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Clinical utility of contrast-enhanced spectral mammography as an adjunct for tomosynthesis-detected architectural distortion

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ABSTRACT

Objective: Supplement tomosynthesis-detected architectural distortions (AD) with CESM to better characterize malignant vs benign lesions.
Methods: Retrospective review CESM prior to biopsied AD. Pathology: benign, radial scar, or malignant.
Results: 49 lesions (45 patients). 29 invasive cancers, 1 DCIS (range, 0.4–4.7 cm); 9 radial scars; 10 benign. 37 (75.5%) ADs had associated enhancement. PPV 78.4% (29/37), sensitivity 96.7% (29/30); specificity, 57.9% (11/19); NPV, 91.7% (11/12). False-positive rate 21.6% (8/37); false-negative rate, 8.3% (1/12). Accuracy 81.6% (40/49).
Conclusions: High sensitivity and NPV of CESM in patients with AD is promising as an adjunct tool in diagnosing malignancy and avoiding unnecessary biopsy, respectively.

1. Introduction

The Breast Imaging Reporting and Data System (BI-RADS) lexicon defines an architectural distortion (AD) as a distortion of breast tissue with no definite visible mass but with spiculations that radiate from a point with focal retraction or distortion at the edge of the parenchyma [1,2]. The differential diagnosis for AD is wide-ranging—from malignancy to a variety of benign outcomes such as radial scar, complex sclerosing lesions, and postoperative changes. Primary AD (defined as cases that did not occur from breast intervention, trauma, or infection) has been associated with breast malignancy in one-half to two-thirds of cases [3,4]. Given the high rate of malignancy associated with these lesions, breast imagers typically recommend image-guided biopsy or surgical excision of the suspicious area when a patient has primary architectural distortion.

Increased clinical use of digital breast tomosynthesis (DBT) has increased detection of AD [5–9]. In a recent study, architectural distortion was identified more readily with tomosynthesis than with 2-dimensional (2D) mammography; 73% of identified distortions were seen on tomosynthesis only, and 21% of those 2D-occult distortions yielded a cancer diagnosis [8]. In a study by Ray et al. [10], 36% of ADs identified with tomosynthesis yielded a cancer diagnosis. Because approximately 60% of the time these AD cases are related to benign entities, it is important and helpful to identify distinguishing features that may persuade or dissuade a radiologist to biopsy the lesion.

Although a few studies have examined the use of magnetic resonance imaging (MRI) of the breast to better characterize AD [11–15], previous studies have shown MRI to be a useful adjunct to conventional imaging, given the high sensitivity of MRI in the detection of invasive tumors. Normal MRI findings were reassurance that the abnormalities represented summation artifacts and led to increased confidence in close radiographic follow-up of these patients [16].

Contrast-enhanced spectral mammography (CESM), a newer breast imaging modality than MR, provides practitioners with an additional way to assess enhancement characteristics of abnormal mammographic findings, using standard mammographic equipment. In instances where an area of AD is seen on mammography or tomosynthesis, CESM could be used to supplement further characterization of the distortion. To our knowledge, no literature addresses the use of CESM to better characterize tomosynthesis detected AD. Therefore, we designed this study to investigate whether breast CESM as an adjunct, diagnostic tool can

Abbreviations: AD, architectural distortion; BI-RADS, Breast Imaging Reporting and Data System; CC, craniocaudal; CESM, contrast-enhanced spectral mammography; CI, confidence interval; DBT, digital breast tomosynthesis; DCIS, ductal carcinoma in situ; DE-CESM, dual-energy contrast-enhanced spectral mammography; FFDM, full-field digital mammography; MLO, mediolateral oblique; MRI, magnetic resonance imaging; ROC, receiver operating characteristic; 2D, 2-dimensional; US, ultrasound.

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be used to effectively exclude nonmalignant lesions in patients with AD on tomosynthesis, thereby reducing the need for needle biopsies or surgical excisions.

2. Methods and materials

2.1. Patient selection

The cases for this study were collected from an ongoing institutional review board approved research protocol in order to better characterize BI-RADS 4 and 5 lesions. Informed consent was obtained from all participants before a CESM was performed. We retrospectively selected the cases of tomosynthesis-detected AD who underwent a dual-energy (DE)-CESM from August 28, 2014, through January 13, 2016 (410 total), prior to their biopsy or surgical excision. We included lesions that met the following criteria: 1) AD in patients with category 4 or 5 lesions according to BI-RADS; 2) available pathologic results from either image-guided or surgical biopsies; and 3) at least one year of postbiopsy imaging or clinical follow-up. To capture the lesions of AD only, mammographic masses with spiculation were excluded (BI-RADS 5 lesions) as were lesions with AD related to known benign causes, such as a stable postsurgical scar (BI-RADS 2).

2.2. Imaging work-up and interpretation

Screening and/or diagnostic mammograms done which demonstrated tomosynthesis-detected AD were reviewed. Cases were interpreted by dedicated breast imagers (4 of whom are fellowship-trained; the fifth has more than 25 years of experience reading mammograms). Patients with AD on screening mammography were recalled for additional diagnostic mammographic views as part of a standard diagnostic protocol (typically mediolateral tomosynthesis and spot-compression tomosynthesis projections) and an ultrasound examination, which was done with a standard, high-frequency transducer.

2.3. CESM technique

The patients were seated in the mammography suite to minimize vasovagal episodes. They received contrast via a single-lumen power injector: 1.5 mL/kg of Omnipaque 350 (GE Healthcare, Inc. Princeton NJ USA) at a rate of 3 mL/s. Exactly 2 min after contrast administration we compressed the breast and obtained images. The examination began with the mediolateral oblique (MLO) view of the affected breast (because this view encompasses the most breast tissue). Next, images on the craniocaudal (CC) view were acquired. Image acquisition was completed within 7 min. The low-energy and recombined images were immediately available after the study to an interpreting radiologist.

A total of 4 standard, low-energy (standard mammographic) views and 4 recombined (or contrast-enhanced) views were available, including bilateral CC and MLO projections at both settings. Readings were performed on dedicated workstations that were calibrated for controlled, ambient-lighting conditions and compared with prior examinations, if available, and the conventional screening or diagnostic mammogram that had the initial finding of AD.

The recombined CESM images (iodine-enhanced) were reviewed by 5 breast fellowship trained breast imagers. Reading criteria were based on the intensity of contrast enhancement of the lesion (none, mild, moderate, and marked) similar to those described in the BI-RADS lexicon for MRI, developed by the American College of Radiology [2]. Background parenchymal enhancement of the breasts was also noted (none, mild, moderate, and marked; asymmetric or symmetric), as previously described [17]. Lesions that showed enhancement beyond breast background were considered to be abnormal.

2.4. Data collection and statistical analysis

The AD descriptors, sonographic correlates, and enhancement characteristics were recorded from the radiology reports created by the interpreting radiologist in standard practice who were blinded to the diagnostic outcome at the time of interpretation.

Descriptive statistics were used to describe characteristics of the data set. Pathologic results were used to calculate rates of true-positive, true-negative, false-positive, and false-negative lesions [18]. The pathologic results were collected from the biopsy or surgical excision reports, or both, and divided into benign, radial scar, high-risk, or malignant lesions. A true-positive case was defined by histopathology and included invasive ductal carcinoma, invasive lobular carcinoma, and ductal carcinoma in situ (DCIS). A true negative was defined by non-malignant histopathology after image guided biopsy and all cases had at least benign imaging/clinical follow-up of 1 year.

3. Results

Over the 17-month study period, 410 CESM examinations were performed. No severe IV contrast reactions were reported. Mild hives in one patient resolved with po Benadryl and observation.

The data set included 49 lesions in 45 patients (4 patients had 2 qualifying lesions each). Ultrasound examinations were performed in 48 of the 49 lesions, and a corresponding sonographic correlate was visualized in 30 of these 49 lesions (61.2%). Calcifications within the area of distortion were targeted for biopsy in the 1 case where ultrasonography was not performed. If a sonographic correlate was found to correspond to the AD, the lesion was biopsied via ultrasound (Table 1–3).

The following types of biopsies were performed on the 49 biopsy-confirmed lesions: 12-gauge core ultrasound biopsy, 30; 12-gauge core tomosynthesis-guided biopsy, 18; and surgical biopsy, 1. The surgical biopsy was performed because the distortion could not be seen from a position considered acceptable for a safe, nonsurgical biopsy.

The histopathologic findings showed 29 invasive carcinomas and 1 case of ductal carcinoma in situ without invasion. The positive predictive value of AD was 30/49 (61%). Of the invasive carcinomas, 16 were invasive ductal carcinomas (4 lesions with concomitant ductal carcinoma in situ), 12 were invasive lobular carcinoma (1 case with concomitant ductal carcinoma in situ), and 1 was low-grade adenosquamous carcinoma (Table 1, Figs. 1 and 2). There were 9 radial scars, 2 of which contained high-risk lesions (atypical ductal hyperplasia and flat epithelial atypia) (Table 2); and 10 benign lesions, including fat necrosis (Fig. 3). The 4 patients with 2 lesions had 2 biopsies each. One of these patients had 2 biopsies with benign results; the second had 2 areas of invasive ductal carcinoma; the third had 1 area of invasive ductal carcinoma and 1 area of invasive lobular carcinoma; and the fourth had invasive lobular carcinoma and a benign biopsy. On histology, the malignant lesions ranged in size from 0.4 cm to 4.7 cm.

The initial diagnostic imaging reports were used to determine AD enhancement on CESM. The radiologists were blinded to the lesions as the study was performed prior to the image guided biopsy. Of the 19 benign lesions, 32% (6/20) had moderate or marked BPE with the remainder of the cases showing mild or no BPE. Similarly, of the malignant lesions, 27% (8/30) had moderate or marked BPE with the remainder of the cases showing mild or no BPE.

Of the 49 lesions, 37/49 (75.5%) of the ADs enhanced on CESM (Table 3). Of these, 29 were malignant (including invasive and DCIS lesions), with a positive predictive value of enhancement on CESM of 29/37 (78.4%) (95% CI, 61.8%–90.2%). The sensitivity of enhancement on CESM for AD was 29/30 (96.7%) (95% CI, 82.8%–99.9%), the specificity was 11/19 (57.9%) (95% CI, 33.5%–79.8%), and the negative predictive value was 11/12 (91.7%) (95% CI, 61.5%–99.8%). The false-positive rate was 8/37 (21.6%) (95% CI, 9.8%–38.2%), and the false-negative rate was 1/12 (8.3%) (95% CI, 0.2%–38.5%). The 1 case of malignancy in which the lesion did not enhance was a 4-mm cancer (Fig. 4) that, in