Comparative Measurement of Breast Volume and Dense Tissue Volume Based on Breast MRI and Low Dose Chest CT

Xiaoyong Wang[1], Jeon-Hor Chen[1], Yen-Hsiu Liao[2], Peter T Fwu[1], Muqing Lin[1], and Min-Ying Su[1]

[1]*Center for Functional Onco-Imaging, Department of Radiological Sciences, University of California, Irvine, CA, United States,* [2]*Department of Radiology, China Medical University Hospital, Taichung, Taiwan*

Background and purpose:

Breast density has been established as an independent risk factor for development of breast cancer. If the density can be measured, it will help clinicians and their patients to choose a personalized management protocol that is optimal based on each woman's benefit vs. risks. Developing quantitative analysis method to evaluate breast density is an active research area. Mammography is the most commonly used breast imaging modality, but since it is based on 2D projection, not optimal for volumetric measurement of density. Breast MRI acquires 3D images that are suitable for volumetric analysis, but currently only high risk women with lifetime risk >20% will receive screening breast MRI. The low dose chest computed tomography (CT) is increasingly being used for lung cancer screening. According to a report from The National Lung Screening Trial (NLST), a 20 percent reduction in deaths from lung cancer among current or former heavy smokers who were screened with low-dose helical CT versus those screened by chest X-ray was noted [1]. Among the participants, more than 40% are female [1]. With the full coverage of whole chest area and the soft tissue contrast presented on low dose chest CT, the images can be exploited for analysis of breast density, and subsequently used in risk management. We have developed MRI-based dense tissue segmentation methods by using sophisticated computer-assisted algorithms [2]. In this study we modified the methods for segmentation of breast density on low dose CT. As the first pilot study, we only selected women who have both CT and breast MRI for analysis, so the density segmented on low dose CT can be compared to the MRI-based results as the ground truth.

Methods:

Fifteen healthy female subjects who had received both low dose CT and breast MRI for screening purposes done within one year at our institution were selected for this study. The CT images were acquired using a GE multi-detector CT scanner and the breast MRI was performed on a 3.0T GE scanner. The density segmentation on MRI was performed using a previously developed method [2], which first identified the chest wall muscle for separation of breast from the body, and then distinguished the fibroglandular tissue from the fatty tissue within the breast. For the quantification of breast density on CT, a similar analysis approach was applied to first segment the breast from the body, and then to separate dense tissues from fatty tissues. Because the patient is scanned in supine position in CT scan, the gravity would pull the breast tissues down to the lateral side of the body, and a different body landmark has to be used for the initial cropping. A horizontal line connecting the anterior end of the bilateral latissimus dorsi muscles at the aortic arch level was drawn (**Fig.1a**), and this line was applied to all other slices to remove the posterior non-breast tissues below the line. In all 15 cases, this anatomic landmark could preserve all fibroglandular tissues regardless of breast morphologies. The next step was to extract the breast boundary by Fuzzy c-means (FCM) algorithm (**Fig.1b**), and identify the chest wall muscle using region growing and FCM for exclusion (**Fig.2**). Finally, FCM was applied within the breast region to separate dense from fatty tissue (6 cluster, 2 for dense and 4 for fatty tissues).

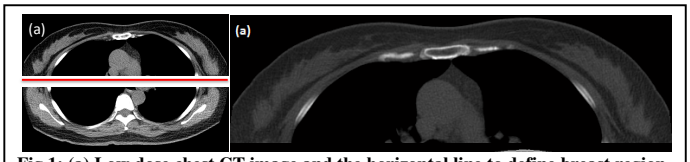

Fig 1: (a) Low dose chest CT image and the horizontal line to define breast region. (b) FCM clustering; chest wall muscle and dense tissue are in the same cluster.

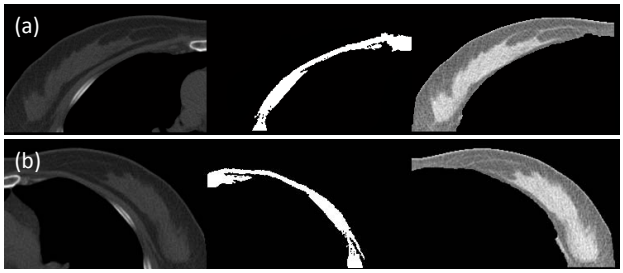

Fig 2: Based on the FCM results in Fig.1, a region growing algorithm is applied to define the chest wall muscle for exclusion; then a clean breast region is obtained.

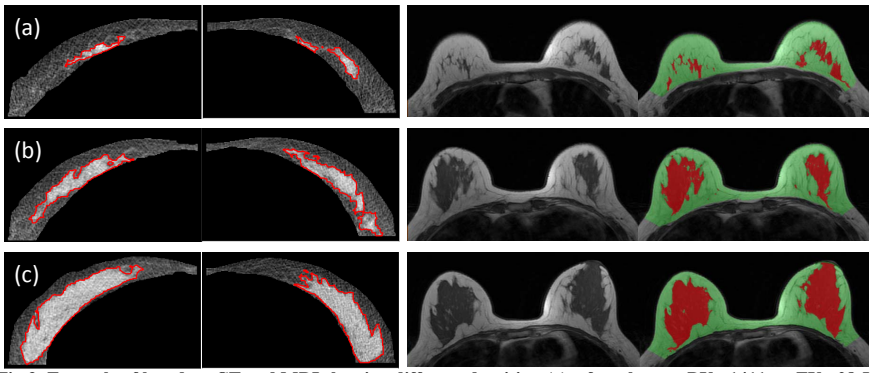

Fig 3: Example of low dose CT and MRI showing different densities. (a) a fatty breast, BV= 1411 cc, FV= 28.5 cc, PD= 2.0 %; (b) a moderate dense breast, BV= 1006 cc, FV= 176 cc, PD= 17.5 %; (c) an extreme dense breast, BV= 1045 cc, FV= 370 cc, PD= 35.4 %.

Results:

For each subject, the breast volume (BV), fibroglandular tissue volume (FV) and the percent density (PD) from the left and the right breasts were separately measured. **Figure 3** shows the final segmentation results based on CT and MRI in three case examples. The results from the left and the right breasts were averaged for each subject and the mean value was used for the correlation analysis between MRI and CT, as shown in **Figure 4**. The correlation between MRI and CT is very high for all three measured parameters (BV, FV, and PD), with r > 0.98. The mean values averaged from all 15 subjects are summarized in **Table 1**, which shows very small differences in the mean BV, FV, and PD measured on CT vs. MRI.

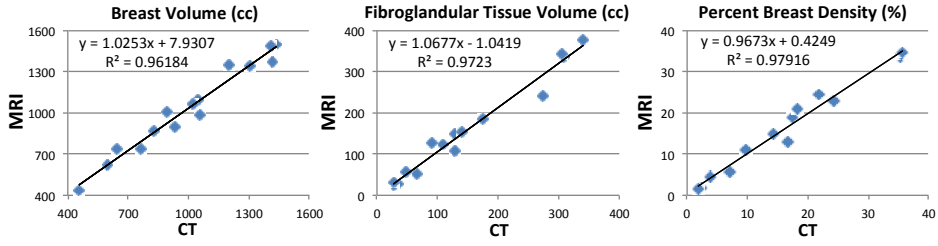

Fig 4: Correlation of breast volume, fibroglandular volume, and percent density measured on MRI vs. low dose CT.

Table 1: Comparison of BV, FV, and PD measured on MRI vs. CT [mean±stdev]

	MRI	Low dose CT
BV (cc)	1036 ± 327	1003 ± 334
FV (cc)	156 ± 119	148 ± 112
PD (%)	16.4 ± 11.8	16.3 ± 12.0

Discussion:

We present a breast segmentation method on low dose chest CT images, and tested the method in 15 healthy volunteers. As the role of imaging is slowly shifting from diagnosis to screening, many more screening scans will be performed. Despite of radiation concern, low dose chest CT is considered an appropriate screening tool, and is expected to be more widely used for lung cancer screening. Our method can be applied to measure breast density on CT, and the obtained information may help women to choose the most appropriate management protocol by providing a more accurate estimate of risk through consideration of density.

References: **[1]** Aberle DR. N Engl J Med. 2011; 365(5):395-409. **[2]** Lin et al. Medical Physics 2011; 38:5-14.