REVIEW ARTICLE

CONTENTS

Multimodal management of breast architectural distortion: an analytical literature review

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ABSTRACT

Aim: The objective of this literature review was to determine the optimal diagnostic algorithm for breast cancer detection associated with architectural distortion.

Materials and Methods: The Pubmed, Google Scholar, Web of Science, and Scopus databases was used to search for materials on architectural distortion, associated pathologies, and radiological imaging methods.

Conclusions: Architectural distortions may represent both benign and malignant pathology, but ultrasound, magnetic resonance, and roentgenological signs may not always with confidence determine the etiology of these changes. Therefore, the correct diagnostic algorithm which uses contrast imaging methods and digital breast tomosynthesis can prevent potentially exceeding radiation exposure, and unnecessary biopsies, change surgical operation volumes, decrease patient stress from procedures, and reduce the number of resources spent. After analyzing a number of scientific sources, we recommend morphological verification of all architectural distortions that are not the result of surgery, trauma, or that accumulate contrast media during breast imaging.

KEY WORDS: breast cancer, digital breast tomosynthesis, breast magnetic resonance imaging, breast ultrasound, contrast-enhanced mammography

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INTRODUCTION

Architectural distortion (AD) is a deformity of normal breast parenchyma without an obvious visualized mass [1-3]. AD is the third most common manifestation of non-palpable breast cancer (BC), and 12–45% of them are missed BC on full-field digital mammography (FFDM) [4-9]. An AD can be main or associated finding that is combined with signs of an underlying mass [3]. Interpretation of the data and further tactics for AD is challenging due to the large number of pathologies associated with AD, including both benign and malignant processes, such as sclerosing adenosis, radial scar, various types of breast cancer, fat necrosis, and other changes associated with surgery, biopsy, or trauma [1, 4, 5, 10-12]. Correctly chosen diagnostic tactics, the use of modern diagnostic methods, such as contrast-enhanced mammography (CEM) and digital breast tomosynthesis (DBT), can prevent potential radiation exposure, unnecessary biopsies, change the scope of surgery, or determine the feasibility of surgery in general, which reduces the amount of stress for women.

AIM

The objective of this literature review was to determine the optimal diagnostic algorithm for breast cancer detection associated with architectural distortion.

MATERIALS AND METHODS

The Pubmed, Google Scholar, Web of Science, and Scopus databases was used to search for materials on architectural distortion, associated pathologies, and radiologic research methods.

REVIEW AND DISCUSSION

In this article, in addition to diagnostic methods in radiology, we will consider the main benign and malignant findings that can be represented by AD. Among the malignant findings represented by AD the most common were invasive lobular carcinoma (ILC), invasive ductal carcinoma (IDC), and ductal carcinoma in situ (DCIS) [1, 10-12]. Invasive cancer forms account

for 78–90% of malignant pathology [9, 13-15]. The most frequent benign findings associated with AD include radial scar, sclerosing adenosis, parenchymal changes, and fat necrosis after surgery, biopsies, and trauma [1, 4, 5, 10-12, 16].

MAMMOGRAPHY

AD accounts for about 6% of pathological findings visualized during FFDM [4,5]. Most often, AD and all the related pathologies are incidental asymptomatic mammographic findings and less often palpable lumps [1, 4, 5, 10, 17-19]. The average age of patients with an AD that hides a malignant pathologies is 59 years and 55 years for a benign pathology [1]. AD is the most commonly missed pathology in false-negative results, which may be related to diagnostic errors or reduced sensitivity of FFDM due to the density of the breast parenchyma, peculiarities of glandular tissue distribution, and tumor type [2, 20]. During the data collection, no correlation was found between the AD detection and age, race, family history, and individual history of BC treatment, which would help to correlate AD pathologies.

According to the Breast Imaging-Reporting and Data System (BI-RADS) Atlas, radiologically, AD is most often presented as an area with radial spicules emanating from a single point and localized retraction or distortion of the parenchymal margin [3]. It is worth noting that no sonographic, radiologic, or magnetic resonance (MR) signs can be used with certainty to identify the pathology hidden by an AD [10, 21-23]. It has been suggested that AD with concomitant findings such as calcifications increases the risk of BC; therefore, it is important to report the location and concomitant findings, although some authors consider these data to be statistically insignificant [3, 24, 25].

DIGITAL BREAST TOMOSYNTHESIS

In recent years, DBT has become a highly sensitive method for detecting AD and generally increases sensitivity and accuracy compared to FFDM, and reduces the patient recall rate [6, 7, 24, 26, 27]. DBT is the most informative for breasts with dense parenchyma, it helps to partially eliminate summation artifacts and detect findings hidden in the dense parenchyma [7, 24, 28, 29]. DBT improves the AD visualization and also detects from 9.2% to 74% of ADs that are mammographically occult [6, 8, 10, 20, 27, 28, 30, 31]. Lee [21] argues that in addition to AD, DBT has the advantage of visualizing human epidermal growth factor receptor 2 (HER-2) negative bulky masses with a low histologic differentiation grade. The percentage of BC after core-needle biopsy (CNB) or surgery was lower (10.2%) if the AD was seen only on DBT compared to the AD on FFDM (43.4%) [32]. DBT-only ADs were malignant in 33–68% of cases [22, 28] with positive predictive value (PPV) accounting for 9.8–50% [10, 14, 22, 30, 31].

The disadvantages of DBT includes a higher radiation exposure compared to conventional FFDM and an increase in the number of false-positive results [7, 28].

Difficulties in interpreting AD on FFDM can be caused by linear anatomical structures such as ligaments, vessels, ducts that simulate AD in cross-sections [9]. For example, Langman [33] describes an AD area on FFDM caused by an additional axillary muscle present in 7% of population. To improve the visualization of AD visualized in two or only one projection, the use of a targeted image or new full-field images in other projections is recommended [6, 7, 12].

ILC is the most common malignant pathology visualized on FFDM as AD and accounts for 16–20% of cases [34]. Due to late diagnosis, it most often manifests clinically as a palpable lump area, and as diffuse lesions, the breast is retracted, wrinkled, with thickened skin and nipple retraction [1, 7, 11]. An AD with or without a central hypo- or isodense mass is a classic FFDM sign of ILC [34, 11]. Much less commonly, ILC is presented as a mass with even or distinct edges, a developing asymmetry area [35]. IDC on FFDM is presented as a mass with uneven or distinct even contours, with the "white star" signs, AD with concomitant grouped amorphous, pleomorphic, fine linear calcifications [1, 11, 34]. DCIS is a precancerous condition with a tendency to transform into an invasive tumor that develops in the terminal ducts [5]. With the development of FFDM and the spread of screening programs, the pathology has become a common group of BC [5, 36]. FFDM usually detects it as grouped or segmental pleomorphic, powdery, or rarely coarse heterogeneous calcifications, in 10–15% of cases as calcification-free masses, and in 2–10% as AD [4, 5, 11, 36].

The most common benign process is radial scar, which occurs as a result of idiopathic processes not associated with trauma or surgery and is visualized as an AD on FFDM in 50–74.4% [4, 21, 18, 37]. On FFDM, it is presented as an area with a radiolucent central core and radiating contours, which may contain calcifications [4, 5, 18]. It is believed that the increase in the number of detected radial scar and AD is associated with the widespread use of DBT [11]. Radial scar detected on DBT is associated with BC in almost a third of the cases on the post-surgery material [7, 34, 38]. It is still unclear whether radial scar is a marker of the increased risk of BC or a precancerous condition in itself [18]. The asso-

ciation between radial scar and BC may be the cause of insufficiently informative CNB, due to the small amount of material collected or failure to reach the malignancy site [34, 37]. To establish a more accurate diagnosis, it is suggested that vacuum-assisted breast biopsy (VABB) with 8G and 11G needles be performed, if possible, as an alternative to excisional biopsy in some cases [18]. The highest diagnostic accuracy is achieved with 12 columns of material collected by VABB, but accuracy does not increase with increasing amounts of material [37]. The rate of upgrade of radial scar to BC on the post-surgery material was 8–19.5% [18, 34, 37]. Interestingly, the presence of calcifications in the histologic material increased the risk of BC threefold, and the risk of atypia—almost 10 times [18]. Williams [39] observed in the case of atypical ductal hyperplasia that the upgrade was detected on the post-surgery material in 17.7% of cases, and Villa-Camacho [23] reported an upgrade on AD with atypia in 28.2% of cases. Given the high risk of radial scar upgrade on the post-surgery material after CNB, especially in the presence of atypia in the histologic material, surgical removal of radial scar or VABB is recommended to establish the definitive diagnosis [12, 18, 37, 38]. In patients with benign concordant findings, annual FFDM is recommended [15].

Sclerosing adenosis is a benign proliferative pathology that is usually detected in perimenopausal women [5, 19]. Core-needle biopsy is recommended after cytologic diagnosis, as sclerosing adenosis can coexist with various forms of cancer and other benign processes [8, 19, 34]. On FFDM, it is represented by calcifications (grouped, punctate, powdery, or amorphous, rarely pleomorphic) and masses, and some studies indicate that AD is the most common FFDM finding in case of sclerosing adenosis [5, 8, 34].

AD often occurs at the site of surgery; therefore, it is important to look at whether architectural changes are detected along with the site of surgery [11]. After reduction mammoplasty, the FFDM shows downward displacement of glandular tissue, fat necrosis, skin thickening, paraareolar skin calcifications, and the AD has a characteristic vortex-like appearance [8, 11].

Changes after biopsies may disappear within weeks to months and rarely progress [11]. Rarely, they can be presented on FFDM as AD, seromas, or dystrophic calcifications [5]. Miner [40] describes the formation of AD at the site of a large cyst aspiration.

A special mention should be made of fat necrosis, which is a benign inflammatory process of adipose tissue that represents almost 3% of all breast masses [4, 16]. The clinical manifestation of fat necrosis is a lump, usually in the subareolar area [16]. Mammographically, it is visualized as an oil cyst with a clear center and a thin capsule with even or wavy contours, large rod-like calcifications, rarely focal asymmetries, microcalcifications, and concomitant changes with skin deformation on the subcutaneous fat tissue around the area of interest [4, 16]. Fat necrosis may appear as a mass with radiating contours if the inflammatory process is dominated by fibrous changes [4, 16].

Post-surgery and post-radiation changes in the breast parenchyma (skin and breast edema) should stabilize or decrease in size within 1–3 years after surgery and radiation therapy [5, 7, 11]. Increased size, new masses, or a change in appearance should raise suspicion of BC [5]. If AD is found to be associated with post-surgery changes, routine annual screening is recommended [11]. A thorough history and breast examination for scarring, skin and areola changes are important for this [5, 7, 11, 12]. If in doubt whether the surgical site coincides with the area of interest, we use cutaneous markers [5].

MAGNETIC RESONANCE IMAGING (MRI)

The diagnostic value of MRI is higher than FFDM for AD detection [2, 25]. Mei [2] found that with the additional application of MRI to FFDM, the sensitivity and specificity increased from 86.3% and 41.7% to 98.1% and 97.5%, respectively. MRI signs of AD are an area of localized retraction and distortion of the parenchyma without obvious signs of a mass and without contrast agent (CA) accumulation [3]. malignant pathology in the form of AD on MRI can be defined as an irregularly shaped mass with indistinct contours or non-mass enhancement (NME) [17, 20, 25]. In the Amitai study [17], out of 175 women, 61% of AD did not demonstrate CA accumulation, and none of these patients were subsequently diagnosed with malignancy. In 30% of women with contrast-enhanced masses, BC was diagnosed after biopsy [17]. ADs associated with BC were characterized by plateau and washout kinetics in most cases [17]. The most common pathology that accumulated CA was radial scar [17]. If the MRI results are negative, we continue to monitor the AD without additional invasive interventions, but we should pay attention to the low specificity of MRI [17, 20]. Samreen [12] suggests that the next DBT should be performed in 6 months if there is no MRI correlation of the pathology.

ILC on MRI is most often defined as a single mass with uneven radiating contours, sometimes, as with IDC, smaller masses or contrasting foci are present around, AD, focal or regional heterogeneous CA accumulation, NME are observed [1, 35]. The late-phase washout is achieved much more rarely than with IDC,

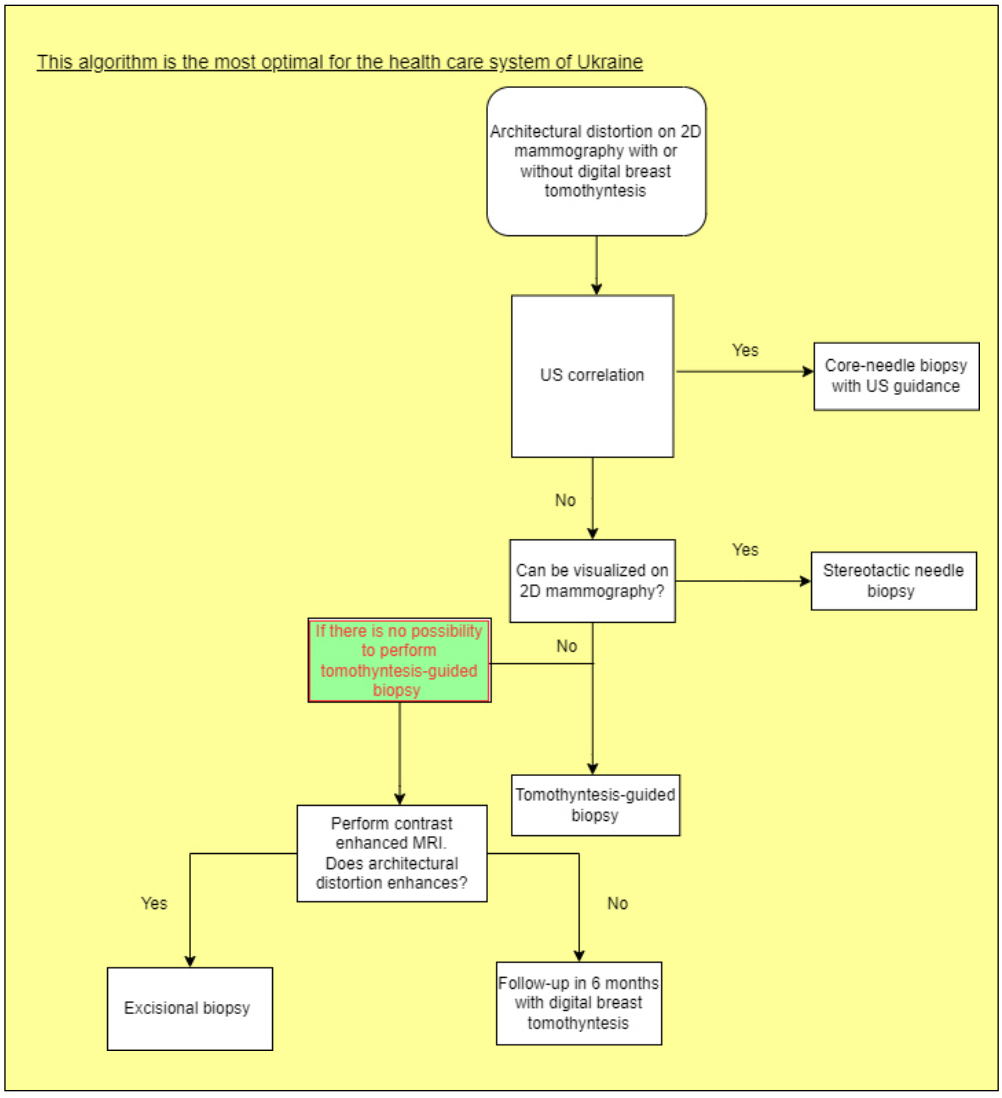

Fig. 1. This algorithm is the most optimal for the health care system of Ukraine.

but it more often has a kinetic plateau [1]. MR-findings representing IDC are characterized by a mass with uneven or radiating contours that accumulates CA in the periphery as a rim in 40% of cases and less commonly as a rounded mass with lobulated contours, NME [1]. Plateau or washout kinetics are present in 76–91% of cases and are more characteristic of masses with a higher differentiation grade [1].

Radial scar has a wide range of findings: enhanced bulky mass and NME, AD, almost all the findings had type 1 and type 2 kinetic curve, and most had uneven or radiating edges, which makes differential diagnosis with BC difficult [19].

A post-surgery scar on MRI can normally be contrasted in the first 12 months after surgery [5]. Any MRI CA accumulation at the site of surgery for BC after 18 months should be evaluated with caution and require further verification [5]. There may be a signal void in the operation location due to surgical marks and large rod-like dystrophic calcifications, which can be correlated with by means of FFDM [5].

The MRI signs of fat nectosis are characterized by a predominance of fat density in the mass, although a significant amount of variation is possible depending on the amount of inflammatory changes, fat content, and fibrosis stage [4, 16]. The most common MRI sign of fat necrosis is a rounded or oval fat cyst with a hypointense T1 signal on fat saturation images [16]. Kinetic analysis is not helpful in the evaluation, as fat necrosis has a whole range of kinetic curve signs for benign and malignant findings [16]. Short tau inversion recovery (STIR) mode visualizes the characteristic "black hole" sign, which appears as a central hypointense mass [16].

CONTRAST-ENHANCED MAMMOGRAPHY

A new method that expands the diagnostic capabilities of FFDM is CEM, an alternative to MRI when the latter is not possible. This method uses the principle of dual-energy subtraction to evaluate contrast enhancement of breast masses [8]. Similar to MRI, CEM

helps to define pathology characteristics, perform local staging, and assess response to neoadjuvant chemotherapy, but at a lower cost [8, 13]. Goh [8] found that ADs with little or no contrast enhancement have a lower risk of malignancy, as opposed to more obvious contrast enhancement, and the negative predictive value (NPV) of masses without suspicious CA accumulation was 100%. At the same time, CEM has a high sensitivity to AD contrast enhancement, reaching 96.7%, specificity of 57.9%, and NPV for BC up to 91.7% on the example of 49 ADs, which suggests mandatory verification of all contrasted masses [13]. The phenomenon of background parenchymal enhancement remains a diagnostic problem, which can mask BC and complicates the assessment of masses [8]. If the AD on CEM is contrasting but the biopsy shows benign findings with no signs of increased risk, the next FFDM can be performed routinely [31].

ULTRASOUND (US)

The ultrasound correlation of AD on FFDM is present in 40–87.6% of cases, and the presence of correlation increases the risk of detecting BC [13, 14, 17, 21-23, 31]. Wadhwa [12] found that the risk of BC is three times higher if the AD has US correlation compared to a finding without US correlation (63.1% v 17.7%). AD on US is defined as compression of the tissue around the tumor, obliteration of the tissue planes by an infiltrating lesion, straightening or thickening of Cooper's ligaments, and an echogenic rim around the finding [3]. The authors' opinions and study results differed on what to do with AD without US correlation. Thus, some argue that in the absence of US correlation with an FFDM finding, it is more likely to assume that the AD is a benign process [6, 24]. Other studies indicate that 17.7–27.9% of BCs were without US correlation, indicating that the absence of US correlation cannot completely exclude BC [21, 31].

US visualizes ILC as a hypoechoic mass with uneven and indistinct radiating contours, with posterior shadowing, and rarely as a rounded hypoechoic mass [1, 35]. The best correlation with US is present when AD is visualized in two standard mammographic planes [34]. IDC is most often present as a hypoechoic mass with uneven contours and posterior shadowing [1].

US findings of radial scar are characterized by a hypoechoic mass or AD that visually mimics a malignant mass [4]. AD represents radial scar in 44.2% of cases on US [18]. Sclerosing adenosis on ultrasound looks like a solid hypoechoic heterogeneous nodule, which can be clinically manifested as a mass [19]. Other signs on US include both distinct and indistinct contours, and mild to moderate blood flow [19].

US is used as an additional method for detecting post-surgery seromas, hematomas, and abscesses, but it should be remembered that post-surgery findings can mimic BC due to hypoechoic areas with indistinct margins [4, 5]. A fat necrosis is visualized as a cystic mass with septa or a solid mass with distinct or indistinct edges in the background of the AD, and posterior acoustic shadowing [4, 16].

Although a significant number of malignant and benign pathologies hidden under the AD, the frequency and improvement of AD visualization only increased over the years. But radiologists still have difficulties in identifying this radiological sign and choosing further tactics for patients, against the background of the emergence of new sensitive diagnostic methods (CEM and DBT) and already existing ones (MRI, FFDM, US). We aimed to systematize signs visualized by various radiological methods to give a better understanding of what AD can look like and what to do with it. The acquired knowledge will have a positive effect on medical algorithms, minimizing the number of unnecessary surgical and minimally invasive interventions for patients, can change the tactics of surgical intervention and more systematically assessing the risks and benefits for the patient.

ALGORITHM

If AD is present on the FFDM and we cannot be sure about previous surgery, biopsy, or trauma than ultrasound should be used for targeting and performing CNB [3, 21]. When ultrasound-guided CNB is not possible, radiology-guided CNB (stereotactic or DBT) is recommended, with postbiopsy marker placement and repeat mammography to ensure the correct biopsy site, and further marking before surgery if necessary [7, 12].

If AD is visualized only on tomosynthesis scans and it is not possible to perform a CNB, MRI or CEM may be additionally recommended as an alternative to tomosynthesis-guided core biopsy. Excisional biopsy is recommended in the presence of accumulation of contrast media, and follow-up in 6 months is recommended in the absence of accumulation [7] (Fig. 1).

CONCLUSIONS

Because architectural distortion represents a significant amount of benign and malignant pathologies , and ultrasound, MRI, and mammographic signs cannot determine the etiology of architectural distortion with certainty. We recommend that all architectural distortions that are not due to surgery, trauma, or biopsy and have contrast agents accumulation on MRI or CEM must be verified.

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CONFLICT OF INTEREST

The Authors declare no conflict of interest

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