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Case Report

Assessment of Neoadjuvant Treatment Response Using Automated Breast Ultrasound in Breast Cancer

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Conflict of Interest
The authors declare that they have no competing interests.

ABSTRACT

Breast imaging techniques are used to assess the tumor response to neoadjuvant treatment (NAT), which is increasingly one of the preferred therapeutic options and increases the rate of breast conservation for breast cancer. Herein, we report a case in which a woman was diagnosed with invasive ductal carcinoma in the left breast and received NAT before surgery. Automated breast ultrasound (AB US) was regularly performed before and during the NAT to evaluate the tumor response to NAT by measuring diameter changes and volume reductions of the tumor. Images showed that the tumor size was significantly reduced and disappeared after 7 cycles of NAT, except for macrocalcification. Postoperative histopathological examination confirmed that there were no residual tumor cells. We found that AB US overcame the limitations of handheld US, such as operator dependence, poor reproducibility and limited field of view, and can be an alternative modality to assess the tumor response of NAT in the absence of magnetic resonance imaging (MRI) instruments.

Keywords: Breast Neoplasms; Neoadjuvant Therapy; Treatment Outcome; Ultrasonography

INTRODUCTION

Neoadjuvant treatment (NAT) is widely used in breast cancer treatment to induce tumor shrinkage and increase the rate of breast conservation [1,2]. Tumor size regularly measured by mammography, ultrasound (US) and magnetic resonance imaging (MRI) during NAT and before surgery is necessary to evaluate the tumor response of NAT and is an important consideration in surgical planning [3,4]. We report a case in which breast cancer response was assessed during NAT with automated breast ultrasound (AB US).

CASE REPORT

A 53-year-old woman accidentally touched a mass in her left breast. Breast ultrasound indicated a 4.5 cm irregular mass, with enlarged ipsilateral axillary lymph nodes. Breast Imaging Reporting and Data System (BI-RADS) category 5 was assigned. The histopathological examination after core needle biopsy revealed an invasive ductal carcinoma

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of the estrogen receptor-positive and human epidermal growth factor 2-positive subtype and positive axillary lymph nodes. After a multidisciplinary discussion, the patient received NAT, which was an EC-THP regimen (4 cycles of epirubicin/cyclophosphamide followed by 4 cycles of docetaxel/trastuzumab/pertuzumab), before surgery. AB US (Invenia ABUS 2.0, Automated Breast Ultrasound System; GE Healthcare, Wuxi, China) was performed before NAT on August 11, 2020; after 2 cycles on October 09, 2020; after 5 cycles on December 11, 2020; and after 7 cycles on February 10, 2021 to assess the tumor response. Images showed that the tumor size was significantly reduced and disappeared after 7 cycles of NAT, except for macrocalcification (**Figure 1**). The tumor 3D images from AB US reconstructed by 3D Slicer (Brigham and Women's Hospital, Harvard Medical School, Boston, MA, USA) also showed reductions in tumor volume (**Figure 2**, **Supplementary Video 1**). After 8 cycles of NAT, the patient underwent surgery. Postoperative histopathological examination confirmed that there were no residual tumor cells in the breast and axillary lymph nodes, indicating pathological complete response (pCR).

DISCUSSION

Imaging techniques, such as mammography, US, MRI and positron emission tomography (PET), are important approaches for evaluating residual tumor size during NAT for breast cancer, [3,5]. By assessing the tumor response, these techniques not only guide the selection of treatment regimens and reduce the unnecessary toxicity of ineffective regimens but also assist clinical decision-making about performing conservative breast surgery [4].

Changes in tumor diameter are an important criterion for response evaluation in solid tumors [6], and volume reduction has a stronger association with recurrence-free survival than other prognostic indicators [7]. MRI is the most accurate imaging modality for predicting residual tumor size during NAT [8,9]. However, MRI is time-consuming, expensive and requires the injection of a contrast agent, which hampers MRI popularity in developing countries. US is the most popular modality to assess tumor response and a reasonable alternative strategy for predicting residual lesions with NAT [10]. It was reported that MRI estimated the residual tumor size with < 10-mm discordance in 54% of patients, overestimated the size in 28% and underestimated the size in 18%, while US was reported as 63%, 20% and 17%, respectively. US was at least as good as breast MRI in providing information on residual tumor size following neoadjuvant chemotherapy [11].

AB US, which was initially developed for breast cancer screening, acquires standardized US images of the whole breast with a 15.4 cm wide imaging field, overcoming the limitation of small fields of view and addressing the operator dependence associated with handheld ultrasound (HH US) [12,13]. In this case, AB US was performed before and during the NAT. Reductions in tumor size with a concentric shrinkage pattern were shown in grayscale images. Reconstructed 3D images of tumors and automated or semiautomated volumetric measurements were also available with 3D Slicer, which provided intuitive changes in tumor size. Calcification in AB US images remained despite pCR, which is consistent with reports that calcification appearance does not clearly change after NAT, the persistence of calcifications does not necessarily indicate residual disease, and calcification patterns are not related to the pCR rate [14,15].

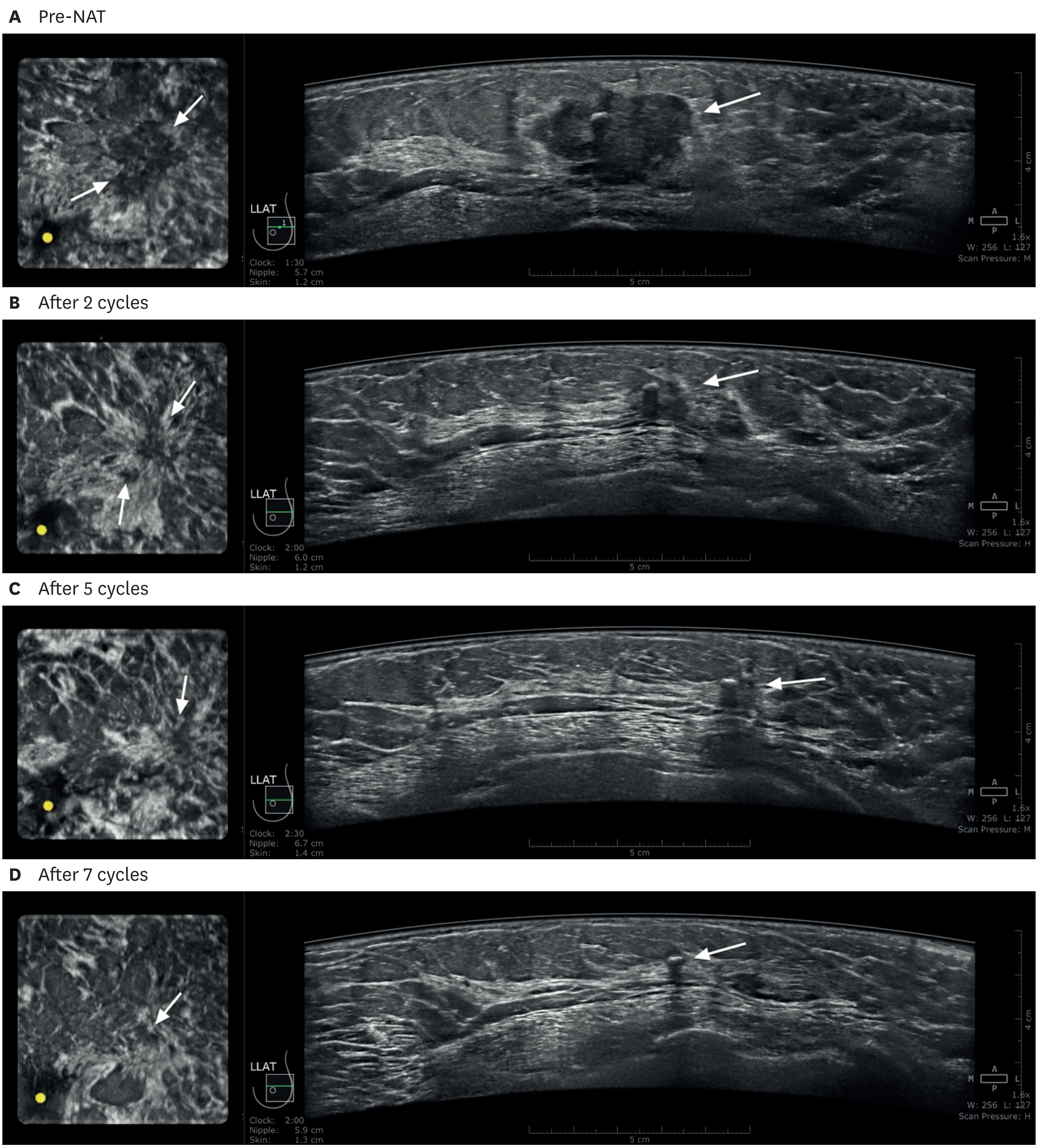

Figure 1. Coronal (left) and transverse (right) automated breast US images in a 53-year-old woman with invasive ductal carcinoma of the estrogen receptor–positive and human epidermal growth factor 2–positive subtypes before and during NAT, with macrocalcification in the mass (arrows) as a landmark. (A) Baseline images obtained before NAT showed an irregular mass in the left upper outer breast. The maximal diameter of the mass was 4.5 cm. (B) On images obtained after 2 cycles of NAT, the mass showed a concentric shrinkage pattern. The maximal diameter of the residual mass was 3.1 cm (31% reduction of the initial tumor diameter). (C) On images obtained after 5 cycles of NAT, the maximal diameter of the residual mass was 1.1 cm (76% reduction of the initial tumor diameter). (D) On images obtained after 7 cycles of NAT, the mass disappeared except for macrocalcification. Note: To observe the mass on the same transverse plane to ensure a precise comparison in different cycles, we chose the macrocalcification in the mass as a landmark. The transverse images in (A) and (B) do not show the maximal diameter of the mass. The yellow point indicates the nipple.
NAT = neoadjuvant treatment; LLAT= left lateral.

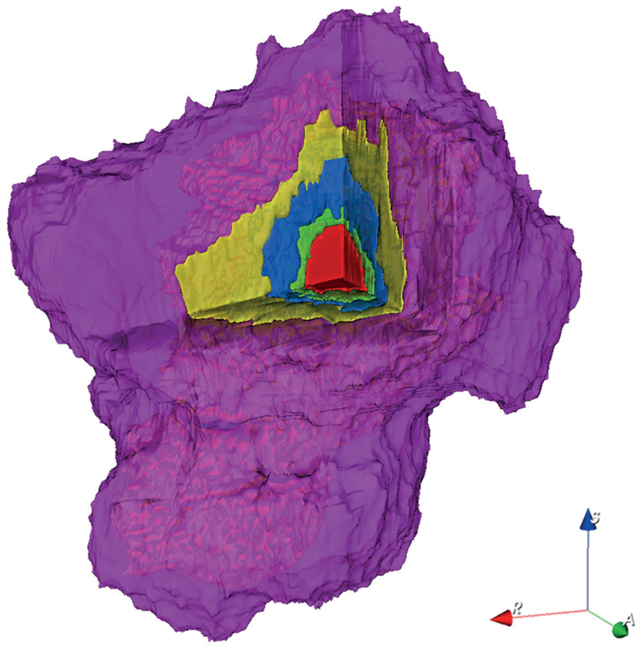

Figure 2. The 3D volume of tumors from automated breast US images reconstructed by 3D Slicer in the same woman was measured as 26.6 cm^3 before neoadjuvant treatment (NAT; purple), 9.5 cm^3 (64% volume reduction) after 1 cycle of NAT (yellow), 2.6 cm^3 (90% volume reduction) after 2 cycles of NAT (blue), 0.7 cm^3 (97% volume reduction) after 3 cycles of NAT (green) and 0.3 cm^3 (99% volume reduction) after 5 cycles of NAT (red).
US = ultrasound; NAT = neoadjuvant treatment; S = superior; A = anterior; R = right.

In conclusion, AB US, which is less time-consuming and less expensive than MRI and does not require the injection of a contrast agent, can be an alternative modality for assessing the tumor response to NAT in low- and middle-income countries. AB US not only overcomes the limitations of HH US but also allows the reconstruction of 3D images and volumetric measurements of tumor size.

SUPPLEMENTARY MATERIAL

Supplementary Video 1

The movie produced by 3D Slicer shows reductions in tumor volume during NAT based on automated breast US images. Upper left: transverse plane; Lower left: coronal plane; Lower right: sagittal plane; Upper right: 3D reconstruction. Purple: before NAT; Yellow: after 1 cycle of NAT; Blue: after 2 cycles of NAT; Green: after 3 cycles of NAT; Red: after 5 cycles of NAT.

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