Reproducible surveillance US using real-time virtual sonography in short-interval follow-up for BI-RADS 3 mass lesions: first experience

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Aims and objectives

In the BI-RADS US lexicon, a solid mass with an oval shape, circumscribed margins, and parallel orientation is classified as category 3. This mass should have a risk of malignancy of less than 2%. For lesions with benign characteristics, emerging data suggest that surveillance US for short-interval follow-up is an acceptable alternative to biopsy. For this reason, a definite interpretation based on both the assessment of US morphological features and the measurement of the target lesion diameter is required. However, inconsistent reproducibility of US due to operator dependence is still a clinical issue, particularly for small lesions.

Recently, real-time virtual sonography (RVS), which coordinates US and magnetic resonance imaging (MRI) using a magnetic position tracking system, has been introduced in breast imaging (Nakano et al. 2009; Nakano et al. 2012a, 2012b). This image fusion technique can simultaneously display the results of different imaging modalities in a side-by-side format on the monitor. Recent RVS technological advances have made it possible to serially coordinate a present US image and a past US image reconstructed from previously acquired US volume data (Nakano et al. 2014).

The present study evaluated the utility of surveillance US using RVS in short-interval follow-up for BI-RADS category 3 mass lesions.
Methods and materials

Patients

This retrospective study was undertaken with the approval of our hospital's institutional review board. The need for written informed consent for this evaluation was waived. Study cases consisted of incidentally detected solid breast masses classified as BI-RADS category 3 mass lesions following US examination between September 2010 and December 2012 at Aichi Medical University Hospital. In 20 women, the abnormalities were sonographically diagnosed as BI-RADS category 3 upon initial US. Subsequently, surveillance US using RVS for short-interval follow-up was performed for over 24 months. A total of 23 lesions were evaluated in this study. US was performed using a 13-MHz linear-array transducer (EUB-8500, Hitachi Medical Corporation, Japan).

A typical BI-RADS category 3 mass lesion was defined as a hypoechoic, homogeneous solid mass with an oval shape, circumscribed margins with no more than two or three gentle lobulations, the long axis parallel to the skin, and no acoustic shadowing. Women with typically benign cysts or intramammary lymph nodes (BI-RADS category 2) or with masses suspicious for malignancy (BI-RADS categories 4 and 5) were excluded from this study. At the time of initial US, the clock-face position, distance from the nipple, maximum diameter of the target lesion, and orientation of the probe were recorded as baseline data.

RVS Technique

The RVS system consisted of US equipment, a magnetic generator, a magnetic sensor, and a workstation with built-in RVS software. The magnetic sensor was installed on the tip of probe, and information regarding the position and motion of the probe was transferred to the workstation (Fig. 1,2).

RVS can be used to simultaneously examine US images obtained at different times, as the positional information of the reference point is contained in all US volume data. The US scanning for acquisition of US volume data was previously performed by one horizontal pass after positional registration at the reference point. The US scanning, including measurement of the target lesion's maximum diameter, was performed in one direction with a scan speed between 2-3 cm/second. The maximum scanning time was 10 seconds. The positional information of the US volume data was documented during the US scanning. To avoid artifacts associated with respiratory movement, all US scanning to obtain the US volume data was performed during breath-holding.

The US volume data were stored on DICOM data. To standardize the positional information of the reference point in all US volume data, we used the CT volume data of the phantom to mark a virtual reference point for the synchronization. The workstation computed positional and imaging information, and RVS simultaneously displayed both
a current US image and the reconstructed past US image corresponding to the present probe plane in side-by-side format on the monitor. After surveillance US using RVS, new US volume data were documented in each terms for review at a later date. When a positional discrepancy occurred, we resumed RVS after an almost identical US image with re-adjusted position, and probe inclination was fitted to the freeze of the reconstructed US image. We excluded women with pacemakers from this study because of the possible harmful influence of the magnetic field. We also excluded women with a previous history of breast cancer surgery. To avoid transformation of the US images by compression, the probe was applied gently, with only enough pressure to maintain full contact with the skin.

**Surveillance US using RVS, and biopsy technique**

For the short-interval follow-up study, surveillance US using RVS was scheduled at 6, 12, and 24 months after initial US. Three-dimensional assessment of morphologic features was performed while serially checking past US volume data corresponding to the present US probe position. If we observed interval progression in terms of increased size (more than 25% of the original diameter) or changes in other features, a breast biopsy was considered. Biopsies were also performed if requested by patients or surgeons, in each case under US guidance using an automatic spring-loaded biopsy device.

**Statistics**

Statistical analysis of lesion diameter was performed using SPSS 21.0 software (SPSS Inc., Chicago, IL, USA). For within-group analysis of the diameters of BI-RADS category 3 mass lesions obtained at each time point, multiple comparisons were performed with the Friedman test. Statistical significance was accepted if the p value was less than 0.05.
Fig. 1: Configuration of real-time virtual sonography (RVS) using US volume data

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**Fig. 2:** Transformation between the present US image and the past reconstructed US image coordinate frame using RVS

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Results

Lesions

The mean age of the 20 women in the study was 44 years (range, 29-70 years). Seventeen of the 20 women were aged 40 years or older. On initial US, the mean baseline diameter of the target lesions was 8.2 ± 4.2 mm (range, 5-22 mm). All lesions were non-palpable and mammographically occult. The mean observation period was 34 months (range, 25-40 months).

On the basis of patient preference, biopsies were performed on 4 (17%) of 23 masses. The biopsied lesions were benign, and the final histopathologic diagnoses were fibroadenoma (n = 2), fibrocystic disease (n = 1), and papilloma (n = 1).

Detection rate of target lesions by RVS

All 23 masses were successfully detected and incorporated into the US volume data, and same-position comparisons were performed between current US and reconstructed past US at each surveillance US visit. Although two cases were isoechogenic, one was situated adjacent to the superficial mammary fascia in the superficial fat (Fig. 3), and the other was situated adjacent to the retromammary fascia in the retromammary fat (Fig. 4). Two cases were detected with RVS supplementation. The technical success rate of RVS was 100% in our patient series.

Target lesion feature analysis by RVS

All 23 masses were diagnosed as BI-RADS 3 lesions, and all remained stable in terms of morphological characteristics. No case was upgraded to BI-RADS category 4 or 5. The patterns of change between short-term follow-up visits were evaluated in 20 women. The mean diameters of target lesions at baseline, 6, 12, and 24 months were 8.2 mm ± 4.2 (range, 5-22 mm), 8.4 mm ± 4.5 (range, 5-24 mm), 8.1 mm ± 4.5 (range, 5-24 mm), and 8.3 mm ± 5.0 (range, 5-27 mm), respectively.

Statistical analysis using a Friedman test with multiple comparisons revealed no significant difference between the diameters at each time point (p = 0.785). The percentages of change against the baseline diameter in the initial US at 6, 12, and 24 months were -0.2% ± 9.5 (range, -16.6-20%), -1.1% ± 8.4 (range, -16.6-20%), and 1.4% ± 19.1 (range, -16.6-80%), respectively. Although most lesions exhibited growth rates under 20%, a rate of over 25% was observed in one of the 20 women during short-term follow-up. A solitary mass increased in size from 5 to 9 mm between the 12- and 24-
month time points (80% progression). US-guided biopsy revealed fibrocystic disease at histological analysis.
Fig. 3: Comparison of US volume data, including maximum diameters of BI-RADS 3 mass lesions, at different time points (A: Phantom, B: real time US, C: initial US (24 month before))

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Fig. 4: Comparison between present and past US images of a BI-RADS 3 mass lesion in the retromammary fat (A: real time US, B: initial US (24 month before))

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Conclusion

In conclusion, we used RVS to accurately compare US images of BI-RADS category 3 mass lesions, taken at different time points in the same plane, without operator dependence. RVS can improve the reproducibility of breast US as well as interexaminer reliability in surveillance US.
References


