Clinical Imaging 51 (2018) 252–259

Contents lists available at ScienceDirect

Clinical Imaging

journal homepage: www.elsevier.com/locate/clinimag

Significance of microvascular evaluation of ductal lesions on breast ultrasonography: Influence on diagnostic performance

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ARTICLE INFO

Keywords:
Breast
Breast duct
Microvascular imaging
Superb Microvascular Imaging
Ultrasonography

ABSTRACT

We aim to investigate the significance of microvascular ultrasonography in breast ductal lesions for distinguishing benign from malignant lesions. Sixty-two ductal lesions were evaluated with gray-scale and three Doppler techniques before biopsy, Superb Microvascular Imaging (SMI), color Doppler (CDI), and power Doppler imaging (PDI). We evaluated number, distribution, and morphology of vessels. The area under the ROC curve of combined use of Doppler imaging was greater than that of gray-scale only and SMI had higher value than CDI and PDI ($p < 0.05$). Microvascular ultrasonography improves diagnostic performance that distinguishes benign from malignant breast ductal lesions, and SMI is superior to CDI and PDI.

1. Introduction

In the fifth edition of the American College of Radiology Breast Imaging Reporting and Data System (BI-RADS) – Ultrasound (US), abnormal duct changes are defined as cystic dilatation of a duct or ducts involving irregularities in caliber and/or arborization, extension of duct(s) to or from a malignant mass, or the presence of an intraductal mass, thrombus, or detritus [1]. BI-RADS - US lexicon does not include detailed imaging evaluation or recommendations for mammary duct lesions. In addition, duct changes are not considered as unique features, but are classified as one of the associated features of a mass or calcification including architectural distortion, skin changes, edema, vascularity, and elasticity assessment.

However, mammary duct lesions are caused by various benign and malignant diseases. Benign duct lesions include duct ectasia, blocked ducts, periductal mastitis, apocrine metaplasia, intraductal papilloma, or papillomatosis. Malignant duct lesions are related to ductal carcinoma in situ, invasive ductal carcinoma, and Paget disease [2]. According to a retrospective study performed by Hsu et al., the malignancy rate of mammary duct dilations was 15% (26/172) and the frequency of high-risk lesions was 19% (32/172) [3]. In addition, pure ductal dilatations without associated masses on breast US had 9% malignancy rate in a study by Song et al. [4]. Therefore, breast ductal lesions are clinically significant.

High-resolution gray-scale US is useful to evaluate breast ductal lesions. On gray-scale US, malignant ductal lesions frequently show hypoechoic intraductal mass, segmental longer distribution, duct wall thickening or nonsubareolar location [3, 4]. However, gray-scale US is limited for assessment of ductal lesions because secretion or debris can be confused with intraluminal solid tumor, leading to tissue biopsy. Hamed et al. [5] demonstrated color and power Doppler are sensitive (94%) for detecting blood flows in intraductal echogenic lesions and helpful to distinguish intraductal tumors from inspissated secretions.

Angiogenesis and vascular remodeling seem to be the major mechanisms of breast malignancy, and microvascular density is higher in malignant breast lesions than in benign lesions [6]. Conventional color Doppler imaging (CDI) and power Doppler imaging (PDI) have been widely used for evaluation of tumor vascularity. However, CDI and PDI are difficult to observe in small and slow microvessels because of low sensitivity [7–10]. Superb Microvascular Imaging (SMI; Toshiba Medical Systems, Tokyo, Japan) is a recently developed Doppler technique that effectively separates low-speed flow signals from tissue motion

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https://doi.org/10.1016/j.clinimag.2018.05.024
Received 5 January 2018; Received in revised form 10 May 2018; Accepted 31 May 2018

artifacts, preserving low-flow signals in microvessels [7, 9–12]. Recent preliminary studies have reported that SMI is a promising technique for visualizing microvessels and improves diagnostic performance compared with conventional color or power Doppler US for breast masses [7, 9–12].

The purpose of this study was to investigate the significance of microvascular evaluation in ductal lesions on breast US by comparing gray-scale only with combined use of Doppler US–CDI, PDI, and SMI.

2. Materials and methods

2.1. Patients

From December 2014 to March 2016, we collected 65 consecutive patients who were scheduled to undergo US-guided biopsy due to focal ductal lesions without associated mass on breast US. At our institute, breast US was performed on both sides by radiologists after reviewing previous breast images. We did not include diffuse duct dilatations related to lactation, pregnancy, or hyperlipidemia. Among these 65 patients, four patients were excluded because of recent breast excision within 1 year (n = 3) or poor image quality (n = 1). A total of 62 ductal lesions in 61 women aged 28–80 years (mean, 46.2 years) were enrolled in this study. There were eight women with nipple discharge, five women with breast pain, two women with breast lumps, and 46 women with no symptoms. Forty-six asymptomatic women underwent breast US for mammographic abnormality (n = 34), screening (n = 5), follow-up examination of BI-RADS category 3 lesions in the ipsilateral or contralateral breast (n = 4), follow-up examination after excision of contralateral breast lesions (n = 3). Mammographic abnormalities in 34 women were asymmetry (n = 14), calcifications (n = 13), solitary dilated duct (n = 2), mass (n = 1), and contralateral lesions (n = 4).

At our institute, if a patient had focal dilatation of mammary ducts on gray-scale US, we evaluated additional findings such as ductal wall thickening, intraductal calcifications, and intraductal mass [4]. If there was an additional positive finding, we recommended tissue diagnosis. Before tissue biopsy, we evaluated the lesion with gray-scale US and the vascularity with the three Doppler US techniques of SMI, CDI, and PDI at the same plane. Sixty patients had solitary ductal lesions and the remaining one patient had two ductal lesions, one in each breast. Fig. 1 shows a flow chart of the study population. This prospective study was conducted with institutional review board approval and the written informed consent was obtained.

2.2. Image acquisition

Breast US examinations were performed by two radiologists with 16 years of experience (B.K.S) and 5 years of experience (S.E.S.) in breast imaging, respectively, using an Aplio 500 (Toshiba Medical Systems Corporation, Tokyo, Japan) with a 7–18-MHz linear transducer. They underwent breast US after they reviewed previous breast images. When a ductal lesion was found in a transverse or longitudinal scan, the radial scan was obtained by positioning the US transducer parallel to the longitudinal plane of the ductal lesion. Gray-scale 2D images of breast ductal lesions were obtained, and vascularity in ductal lesions was evaluated in the same plane with CDI, PDI, and SMI. The region of interest used to obtain vascular images in ductal lesions was set to include normal surrounding breast tissue sufficient to assess the difference in vascularity between the ductal lesion and normal tissues. Minimal compression was applied with the transducer to preserve flows of small vessels. The settings of Doppler techniques were adjusted such that the sensitivity to low-velocity flows was increased and flash artifacts were minimized. The parameters of CDI and PDI were as follows: velocity scale < 2.5 cm/s, dynamic range of 20 dB, and frame rate of 8–11 frames per second. SMI examination was performed with color mode, and the parameters were a velocity scale < 2.5 cm/s, dynamic range of 21 dB, and frame rate of 27–60 frames per second. Doppler examination was performed with a low wall filter and as high a gain as possible.

If we suspected intraductal calcifications on gray-scale US, we performed MicroPure™ imaging (Toshiba Medical Systems, Tokyo, Japan), a calcification-enhancing algorithm. MicroPure™ imaging shows calcifications as bright white dots and suppresses the background texture to dark blue, increasing the contrast between calcifications and surrounding tissues [13]. Thirty out of a total of 62 duct lesions were acquired using MicroPure™ imaging.

After image acquisition, US-guided core needle biopsy with a 14-gauge automated gun system using a 23-mm throw (Max-Core gun; Bard, Covington, GA, USA) or 9-gauge or 12-gauge vacuum-assisted biopsy (ATEC; Hologic, Inc., Bedford, MA, USA) was performed for histopathological diagnosis.

2.3. Image interpretation

Representative images of gray-scale US and vascular US including CDI, PDI, and SMI for each ductal lesion were selected and converted

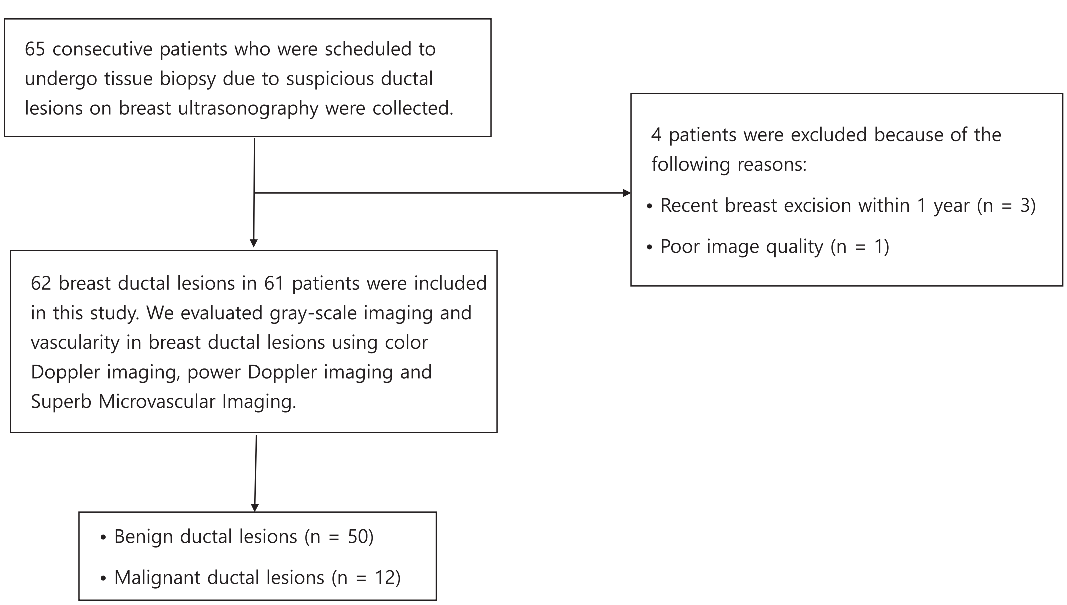

Fig. 1. Flow chart of the study population.