Received:
16 April 2013

Revised:
5 September 2013

Accepted:
11 September 2013

doi: 10.1259/bjr.20130220

Cite this article as:

Liu K, Xie P, Peng W, Zhou Z. The features of breast lymphoma on MRI. *Br J Radiol* 2013;86:20130220.

FULL PAPER

The features of breast lymphoma on MRI

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Objective: To investigate the morphological features of breast lymphoma (BL) on MRI.

Methods: MRI features of 20 patients with BL (12 primary and 8 secondary) were reviewed according to Breast Imaging-Reporting and Data System categories.

Results: 19 cases were unilateral and 1 was bilateral. According to the enhanced images, of the 20 cases, BL presented as a mass in 11 (55%), as an enhancement with no mass effect in 7 (35%) and as a mass and mixed enhancement with no mass effect in 2 (10%). There were 38 masses and 44 lesions with no mass effect in our study. All lesions showed mild heterogeneous internal enhancement. For lesions with mass effect,

the margins were smooth in 32% (12/38) and irregular in 68% (26/38); and the shape was oval in 87% (32/38). Kinetic curve assessment (13 cases, 38 lesions) revealed that the average initial rise rate was 104%. The type II enhancement curve appeared in 55% (21/38) of lesions. No significant differences between the primary and secondary BL were observed for any of the MRI features.

Conclusion: BL mostly appeared oval with irregular margins showing mild heterogeneous internal enhancement and/or as enhanced lesions with no mass effect with mild heterogeneous internal enhancement.

Advances in knowledge: Some special features on MRI are useful for the diagnosis of BL.

Breast lymphoma (BL) is a rare neoplasm that accounts for approximately 0.15% of malignant mammary neoplasms [1]. Most BLs are B-cell lymphomas and are rarely diagnosed as T-cells or other histiocytic lymphomas [2]. BL can be classified as either primary or secondary. The diagnosis of primary BL is limited to patients with no evidence of systemic lymphoma or leukaemia when the breast lesion is detected. Clinically, the disease should involve only the breast or the breast and ipsilateral lymph nodes. Secondary BL typically manifests with multiple breast lesions and known previous disease or with simultaneous lesions in the breast and one or more non-mammary organs [3,4].

There are some reviews of the features of BL imaging in the literature [5–19], but until now, the findings of MRI have, to the best of our knowledge, only been described in case reports [16,18,19] and in two articles with small sample sizes of 7 and 8 BLs [8,20]. Thus, the MRI findings of BL need further study. The aim of this study was to further investigate the MRI features of BL by documenting the morphological characteristics and dynamic contrast enhancement kinetic patterns according to the Breast Imaging-Reporting and Data System (BI-RADS) descriptors.

MATERIALS AND METHODS

Patients

From February 2006 to June 2012, 20 patients with BL who underwent pre-treatment breast MRI examination were included in this study. The diagnosis of BL was verified by fine-needle aspiration cytology/core needle biopsy in 12 cases and by surgery in 8 cases. The breast MRI was performed before biopsy and surgery. The institutional review board approved this retrospective study and waived informed consent.

Imaging techniques

The MRIs used a 1.5 T superconducting magnet (Signa Twinspeed Excite; GE Medical Systems, Milwaukee, WI) for 7 patients and a 3.0 T magnet (Signa HDxt, GE Medical Systems) for 13 patients.

For the 1.5 T magnet, axial T_1 weighted fast spin echo [repetition time (TR) ms/echo time (TE) ms, 460/10] and axial fat-suppressed T_2 weighted fast spin-echo (TR/TE, 3200/85) sequences were performed with a 32-cm field of view (FOV), 5-mm slice thickness with a 1-mm gap and a 320×160 matrix. A two-dimensional axial fat-suppressed T_1 weighted fast spoiled gradient-recall-echo sequence (TR/TE, 210/5; flip angle, 80°; other parameters, same as above) was obtained before and at 1 min after a bolus injection of 0.1 mmol kg⁻¹ of body weight of gadolinium dimeglumine.

For the 3.0 T magnet, the diagnostic MRI protocol began with a fast spin echo axial T_2 weighted with fat saturation (TR/TE, 6000/68) and axial T_1 weighted (TR/TE, 780/8) sequence with a 32-cm FOV, 5-mm slice thickness with a 1-mm gap, and a 320×256 matrix. Next, axial dynamic high-resolution simultaneous imaging of both breasts with the VIBRANT™ (GE Healthcare, Waukesha, WI) sequence (TR/TE, 4.2/2.1; inversion time, 13 ms; flip angle, 15°) was performed before and at 1 and 2 min after a bolus injection of 0.1 mmol kg⁻¹ of body weight of gadolinium dimeglumine (FOV, 32 cm; matrix, 320×256; thickness, 5 mm). Finally, a sagittal VIBRANT sequence was performed 3 min after a contrast medium injection (FOV, 26 cm; matrix, 320×200; thickness, 5 mm).

Imaging interpretation

Two radiologists with 7 years' and 3 years' experience in breast MRI reviewed each breast MRI examination in consensus. For each patient, the side of the lesion and the lesion size (maximum diameter) on MRI were recorded. The unenhanced T_1 weighted image and T_2 weighted image appearance of the lesions were described as iso-, hyper- or hypointense relative to the breast parenchyma. The presence or absence of skin thickening in the same quadrant as the lesion was recorded, and if present, its distance from the lesion was also recorded. The lesions were evaluated according to the BI-RADS MRI lexicon for enhanced breast lesions [21].

Kinetic curve assessment (13 cases at 3 T) was performed by placing a freehand region of interest (ROI) on the fastest-enhancing portion of the lesion, avoiding an ROI size of < 3 pixels. The fastest-enhancing portion of the lesion was defined as the brightest portion with exclusion of blood vessels and hemorrhage in the lesion after enhancement. In our study, T_{0min} , T_{1min} and T_{2min} represent the signal intensities of the lesions before and at 1 min and 2 min after contrast medium administration, respectively. In our series, the sagittal images have a higher signal intensity than the transversal images for the different imaging parameters, but the signal intensity of a normal breast tissue changed slightly before and after the contrast medium administration. Therefore, we standardised the signal intensity of the lesion on the sagittal images as T_{3min} using the following formula: $T_{3min} = (T_{2min-breast}/Sag_{breast}) \times Sag_{lesion}$, where $T_{2min-breast}$ and Sag_{breast} represent the normal breast signal intensities of the 2-min transversal and sagittal images, respectively, after the contrast medium administration, and where Sag_{lesion} represents the signal intensity of the lesion on the sagittal images. The initial rise rate (percentage change in the signal intensity course) was calculated according to the following formula: $(T_{1min} - T_{0min})/T_{0min} \times 100$. The type of enhancement curve was classified as Type I (when the curve exhibited a steady signal intensity increase, namely the persistent type), Type II (when the curve exhibited a fast early upstroke followed by a plateau, namely the plateau type) and Type III (when the curve exhibited a fast early upstroke followed by a loss of signal intensity, namely the washout type).

Statistical analysis

For statistical analysis, the SPSS® statistical software package was used (v. 16.0; SPSS Inc, Chicago, IL). Continuous variables

were analysed using the Mann–Whitney *U*-test, and categorical variables were analysed using the Fisher's exact test. $p < 0.05$ indicated statistical significance.

RESULTS

The study population included 20 females (mean age, 52 years; range, 37–80 years). The histological diagnosis of BL was classified as follows: 19 diffuse large B-cell lymphomas (DLBCL) and 1 follicular lymphoma (30% follicular lymphoma and 70% DLBCL). 12 cases were primary BLs, and 8 cases were secondary BLs.

The MRI features of the BLs are listed in Table 1. Among the cases, 95% (19/20) were unilateral (Figures 1 and 2) and only 5% (1/20)

Table 1. MRI findings of breast lymphoma (20 cases)

Features	<i>n</i>
Age (years)	52±12 (range, 37–80)
Lesion size (mm)	62±35 (range, 16–138)
Unilateral/bilateral (case)	19/1
Single/multiple lesion (case)	13/7
Left/right in unilateral (case)	13/6
Axillary adenopathy (case)	14
Increasing vascularity (case)	20
Skin thickening (case)	9
Patterns of enhancement (case)	
With mass effect	11
With and without mass effect	2
With no mass effect	7
Mass shape (lesion)	
Oval	32
Lobulated	4
Irregular	2
Mass margin (lesion)	
Irregular	26
Smooth	12
Enhancement with no mass effect (case)	
Segmental	3
Regional	5
Diffuse	1
Maximum peak of signal intensity within the first 2 min	1113±379
Initial rise rate (%)	104±30
Enhancement curve (lesion)	
Type I (persistent)	5
Type II (plateau)	21
Type III (washout)	12

Figure 1. Images (performed at 3 T) of a 44-year-old female with a right primary breast lymphoma (diffuse large B-cell lymphoma). (a) An unenhanced T_1 weighted transverse MRI shows a segmental hypointense area in the right breast. (b) The precontrast T_2 weighted fat-suppressed appearance is hyperintense in the breast parenchyma. (c-e) The T_1 weighted transverse and sagittal contrast-enhanced images show mild segmental heterogeneous enhancement and signs of increasing vascularity. (f) The kinetic curve assessment shows the maximum peak of signal intensity of lesions within the first 2 min of 1003, the initial rise rate of 83% and a type II (plateau type) enhancement curve.

Figure 2. Images (performed at 3 T) of a 55-year-old female with a right secondary breast lymphoma (diffuse large B-cell lymphoma). (a) An unenhanced T_1 weighted transverse MRI shows a hypointense mass in the right breast. (b) The precontrast T_2 weighted fat-suppressed appearance is hyperintense in the breast parenchyma. (c-e) The T_1 weighted transverse and sagittal contrast-enhanced images show an oval mass with mild heterogeneous internal enhancement, signs of increasing vascularity and skin thickening. (f) The kinetic curve assessment shows the maximum peak of signal intensity of lesions within the first 2 min of 1597, the initial rise rate of 154% and a type III (washout-type) enhancement curve.

were bilateral (Figure 3). Among the unilateral BLs, 65% (13/19) occurred in the left breast and 35% (6/19) occurred in the right breast. In addition, 65% (13/20) of all cases showed a single lesion in the breast (Figures 1 and 2) and 35% (7/20) showed multiple lesions (Figure 3). The average lesion size was 68 mm (range, 15–138 mm). Axillary adenopathy was present in 70% (14/20) of cases. Skin thickening was observed in 45% (9/20) of cases (Figure 2), which showed an average distance of 6 mm to the skin (range, 2–20 mm). Signs of increasing vascularity were found in 100% (20/20) of cases (Figures 1–3).

In all lesions, BL appeared mildly hypointense on the precontrast T_1 weighted image and hyperintense or mildly hyperintense on the pre-contrast T_2 weighted fat-suppressed image (Figures 1–3).

Among the cases, BL appeared as a lesion with mass effect in 55% (11/20) (Figure 2), as enhancement with no mass effect in 35% (7/20) (Figures 1 and 3) and as mixed enhancement with and without mass effect in 10% (2/20) only. There were 38 lesions with mass effect and 44 lesions with no mass effect in our study. All lesions showed mild heterogeneous internal enhancement (the area of significant variable signal intensity was <10% of the area of lesion) (Figures 1–3). For the lesions with mass effect, the margin of the masses was smooth in 32% (12/38) and irregular in 68% (26/38), and the shape of the masses was oval (the ratio between the long and short diameter in a slice at the maximum size of the lesion >1.2) for 84% (32/38) (Figure 2).

The kinetic curve assessments of 13 cases (38 lesions) performed at 3 T were analysed. The average ROI size was 5.7 cm^2 (range, 1.1–20.0 cm^2). The average maximum peak of signal intensity of lesion within the first 2 min was 1102 (range, 543–1936), the

average initial rise rate was 104%. The enhancement curve appeared as Type II in 55% of the lesions (21/38) (Figure 1), Type III in 32% of lesions (12/38) (Figure 2) and Type I in 13% of lesions (5/38).

The MRI features of the primary and secondary BLs are given in Table 2. No significant differences were detected between the primary and secondary BLs for any of the MRI features measured. However, compared with secondary BL, primary BL showed a larger lesion size (75 mm vs 59 mm) on MRI, a higher frequency of enhancements with no mass effect [50% (6/12) vs 13% (2/8)] and a lower frequency of type II enhancement curve [40% (6/15) vs 65% (15/23)].

DISCUSSION

In our series, the mean age of the population was 52 years, which was younger than the mean age of 63 years in the study by Rizzo et al [8], and 95% (19/20) of the histological diagnoses were DLBCL, in agreement with past results [2].

In our study, BL appeared mildly hypointense on the pre-contrast T_1 weighted image and hyperintense or mildly hyperintense on the precontrast T_2 weighted fat-suppressed image in all lesions. Our results for the BL appearance on the precontrast T_1 weighted and T_2 weighted images were consistent with the results of Rizzo et al [8] and Surov et al [20].

Our results showed that the main appearance of the BLs was with a mass effect [55% (11/20)], which was consistent with the results of Rizzo et al [8]. With regard to the lesions with mass effect (38 lesions), 84% had an oval shape, 68% had irregular margins and 100% showed mild heterogeneous

Figure 3. Images (performed at 1.5 T) of a 47-year-old female with bilateral primary breast lymphoma (diffuse large B-cell lymphoma). (a) An unenhanced T_1 weighted transverse MRI shows a diffuse hypointense area in the right breast and a regional hypointense area in the left breast. (b) The precontrast T_2 weighted fat-suppressed appearance is hyperintense in the breast parenchyma. (c,d) The T_1 weighted transverse and sagittal contrast-enhanced MR images show lesions with no mass effect with mild heterogeneous internal enhancement.

Table 2. The MRI features of primary (12 cases) and secondary (8 cases) breast lymphomas

Features	Primary	Secondary	<i>p</i> -value
Age (years)	53±14	52±8	0.616
Lesion size (mm)	75±38	59±30	0.316
Single/multiple lesion (case)	8/5	5/2	1.000
Unilateral/bilateral (case)	12/1	8/0	1.000
Left/right in unilateral (case)	8/3	5/3	1.000
Axillary adenopathy (case)	8	6	1.000
Increasing vascularity (case)	12	8	1.000
Skin thickening (case)	6	3	0.670
Pattern of enhancement (case)			
With mass effect	5	6	
With and without mass effect	1	1	
With no mass effect	6	1	0.219
Shape of mass (lesion)			
Oval	15	19	
Lobulated	1	2	
Irregular	0	1	1.000
Mass margin (lesion)			
Irregular	13	20	
Smooth	3	2	0.632
Enhancement with no mass effect (case)			
Segmental	3	1	
Regional	3	1	
Diffuse	1	0	1.000
Maximum peak of signal intensity within the first 2 min	1091±385	1139±406	0.886
Initial rise rate (%)	102±30	106±38	1.000
Enhancement curve (lesion)			
Type I (persistent)	3	2	
Type II (plateau)	6	15	
Type III (washout)	6	6	0.323

internal enhancement. To our knowledge, invasive ductal carcinomas (IDC), ductal carcinoma in situ (DCIS), phyllodes breast tumours, and fibroadenomas may have a mass effect [22–25], but they usually have an irregular, lobulated, round shape, which is not similar to the oval shape of BLs appearing as mass. Additionally, IDC and DCIS usually show heterogeneous enhancement, which is different from the mild heterogeneous enhancement of BLs [22,25]. Furthermore, most fibroadenomas have smooth margins, but most BLs have irregular margins [23,24].

In our study, enhancement with no mass effect was observed in 35% of cases (7/20) and mixed enhancement with and without mass effect was observed in 10% of cases (2/20). All 44 of the lesions with enhancement with no mass effect showed mild heterogeneous internal enhancement. BLs with enhancement

with no mass effect often need to be differentiated from IDC, DCIS and mastitis. These diseases mostly show heterogeneous internal enhancement, which is not consistent with the mild heterogeneous internal enhancement of BL. Furthermore, mastitis mostly shows rim or rim-like enhancement on contrast-enhanced MRI with central hypointense areas appearing hyperintense on T_2 weighted imaging [26], and the lesions of DCIS with no mass effect show a predominantly clumped internal enhancement pattern [22], which was not found in this study of BL.

In our study, the kinetic curve assessment showed that the average maximum peak of signal intensity of lesions within the first 2 min was 1102, and the average initial rise rate was 104%, which is in agreement with a recent study showing a rate of 110% [8]. Most BLs [21(55%)/38] showed a Type II enhancement curve, which was consistent with the results of recent studies [8,20].

Surov et al [20] reported that the size of the intramammary lesions identified was larger in primary than in secondary lymphoma, which agreed with the results of our study showing that primary BLs were larger than secondary BLs (75 mm vs 59 mm, respectively). Additionally, in our study, primary BLs had a higher frequency of enhancements with no mass effect (50% vs 13%) and a lower frequency of type II enhancement curve (43% vs 83%). However, these MRI features were not significantly different in our study and need further research.

Although to our knowledge our series is the largest reported, the numbers are still relatively small, and our results might be biased owing to the limited sample size. In addition, the retrospective design is a limitation of our investigation. The 12 patients

diagnosed using fine-needle aspiration cytology or core-needle biopsy restricted our imaging histopathology comparing research for all cases. Another possible limitation of our investigation is that the images of the 20 patients were acquired using 2 MRIs with different magnetic fields. However, in our study, the kinetic enhancement analysis was made only for the 3-T patients, although we believe that the strength difference between the 1.5-T and 3.0-T magnets is not great and that the MRIs can form similar enhancement degrees in breast lesions if suitable imaging parameters are provided [27].

In conclusion, most of the BLs appeared as oval masses with irregular margins showing mild heterogeneous internal enhancement and/or as lesions with no mass effect with mild heterogeneous internal enhancement.

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