PhD Thesis Title: Use of volumetric analysis and imaging parameters to improve mammographic imaging

Author: Susie Lau
Email: slau007@hotmail.com
Institution: University of Malaya, Malaysia
Supervisors: Prof Dr Kwan-Hoong Ng, Prof Dr Yang Faridah Abdul Aziz
Graduation Date: October 21, 2017
Available Online: N/A

Abstract:

Breast density is a strong risk factor associated with breast cancer. Currently, no standard method exists for measuring breast density. This research is divided into four parts. Firstly, the sensitivity and robustness of a volumetric breast density (VBD) measurement system, Volpara, to errors in various imaging parameters (compressed breast thickness (CBT), tube voltage (kVp), filter thickness, tube current-exposure time product (mAs), detector gain, detector offset and image noise) were analyzed. Secondly, differences in VBD, breast granularity and mean glandular dose (MGD) were investigated among the three Malaysian ethnic groups. Thirdly, mammographic compression parameters [compression force (CF), compression pressure (CP), CBT and breast contact area (CA)] in Asian women were compared with Caucasian women. Lastly, volumetric measures [fibroglandular tissue volume (FGV), breast volume (BV), VBD, Volpara Density Grade (VDG) and MGD] in full field digital mammography (FFDM) were compared with those in digital breast tomosynthesis (DBT) for Asian women. Volpara was found to be robust for clinical use despite being sensitive to CBT and kVp. The maximum shifts in mean (1.2%) and median (1.1%) of estimated VBD for the study population occurred as CBT was decreased by 10%. Chinese women have significantly higher VBD and breast granularity (11.6±6.1% and 21.0±11.3%, respectively) than Malay women (9.7±5.7% and 16.0±9.6%, respectively) and Indian women (8.6±5.3% and 14.0±8.0%, respectively) ($p<0.05$). Nevertheless, Chinese women received significantly lower MGD (1.8±0.6 mGy) than Malay women (2.2±0.7 mGy) and Indian women (2.1±0.7 mGy) ($p<0.05$) because Chinese women have significantly lower CBT (4.9±1.1 cm) than Malay women (5.5±1.0 cm) and Indian women (5.5±1.0 cm) ($p<0.05$). Since current force-based mammographic compression protocols are largely optimized for Caucasian women, Asian women are subjected to inappropriate protocols. The lack of consistent guidelines led to variation in CF and CP among Asian and Caucasian women. CF applied in Dutch women was significantly higher than Asian and US women ($p<0.001$); whereas, CP applied in Asian women was significantly higher than Dutch and US women ($p<0.001$) because Asian women have significantly smaller breast CA than Dutch and US women ($p<0.001$).

Reducing CF from 12.0 daN to 9.0 daN has limited effect on image quality and MGD. Consequently, a general CF of 9.0 daN was proposed for Asian women. All volumetric measures in FFDM investigated were very strongly and significantly correlated with those in DBT ($p<0.0001$). Although there was no significant difference in BV ($p=0.42$), FGV and VBD in FFDM were significantly higher than those in DBT ($p<0.0001$). VBD overestimation in FFDM became more prominent in denser breasts. The absolute differences for the mean (0.5%) and median (0.2%) of VBD between FFDM and DBT were very small. MGD in FFDM was significantly lower than that in DBT ($p<0.0001$). The absolute differences for the mean and median of MGD between FFDM and DBT were 15.8% and 10.5%, respectively. VDG in FFDM and DBT agreed substantially ($\kappa=0.79$). In conclusion, FFDM and DBT are equally robust imaging modalities for VBD measurement. The results obtained from this research can be used to improve current practice in mammographic imaging.

References to author publications that relate specifically to the dissertation:

1. Ng K-H, **Lau S**. "Measurement and clinical use of breast density." In: Fujita H, Hara T, Muramatsu C, eds. *Breast Imaging. IWDM 2014. Lecture Notes in Computer Science.* Vol 8539. Cham: Springer; 2014:16-23.

2. Zakariyah N, Ng K-H, **Lau S**, Rahmat K, Fadzli F, Taib NAM. "Is volumetric breast density related to body mass index, body fat mass, waist-hip ratio, age and ethnicity for Malaysian women?" In: Fujita H, Hara T, Muramatsu C, eds. *Breast Imaging. IWDM 2014. Lecture Notes in Computer Science.* Vol 8539. Cham: Springer; 2014:251-256.

3. Ng KH, **Lau S**. Vision 20/20: "Mammographic breast density and its clinical applications." *Med Phys.* 2015;42(12):7059-7077.

4. **Lau S**, Ng KH, Abdul Aziz YF. "Volumetric breast density measurement: sensitivity analysis of a relative physics approach." *BJR*, British Institute of Radiology 2016;89(1066):20160258.

5. Zakariyah N, Pathy NB, Taib NAM, Rahmat K, Judy CW, Fadzil F, **Lau S**, Ng KH. "The relationships between breast volume, breast dense volume and volumetric breast density with body mass index, body fat mass and ethnicity." *Journal of Physics: Conference Series.* 2016;694(1):012050.

6. **Lau S**, Abdul Aziz YF, Ng KH. "Mammographic compression in Asian women." *PLoS ONE.* 2017;12(4):e0175781.