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Automated volumetric breast density estimation: A comparison with visual assessment

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AIM: To compare automated volumetric breast density (VBD) measurement with visual assessment according to Breast Imaging Reporting and Data System (BI-RADS), and to determine the factors influencing the agreement between them.

MATERIALS AND METHODS: One hundred and ninety-three consecutive screening mammograms reported as negative were included in the study. Three radiologists assigned qualitative BI-RADS density categories to the mammograms. An automated volumetric breast-density method was used to measure VBD (% breast density) and density grade (VDG). Each case was classified into an agreement or disagreement group according to the comparison between visual assessment and VDG. The correlation between visual assessment and VDG was obtained. Various physical factors were compared between the two groups.

RESULTS: Agreement between visual assessment by the radiologists and VDG was good (ICC value = 0.757). VBD showed a highly significant positive correlation with visual assessment (Spearman's $\rho = 0.754$, $p < 0.001$). VBD and the x-ray tube target was significantly different between the agreement group and the disagreement groups ($p = 0.02$ and 0.04, respectively).

CONCLUSION: Automated VBD is a reliable objective method to measure breast density. The agreement between VDG and visual assessment by radiologist might be influenced by physical factors.

Introduction

The breast is mainly composed of fibroglandular tissue embedded in a background of fatty tissue. The amount of fibroglandular tissue and fat varies among women. Breast density refers to the appearance of this fibroglandular tissue in a mammogram. Mammographically, density is quantified as percent density, percentage of total breast area occupied by dense fibroglandular tissue. Mammographic breast density is important for the following reasons: first, dense fibroglandular tissue may obscure calcifications or lesions and lower the sensitivity of mammography in the detection of breast cancer in dense breasts.[1] Second, increased mammographic breast density is a significant risk factor for developing breast cancer.[2–4] Therefore, if mammographic breast density is measurable, it might be used to develop an optimized strategy for breast cancer surveillance.

There have been various methods used to measure mammographic breast density. Conventionally, the qualitative description in Breast Imaging Reporting and Data System (BI-RADS) has been used.[5] The BI-RADS density category of breast composition is an area-based visual assessment by a radiologist. The fourth edition of BI-RADS included quantitative assessments divided into quartiles.[5] However, it has been suggested that subjective assessment of mammographic density showed variable intra- and interobserver agreement causing a lack of reliability regarding the BI-RADS density category.[6,7] Accordingly,

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quantitative measurement of mammographic density was attempted by Wolfe et al.[6] in 1987 using manual planimetry. Since then, several studies have shown the automated measurement of breast density by computer assistance with greater intra- and interobserver reproducibility.[1,8,9] Most of the previously reported automated methods used area-based data acquisition in order to estimate breast density.[1,10,11] Recently, several methods for the fully automated volumetric estimation of breast density have been reported.[12–15] These models showed variable results in predicting the risk of breast cancer compared with the area-based measurement of breast density.[13,14,16] However, there is no study concerning the relationship between volumetric breast density (VBD) using Volpara (version 1.4; Volpara™, Matakina International, Wellington, NZ) and visual assessment, and about the factors influencing the agreement between them.

In the present study, the present authors describe their experience with Volpara, an automated method to measure the volume of breast dense tissue from a digital mammography. The purpose of the present study was to evaluate the feasibility of this software by comparing it to the qualitative BI-RADS density category, and to determine the factors influencing the disagreement between Volpara and the BI-RADS density category.

Materials and methods

Patients

The institutional review board approved this study. Informed consents were obtained. Between October 2011 and November 2011, 849 healthy women received four-view screening mammograms at Samsung Medical Center Sungkyunkwan University School of Medicine. Mammograms that were considered to be negative (BI-RADS category 1) were selected in order to eliminate effects of mass or calcification on density estimation. Patients with any prior history of breast surgery or breast symptoms were excluded. Among 849 healthy women received screening, 656 had negative mammograms. Of these women, only 193 agreed to the use of their information in the study; these comprised the study cohort of this retrospective study.

Mammography in two standard imaging planes [mediolateral oblique (MLO) and craniocaudal (CC)] was performed using Senographe 2000D (GE Healthcare, Milwaukee, WI, USA) and Selenia (Hologic, Bedford, MA, USA) machines.

Volumetric assessment of mammographic breast density

Volpara analyses raw digital mammograms in a fully automated, volumetric method, and provides VBD (% breast density) by averaging the CC and MLO views of each breast (Fig 1). A complete description of the method is found elsewhere.[17] Different types of breast tissue absorb x-ray differently when an x-ray penetrates the breast; fibroglandular tissue absorbs roughly twice the amount as fat tissue. Volpara works by using a model of the physics regarding digital mammography in order to work backwards from the pixel value in the image to the x-ray attenuation between the pixel and the x-ray source. It calculates the types of tissue that must have been present between the pixel and the x-ray source. Then, the volume of fibroglandular tissue in cubic centimetres, the volume of breast tissue in cubic centimetres, and their ratio are obtained to acquire quantitative VBD. The Volpara Density Grade (VDG) is the VBD threshold at various levels, which can be used to obtain an approximate BI-RADS breast composition classification. The VBD value was always smaller than visual assessment, VDG based on VBD was determined automatically. VBD of 0–4.8% converts to VDG 1, 4.8–8% to VDG 2, 8–15.1% to VDG 3, and ≥15.1% to VDG 4.[17]

Mammogram density analysis performed by readers

Two board certified radiologists (H.B.K., K.E.S.) who each had several years of experience in reading mammograms (17 years and 7 years) and a 3rd-year radiology resident (S.J.M.) independently read the sets of four-view screening mammograms. All readers were blinded to their own previous results and those of other readers. The three radiologists read the data sets again 4 weeks later in order to evaluate the intra-observer agreement. They rated breast density according to the qualitative BI-RADS density category: category 1 implies breast tissue that is less than 25% glandular; category 2, breast tissue that is approximately 25–50% glandular; category 3, breast tissue that is approximately 51–75% glandular; and category 4, breast tissue that is more than 75% glandular.

Certain factors, which may affect breast density measurement [i.e., tube current, tube voltage, recorded breast thickness, breast volume, VBD (%), manufacturer (GE/Hologic), target (molybdenum/rhodium), filter (molybdenum/rhodium)] were retrieved by Volpara software. Each case was classified into the agreement or disagreement group according to the comparison between the BI-RADS density category and VDG by the three readers in consensus. The readers were blinded to the results of VDG during the consensus meeting.

Statistical analysis

The intra- and interobserver agreement between the three radiologists in the evaluation of breast density and agreement between the BI-RADS density category and VDG were determined with the intraclass correlation coefficient (ICC). Interobserver agreement was obtained by calculating only the first scoring of each reader. The ICC represents concordance, where 1 is perfect agreement and 0 is no agreement at all. Spearman's correlation coefficient was used to evaluate the correlation between visual assessment by the radiologists and VBD.

Various factors were compared between the agreement and disagreement groups. The *t*-test or Mann–Whitney *U*-test was used for continuous data. Fisher's exact test was used for categorical data. A *p*-value of less than 0.05 was