Abstract: To evaluate magnetic resonance imaging (MRI) findings, according to Breast Imaging-Reporting and Data System (BI-RADS), and to relate them with molecular subtypes of breast cancer. The MRI findings were reviewed retrospectively in 201 women diagnosed of invasive breast cancer confirmed by surgery and were compared with the molecular subtypes. Following the BI-RADS, MRI findings included disease type, size, enhancement, morphology and contrast kinetics. In mass-like lesion types were studied shape, margin and enhancement, and in nonmass-like lesion types, distribution modifiers and internal enhancement. Chi-squared analysis showed significant association (p < 0.01) between molecular subtypes and lesion type on MRI and histologic grade. Shape, margin and mass enhancement (p < 0.05) also showed significant association among molecular subtypes. Triple negative were more frequently unifocal and mass-like lesion, high histologic grade, round shape, smooth margin, and rim enhancement. Luminal-A were more frequently low grade, mass-like lesion, irregular shape and spiculated or irregular margin. Luminal-B were more frequently moderate-low grade, mass-like lesion, nonirregular shape and spiculated margin. HER-2-enriched were more frequently moderate grade, nonmass-like lesion and multicentric lesions were more present than in other subtypes. There are significantly different MRI features, according to BI-RADS, between the molecular subtypes breast cancer.

Key Words: BIRADS, breast cancer, magnetic resonance, molecular subtypes, MRI

Multiple studies supporting the usefulness of breast magnetic resonance imaging (MRI). The MRI has shown to be superior to conventional techniques in identifying additional sites of otherwise occult malignancy (1, 2). MRI is considered to be an important prognostic factor. Fischer et al. and others authors demonstrated that preoperative breast reso- nance reduces the incidence of local recurrence (3–5).

Therefore, the MRI is a very important tool because it can change the medical-surgical strategy proposed initially and allows better surgical planning. MRI is a non-invasive imaging technique in order to obtain information on the location and extent of breast cancer, as well as assessments of tissue characteristics that can monitor and predict treatment response and guide patient management.

On the other hand some authors have gone beyond the diagnosis and have evaluated the usefulness of the MRI in response to chemotherapies. Loo et al. have shown a different sensitivity of MRI to monitor response during neo-adjuvant chemotherapy according to breast cancer subtype (6).

The use of MRI after contrast-enhanced administration, respecting the appointed weeks postbiopsy (7), allows not only morphological parameters but also functional study through kinetic curves that are influenced by tumor biology.

Some publications have already demonstrated that (dynamic contrast-enhanced [DCE]) MRI parameters are correlated with the vascularity of the tumor and can to serve for differentiation between the different histopathological types of tumors (8–11).

The new techniques used in pathology as well as the immunohistochemistry have allowed us to evaluate new markers such as hormone receptor, human
epidermal growth factor receptor-type2 (HER2) and proliferation index.

Perou et al. suggested four intrinsic breast cancer subtypes (luminal-A, luminal-B, HER2-enriched, triple-negative) that could be defined at the gene expression level (12).

The most frequently markers routinely employed to recapitulate the prognostic and predictive information of the intrinsic subtypes and to select therapy (13–15) are estrogen receptor (ER), progesterone receptor (PR) and HER2. The luminal-A subtype (ER positive, HER2 negative, PR weak or strong positive) respond to hormone therapy and carry usually, an excellent prognosis. The luminal-B (ER positive, HER2 negative or positive, PR may be positive or negative) have a worse prognosis than luminal-A but tend to be generally better than that of pure HER-enriched. HER-2-enriched (HER2 positive, ER and PR negative) are more aggressive but can be treated with monoclonal antibodies directed against the erbB-2 membrane receptor. Triple-negative (ER, PR and HER2 negative) are the most aggressive subtypes and usually respond to chemotherapy (6).

If it were possible to differentiate the subtypes of breast cancer according to the MRI characteristics, then the MRI findings could help establish an earlier prognosis and treatment.

Based on these premises, we hypothesized that the Breast Imaging Reporting and Data System (BI-RADS) descriptors can provide useful information as parameters of image in MR and correlate with histologic subtypes.

The objective of the study was to retrospectively evaluate the radiological characteristics on MRI, according to BI-RADS system, of the different molecular subtypes of breast cancer.

**MATERIALS AND METHODS**

The MRI findings were reviewed retrospectively in 224 women consecutively diagnosed of invasive breast cancer confirmed by core needle biopsy followed by surgery between February 2011 and June 2013. Breast MRI was performed in all these women because is routine in our institution for preoperative staging since according to international recommendations, MRI may be useful to determine the extent of disease and the presence of multifocality and multicentricity in patients with invasive carcinoma.

Magnetic resonance imaging examinations were performed 20 days after of core needle biopsy to avoid confounding features such hemorrhage was also analysed the histological findings and molecular subtypes of these patients.

Fourteen patients were excluded from analysis because received neo-adjuvant chemotherapy before MRI. The data on others nine patients were excluded because of incomplete information on ER, PR, and HER2 status.

Therefore, the data on a total of 201 patients were included in our study.

All patients were women between the ages 32 and 83 years (mean, 56 years).

**MRI Technique**

Magnetic resonance imaging examinations were performed with the patients in the prone position by using a 1.5-T MRI unit (Gyroscan Intera; Philips Medical Systems, Best, the Netherlands) with breast-surface coils. A localizing sequence was followed by axial turbo spin-echo T2-weighted imaging (repetition time ms/echo time ms, 4684/130; matrix, 256 × 256). Other parameters were as follows: field of view (FOV), 35 cm; section thickness, 4 mm; and intersection gap, 0 mm.

After, DWI Spin-echo was performed using spectral attenuated inversion recovery (SPAIR) sequence on the axial plane with the following parameters: TR/TE 9373/72 ms, matrix 80 × 80 pixels, FOV 34 cm, slice thickness 4 mm and acquisition time 224 seconds and two order factor b (0 and 800).

This examination was followed by a dynamic study that consisted of serial imaging by axial with a three-dimensional fast field-echo T1-weighted sequence (4.0/2.0; flip angle, 10°; matrix, 352 × 352) with fat suppression (SPAIR). The parameters were as follows: FOV, 44 cm; section thickness, 2 mm; and intersection gap, 0.8 mm.

Gadodiamida (Omniscan; General Electric Healthcare, Bio-Sciences, La Florida, Madrid, Spain) was administered as a bolus intravenous injection (2 mL/s) at a dose of 0.1 mmol/kg of body weight followed by a 20 mL saline solution flush.

Other acquisition fast field-echo T1-weighted sequence by sagittal acquisition and with fat suppression (SPAIR) was performed over a period of 6 minutes after intravenous contrast material injection, the parameters were as follows: 4.0/2.0; flip angle, 10°; matrix, 192 × 192; FOV, 44 cm; section thickness, 2.5 mm; and intersection gap, 0.8 mm.
Subtracted images from DCE MRI (early postcontrast-precontrast) were superimposed for cancer lesions detection.

MRI Findings

Magnetic resonance imaging in 201 patients with breast cancers were randomized and were reviewed by two radiologists using the BI-RADS MR lexicon (16) without knowledge of the clinicopathologic findings.

Magnetic resonance imaging findings included type of enhancement, morphology and contrast Kinetics. The lesion type, according to BI-RADS was classified in mass or nonmass-like-enhancement. In the mass lesions were studied the shape, margin and type of enhancement, while in the nonmass-like-enhancement were studied the distribution modifiers and internal enhancement pattern.

For the time-signal intensity curves, the patterns were categorized into three types (persistent, plateau or washout pattern) on the images obtained during the last three phases of contrast material enhanced dynamic MRI, according to the BI-RADS. In addition, we recorded the size and number of tumors.

Pathologic Features and Classifications of Molecular Subtypes

We retrospectively reviewed the clinicopathological data including age, histologic type (ductal, lobular and others), pathologic grade (1–3), tumor size (largest diameter) and disease type. The disease type was classified as one of the following three types (17): The unifocal was defined when only one malignant focus was found in the breast, the multifocal was defined when more than one malignant focus was seen in the same quadrant, and the multicentric was defined when more than one malignant focus was shown in more than one single quadrant.

Breast specimens were analysed by one pathologist with more than 5 years of experience in breast histologic evaluation, who were blinded to the results of MRI. The histologic type of breast cancer was defined according to the WHO classification (18).

We used an immunohistochemistry (IHC) assay for three surrogate markers of ER, PR, and HER2. IHC was performed for ER (SP1; Roche Diagnostics GmbH, Sandhofer Strasse, Mannheim, Germany), PR (1E2; Roche Diagnostics GmbH) and HER2neu (4B5, Roche Diagnostics GmbH) as a routine clinical diagnostic procedure. The cut-off values for ER and PR were 10% positive cells, irrespective of intensity.

HER2 status was reassessed according to recently published guidelines (19). Positivity was defined as 3+ score by IHC in >30% of invasive tumor cells using the Her2neu. Equivocal cases at IHC (2+ score) were subjected to fluorescence in situ hybridization analysis. A ratio of HER2 gene signals to chromosome 17 signals of more than 2.2 was used as a cut-off to define HER2-gene amplification.

The study population was grouped into four subtypes: luminal-A (ER and PR positive, HER2 negative), luminal-B (ER and PR positive, HER2 positive), HER-2-enriched (ER and PR negative, HER2 positive) and triple negative (ER negative, PR negative and HER2 negative).

So we study in the luminal-B only the cases with ER/PR positive and HER2 positive, due to be positive for HER2 receptor have a worse prognosis than luminal-A but tend to be generally better than that of pure HER-2-enriched tumors and maybe also could have a different imaging findings.

Statistical Analysis

To compare the MRI findings, mass or nonmass-like-enhancement, between the subtypes of breast cancer, we used the chi-square test ($\chi^2$). Fisher test was used to show the association between type of mass enhancement and the different molecular subtypes.

The ANOVA test was used to verify that there was no tumor size-related bias between groups.

Rho Spearman coefficients were calculated to quantify the correlation between MRI and pathologic tumor size.

All analyses were performed by using software (SPSS version 15.0; SPSS, Chicago, IL.), with p < 0.05 considered to indicate a significant difference.

RESULTS

Patients and Pathology

Patient’s characteristics and distribution of molecular subtypes are summarized in Tables 1 and 2.

The luminal-A, luminal-B, HER-2-enriched and triple-negative subtype accounted for 143 (71.1%), 15 (7.5%), 26 (12.9%), and 17 cases (8.5%) respectively.

Women with triple-negative subtype were more likely to have histologic high grade tumors (76.5%),
for the women with HER-2-enriched moderate grade (65.4%), women with luminal-B low-moderate grade (40–46.7%) while women with luminal-A were more frequent low grade (52%), all \( p < 0.05 \).

Most of the tumors were infiltrating ductal carcinomas. There were five cases of mucinous carcinoma and three cases of medullary carcinoma. Medullary carcinoma was significantly associated with triple-negative breast cancer \( (p < 0.05) \).

Unifocal lesions were identified in 106 (52.7%) patients, multifocal in 67 (33.3%), multicentric in 29 (13.9%) and bilateral disease was detected in 2 (1.92%) cases. There was association between unifocal lesions and different subtypes of breast cancer \( (p = 0.007) \). Triple negative was presented in 88% of cases as unifocal.

The multicentric lesions are more frequently detected in HER-2-enriched subtype, with 26.9%.

Of the 29 multicentric tumors, 20 was luminal-A, 7 HER-2-enriched and two triple-negative. In seven cases (25%) the tumor had ductal carcinoma in situ as a second lesion, and the remaining 22 (75%) the index tumor had invasive ductal cancer as a second lesion. All invasive multicentric tumors exhibited the same hormone status in both the index and the second lesion.

There was no tumor size-related bias between the groups \( (p = 0.205) \). Mean tumor diameter was 16 mm (range 1–100).

**MRI Findings**

All the 201 lesions were identified as areas of enhancement at DCE MRI and as hyperintense at DWI.

Chi-squared analysis showed significant association \((p < 0.01)\) between molecular subtypes and lesion type (mass or nonmass like) on MRI. The majority of triple-negative breast cancers (94.1%) were mass-like enhancement. Also for the luminal-A and luminal-B the most frequent type were the mass-like lesion (67.8% and 80% respectively). Nonmass-like enhancement pattern was most frequent in HER-2-enriched subtype.

Statistical analysis showed significant associations for shape between subtypes of breast cancer \( (p = 0.037) \) (Table 3).

Triple-negative tumors showed more often nonirregular shape 87.4% (i.e., round, oval or lobulated) than others tumors, being the most common the round shape (62.5%). the triple-negative tumors presented significantly more often with smooth margin (62.5%) than the luminal-A (3%), Luminal-B (8.3%) and HER-2-enriched (0%) \( (p = 0.000) \). Fisher test showed statistically significant associations between type of mass enhancement and subtypes \( (p = 0.045) \). Triple-negative tumors was presented as a rim enhancement in 68.7% of the cases and as a

### Table 1. Classification and Distribution of Breast Cancer Subtype by ER, PR, and HER2 Status

| Subtype       | ER and/or PR | HER2  | n   | %   |
|---------------|--------------|-------|-----|-----|
| Luminal A     | Positive     | Negative | 143 | 71.1|
| Luminal B     | Positive     | Positive | 15  | 7.5 |
| HER2          | Negative     | Positive | 26  | 12.9|
| Triple negative| Negative     | Negative | 17  | 8.5 |
| Total         |              |         | 201 | 100 |

### Table 2. Clinicopathologic Data

| Characteristic                  | Luminal A \( (n = 143) \) | Luminal B \( (n = 15) \) | HER2 \( (n = 26) \) | Triple negative \( (n = 17) \) | p value |
|--------------------------------|-----------------------------|--------------------------|-------------------|-------------------------------|---------|
| Tumor size (mm)                 | 16 (1–100)                  | 10 (5–17)                | 13 (6–25)         | 21 (10–70)                    | 0.205   |
| Histologic tumor grade          |                             |                          |                   |                               |         |
| Low                            | 74 (51.7)                   | 6 (40)                   | 4 (15.4)          | 0 (0)                         | 0.000   |
| Moderate                       | 63 (44.1)                   | 7 (46.7)                 | 17 (65.4)         | 4 (23.5)                      |         |
| High                           | 6 (4.2)                     | 2 (13.3)                 | 5 (19.2)          | 13 (76.5)                     |         |
| Histologic tumor type           |                             |                          |                   |                               |         |
| Invasive ductal carcinoma       | 117 (81.8)                  | 11 (73.3)                | 24 (92.3)         | 15 (88.2)                     | 0.239   |
| Invasive lobular carcinoma      | 21 (14.7)                   | 3 (20)                   | 2 (7.7)           | 0 (0)                         | 0.239   |
| Medullary carcinoma             | 0 (0)                       | 1 (6.6)                  | 0 (0)             | 2 (11.7)                      | 0.001   |
| Mucinous carcinoma              | 5 (3.5)                     | 0 (0)                    | 0 (0)             | 0 (0)                         | 0.556   |
| Disease type                    |                             |                          |                   |                               |         |
| Unifocal lesion                 | 68 (47.6)                   | 9 (60)                   | 14 (53.8)         | 15 (88)                       | 0.007   |
| Multifocal lesion               | 55 (38.5)                   | 6 (40)                   | 5 (19.2)          | 0 (0)                         |         |
| Multicentric lesion             | 20 (14)                     | 0 (0)                    | 7 (26.9)          | 2 (12)                        |         |
| Axillary lymph node positivity  | 39 (27.3)                   | 5 (33.3)                 | 8 (30.8)          | 2 (11.7)                      | 0.474   |
heterogeneous enhancement in 31%. There was no homogeneous enhancement in triple-negative.

Luminal-A presented the most frequent shape (53.6%) with spiculated (69.1%) and irregular margin (27.8%). Luminal-A was presented more frequently as a rim enhancement (33%) and dark internal septation (30%) (Fig. 1).

Also for HER-2-enriched that manifest as a masses, round was the most frequent shape with speculated (63.6%) and irregular margin (36.4%). The nonmass-like-enhancement pattern was the most frequent pattern in HER-2-enriched subtype (57.7%) (Fig. 2). HER-2-enriched was presented more often as a ductal (26.7%) and regional distribution (26.7%) but there was not statistically significant associations (p = 0.988). The more frequently internal enhancement for the HER-2-enriched was clumped (40%) and heterogeneous enhancement in 31%. There was no homogeneous enhancement in triple-negative.

Table 3. Evaluated Imaging Features, Tumour Size and Kinetics on MRI Stratified by Subtype

| Variable                      | Luminal A, 143 | Luminal B, 15 | HER2, 26 | Triple negative, 17 | p value |
|-------------------------------|----------------|--------------|----------|---------------------|---------|
| Mass-like                     |                |              |          |                     |         |
| Shape                         |                |              |          |                     |         |
| Round                         | 22 (22.7)      | 5 (41.7)     | 5 (45.5) | 10 (62.5)           | 0.037   |
| Oval                          | 14 (14.4)      | 2 (16.7)     | 2 (18.2) | 1 (6.2)             |         |
| Lobular                       | 9 (9.3)        | 1 (8.3)      | 2 (18.2) | 3 (18.7)            |         |
| Irregular                     | 52 (53.6)      | 4 (33.3)     | 2 (18.2) | 2 (12.5)            |         |
| Margin                        |                |              |          |                     |         |
| Smooth                        | 3 (3)          | 1 (8.3)      | 0 (0)    | 10 (62.5)           | 0.000   |
| Irregular                     | 27 (27.8)      | 1 (8.3)      | 4 (36.4) | 3 (18.8)            |         |
| Spiculated                    | 67 (69.1)      | 10 (83.3)    | 7 (63.6) | 3 (18.8)            |         |
| Mass enhancement              |                |              |          |                     |         |
| Homogeneous                   | 2 (2)          | 1 (8.3)      | 0 (0)    | 0 (0)               | 0.045   |
| Heterogeneous                 | 23 (23.7)      | 2 (16.7)     | 3 (27.3) | 5 (31.2)            |         |
| Rim enhancement               | 32 (33)        | 2 (16.7)     | 2 (182)  | 11 (68.7)           |         |
| Dark internal septation       | 29 (30)        | 4 (33.3)     | 4 (36.4) | 0 (0)               |         |
| Enhance internal septation    | 8 (8.2)        | 3 (25)       | 2 (18.2) | 0 (0)               |         |
| Central enhancement           | 3 (3)          | 0 (0)        | 0 (0)    | 0 (0)               |         |
| Nonmass-like                  | 46 (32.2)      | 3 (20)       | 15 (57.7)| 1 (5.9)             | 0.003   |
| Distribution Modifiers        |                |              |          |                     |         |
| Focal area                    | 4 (8.7)        | 0 (0)        | 1 (6.7)  | 0 (0)               | 0.988   |
| Linear                        | 1 (2.2)        | 0 (0)        | 0 (0)    | 0 (0)               |         |
| Ductal                        | 9 (19.6)       | 1 (33.3)     | 4 (26.7) | 0 (0)               |         |
| Segmental                     | 6 (13)         | 1 (33.3)     | 3 (20)   | 0 (0)               |         |
| Regional                      | 12 (26.1)      | 0 (0)        | 4 (26.7) | 0 (0)               |         |
| Multiple regions              | 12 (26.1)      | 1 (33.3)     | 2 (13.3) | 1 (100)             |         |
| Diffuse                       | 2 (43)         | 0 (0)        | 1 (6.7)  | 0 (0)               |         |
| Internal enhancement          |                |              |          |                     |         |
| Homogeneous                   | 4 (8.7)        | 0 (0)        | 0 (0)    | 0 (0)               | 0.564   |
| Heterogeneous                 | 18 (39.1)      | 1 (33.3)     | 5 (33.3) | 0 (0)               |         |
| Stippled, punctuate           | 0 (0)          | 0 (0)        | 0 (0)    | 0 (0)               |         |
| Clumped                       | 12 (26.1)      | 0 (0)        | 6 (40)   | 0 (0)               |         |
| Reticular, dendritic          | 12 (26.1)      | 2 (66.7)     | 4 (26.7) | 1 (100)             |         |
| Diameter MRI (mm)*            | 26.7 (7-130)   | 18 (10-40)   | 27.8 (10-62)| 23.8 (12-54)        |         |
| Dynamic curve type MRI        |                |              |          |                     |         |
| Type 1 continuous             | 8 (5.6)        | 0 (0)        | 0 (0)    | 2 (11.8)            | 0.607   |
| Type 2 plateau                | 77 (53.8)      | 9 (60)       | 13 (50)  | 8 (47.1)            |         |
| Type 3 washout                | 58 (40.6)      | 6 (40)       | 13 (50)  | 7 (41.2)            |         |

Note: Unless otherwise indicated, data are numbers of tumours lesions, with percentages in parentheses.

*Data are means, with ranges in parentheses.

Figure 1. Eighty-year-old woman with luminal A infiltrating ductal carcinoma. Axial fat-suppressed contrast-enhanced T1-weighted MR images shows a irregular mass with spiculated margins and heterogeneous mass enhancement.
There was no homogeneous internal enhancement in HER-2-enriched. Conversely, luminal-B presented more often with spiculated margin (83.3%) than the others tumors. This subtype was presented as a dark internal septation (33%) and enhancing internal septation (25%).

There was no statistically significant differences between the dynamic curve type in MRI and the different subtypes. There was no persistent enhancement in luminal B neither HER-2-enriched. Plateau curve and washout curve were seen more often in all of subtypes of breast cancer.

Correlations Between MRI Findings and Histologic Findings

There are moderate correlation (Rho Spearman correlation coefficient = 0.40) between tumor size quantified by MRI and tumor size quantified by histopathology postsurgery.

DISCUSSION

Our study results show that several MR imaging findings are suggestive of different molecular subtype of breast cancer. For example, triple-negative show more frequently mass lesion type, round shape, smooth mass margin and rim enhancement that the others tumors (Fig. 3). Also, triple-negative were more frequent high grade tumors and unifocal lesions (17,20).

Uematsu et al. (21) compared the MRI findings of triple-negative (ER-negative/PR-negative/HER2-negative) with those of ER-positive/PR-positive/HER2-negative and concluded that triple-negative cancers were likely to have high histologic grade, unifocal lesion, and to be associated with mass lesion type, smooth mass margin and rim enhancement. However, their analysis did not include MRI findings of ER-positive/PR-positive/HER2-positive neither ER-negative/PR-negative/HER2-positive. Wang et al. (22) compared the mammographic and ultrasonographic findings of ER-negative/HER2-negative cancers with those of ER-negative/HER2-positive and concluded that ER-negative/HER2-positive were likely to have spiculated margins and to be associated with calcifications, while ER-negative/HER2-negative were more likely to appear as smooth or circumscribed masses. However, their analysis did not include MRI findings.

Schrading and Kuhl (23) reported that familial breast cancer tends to exhibit smooth mass margins. Accordingly, specific subtypes of high-grade tumors, such as triple-negative and familial breast cancers are likely to manifest with benign morphologic features (23).

We found that medullary carcinoma were significantly associated with triple-negative subtype, which is in agreement with previous studies (21,24).

Our study results show that HER2 subtype was more likely to have moderate histologic grade and it was presented more frequently as a unifocal lesion.
Seo et al. (25) reported that breast cancers with HER2 positivity are often characterized by tumor stage II or III at the time of diagnosis and were more frequently multifocal. This study differs from our results probably by the fact that their study included all tumors with HER2 status positivity and was not differentiated ER and PR status (positive or negative) within the group.

We found that HER2 tumors significantly presents as a nonmass-like in MRI. The distribution modifiers are ductal, segmental, and regional with heterogeneous internal enhancement. For those cancers with HER2 subtype that manifested as mass lesions, in our study they appeared more frequently with round shape and spiculated margins. These results are consistent with those described in previous reports. Ko and colleagues (26) described that HER2-positive tumors more often correspond to nonmass lesions compare with others breast cancer subtypes. For HER2-positive cancers that manifested as masses, microlobulated or angular margins were most frequent type of margins. Also, Youk and colleagues (27) described that the majority HER2-positive cancers presented most often round or oval shape, spiculated or irregular margins and heterogeneous enhancement.

Another finding of our study was that several MRI findings, such as mass lesion, irregular shape, spiculated margin and heterogeneous enhancement are suggestive of histopathologically luminal-A breast cancer. Luminal-A were likely to have moderate-low histologic tumor grade and multifocal or multicentric lesions.

Several studies considering MRI findings, reported that the majority of breast cancers with ER-positive are often characterized by mass-enhancement, with irregular shape and spiculated or irregular margins.

In addition, Uematsu et al. (21) reported that ER-positive HER2-negative cancers tends to exhibit mass-enhancement, irregular or oval shape, with irregular margins and heterogeneous internal enhancement. Also, Youk et al. (27) described similar MRI findings in their study.

There are far fewer published studies of the imaging features of luminal-B tumors. Most of the studies described the imaging findings in ER-positive breast cancers.

Our study results show that luminal-B subtype more frequently present to a mass-like-enhancement lesion with round or irregular shape and spiculated margins. Dark internal septation mass-enhancement was also seen in these tumors and presented plateau or washout kinetics in all cases.

According to our results luminal-B subtype shares common imaging findings with luminal-A and HER2. For example, the round shape is more characteristic in HER2, while irregular shape is more characteristic in luminal-A. The variability in the radiological findings of luminal-B tumors could be due to the fact that they share RE-positivity with the luminal-A and they also share HER2-positivity with the HER2 subtype tumors.

HER2 receptor positivity were present in the subtype luminal-B (RE-positive) and in the subtype HER2 (RE-negative) breast cancers. There was not a single group for all HER2-positive tumors and this may have influenced on our results compared with others studies.

The greatest limitation of this study was a relatively small study where some of the tumors subtypes included a low number of tumors.

Another disadvantage of our study is the wide variety of radiological findings rated according to the BI-RADS system. For this reason, the precision statistical in this study is low, as reflected by the fact that our cases are highly distributed in all categories.

Also, our study examined only the MRI findings of the different breast cancers and not their characteristics in other techniques.

Finally, another limitation is that this is a retrospective study, and unrecognized biases might have influence our results.

Nonetheless these limitations, we believe in the potential future of the MRI for assist in the characterization and therapeutic planning of the different subtypes of breast cancer that required more investigations.

In summary, this study evaluated the MRI findings in the different subtypes of breast cancer according to BI-RADS system.

REFERENCES

1. Sardanelli F, Giuseppetti GM, Panizza P, et al. Sensitivity of MRI versus mammography for detecting foci of multifocal, multicentric breast cancer in fatty and dense breasts using the whole breast pathologic examination as a gold standard. AJR Am J Roentgenol 2004;183:1149–57.
2. Bartella L, Morris EA. Advances in breast imaging: magnetic resonance imaging. Curr Oncol Rep 2006;8:7–13.
3. Fischer U, Zachariae O, Baum F, von Heyden D, Funke M, Liersch T. The influence of preoperative MRI of the breasts on recurrence rate in patients with breast cancer. Eur Radiol 2004;14:1725–31.
4. Brennan ME, Houssami N, Lord S, et al. Magnetic resonance imaging screening of the contralateral breast in women with newly diagnosed breast cancer: systematic review and meta-analysis of incremental cancer detection and impact on surgical management. J Clin Oncol 2009;27:9560–9.

5. Obdeijn IM, Tilanus-Linthorst MM, Sprok S, et al. Preoperative Breast MRI can reduce the rate of tumor-positive resection margins and reoperations in patients undergoing breast-conserving surgery. AJR Am J Roentgenol 2013;200:304–10.

6. Loo CE, Straver ME, Rodenhuis S, et al. Magnetic resonance imaging response monitoring of breast cancer during neoadjuvant chemotherapy: relevance of breast cancer subtype. J Clin Oncol 2011;29:660–6.

7. Blaemke DA, Gatsenis CA, Chen MH, et al. Magnetic resonance imaging of the breast prior to biopsy. JAMA 2004;292:2735–42.

8. Montemurro F, Martinich L, Sarotto I, et al. Relationship between DCE-MRI morphological and functional features and histopathological characteristics of breast cancer. Eur Radiol 2007;17:1490–7.

9. Tuncbilek N, Karakas HM, Okten OO. Dynamic magnetic resonance imaging in determining histopathological prognostic factors of invasive breast cancers. Eur J Radiol 2005;53:199–205.

10. Chang YW, Kwon KH, Choi DL, et al. Magnetic resonance imaging of breast cancer and correlation with prognostic factors. Acta Radiol 2009;50:990–8.

11. Martinich L, Deantoni V, Bertotto I, et al. Correlations between diffusion-weighted imaging and breast cancer biomarkers. Eur Radiol 2012;22:1519–28.

12. Perou CM, Sorlie T, Eisen MB, et al. Molecular portraits of human breast tumours. Nature 2000;406:747–52.

13. Denley H, Pinder SE, Elston CW, Lee AH, Ellis IO. Preoperative assessment of prognostic factors in breast cancer. J Clin Pathol 2001;54:20–4.

14. Rakha EA, El-Sayed ME, Green AR, et al. Biologic and clinical characteristics of breast cancer with single hormone receptor positive phenotype. J Clin Oncol 2007;25:4772–8.

15. Cheang MC, Chia SK, Voduc D, et al. Ki67 index, HER2 status, and prognosis of patients with luminal B breast cancer. J Natl Cancer Inst 2009;101:736–50.

16. American College of Radiology. Breast Imaging Reporting and Data System (BI-RADS), 4th ed. Reston, VA: American College of Radiology, 2003.

17. Houssami N, Ciatto S, Macaskill P, et al. Accuracy and surgical impact of magnetic resonance imaging in breast cancer staging: systematic review and meta-analysis in detection of multifocal and multicentric cancer. J Can Oncol 2008;26:3248–58.

18. Elston CW, Ellis IO. Pathological prognostic factors in breast cancer. I. The value of histological grade in breast cancer: experience from a large study with long-term follow-up. Histopathology 1991;19:403–10.

19. Wolff AC, Hammond ME, Schwartz JN, et al. American Society of Clinical Oncology/College of American Pathologists guideline recommendations for human epidermal growth factor receptor 2 testing in breast cancer. J Clin Oncol 2007;25:118–45.

20. Gore JC, Manning HC, Quares CC, Waddell KW, Yankelev TE. Magnetic resonance in the era of molecular imaging of cancer. Magn Reson Imaging 2011;29:587–600.

21. Uematsu T, Kasami M, Yuen S. Triple-Negative breast cancer: correlation between MR imaging and pathologic findings. Radiology 2009;250:638–47.

22. Wang Y, Ikeda DM, Narasimhan B, et al. Estrogen receptor-negative invasive breast cancer: imaging features of tumors with and without human epidermal growth factor receptor type 2 overexpression. Radiology 2008;246:367–75.

23. Schrading S, Kuhl CK. Mammographic, US and MR imaging phenotypes of familial breast cancer. Radiology 2008;246:58–70.

24. Reis-Filho JS, Tutt AN. Triple negative tumors: a critical review. Histopathology 2008;52:108–18.

25. Seo BK, Pisano ED, Kuzimak CM, et al. Correlation of HER-2/neu overexpression with mammography and age distribution in primary breast carcinomas. Acad Radiol 2006;13:1211–8.

26. Ko ES, Lee BH, Kim HA, Noh WC, Kim MS, Lee SA. Triple-negative breast cancer: correlation between imaging and pathological findings. Eur Radiol 2010;20:1111–7.

27. Youk JH, Son EJ, Chung J, Kim JA, Kim EK. Triple-negative invasive breast cancer on dynamic contrast-enhanced and diffusion-weighted MR imaging: comparison with other breast cancer subtypes. Eur Radiol 2012;22:1724–34.