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A Survey of Patient Experience During Molecular Breast Imaging

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Molecular breast imaging (MBI) is one of several options available to patients seeking supplemental screening due to mammographically dense breasts. Patient experience during MBI may influence willingness to undergo the test but has yet to be formally assessed. We aimed to assess patient comfort level during MBI, to compare MBI comfort with mammography comfort, to identify factors associated with MBI discomfort, and to evaluate patients' willingness to return for future MBI. **Methods:** A 10-question survey was sent by e-mail to patients undergoing MBI between August and December 2022 to obtain quantitative assessments and qualitative opinions about MBI. **Results:** Of 561 invited patients, 209 (37%) completed the survey and provided study consent. Their average age was 60.1 y (range, 40–81 y). Of the 209 responders, 202 (97%) were presenting for screening MBI, 195 (94%) had dense breasts, and 46 (22%) had a personal history of breast cancer. The average rating of MBI comfort was 2.9 (SD, 1.5; median, 3.0) on a 7-point scale (1 indicating extremely comfortable and 7 indicating extremely uncomfortable). The rating distribution was as follows: 140 (67%) comfortable (rating, 1–3); 24 (12%) neither comfortable nor uncomfortable (rating, 4); and 45 (22%) uncomfortable (rating, 5 or 6). No responders gave a 7 rating. The most frequently mentioned sources of discomfort included breast compression ($n = 16$), back or neck discomfort ($n = 14$), and maintaining position during the examination ($n = 14$). MBI comfort was associated with responder age (74% ≥55 y old were comfortable, versus 53% <55 y old [$P = 0.003$]) and history of MBI (71% with prior MBI were comfortable, versus 61% having a first MBI [$P = 0.006$]). Of 208 responders with a prior mammogram, 148 (71%) said MBI is more comfortable than mammography (a significant majority [$P < 0.001$]). Of 202 responders to the question of whether they were willing to return for a future MBI, 196 (97%) were willing. A notable factor in positive patient experience was interaction with the MBI nuclear medicine technologist. **Conclusion:** Most responders thought MBI to be a comfortable examination and more comfortable than mammography. Patient experience during MBI may be improved by ensuring back support and soliciting patient feedback at the time of positioning and throughout the examination. Methods under study to reduce imaging time may be most important for improving patient experience.

Key Words: molecular breast imaging; survey; patient experience; comfort

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Breast density notification legislation, which requires facilities performing mammography to notify a woman about the implications of breast density, is currently active in most U.S. states, with a federal requirement going into effect on September 10, 2024 (*1*,*2*). The specifics of breast density notification information provided to patients currently differ by state, yet these notifications have been associated with increased patient awareness that density can mask cancers on mammography and that density is a risk factor for breast cancer (*3*–*5*). Notifications in 18 states include a recommendation that patients with dense breasts consider supplemental screening tests, and 22 states thus far have adopted legislation to expand insurance coverage of supplemental screening. These trends are likely to increase clinical offerings and patient demand for supplemental breast imaging.

Despite growing recognition of mammography's limitations in dense breasts, there is not yet a widely endorsed best practice standard regarding the type or frequency of supplemental screening that should be recommended for women based on breast density. Supplemental screening modalities of whole-breast ultrasound, MRI, contrast-enhanced mammography, and molecular breast imaging (MBI) have all been shown to increase cancer detection in dense breasts, relative to detection with either 2-dimensional full-field digital mammography or newer 3-dimensional digital breast tomosynthesis (*6*). The greatest incremental yields in cancer detection are obtained with vascular techniques of MRI, contrast-enhanced mammography, and MBI, which detect an additional 8.1–16.0 breast cancers per 1,000 women screened after mammography, whereas whole-breast ultrasound detects only an additional 2.0–2.7 breast cancers per 1,000 women after mammography (*6*).

However, other factors beyond cancer detection influence supplemental screening use in practice. A recent survey

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reported on the substantial variability of supplemental screening among facilities across the United States, with screening whole-breast ultrasound most offered among practices surveyed. Variability in offerings was associated with referring provider preferences, radiologist expertise, and patient knowledge about breast density (*7*). Additionally, equipment availability and insurance coverage for supplemental breast imaging tests vary among practices. Finally, as has been seen in the patient-led advocacy for breast density notification legislation, patient demand is a primary driver of supplemental screening promotion; hence, for any supplemental screening technique to be successfully implemented in practice, patient acceptance and willingness to undergo the test are key.

In our clinical practice, MBI is recommended as a supplement to digital breast tomosynthesis screening for patients who have dense breasts and do not meet criteria for breast MRI because of breast cancer risk or contraindications, as well as patients who prefer not to undergo breast MRI because of cost, claustrophobia, or other concerns. MBI is a nuclear medicine technique that uses a dedicated cadmium zinc telluride–based dual-head γ-camera to image the uptake of ^{99m}Tc-sestamibi in the breast. A clinical trial performed at our center showed that when MBI screening was added to full-field digital mammography among patients with dense breasts, the overall cancer detection rate (per 1,000 screened) increased from 3.2 to 12.0 ($P < 0.001$) and the invasive cancer detection rate increased from 1.9 to 8.8 ($P < 0.001$), with a relatively low decrease in specificity from 89% with mammography alone to 83% with the combination of mammography and supplemental MBI (*8*). A recently completed multicenter trial is evaluating how well MBI screening performs as a supplement to digital breast tomosynthesis among women with dense breasts; preliminary findings suggest that similar gains in cancer detection will be achieved (*9*).

Despite the promising performance of MBI, patient experience during MBI and willingness to undergo the test have yet to be formally evaluated. MBI is thought to offer some comfort advantages relative to other modalities. MBI is performed with the patient in an upright and seated position, thus avoiding claustrophobia or discomfort from lying prone as experienced during MRI. MBI uses lighter breast compression than a mammogram, just enough to stabilize the breast and prevent motion. However, MBI requires an injection of a radiotracer and a much longer time to acquire images than mammography, in which the patient is asked to remain as still as possible for up to 10 min per view acquired. To date, only 1 study has reported on patient comfort during MBI. In a study of 100 patients, a low average pain score (0.8 on a scale of 0–10) suggests MBI to be well tolerated (*10*). However, to our knowledge, no study has yet sought to identify specific sources of discomfort during MBI or reported patients' opinions about their experience.

The purpose of this study was to examine the patient experience of MBI through a survey. We aimed to assess patient comfort level during MBI, to compare MBI comfort with mammography comfort, to identify factors associated with MBI discomfort, and to evaluate patients' willingness to return for future MBI.

MATERIALS AND METHODS

Survey and Data Collection

This Health Insurance Portability and Accountability Act (HIPAA)–compliant study was approved by our Institutional Review Board.

All female patients who had MBI examinations at Mayo Clinic in Rochester, MN, and had provided an e-mail address in their medical record were eligible. The survey was offered to 561 patients who had MBI examinations between August 2022 and December 2022. During this time, a total of 992 patients received MBI examinations; however, the likelihood of survey invitation was dependent on the availability of study staff to send invitations. Those sending invitations had no knowledge of patient characteristics other than the date of MBI. Survey invitations were sent via e-mail as close to the MBI examination date as possible, targeted within 2 d after MBI. No compensation was offered for participation.

The survey comprised 10 questions (provided in the supplemental materials; available at http://jnmt.snmjournals.org), designed to determine whether patients had any preexisting discomfort or pain before MBI; how they rated their comfort level during MBI; any sources of discomfort during MBI; how the comfort of MBI compared with that of mammography; willingness to have MBI in the future and factors that influence willingness; and finally, any other opinions about the MBI examination.

Patients who completed the survey were sent a second e-mail, requesting authorization to use and disclose protected health information, per the HIPAA privacy rule, to permit prospective use of medical record information in the study analysis. Survey responders were defined as those who returned the completed survey and the HIPAA authorization. The following information was collected from responders via record abstraction: age, race and ethnicity, body mass index (BMI) within 1 y of MBI, personal history of breast cancer, history of MBI, and indication for current MBI. Breast density, reported according to the categories of the Breast Imaging Reporting and Data System (American College of Radiology), was obtained, as available, from the most recent mammogram performed before MBI. As a surrogate for breast size, compressed breast thickness during MBI examinations and mammograms was abstracted from the respective right craniocaudal views, or the left craniocaudal view if right craniocaudal was not available.

Nonresponders were defined as those who did not complete the survey or did not provide HIPAA authorization. To assess for response bias, with an institutional review board–approved waiver of consent and waiver of HIPAA authorization, basic demographic information was abstracted from the medical records of nonresponders who previously gave general permission to use medical records for research, per Minnesota Research Authorization.

MBI

The MBI protocol was performed according to practice standards (*11*). Per our local practice, several measures were taken to ease radiotracer injection and increase uptake in breast tissue: the patients were asked to be well hydrated but to avoid calorie intake for 3 h before the MBI appointment time and were briefly wrapped with a warm blanket for 3–5 min before injection.

Certified nuclear medicine technologists with additional training in breast imaging techniques injected the radiotracer, positioned the breasts, and operated the γ-camera as previously described by Swanson et al. (*12*). The patients received an intravenous injection of 296 MBq (8 mCi) of ^{99m}Tc-sestamibi in an antecubital vein. Imaging commenced within a few minutes of injection (average, 2 min; range, 1–10 min). Images were acquired with a dual-head cadmium zinc telluride–based γ-camera dedicated to breast imaging (LumaGEM; CMR Naviscan).

The patients were seated in a mammography chair during imaging, with a pillow placed behind the back for support. Each breast was imaged separately for 2 views (craniocaudal-analogous and mediolateral oblique–analogous positions). To position for imaging, the technologist placed the breast on the lower detector and slowly applied compression by moving the upper detector via a foot pedal, with the intent of immobilizing the breast but not causing painful compression to the breast tissue. The technologist made positioning adjustments as necessary based on patient feedback to optimize comfort before starting imaging. Each acquisition was 10 min, totaling 40 min of acquisition time for a 2-view bilateral examination. The patients were given an option to watch television or use their personal device during the examination.

All 992 patients undergoing MBI during the study period completed the entire examination.

Analysis

The survey sample size was selected to provide sufficient power to detect whether a majority of women (>50%) feel that MBI is more comfortable than mammography. Assuming that at least 60% of women would agree with survey question 5—"MBI is more comfortable than a mammogram"—150 completed surveys would give 80% power to conclude that the result is significantly more than 50% (5% 1-sided type I error rate, 1-sample test for a proportion using a normal approximation). To allow for the possibility of missing data and secondary analyses, we aimed to collect at least 200 completed surveys.

Potential response bias was assessed by comparing the demographic characteristics (age, BMI within 1 y of MBI examination, race, and ethnicity) of the survey responders and nonresponders using χ^2 tests for categorical characteristics and 2-sample *t* tests for age and BMI. A 1-sample test for a proportion (normal approximation) was used to determine whether the observed proportion of women who said MBI is more comfortable than mammography was significantly greater than 0.50, and the observed percentage was reported along with a 95% CI. Free-text answers to open questions were grouped by theme and examined for trends, and the percentage answering within each theme was summarized using the total number of survey respondents as the denominator (n = 209). Associations between comfort ratings and patient factors of interest were examined with χ^2 or Fisher exact tests for categorical data and with ANOVA or Kruskal–Wallis tests for continuous or ordinal data (as appropriate). Compressed breast thickness was compared between MBI and mammography with a paired *t* test. *P* values of less than 0.05 were considered statistically significant. Analyses were conducted using SAS version 9.4 (SAS Institute Inc.), and figures were generated using R version 4.2.2.

RESULTS

Participant Characteristics

Of 561 patients who were sent an e-mail invitation, 209 (37%) completed both the survey and the HIPAA authorization (the analysis set), and 352 (63%) either did not complete the survey or did not complete the HIPAA authorization (Fig. 1). Among the 352 nonresponders, 316 did not respond or had an incomplete survey and 36 completed the survey but did not provide HIPAA authorization. Demographic data were available for 323 nonresponders per general consent for research via Minnesota Research Authorization. Responders and nonresponders did not differ significantly with respect to age, race/ethnicity, or BMI (all $P > 0.05$).

The median time from MBI to survey response was 5.2 d (SD, 4.5 d; range, 0–29 d). Two hundred of 209 (96%) responders completed the survey within 14 d of MBI.

The characteristics of the responders are given in Table 1. All were female, with average age of 60.1 y (range, 40–81 y). Of the 209 responders, 195 (94%) had dense breast tissue (Breast Imaging Reporting and Data System C [heterogeneously dense] or D [extremely dense] density) and 46 (22%) had a personal history of breast cancer. Forty-one of 209 (20%) responders were having MBI as part of a research trial evaluating the performance of MBI screening in women with dense breasts (*13*), whereas 168 (80%) had a clinically ordered MBI. The MBI indication was categorized as a screening examination in 202 of 209 (97%) responders, including screening as a supplement to mammography in 201 (due to dense breasts [n = 143], dense

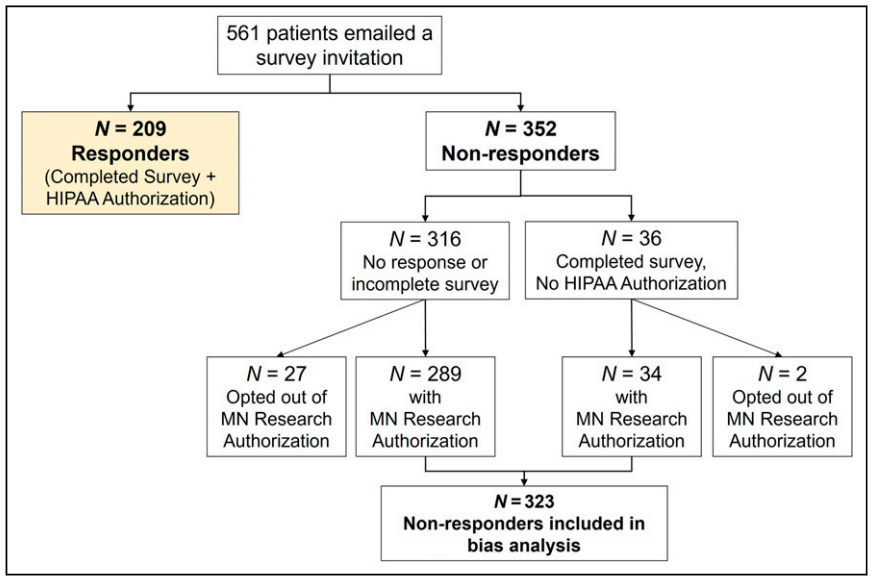

FIGURE 1. Flowchart of survey responders and nonresponders. MN = Minnesota.

TABLE 1
Characteristics of Survey Responders (n = 209)

Characteristic	Value
Age	
Mean ± SD (y)	60.1 ± 10.5
Median (y)	61.1 (range, 40–81)
Category (n)	
40–49 y	44 (21%)
50–59 y	54 (26%)
60–69 y	69 (33%)
≥70 y	42 (20%)
Race (n); n = 207	
White	197 (95%)
Black or African American	2 (1%)
Asian	8 (4%)
American Indian/Alaskan Native	0
Native Hawaiian/Pacific Islander	0
Ethnicity (n); n = 206	
Hispanic or Latino	5 (2%)
Not Hispanic or Latino	201 (98%)
BMI category (n); n = 198	
<18.5 kg/m^2	5 (3%)
18.5 to <25 kg/m^2	99 (50%)
25 to <30 kg/m^2 (overweight)	62 (31%)
≥30 kg/m^2 (obese)	32 (16%)
Menopausal status	
Premenopausal	54 (26%)
Postmenopausal	143 (68%)
Unknown	12 (6%)
Personal history of breast cancer (n)	46 (22%)
MBI history* (n)	
First-time MBI	76 (36%)
At least 1 prior MBI	133 (64%)
MBI indication	
Screening	202 (97%)
Diagnostic	7 (3%)
Breast Imaging Reporting and Data System breast density (n); n = 208	
A: Almost entirely fat	1 (<1%)
B: Scattered fibroglandular densities	12 (6%)
C: Heterogeneously dense	156 (75%)
D: Extremely dense	39 (19%)
MBI compressed thickness on craniocaudal view; n = 208†	
Mean ± SD (cm)	5.9 ± 1.5
Median (cm)	6.1 (range, 1.3–9.3)
Category (n)	
<4 cm	19 (9%)
4–8 cm	176 (85%)
>8 cm	13 (6%)
Mammography compressed thickness on craniocaudal view (cm); n = 204†	
Mean	5.4 ± 1.4
Median	5.4 (range, 1.6–9.1)

*History of prior MBI was obtained from survey question 1 for 208 responders and verified via medical record review for 1 responder with missing response to survey question 1.

†Reported for all available data. Among 203 patients with compressed thickness available for both MBI and mammography, mean thickness was 5.9 cm (SD, 1.5) for MBI and 5.3 cm (SD, 1.4) for mammography.

breasts and elevated risk [n = 50], or elevated risk only [n = 8]) and primary screening in 1 patient who refused mammography. MBI was performed for a diagnostic indication in 7 of 209 (3%) responders, including short-interval follow-up of a finding on prior MBI (n = 6) and evaluation of a palpable concern in 1 patient who was unable to tolerate mammography.

Although the compressed breast thickness on MBI was significantly higher than on mammography (n = 203 patients with available data on both), the magnitude of the difference was not clinically meaningful. The average thickness of craniocaudal views on mammography was 5.3 cm (SD, 1.4 cm), versus 5.9 cm (SD, 1.5 cm) on MBI (average difference, 0.6 cm; 95% CI, 0.5–0.7; P < 0.001).

Comparison of MBI and Mammography Comfort

When asked to compare the comfort of MBI with that of mammography (applicable to 208 of 209 responders indicating a previous mammogram), a significant (P < 0.001) majority, 148 of 208 (71%; 95% CI, 65%–77%), said MBI was more comfortable than mammography; 41 (20%) said they were about the same; and 19 (9%) said mammography was more comfortable than MBI. Of note, the median time between MBI and the most recent mammogram before MBI was 1 d (reflecting typical practice at the clinic, to schedule both procedures close together).

MBI Comfort Ratings

When asked to rate comfort during MBI on a 7-point scale, with 1 indicating extremely comfortable and 7 indicating extremely uncomfortable, the average rating was 2.9 (SD, 1.5; median, 3.0). The distribution of comfort ratings is depicted in Figure 2.

Table 2 shows the grouped comfort rating categories of comfortable (rating, 1–3), neither comfortable nor uncomfortable (rating, 4), or uncomfortable (rating, 5–7) by patient characteristics. Of 209 responders, 76 (36%) were having a first-time MBI, whereas 133 (64%) had a history

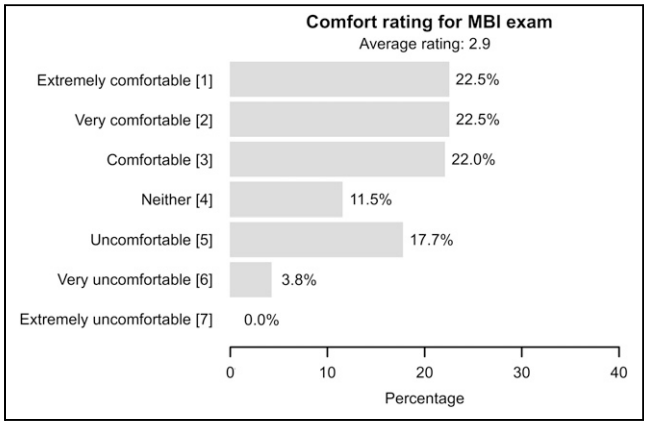

FIGURE 2. Distribution of ratings for comfort during MBI, on 7-point scale. Responses ranged from 1 (zero discomfort during examination) to 7 (so uncomfortable that patient had difficulty completing examination).

TABLE 2
Grouped MBI Comfort Ratings, Overall and by Patient Characteristics, in Answer to Survey Question 4 ("During This Recent MBI Examination, How Comfortable Were You on Scale of 1 to 7?")

Parameter	Total	Comfortable (rating, 1–3)	Neither comfortable nor uncomfortable (rating, 4)	Uncomfortable (rating, 5–7)	*P*
All responders (*n*)	209	140 (67%)	24 (12%)	45 (22%)	—
Age (*n*)					
<55 y	68	36 (53%)	14 (21%)	18 (27%)	0.003
≥55 y	141	104 (74%)	10 (7%)	27 (19%)	
Mean ± SD (y)	209	61.5 ± 10.4	54.7 ± 10.1	58.7 ± 10.2	0.008
BMI (*n*)					
<25 kg/m^2	104	63 (61%)	15 (14%)	26 (25%)	0.19
25 to <30 kg/m^2	62	41 (66%)	5 (8%)	16 (26%)	
≥30 kg/m^2	32	26 (81%)	3 (9%)	3 (9%)	
Mean ± SD (kg/m^2)	196	26.1 ± 4.9	24.7 ± 5.5	24.5 ± 3.8	0.14
Compressed breast thickness on MBI, craniocaudal view (*n*)					
<4 cm	19	11 (58%)	3 (16%)	5 (26%)	0.72
4–8 cm	176	121 (69%)	19 (11%)	36 (21%)	
>8 cm	13	8 (62%)	1 (8%)	4 (31%)	
Mean ± SD (cm)	208	6.1 ± 1.4	5.5 ± 1.8	5.7 ± 1.5	0.11
Reported preexisting pain (*n*)					0.66
No	192	130 (68%)	21 (11%)	41 (21%)	
Yes	17	10 (59%)	3 (18%)	4 (24%)	
MBI history (*n*)					0.006
At least 1 prior MBI	133	94 (71%)	19 (14%)	20 (15%)	
First-time MBI	76	46 (61%)	5 (7%)	25 (33%)	

of at least 1 prior MBI. Those with a prior MBI were more likely to rate the procedure as comfortable than those having MBI for the first time (71% vs. 61%, respectively; $P = 0.006$). Older patients were more likely to rate the MBI as comfortable than younger patients (74% vs. 53% for age > =55 y vs. < 55 y, respectively; $P = 0.003$). The comfort rating did not differ significantly by BMI or compressed breast thickness (Table 2).

Preexisting pain before MBI was reported by 17 of 209 responders (8%) in response to survey question 2. Preexisting pain was in the breast ($n = 10$), lower back ($n = 2$), shoulder ($n = 2$), ribs ($n = 1$), or underarm ($n = 1$) or was described as general pain with no specific location ($n = 1$). Preexisting pain did not differ significantly by reported comfort level (Table 2).

When given the opportunity to describe any discomfort or pain experienced during the MBI examination (survey questions 5 and 10), 64 of 209 (31%) responders provided comments mentioning at least 1 factor causing discomfort. Of these 64, 20 (30%) still rated their overall comfort during MBI as either 2 (very comfortable, $n = 12$) or 3 (comfortable, $n = 8$). Discomfort experienced during MBI was most attributed to breast compression ($n = 16$), back or neck discomfort ($n = 14$), and maintaining position during MBI ($n = 14$). Categorized comments pertaining to discomfort are listed in Table 3. Of the 14 responders who commented on back or neck discomfort during MBI,

TABLE 3
Location and Type of Discomfort During MBI

Source of discomfort	*n*
Breast compression	16 (8%)
Back or neck discomfort	14 (7%)
Maintaining position for duration of examination	14 (7%)
Pressure on chest wall or ribs	8 (4%)
Temporary discomfort during positioning	7 (3%)
Detector edges in contact with underarms or axilla	5 (2%)
Skin pulling	4 (2%)
Difficulty breathing normally	4 (2%)
Uncomfortable chair	3 (1%)
Lack of place to rest chin	3 (1%)
Lack of place to rest arms	2 (1%)
Intravenous injection	2 (1%)
Wearing of face mask*	2 (1%)
Face in contact with camera	1 (1%)
Shoulder pain	1 (1%)
Knees straddling gantry	1 (1%)

*Masking requirements due to coronavirus disease 2019 pandemic were in place during study period.

Of 209 total survey responders, 64 women provided at least 1 comment on discomfort of procedure. Responders may have commented on multiple factors of discomfort. Sources of discomfort were abstracted from free text responses to survey questions 5 and 10.

5 additionally mentioned preexisting issues with back discomfort before presenting for the MBI examination.

Willingness to Have MBI

Of 202 women who responded to question 7—"Would you be willing to have another MBI examination in the future?"—196 (97%) answered "Yes," 5 (2.5%) answered "Not sure," and 1 (0.5%) answered "No." Of the 202 responders to this question, all 129 (100%) of those who had a prior MBI answered "Yes," compared with 67 of 73 (92%) of those having a first-time MBI ($P = 0.002$). Among the 6 first-time MBI patients not answering "Yes," most (5) were "Not sure," whereas only 1 said "No" regarding willingness for a future MBI.

Reasons that influence wanting and not wanting MBI in the future, as offered to 209 responders in survey questions 8 and 9, are depicted in Figure 3. Reasons selected for wanting a future MBI included additional screening for dense breasts ($n = 194$, 93%); recommendation by a health care provider ($n = 126$, 60%); additional screening for high risk of breast cancer ($n = 53$, 25%); and insurance payment for some or all of the MBI cost ($n = 55$, 26%). Other reasons for wanting a future MBI were entered as free text: "MBI discovered my breast cancer when mammogram did not" and "Mammogram sets off my lymphedema; MBI doesn't." Reasons selected for not wanting a future MBI included concern about the cost ($n = 38$, 18%); concern about radiation (28, 13%); the long duration of the examination (22, 11%); the discomfort of the examination (13, 6%); and not wanting to have an injection (9, 4%). Beyond these reasons, 1 responder specified "inconvenient location" as a reason for not wanting a future MBI.

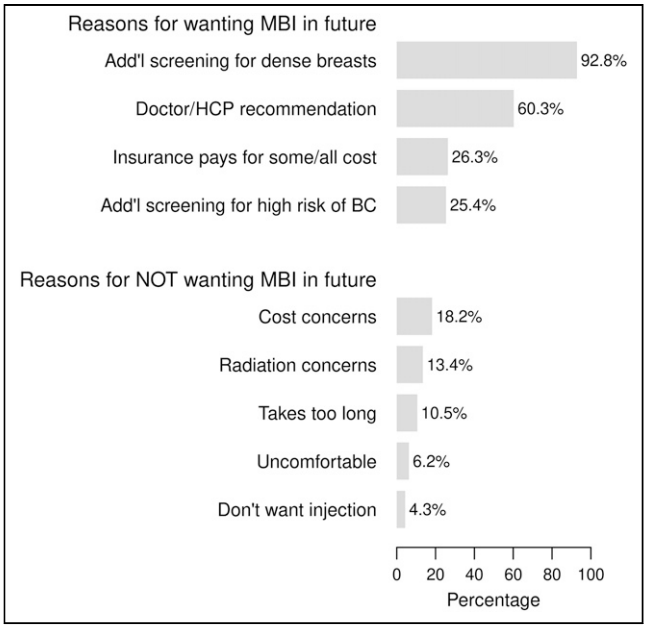

FIGURE 3. Reasons for wanting or not wanting to have future MBI. Percentages are from total of 209 survey responders. Responders may have given multiple reasons for both wanting and not wanting MBI in future. BC = breast cancer; HCP = health care practitioner.

Additional Opinions

Responses to the final survey question, which allowed responders to provide any other free-text opinions about the MBI examination, were provided by 26 of 209 (12%) survey responders. Select comments are listed in Table 4. One theme that emerged from the additional opinions was patient appreciation for the MBI technologists, with 10 responders expressing that the technologist did a good job or made the MBI more comfortable. Seven responders expressed that the MBI was comfortable, and 5 responders mentioned liking being able to watch television during the examination.

DISCUSSION

In this survey of MBI patients, we found that overall, most patients had a comfortable experience during MBI. Comfort level ratings showed 78% of responders thought the MBI was extremely comfortable, very comfortable, comfortable, or a neutral category of "neither comfortable nor uncomfortable." Additionally, 71% of responders stated MBI was more comfortable than mammography. However, 22% of patients gave MBI a rating of uncomfortable or very uncomfortable, suggesting some opportunities to improve patient comfort. Despite these reports of discomfort, 97% of responders indicated they would be willing to have an MBI in the future, with 93% wanting MBI as an additional screening test for dense breasts.

Survey responses identified specific factors that caused discomfort during the MBI, some of which may be addressed through modifications to the MBI system. For instance, rounded detector edges, arm and chin rests, and a modified gantry with room for patient legs would solve some ergonomic issues that were mentioned by responders and are well known to our team of technologists as a limitation of the current system. Survey results reinforced the importance of positioning the patient with her back well supported in the chair, using pillows for additional support (*12*). Some responders stated they felt some temporary discomfort during MBI but that the technologist was able make adjustments, such as repositioning the breast or providing additional back support, so the patient was more comfortable. These responses confirm our practice of seeking feedback from the patient both after initial breast compression and throughout the examination.

Breast compression was mentioned as a primary source of discomfort among 8% of responders. For some patients, any amount of compression to sensitive breast tissue may cause discomfort. MBI does not require the same magnitude of compression force as in mammography, as the 140-keV

TABLE 4
Selected Free-Text Responses to Survey Question 10 ("If You Have Other Opinions About Your Recent MBI Examination, Please Share Them Here")

Experience	Comment
Positive	It is very comfortable, and wonderful to have the television distraction.
	MBI is pretty easy; you get to sit and watch television while the examination is going on. I don't mind having it done at all. With dense breast I like having additional screening done.
	Staff was pleasant and did great job during examination and in trying to make me as comfortable as possible during examination.
	Last MBI scan was so comfortable, I almost fell asleep.
	Overall good experience. Appreciated warm blanket and back support with pillow. Nice to have television. Excellent tech.
	I want to commend the young woman who was tasked with positioning me for this test. She was very sensitive to my comfort, apologized for all the maneuvering but was thorough in her work. She did a great job!
	I felt nuclear medicine tech was courteous, did a nice job of instructing me as to what she needed from me for positioning, etc., was responsive to my questions about the procedure and tracer, and interacted with me in an interested, positive manner.
	I liked it better than a mammogram.
	It was great. I would gladly stop doing mammograms if that was an option and replace it with MBI.
Mixed	Examination was slightly uncomfortable but very manageable. Person who did it made experience comfortable.
	I would still get these examinations even though they are uncomfortable because I value the outcome of these examinations in health prevention.
	I believe any discomfort I had was due to length of time sitting still during examination. Being able to stretch a little helped.
	Length of compression is worst part, because tightness is less than regular mammogram. Technician was very good, respectful, and compassionate. Some of the discomfort is due to the masking requirements, as it is difficult to breathe when you're jammed against a machine with your breast squeezed for 10 min at time! Television was a huge help in passing time—great idea.
	Compression from MBI was fine; it was the chair that was uncomfortable and the time involved in an awkward position; to have a place to rest your head would help. Otherwise, no complaints. The television was nice.
Negative	I recommend ordering chairs that move more easily for technologists. It seemed like an athletic feat for them to position me correctly. I felt bad for all of their twisting, pushing, and propping.

γ-rays are more penetrating than a mammogram's low-energy x-rays in breast tissue and not attenuated by dense fibroglandular tissue. MBI compression force is not routinely measured in existing equipment but has been estimated to be approximately 67 N (15 pound-force) (*10*), compared with 170 N (28 pound-force) typically applied in screening mammography. However, because MBI has longer imaging times of up to 10 min per view, the technologist still must apply enough compression to keep the breast immobilized for the entire acquisition. This requirement for MBI compression may explain why we found compressed breast thickness with MBI to be only 0.6 cm greater, on average, than that with mammography.

Discomfort during MBI was specifically attributed to maintaining position for the duration of the examination by 7% of responders. Several other factors contributing to MBI discomfort (i.e., back or neck discomfort, detector edges contacting underarms or axilla, difficulty breathing normally) could likely be lessened if the duration of the MBI examination were shorter. Work under way to perform denoising of MBI acquisitions has shown promise in allowing shorter acquisition times, lower radiation doses, or both, while maintaining similar image quality to 10-min views (*14*). Other work on novel detector designs for MBI may also provide faster imaging times and lower radiation doses in the future (*15*).

A limitation of this study was that by surveying women who had recently completed MBI, we captured opinions from only those who had already decided to undergo MBI. Thus, this survey was not able to collect opinions about MBI from women who may have previously had a negative experience with MBI and declined subsequent MBI screening because of comfort issues or other reasons. However, among those surveyed who were having a first-time MBI, 92% were willing to return for another MBI in the future. Another limitation was that we were required to exclude women ($n = 36$) who had completed the survey but did not provide study-specific consent via HIPAA authorization to use their responses and medical record information; therefore, it is unknown whether the experience of these patients with MBI was similar to that of the 209 responders who did provide consent. We also recognize that our study sample comprised nearly all white (95%) and non-Hispanic (98%) women, which may limit the generalizability of our results to women of other races and ethnicities.

A strength of this study was the survey response rate. The response rate of 37% is consistent with or better than that of other imaging experience surveys that have contacted patients via e-mail invitation (*16*,*17*). Survey response was also timely. with the median time from MBI to response being 5.2 d. We assessed for potential response bias and found no difference in age, race and ethnicity, or BMI between responders and nonresponders.

A strength of our survey design was that in addition to multiple-choice responses, we included collection of free-text opinions that led to additional insights about the patient experience during MBI.

Although we did not specifically solicit opinions about the MBI technologist, when given the opportunity to share other opinions about MBI, several patients expressed a positive interaction with the technologist and appreciation for the technologist's efforts to make the examination more comfortable. These findings underscore the critical role of technologist in patient experience of MBI, which is unique among nuclear medicine tests. In MBI, the technologist physically maneuvers the patient's body and handles the breasts to optimize positioning on the camera. The MBI technologist also remains in the room near the patient for approximately 40 min of imaging time. Thus, the technologist's abilities to establish trust, converse appropriately, and keep the patient comfortable during this time may have the greatest impact on the overall patient experience during MBI.

CONCLUSION

Most survey responders thought the MBI examination was comfortable, even more so than mammography. Despite some complaints of discomfort, nearly all participants were willing to have MBI in the future. The survey results identified opportunities to improve MBI patient comfort such as providing back support and soliciting feedback from the patient throughout the examination to address discomfort as much as possible. Future modifications to the MBI gantry and implementation of new tools to decrease the examination length are likely to improve patient comfort and the overall experience with MBI.

DISCLOSURE

Financial support for this work was provided by Mayo Clinic Foundation and National Institutes of Health grant R01CA239200. Carrie Hruska and Michael O'Connor receive royalties for technologies licensed to CMR Naviscan, a manufacturer of MBI systems; Katie Hunt has rights to receive future royalties from the licensing of a device, product, or technology from CMR Naviscan. No other potential conflict of interest relevant to this article was reported.

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KEY POINTS

QUESTION: What do patients experience during an MBI examination?

PERTINENT FINDINGS: Most survey responders indicated that MBI is a comfortable test and that MBI is more comfortable than mammography. Despite some reports of discomfort, 97% of survey responders stated that they would be willing to have a future MBI.

IMPLICATIONS FOR PATIENT CARE: Key targets to improve patient comfort include technologist intervention to ensure proper patient positioning, possible modifications to the MBI system ergonomics, and future strategies to reduce acquisition time.

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