Egyptian Journal of Radiology and Nuclear Medicine

RESEARCH

Open Access

Breast edema score at breast MRI: its value in prediction of molecular subtype of breast cancer and its impact on axillary LN metastasis

Ebtsam Ahmed Mohammed Abdelbary[1*], Amal Rayan Ibrahim[2], Khalid Mohammad Rezk[3] and Nagham Nabil Omar[4]

Abstract

Background Since many newly diagnosed breast cancer patients have breast MRI, the value of preoperative breast magnetic resonance imaging would improve if molecular subtypes could be consistently identified, and prognostic information provided in addition to diagnostic imaging. Breast edema may improve the ability to predict molecular subtypes and clinical and pathological outcomes in invasive breast cancer patients. The prognosis for breast cancer prognosis based on the findings of breast edema by magnetic resonance imaging will be useful in both pretreatment planning and prognosis. Breast edema on T2-weighted images and STIR was scored on a scale of 1 to 4, as follows: (a) breast edema score (BES) 1, no edema; (b) BES 2, peritumoral edema; (c) BES 3, pre pectoral edema; and (d) BES 4, subcutaneous edema (suspicious for occult inflammatory breast cancer "IBC"). Axillary lymph node status and number were also evaluated in T2 and STIR and after contrast administration. The aim of this work was to assess the role of tumour-related breast edema MRI features in distinguishing molecular subtypes of breast cancer and its effect on pathological axillary lymph nodes in patients with breast cancer.

Results There was a highly significant difference between BES with respect to the molecular subtypes of breast cancer, size of the mass, Ki-67 expression, LN status, and LN number ($p < 0.0001$, 0.045, < 0.0001, < 0.0001, and < 0.0001 respectively). However, there was no significant difference between BES and histopathological grade in studied masses, such as p-value = 0.49.

Conclusions Tumour-related breast edema MRI characteristics may be useful in distinguishing molecular subtypes of breast cancer and could be used as a promising feature to improve the predictive performance of pathological axillary lymph nodes in patients with breast cancer, contributing to preoperative treatment planning and prognostic outcome.

Keywords MRI, Breast edema, Luminal A, Luminal B, HER2+, Triple negative

*Correspondence:
Ebtsam Ahmed Mohammed Abdelbary
ebtsamabdelbary@gmail.com
Full list of author information is available at the end of the article

Springer Open

© The Author(s) 2024. **Open Access** This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit http://creativecommons.org/licenses/by/4.0/.

Background

Breast cancer (BC) is a complex disease with various symptoms, histological types, and molecular subtypes [1, 2]. It is essential to adequately characterise the characteristics of BC, since these varied characteristics can result in different responses for each patient. BC was the most diagnosed cancer in 2020, accounting for 2.3 million new cases worldwide (11.7%) [3].

Using genotype–phenotype classification, invasive breast cancer is divided into four subtypes based on immunohistochemistry (IHC) of several molecular markers, such as the estrogen receptor (ER), progesterone receptor (PR), human epidermal growth factor receptor-2 (HER2), and Ki-67 index: (1) luminal A; (2) luminal B (HER2 negative or HER2 positive); (3) HER2-enriched; and (4) triple-negative (TN) [4].

Breast edema on T2-weighted images was graded on a scale of 1 to 4, as follows: (a) no edema (BES 1); (b) peritumoral edema (BES 2); (c) pre pectoral edema (BES 3); and (d) subcutaneous edema (BES 4) (suspicious for occult IBC) [5].

Breast edema is a prognostic factor for breast cancer and is attributed to lymphovascular invasion (LVI), lymph node metastases, and histological grade [6, 7].

Peritumoral edema detected on T2-weighted breast MRI has been considered one of the crucial indicators of invasive breast cancer prognosis [8, 9]. In addition, as a higher grade of breast edema, pre-pectoral and subcutaneous breast edemas are related to extensive lymphovascular invasion and poorer prognosis in breast cancer patients [5, 10]. Several studies have also found that individuals with breast cancer who have peritumoral edema had a greater frequency of axillary LN involvement [11].

Pathogenic processes explaining the imaging features of breast-associated edema are unidentified. Research studies have suggested that tumour angiogenesis, increased vascular permeability, and lymphatic drainage defects may induce regional or diffuse edema around the tumour [7, 10, 12]. Additionally, increasing hyaluronic acid levels, which is an extracellular glycosaminoglycan implicated in tumour growth, may cause peritumoral stromal tissue hydration and higher T2 signals in cases of breast cancer [13, 14]. BES has a favourable relationship with clinicopathological variables. Moderate and severe edemas (BES 3 and 4) were attributed to invasive clinicopathological features such as a higher clinical T stage, a higher Ki-67 index, HER2-positive and triple-negative subtypes, and positive lymphovascular invasion (LVI). Histopathological findings such as lymphovascular invasion, vessel ectasia, and stromal fibrosis are all involved in peritumoral edema [15]. Some studies also found that edema-related breast tumours were more common in Non luminal subtypes, tumours with high Ki-67 levels, and larger tumours [16].

The work aimed to assess the role of tumour-related breast edema MRI features in distinguishing molecular subtypes of breast cancer and its effect on pathological axillary lymph nodes in patients with breast cancer, which valuably helps in preoperative treatment planning and prognosis.

Methods

It was a retrospective study of a 2-year duration which was conducted at the diagnostic and interventional radiology department, on 60 patients presented by 169 masses, the mean SD for patient age was 46.3 ± 10.8 years old, 66 lesions (39.1%) were Luminal A, 37 lesions (21.9%) were` Luminal B, 30 lesions (17.7%) were HER2+, and 36 lesions (21.3%) were TN. The protocol was reviewed and approved by the Medical Ethics Committee. IRP local approval number: 04-2023-300141. The inclusion criteria were the patients diagnosed with breast cancer who had complete medical records, including MRI and biopsy with histopathology and immunohistochemistry. Exclusion criteria include patients who received neoadjuvant therapy and patients who have incomplete medical records.

MR imaging studies were performed on a 1.5 T scanner (Sempra, Siemens, Erlangen, Germany). The patient was placed in the prone position with both breasts placed adequately in a double breast coil (four-channel phased array coil), MRI sequences were: 1. Axial T1WI. 2. Axial T2WI. 3. Axial STIR. 4. DCE-MRI with post-processing subtraction images.

MRI acquisition protocol

MRI protocols include Axial T2-weighted fast spin echo sequence: TR = 3840 ms, TE = 81 ms, slice thickness = 3.5 mm, and matrix = 448 × 448.

Coronal T2-weighted fast spin echo sequence: TR = 3840 ms, TE = 81 ms, slice thickness = 3.5 mm, and matrix = 448 × 448.

Short tau inversion recovery – axial: TR = 8540 ms, TE = 59 ms, TI = 170 ms, slice thickness = 3.5 mm, and matrix = 320 × 314.4.

The standard dynamic protocol commenced with a coronal three-dimensional rapid field echo (thrive) sense non-enhanced T1-weighted sequence. A gadolinium-containing contrast was administered at a dose of 0.2 ml/kg by power injection at a speed of 2.0 ml/s and flushed with 20 ml of saline solution at the same rate. Dynamic imaging was then done in five consecutive series at 90-s intervals. Standard subtraction images were obtained by subtracting precontrast images from the early peak post-contrast image.

MRI analysis

The images were retrieved for all patients from the picture archiving and communication systems (PACS) and read by two breast radiologists (with > 10 and > 15 years of experience). Both radiologists were blinded to the pathological results. The images were analysed as follows: The largest diameter in the maximum cross section of an axial T1 Gd-enhanced MRI was used to quantify tumour size (by mm). We used a T2-weighted sequence and Gd-enhanced MRI to assess breast edema, which was defined as an area with high signal intensity on a T2-weighted sequence without enhancement to indicate breast edema.

Breast edema was classified into four categories based on the findings on T2-weighted and STIR sequences, as follows: (a) breast edema score (BES) 1, no edema; (b) BES 2, peritumoral edema; (c) BES 3, prepectoral edema; and (d) BES 4, subcutaneous edema (suspicious for occult IBC). On MRI, the axillary LN status was assessed; L.Ns with a round or irregular outline, cortical thickness greater than 3 mm, and lack of a fatty hilum were considered suspicious of metastasis. The axillary LN status was classified as positive (presence of at least one suspicious LN) or negative (no suspicious L.Ns). The cutoff value for the number of suspicious lymph nodes to assess axillary LN burden (pALN) was 3 L.Ns, i.e.: Metastatic axillary LNs < 3 in number are considered low axillary LN burden (pALN), while metastatic axillary LNs > 3 in number are considered high pALN. Also, some patients had an axillary nodal mass, so whether there was a nodal mass or not.

Surgical procedures

All preoperative metastatic examinations were performed on all patients treated in this study. The suitable procedure involves either modified radical mastectomy, breast conservative mastectomy, oncoplastic breast surgery and some patients with negative or low suspicious axillary LN metastasis by preoperative MRI undergo sentinel LN Biopsy.

Pathological analysis

Histologic grade, Ki-67 index, estrogen receptor (ER) status, progesterone receptor (PR) status, and human epidermal growth factor receptor 2 (HER2) status were all collected for study. We set the Ki-67 index cut-off at 20%. The biopsy samples were tested for ER, PR, and HER2 status using histopathological immunohistochemistry (IHC) in the pathology department, and fluorescence in situ hybridisation testing was required when the HER2 status was equivocal (2+). The molecular subtype was determined using the 2013 St. Gallen International Breast Cancer Conference classification.

Statistical analysis

Data were analysed using SPSS version 26 (Statistical Software package version 26). A descriptive analysis was performed. Quantitative data was represented as mean, standard deviation, median, and range. Qualitative data is reported as frequencies and percentages. Categorical data was analysed using the Chi-square test and Kruskal–Wallis test to compare groups with nonparametric independent variables. Graphs were produced using Excel or SPSS version 26. The *p*-value was considered significant if it was less than 0.05.

Results

The study was carried out on 60 patients presented with 169 masses. The mean ± SD for the patient's age was 46.3 ± 10.8 years old, 66 lesions (39.1%) were luminal A, 37 lesions (21.9%) were luminal B, 30 lesions (17.7%) were HER2 + , and 36 lesions (21.3%) were TN.

There was a highly significant difference between BES and molecular subtypes of breast cancer in studied masses as a *p*-value < 0.0001; Table 1.

There was a highly significant difference between BES in terms of molecular subtypes of breast cancer ($p < 0.0001$); Fig. 1, BES 2; was seen more frequently in the

Table 1 Correlation between BES and molecular subtypes of breast cancer in studied masses (n = 169)

	Breast Edema Score (BES)				Total	*p* value
	BES 1	BES 2	BES 3	BES 4		
Molecular subtypes						
Luminal A	6	25	20	15	66	< 0.0001*
Luminal B	0	10	12	15	37	
HER 2	4	25	0	1	30	
Triple Negative	0	10	5	21	36	
Total	10	70	37	52	169	

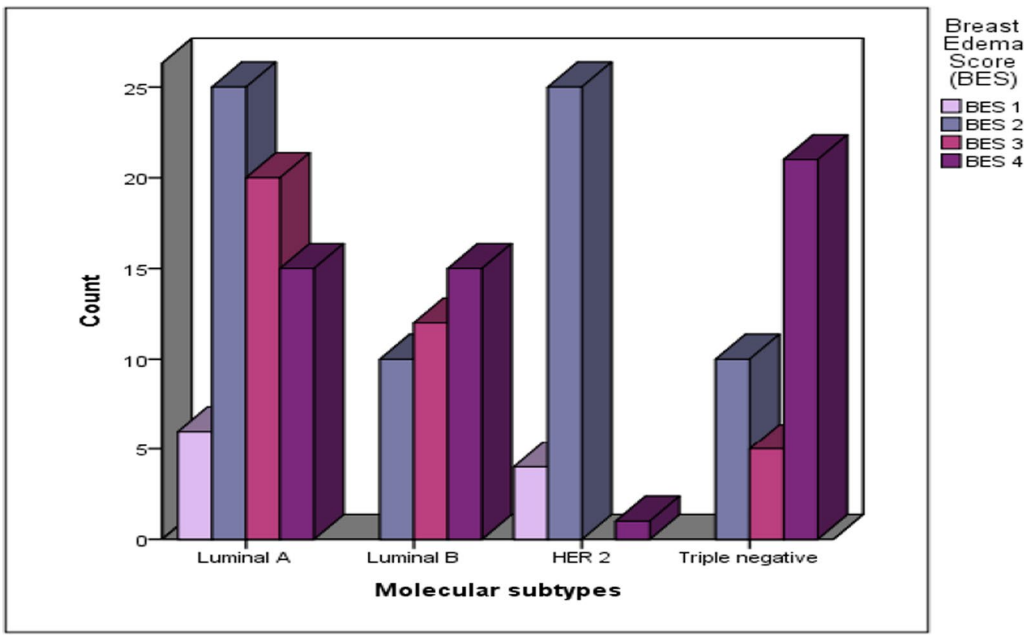

Fig. 1 A bar graph shows the correlation between BES and molecular subtypes of breast cancer in studied masses (n = 169)

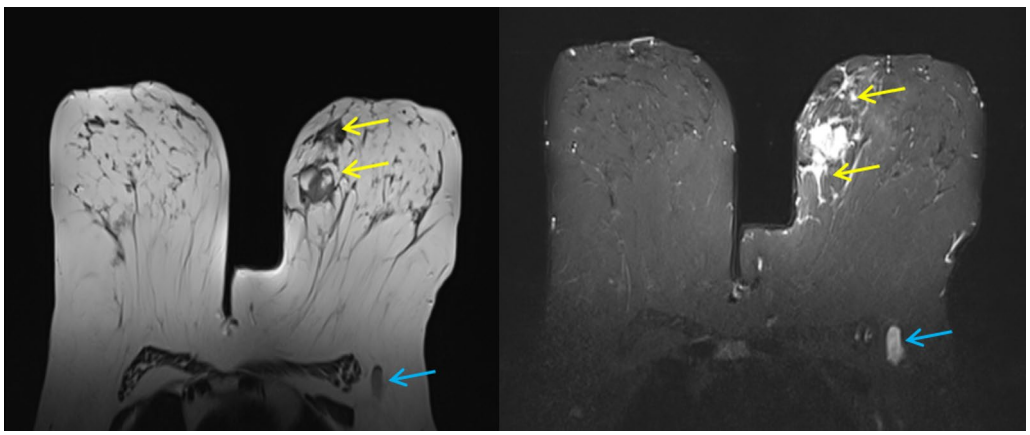

Fig. 2 A 59-year-old patient with left breast IDC-NST, immunohistochemistry revealed negative ER and PR, positive HER-2 with a high Ki-67 level indicative of HER-2 breast cancer. Axial T2-WI and STIR show left multifocal masses with perilesional edema (BES 2), yellow arrow, with ipsilateral suspicious axillary L. Ns, blue arrow

HER2 + subtype in 25 masses (83.3% of HER2 + masses); Fig. 2, while BES 4; was seen more in the TN subtype in 21 masses (58.3% of TN masses); Fig. 3, followed by the luminal B subtype (40.5% of LB masses), which was found to be the most predominant type of edema among luminal B masses. BES 1 is not found at all in both luminal B and TN subtypes, indicating that these two subtypes must have breast edema regardless of their score.

There was a significant difference between BES and the mass size in the masses studied as *p*-value = 0.045.

There was a significant difference between BES as regards tumour size; larger masses are noted to be associated with the highest score of breast edema (BES 4); Fig. 4. The mean size associated with BES 4 was 22.7 ± 18 mm, while the mean size associated with BES 1 was 10.9 ± 6.4 mm; Table 2. A larger tumour size was found in TNBC, therefore associated with the highest BES, Fig. 5 & smaller mass associated with BES 2, Fig. 6.

There was no significant difference between BES and histopathological grade in the masses studied as *p* value = 0.49; Table 3.

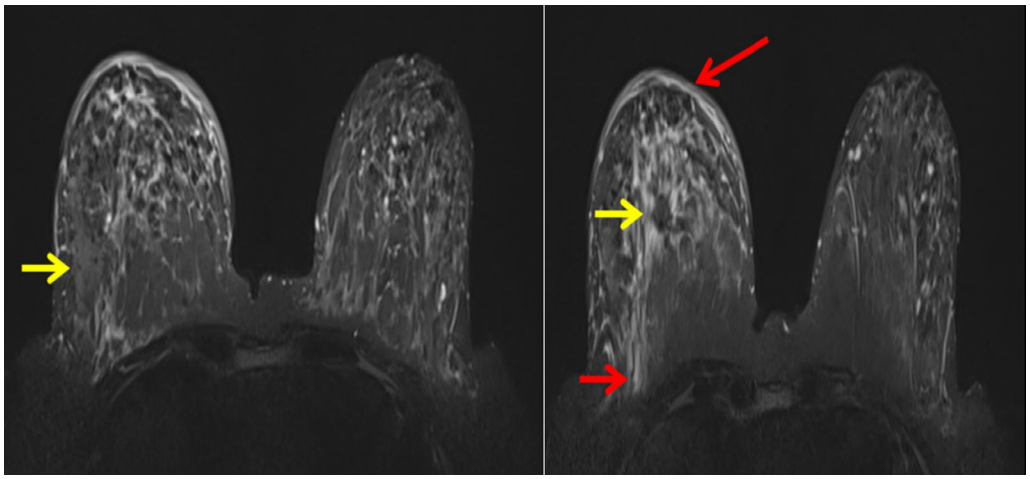

Fig. 3 A 50-year-old female patient with right breast IDC-NST, Immunohistochemistry revealed negative ER, PR, and HER-2 with high Ki-67 levels indicative of triple-negative breast cancer. Axial STIR shows the masses, yellow arrows, perilesional breast edema, pre-pectoral edema and extends to the SC region (BES 4), red arrows

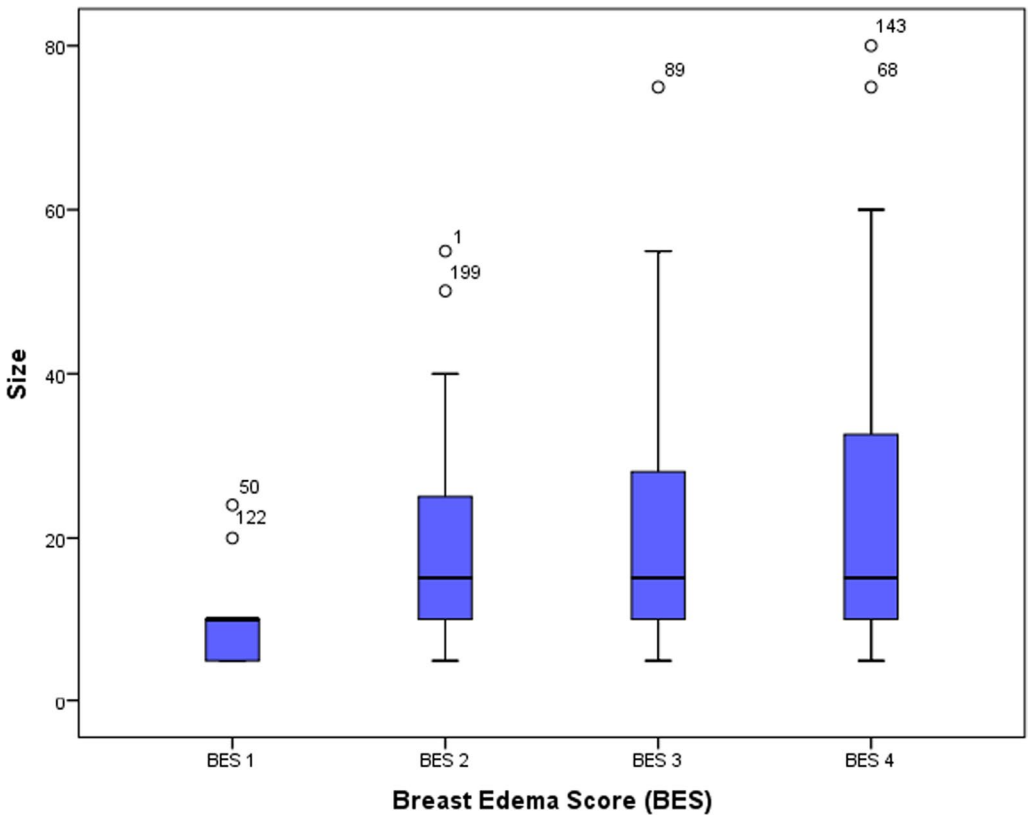

Fig. 4 A box plot graph shows a comparison between BES and tumour size (in mm) in the masses studied masses (n = 169)

There was a highly significant difference between BES and Ki-67 in the masses studied with a p value < 0.0001.

There was a highly significant difference between BES with respect to Ki-67 expression ($p < 0.0001$); Table 4, about 43% of tumours with low ki-67 expression show BES 2. Collectively BES 1 and BES 2 represent about 55.7% of total masses with low Ki-67 expression. While 60.3% of total masses with high Ki-67 show higher scores

Table 2 Comparison between BES and tumour size (in mm) in studied masses (n = 169)

Breast Edema Score (BES)	N	Mean ± SD (mm)	*p* value
Size			
BES 1	10	10.9 ± 6.4	0.045*
BES 2	70	17 ± 11.5	
BES 3	37	22.2 ± 16.4	
BES 4	52	22.7 ± 18	
Total	169		

of breast edema; BES 3 and BES 4, no masses with high Ki-67 show BES 1; Fig. 7.

Higher tumour grade and Ki67 index indicate a poor prognosis, and both were found to be the highest in TN breast cancer.

There was a highly significant difference between BES and lymph node status in the masses studied as *p*-value < 0.0001; Table 5.

BES 2 was found in 62.5% of masses with absent axillary LN metastasis. BES 4 was found more frequently in masses with bilateral axillary L.N metastases; Fig. 8.

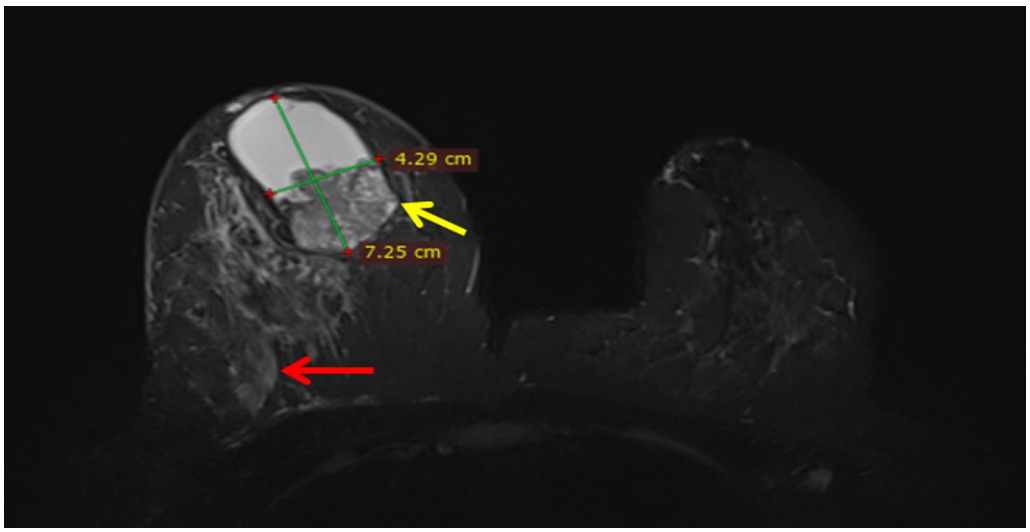

Fig. 5 A 23-year-old patient with right breast IDC (medullary type), immunohistochemistry revealed negative levels of ER, PR, and HER-2 with high Ki-67 levels indicative of triple negative breast cancer. Axial STIR shows a large mass, a yellow arrow, with perilesional and pre-pectoral edema (BES 3), and a red arrow

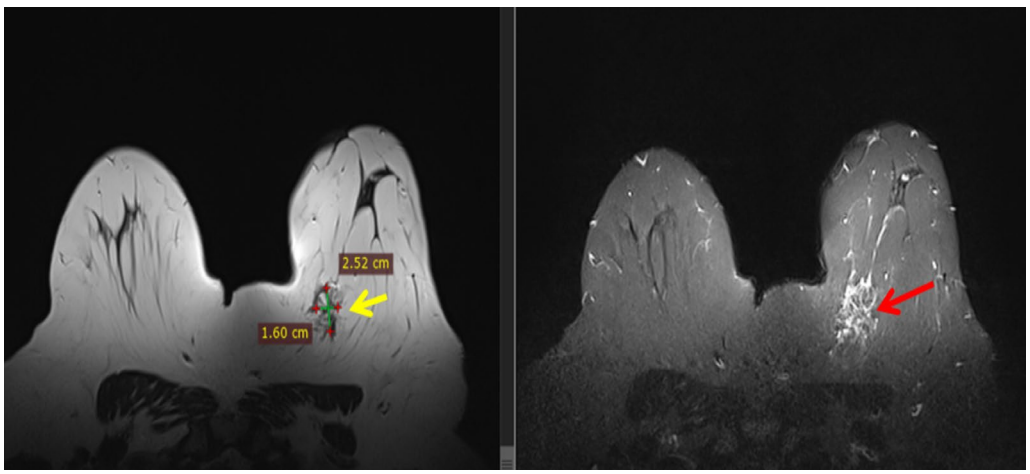

Fig. 6 52-year-old female patient with left breast IDC with DCIS component grade II, Immunohistochemistry revealed positive ER and PR, and negative HER-2 with low Ki-67 level indicative of luminal A breast cancer. The axial T2-WI and STIR show a small mass, a yellow arrow, with only perilesional edema (BES 2), a red arrow

Table 3 Correlation between BES and histopathological grade in studied masses (n = 169)

	Breast Edema Score (BES)				Total	*p* value
	BES 1	BES 2	BES 3	BES 4		
Histopathological Grade						
Grade II	8	56	32	38	134	0.49 (NS)
Grade III	2	14	5	14	35	
Total	10	70	37	52	169	

Table 4 Correlation between BES and Ki-67 expression in studied masses (n = 169)

	Breast Edema Score (BES)				Total	*p* value
	BES 1	BES 2	BES 3	BES 4		
Ki-67						
NA	0	7	0	10	17	< 0.0001*
Low	10	34	20	15	79	
High	0	29	17	27	73	
Total	10	70	37	52	169	

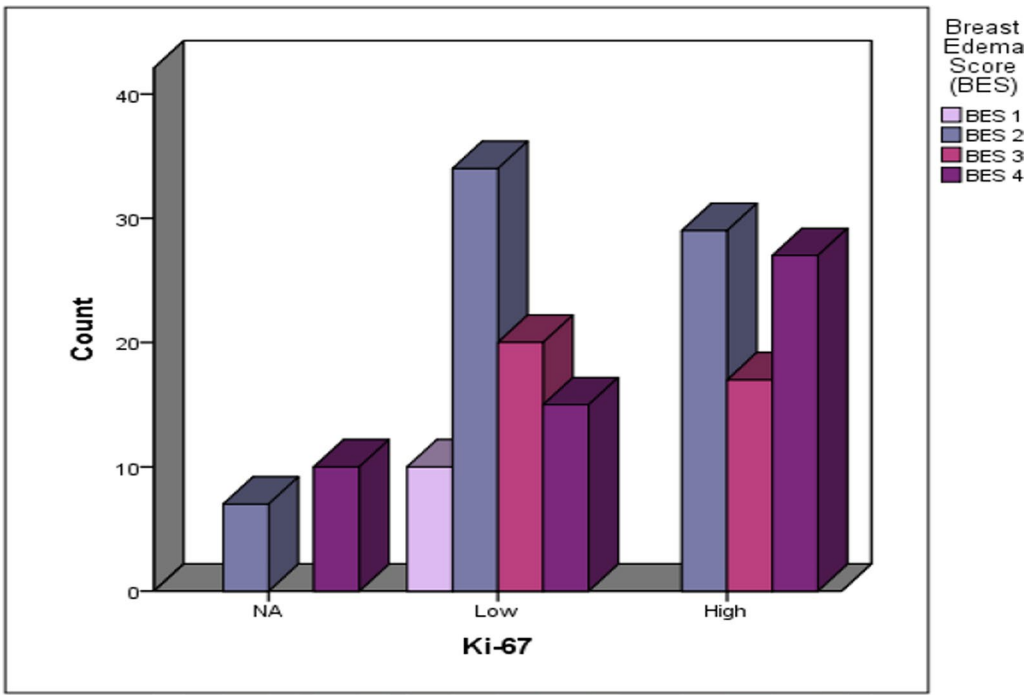

Fig. 7 A bar graph shows the correlation between BES and Ki-67 expression in the masses studied masses (n = 169)

There was a highly significant difference between BES and lymph node number in the masses studied as *p*-value < 0.0001.

Metastatic axillary LNs < 3 were found more frequently in masses with BES 2, i.e., low axillary LN burden. Metastatic axillary LNs > 3 were found to be associated with higher breast edema scores BES 3 and BES 4 (both together represent 68.4% of all masses associated with bilateral axillary L.N metastasis) i.e. high axillary LN burden; Table 6. The presence of nodal mass was more frequently associated with BES 4 (69.2%); Fig. 9.

Table 5 Correlation between BES and lymph node status in studied masses (n = 169)

	Breast Edema Score (BES)				Total	*p* value
	BES 1	BES 2	BES 3	BES 4		
L.N Status						
Negative	2	15	6	1	24	< 0.0001*
Ipsilateral	0	27	17	18	62	
Bilateral	7	28	14	33	82	
Contralateral	1	0	0	0	1	
Total	10	70	37	52	169	

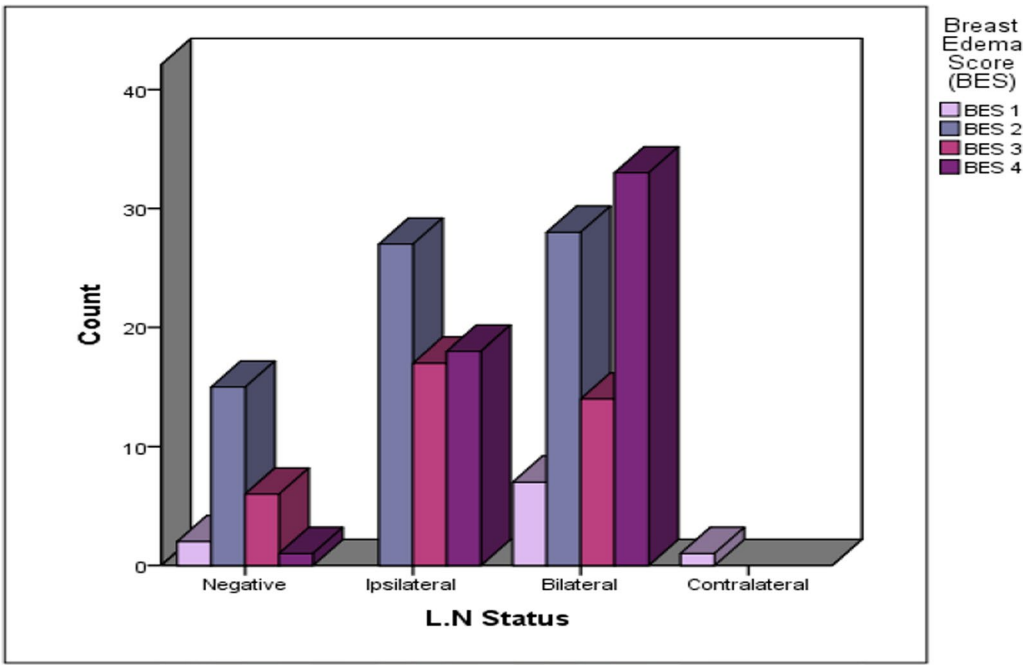

Fig. 8 A bar graph shows the correlation between BES and lymph node status in the studied masses (n = 169)

Table 6 Correlation between BES and lymph node number in the studied masses (n = 169)

	Breast Edema Score (BES)				Total	*p* value
	BES 1	BES 2	BES 3	BES 4		
L.N Number						
No Lymph nodes	2	15	6	1	24	< 0.0001*
Less than 3	4	33	21	23	81	
More than 3	3	9	12	14	38	
Nodal mass	0	7	1	18	26	
Total	10	70	37	52	169	

Discussion

Breast edema is a prognostic factor for breast cancer and is attributed to lymphovascular invasion (LVI), lymph node metastases, and histological grade [6, 7].

Peritumoral edema detected on T2-weighted breast MRI has been considered one of the crucial indicators of invasive breast cancer prognosis [8, 9]. In addition, as a higher grade of breast edema, pre-pectoral and

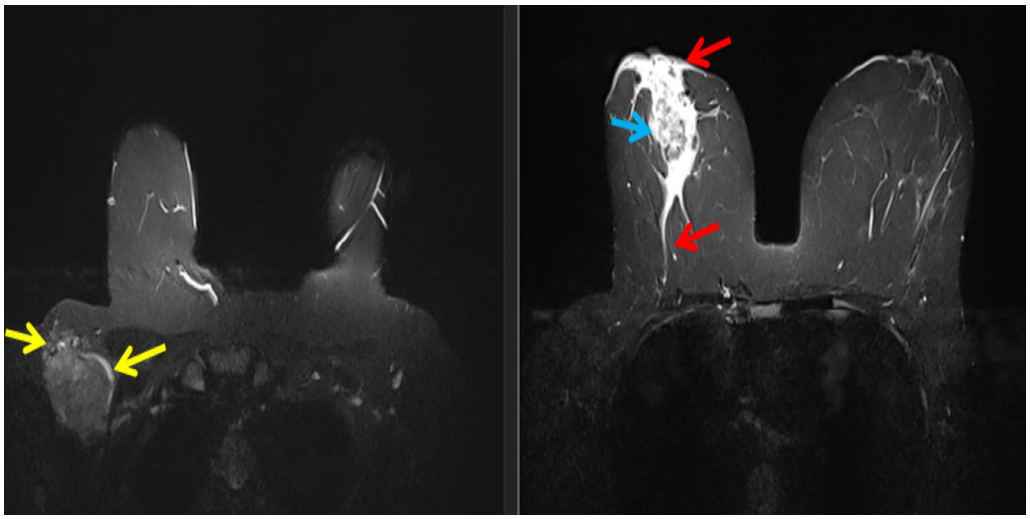

Fig. 9 A 41-year-old patient with grade III IDC-NST in the right breast, immunohistochemistry revealed positive ER and PR, and positive HER-2 with high Ki-67 level indicative of luminal B breast cancer. The axial STIR shows the right breast mass, blue arrow, associated with breast edema extending to the SC region (BES 4), red arrow, with ipsilateral axillary nodal mass, yellow arrows

subcutaneous breast oedemas are related to extensive lymphovascular invasion and poorer prognosis in breast cancer patients [5, 10].

According to the results of the current study, there was a highly significant difference between the breast edema scores with respect to the molecular subtype of breast cancer; breast edema was absent in 10 lesions (BES 1), 60% of which were luminal A subtype, perilesional edema (BES 2) was more prevalent among HER2 lesions (83.3% of HER2 masses), skin and SC edema (BES 4) was seen more in the TN subtype in 21 lesions (58.3% of TN masses) and it was shown to be the most common edema score among luminal B masses (40.5%).

These findings were similar to the study conducted by Huang et al. [4], which showed that peritumoral edema was more prevalent in HER2-enriched breast cancer.

HER2 is a receptor tyrosine kinase that belongs to the epidermal growth factor receptor family [17]. HER2 expression is related to overexpression of vascular endothelial growth factor overexpression, which can promote angiogenesis and vascular permeability, and then to a subsequent increase in extracellular fluid [18, 19].

Since TNBC was frequently associated with BES 4, our findings were partially consistent with the findings of a previous study by Xu et al. [16], who concluded that moderate to severe edema (BES 3 and 4) was more likely associated with biologically invasive clinicopathological characteristics such as higher clinical T stage, higher Ki-67 index, HER2-positive and triple-negative subtypes, and positive lymphovascular invasion status.

Furthermore, greater grades of breast edema (prepectoral BES 3 and subcutaneous BES 4) are usually associated with significant lymphovascular infiltration and a worse prognosis in breast cancer patients [5].

The most common type of edema among luminal B masses in this study was subcutaneous edema BES 4 (40.5%), which was comparable with a recent study by Huang et al. [4], which determined that the presence of subcutaneous edema was more common in luminal B tumours (HER2 positive) tumours.

There was significant difference between BES with respect to tumour size in this study. Larger masses were found to be associated with the highest score of breast edema (BES 4). The mean size associated with BES 4 was 22.7 ± 18 mm, while smaller lesions were associated with only perilesional edema (BES 2) or no edema at all (BES 1); the mean size associated with BES1 was 10.9 ± 6.4 mm, which may explain the predominance of BES 4 between TNBC lesions in our study. These findings were comparable with the findings of previous research by Huang et al. [4], who determined that intramammary edema was more prevalent in masses bigger than 2 cm in diameter. Panzironi et al. [8] likewise showed that tumours with intramammary edema were larger than 2.5 cm in diameter. Baltzer et al. [12], supported these findings, indicating that the tumour volume was large enough to increase the peritumoral pressure, which increased the vascular permeability of the tumour, resulting in the release of more cytokines, which resulted in accumulation of fluid in the breast tissues. A larger tumour was also more likely to cause higher angiogenic and proteolytic activity, contributing to the presence of intramammary edema. Recent research found that reducing tumour volume with

neoadjuvant treatment could ameliorate intramammary edema [11].

In this study, there was no significant difference between BES regarding the tumour's histopathological grade. This was inconsistent with a previous study conducted by Uematsu et al. [6], who found that cancers without breast edema (BES 1) are smaller, have a lower histologic grade, and have a lower tendency to lymph node metastasis.

There was a highly significant difference between BES in Ki-67 expressions ($p < 0.0001$), 43% of tumours with low ki-67 expression show BES 2. BES 1 and BES 2 represent 55.7% of total masses with low expression of Ki-67. However, 60.3% of tumours with high expression of Ki-67 show higher scores of breast edema, BES 3, and BES 4. BES 1 not seen in tumours with high expression of Ki-67. Ki-67 overexpression was found in TN breast cancer and indicates a poor prognosis.

TNBC distinguished by the absence of all three receptors (ER, PR, and HER2), and it is associated with more aggressive disease progression, a greater recurrence rate, a worse prognosis, and a shorter survival rate if compared to other subtypes [20]. TN breast cancer is a high proliferation subtype (increased Ki-67 expression) suggesting more aggressive activity, such as mitosis, angiogenesis, lymphatic, and vascular blockage, as previously documented [21].

Several authors also believed that SC edema was associated with poor drainage caused by lymphatic obstruction and was considered the final stage of intramammary edema [6, 22].

There was a highly significant difference between BES and LN status and number. BES 2 was found in 62.5% of tumours with absent axillary LN metastasis. BES 4 was found more frequently in masses with bilateral axillary LN metastasis. Metastatic axillary LN < 3 in number were found more frequently in BES 2, which have a low axillary LN burden.

An association was observed between prepectoral edema and axillary adenopathy. Pathophysiological explanations for prepectoral edema can be found in the structure of the lymphatic drainage system, revealing a probable relationship between prepectoral edema and lymphatic dissemination. The cause of lymphatic obstructions inside the breast, is blocked lymphatic channels that explain the development of prepectoral edema [23].

In breast cancer, the lymphatic system is the main route of regional metastases. The collection of peritumoral fluid is strongly related to the malfunctioning of lymphatic vessels, which are essential for controlling tumour development and metastasis [24].

In this study, Metastatic axillary L.N > 3 in number were found in higher breast edema scores BES 3 and BES 4 (both together represent 68.4% of all masses associated with bilateral axillary L.N metastasis), high axillary LN burden, which was proportional to the BES, this was consistent with previous studies conducted by Liang et al., Xu et al., Byon et al., and Moradi et al. [9, 11, 16, 25], who concluded that individuals with severe breast edema were more likely to have a high axillary L.N burden. In this study, nodal mass was associated more frequently with BES 4 (69.2%).

Limitations of this study were that it was a single institution retrospective study. Thus, results could not be generalised. A larger sample size and long-term outcome should be considered before the correlation between breast edema score and axillary L.N metastasis and before relying on BES to predict molecular subtypes of breast cancer.

Conclusions

Tumour-related breast edema MRI characteristics may be useful in distinguishing molecular subtypes of breast cancer and could be used as a promising feature to improve the predictive performance of pathological axillary lymph nodes in patients with breast cancer, contributing to preoperative treatment planning and prognostic outcome.

Abbreviations

BES	Breast Edema Score
BC	Breast cancer
DCE-MRI	Dynamic contrast-enhanced magnetic resonance imaging
ER	Estrogen receptor
HER 2	Herceptin 2
IBC	Inflammatory breast carcinoma
IHC	Immunohistochemistry
LN	Lymph node
LVI	Lymphovascular invasion
MRI	Magnetic resonance imaging
pALN	Axillary LN burden
PR	Progesterone receptor
STIR	Short tau inversion recovery
THRIVE	T1 high-resolution isotropic volumetric examination
TN	Triple negative
T2 WI	T2-weighted image

Acknowledgements

None.

Author contributions

All the authors have contributed in conceptualizing and designing the study, retrieval, analysis and interpretation of data. All authors of this paper have read and approved the final version submitted. The contents of this manuscript have not been copyrighted or published previously. The contents of this manuscript are not now under consideration for publication elsewhere. The contents of this manuscript will not be copyrighted, submitted, or published elsewhere, while acceptance by the Journal is under consideration. There are no directly related manuscripts or abstracts, published or unpublished, by any authors of this paper. All authors read and approved the final manuscript.

Funding

No funding was required for the study.

Availability of data and materials
The datasets generated and/or analyzed during the current study are not publicly available for maintaining the anonymity but are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
The protocol was reviewed and approved by the "Institutional Review Board" of the faculty of medicine in Assuit University- Assuit- Egypt. IRP local approval number: 04-2023-300141.

Consent for publication
We have used images maintaining the anonymity of the participants. Our research was retrospective study and not require informed consent from the patient to obtain an ethical approval.

Competing interests
The authors declare that they have no competing interests.

Author details
[1]Radiology Department, Faculty of Medicine, Sohag University, Sohag, Egypt. [2]Clinical Oncology Department, Faculty of Medicine, Assuit University, Asyut, Egypt. [3]Surgical Oncology Department, South Egypt Cancer Institute, Assuit University, Asyut, Egypt. [4]Radiology Department, Faculty of Medicine, Assuit University, Asyut, Egypt.

Received: 17 December 2023 Accepted: 24 March 2024
Published online: 05 April 2024

References

1. Polyak K (2011) Review series introduction Heterogeneity in breast cancer. J Clin Invest 121(10):2011–2013. https://doi.org/10.1172/JCI60534.3786
2. Malhotra GK, Zhao X, Band H, Band V (2010) Histological, molecular and functional subtypes of breast cancers. Cancer Biol Ther 10(10):955–960. https://doi.org/10.4161/cbt.10.10.13879
3. Sung H (2021) Global cancer statistics 2020: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. CA Cancer J Clin 71(3):209–249. https://doi.org/10.3322/caac.21660
4. Huang Z (2022) Intramammary edema of invasive breast cancers on MRI T 2 -weighted fat suppression sequence: correlation with molecular subtypes and clinical-pathologic prognostic factors. Clin Imaging 83:87–92. https://doi.org/10.1016/j.clinimag.2021.12.023
5. Harada TL (2021) Evaluation of breast edema findings at T2-weighted breast MRI is useful for diagnosing occult inflammatory breast cancer and can predict prognosis after neoadjuvant chemotherapy. Radiology 299(1):53–62. https://doi.org/10.1148/RADIOL.2021202604
6. Uematsu T, Kasami M, Watanabe J (2014) Is evaluation of the presence of prepectoral edema on T2-weighted with fat-suppression 3 T breast MRI a simple and readily available noninvasive technique for estimation of prognosis in patients with breast cancer? Breast Cancer 21(6):684–692. https://doi.org/10.1007/s12282-013-0440-z
7. Cheon H (2018) Invasive breast cancer: prognostic value of peritumoral edema identified at preoperative MR imaging. Radiology 287(1):68–75. https://doi.org/10.1148/radiol.2017171157
8. Panzironi G, Moffa G, Galati G, Marzocca F, Rizzo V, Pediconi F (2020) Peritumoral edema as a biomarker of the aggressiveness of breast cancer: results of a retrospective study on a 3 T scanner. Breast Cancer Res Treat 181(1):53–60. https://doi.org/10.1007/s10549-020-05592-8
9. Byon JH (2021) Added value of MRI for invasive breast cancer including the entire axilla for evaluation of high-level or advanced axillary lymph node metastasis in the post-ACOSOG Z0011 trial era. Radiology 300(1):46–54. https://doi.org/10.1148/radiol.2021202683
10. Uematsu T (2015) Focal breast edema associated with malignancy on T2-weighted images of breast MRI: peritumoral edema, prepectoral edema, and subcutaneous edema. Breast Cancer 22(1):66–70. https://doi.org/10.1007/s12282-014-0572-9
11. Liang T, Hu B, Du H, Zhang Y (2020) Predictive value of T2-weighted magnetic resonance imaging for the prognosis of patients with mass-type breast cancer with peritumoral edema. Oncol Lett 20(6):1–1. https://doi.org/10.3892/OL.2020.12177
12. Baltzer PTA (2010) Sensitivity and specificity of unilateral edema on T2w-TSE sequences in MR-mammography considering 974 histologically verified lesions. Breast J 16(3):233–239. https://doi.org/10.1111/j.1524-4741.2010.00915.x
13. Kettunen T (2020) Peritumoral ADC values in breast cancer: region of interest selection, associations with hyaluronan intensity, and prognostic significance. Eur Radiol 30(1):38–46. https://doi.org/10.1007/s00330-019-06361-y
14. Koyama H (2008) Significance of tumor-associated stroma in promotion of intratumoral lymphangiogenesis: pivotal role of a hyaluronan-rich tumor microenvironment. Am J Pathol 172(1):179–193. https://doi.org/10.2353/ajpath.2008.070360
15. Park NJY (2021) Peritumoral edema in breast cancer at preoperative MRI: an interpretative study with histopathological review toward understanding tumor microenvironment. Sci Rep 11(1):12992. https://doi.org/10.1038/s41598-021-92283-z
16. Xu Z (2022) MRI characteristics of breast edema for assessing axillary lymph node burden in early-stage breast cancer: a retrospective bicentric study. Eur Radiol. https://doi.org/10.1007/s00330-022-08896-z
17. Mendelsohn J, Baselga J (2006) Epidermal growth factor receptor targeting in cancer. Semin Oncol. https://doi.org/10.1053/j.seminoncol.2006.04.003
18. Karan B, Pourbagher A, Torun N (2016) Diffusion-weighted imaging and 18F-fluorodeoxyglucose positron emission tomography/computed tomography in breast cancer: correlation of the apparent diffusion coefficient and maximum standardized uptake values with prognostic factors. J Magn Reson Imaging 43(6):1434–1444. https://doi.org/10.1002/jmri.25112
19. Park SH, Choi HY, Hahn SY (2015) Correlations between apparent diffusion coefficient values of invasive ductal carcinoma and pathologic factors on diffusion-weighted MRI at 3.0 Tesla. J Magn Reson Imaging 41(1):175–182. https://doi.org/10.1002/jmri.24519
20. Dent R (2007) Triple-negative breast cancer: clinical features and patterns of recurrence. Clin Cancer Res 13(15):4429–4434. https://doi.org/10.1158/1078-0432.CCR-06-3045
21. Whitman GJ, Albarracin CT, Gonzalez-Angulo AM (2011) Triple-negative breast cancer: what the radiologist needs to know. Semin Roentgenol. https://doi.org/10.1053/j.ro.2010.09.004
22. Uematsu T (2012) MRI findings of inflammatory breast cancer, locally advanced breast cancer, and acute mastitis: T2-weighted images can increase the specificity of inflammatory breast cancer. Breast Cancer 19(4):289–294. https://doi.org/10.1007/s12282-012-0346-1
23. Sutton EJ (2016) Breast cancer molecular subtype classifier that incorporates MRI features. J Magn Reson Imaging 44(1):122–129. https://doi.org/10.1002/jmri.25119
24. Kataru RP (2019) Tumor lymphatic function regulates tumor inflammatory and immunosuppressive microenvironments. Cancer Immunol Res 7(8):1345–1358. https://doi.org/10.1158/2326-6066.CIR-18-0337
25. Moradi B, Gity M, Etesam F, Borhani A, Ahmadinejad N, Kazemi MA (2020) Correlation of apparent diffusion coefficient values and peritumoral edema with pathologic biomarkers in patients with breast cancer. Clin Imaging. https://doi.org/10.1016/j.clinimag.2020.08.020

Publisher's Note

Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.