)	81 (11.2)	106 (14.6)

Abbreviations: MRI = magnetic resonance imaging; CPM = contralateral prophylactic mastectomy; BCS = breast conserving surgery; RT= radiation therapy.

Table 3

Unadjusted and adjusted1 odds ratios (OR) and 95% confidence intervals (95% CI) for the association between MRI and surgical treatments among women diagnosed with non-metastatic breast cancer, Stages 0–III (N=13,097)

	Mastectomy vs. BCS (N=13,097)			Mastectomy with CPM vs. Mastectomy without CPM (N=4,424)			Reconstruction vs. no Reconstruction (N=4,424)			BCS with RT vs. BCS without RT (N=8,673)		
MRI	**OR**	**95% CI**		**OR**	**95% CI**		**OR**	**95% CI**		**OR**	**95% CI**	
Unadjusted	1.55	1.42	1.71	1.64	1.40	1.91	1.60	1.37	1.86	1.13	0.99	1.30
Adjusted[1]	1.32	1.16	1.50	1.32	1.05	1.65	1.56	1.24	1.97	0.84	0.70	1.00

[1]Adjusted for age at diagnosis, race, urban/rural status, family history of breast cancer, year of diagnosis, mode of detection, stage, histology, tumor size, grade, ER/PR/nodal status and BCSC site.

Abbreviations: MRI = magnetic resonance imaging; BCS = breast conserving surgery; RT = radiation therapy; CPM = contralateral prophylactic mastectomy; BCSC = Breast Cancer Surveillance Consortium.