Pre-operative MR imaging in patients with DCIS: impact of VAB procedure-related changes

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Aims and objectives

DCIS DIAGNOSIS: STEREOTACTIC VAB

Ductal carcinoma in situ (DCIS) diagnosis has markedly increased in the last decades mainly due to the widespread use of screening mammography. Nowadays DCIS accounts for nearly 25% of breast cancer undergoing surgical treatment [1-3]. Microcalcifications are the most common mammographic presentation of DCIS [4-6].

Percutaneous stereotactic vacuum-assisted breast biopsy (VAB) is the diagnostic tool of choice in the case of microcalcifications or non-palpable lesions visible only on mammograms. Vacuum-assisted biopsy (VAB) is preferred due to the possibility of obtaining multiple specimens with a single insertion, larger tissue specimens and greater calcifications retrieval rates resulting in lower frequency of histologic underestimation and lower biopsy repetitions [7-10].

A localizing clip is often placed as marker at the end of the biopsy. VAB procedure-related changes such as air and hematoma are common findings on mammograms acquired immediately after VAB, as well as few weeks later, regardless of the needle size and the VAB-system used during the procedure [11-14].

EFFECTS OF VAB ON MRI

MR imaging has become an important tool in patients with DCIS diagnosis; an accurate pre-operative evaluation of breast cancer extent may be useful in women undergoing breast-conserving surgery in order to reduce re-excision and recurrence [15,16]. According to the literature, MR imaging alone or in conjunction with mammography shows high correlation with final pathologic size of DCIS lesions than mammography alone [17-20]. Since pre-operative MR imaging is often performed soon after cancer diagnosis with percutaneous biopsy, VAB procedure-related changes may also impair MR imaging evaluation.

PURPOSE

The purpose of this study was to evaluate the spectrum of VAB procedure-related changes (i.e. hematoma, clip artifact, needle tract) on breast MR imaging in patients with
newly diagnosed DCIS at vacuum-assisted biopsy under stereotactic guidance, and their impact in the pre-operative assessment of breast cancer extent.
Methods and materials

STUDY SUBJECTS

From September 2012 to February 2015, in this retrospective study, 209 consecutive VABs of the breast were performed at our institution under stereotactic guidance. We included patients who had VAB diagnosis of pure DCIS and then underwent pre-operative breast MR imaging (performed within 60 days from biopsy); final population included 47 patients (mean ± standard deviation (SD) age, 60.4 ± 9.0 years; range 43.0 - 80.0 years).

Biopsied lesions were microcalcifications; they were not palpable and not visible at ultrasound examination; architectural distortion was associated in 4 cases (8.5%). According to the ACR BI-RADS lexicon, 38 (80.9%) lesions were classified as BI-RADS 4, 6 (12.8%) lesions as BI-RADS 5, 3 (6.3%) lesions classified as BI-RADS 3.

STEREOTACTIC VAB

VAB under stereotactic guidance was performed by radiologists with more than five years of experience. Biopsies were performed using a prone stereotactic table (Mammobed, Giotto, IMS). Three different VAB devices with three different needles were used: an 11-gauge Mammotome (®) (Devicor Medical Products, Cincinnati, OH, USA) probe; a 10- or 12-gauge EnCor (®) (Bard-SenoRx Tempe, AZ, USA) probe and a 9-gauge Eviva (®) (Hologic, Inc, Marlborough, MA, USA) probe. Standard procedure in our department, usually, includes 12 cores collection; the procedure stopped after 6 samples if patient reported pain or discomfort and presence of calcifications was ensured at the specimen radiography. The biopsy cavity was marked with a titanium non-magnetic localizing clip Mammomark™ (Devicor Medical Products, Cincinnati, OH, USA), Senomark™ (Bard-SenoRx Tempe, AZ, USA) or SecurMark™ (Hologic, Inc, Marlborough, MA, USA) in 40/47 cases and two-view post-procedure mammograms were obtained in all this cases; were excluded some selected cases (e.g. lesion maximum diameter greater than 30 mm).

MR EXAMINATION
MR examination was performed on a 1.5 T scanner (Magnetom Avanto, Siemens Medical System, Erlangen Germany) with a dedicated, bilateral, 7-channel phased-array coil and the patient was in prone position. The protocol of breast MRI performed in our department includes T2-weighted Short-Tau-Inversion-Recovery (STIR) imaging and Dynamic contrast-enhanced study (DCE); imaging acquisition parameters are summarized in table 1 (fig. 1). Gadobenate Dimeglumine (Gd-BOPTA-Multihance, Bracco, Milan, Italy) was administered as an automated bolus injection at a dose of 0.1 mL/kg body weight at a flow rate of 2 mL/s, followed by flushing of 20 mL of saline. Serial dynamic images were acquired before injection of contrast agent and five times after the start of injection. After the examination, images underwent post-processing: subtraction of the pre-contrast images from the post-contrast images.

IMAGING ANALYSIS

Two experienced radiologists (more than five years experience in breast imaging), informed about the location of biopsied lesion, evaluated in consensus anonymized MR images of each patient, during a singular reading session. They classified each of 47 biopsied lesions in three categories (table 2- fig.2), according to absence/presence of post-biopsy changes (hematoma, seroma, "black hole" artifact, needle tract) that did not mask biopsied lesions (category A), or that impaired partially (category B) or significantly (category C) their detection.

Post-biopsy changes were evaluated as follow:

- the needle tract: a linear signal alteration starting from the skin at the presumed needle entrance site and directing to the area of lesion enhancement or biopsy related changes;
- "black hole" artifact: susceptibility artifact on pre-contrast T1-weighted images caused by localizing clips;
- hematoma or seroma: in particular, we referred to seroma when a well-circumscribed mass lesion homogeneously hyperintense on STIR and hypointense on T1-weighted images was present without evidence of cystic lesion close to the biopsy site in prior US examination and mammograms. The presence/absence of peripheral rim enhancement around hematoma or seroma cavity was annotated; we named it "perifocal inflammation" when a thin (<2 mm) well-defined border with a continuous enhancement curve was present whereas we referred to "suspicious rim enhancement" when thick and irregular margins and/or nodular components were observed.

STATISTICAL ANALYSIS
Descriptive statistics were performed. Kruskal-Wallis test or chi-square test were used to evaluate significant differences among the categories concerning needle size, number of samples, time interval between biopsy and MR examination, presence of immediate hematoma/seroma, presence of residual calcifications, and final pathologic diagnosis of surgical specimens. Moreover, in patients undergoing breast-conserving surgery (BCS), the Chi-square test was used to evaluate the differences concerning the breast MRI negative predictive values (NPV) for tumor-negative resection margins between category A versus category B and C (p<0.005 was considered significant).
**Fig. 1:** Table 1: MR imaging acquisition parameters

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### Table 2: Categorization of Biopsied Lesions

<table>
<thead>
<tr>
<th>Categories</th>
<th>Definitions</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Mass or non-mass area of enhancement at the presumed biopsied site without post-biopsy changes or presence of biopsy changes (e.g., small seroma/hematoma with perifocal inflammation) that do not impair lesion demarcation and assessment (size in the transversal plane, morphology and enhancement kinetics assessment) or completely absence of enhancement in cases without marking clip.</td>
</tr>
<tr>
<td>B</td>
<td>Mass or non-mass area of enhancement at the presumed biopsied site with margins that cannot be separated from post-biopsy changes e.g. because of a peripheral rim enhancement associated to hematoma, that is continuous to the presumed lesion enhancement or a “black hole” artifact that partially masks the lesion enhancement.</td>
</tr>
<tr>
<td>C</td>
<td>Presence of marked post-biopsy changes e.g. hematoma/seroma with peripheral rim enhancement or “black hole” artifact alone without any area of mass or non-mass enhancement clearly attributable to the biopsied lesion.</td>
</tr>
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</table>
Results

MR IMAGING FINDINGS POST BIOPSY

Needle tract was evident in 9/47 cases (19.1%) and a thin faint area of enhancement was visible in 4/9 cases along the tract on post-contrast images. Susceptibility artifact caused by localizing clips was evident in all cases where the clip was placed after VAB. A seroma was present in the biopsy site in 5/47 (10.6%) cases and mean maximum diameter ± SD was 13±3.2 mm (range, 9-16 mm). Hematoma was present in 15/47 (31.9%) cases and the mean maximum diameter ± SD was 18.7 mm ±7.1. With the exception of one case, all of 20 seroma/hematomas evident on MR imaging were visible on mammograms acquired after VAB.

LESIONS IDENTIFICATION AND IMAGING ANALYSIS

A reliable DCIS detection was possible in 23/47 (49%) cases (category A-fig. 3 and 4); 16/47 (34%) cases were classified as category B (fig. 5 and 6) and 8/47 (17%) cases as category C (fig. 7 and 8).

There were no significant differences among the three categories for all the evaluated parameters (table 3- fig. 9). In particular, the mean time difference between the VAB procedure and MR examination was not significant. Presence of "black hole" artifact, hematoma and/or seroma or their combination compromised the detectability of DCIS (category B and C) in 8/24 (33.3%), 12/24 (50%) and 4/24 (16.7%) cases respectively. Within the patients undergoing BCS (25/47), 11/25 (44%) cases were included in category A and resection margins were positive in 2/11 (18.2%) cases; 14/25 (56%) cases were part of category B and C and margins were positive in 2/14 (14.3%). The NPV was 81.8% and 85.7% for category A and for category B and C, respectively, and the difference was not significant (p=0.60).
<table>
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<th>Categories</th>
<th>Definitions</th>
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<tr>
<td>A</td>
<td>mass or non-mass area of enhancement at the presumed biopsied site without post-biopsy changes or presence of biopsy changes (e.g. small seroma/hematoma with perifocal inflammation) that do not impair lesion demarcation and assessment (size in the transversal plane, morphology and enhancement kinetics assessment) or completely absence of enhancement in cases without marking clip</td>
</tr>
<tr>
<td>B</td>
<td>mass or non-mass area of enhancement at the presumed biopsied site with margins that cannot be separated from post-biopsy changes e.g. because of a peripheral rim enhancement associated to hematoma, that is continuous to the presumed lesion enhancement or a “black hole” artifact that partially masks the lesion enhancement</td>
</tr>
<tr>
<td>C</td>
<td>presence of marked post-biopsy changes e.g. hematoma/seroma with peripheral rim enhancement or “black hole” artifact alone without any area of mass or non-mass enhancement clearly attributable to the biopsied lesion</td>
</tr>
</tbody>
</table>

**Fig. 2:** Table 2: categorization of biopsied lesions

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Fig. 3: 60-years-old woman with VAB diagnosis of high grade DCIS of the left breast confirmed at final histopathologic diagnosis. A and C. Mammograms (CC and MLO) show coarse granular calcifications, within a denser area of the breast, with linear distribution and 20 mm extent in the upper Outer quadrant, that underwent stereotactically guided 9-gauge VAB. B and D. Mammograms (CC and MLO) acquired after VAB procedure show residual microcalcifications in association with the presence of air and the localizing clip (black circle) at the biopsy site.
**Fig. 4:** Axial images from MR performed 45 days after the VAB procedure. The "black hole" artifact (black arrow) due to the clip placed during stereotactic biopsy is evident on T1-weighted pre-contrast (A) and post contrast subtracted (B) images. In association to the clip artifact, the same slice clearly shows, at the biopsied site, a suspicious mass area of enhancement (white arrow) very close to the pectoral muscle on T1-weighted post contrast-enhanced subtracted image(B). This lesion was included in category A.

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Fig. 5: 60-years-old woman with VAB diagnosis of high grade DCIS of the right breast confirmed at final histopathologic diagnosis. A and C. Mammograms (MLO and CC) show fine linear and branching calcifications, with linear distribution and 50 mm extent in the lower-outer quadrant of the right breast, that underwent stereotactically guided 11-gauge VAB. B and D. Mammograms (MLO and CC) acquired after VAB procedure show residual microcalcifications in association with the presence of air and the localizing clip (black circle) at the biopsy site.

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Fig. 6: Axial images from MR performed 22 days after the VAB procedure. T1 weighted pre-contrast (A) and post-contrast subtracted (B) images show a linear signal alteration (needle tract- black arrow) starting from the skin at the presumed needle entrance site and directing to the "black hole" artifact (localizing clip-blue arrow). A thin faint area of enhancement is visible along the tract on post-contrast image (B). Furthermore, the same slice shows an ovalar area that was hypointense on T1 weighted pre-contrast (A) image and hyperintense on STIR image (C), with an irregoular suspicious rim enhancement on T1 post-contrast subtracted image (B), that is attributable to seroma cavity (white arrow) post-VAB at the biopsy site. These changes are in continuous, in a more caudal slice (D), with a non mass area of enhancement (black star) on T1 weighted post contrast subtracted image, extending for 15 mm. DCIS assessment was partially limited by post biopsy changes. Lesion was included in category B.

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Fig. 7: 59-years-old woman with VAB diagnosis of high grade DCIS of the right breast confirmed at final histopathologic diagnosis. A and C. Mammograms (CC and MLO) show fine pulverulent calcifications with linear distribution and 15 mm extent in the upper-outer quadrant of the right breast, that underwent stereotactically guided 12-gauge VAB. B and D. Mammograms (CC and MLO) acquired after VAB procedure show residual microcalcifications in association with the presence of air, a round opacity (white arrow) corresponding to immediate hematoma and the localizing clip (black circle) at the biopsy site.

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Fig. 8: Axial images from MR performed 30 days after the VAB procedure. The "black hole" artifact (black arrow) due to the clip placed during stereotactic biopsy is particularly evident on T1-weighted pre-contrast (A) and STIR (C) images. In association to the clip artifact, the same slices show a round mass area (white arrow), that is hypo-hyperintense on T1 weighted pre-contrast image (A), hyperintense on STIR image (C), hypointense with peripherical thin "ring" enhancement on T1-weighted contrast-enhanced subtracted image (B), which corresponds to hematoma post-VAB. There is no clear evidence of suspicious areas of enhancement at the biopsy site. The biopsy changes significantly impaired the pre-operative assessment of DCIS and the lesion was included in category C.

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<table>
<thead>
<tr>
<th>Parameter</th>
<th>Category A</th>
<th>Category B</th>
<th>Category C</th>
<th>Overall</th>
<th>p</th>
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<tbody>
<tr>
<td>Time interval</td>
<td>24.52</td>
<td>22.44</td>
<td>21.38</td>
<td>23.26</td>
<td>0.59</td>
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<tr>
<td>VAB/MR examination [days] *</td>
<td>6.98</td>
<td>8.90</td>
<td>11.72</td>
<td>8.47</td>
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<tr>
<td>Maximum extent on Mx [mm] *</td>
<td>25.00</td>
<td>22.50</td>
<td>18.98</td>
<td>21.57</td>
<td>0.02</td>
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<tr>
<td>Needle size</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9 or 10 G</td>
<td>16 (69.6)</td>
<td>12 (75)</td>
<td>5 (62.5)</td>
<td>33 (70.2)</td>
<td>0.82</td>
</tr>
<tr>
<td>11 or 12 G</td>
<td>7 (30.4)</td>
<td>4 (25)</td>
<td>3 (37.5)</td>
<td>14 (29.8)</td>
<td></td>
</tr>
<tr>
<td>Number of samples</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 samples</td>
<td>7 (30.4)</td>
<td>6 (37.5)</td>
<td>1 (12.5)</td>
<td>14 (70.2)</td>
<td>0.46</td>
</tr>
<tr>
<td>12-16 samples</td>
<td>16 (69.6)</td>
<td>10 (62.5)</td>
<td>7 (87.5)</td>
<td>33 (29.8)</td>
<td></td>
</tr>
<tr>
<td>Mx after VAB</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Mx not performed (n=8)</td>
<td>4 (17.4)</td>
<td>3 (18.7)</td>
<td>1 (12.5)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Immediate</td>
<td>13 (56.5)</td>
<td>11 (68.7)</td>
<td>7 (87.5)</td>
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<tr>
<td>hematoma/seroma (n=31/39)</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Residual calcifications (n=33/39)</td>
<td>18 (78.3)</td>
<td>11 (68.7)</td>
<td>4 (50)</td>
<td></td>
<td></td>
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<td>Final pathologic diagnosis</td>
<td></td>
<td></td>
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<tr>
<td>DCIS (n=39)</td>
<td>19 (82.6)</td>
<td>12 (75)</td>
<td>8 (100)</td>
<td></td>
<td>0.31</td>
</tr>
<tr>
<td>Inv Ca (n=8)</td>
<td>4 (17.4)</td>
<td>4 (25)</td>
<td>0 (0)</td>
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</table>

*Mean = standard deviation
Data in parentheses are percentages

Fig. 9: Table 3: differences among the three categories for all the evaluated parameters

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Conclusion

Post-VAB biopsy changes might affect DCIS detection on MRI, though pre-operative assessment of the breast cancer is not significantly compromised. Some limitations of our study need to be considered including the retrospective design and the small size population. Furthermore, our study focused on local assessment of biopsied lesion (e.g. the extension) and not on the evaluation of multicentric and/or contralateral disease.
Personal information

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References


