Functional imaging can be defined as technique that gives information about the vascularity, metabolism or cellular activity of a lesion or organ. Functional magnetic resonance imaging (MRI) techniques including dynamic contrast enhanced (DCE) MR, diffusion weighted imaging (DWI), blood oxygen level dependent (BOLD) MR can give information the tumor microenvironement. Nuclear medicine has traditionally given functional information such as metabolism and proliferation and this has been exploited in PET by using different radiotracers. Breast cancer has a marked degree of tumoral heterogeneity reflecting clonal diversity which exhibit various metabolic and functional phenotypic characteristics. This variation can result in differential response to treatment creating a challenge in the identification of the best therapeutic regimen for each patient. Vascular and proliferation measures can be used to predict response to treatment. Advances in genetics and pathology have improved our understanding of the tumor and facilitated tumor classification but the impact of the microenvironment on prognosis and treatment still remains poorly understood. This lecture will focus on various functional imaging techniques using breast cancer as a paradigm.

It has long been recognised that despite the clonal origin, tumors are intrinsically heterogeneous in many of their biologic properties. A large body of evidence suggests that tumors with similar genetic profiles can also exhibit heterogeneous phenotypes, suggesting that the physiological characteristics of the tumor microenvironment also play a significant role in defining cell metabolism. The relative contribution of these features to BC progression and treatment varies among tumor sub-types and greatly impacts clinical outcome. One limitation of the current treatment approaches lies in the fact that a single tissue sample cannot holistically represent the functional, physiological and morphological characteristics of tumors. Since complementary information from functional imaging modalities, such as PET and MRI, can provide a macroscopic depiction of the underlying tumor biology, it can be hypothesised that the diverse relationships between tumor profiles and micro-environmental factors will be manifested in the imaging findings. Prognostic information may be derived from the quantitative analysis of medical imaging data. The tumor microenvironment is created and is as a result of cancerous cells evolving and interacting with the host tissues. Multi-modal imaging approaches can offer spatially resolved distributions of functional macro-parameters, such as vascularity, proliferation, perfusion, hypoxia, cellularity, cell viability that can be linked to molecular phenotypes and immune and inflammatory changes. The ability to quantify and monitor changes in the microenvironment in vivo may provide insight into the development of diverse clones of cells and the role of macrophages and the immune response.

In order to undertake quantitative analysis imaging data must be collected with both high spatial and high temporal resolution. Advances in MR techniques together with higher field strengths have allowed this to happen. Pharmacokinetic modelling of DCE-MRI data can be used to derive biomarkers of tumor perfusion, which can indicate aggressiveness of disease, disease prognosis and prediction of response by monitoring changes during neoadjuvant chemotherapy (NACT). Koo et al found that tumors with higher Ktrans and kep together with lower ve values at 1.5T were associated with poor prognosis and were often the triple negative cancers. Changes in Ktrans have also been investigated as early predictive markers of therapeutic outcome at 1.5 and 3T field strengths.

Diffusion-weighted magnetic resonance imaging (DW-MRI) and apparent diffusion coefficient (ADC) enables characterisation of lesions based on differences in water diffusivity and in turn reflects tissue cellularity and the integrity of membranes. Bi-exponential signal decay has been observed over a range of b-values, with the lower b values related to perfusion (expressed as Dp,
the pseudo-diffusion coefficient, and \( f \), the vascular fraction) and higher b-values (>200s/m\(^2\)) giving true tissue diffusivity (\( D_t \)). This phenomenon is known as intra-voxel incoherent motion (IVIM). Tissue diffusion has been shown to be a somewhat reliable predictor of therapeutic response in breast cancer.

FDG-PET has been used in staging of breast cancer and also to predict response to NACT to good effect. The proliferation tracer FLT-PET demonstrates cell turnover and may have specific role in some targeted chemotherapy regimes. FES-PET is able to demonstrate the oestrogen receptor status and has been investigated as a tool to assess receptor activity which has implications for both treatment and prognosis. Similarly HER2 PET radiotracers are being developed for the same purpose for the 15% positive breast tumors and may have a role in assessing metastatic deposits which can change their receptor status and exhibit a mixed picture. Hypoxia has been shown to be an adverse predictive factor in many treatments. FMISO and FAZA are being investigated to assess the hypoxic fraction in tumors and to determine what effect this has on outcome.

A multimodal approach creates the opportunity to better interrogate the tumor microenvironment and may offer further insight into treatment opportunities.
The heterogeneity of breast cancer has been widely recognized, resulting in the identification of different molecular subtypes. Between these subtypes, differences exist in patient outcome as well as treatment options. Other established poor prognostic markers include a younger age, a large tumor size, the presence of axillary nodal metastasis, a high histologic grade, lymphovascular invasion, a high Ki-67 index, negative estrogen receptor (ER) expression, and human epidermal growth factor receptor 2 (HER2) overexpression. Women with a higher risk of early relapse appear to benefit from the use of novel or more intensive adjuvant treatment. However, as variation in outcome continues to exist within subtypes and it is difficult to accurately predict the poor prognosis for individual patients using current prognostic markers, more individualized patient-tailored therapy demands additional stratification of breast cancer outcome.

Breast imaging may provide useful information of the cancer while it is commonly used in daily practice and it is still in vivo. Preoperative MR imaging features of primary breast tumors may have the potential to act as prognostic biomarkers by providing morphologic and kinetic features representing inter- or intra-tumor heterogeneity and the microenvironment. As an effort to find imaging features associated with clinical outcome, many researches have been performed to investigate relationships between MR imaging features, molecular subtypes, and clinical outcome of breast cancer. Most widely known features would be rim enhancement, defined as the strong enhancement at the periphery of a tumor compared with that at the center; the presence of peritumoral edema displayed on T2-weighted images (T2WI); and the prepectoral location, appeared to be associated with aggressive tumor biology and a poor outcome. In addition, background parenchymal enhancement (BPE) was reported as a potential biomarker for poor outcome.

In this lecture, I will introduce and review possible imaging features associated with clinical outcome including results of my institution.

References

Application of new technology in breast imaging

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SS 06 BR-02 09:40
BI-RADS 3 lesions in screening automated breast volume scanner: comparison with 6-months follow-up hand-held breast US
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PURPOSE: To assess the value of automated breast volume scanner as a screening tool for diagnosing BI-RADS category 3 lesions, compared with 6-months follow-up hand-held breast US.

MATERIALS AND METHODS: In this study, total 1117 patients with first screening breast ultrasound (US) examination by ABVS from September 2014 to December 2015 were retrospectively evaluated. We included patients with at least one BI-RADS category 3 lesions and a 6 months follow-up hand-held breast US exam. BI-RADS category assigned at a 6 months follow-up hand-held breast US and pathologic findings in cases undergoing biopsy were collected. Using the BI-RADS lexicons, the images of the category 3 lesion detected by ABVS were analyzed and reasons for changing the BI-RADS category at follow-up hand-held breast US exam were discussed.

RESULTS: Among the 213 patients was diagnosed as BI-RADS category 3, 41 patients had a 6 months follow-up hand-held breast US. In 41 patients, 62 BI-RADS category 3 lesions were identified. After 6 months, category was downgraded to BI-RADS 1/2 in 15/62 (24%) and upgraded to BI-RADS category 4 in 2/62 (3%). BI-RADS category 1 was assigned to 8 cases of misdiagnosed fat lobule and to 4 lesions which were no more detectable. BI-RADS category 2 was assigned to 3 lesions that received a subsequent diagnosis of simple cyst. Biopsy was performed in 2 lesions which presented size increased at the 6 months follow-up. Pathologic diagnosis of two lesions was non-proliferative change and sclerosing adenosis.

CONCLUSION: The downgrade rate of BI-RADS category 3 lesions diagnosed by ABVS was high, but a missed cancer had not occurred at 6 months follow up. ABVS is a reliable screening tool for diagnosing BI-RADS category 3 lesions.
only could be feasible and may be an alternative screening method in asymptomatic women in their 40s.

SS 06 BR-03 10:00
Analysis of CAD detected lesions and false marks: initial experience of CAD for automated breast US
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PURPOSE: To evaluate the diagnostic performance using CAD (computer aided detection) for automated breast ultrasound (US) and to analyze the characteristics of CAD detected lesions and the causes of false marks.

MATERIALS AND METHODS: Total 40 breast cancer patients who underwent automated breast US for detect multiple suspicious lesions found on MRI were included. We applied the CAD (QVCAD™) to all of the automated breast US examinations. We evaluated the diagnostic accuracy of CAD. Then, we analyzed the characteristics of CAD detected lesions and the causes of false positive, false negative cases, and false marks.

RESULTS: Of total 122 suspicious lesions found on MRI of 40 patients, 52 daughter nodules near main breast cancer were excluded, and then 71 lesions were analyzed. The sensitivity, specificity, PPV and NPV of CAD for automated breast US were 75.5%, 90.9%, 94.9%, and 62.5%, respectively. 81.4% (35/43) invasive ductal cancer was detected by CAD. 85.3% (29/34) invasive ductal cancer showing mass (exclude nonmass) was detected by CAD. 90.3% (28/31) invasive ductal cancer more than 1 cm mass (exclude nonmass and less than 1 cm mass) was detected by CAD. The mean size of true positive versus false negative mass lesion was 2.08 ± 0.85 cm versus 1.6 ± 1.28 cm (p < 0.05). False positive lesion included a sclerosing adenosis and a usual ductal hyperplasia. Additionally, in total 24 false marks, the most common (19/24) cause was marginal or subareolar shadowing, then, 3 simple cysts, a hematoma, and a skin wart.

CONCLUSION: Promising detection sensitivity was obtained from the CAD for automated breast US on invasive ductal cancer showing mass which is more than 1cm sized.

SS 06 BR-04 10:10
Long-term outcome of ductal carcinoma in situ detected at screening mammography or US: association between screening method of detection and recurrence
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PURPOSE: To investigate whether the method of detection is associated with survival outcome in women with ductal carcinoma in situ (DCIS) detected at screening mammography or ultrasound (US).

MATERIALS AND METHODS: The Institutional Review Board approved this retrospective study. A review of the database of our institution identified 827 patients with DCIS (median age 47.9 years, range 25-81 years) detected at screening mammography (n = 638) or US (n = 189) between October 2004 and December 2011. The imaging and clinicopathologic data were collected. Five-year disease-free survival (DFS) rates were assessed by the Kaplan-Meier method and compared by log-rank test according to the screening method (mammography vs. US). Cox regression modeling was used to determine association between the screening method and recurrence with adjustments for other variables. Subgroup analyses were performed to determine the factors associated with recurrence according to the screening method.

RESULTS: At a median follow-up of 9 years, there were 50 (6%) recurrences (26 ipsilateral, 24 contralateral breast) and no death events. The 5-year DFS rates were not significantly different between the method of detection (mammography 94.9% vs. US 95.6%; p = 0.26). In multivariate analyses, intermediate (Hazard ratio [HR] = 7.04, p = 0.01) and high (HR = 10.25, p = 0.04) nuclear grades were significantly associated with recurrence compared with low nuclear grade in screening mammography-detected DCIS, and positive HER2 status (HR = 7.07, p = 0.03) and postmenopausal status (HR = 6.61, p = 0.03) were significantly associated with recurrence in screening US-detected DCIS.

CONCLUSION: In women with screening-detected DCIS, the method of detection was not associated with survival outcome. Higher nuclear grade was significantly associated with recurrence in screening mammography-detected DCIS, and positive HER2 and postmenopausal status were significantly associated with recurrence in screening US-detected DCIS.
Digital breast tomosynthesis - synthesized 2D images (C-view) versus original full field digital mammography (FFDM) in BI-RADS categorization and density assessment

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PURPOSE: To compare C-View images to FFDM in BI-RADS categorization and breast density assessment. We hypothesized that C-view are equivalent to FFDM and can replace it in routine clinical practice.

MATERIALS AND METHODS: 380 patients were included with FFDM and tomosynthesis performed in all patients. The breast tomosynthesis images were synthesized to 2D images (C-View). FFDM and C-View images were evaluated by three readers independently and at separate seating. BI-RADS category and breast density were assessed. Histopathology findings (n = 40) were compared between FFDM and C-View. Sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) of C-View was calculated with FFDM as standard of reference, and PPV of both C-View and FFDM was calculated with histopathology as gold standard. Agreement for BI-RADS categories and breast density between C-View and FFDM in readers were assessed.

RESULTS: Substantial agreement in all readers in BI-RADS category and density assessment between C-View and FFDM (κ: 0.811, 0.888, 0.934, p < 0.001 and κ: 0.988, 0.946, 0.982, p < 0.001). When taking FFDM as standard of reference, C-View yielded > 94% sensitivity, > 98% specificity with > 88% PPV and > 99.4% NPV, with comparable PPV between C-View and FFDM with histopathology as gold standard. Agreement for BI-RADS categories and breast density between C-View and FFDM in readers were assessed.

CONCLUSION: Synthesized 2D images are comparable to original FFDM in BI-RADS categorization and density assessment with substantial reduction in radiation dose to the breast.

Validation of a web browser-based semi-automated method for MRI breast density measurement

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PURPOSE: Breast density, defined as the ratio of fibroglandular tissue to fatty tissue, can be estimated from mammograms and MRIs. High breast densities have increased risk of breast malignancy. To validate a web browser-based semi-automated method for determination of breast density from MRI studies.

MATERIALS AND METHODS: Patients who underwent breast MRI in Hospital Selayang from June to December 2016, who had at least 1 normal breast MRI, were included. Volumetric T1 and T1FS MRI images were loaded into mcdcmViewer (http://isodense.com/mcdcm). Identification and separation of the chest wall was performed manually on at least 2 slices, with the software performing the interpolation of the in-between slices. Representative signal intensities for fibroglandular tissue, fat and air were sampled manually. Subsequently, the software would automatically segment the relevant tissues and calculate the breast density for all the slices within the defined range. The densities of five slices per breast were compared to the reference standard, which was determined via blinded manual segmentation of those 5 slices by a single radiologist using commercial software (Adobe Photoshop).

RESULTS: A total of 10 normal breasts (50 slices) were included. The semi-automated method shows excellent intraclass correlation with the reference standard for both T1 (0.964) and T1FS (0.961). Pearson correlation was excellent in both T1 (r = 0.95, p < 0.001) and T1FS (r = 0.94, p < 0.001). Spearman correlation for density groups were likewise excellent (T1: r = 0.835, T1FS: r = 0.828; p < 0.001).

CONCLUSION: Synthesized 2D images are comparable to original FFDM in BI-RADS categorization and density assessment with substantial reduction in radiation dose to the breast.
Manual segmentation of the chest wall is represented by the yellow line. Note that the algorithm does not include the right nipple (uncolored) as part of fibroglandular tissue.

**CONCLUSION:** The tested semi-automated method shows excellent correlation with manual segmentation and can be used as a tool for rapid MRI breast density measurement.

**SS 06 BR-07 10:40**

**MRI surveillance for women with a personal history of breast cancer: comparison between abbreviated and full diagnostic protocol**

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**PURPOSE:** To compare the diagnostic performance of breast magnetic resonance imaging (MRI) with abbreviated protocol (ABP) and full diagnostic protocol (FDP) in women with a personal history of breast cancer.

**MATERIALS AND METHODS:** From September 2015, we started to obtain screening breast MRI in patients with a personal history of breast cancer using ABP. ABP consists of T2-weighted scanning and dynamic contrast enhanced imaging including one pre-contrast and two post-contrast scanning of gradient echo sequence at 80 and 160 seconds after contrast injection. Among the total 2918 screening breast MRIs using ABP, we selected 381 cases that were confirmed by histological diagnosis or by negative follow up images after one year. As a control group, we selected postoperative screening breast MRIs using FDP of recent 7 years before September 2015. We matched patients’ age, interval between the cancer surgery and MRI examination, and stage of the operated breast cancer. Finally 311 matched cases from ABP and FDP groups were included. We analyzed diagnostic performance for detecting recurrent breast cancer including specificity, sensitivity, positive predictive value (PPV), negative predictive value (NPV), accuracy, and area under the curve (AUC) and compared the results between ABP and FDP.

**RESULTS:** The sensitivity and NPV were 100% in both ABP and FDP. Specificity, PPV, accuracy, and AUC of ABP and FDP were 95.7% vs. 96.1%, 40.9% vs. 14.3%, 95.8% vs. 96.1%, and 97.9% vs. 98.1%, respectively. Specificity, accuracy and AUC were higher in ABP than FDP suggesting decreased number of false positive cases. ABP can provide a better choice that has similar diagnostic performance and shorter MRI acquisition time in MRI surveillance for women with a personal history of breast cancer.

**SS 06 BR-08 10:50**

**Accuracy and outcomes of screening breast US in women with a personal history of early-stage breast cancer**

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**PURPOSE:** To evaluate the performances of breast ultrasonographic (US) screening in women with a personal history of breast cancer (PHBC) by comparison with those in women without personal history of breast cancer (non-PHBC).

**MATERIALS AND METHODS:** Between January 2013 and December 2013, 12,747 consecutive screening whole breast US examinations were identified. Among them, women with an initial early-stage breast cancer (including stage 0 to II) were eligible. Non-PHBC women who underwent incident screens at least 9 months ago and had negative mammography and at least 1-year follow-up were matched 1:1 to PHBC women according to breast density and age. Screening performance measures were calculated and compared between the two groups by using generalized estimation equation or chi-square test. Characteristics of screen-detected and interval cancers were described.

**RESULTS:** There were 3435 exams in 3226 PHBC women (mean age, 52.3; range, 24-83 years) and 3291 exams in 3226 matched women without PHBC (mean age, 52.2; range, 25-84 years) (603 fatty, 2623 dense women for each group). Fourteen cancers (10 screen-detected, 4 interval cancers) were observed in PHBC women and 13 cancers (12 screen-detected, 1 interval cancer) in non-PHBC women. Performances of PHBC versus non-PHBC women were similar in the following outcomes; cancer detection rate of 2.9 per 1000 vs. 3.6 per 1000 (p = 0.6), interval cancer rate of 1.2 per 1000 vs. 0.3 per 1000 (p = 0.23), sensitivity of 71.4% (10/14) versus 92.3% (12/13) (p = 0.33), positive predictive value of 10.9% (4/37) versus 21.1% (12/57) (p = 0.20). Specificity and abnormal interpretation rate of PHBC were better than those of non-PHBC as follows; 93.2% (3176/3421) versus 89.6% (2917/3278) (p < 0.001) and 7.4% (255/3435) versus 11.2% (373/3291) (p < 0.001). In addition, 70% (7/10) of screen-detected cancers and 50% (2/4) of interval cancers in PHBC women were stage I or II, while all observed cancers (100%, 13/13)
were stage I or II in non-PHBC women (64.3% [9/14] vs. 100% [13/13], p = 0.04).

**CONCLUSION:** US screening in PHBC women detects early second breast cancers with higher specificity, however, has more advanced stage observed cancers, relative to those in non-PHBC women.

**CLINICAL IMPLICATION:** Supplemental breast US screening in addition to mammography is recommendable for breast cancer survivors, although more advanced stage cancers are observed than those in non-PHBC women.

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**SS 06 BR-09 11:00**

**Effect of training on breast US performance and agreements on BI-RADS US features for radiology residents: a multicenter study using dedicated education material for breast US**

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**PURPOSE:** To evaluate the effect of training diagnostic performances on breast ultrasonography (US) and agreements on US BI-RADS features for radiology residents after training sessions using video clips.

**MATERIALS AND METHODS:** This study is a prospective study including patients and radiology residents from 8 institutions. From Oct 2013 to Apr 2014, 120 breast masses in 120 women that were pathologically-confirmed with percutaneous biopsy, surgical excision, or those with typically benign features on breast US were prospectively included. Representative grayscale images of the breast masses along with video clips were recorded, among which 54 were used as education set, and 66 were used as test set. Sixty-one radiology residents who were scheduled to be trained in the breast radiology section from the 8 institutions individually reviewed the test set three times, immediately before, 1-month after, and 6-months after training. Diagnostic performances of the residents and agreements on US BI-RADS features were evaluated and compared, to each test period and to the test results of 6 experienced breast radiologists.

**RESULTS:** For diagnostic performances of the 61 residents, sensitivity (91.0%), negative predictive value (NPV, 93.1%), and area under the receiver operating characteristics curve (AUC, 0.808) was significantly improved in 1 month (96.3%, 96.4%, 0.836) and 6 months (96.3%, 96.5%, 0.840) after training (all ps < 0.05, respectively). Agreements on US BI-RADS features showed significant improvement in 1-month and 6-months after training for orientation (κ = 0.495 to 0.569, 0.570), echogenicity (κ = 0.305 to 0.339, 0.345), margin (κ = 0.194 to 0.268, 0.272), and calcifications (κ = 0.428 to 0.481, 0.488), respectively (all ps < 0.05). The total number of US examinations and sessions/week that the resident was involved in breast US imaging were factors that significantly improving the AUC values.

**CONCLUSION:** Training using education material dedicated for breast US imaging were effective in improving the diagnostic performances of radiology residents and agreements on US BI-RADS features.
CONCLUSION: Microcalcifications of DCIS were correlated with pathologic and biological prognostic factors. Microcalcifications were associated with poor prognostic factors such as high nuclear grade and comedo necrosis. Poor prognostic factors like ER negative or HER2 positive types were correlated with microcalcifications on imaging.

RESULTS: The correlation coefficient (r) between tumor size on ultrasound images (mean, 24.1 ± 17.2 mm) (r = 0.644) and that on conventional images (mean, 27.3 ± 19.8 mm) (r = 0.511) was similar to that on histopathology (mean, 27.9 ± 18.2 mm), (difference between the correlations, p = 0.123). Contrary to in patients with minimal to moderate BPE, in patients with marked BPE, the correlation coefficient was higher on ultrasound images than that on conventional images (r = 0.918 vs. 0.430, p = 0.013). No difference was found in correlation coefficients in subgroup analyses, according to the lesion type, ER positivity, and receipt of NST (all ps > 0.05).

CONCLUSION: In patients with marked BPE, evaluation of tumor extent was more accurate on Ultrafast MR images than on conventional MR images.

CLINICAL RELEVANCE: Ultrafast MRI shows improved lesion extent evaluation in women with marked BPE, which shows potential utility in improving diagnostic performance of MRI for women with marked BPE.

PURPOSE: To predict the sentinel lymph node (SLN) metastasis in patients with breast cancer using dynamic contrast-enhanced magnetic resonance imaging (DCE-MRI) and diffusion weighted imaging (DWI).

MATERIALS AND METHODS: Among 1189 breast cancer patients who were enrolled. They underwent 3.0-T DCE-MRI, including DWI with b value 0 and 800 s/mm². We compared MRI
features (adjacent vessel sign, whole-breast vascularity, background parenchymal enhancement, signal enhancement ratio [SER], internal enhancement, initial enhancement pattern, late enhancement pattern, tumor-apparent diffusion coefficient [T-ADC], peritumoral ADC and peritumor-tumor ADC ratio) and clinico-pathologic variables (age, stage, histologic grade, nuclear grade, extensive intraductal carcinoma component [EIC], existence of lymphovascular invasion [LVI] and immunohistochemical profiles) between patients with SLN metastasis and no lymph node metastasis. The area under the receiver operating characteristic curves (AUC) was calculated to measure and compare the predictability of SLN metastasis using MRI features and clinico-pathologic variables.

RESULTS: Among the 352 women, 64 women (18.2%) showed SLN metastasis, but 288 women (81.8%) had no SLN metastasis. On MRI, peritumor-tumor ADC ratio (OR = 16.31, 95% confidence intervals [CI] 2.10-127.01) was independently associated with SLN metastasis. Among clinico-pathologic variables, stage (OR = 9.83, 95% CI 4.50-21.45), EIC (OR = 36.50, 95% CI 9.13-146.15), LVI (OR = 4.52, 95% CI 4.52-23.92) and CD31 (OR = 3.77, 95% CI 1.19-12.01) were independently associated with SLN metastasis. The area under the receiver operating characteristic curves (AUC) of combining the selected MRI features and clinico-pathologic variables was higher than that of clinico-pathologic variables (p < 0.05).

CONCLUSION: Peritumor-tumor ADC ratio on MRI could be useful for preoperative prediction of SLN metastasis. The use of MRI features in conjunction with clinico-pathologic variables could improve in predictive performance of SLN metastasis.

SS 12 BR-04 16:30
Preoperative breast MRI in women with invasive lobular carcinoma: surgical outcomes according to propensity score matching
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PURPOSE: To evaluate if patients diagnosed with invasive lobular carcinoma differentially benefit from preoperative breast MRI, we analyzed adequate changes in surgical management and outcomes-initial mastectomy, reoperation, and final mastectomy rates.

MATERIALS AND METHODS: Institutional Review Board approved this retrospective study, and the requirement for informed consent was waived. We identified patients with invasive lobular carcinoma and underwent surgery from January 2005 to December 2016 (n = 603). We calculated the MR detection rate of additional lesions occult to mammography and ultrasound, and analyzed if surgical management was altered due to MR finding. We also used propensity score matching to account for the differential likelihood of exposure to MRI, controlling 19 unadjusted confounders including patient demographics, tumor characteristics, and various clinical features. Surgical outcomes - initial mastectomy, reoperation, and final mastectomy rates - were compared.

RESULTS: 369 (61.2%) patients received preoperative breast MRI. Additional lesion detection was observed in 145 (39.3%), among them 95 (65.5%) were diagnosed as malignant. A change in surgical management due to MR finding occurred in 94 (25.5%). According to the postoperative pathology finding, this change was adequate for 84 (89.4%) of these patients. An unnecessary surgical management occurred for 10 (10.6%) patients. In the propensity score-adjusted analysis, breast MRI was associated with lower odds of reoperation (OR 0.112; 95% CI [0.043-0.292], p = 0.000), and equal likelihood of initial (OR 1.000; 95% CI [0.660-1.515], p = 1.000) and final (OR 0.773; 95% CI [0.515-1.161], p = 0.214) mastectomy compared to matched patients without breast MRI.

CONCLUSION: Preoperative MRI is useful for detecting additional synchronous malignancy and significantly reduces reoperation without increasing the rate of mastectomy in patients with invasive lobular carcinoma.

SS 12 BR-05 16:40
Quantitative diffusion kurtosis imaging and diffusion weighted imaging for the differentiation of additional suspicious lesions on preoperative breast MRI of patients with known breast cancer
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PURPOSE: To investigate the potential of quantitative diffusion-weighted imaging (DWI) and diffusion kurtosis imaging (DKI) for the differentiation of additional suspicious lesions in patients with known breast cancer.

MATERIALS AND METHODS: This study included 45 women with newly diagnosed breast cancer who had additional suspicious breast lesions on preoperative breast MRI. Fifty-three pathologically confirmed breast lesions larger than 1cm were included. DKI (with b values of 0-3000 sec/mm²) and conventional diffusion-weighted imaging data (using b values of 50-1000 sec/mm²) were acquired. Kurtosis and diffusion coefficients from DKI and apparent diffusion coefficients from DWI...
were measured and compared according to lesion type. 

**RESULTS:** The median size on MRI was 12 mm (range, 11.92 mm). Twenty-three lesions (43.4%) were benign and 30 (56.6%) were malignant (ductal carcinoma *in situ* [DCIS], n = 14; invasive carcinoma, n = 16). For all 53 breast lesions, none of the DKI and DWI parameters were significantly different between benign and malignant lesions. 50th percentile diffusivity coefficients were lower in malignant lesions than those in benign lesions with borderline significance (p = 0.088, 1.25 [range, 0.44-2.80] vs. 1.34 [range, 0.81-2.45]). When excluding 14 malignant lesions that were confirmed as DCIS, there were significant differences between benign and malignant lesions for diffusivity coefficient parameters (mean diffusivity coefficient [p = 0.032], 50th percentile diffusivity coefficient [p = 0.026], 75th percentile diffusivity coefficient [p = 0.026], 90th percentile diffusivity coefficient [p = 0.030], maximum diffusivity coefficient [p = 0.046]). Among DWI parameters, only 75th percentile ADCs were significantly lower in malignant lesions (p = 0.035). Mean ADCs (p = 0.063), 50th percentile ADCs (p = 0.059) were lower in malignant lesions with borderline significance.

**CONCLUSION:** Quantitative DWI and DKI parameters have limited value in the differentiation of additional suspicious lesions seen at preoperative breast MRI in breast cancer patients. DKI parameters may be more useful than DWI parameters for the differentiation between benign lesions and invasive carcinoma.

**SS 12 BR-06 16:50**

**Diffusion tensor MR imaging of breast cancer: associations between diffusion metrics and histologic prognostic factors**

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**PURPOSE:** To investigate whether quantitative diffusion metrics derived from diffusion tensor imaging (DTI) are associated with histological prognostic factors in patients with breast cancer.

**MATERIALS AND METHODS:** Institutional Review Board approval and written informed consent were obtained. Between June 2016 and January 2017, 251 women (mean age, 53.4 years; range, 25-93 years) with breast cancer (230 invasive and 21 *in situ*) who had undergone preoperative MR imaging with DTI using a 3.0 Tesla scanner were identified. Diffusion gradients were applied in 20 directions with b values of 0 and 1000 s/mm². DTI metrics such as mean diffusivity (MD) and fractional anisotropy (FA) were measured for breast lesions by two radiologists and correlated with histologic prognostic factors (histology; invasive size; histological grade; lymphovascular invasion; axillary nodal status; estrogen receptor, progesterone receptor, human epidermal growth factor receptor-2, Ki-67, and p53 status) using a Mann-Whitney U test and linear regression analysis.

**RESULTS:** MD and FA values in invasive breast cancers were significantly lower than those in ductal carcinoma _in situ_ lesions (1.009 ± 0.256 × 10⁻³ mm²/s vs. 1.288 ± 0.211 × 10⁻³ mm²/s, p < 0.001; 0.291 ± 0.099 vs. 0.352 ± 0.094, p = 0.008; respectively). In patients with invasive breast cancer, larger tumor size (> 2 cm), high histological grade (grade 3), lymphovascular invasion, and axillary node metastasis showed significant associations with low MD values (p < 0.001, p = 0.008, p < 0.001 and p < 0.001, respectively). Larger tumor size, and high histological grade also showed significant associations with low FA values (p < 0.001 and p = 0.008, respectively). By multivariate stepwise linear regression analysis, larger tumor size, high histological grade, and axillary node metastasis were independently associated with low MD values (p = 0.007, p = 0.045 and p = 0.009, respectively). Larger tumor size, and high histological grade were also independently associated with low FA values (p < 0.001 and p = 0.025, respectively).

**CONCLUSION:** DTI-derived diffusion metrics such as MD and FA are associated with histologic prognostic factors in patients with breast cancer.

**SS 12 BR-07 17:00**

**Preoperative breast MR imaging kinetic features using computer-aided diagnosis: association with survival outcome in invasive breast cancer patients**

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**PURPOSE:** To evaluate whether preoperative breast dynamic contrast-enhanced (DCE) magnetic resonance (MR) imaging kinetic features assessed using computer-aided diagnosis (CAD) can predict survival outcome in invasive breast cancer patients.

**MATERIALS AND METHODS:** The Institutional Review Board approved this retrospective study, and waived the need for informed consent. Between March and December 2011, 301 women who underwent preoperative DCE MR imaging for invasive breast cancer, with CAD data, were identified. The Cox proportional hazards model was used to determine the association between the kinetic features assessed by CAD and recurrence-free survival (RFS). The peak signal intensity and kinetic enhancement profiles were compared with the clinical-pathological variables using
Background parenchymal enhancement on breast MRI may not be associated with outcome of patients with unilateral ER-positive, HER2-negative, node-negative invasive breast cancer

PURPOSE: To investigate whether parenchymal enhancement of contralateral breast on preoperative dynamic-contrast enhanced (DCE) MRI is associated with therapy outcome in ER-positive, HER2-negative, node-negative invasive breast cancer.

MATERIALS AND METHODS: 289 patients with unilateral ER-positive, HER2-negative, node-negative breast cancer larger than 5mm who underwent DCE-MRI were included. Parenchymal enhancement was assessed qualitatively and quantitatively, using ROI (early and delayed enhancement rate, signal enhancement ratio (SER), and late enhancement ([S6-S1]/S1)). Cox regression was used to determine associations with recurrence-free survival and distant metastasis-free survival. Interobserver variability for parenchymal enhancement was assessed.

RESULTS: The median follow-up time was 63.8 months. There were 17 of 289 (5.9%) recurrences (5 locoregional recurrences and 12 distant metastases). Multivariate analysis showed receipt of total mastectomy (hazard ratio [HR] = 4.390) and high Ki-67 expression level (HR = 5.757) were independent factors associated with worse recurrence-free survival (all ps < 0.05). High Ki-67 expression level was associated with worse distant metastasis-free survival with borderline significance (HR = 3.309, p = 0.059). Both quantitative and qualitative assessments of parenchymal enhancement were not associated with outcome (all ps > 0.05). Even after adjustment for the menstrual cycle, there was no association between parenchymal enhancement and outcome. There was good agreement between qualitative (κ = 0.700) and good to perfect agreement for most quantitative parameters of parenchymal enhancement (ICC: early enhancement rate, 0.831; delayed enhancement rate, 0.840; SER, 0.340; late enhancement, 0.793).

CONCLUSION: Contralateral breast parenchymal enhancement, assessed using ROI, showed no significant association with therapy outcome in patients with unilateral ER-positive, HER2-negative, node-negative invasive breast cancer.
Irregular shape and rim enhancement pattern on MRI findings (p = 0.004). The mean ADC value was also significantly lower in mass group than non-mass group. The diagnostic accuracy of pSUV/ADC (87.8%) was higher than pSUV (83.6%) and ADC values (17.6%) for invasive breast cancer.

CONCLUSION: The pSUV, mean ADC value and pSUV/ADC are useful indexes for predicting the prognosis of breast cancers.

SS 12 BR-10 17:30 Prediction of low-risk ductal carcinoma in situ using whole-lesion histogram analysis of the apparent diffusion coefficient
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PURPOSE: To investigate the value of histogram-derived apparent diffusion coefficient (ADC) metrics obtained from whole-lesion assessment of diffusion-weighted imaging (DWI) for predicting a low-risk ductal carcinoma in situ (DCIS).

MATERIALS AND METHODS: The Institutional Review Board approved this retrospective study, and waived informed consent. The authors identified 93 women (mean age, 51.9 years; range, 32-76 years) with pure DCIS, who had undergone preoperative MR imaging and DWI from 2013 to 2016. Histogram analysis of pixel-based ADC data of the whole tumor volume and conventional measurement of the mean ADC by placing regions of interest were performed by two radiologists. The mean, median, and 5th and 95th percentile ADCs obtained from whole-lesion histogram and the ROI-based mean ADC were compared between low-grade and non-low-grade DCIS. Associations of whole-lesion histogram ADC metrics with low-grade DCIS were evaluated by receiver operating characteristics (ROC) curve and logistic regression analyses.

RESULTS: In whole-lesion histogram analysis, the mean, median, and 5th and 95th percentile ADCs were significantly different between low-grade and non-low-grade DCIS (1.522, 1.536, 1.207, and 1.854 × 10^{-3} mm²/s vs. 1.270, 1.261, 0.917, and 1.657 × 10^{-3} mm²/s, respectively; p = 0.004, 0.004, 0.003, and p = 0.024, respectively). However, ROI-based mean ADC was not significantly different (p = 0.278). ROC curve analysis for the differentiation between low-grade and non-low-grade DCIS groups revealed that the most effective threshold for the 5th percentile ADC was > 1.078 × 10^{-3} mm²/s (sensitivity 80%, specificity 75.9%, area under the curve [AUC] 0.786, p = 0.001). No differences in the AUC were found among the ADC metrics of whole-lesion histogram. Multivariate regression analysis revealed that a higher 5th percentile ADC (> 1.078 × 10^{-3} mm²/s; odds ratio [OR] = 10.494, p = 0.016), smaller tumor size (≤ 2 cm; OR = 12.692, p = 0.008), and low Ki-67 status (< 14%; OR = 10.879, p = 0.046) were significantly associated with low-grade DCIS.

CONCLUSION: Assessment with whole-lesion histogram analysis of the ADC could be helpful for identifying patients with low-risk DCIS.

SS 12 BR-11 17:40 Radiomics signature on 3T DCE-MRI for estrogen receptor-positive invasive breast cancers: preliminary results in predicting oncotype DX Test recurrence score
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PURPOSE: To evaluate the ability of radiomics signature based on 3T dynamic contrast-enhanced (DCE) magnetic resonance imaging (MRI) to distinguish estrogen receptor (ER)-positive invasive breast cancers between the low and non-low Oncotype DX (OD) risk categories.

MATERIALS AND METHODS: This retrospective study was approved by the Institutional Review Board. The requirement to obtain informed consent was waived. We enrolled 67 women with ER-positive invasive breast cancer who performed preoperative 3T MRI and OD assay between May 2011 to March 2016. We divided the patients into low (OD recurrence score (RS) < 18) and non-low risk (RS ≥ 18) groups. Extracted radiomics features included 10 morphological, 76 histogram-based, and 72 higher-order texture features. A radiomics signature (Rad-score) was generated using the least absolute shrinkage and selection operator (LASSO). Stepwise logistic regression analysis was performed to investigate the association between clinicopathologic factors, MR imaging findings, or Rad-score and OD risk groups. The area under the receiver operating characteristic curve (Az) were used to assess classification performance of Rad-score.

RESULTS: The Rad-score was constructed for each tumor by extracting thirteen of 158 radiomics features (8.2%). A higher Rad-score (odds ratio [OR], 23.941; p < 0.001) and high Ki-67 expression (OR, 17.809; p = 0.001) were associated with non-low OD risk group. The Rad-score enabled differentiation between low and non-low risk OD groups with an Az of 0.822.

CONCLUSION: The Rad-score was highly associated with the low and non-low OD risk classifications in...
patients with ER-positive invasive breast cancers.

Purpose: To compare the time to enhancement (TTE) of breast cancer at ultrafast breast DCE-MRI according to the histopathological characteristics.

Materials and Methods: Between January and April 2017, 86 consecutive breast cancer patients (mean age, 51.3; range, 27-78 years) who underwent the ultrafast breast DCE-MR examinations and subsequent surgery were identified. A total of 88 breast cancers (75 IDC and 13 DCIS) were included for analysis. Ultrafast-MRI images were obtained using time-resolved angiography with stochastic trajectories sequence with a 4.5 second resolution for 20 phases (TR/TE 4.1/1.3 ms, 1.1 × 1.1 × 1.0 mm³ voxel) before conventional high spatial resolution DCE-MRI images. One radiologist aware of tumor location but no other clinical or histopathologic information reviewed the ultrafast-MR images and assessed the TTE of the tumor. TTE was calculated as the phase of initial enhancement of tumor relative to the descending aorta, multiplied by 4.5 sec. Phase of initial enhancement was defined as the timing when the signal intensity of a region of interest became more than twice than that of non-enhancement images. Independent sample t-test was performed to compare the mean TTE according to the histologic type (invasive cancer vs. DCIS), histologic grade (high vs. low grade), lesion type (mass vs. non-mass), tumor subtype (luminal vs. HER-2 enriched vs. triple negative subtype) and level of Ki-67 (> 20% vs. ≤ 20%).

Results: Mean TTE of triple-negative subtype (TNBC) was shorter than that of non-TNBC (9.00 ± 0.00 vs. 11.61 ± 4.49, p < 0.001). Mean TTE of tumor with high Ki-67 (> 20%) was shorter than that of tumor with low Ki-67 (≤ 20%) (9.00 ± 0.00 vs. 11.50 ± 4.44, p < 0.001). No difference was found in the TTE between IDC and DCIS (11.22 ± 4.40 vs. 12.46 ± 4.17, p = 0.347), high grade and low grade IDC (10.13 ± 2.47 vs. 11.62 ± 4.88, p = 0.087), high grade and low grade DCIS (12.00 ± 5.20 vs. 12.60 ± 4.14, p = 0.838), or mass and non-mass type (11.10 ± 4.14 vs. 11.40 ± 4.83, p = 0.775).

Conclusion: TTE of aggressive breast tumors is shorter than that of less aggressive breast tumors at ultrafast breast DCE-MRI.

Clinical Relevance: Early kinetic information of breast tumors at Ultrafast-MR images has the potential to provide information of refined tumor characterization.
RESULTS: We evaluated the immunohistologic features determined size using intraclass correlation coefficient (ICC). We also evaluated the immunohistologic features including ER, PR, HER-2, p53, CK5/6, and Ki-67 (all ps > 0.05).

CONCLUSION: Both of CESM and breast MRI showed good agreement with pathology in measuring tumor size, and the most accurate method was CC view of CESM.

PURPOSE: To compare the accuracy of contrast-enhanced spectral mammography (CESM) and breast magnetic resonance imaging (MRI) for size measuring of histologically proven breast cancers.

MATERIALS AND METHODS: Between November 2016 and March 2017, a total of 52 women with 54 breast cancer underwent CESM and breast MRI before surgery. The maximum diameter of the main lesion was measured on early (2 minutes after contrast injection), delayed (7 minutes after contrast injection) MLO view, CC view of CESM, and sagittal, axial maximal intensity projection (MIP) reconstructions, early-subtracted dynamic contrast-enhanced (DCE) T1-weighted images of MRI. We also calculated the maximum diameter of CESM (either early, delayed MLO or CC view), and MIP reconstruction (either sagittal or axial image). We blindly reviewed all images, and evaluated visibility of tumor. Bland-Altman plot was used, and we analyzed the agreement between CESM, MRI and pathology-determined size using intraclass correlation coefficient (ICC). We also evaluated the immunohistologic features using the best result of size agreement.

RESULTS: There were invasive ductal carcinoma (n = 37), ductal carcinoma in situ (n = 10), invasive lobular carcinoma (n = 4), and the other histologic types (n = 3). Breast cancers were visible in 98.1% of CESM, 100% of MIP reconstruction and 96.3% of DCE images of MRI. Mean pathology-determined tumor size was 21.4 ± 15.1 mm, and showed good agreement (k > 0.75) with all parameters of CESM and MRI especially with the best result in CC view of CESM (k = 0.865) compared with the delayed MLO view of CESM (k = 0.843), axial MIP (k = 0.836), DCE-MRI (k = 0.831), early MLO view of CESM (k = 0.802), sagittal MIP (k = 0.795), maximum diameters of CESM (k = 0.791) and MIP reconstruction (k = 0.779) images in order. However, using the CC view of CESM which showed most accurate result, the measured size showed no significance with all immunohistologic features including ER, PR, HER-2, p53, CK5/6, and Ki-67 (all ps > 0.05).

CONCLUSION: Both of CESM and breast MRI showed good agreement with pathology in measuring tumor size, and the most accurate method was CC view of CESM.
3, 43 (5.79%), 27 (3.64%) and 47 (6.33%) lesions into categories 4A, 4B and 4C, respectively, and 363 (48.92%) into category 5, compared with 276/742 (37.19%), 199 (26.82%), 93 (12.53%) and 172 (23.18%) in BI-RADS 4A, 4B, 4C, and 5 based on conventional US and mammography. Selecting CEUS-based BI-RADS category 3 as an appropriate cut-off gave accuracy, sensitivity, specificity, positive and negative predictive values of 80.05%, 98.26%, 64.32%, 70.42% and 97.71%, respectively for the diagnosis of malignant disease. The cancer-to-biopsy yield was 64.3% with CEUS-based BI-RADS 3 selected as the biopsy threshold compared with 46.42% otherwise, while the biopsy rate was only 72.2% compared with 100% otherwise. Overall, only 1.74% of invasive cancers were misdiagnosed as BI-RADS 3 we use nowadays.

**CONCLUSION:** This study suggests that evaluation of BI-RADS 4 or 5 breast lesions with CEUS results in reduced biopsy rates and increased cancer-to-biopsy yields.

**SS 21 BR-03 10:10**

**Low-dose perfusion CT of the breast: quantitative assessment of tumor vascularity and correlation with biological features in breast cancer**

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**PURPOSE:** To prospectively evaluate the feasibility of low-dose perfusion computed tomographic (CT) technique in the prone position to breast cancer for quantification of tumor vascularity and to correlate perfusion CT parameters with biological characteristics.

**MATERIALS AND METHODS:** Low-dose perfusion CT in the prone position was performed in 70 patients with invasive breast cancers. CT was performed with a spectral CT (iQon, Philips Healthcare) after contrast media (Xenetix350, Guerbet) injection. On CT perfusion maps, perfusion (mL/100 g/min), blood volume (mL/100 g), time to peak (sec), and peak enhancement (HU) were measured in the tumor, normal breast glandular tissues, and fat by using commercial perfusion software. Pathologically, lymph node status, tumor grade, estrogen receptor, progesterone receptor, human epidermal growth factor receptor 2, and Ki67 level were evaluated. Statistically, CT perfusion indexes of the tumor and normal muscle or fat were compared using the Wilcoxon signed rank test and CT indexes were correlated with histological characteristics with the Mann-Whitney or Kruskal-Wallis test.

**RESULTS:** In breast cancers, perfusion, blood volume, and peak enhancement values were significantly higher and time to peak was significantly shorter than these values in normal glandular tissues and fat (p < 0.0035). Perfusion significantly increased in breast cancers with, high grade or high mitotic count (p < 0.05). Time to peak decreased in cancers with estrogen receptor positive, high Ki67 level, or high grade (p < 0.05). Peak enhancement significantly increased in high nuclear grade (p < 0.05).

**CONCLUSION:** Low-dose perfusion CT in the prone position is feasible to quantify tumor vascularity in breast cancers and perfusion CT parameters are significantly correlated with tumor biological characteristics.
Contrast-enhanced US: prediction of response to neoadjuvant chemotherapy for breast cancer and interobserver agreement

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PURPOSE: To evaluate the contrast-enhanced ultrasound (CEUS) using the different region of interest (ROI) and time-intensity curve for predicting the response of breast cancer to neoadjuvant chemotherapy (NAC) and to assess the interobserver agreement.

MATERIALS AND METHODS: The Institutional Review Board approved this prospective study. This study included 41 breast cancer patients (mean age, 46.6 years; range, 25-67 years) who underwent NAC. CEUS by Philips iU22 with Sonovue as contrast agent was performed before and after NAC, and the time-intensity curve with advanced US quantification software (Q LAB) was analyzed in 4 ROI types. ROI 1 was placed on the hot spot area, ROI 2 on the enhanced total tumor, ROI 3 on the entire tumor area of gray-scale US, ROI 4 on the outside of tumor. CEUS characteristics were compared according to the Miller-Payne score, and interobserver agreement for two readers was measured.

RESULTS: Eleven (26.8%) patients of 41 showed a good response (Miller-Payne score of 4 or 5), and 30 (73.2%) showed a poor response (Miller-Payne score of 1, 2, or 3). The good responder had significantly (p = 0.001) higher mean wash-out rate (WoR, 69.6 a.u) on ROI1/4 after NAC, than that of poor responder (67.2 a.u). The area under the receiver operating characteristic curve (AUC = 0.81) of this WoR was highest among the single parameters and the cutoff was 29.6 a.u. Between good responder and poor responder, fall time after NAC on ROI 1; mean transit time (mTT) before NAC, Wo AUC, Wash-in (Wi) and Wo AUC after NAC on ROI1/4; mTT before NAC and Variation mTT on ROI2/4; mTT before NAC on ROI3/4 also showed significant difference (p < 0.05). Regarding concordance correlation coefficients, WoR on ROI2 before NAC, peak enhancement, WiR before NAC on ROI2 and WiR, WoR, area before NAC, WoR after NAC on ROI3 showed substantial to moderate agreement. There were poor agreements on the other parameters.

CONCLUSION: CEUS images may enable the prediction of the response to NAC in breast cancer, however further effort should be needed to enhance the degree of agreement.

The influence of lesion depth on sonoelastographic assessment of breast lesions: comparison of strain and shear wave elastography

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PURPOSE: To evaluate the effects of lesion depth on diagnostic accuracy of ultrasound elastography in differentiating benign and malignant breast lesion and to compare the difference of effects between strain elastography (SE) and shear wave elastography (SWE).

MATERIALS AND METHODS: Between October 2015 and April 2016, 152 women (mean age, 48.7 ± 11.5 years) with 152 lesions scheduled for biopsy were enrolled in this IRB approved, prospective study. Before biopsy, each lesion was examined with strain and shear wave elastography. In order to evaluate the influence of lesion depth, we measured vertical diameter from the skin to the center of the lesion and divided into three groups (superficial, middle and deep) for quantifying. Diagnostic accuracies of color map (CM), maximum elasticity (SRmax) and average elasticity (SReave) of SE and maximum elasticity (SWe max) and mean elasticity (SWe mean) of SWE were compared according to lesion depth.

RESULTS: The diagnostic accuracies of SWe max and SWe mean were significantly associated with lesion depth (SWe max, p = 0.009; SWe mean, p = 0.0034). And SWe max and SWe mean showed that lesions were located at deep layer of breast reduced diagnostic accuracy compared with lesions were located at superficial and middle layer. On the other hand, diagnostic accuracies of CM, SRmax and SReave of SE were not influenced by lesion depth (CM, p = 0.0565; SReave, p = 0.1188; SRmax, p = 0.0795).

CONCLUSION: Lesion depth influences the diagnostic accuracy of SWE. Lesions which were located at deep layer of breast parenchyma lowers the diagnostic accuracy compared with lesions at middle or superficial layer of breast parenchyma. The diagnostic accuracy of SE is not influenced by lesion depth.
Pretreatment prediction of pathologic complete response to neoadjuvant chemotherapy in breast cancer: perfusion metrics of dynamic contrast enhanced MR

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PURPOSE: To investigate imaging metrics of predicting treatment response in pretreatment dynamic contrast enhanced-MRI (DCE-MRI) - pathologic complete response (pCR) or non-pCR in breast cancer patients who treated with neoadjuvant chemotherapy (NAC).

MATERIALS AND METHODS: Seventy-four breast cancer patients, who received NAC followed by breast conserving surgery or mastectomy, were retrospectively reviewed. All patients underwent breast MRI before the first cycle of NAC. Perfusion metrics - Ktrans, Kep and Ve of tumor were measured by both two- and three-dimensionally and those of background parenchyma of contralateral breast in two-dimensional way. Receiver-operating characteristic (ROC) analysis and multivariable logistic regression were used to compare the ability of perfusion parameters to predict pCR.

RESULTS: Of 74 patients, 13 patients (17.5%) achieved pCR in final pathology. Fifty percentile of each perfusion metrics - Ktrans, Kep, and Ve of tumor (AUC = 0.624, 0.575 and 0.487 respectively), and their skewness (AUC = 0.647, 0.535 and 0.641 respectively) in 3D histogram analysis were associated with pCR. Perfusion metrics of contralateral breast parenchyma in 2D analysis also showed predictive ability of pCR (AUC = 0.683, 0.627 and 0.629, respectively). The model combining the perfusion metrics of contralateral breast background parenchyma and those of the tumor had higher predictive value than single parameters. Especially the combination of Ktrans of contralateral breast background parenchyma with the skewness of Ktrans in tumor had the highest predictive power to predict pCR (AUC = 0.760, p = 0.001).

CONCLUSION: Combined perfusion metrics of tumor and background parenchyma of contralateral breast in pretreatment breast MRI can make early prediction for pCR of breast cancer.
SS 21 BR-08 11:00
Feasibility of synthetic diffusion weighted MR images (DWI): qualitative and quantitative comparison of synthetic versus acquired DWI in patients with breast cancer
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PURPOSE: To investigate the feasibility of synthetic diffusion weighted MR images (DWI) by comparison and analysis of inter-method agreement between the synthetic and the acquired DWI in the patients with breast cancer

MATERIALS AND METHODS: This retrospective study included 129 biopsy-proven breast cancers of 126 women (age, 25-83 years; mean, 52.5 years), who underwent breast magnetic resonance imaging (MRI) as part of preoperative evaluation from March 2016 to March 2017. Two breast radiologists having not informed of the findings of dynamic contrast-enhanced images independently assessed the image-sets of synthetic b = 1000 s/mm² DWI (S-1000) and acquired b = 1000 s/mm² DWI (A-1000). The S-1000 were reformatted by calculation of apparent diffusion coefficient curve obtained from the acquired b = 0 s/mm² DWI and b = 500 s/mm² DWI. Visual assessment for the S-1000 and the A-1000 was done by using a 4-point grading system. As the quantitative analysis, signal-to-noise ratio (SNR), contrast-to-noise ratio (CNR), and contrast of tumor-to-parenchyma (TPC) were calculated. The sensitivity of the S-1000 and the A-1000 was determined via final histopathologic diagnosis as the gold standard and inter-method agreement between the S-1000 and the A-1000 was determined via final histopathologic diagnosis as the gold standard and was compared by using the McNemar's test. Weighted kappa statistics were used to evaluate the inter-method agreement between the S-1000 and the A-1000. SNR, CNR, and TPC of the S-1000 and the A-1000 were compared using the paired t-test.

RESULTS: The sensitivity of the S-1000 (radiologist 1, 84.1%; radiologist 2, 87.3%) and that of the A-1000 (radiologist 1, 85.7%; radiologist 2, 88.9%) by the two radiologists did not show significant differences, respectively (all ps > 0.05). Inter-method agreement for the visual assessment scoring between the S-1000 and the A-1000 showed substantial agreements in both radiologists, respectively (radiologist 1, k = 0.730; radiologist 2, k = 0.738). SNR of the S-1000 was higher than that of the A-1000 (p < 0.001). Statistically-significant differences were not found between CNR and TPC of the S-1000 and those of the A-1000 (all ps > 0.05).

CONCLUSION: The S-1000 obtained from the A-0 and the A-500 were comparable to the A-1000 of breast cancer patients, and it may be helpful for reducing acquisition time in clinical setting.

SS 21 BR-09 11:10
Qualitative and quantitative US indexes of tumor vascularity in breast masses on superb microvascular imaging (SMI) and contrast-enhanced US (CEUS): correlation with histologic vascular parameters
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PURPOSE: To evaluate the correlation between qualitative and quantitative ultrasound (US) indexes of tumor vascularity on superb microvascular imaging (SMI) and contrast-enhanced ultrasound (CEUS) and histologic vascular parameters in breast masses.

MATERIALS AND METHODS: This prospective study was approved by the IRB and written informed consent was obtained. SMI and CEUS were performed on 98 suspicious solid breast masses (57 benign and 41 malignant) prior to biopsy. We used Aplio 500 US (Toshiba Medical Systems Corporation, Japan) and SonoVue contrast agent (Bracco, Italy). Two radiologists analyzed quantitative and qualitative vascularity indexes of SMI (vascular index, vessel morphology, distribution, and penetrating vessel) and CEUS (time intensity curve parameters and enhancement pattern). We measured histological vascular parameters (microvessel density and diameter). Comparisons of histological parameters according to tumor type, grade, and hormone receptor were made using t- and Mann-Whitney test. Correlations analysis between US indexes and histologic parameters was performed using spearman’s correlation and Kruskal-Wallis test with Bonferroni correction.

RESULTS: Microvessel density was significantly higher in malignant masses than benign masses and malignant masses with negative estrogen receptor or high grade showed higher microvessel density than those with positive estrogen receptor or low grade (p < 0.05). Microvessel diameter was not different between benign and malignant masses (p > 0.05). Quantitative US indexes including peak intensity (r = 0.546), slope (r = 0.462) and area (r = 0.574) on CEUS and vascular index (r = 0.634) on SMI showed all significant correlation with microvessel density (p < 0.01 for all). Qualitative US indexes including enhancement degree, enhancement order, penetrating vessel, perfusion defect on CEUS and vessel morphology, distribution, penetrating vessel had significant correlation with microvessel density (p < 0.01 for all).
for all).

**CONCLUSION:** Qualitative and quantitative US indexes of tumor vascularity on SMI and CEUS have significant correlation with histologic microvessel density in the corresponding tumor region. US vascularity indexes on SMI and CEUS could be used as surrogate marker for histologic tumor microvessel density.