Original Article

Recent trends in total mastectomy techniques and post-mastectomy breast cancer reconstruction: a population-based analysis

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Background: In the last decade, more women are undergoing post-mastectomy reconstruction. The purpose of this study is to examine the evolving changes in mastectomy techniques and post-mastectomy reconstruction for breast cancer patients.

Methods: Patients in the Surveillance, Epidemiology, and End Results (SEER) database were included from 2004 to 2014 based on a diagnosis of breast cancer using the ICD O-3 primary site codes: C50.0–50.6 and C50.8–50.9 who underwent a nipple sparing, total simple, modified radical, or radical mastectomy. Patients were categorized into 2- or 3-year cohorts based on their year of diagnosis.

Results: A total of 263,161 breast cancer cases were identified. Patients tended to be middle-aged females (mean age: 59.6 years old). 35.0% of patients received a total simple mastectomy in the 2004–2005 cohort compared to 61.8% of patients in the 2012–2014 cohort (P<0.001). Regarding reconstruction technique, 14.7% of patients received post-mastectomy breast reconstruction in the 2004–2005 cohort while 31.7% received post-mastectomy breast reconstruction in the 2012–2014 cohort (P<0.001).

Conclusions: Breast cancer patients who undergo mastectomies are likely to be middle-aged Caucasian females. An increased percentage of patients who receive mastectomies have lower stage disease. A higher number of patients are receiving total simple mastectomies over time as compared to modified radical mastectomies. Patients who receive a total simple mastectomy have a higher chance of receiving breast reconstruction. Finally, the use of breast implant reconstruction has increased compared to tissue reconstruction for mastectomy patients.

Keywords: Breast cancer; mastectomy techniques; breast reconstruction

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Introduction

Breast cancer is the second most common cause of cancer death in women (1). Surgical efforts to improve patient survival include the use of breast conserving therapy or breast mastectomy (2,3). Different mastectomy techniques require the removal of different amounts of tissue and/

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or the need for the removal of surrounding structures (4). The use of post-mastectomy breast reconstruction has been noted to improve a patient's quality of life without impacting survival outcomes (5,6). In response, post-mastectomy breast reconstruction rates have been increasing (7). While some studies report high-risk tumors as a possible barrier to breast reconstruction, recent trends and factors associated with breast reconstruction and its relation to mastectomy techniques have not been well-studied (8). The Surveillance, Epidemiology, and End Results (SEER) database is a population-based database consisting of 18 different state registries (9). Each state registry consists of specific chosen regions chosen to represent the general population in the United States (10). The SEER database provides access to demographic, treatment, and survival information. By utilizing the SEER database in this study, trends in breast cancer mastectomies and reconstructions can be further evaluated. Furthermore, variables from patient cases between 2004 and 2014 which may impact a patient's ability to receive post-mastectomy breast reconstruction will be identified. We present the following article in accordance with the STROBE reporting checklist (available at https://abs.amegroups.com/article/view/10.21037/abs-21-146/rc).

Methods

Case-based data were obtained using the National Cancer Institute's SEER database. Patients from the SEER database were included from 2004–2014. The SEER 18 registry research data with custom treatment data (released April 2017, based on the November 2016 submission) were utilized (11). It is notable that there is a significant time lag bias, but this was the most recent release of the database when the study was originally conducted. Cases were included based on a diagnosis of breast cancer using the ICD O-3 primary site codes of C50.0–50.6 and 50.8–50.9. Patients were included based on the receipt of a nipple sparing, total (simple), modified radical, or radical breast mastectomy using documented site surgery codes as well as reconstruction type. Patients who did not meet these criteria were not included in the database report. Patients were grouped according to their year of diagnosis into 2- or 3-year (2004–2005; 2004 and 2005 year of diagnosis patients were grouped together to maintain 3-year cohorts thereafter) cohorts to compare features between groups and assess for changes in demographic, treatment, and reconstruction data over time. Given that this study is secondary analysis of de-identified public use patient data, our study did not require IRB approval. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013).

Statistical analysis

All data analyses were performed with SPSS 24.0 (IBM Corporation, Armonk, NY, USA), SigmaPlot 12.5 (Systat Software, San Jose, CA, USA), and MedCalc software 16.8 (MedCalc Software bvba, Ostend, Belgium). All continuous variables were tested for normal distribution as determined by the Kolmogorov-Smirnov test. Categorical variables were summarized by frequency, percentage, and/or range. Continuous variables were summarized by mean (SD) or median (range) where appropriate. Comparisons of categorical variables were performed using a Chi-Square test. To assess the relationship between mastectomy type and breast reconstruction, univariable and multivariable logistical regression analyses were performed to adjust for potential confounding variables. Variables significant at the 0.10 α level were considered for inclusion into the multivariable logistic regression model. A backward conditional elimination approach was used to determine the final multivariable model. A P value of <0.05 was considered to indicate a statistically significant difference for all statistical tests.

Results

Demographics

A total of 263,164 patients who were diagnosed with a breast malignancy received a mastectomy based on the aforementioned search criteria. The number of cases in each 2- and 3-year cohort was listed over time as shown in *Table 1*. 98.6% of patients in this study were female. In each year of diagnosis cohort, the percentage of male patients ranged from 1.4% to 1.5%. In the 2004–2005 cohort, 34,462 patients (81.4%) were Caucasian, 4,239 (10.0%) were African American, 3,500 (8.3%) were classified as other (including Asian/Pacific Islanders or American Indian/Alaskan Natives), and 110 (0.3%) were of unknown race. In the 2012–2014 cohort, 59,045 patients (77.7%) were Caucasian, 8,641 (11.4%) were African American, 7,826 (10.3%) were classified as other (including Asian/Pacific Islanders or American Indian/Alaskan Natives), and 437 (0.6%) were of unknown race ($P<0.001$). The mean age

Table 1 Patient demographics

Characteristics	Total	2004–2005	2006–2008	2009–2011	2012–2014	P value
Cases (%)	263,164 (100.0)	42,311 (16.1)	69,787 (26.5)	75,117 (28.5)	75,949 (28.9)	
Mean age (range), years	59.6 (10.0–85.0)	60.2 (13.0–85.0)	59.9 (12.0–85.0)	59.5 (10.0–85)	59.3 (14.0–85.0)	<0.001
Age at diagnosis, n (%)						0.13
≥55 years	161,460 (61.4)	26,140 (61.8)	42,850 (61.4)	45,885 (61.1)	46,585 (61.3)	
<55 years	101,704 (38.6)	16,171 (38.2)	26,937 (38.6)	29,232 (38.9)	29,364 (38.7)	
Sex, n (%)						0.65
Female	259,359 (98.6)	41,710 (98.6)	68,785 (98.6)	74,048 (98.6)	74,816 (98.5)	
Male	3,805 (1.4)	601 (1.4)	1,002 (1.4)	1,069 (1.4)	1,133 (1.5)	
Race, n (%)						<0.001
Other*	24,346 (9.3)	3,500 (8.3)	6,054 (8.7)	6,966 (9.3)	7,826 (10.3)	
Black	28,440 (10.8)	4,239 (10.0)	7,389 (10.6)	8,171 (10.9)	8,641 (11.4)	
White	209,219 (79.5)	34,462 (81.4)	56,041 (80.3)	59,671 (79.4)	59,045 (77.7)	
Unknown	1,159 (0.4)	110 (0.3)	303 (0.4)	309 (0.4)	437 (0.6)	
AJCC overall stage, n (%)						<0.001
Stage I	93,233 (35.4)	14,144 (33.4)	23,976 (34.4)	27,065 (36.0)	28,048 (36.9)	
Stage II	102,599 (39.0)	16,208 (38.3)	26,634 (38.2)	29,211 (38.9)	30,546 (40.2)	
Stage III	50,863 (19.3)	8,867 (21.0)	14,248 (20.4)	14,202 (18.9)	13,546 (17.8)	
Stage IV	7,773 (3.0)	1,291 (3.1)	2,137 (3.1)	2,334 (3.1)	2,011 (2.6)	
Unknown	8,603 (3.3)	1,801 (4.3)	2,791 (4.0)	2,304 (3.1)	1,797 (2.4)	

P<0.05 considered statistically significant. *, other includes Asian/Pacific Islanders, American Indian/Alaskan Natives. AJCC, American Joint Committee on Cancer.

at diagnosis was 59.6 years (range, 10.0–85.0 years) for the total cohort. 61.4% of patients were diagnosed at or above age 55. Regarding overall American Joint Committee on Cancer (AJCC) staging, 71.7% had stage I or II cancers in the 2004–2005 cohort while 77.1% had stage I or II cancers in the 2012–2014 cohort (P<0.001). 24.1% had stage III or IV cancers in the 2004–2005 cohort while 20.4% had stage III or IV cancers in the 2012–2014 cohort (P<0.001) (*Table 1*).

Treatment

Regarding mastectomy technique, in the 2004–2005 cohort, 0.2% of patients received a nipple sparing mastectomy, 35.0% received a total simple mastectomy, and 64.0% received a modified radical mastectomy (*Table 2*). In the 2012–2014 cohort, 3.5% of patients received a nipple sparing mastectomy, 61.8% of patients received a total simple mastectomy while 34.1% received a modified radical mastectomy (P<0.001). Regarding reconstruction technique, 14.6% of patients received post-mastectomy breast reconstruction in the 2004–2005 cohort while 31.7% received post-mastectomy breast reconstruction in the 2012–2014 cohort (P<0.001) (*Table 2*). In the 2004–2005 cohort, 5.8% of patients received tissue-based reconstruction, 4.5% received implant-based reconstruction, 1.3% received combined tissue and implant-based reconstruction, and 3.0% received reconstruction which was not otherwise specified. In the 2012–2014 cohort, 9.6% of patients received tissue-based reconstruction, 12.3% received implant-based reconstruction, 4.5% received combined tissue and implant-based reconstruction, and 5.3% received reconstruction which was not otherwise specified (P<0.001). Regarding type of reconstruction based on receipt of radiation, 75.6% of patients who did not receive radiation did not receive post-mastectomy

Table 2 Treatment

Characteristic	Total	2004–2005	2006–2008	2009–2011	2012–2014	P value
Mastectomy type, n (%)						<0.001
Nipple sparing mastectomy	3,474 (1.3)	80 (0.2)	171 (0.2)	601 (0.8)	2,622 (3.5)	
Total simple mastectomy	131,213 (49.9)	14,802 (35.0)	29,549 (42.3)	39,938 (53.2)	46,924 (61.8)	
Modified radical mastectomy	126,277 (48.0)	27,060 (64.0)	39,393 (56.4)	33,936 (45.2)	25,888 (34.1)	
Radical mastectomy	2,200 (0.8)	369 (0.9)	674 (1.0)	642 (0.9)	515 (0.7)	
Reconstruction type*, n (%)						<0.001
No reconstruction	198,261 (76.3)	36,014 (85.3)	56,563 (81.3)	55,567 (74.6)	50,117 (68.3)	
Tissue reconstruction only	20,401 (7.9)	2,453 (5.8)	5,011 (7.2)	5,891 (7.9)	7,046 (9.6)	
Implant only	23,202 (8.9)	1,918 (4.5)	4,660 (6.7)	7,609 (10.2)	9,015 (12.3)	
Combined tissue and implant	7,356 (2.8)	559 (1.3)	1,155 (1.7)	2,364 (3.2)	3,278 (4.5)	
Reconstruction NOS	10,470 (4.0)	1,287 (3.0)	2,227 (3.2)	3,085 (4.1)	3,871 (5.3)	
Chemotherapy, n (%)						<0.001
Yes	126,771 (48.2)	19,873 (47.0)	33,835 (48.5)	36,497 (48.6)	36,566 (48.1)	
No/unknown	136,393 (51.8)	22,438 (53.0)	35,952 (51.5)	38,620 (51.4)	39,383 (51.9)	
Radiation, n (%)						<0.001
None/unknown	203,114 (77.2)	32,883 (77.7)	54,044 (77.4)	57,706 (76.8)	58,481 (77.0)	
Beam radiation	59,047 (22.4)	9,251 (21.9)	15,421 (22.1)	17,142 (22.8)	17,233 (22.7)	
Other radiation	1,003 (0.4)	177 (0.4)	322 (0.5)	269 (0.4)	235 (0.3)	
Treatment type, n (%)						<0.001
Surgery only	125,976 (47.9)	20,893 (49.4)	33,270 (47.7)	35,529 (47.3)	36,284 (47.8)	
Surgery and chemotherapy	77,138 (29.3)	11,990 (28.3)	20,774 (29.8)	22,177 (29.5)	22,197 (29.2)	
Surgery and radiation	10,417 (4.0)	1,545 (3.7)	2,682 (3.8)	3,091 (4.1)	3,099 (4.1)	
Surgery and chemoradiation therapy	49,633 (18.9)	7,883 (18.6)	13,061 (18.7)	14,320 (19.1)	14,369 (18.9)	

P<0.05 considered statistically significant. *, detailed reconstruction data for nipple sparing mastectomy unavailable. NOS, not otherwise specified.

reconstruction as compared to 78.9% of patients who did receive radiation (P<0.001). 8.2% of patients who did not receive radiation underwent tissue-based reconstruction as compared to 6.7% of patients who underwent radiation (P<0.001). 9.2% of patients who did not receive radiation underwent implant-based reconstruction as compared to 8.1% of patients who underwent radiation (P<0.001).

Regarding total treatment, modalities included: surgical care only, surgery and chemotherapy, surgery and radiation, and surgery, radiation, and chemotherapy. In the 2004–2005 cohort, 49.4% of patients underwent surgical care only, 28.3% received surgery and chemotherapy, and 18.6% received surgery, radiation, and chemotherapy. In the 2012–2014 cohort, 47.8% of patients underwent surgical care only, 29.2% received surgery and chemotherapy, and 18.9% received surgery, radiation, and chemotherapy (P<0.001) (*Table 2*). Regarding receipt of radiation by stage, 4.3% of patients with stage I cancer, 21.3% of patients with stage II cancer, 57.9% of patients with stage III cancer, and 40.4% of patients with stage IV cancer received radiation as a part of their care (P<0.001). Regarding receipt of radiation by mastectomy type, 14.3% of patients who underwent a total simple mastectomy received radiation, 31.6% of patients who underwent a modified radical mastectomy received

Table 3 Effect of mastectomy type on receipt of reconstruction: univariable and multivariable logistical regression analysis

Variable	Univariable analysis: OR (95% CI)	Multivariable analysis: aOR (95% CI)
Mastectomy type		
Total simple mastectomy	Reference	Reference
Modified radical mastectomy	0.44 (0.43–0.45)	0.55 (0.54–0.56)
Radical mastectomy	0.88 (0.80–0.97)	1.06 (0.96–1.17)
Year of diagnosis		
2004–2005	Reference	Reference
2006–2008	1.34 (1.29–1.38)	1.30 (1.26–1.35)
2009–2011	2.01 (1.95–2.08)	1.88 (1.81–1.94)
2012–2014	2.95 (2.86–3.04)	2.55 (2.46–2.63)
Age at diagnosis		
≥55 years	Reference	Reference
<55 years	3.63 (3.57–3.70)	3.86 (3.78–3.94)
Sex		
Male	Reference	Reference
Female	28.85 (21.21–39.25)	23.28 (17.08–31.73)
Race		
White	Reference	Reference
Black	0.77 (0.75–0.79)	0.73 (0.71–0.76)
Other*	0.65 (0.63–0.68)	0.51 (0.49–0.53)
Unknown	1.05 (0.92–1.20)	0.82 (0.71–0.95)
AJCC overall stage		
Stage I	Reference	Reference
Stage II	0.75 (0.74–0.77)	0.69 (0.68–0.71)
Stage III	0.49 (0.47–0.50)	0.47 (0.45–0.48)
Stage IV	0.28 (0.26–0.30)	0.27 (0.25–0.29)
Unknown	0.50 (0.48–0.53)	0.52 (0.49–0.55)
Treatment type		
Surgery only	Reference	Reference
Surgery and chemotherapy	1.46 (1.43–1.50)	1.33 (1.30–1.36)
Surgery and Radiation	0.56 (0.53–0.60)	0.75 (0.71–0.80)
Surgery and chemoradiation	1.06 (1.03–1.09)	1.27 (1.23–1.31)

*, other includes Asian/Pacific Islanders, American Indian/Alaskan Natives. OR, odds ratio; aOR, adjusted odds ratio; AJCC, American Joint Committee on Cancer.

radiation, and 32.1% of patients who underwent a radical mastectomy received radiation (P<0.001).

Factors associated with the receipt of breast reconstruction

On univariate analysis, patients who received a modified radical mastectomy had a reduced chance (OR 0.44, 95% CI: 0.43–0.45) of receiving breast reconstruction as compared to those who received a total simple mastectomy (*Table 3*). After adjusting for relevant covariates, patients who received a modified radical mastectomy [adjusted OR (aOR): 0.48, 95% CI: 0.47–0.49] were associated with a reduced chance of receiving breast reconstruction as compared to patients who received a total simple mastectomy (*Table 3*). In the multivariate analysis, patients who were below the age of 55 had a higher chance of receiving post-mastectomy breast reconstruction as compared to those diagnosed at or greater than the age of 55 (aOR: 3.72; 95% CI: 3.64–3.79) (*Table 3*). Additionally, in the multivariate analysis, patients in the 2006–2008 (aOR: 1.30; 95% CI: 1.26–1.35), 2009–2011 (aOR: 1.88; 95% CI: 1.81–1.94), and 2012–2014 (aOR: 2.55; 95% CI: 2.46–2.63) cohorts had a higher chance of receiving post-mastectomy breast reconstruction as compared to those diagnosed in the 2004–2005 cohort. Finally, in the multivariate analysis, patients who received surgery and chemotherapy (aOR: 1.33; 95% CI: 1.30–1.37) had an increased chance of receiving post-mastectomy breast reconstruction while patients who received surgery and radiation (aOR: 0.77; 95% CI: 0.73–0.82) had a decreased chance of receiving post-mastectomy breast reconstruction (*Table 3*).

Discussion

Several important points were identified for post-mastectomy patients based on the results of this study. 98.5% of patients in this study were female. Breast cancer in male patient has been estimated to make up approximately 1% of all breast cancers (12). This percentage is similar to the percent of male patients in this study (1.5%). Most patients in this study were of older age (61.4% of patients ≥55 years of age at diagnosis). Killelea *et al.*'s study similarly noted 62% of breast cancer patients were diagnosed at >50 years of age (13). A large majority of patients in this study were of Caucasian race. However, African American and patients in the "other" race category (including Asian/Pacific Islander or American Indian/Alaskan Native patients) had a slight increase in mastectomy rates for breast cancer over time.

The American Cancer Society's 2019 cancer statistics for African Americans reported an increase in the incidence of breast cancer in African American patients (14). There have been targeted efforts to increase screening, education, and access to care for this population (15), which could account for this increase in mastectomy rates for African American breast cancer patients. While the increased percentage of African American breast cancer cases could be due to a true increased rate or increased access to care, caution must be noted as this increased percentage could additionally be attributed to the continuous expansion of the SEER database. To create a sample population representative of the national population, SEER registries containing a larger population of African Americans could have been added to the most recent cohorts in this study, thus accounting for the higher percentage of African American cases seen over time in this study. Future studies may seek to further examine if the rates of mastectomy are increasing among African American patients. Finally, the percentage of overall AJCC stage I or II cancers for patients receiving total simple/radical mastectomies increased over time from the 2004–2005 cohort to the 2012–2014 cohort (P<0.001). Mahmood *et al.* demonstrated an increased rate of mastectomies for early-stage cancers over time (16). Albornoz *et al.* revealed an increasing number of early-stage breast cancer patients who are eligible to receive breast-conserving surgeries are receiving mastectomies instead. Albornoz *et al.* attributes the advancements in technique and availability of breast reconstruction as a partial explanation as to why patients are choosing to undergo mastectomies (17). Additionally, increased media-related awareness could contribute to more patients receiving mastectomies with the goal of having post-mastectomy reconstruction (18).

Regarding mastectomy technique, the percentage of total simple mastectomies increased significantly over time. Based on the results of our multivariable logistical regression analysis, one partial explanation for the increased use of total simple mastectomies over time could be due to the decreased chance of receiving a breast reconstruction for patients who underwent a modified radical mastectomy (aOR: 0.55; 95% CI: 0.54–0.56). Regarding reconstruction technique, the percentage of patients receiving reconstruction increased significantly over time. Furthermore, the use of breast implants surpassed the use of tissue reconstruction. The greater use of implants for reconstruction may be due to ease of use and decreased operative time. However, several studies have also shown that the use of implant-based reconstruction is associated with lower rates of mastectomy skin flap necrosis (19,20). Finally, regarding treatment modalities, our multivariable analysis demonstrated that patients who received surgery and radiation therapy had a reduced chance of receiving breast reconstruction as compared to those who received surgery only (aOR: 0.57; 95% CI: 0.71–0.80). Side effects such as capsular contracture and implant exposure have been reported for post-reconstruction patients who undergo radiation (21,22). Additionally, a higher percentage of patients with stage II, III, or IV cancers received radiation. Our study identified both receipt of radiation therapy and higher-staged cancers were associated with a reduced chance of receiving post-mastectomy reconstruction. Furthermore, our study found that implant-based reconstruction was the most common type of reconstruction performed for patients who received radiation although this was less likely to be performed compared to patients who did not receive radiation.

There are several limitations to this study. First, data is only available up to 2014 and thus the latest data are not described. However, the information here remains valuable because it identifies trends over a ten-year period. Additionally, the SEER database includes a large sample size and, as such, multiple variables were found to be clinically significant in the multivariate analysis although differences may not be clinically relevant. Furthermore, in the SEER database, both chemotherapy and radiotherapy data are classified as: "yes" or "no/unknown". Given this classification, conclusions regarding treatment must be interpreted with this in mind. There are several other mastectomy types and subtypes which were not listed in the SEER database and thus not included in this study. Finally, detailed information regarding breast reconstruction such as patients who underwent a nipple sparing mastectomy was not available which would have been a great addition to the existing data. Future studies may wish to assess the interactions of age and racial background on the types of mastectomies and reconstructions performed, but this was beyond the scope of this publication. Regardless of these limitations, our analysis of the SEER database provided information of breast cancer cases and treatment patterns with extraction of data on race, mastectomy types, and reconstruction techniques. The SEER database is a US-based national database and therefore is representative of United States trends but may not necessarily reflect trends in other countries.

Conclusions

The SEER database was chosen in our study as it provided the opportunity to examine a large number of breast cancer cases within the United States. Our data analysis identified critical information regarding treatment characteristics that will allow healthcare providers and institutions to examine recent trends in breast cancer management. These data may further patient education as well as potentially impact practice patterns.

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Footnote

Reporting Checklist: The authors have completed the STROBE reporting checklist. Available at https://abs.amegroups.com/article/view/10.21037/abs-21-146/rc

Peer Review File: Available at https://abs.amegroups.com/article/view/10.21037/abs-21-146/prf

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://abs.amegroups.com/article/view/10.21037/abs-21-146/coif). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013).

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