MRI is a versatile imaging modality in head and neck cancer imaging providing not only anatomical but also functional information. Functional MRI techniques include diffusion weighted imaging (DWI/IVIM), dynamic contrast enhanced MRI (DCE), magnetic resonance spectroscopy (MRS) and more recently chemical exchange saturation transfer (CEST) imaging and arterial spin labeling (ASL).

However, the head and neck remains a technically challenging region in which to acquire functional MRI data and maps. Standardization of imaging protocols and functional map analysis is problematic, not least because functional techniques, such as DWI, are being continually modified, while sophisticated methods of functional map analysis are being devised to take tumor heterogeneity into account. As a result an ever increasing number of different functional parameters are being reported in the literature. Furthermore, in regard to the prediction and assessment of radiotherapy (RT) or chemoradiotherapy (CRT) response, a wide range of different outcome measures have been used to correlate with the functional data, and post treatment follow-up time periods are often limited. Despite these drawbacks current research shows functional MRI is a promising tool for head and neck cancer evaluation with regard to the following.

1. Tumor characterization
Functional differences have been found in tumors in the head and neck, including between malignant and benign cervical nodes (DWI); lymphoma and squamous cell carcinoma (DWI, DCE & MRS); the major groups of salivary gland tumors (DWI, DCE & MRS).

2. Pre-treatment response prediction
Tumor hypoxia, reduced perfusion and a high stromal content decrease the delivery of oxygen and/or cytotoxic drugs so rendering the tumor more resistant to chemoradiotherapy. Patients with squamous cell carcinoma have been shown to have a poorer outcome when the pre-treatment tumor has higher ADC on DWI (believed to reflect hypoxia and high stromal content) or lower vascularity on DCE as measured by the Ktrans. A low extravascular extracellular space (Ve) on DCE also has been linked with a poorer outcome.

3. Intra-treatment response monitoring
This is an area where functional imaging, especially DWI, may have the greatest potential future role in cancer management with the goal of allowing response adapted therapy at an early stage in treatment. A few days into a course of treatment tumors may show a transient decrease in ADC (cell swelling), but thereafter tumors are expected to show a progressive increase in ADC over the course of treatment as cells die. Most interim scans have been performed around two weeks after the start of treatment. At this time point differences can already be found between non-responders and responders, the non-responders showing a significantly lower rise in ADC. A fall in ADC at this time point or later in treatment after an initial rise, believed to represent a repopulation of tumor cells, has also been linked with an unfavorable response.

Residual cancers tend to show greater restriction in diffusion (lower ADC values) than benign post treatment masses, however care must be taken to avoid areas of resolving necrosis (hyalinization) and fibrosis both of which can show restricted diffusion. Research into squamous cell carcinoma suggests that visual analysis of the DWI images + ADC maps (residual cancer = high signal intensity on b-1000 DWI + low signal intensity on the ADC map), may be superior to the measurement of ADC values. Residual cancers also appear to less vascular on DCE and show persistent Choline peaks on MRS when compared to benign post treatment masses.
Angiogenesis has long been established as a key element in the pathophysiology of tumor growth and metastasis. Increasingly, new molecularly targeted antiangiogenic drugs are being developed in the fight against cancer. These drugs bring with them a need for an accurate means of diagnosing tumor angiogenesis and monitoring response to treatment. Imaging techniques can offer this in a noninvasive way, while also providing functional information about the tumor. Among the many clinical imaging techniques available, CT and MRI can provide relatively good spatial resolution with limited side effects. Dynamic contrast-enhanced (DCE)-MRI is rapidly emerging as a standard method for directly measuring angiogenesis during angiogenesis-inhibitor drug trials. As macromolecular MR contrast agents become available, they will inevitably be utilized in the assessment of tumor perfusion and vessel permeability. Meanwhile, technological advances have made imaging at a molecular level a possibility. They have brought the potential to directly target MR contrast agents to markers of angiogenesis, however, substantial gains in sensitivity brought about by improved coils, pulse sequences, and contrast agents will be needed. Herein, we discuss the tumor angiogenesis, CT and MRI technique, clinical applications.

Introduction

Angiogenesis has long been established as a key element in the pathophysiology of tumor growth and metastasis. Increasingly, new molecularly targeted antiangiogenic drugs are being developed in the fight against cancer. These drugs bring with them a need for an accurate means of diagnosing tumor angiogenesis and monitoring response to treatment. Imaging techniques can offer this in a noninvasive way, while also providing functional information about the tumor. Among the many clinical imaging techniques available, CT and MRI can provide relatively good spatial resolution with limited side effects. Dynamic contrast-enhanced (DCE)-MRI is rapidly emerging as a standard method for directly measuring angiogenesis during angiogenesis-inhibitor drug trials. As macromolecular MR contrast agents become available, they will inevitably be utilized in the assessment of tumor perfusion and vessel permeability. Meanwhile, technological advances have made imaging at a molecular level a possibility. They have brought the potential to directly target MR contrast agents to markers of angiogenesis, however, substantial gains in sensitivity brought about by improved coils, pulse sequences, and contrast agents will be needed. Herein, we discuss the tumor angiogenesis, CT and MRI technique, clinical applications.

Tumor angiogenesis

Angiogenesis is the process by which new blood vessels are formed. This process occurs physiologically during wound healing, embryogenesis, and corpus luteum formation. More recently, angiogenesis has been recognized as a key element in the pathophysiology of tumor growth and metastasis. Once tumors grow beyond a diameter of 1-2 mm, passive diffusion is no longer sufficient to support the viability of malignant cells, and neovascularization becomes a necessity.

The point at which these ‘normal’ processes differ from pathological angiogenesis is in the tightly regulated balance of pro- and anti-angiogenic signals. During normal physiological angiogenesis, new vessels rapidly mature and become stable. By contrast, tumors - described as “wounds that never heal” - have lost the appropriate balances between positive and negative controls. One characteristic feature of tumor blood vessels is that they fail to become quiescent, enabling the constant growth of new tumor blood vessels. Consequently, the tumor vasculature develops unique characteristics and becomes quite distinct from the normal blood supply system. Tumor blood vessels are architecturally different from their normal counterparts - they are irregularly shaped, dilated, tortuous and can have dead ends. They are not organized into definitive venules, arterioles and capillaries like their normal counterparts, but rather share chaotic features of all of them. The vascular network that forms in tumors is often leaky and hemorrhagic, partly due to the overproduction of vascular endothelial growth factor (VEGF).

Blood flows irregularly in tumor vessels, moving more slowly and sometimes even oscillating. This leads to dysfunctional capillaries. Tumors can be quite heterogeneous in their vascular patterns, and are able to overproduce their capillary networks. In normal tissues, by contrast, vessel density is dynamically controlled by the metabolic needs of nutrients and oxygen. So, the structural and functional abnormalities in tumor vessels reflect the pathological nature of their induction and cause hypoxia.

Regions with hypoxic tissue (pO2 < 10 mmHg) are a characteristic feature of many tumors. Tumor hypoxia may cause resistance to treatment and promote metastatic spread. Studies of several histological types of cancer have suggested that patients with hypoxic tumors may benefit from particularly aggressive treatment.

CT perfusion

The basic principle of CTP is the continuous recording of x-ray attenuation over a fixed area of interest during passage of a fast bolus of iodinated contrast medium through the region. This dynamic acquisition covers the first pass of iodinated contrast medium in the regional vascular bed, during which it has an intravascular distribution. This enables creation of time-attenuation curves by using a deconvolution-based algorithm and generation of perfusion parameters such as BV, BF, MTT, and CP, which allow evaluation of the hemodynamic biologic status of a lesion.
DCE-MRI perfusion

The angiogenic process is heterogeneous within tumors, with some vessels demonstrating maturity and other vessels demonstrating incomplete layers with high permeability and fragility. As previously mentioned, angiogenic vessels have large gaps between the endothelial cells, the endothelium, and the basement membranes, as well as between the basement membrane and the pericytes, making the vessels hyperpermeable to many macromolecules. These properties can be exploited by DCE-MRI. MR contrast agents that leak slowly through the normal vasculature are able to pass more quickly through tumor vessels to produce differential enhancement. This results in a fast “wash-in” of contrast coupled with the rapid “wash-out,” and allows a functional analysis of the tumor microcirculation. DCE-MRI is performed with low-molecular-weight contrast media (LMCM) or macromolecular contrast media (MMCM). Gd-diethylenetriamine pentaacetic acid (Gd-DTPA) is the LMCM agent with the longest clinical track record and has a molecular weight (mW) of 567 Daltons (Da). The majority of DCE-MRI studies rely on LMCM because of their clinical availability, but MMCM are being increasingly investigated. As blood carrying a LMCM flows through tumor vasculature, the contrast agent molecule leaks into the interstitial space and accumulates there. Interaction between the paramagnetic Gd3+ ion and adjacent water protons enhances tissue longitudinal (T1) relaxation rate, generating a brighter signal in T1-weighted images. The magnitude and rate of signal enhancement are determined by tissue vascular fraction, perfusion, microvascular permeability, and relative volume of the extracellular extravascular space (EES). The brightness information can be converted to contrast agent concentration with the linear relationship between gadolinium concentration and T1 relaxation rate. The dynamic change of contrast agent concentration can be described by various model-free parameters or fitted to a pharmacokinetic model (Figs. 1, 2), yielding parametric maps that give an intuitive and quantifiable illustration of tumor vascular heterogeneity. The most commonly used pharmacokinetic and model-free parameters are summarized in Tables 1 and 2, using the standard nomenclature proposed in the consensus paper by Tofts et al. Details about the use and interpretation of these parameters are beyond the scope of this paper. Interested readers are referred to the in-depth reviews written by Tofts et al. and Evelhoch.

**TABLE 1: Pharmacokinetic parameters often used in DCE-MRI pharmacokinetic analysis.**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Definition</th>
<th>Units</th>
<th>Alternative names</th>
</tr>
</thead>
<tbody>
<tr>
<td>$K^\text{trans}$</td>
<td>Volume transfer constant between EES and blood plasma</td>
<td>$\text{min}^{-1}$</td>
<td>$EF$, $K^\text{eff}$</td>
</tr>
<tr>
<td>$v_i$</td>
<td>EES volume per unit tissue volume</td>
<td>N/A</td>
<td>Interstitial space</td>
</tr>
<tr>
<td>$v_p$</td>
<td>Blood plasma volume per unit tissue volume</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>$k_P$</td>
<td>Rate constant from EES to blood plasma</td>
<td>$\text{min}^{-1}$</td>
<td>$k_{21}$</td>
</tr>
<tr>
<td>$k_W$</td>
<td>Rate constant from blood plasma to EES</td>
<td>$\text{min}^{-1}$</td>
<td>$k_{12}$</td>
</tr>
<tr>
<td>$k_{el}$</td>
<td>Elimination rate constant</td>
<td>$\text{min}^{-1}$</td>
<td></td>
</tr>
<tr>
<td>$Amp$</td>
<td>Amplitude of the normalized dynamic curve</td>
<td>N/A</td>
<td>A</td>
</tr>
</tbody>
</table>
extravascular space and is, therefore, a key measurement in tumor neoangiogenesis.

Differential of benign from malignant tumors

In 2008, a study using first-pass DCE perfusion-weighted MR imaging in both benign and malignant head and neck tumors was able to demonstrate the feasibility of the technique in quantifying perfusion parameters. The authors also showed that all perfusion parameters (including BF, BV, extravascular extracellular volume, difference in bolus arrival time between arterial input and tissue, MTT, permeability, and extraction ratio maps) were significantly different between tumor and normal muscle tissue, thus suggesting that perfusion-weighted MR imaging had the potential to be an additional tool in biologic imaging of head and neck cancer.

References

Correlation between quantitative perfusion/diffusion MRI parameters and human papillomavirus status in oropharyngeal squamous cell carcinoma

Miran Han, Jin Wook Choi, Sun Yong Kim
Ajou University Hospital, Korea.
radwchoi@gmail.com

PURPOSE: To investigate the differences in perfusion parameters from dynamic contrast enhanced MR imaging (DCE-MRI) and ADC values from DWI according to the presence of biologically active human papillomavirus (HPV) in oral cavity and oropharyngeal squamous cell carcinoma (SCC).

MATERIALS AND METHODS: From March 2012 to March 2015, a total of 24 patients with pathologically confirmed oral cavity and oropharyngeal SCC and evaluated HPV status was enrolled in this retrospective study. DCE-MRI and diffusion images were post-processed using commercially available software (nordicICE, NordicNEuroLab). Quantitative parameters (Ktrans, Kep, Ve, Vp, AUC60-area under the signal intensity-time curve at initial 60s) from DCE-MRI and ADC value from DWI were calculated within the manually placed ROI plotted around the main tumor on every image slice. Histogram parameters consisting of mean, median, 25th, 75th percentile value, skewness and kurtosis of DCE-MRI parameters and ADC values were compared between the HPV-positive and -negative groups using the Mann-Whitney U test. ROC analysis was performed with the presumptive parameters to estimate diagnostic performance in predicting HPV status.

RESULTS: 12 patients were HPV-positive (50.0%). Mean (p = 0.006), median (p = 0.006), 25th (p = 0.012), 75th (p = 0.005) percentile value of Kep were significantly higher in HPV-positive group (p = 0.006). Any other perfusion parameters and ADC value were not significantly different between HPV-positive and -negative patients. On ROC analysis, the mean Kep showed good diagnostic performance with AUC of 0.83 for HPV positivity.

CONCLUSION: Our preliminary evidence promise imaging parameters could reflect HPV status in oral cavity and oropharyngeal SCC.

Application of cardiac gating for reproducibility improvement in measurement of intravoxel incoherent motion parameters in the head and neck

Koung Mi Kang, Seung Hong Choi
Seoul National University Hospital, Korea.
choiseunghong@gmail.com

PURPOSE: To prospectively evaluate whether cardiac gating can improve the reproducibility of the apparent diffusion coefficient (ADC) and intravoxel incoherent motion (IVIM)-derived parameters in the head and neck, we performed IVIM DW (diffusion-weighted) imaging using 4b values (4b), 4b values with cardiac gating (4b gating) and 17b values (17b).

MATERIALS AND METHODS: Institutional Review Board approval and informed consent was obtained. We performed IVIM DW imaging twice per person on nine healthy volunteers using 4b, 4b gating and 17b sets. The ADC, perfusion fraction (f), diffusion coefficient (D) and perfusion-related diffusion coefficient (D*) were calculated in the brain, masticator muscles, parotid glands, submandibular glands (SMG), tonsils and bones. An inter-class coefficient (ICC), Bland-Altman analysis (BAA) and the coefficient of variation (CV) were used to assess short-term test-retest reproducibility of 4b, 4b gating and 17b sets. A Kruskal-Wallis test was used to investigate whether 4b, 4b gating and 17b had significant influences on the parameters.

RESULTS: ICC was excellent for ADC, f and D maps; except the D* map. All parameters exhibited their lowest CV in the 4b gating set. BAA revealed the narrowest 95% limits of agreements using 4b gating for f, D and D* and 17b for ADC. In the subgroup analysis, almost all parameters in brain, muscle, parotid gland and SMG exhibited the best reproducibility using 4b gating. In the Kruskal-Wallis test, there was no statistically significant difference among the three methods in any parameters except D*.
Traditionally, the tumor grading is evaluated by pathologic examination of tissue. But, the histopathologic grading system for brain tumor has inherent limitations, especially glioma gradings, such as sampling error, interpreters’ variation and a variety of classification systems. The histologic evaluation of the tumoral angiogenesis (i.e., microvascular density [MVD], microvascular cellular proliferation [MVCP], total vascular area [TVA]) is main decision maker for the diagnosis of the high grade glioma, but is limited by regional heterogeneity, and small size or a limited number of surgical specimen. Therefore, we need for in vivo clinical imaging methods that can evaluate perfusion status in the entire tumor and can guide the biopsy for malignant portion and provide the information about the effect or prognosis after treatment.

Dynamic susceptibility-contrast MR & dynamic contrast-enhanced MR or CT perfusion study suggest the hemodynamic and vascular pathophysiologic information of the tumor by providing various parameters or imaging biomarkers such as tumor blood volume, vascular permeability, blood flow, and the size of extravascular extracellular space.

Correlation of perfusion parameters with histologic angiogenesis markers has been studied as follows: 1) strong correlation between BV (blood volume) and MVD, could indicate total tumor vasculature; 2) strong correlation between PS (permeability surface-area product: in brain tumor, PS $\propto K^{\text{trans}}$) and MVCP, indicate the immature vasculature, hence, sites of active angiogenesis.

Brain tumor perfusion imaging can be used as follows: 1) the assessment of angiogenesis [i.e., glioma gradings], 2) the differential diagnosis between high grade glioma and other brain lesions such as lymphoma or tumefactive demyelinating disease, 3) the evaluation of response to anti-angiogenic regimens, 4) distinguishing true progression from post-treatment change [i.e., radiation necrosis], 5) prediction the prognosis after treatment.

MR perfusion, is the most commonly used imaging technique for evaluating brain tumors, have certain limitations such as nonlinear relationship of the signal intensity with the contrast and susceptibility artifacts due to hemorrhage and various post-operative changes. In spite of the concerning about radiation hazards, CT perfusion technique, especially whole brain CT perfusion by using 320 row-MDCT, could be wisely applicable for the study of brain tumors: 1) useful for quantitative estimation of the perfusion parameters as imaging biomarkers, 2) faster scanting time, wider availability, and lower cost, 3) providing additional informations by using one-stop scanning such as conventional non-CE and CE CT images, CTP imagings (BF, BV, TTP, MTT, PS ), 4D CT angiogram imaging for the evaluation of tumoral vascular information and adjacent arterial and venous structural information (i.e., presence of dural sinus invasion, location of the large superficial veins at the route of the incision, etc.) under the acceptable effective radiation dose.

In this short talk, we will discuss the short review of CT perfusion parameters, application in neuro-oncologic field, and advantages & challenges of whole brain CTP.

References
Stroke is a well-known leading cause of death and disability worldwide. Because it is very difficult to distinguish an ischemic stroke from a hemorrhagic stroke, imaging (CT and MRI) plays a critical role in evaluating patients suspected of acute stroke especially before initiating treatment. Over the past few decades, major advances have occurred in stroke imaging and treatment, imaging now provides information beyond the presence or absence of intracranial hemorrhage. In addition to non-enhanced CT, CT angiography and CT perfusion imaging are increasingly available for stroke patients. MRI is also increasingly available as an alternative imaging modality in acute ischemic stroke and allows several non-contrast image acquisition modalities as well as MR angiography and MR perfusion imaging. From the latter and similar to CT perfusion imaging, the important hemodynamic parameters can be derived. In addition to dynamic susceptibility contrast perfusion MR imaging that rely on the application of a gadolinium-based contrast agent, arterial spin labeling perfusion MR imaging measures perfusion by non-invasively, magnetically labeling endogenous water protons.

In this presentation, 1) The fundamental concepts of various brain perfusion methods in acute ischemic stroke and 2) the pros and cons of each perfusion method in acute ischemic stroke are main topics. In addition, our experience of arterial spin labeling perfusion MR imaging in patients with acute ischemic stroke will be presented.
**Perfusion imaging of the brain**

**Chairperson(s)**
Kee-Hyun Chang  
Soonchunhyang University Hospital  
Bucheon, Korea

Ji-hoon Kim  
Seoul National University Hospital, Korea

**MC 01 NR-07 16:50**

**Prediction of thrombolytic efficacy: usefulness of measurement of enhancement in the thrombus on thin-reconstructed perfusion CT**
Eung Yeop Kim, Byong Ho Goh, Dong Hoon Shin  
Gachon University Gil Medical Center, Korea.  
eungyeop.kim@gmail.com

**PURPOSE:** To directly measure enhancement in acute thrombi using thin-reconstructed perfusion CT images for prediction thrombolytic efficacy.

**MATERIALS AND METHODS:** Prior to administration of tissue plasminogen activator (tPA), noncontrast CT (NCCT), 60-second 70-kVp adaptive 4D spiral CT (CTP), and CT angiography (CTA) were prospectively obtained and reconstructed at 1-mm thickness. Length and Hounsfield unit ratio (HUUr) of thrombus were measured using 1-mm NCCT. Collateral circulation was assessed on dynamic CTA that were reconstructed from 1-mm CTP images. Good collateral circulation was defined as the criteria that were used for ESCAPE trial. After spatial motion correction of 1-mm CTP images, circular regions of interest were drawn in the central portion and each end of thrombus to measure the level of HU increase from baseline on time-attenuation curves (TAC). Recanalization was assessed on follow-up vascular imaging studies that were obtained within 24 hours after tPA. Modified TICI 2b or 3 was considered successful recanalization. Thrombus length, HUUr, collaterals, and minimum increase of HU on TAC (HUmin) were compared between the recanalized and non-recanalized groups.

**RESULTS:** Of 57 patients who received tPA therapy, 31 patients (female, 13; mean age, 66.5 years) with occlusions in ICA (n = 7), M1 (n = 8), M1-M2 (n = 6), and M2 (n = 10) were only assessed. Thrombus length ranged 3-45 mm (median, 12 mm; IQR, 7). HUUr was measured from 1.03 to 1.69 (median, 1.26; IQR, 0.19). Good collaterals were noted in 27 patients. HUmin ranged 3-70 HU (median, 15; IQR, 12), and showed negative correlation with thrombus length (rho = -0.410, P = 0.022), but not with HUUr. HUmin was significantly higher in the recanlated group (n = 19) than the non-recanaled group (mean HUmin, 23.79 vs 7.83; P < 0.0001) independent of thrombus location. Thrombus length, HUUr, or collateral status was not significantly different between the two groups. HUmin > 13 was determined with sensitivity of 89.5%, specificity of 91.7%, and AUC of 0.961 for prediction of recanalization.

**CONCLUSION:** HUmin of thrombus was significantly higher in patients with successful recanalization after tPA therapy.

**MC 01 NR-08 17:00**

**Imaging selection criteria for thrombectomy in acute ischemic stroke: comparison between infarct core-penumbra based on perfusion CT and ASPECT score and collateral status based on multi-phase CTA**
Byong Ho Goh, Eung Yeop Kim, Dong Hoon Shin  
Gachon University Gil Medical Center, Korea.  
eungyeop.kim@gmail.com

**PURPOSE:** Recent clinical trials successfully showed the benefit of early recanalization by thrombectomy in patients who were selected by imaging criteria. Two main selection criteria were used as follows: infarct core (relative CBF < 30%) < 70 cc and mismatch ratio > 1.2 assessed by penumbra (Tmax > 6 seconds), and ASPECT score > 5 and good collaterals on multi-phase CTA. Some may wonder which one we should use for patient selection. The aim of this study was to compare these two criteria in the same patients.

**MATERIALS AND METHODS:** We retrospectively enrolled 59 patients (female, 30; mean age, 69.1 years) who underwent both head NCCT, 10-cm 70-kVp CTP with temporal resolution of 1.5 seconds, and head-neck CTA within 8 hours of onset. They had occlusions in the distal ICA (n = 12), M1 (n = 25), and M2 (n = 22), which were confirmed on CTA. To simulate the multi-phase CTA scheme, 1-mm CTP source images were selected at peak arterial, equilibrium, and late venous phases 4.5 seconds apart. Each phase had images obtained for 3 seconds. Maximum-intensity projection images of each phase were displayed together to assess collateral status. Poor collaterals were determined when there is no or minimal collaterals > 50% of the MCA territory. ASPECT score was measured on admission NCCT. Infarct core (relative CBF < 30%) and penumbra (Tmax > 6 seconds) volumes were measured. Patients with infarct core < 70 cc and mismatch ratio > 1.2, and good collaterals and ASPECT score > 5 were considered candidates for thrombectomy. The two imaging selection criteria were compared with McNemar test.

**RESULTS:** ASPECTS < 6 was determined in 4 patients, two of which showed poor collaterals. Poor collaterals were shown in 5 patients, two of which had ASPECTS < 6. Seven patients were consequently considered not eli-
ble for thrombectomy after assessment of ASPECTS and collaterals on multi-phase CTA. Infarct core ≥ 70 was found in 4 patients, all of which had poor collaterals. Penumbra < 10 cc (and infarct core < 1 cc) was determined in two patients, showing good collaterals and ASPECTS of 10. These 6 patients were not considered for thrombectomy on CTP. The two selection criteria showed mismatch in 5 of 59 patients, showing no significant difference (p > 0.05).

**CONCLUSION:** The two imaging selection criteria (infarct core–penumbra based on CTP and ASPECTS and collateral status) were comparable each other.

**MC 01 NR-09** 17:10

**Impact of image denoising on image quality, quantitative parameters and sensitivity of ultra-low-dose volume perfusion CT imaging**

Jong Hye Kim¹, Ahmed Othman², Zeppa Yang¹
¹Seoul National University College of Medicine, Korea, ²RWTH Aachen University, Germany.

**PURPOSE:** To examine the impact of denoising on image quality, quantitative parametric maps, and sensitivity of Ultra-Low-Dose Volume Perfusion CT (ULD-VPCT) imaging in acute stroke.

**MATERIALS AND METHODS:** Simulated ULD-VPCT datasets at 20% dose rate were generated from perfusion datasets of 20 patients with suspected ischemic stroke acquired at 80 kVp/180 mAs. From each ULD-VPCT dataset, four datasets were generated: 1. Not-denoised (ND), 2. Denoised using spatiotemporal filter (D1), 3. Denoised using quanta-stream diffusion technique (D2) and 4. Combination of both methods (D1+D2). In the resulting 100 datasets (80 reconstructed, 20 original), signal-to-noise-ratio (SNR) was measured. Image quality, presence/absence of ischemic lesions, CBV and CBF scores according to a modified ASPECTS-score were assessed by two blinded readers.

**RESULTS:** SNR and qualitative scores were highest for D1+D2 and lowest for ND (all ps ≤ 0.001). In 25% of the patients, ND maps were not assessable and therefore excluded from further analyses. Compared to original datasets, in D2 and D1+D2, both readers correctly identified all patients with ischemic lesions (sensitivity = 1.0, Kappa = 1.0). Lesion size in CBV and CBF maps was most accurately estimated for D1+D2 with a sensitivity of 1.0 (CBV) and 0.94 (CBF) and an inter-rater-agreement of 1.0 and 0.92, respectively.

**CONCLUSION:** An appropriate combination of denoising techniques applied in ULD-VPCT produces diagnostically sufficient perfusion maps at substantially reduced dose rates as low as 20% of the normal low dose scan.

**MC 01 NR-10** 17:20

**Regional comparison of hemodynamic status in adult patients with bilateral moyamoya disease by acetazolamide-challenged perfusion CT: basal ganglia and cerebral cortex**

Seong Eun Ko1, Young Hen Lee2, Hyung Suk Suo1, Bo-Kyoung Je1, Sang-il Suh2, Byungjun Kim3, Jin Man Jung1, Do Young Kwon1, Sang-Dae Kim1, Sung-Kon Ha1, Dong-Jun Lim1
1Korea University Ansan Hospital, 2Korea University Guro Hospital, 3Korea University Anam Hospital, Korea.
youghen@empal.com

**PURPOSE:** Moyamoya disease (MMD) is characterized by stenosis or occlusion of bilateral supraclinoid internal carotid artery or proximal middle cerebral artery (MCA) with basal/leptomeningeal collateral vessels and frequently manifests as cortical infarction. However, functional status of these collateral vessels is not fully evaluated. To assess the role of collateral circulation, we evaluated the hemodynamic status of basal ganglia (BG) mainly supplied by basal vessels and ipsilateral MCA cortex, supplied by leptomeningeal vessels, respectively, using an acetazolamide-challenged perfusion CT (ACZ-PCT).

**MATERIALS AND METHODS:** From our medical records, we retrospectively selected the 26 adult patients (M:F = 7:19; 42.9 ± 11.8 years) with bilateral MMD who underwent both transfemoral cerebral angiography (TFCA) and ACZ-PCT during 4 years. We recorded the cerebral blood flow (CBF) of both basal ganglia (BG) and MCA cortex those are mainly supplied by collateral vessels and ipsilateral MCA cortex, respectively, using an acetazolamide-challenged perfusion CT (ACZ-PCT).

**RESULTS:** Finally, we selected the 35 hemisphere (11 hemisphere with modified Suzuki Score 2, 24 hemisphere with modified Suzuki Score 3) which were supplied by both basal and leptomeningeal collateral vessels. On baseline PCT, there was no significant difference of CBF in BG and ipsilateral MCA cortex (62.5 ± 26.6 vs. 59.4 ± 28.3, p > 0.05). After ACZ infusion, CBF more significantly increased in BG compared to ipsilateral cortex (78.4 ± 27.1 vs. 60.7 ± 33.1, p < 0.01). Therefore, CVRs of BG were better than those of ipsilateral MCA cortex (p < 0.01).

**CONCLUSION:** Our data might reflect that the hemodynamic support of basal vessels might be superior to that of leptomeningeal vessels in patients with MMD.
MC 01 NR-11  17:30  🇺🇸English

### DIFFERENTIATION OF OLIGODENDROGLIAL TUMORS FROM NON-OLIGODENDROGLIAL ASTROCYTOMAS BY MULTIPARAMETRIC HISTOGRAM ANALYSIS OF PERfusion MRI

**PURPOSE:** Differential diagnosis of oligodendroglial tumors (OT) from non-oligodendroglial astrocytoma (NOA) has become increasingly important with the recognition that OTs are uniquely sensitive to chemotherapy and have better prognosis. The purpose of this study was to assess whether there are perfusion parameters to differentiate OT from NOAs, by using multiparametric histogram analysis of perfusion MRI.

**MATERIALS AND METHODS:** DSC and DCE MR images in 69 patients (M:F = 30:39; mean age, 51 years; range, 16–82 years) with histologically-confirmed OTs (n = 22) and NOAs (n = 47) were retrospectively reviewed. Twenty-two patients with OTs included 6 anaplastic oligodendrogliomas, 6 oligodendrogliomas and 10 mixed oligoastrocytomas. NOAs encompassed 6 diffuse astrocytomas, 5 anaplastic astrocytomas and 36 glioblastomas. On DSC and DCE perfusion images, mean and 98 percentile of rCBV, ktrans, and AUC were calculated and evaluated at each tumor groups, respectively. The ratio rCBV/ktrans, rCBV/AUC were also calculated. Each perfusion parameters between OTs and NOAs were compared.

**RESULTS:** The mean rCBV was not significantly different between OTs and NOAs (31.09 for OTs and 36.83 for NOAs). The mean Ktrans and AUC, and 98 percentile of rCBV, ktrans, and AUC were calculated and compared. The ratio rCBV/ktrans, rCBV/AUC were significantly higher in OTs than NOAs (p < 0.001 and 0.02, respectively). The optimal rCBV cutoff value of 1.733, sensitivity and specificity for the differential diagnosis of two groups were 69% (95% CI: 41%, 89%) and 100% (95% CI: 72%, 100%), respectively. Area under the receiver operating characteristic curve was 0.875 (p < 0.001).

**CONCLUSION:** ASL-PWI may provide a reliable and noninvasive means of predicting angiographic vascularity of meningiomas and thus assist in selecting potential candidates for preoperative DSA and embolization in clinical practice.

---

**MC 01 NR-12  17:40  🇺🇸English

### UTILITY OF ARTERIAL SPIN-LABELING PERfusion MRI IN PREDICTION OF ANGIOGRAPHIC VASCULARITY OF MENINGIOMAS

**PURPOSE:** Arterial spin labeling perfusion-weighted imaging (ASL-PWI) enables quantification of tissue perfusion without contrast media administration. Our aim was to explore whether CBF from ASL-PWI can reliably predict angiographic vascularity of meningiomas.

**MATERIALS AND METHODS:** Twenty-seven meningioma patients with intracranial meningiomas, who had undergone preoperative ASL-PWI and DSA prior to surgical resection, were included. Angiographic vascularity was assessed using a 4-point grading scale and meningiomas were classified into two groups: low-vascularity (grade 0 and 1; n = 11) and high-vascularity (grade 2 and 3; n = 16). Absolute CBF, measured at the largest section of the tumor, was normalized to the contralateral gray matter. Correlation between the mean nCBF and angiographic vascularity was determined and the mean nCBF values of the two groups were compared. Diagnostic performance of nCBF for differentiating the two groups was assessed.

**RESULTS:** nCBF had a significant positive correlation with angiographic vascularity (r = 0.718; p < 0.001). The high-vascularity group had a significantly higher nCBF than the low-vascularity group (3.334 ± 2.768 and 0.909 ± 0.468, respectively; p = 0.003). At the optimal nCBF cutoff value of 1.733, sensitivity and specificity for the differential diagnosis of two groups were 69% (95% CI: 41%, 89%) and 100% (95% CI: 72%, 100%), respectively. Area under the receiver operating characteristic curve was 0.875 (p < 0.001).

**CONCLUSION:** ASL-PWI may provide a reliable and noninvasive means of predicting angiographic vascularity of meningiomas and thus assist in selecting potential candidates for preoperative DSA and embolization in clinical practice.
0.89 for reader 2) than in unmethylation group (0.72–0.82 for reader 1; 0.74–0.84 for reader 2) but did not reach statistical significances. Cross validation revealed the same trend of AUCs for each MR imaging methods. The MGMT methylation group showed a significant longer PFS than unmethylation group even with multivariate Cox’s regression (p = 0.0108). But the influence quantity of MGMT methylation status decreased on the PFS on analyses by the inclusion of age, surgical extent, DWI, and DCE imaging, beside DSC imaging.

CONCLUSION: Age, surgical extent, DWI, and DCE imaging results can effect on progression-free survival (PFS) stratified by MGMT methylation status in patients with newly diagnosed glioblastoma.

**Neuroradiology**

**08:00-09:30 Grand Ballroom 105**

**Brain function and connectivity: recent advancement**

**Chairperson(s)**
Jae Hyoung Kim  
Seoul National University Bundang Hospital, Korea

Seung-Koo Lee  
Yonsei University College of Medicine, Korea

**SS 03 NR-01 08:00**

The aberrant low frequency fluctuation, regional homogeneity and functional connectivity of the PCC related to cognitive impairment in subcortical stroke patients: a resting-state fMRI study

Cheng-Yu Peng¹, Yun Jiao², Ying Cui³, Gao-Jun Teng³

¹Jiangsu Key Laboratory of Molecular and Functional Imaging, ²Jiangsu Key Laboratory of Molecular and Functional Imaging, Medical School of Southeast University, ³Jiangsu Key Laboratory of Molecular and Functional Imaging, Department of Radiology, Zhongda Hospital, China.
gjteng@vip.sina.com

**PURPOSE:** This study utilized three different evaluation indexes of resting-state fMRI to demonstrate that the posterior cingulate cortex (PCC) plays a pivotal role in the default mode network (DMN) in post stroke patients with cognitive impairment.

**MATERIALS AND METHODS:** Subcortical stroke patients (n = 27) and age-, sex-, and education-matched healthy controls subjects (n = 30) underwent rs-fMRI scanning and a battery of cognitive function tests. Regional homogeneity (ReHo) and amplitude of low frequency fluctuation (ALFF) were calculated within the DMN between the two groups to obtain the brain areas with significant difference. The group comparison analyses of functional connectivity (FC) were also performed by choosing the significant difference brain areas aforementioned as the seed spots. The potential relationships between ALFF, ReHo and FC values and cognitive performance were evaluated via partial correlation analysis.

**RESULTS:** The patients exhibited significant deficiencies in some cognitive domains (all ps < 0.05). Compared with healthy controls, ALFF and ReHo values both significantly decreased in the PCC in post-stroke patients (Fig. 1A, B). We also observed significantly decreased FC of the PCC within some regions, including the right medial frontal gyrus, bilateral thalamus (medial dorsal nucleus) and right cerebellar subregion (crus II) (Fig. 1C) in stroke patients compared with healthy controls. Moreover, a significant positive correlation was found between the PCC-right cerebellar subregion (crus II) connectivity and MOCA (r = 0.397; p = 0.040), Symbol Digit Modalities Test scores (r = 0.484; p = 0.011) in stroke patients (Fig. 1D). A significant negative correlation was found between the PCC-right cerebellar subregion (crus II) connectivity and Trail Making Test B scores (r = −0.544; p = 0.003) in the subcortical stroke patients (Fig. 1E).

**CONCLUSION:** Post-stroke patients develop aberrant ALFF, ReHo and FC of the PCC respectively. Resting-state connectivity disturbance of PCC-cerebellar subregion (crus II) may be a central role for evaluating the cognitive dysfunction in stroke patients.
Neuroradiology  Sep 10, Thu

SS 03 NR-02  08:10  [English]
Resting-state functional connectivity abnormalities correlate with psychometric hepatic encephalopathy score in cirrhosis
Hua-Jun Chen, Long-Feng Jiang, Hai-Bin Shi
The First Affiliated Hospital of Nanjing Medical University, China.
chj0075@126.com

PURPOSE: Neurocognitive impairment is a common complication of cirrhosis and regarded as the important characteristic for early stage of hepatic encephalopathy (HE). This study aimed to investigate the changes in brain network centrality of functional connectivity among cirrhotic patients and uncover the mechanisms about early HE.

MATERIALS AND METHODS: Twenty-four cirrhotic patients without overt HE and 21 healthy controls were enrolled and underwent resting-state fMRI and Psychometric Hepatic Encephalopathy Score (PHES) tests. Whole-brain functional network was constructed by measuring the temporal correlations of every pairs of brain gray matter voxels; and then voxel-wise degree centrality (DC), an index reflecting importance of a node in functional integration, was calculated and compared between two groups. A seed-based resting-state functional connectivity (RSFC) analysis was further performed to investigate abnormal functional connectivity pattern of those regions with changed DC.

RESULTS: Compared with controls, the cirrhotic patients had worse performances in all neurocognitive tests and lower PHES score. Meanwhile, patients showed decreased DC in bilateral medial prefrontal gyrus and anterior cingulate cortex, left middle frontal gyrus, and bilateral thalamus; while increased DC in right middle occipital gyrus and parahippocampal gyrus/inferior temporal gyrus. The seed-based RSFC analyses revealed that the relevant functional networks, such as default-mode and attention networks, visual network, and thalamo-cortical circuits, were disturbed in cirrhotic patients. The DC changes were correlated with PHES score in patient group.

CONCLUSION: Our findings further confirm brain network disorganization in cirrhotic patients with neurocognitive impairments and may provide a new perspective for understanding HE-related mechanisms.

SS 03 NR-03  08:20  [English]
Drug-induced Parkinsonism versus idiopathic Parkinson’s disease: diagnostic utility of nigrosome 1 MRI at 3T
Eung Yeop Kim, Young Noh, Young Hee Sung
Gachon University Gil Medical Center, Korea.
eungyeop.kim@gmail.com

PURPOSE: Discrimination between drug-induced parkinsonism (DIP) and idiopathic Parkinson’s disease (IPD) is challenging because they may be clinically indistinguishable. Dopamine transporter imaging can help differentiate them, but it is expensive and imposes radiation on patients. We hypothesized that the nigrosome 1 is not affected in patients with DIP unlike in those with IPD. The aim of this study was to investigate whether nigrosome 1 imaging at 3T can help differentiate PD from DIP.

MATERIALS AND METHODS: We enrolled 20 patients with DIP (16 female; mean age, 74) who showed normal activity on 123I-FP-CIT PET (CIT PET), 29 patients with IPD (10 female; mean age, 71; H&Y stage ≤ 2) who showed abnormality on CIT PET, and 18 healthy subjects (10 female; mean age, 66). All participants underwent 3D multi-echo gradient-recalled echo imaging (number of echoes, 6) covering the midbrain parallel to the plane from the posterior commissure and top of the pons (spatial resolution, 0.5 × 0.5 × 1 mm). Two independent reviewers assessed nigrosome 1 on three slices: an upper slice at the lower tip of red nucleus, and two successive lower slices by comparing the signal intensity of the central portion of the nigrosome 1 with that of the white matter lateral to decussation of the superior cerebellar peduncles. Relative hypointensity in either side of nigrosome 1 was considered abnormal. Interobserver observer agreement, diagnostic sensitivity, specificity, and accuracy were analyzed.

RESULTS: Inter-rater agreement was excellent (κ = 0.821). All 29 patients with IPD and three of 18 healthy subjects were rated as abnormal on nigrosome 1 MRI (sensitivity, 100%; specificity, 83.3%; accuracy, 93.6%; positive predictive value [PPV], 90.6%; negative predictive value [NPV], 100% between the patients with IPD and healthy subjects). Three of 20 patients with DIP were considered abnormal on nigrosome 1 MRI (sensitivity, 100%; specificity, 85%; accuracy, 93.9%; PPV, 90.6%; NPV, 100% between the patients with IPD and DIP). Abnormality on MRI was significantly more frequent in patients with IPD (p < 0.0001).

CONCLUSION: Nigrosome 1 imaging at 3T can differentiate IPD from DIP with accuracy of 93.9%.

SS 03 NR-04  08:30  [English]
Disrupted correlation between cortical thickness and functional connectivity in Alzheimer’s disease
Darlene Park, Sang Joon Kim, Ji Eun Park, Seung Won Jang, Ho Sung Kim, Choong Gon Choi, Seung Chai Jung, Joo Young Oh, Woo Hyun Shim
Asan Medical Center, Korea.
skimjb@amc.seoul.kr

PURPOSE: Cortical thinning is a well-known structural change in Alzheimer’s disease (AD) patients. Decreased
connectivity in default mode network (DMN) is reported particularly relevant to AD. However, the relationship between cortical thickness and DMN changes is still unknown. We intended to investigate the potential coupling between cortical thinning and decrease in DMN connectivity in AD.

**MATERIALS AND METHODS:** Forty-two patients with AD and 25 age-matched cognitively normal (CN) subjects were enrolled in this study. 3D-T1 anatomical images and resting state functional MRI (rs-fMRI) were obtained in addition to the conventional T2 and fluid-attenuated inversion recovery (FLAIR) images in both groups. Cortical thickness of the whole brain was analyzed using FreeSurfer software (http://surfer.nmr.mgh.harvard.edu) and connectivity between posterior cingulate cortex (PCC) and medial frontal cortex (MFC) was analyzed by AFNI software (http://afni.nimh.nih.gov/). We measured the correlation coefficient between cortical thickness and DMN connectivity in the whole brain and investigated whether there was difference in correlation coefficient between CN and AD group and searched for the areas with significant correlation difference.

**RESULTS:** There was significant difference in correlation coefficient between CN and AD in both inferior parietal lobules and pars orbitalis. The CN group showed higher cortical thickness and DMN connectivity compared to AD group and there was positive correlation between cortical thickness and DMN connectivity in those areas. In AD group, there was no correlation between cortical thickness and DMN connectivity.

**CONCLUSION:** Our results revealed that correlation between cortical thickness and DMN connectivity was disrupted in AD patients in both IPLs and pars orbitalis. Our results suggest that disrupted correlation between cortical thickness and DMN connectivity in both IPLs and pars orbitalis might be a useful biomarker in the diagnosis and monitoring of patients with AD.

**Fig. 1.** Difference between correlation of cortical thickness and DMN connectivity in AD patients (blue circle) compared to CN (red square). The difference of disrupted correlation was prominent in left inferior parietal lobule. Meanwhile CN group showed positive correlation between cortical thickness and DMN connectivity strength.

**SS 03 NR-05 08:40**

**Multivariate analyses of functional connectivity for discriminating cognitive subgroups of Parkinson’s disease**

Sehjung Yi¹, Na Young Shin², Sanghoon Han¹, Seung-Koo Lee³
¹Yonsei University, ²Ewha Womans University Mokdong Hospital, ³Severance Hospital, Korea.
slee@yuhs.ac

**PURPOSE:** We investigated the alteration of resting-state functional connectivity between the medial temporal lobe (MTL) and precuneus/posterior cingular cortex (PCC) as a function of cognitive impairments in Parkinson’s disease, including mild cognitive impairment to investigation.

**MATERIALS AND METHODS:** Patients with Parkinson’s disease were grouped according to their cognitive status, Intact Cognition (PD-IC), Mild Cognitive Impairment (PD-MCI), and Dementia (PDD), using the Seoul Neuropsychological Screening Battery (SNSB). fMRI of 22 PD-IC, 43 PD-MCI, and 9 PD-D patients were included in the analysis. The resting-state fMRI data were corrected for slice timing and head movement, normalized, and smoothed using SPM8 and DPARSF implemented in MATLAB. Nuisance covariates including head motion parameters, global mean signal, white matter signal, and cerebrospinal fluid signal were regressed out. In order to perform seed based rs-fc analysis, time courses of 90 seed ROIs whose masks were defined by Automated Anatomical Labeling (AAL) template were extracted and used for calculating cross correlations of each pairs of seed ROIs.

**RESULTS:** A one-way ANOVA tested differences in rs-fc among PD-IC, PD-MCI, and PDD groups using the obtained correlation coefficients. It revealed significant group differences in functional connectivity between hippocampus and precuneus (L-L, F(2,71) = 3.33, p < 0.05; L-R, F(2,71) = 5.13, p < 0.01), hippocampus and PCC (L-L, F(2,71) = 4.27, p < 0.05; L-R, F(2,71) = 5.46, p < 0.01; R-R, F(2,71) = 4.23, p < 0.05), and parahippocampal cortex and PCC (L-L, F(2,71) = 4.58, p < 0.05; L-R, F(2,71) = 5.3, p < 0.01; R-L, F(2,71) = 4.77, p < 0.05; R-R, F(2,71) = 5.84, p < 0.01). To illuminate how cognitive status change pertains to rs-fc, we ran seed-based functional connectivity whole-brain analysis using eight seeds of bilateral hippocampus, parahippocampal cortex, precuneus, PCC. To our surprise, instead of consistent decrease as a function of cognitive deficit, PD-MCI showed increased functional connectivity between MTL and precuneus/PCC compared to PD-IC or PDD.

**CONCLUSION:** The results suggest a possibility that this sudden increase in MTL-precuneus/PCC connectivity in MCI can be used as a biomarker of subsequent decline of cognitive functions into dementia in PD.
Visual and vestibular systems interact to encode body motion and location in space. Nevertheless, the existence of cortical areas processing both visual and vestibular signals remains debated. We aimed to identify multisensory brain regions in the posterior peri-sylvian and extrastriate brain regions using 7T functional magnetic resonance imaging. 11 human subjects were stimulated by galvanic vestibular stimulation at the mastoid level and compared to a condition with galvanic cutaneous stimulation of the neck. Subjects were also exposed to linear coherent motion via an optokinetic visual stimulus, contrasted to a condition with static dots. Visuo-vestibular convergence occurred within a parieto-temporal network, which incorporated the human analogue of the monkey parieto-insular vestibular cortex. Areas of convergence were found in: (1) retroinsular cortex mainly in PFcm and PFop within the inferior parietal lobule and parietal operculum in OP1; (2) temporo-parietal junction at the surface of the supra marginal cortex mainly in PF and PFT; (3) posterior middle temporal gyrus and superior temporal sulcus, partially extending in extrastriate area hOc5. Convergences in temporo-parietal junction, posterior middle temporal gyrus and superior temporal sulcus were present in most of the subjects while retroinsular convergences were a less reproductive finding across our subjects. Interestingly, temporo-parietal junction and middle temporal cortices are known to play a major role for bodily self-consciousness through multisensory integration processes and lesions in those regions are known to evoke disorders of somatognosia such as out-of-body experiences. 7T fMRI allows to disentangle in individual subjects which cytoarchitectonic areas are involved in visuo-vestibular interactions amongst the ubiquitous vestibular cortices in the very folded anatomy of the parietal operculum and inferior parietal lobule. (In the attached summary figure, centers of visuo-vestibular convergences of 11 individual subjects are here mapped on a generic semi-inflated brain).
BACKGROUND: Although the majority of studies have focused on finding specific regions of the brain in which the iron concentration is high, no studies have been performed to examine a global variation of susceptibility maps in Alzheimer’s disease (AD). Quantitative susceptibility mapping (QSM) is a novel technique that enables quantification of susceptibility-changing materials inside a magnetic field.

PURPOSE: The objective of this study was to differentiate AD from cognitive normal (CN) and mild cognitive impairment (MCI) using a texture analysis of QSM and 3D T1-weighted image (3DT1WI).

MATERIALS AND METHODS: The participants included 18 elderly CN, 18 MCI, and 18 AD subjects. A fully first-order flow-compensated 3D gradient-echo (GE) sequence was run to obtain axial magnitude and phase images and further to produce QSM data. The sagittal structural 3DT1WI was also acquired with the MPRAGE sequence to obtain brain tissues. The first-order textures of MEAN, SD, and COVSI were calculated from both QSM and 3DT1WI. The second-order textures of “contrast, correlation, energy, homogeneity and entropy” were also calculated from a co-occurrence matrix for both images. The first- and second-ordered textures of entire slices of QSM and brain tissue data were obtained to evaluate group differences of textures using the one-way analysis of variance (ANOVA) test.

RESULTS: For brain tissues inclusive of the brain tissues of QSM, MEAN, SD and decreased from CN to AD, while COVSI increased. For the brain tissues of QSM, the contrast and entropy increased from CN to AD, while energy and homogeneity decreased. For the first order analysis of QSM, normalized mean, standard deviation and covariance of signal intensity (COVSI) separated AD from CN (F = 6.134, p = 0.004085). For the second order analysis of QSM, energy, entropy and homogeneity differentiated AD from CN (F = 5.984, p = 0.004627). For 3DT1W images, normalized mean and COVSI of gray matter distinguished AD from CN (F = 4.413, p = 0.0170).

CONCLUSION: The texture analysis of QSM successively distinguished AD from CN and MCI in a global scale and proved to be more effective than 3DT1WI. The texture variation of QSM also verified the previously reported AD pathologic patterns. Therefore this method can be used as an imaging biomarker to evaluate AD.

SS 03 NR-09 09:20
Correlation analysis between clusters of basic blood markers and white matter integrity in healthy middle and older population: investigated by diffusion tensor imaging
Chang-Woo Ryu1, David Salat2, Jean-Philippe Coutu2
1Kyung Hee University Hospital at Gangdong, Korea, 2Cornell University, USA.
salat@nmr.mgh.harvard.edu

PURPOSE: In the current study, we attempted to investigate how blood metabolic markers cluster in a sample of cognitively healthy older adults and to determine the potential impact of systemic dysfunction on neural health through associations with DTI data.

MATERIALS AND METHODS: 139 middle-aged and older adults were included as subjects. All participants were physically healthy, cognitively intact, and literate with at least a high school education. 12 markers and 4 indicatives (total-cholesterol, HDL, LDL, triglyceride, insulin, fasting glucose, HbA1C, creatinine, BUN, albumin, total protein, GFR, CCR, Insulin-resistance, mean glucose, and cholesterol to HDL ratio) were obtained from venous blood sampling. Principal component method of factor analysis was performed to identify the latent pattern of the underlying a set of variables. DTI was acquired with 60 directions at b = 700 s/mm2 and 10 volumes at b value = 0 s/mm2. TBSS analysis of the DTI data was performed using general linear models to examine regional associations between each factor driven from factor analysis and DTI indices after regressing out age, gender, other four factors and motion parameters.

RESULTS: Out of five factors driven from factor analysis, two factors (insulin/HDL and kidney function factors) were showed association with DTI indices. Insulin/HDL factors showed regional association with FA and axial diffusivity in frontal, occipital and temporal WM and bilateral projection fibers. Kidney function factor showed regional association with mean diffusivity and radial diffusivity.

CONCLUSION: The major clusters of blood markers affecting WM integrity in general healthy adult population is interindividual variables related to insulin/HDL and kidney function. The results potentially suggest that subclinical risk of metabolic syndrome or kidney function possibly contribute to an increased vulnerability for developing further WM degeneration later in life.
Over the past decades brain tumor imaging has shifted from techniques providing purely anatomical information to new approaches providing information about individual tumor biology and pathophysiology. These advances in MR imaging have greatly improved the study of primary and secondary brain tumors and their management in clinical practice providing informations regarding prognosis, influencing therapeutic decisions, and monitoring therapy response. Advanced technique like MR spectroscopy, MR perfusion and diffusion gave access to informations about cellularity, metabolic activity and angiogenesis of tumoral tissue and peritumoral areas. Consequently, it is now possible to sample noninvasively a new lesions inferring data about its homogeneity, grading/attitude toward growth and invasiveness. Fiber-tracking technique, derived from MRI diffusion acquisition, allow to investigate the relationships existing between tumoral tissue and surrounding white matter bundles. This kind of structural information can be associated to activation studies obtained using bold fMRI in order to draw a precise map of functional cortical areas and subcortical functional bundles. These individual maps have a paramount relevance for planning surgical resection and for intraoperative neuronavigation. This is beneficial to obtain a gross total or subtotal resection, that implies a longer survival, particularly in low grade gliomas.

Spectroscopy, diffusion and perfusion has a fundamental role in the follow-up of brain tumors, allowing to early determine the efficacy of new therapies and facilitating the differential diagnosis in troublesome conditions like radionecrosis, pseudoprogression and pseudoresponse.

During the presentation the strenghts, limitations and pitfalls of structural, diffusion-weighted, spectroscopy, persuini and functional imaging will be reviewed in order to understand the role of modern imaging in the care of brain tumor patients.

Finally, the shift from the era of histopathology dictating treatment to the realm of molecular diagnostic and associated targeted therapies, specifically based on the genomic architecture of individual gliomas, will be briefly discussed.
Preoperative imaging features including eloquent area involvement, multifocality, and ependymal involvement in addition to clinical parameters can improve the predictive power for overall survival in elderly glioblastoma patients.

**CONCLUSION:** The NMR metabolomic approach might be a useful modality for diagnosis and prognosis prediction of PCNSL, and MRI features such as ADC value and leptomeningeal enhancement can reflect the metabolic profiles of PCNSL.

**POTENTIAL INTERVENTION:** Further research is needed to validate the diagnostic and prognostic potential of NMR metabolomics in PCNSL.
fying contrast-enhancing, low-grade tumor (World Health Organization [WHO] grades 1 and 2) mimicking high-grade tumor (WHO grade 3 and 4).

MATERIALS AND METHODS: This retrospective study was approved by our Institutional Review Board. Forty-five patients with pathologically proven, solitary, contrast-enhancing tumors were enrolled in this study. APT-derived signals from the calculated APT asymmetry at the offset frequency = 3.5 ppm and normalized cerebral blood volume (nCBV) were measured on solid portions of the tumor using a 90% histogram cutoff (APT90, nCBV90). The diagnostic performance of the imaging parameters was determined by leave-one-out cross validation. Interobserver agreement was assessed using the intra-class correlation coefficient (ICC).

RESULTS: The APT90 demonstrated a significant difference between contrast-enhancing, low-grade and high-grade tumors for both readers (p < 0.001 for both readers). Compared with the nCBV90, adding APT90 significantly improved the area under the receiver-operating-characteristic curve (AUC) for identifying contrast-enhancing, low-grade tumor from 0.80 to 0.97 for reader 1 (p = 0.023) and from 0.82 to 0.97 for reader 2 (p = 0.035), respectively. Using leave-one-out cross validation, the cross-validated AUC of the combination of nCBV90 and APT90 was 0.95 for reader 1 and 0.96 for reader 2. The ICC for the APT90 calculations was 0.89.

CONCLUSION: Histogram analysis of APT imaging provided an added value to MR perfusion imaging for identifying contrast-enhancing, low-grade tumor mimicking high-grade tumor.

Fig. 1. Images obtained in a 64-year-old man with WHO grade 1 tumor (hemangioblastoma). (a) Contrast-enhanced T1-weighted MR image demonstrates a contrast-enhancing solid mass with a cyst in the right cerebellar hemisphere. (b) DSC MR image shows that nCBV is remarkably high in the corresponding contrast-enhancing solid mass. (c) APT image demonstrates that the APT signal intensity and (d) its histogram distribution of the signal intensity are relatively low in the solid portion but remarkably high in the cystic portion, suggesting low-grade tumor.
SS 12 NR-06 17:10 English
Combination of dynamic susceptibility contrast perfusion imaging and susceptibility-weighted imaging for better differential diagnosis of recurrence from radionecrosis in high grade glioma
Tae Hyung Kim, Seung Hong Choi
Seoul National University Hospital, Korea.
verocay@snuh.org

PURPOSE: To investigate whether combination of susceptibility-weighted imaging (SWI) and dynamic susceptibility contrast (DSC) perfusion-weighted imaging (PWI) can improve accuracy of differential diagnosis of true recurrence from radiation (RT) necrosis in high grade glioma patients.

MATERIALS AND METHODS: We enrolled 38 patients treated with RT followed by near-total tumor resection for high grade glioma, who showed newly appearing measurable enhancing lesions on follow-up MRI after more than six months complete response period. The enhancing lesions were confirmed as true recurrence (n = 24) or RT necrosis (n = 14). Mean and each percentile value from the cumulative histograms of normalized CBV (nCBV) and proportion of dark signal intensity on SWI (proSWI, %) within the enhancing lesions were compared between the two groups by using t-test. A multivariable regression model was performed to determine the best predictor of differential diagnosis. The cutoff value of the best predictor obtained from ROC analysis was applied to calculate the sensitivity, specificity, and accuracy for the diagnosis of true recurrence and RT necrosis.

RESULTS: Mean nCBV and the 95th percentile nCBV (nCBV95) was significantly higher in true recurrence than in the RT necrosis (1.12 vs. 3.65, mean nCBV, p < 0.001; 2.31 vs. 7.23, nCBV95, p < 0.004). The significant lower proSWI was observed in the true recurrence than RT necrosis (27.08 vs. 0.36%, proSWI, p < 0.0001). A multivariable regression analysis showed that both nCBV95 and proSWI were independent variables for the differentiation. The combination of nCBV95 and proSWI achieved sensitivity of 100% (24/24), specificity of 92.9% (13/14) and accuracy of 97.4% (37/38) by using the best cut-off values (nCBV95 of 2.7 and proSWI of 1.1%) from ROC analysis. In the subgroup analysis, the all RT necrosis (n = 3) with nCBV of > 2.7 showed obvious hemorrhage (proSWI of > 8.9%).

CONCLUSION: When compared with DSC PWI alone, the combination of SWI and DSC PWI can improve the accuracy of differential diagnosis of true recurrence from RT necrosis in high grade glioma patients, who developed new enhancing lesions after long term complete response.

SS 12 NR-07 17:20 English
Practical value of black-blood imaging in the detection of metastatic brain tumors: comparison of 3D contrast-enhanced black-blood and MP-RAGE imaging
Leonard Sunwoo1, Soo Chin Kim1, Chul-Ho Sohn2
1SMG-SNU Boramae Medical Center, 2Seoul National University Hospital, Korea.
neurorad63@gmail.com

PURPOSE: Contrast-enhanced 3D T1-weighted MR imaging is currently included in the standard protocol for brain metastasis work-up in many institutions. However, the conventional methods, such as magnetization-prepared rapid gradient echo (MP-RAGE), often require considerable time to distinguish small metastatic nodules from the blood vessels. Recently, contrast-enhanced 3D black-blood (BB) MR imaging has been introduced in an effort to improve the tumor detection by suppressing the signal from the blood vessels. The aim of this study is to determine the additional value of BB MR imaging over the conventional 3D MP-RAGE in the detection of brain metastasis.

MATERIALS AND METHODS: The present study was approved by the Institutional Review Board. We enrolled thirty-five patients (16 women; mean age, 60.8 years) with underlying malignancy (lung cancer [n = 28], breast cancer [n = 2], melanoma [n = 2], ovarian cancer [n = 1], germ cell tumor [n = 1], and papillary thyroid carcinoma [n = 1]) who underwent brain MR imaging as a work-up for brain metastasis. All MR images included 3D MP-RAGE and BB sequences using a single dose of contrast medium at 3.0 T. Two reviewers independently interpreted the two sets of MR images (MP-RAGE and BB) to assess the presence of metastatic brain tumors. Elapsed time for reviewing each case was recorded. A third reviewer evaluated the same MR images with an aid of follow-up imaging, which served as the reference. Taken altogether, the detection rates for brain metastasis and reading time between MP-RAGE and BB sequences were compared.

RESULTS: A total of 99 metastatic nodules in 25 patients were detected. There were no metastatic tumors in 10 patients. A significantly larger number of metastatic nodules were noted with BB than with MP-RAGE (p = 0.020, Wilcoxon signed-rank test). Sensitivities for metastatic nodules were 79.8% for MP-RAGE and 93.9% for BB (p = 0.003, McNemar test). Reading time for interpreting BB images was significantly shorter than that for interpreting MP-RAGE images (86.6 s vs. 119.9 s, p = 0.004, Wilcoxon signed-rank test).

CONCLUSION: Use of BB imaging leads to a significant increase in sensitivity for detecting metastatic brain tumors with a significantly shorter reading time.
**SS 12 NR-08**

**The fate of ‘RANO’ criteria based nonmeasurable enhancing lesion in post-treatment glioblastoma patients**

Hye Joung Eom, Ho Sung Kim, Seung Chai Jung, Choong-Gon Choi, Sang Joon Kim

Asan Medical Center, Korea.

radhskim@gmail.com

**PURPOSE:** To investigate the clinical significance of ‘RANO’ criteria-based nonmeasurable enhancing lesion (NEL) detected during follow-up studies in patients with post-treatment glioblastoma.

**MATERIALS AND METHODS:** This retrospective cohort study was approved by the Institutional Review Board. A total of 135 glioblastoma patients (M:F = 79:56; mean age, 56 years) who developed NEL after concurrent chemoradiotherapy (CCRT) were followed for mean of 91 weeks. Primary outcome was measurement of clinical outcome 1 year after the detection of first NEL. Secondary outcome was subgroup analysis stratified by perfusion status, presence of oligodendroglial component, and NEL pattern (nodular vs. marginal). Uni- and multivariable logistic regressions were performed for subgroup analysis.

**RESULTS:** The mean time between CCRT and appearance of NEL was 29 weeks. The primary outcome for NEL revealed progression in 48%, radiation-induced effect in 5%, and disappearance in 15% and 32% remained unmeasurable 1 year after the detection of first NEL. The median time between first NEL detection and its progression was 45 weeks. In the subgroup analysis, positive perfusion status (odds ratio, 3.47; 95% CI, 1.65–7.29) and presence of oligodendroglial component (odds ratio, 0.29; 95% CI, 0.10–0.86) were significantly associated with unfavorable clinical outcome 1 year after the detection of first NEL. Nodular enhancing pattern of NEL showed borderline significance (p = 0.076) in predicting unfavorable outcome at 1 year, compared to marginal pattern.

**CONCLUSION:** About half of NEL defined by ‘RANO’ criteria showed progression at 1-year follow-up and positive perfusion status, absence of oligodendroglial component and nodular pattern were associated with unfavorable clinical outcome.

**SS 12 NR-09**

**Differentiation of hemangioblastoma from metastatic brain tumor using dynamic contrast enhanced MR imaging**

Jihoon Cha, Sung Tae Kim, Hyung-Jin Kim, Yi Kyung Kim, Ha Youn Kim, Gyeong Min Park, Pyeong Jeon, Keon Ha Kim, Hong Sik Byun

Samsung Medical Center, Korea.

st7.kim@samsung.com

**PURPOSE:** The hemangioblastoma is benign brain tumor, however, it frequently mimics metastatic brain tumor. Diffusion weighted image (DWI) and dynamic susceptibility contrast (DSC) perfusion weighted image (PWI) is often used to differentiate brain tumor. Recently, dynamic contrast enhanced MRI (DCE-MRI) is used to evaluate microvascular changes in tumor. The aim of this study was to differentiate hemangioblastoma from metastatic brain tumor using DCE-MRI and compare the diagnostic performance with DWI and PWI.

**MATERIALS AND METHODS:** Between May 2013 and October 2014, DCE-MRI was performed in 7 patients with hemangioblastoma. For comparison, 15 patients with metastatic adenocarcinoma with DCE-MRI were selected (total 22 patients, 11 males; ages, 24–79 years; mean, 53 years). Regions of interest (ROI) were drawn on the contrast-enhanced T1-weighted images including whole enhancing lesions on each slice. DCE-MRI parameters (Ktrans, kep, ve, and vp) were calculated with Philips Intellispace Portal software (extended Tofts model). ADC, relative cerebral blood volume (rCBV) and DCE-MRI parameters were compared between two groups. The diagnostic performances of each parameter were evaluated with receiver operating characteristic (ROC) curve analysis.

**RESULTS:** vp, kep, rCBV and ADC were significantly different between hemangioblastoma and metastatic brain tumor (p < 0.001, p < 0.001, p = 0.002, p = 0.008, respectively). The vp threshold value of 0.012 and the rCBV cutoff value of 8.0 shows highest accuracy for differentiating hemangioblastoma from metastasis. The area under the ROC curve for the vp and rCBV was 0.99 and 0.89, respectively. vp > 0.012 shows 100% sensitivity, 93.3% specificity and 95.5% accuracy and rCBV > 8.0 shows 85.7% sensitivity, 93.3% specificity and 90.9% accuracy for differentiating hemangioblastoma from metastatic brain tumor.

**CONCLUSION:** DCE-MRI was useful to differentiate hemangioblastoma from metastatic brain tumor.
Characteristics of MR contrast agents and different washout patterns in rodent brain tumor models

Kyung Sik Yi¹, Sang-Hoon Cha¹, Chi-Hoon Choi², Chulhyun Lee³, Hong Jun Lee⁴, Janggeun Cho⁵, Seung Tae Woo⁶
¹Chungbuk National University Hospital, ²National Medical Center, ³Korea Basic Science Institute, ⁴Chung-Ang University College of Medicine, ⁵Bayer Healthcare Medical Care, Korea.

shcha@chungbuk.ac.kr

PURPOSE: To investigate dynamic contrast enhancement patterns of different MR contrast agents which have different molecular properties of ionicity and structure, we compared ionic/nonionic and linear/cyclic agents (Gadovist®, Omniscan®, Dotarem®, and Magnevist®) in rodent brain tumor models.

MATERIALS AND METHODS: Human glioblastoma (GBM) tumor cell line (U373, 1X10⁶) were injected into the BALB/c nude mice brain (5 weeks old, n = 16) for rodent brain tumor models. MRI experiments were used a 4.7 T MRI (BioSpec 47/40; Bruker, Germany) with a 25 mm inner diameter quadrature RF coil. Dynamic contrast enhancement MR imaging (3D T1W-GRE sequence, TR/TE = 160.0/2.5 ms, flip angle = 30.0) was performed after i.v. injection with same dose of contrast agents (0.1 mmol/kg, 4 animals each agents respectively) and repeated every 1 minute up to 170 minutes. To compare each dynamic enhancement pattern, T1 signal intensity was measured in the ROI within the brain tumor.

RESULTS: Human GBM cells formed homogeneous intracerebral masses 5-7 days after stereotactic implantation in all animals (Fig. 1). Dynamic enhancement patterns after contrast media injection were different according to the property of contrast media (Fig. 2). At the DCE curves of the brain tumor model, the signal enhancement for ionic agents was prolonged over 80 minutes while that for nonionic agents was less than 30 minutes.

CONCLUSION: Washout patterns in DCE MRI of brain tumors are different according to the ionicity of contrast agents. Thus characteristics of contrast agents should be considered when performing perfusion MRI in brain tumors.
Central nervous system (CNS) infections are relatively rare and treatable life-threatening conditions, but the clinical outcome largely depends on early diagnosis and treatment. Diagnosis of infectious diseases relies on the demonstration of an offending organism using laboratory investigations, such as cerebrospinal fluid (CSF) analysis. Neuroimaging studies play an important role in early diagnosis.

MRI is considered the modality of choice, as it is more sensitive and specific for detection of both parenchymal and meningeal abnormalities.

By using multiple modalities, including some advanced MR techniques, associated with knowledge of major brain infections, should make it possible for the radiologists to fulfill their diagnostic role.
A novel robust method for diffusion MR assessment of spatiotemporal evolution of focal cerebral ischemia in rats

Chi-Hoon Choi¹, Kyung Sik Yi², Hong Jun Lee³, Jinwoo Hwang⁴, Youngjeon Lee⁵, Sang-Rae Lee⁶, Sang-Hoon Cha⁶
¹National Medical Center, ²Chungbuk National University Hospital, ³Chung-Ang University College of Medicine, ⁴Philips Health Care, ⁵National Primate Research Center, Institute of Bioscience and Biotechnology, Korea, ⁶Chungbuk National University College of Medicine, Korea.

SS 15 NR-02 08:30

PURPOSE: Spatiotemporal diffusion MR assessment of ADC-derived brain lesions after middle cerebral artery occlusion (MCAO) in small animal brains has been limited. Because of overlapping apparent diffusion coefficients (ADC) values between normal and lesion, their range was too big to be segmented using a threshold. For better reliable measurement, preprocessing for downsizing variation and standardization is needed; however, it has never been applied on ADC map to our knowledge. For more reliable spatiotemporal assessment of focal cerebral ischemic lesion in rats, we developed novel lesion segmentation technique of ADC intensity standardization using contralateral hemispheric mode.

MATERIALS AND METHODS: Immediately after right MCAO, 3T Diffusion MR Scans were repeated every 10 minutes up to post-occlusion 50 minutes in 33 Sprague-Dawley rats. After successful MCAO was confirmed in seven (7/33) by visual inspection, three of them were rescanned at 100 minutes. Voxel-wise MCAO lesion of each last MR scan was made by two different segmentation methods and compared with digital Hematoxylin and Eosin (H&E) stained pathology with S₀ rensen-Dice coefficient (SDco) respectively; One was using 530 (x 10⁻⁵ mm/sec) as viable threshold value (THR530) and the other was using 80% of relative ADC (rADC) with additional preprocessing (Modr80). The temporal changes of volume and mean rADC of focal cerebral ischemic lesions were analyzed by Modr80.

RESULTS: In most animals (6 of 7), Modr80 showed higher SDco than THR530 (p < 0.05) (Fig. 1), which means segmented lesions by Modr80 were more similar with digitized lesions by contralateral hemispheric mode. The middle cerebral arterial territory seemed to be fixed in early time visually. The MCA territorial lesion volumes were fixed in early time and mostly did not change over time as well as mean rADC in our Modr80 analysis. There were little differences between 50 and 100 minutes in lesion volumes and mean rADC.

CONCLUSION: Using our novel method, we were able to assess spatiotemporal characteristics of focal cerebral ischemia in rats more reliably.

Fig. 1. The comparison of S₀ rensen-Dice coefficient (SDco) by two methods (THR530 and Modr80). In Modr80, SDco was significantly higher by paired t-test (p < 0.05).

SS 15 NR-03 08:40

Imaging differentiation of cerebellopontine angle schwannoma from meningioma with emphasis on usefulness of susceptibility-weighted image (SWI)

Song Lee, Jinhee Jang, Hyun Seok Choi, So Lyung Jung, Kookjin Ahn, Bum-Soo Kim
The Catholic University of Korea, Seoul St. Mary’s Hospital, Korea.
bumrad@catholic.ac.kr

PURPOSE: Differentiation of cerebellopontine schwannoma from meningioma may often be difficult, though several imaging features of them were described in the previous reports. The aim of this study is to identify the key imaging features for distinguishing schwannoma from meningioma and to investigate the usefulness of SWI for differentiation between them.

MATERIALS AND METHODS: Between March 2010 and March 2015, 17 meningiomas and 27 schwannomas involving cerebellopontine angle were pathologically proven in our institute. We included patients 11 meningiomas and 22 schwannomas, who had preoperative SWI. We retrospectively analyzed the MRI features including size, angle by tumor border with adjacent petrous bone, consistency, presence of intratumoral dark signal intensity other than calcification on SWI, blood-fluid level, involvement of internal auditory canal (IAC), dural tail, and involvement of other adjacent intracranial space, as well as CT features including presence of dilatation of IAC, intratumoral calcification, and hyperostosis. Those features were compared between schwannoma and meningioma. Univariate and multivariate analysis were performed to identify associated variables to differentiate schwannoma from meningioma.

RESULTS: Schwannomas more frequently demonstrated intratumoral dark signal intensity on SWI, cystic or solid and cystic consistency, involvement of IAC, and globular angle with adjacent petrous bone on MRI and dilatation of IAC and intratumoral calcification on CT (each p < 0.05), than meningiomas. Dural tail was more common in
meningiomas than schwannomas (p < 0.05). In multivariate analysis, the MRI features of presence of intratumoral dark signal intensity other than calcification on SWI and globular angle by tumor border with adjacent petrous bone were associated with schwannoma (p < 0.05) with sensitivity/specitivity values of 75% / 81.8% and 85% / 72.7%, respectively. Net sensitivity/specitivity using those two features calculated by simultaneous testing was 96% / 59%.

CONCLUSION: Dark spots on SWI, which is suggestive of microhemorrhage, and globular angle with petrous bone can be predictive signs of cerebellopontine angle schwannoma in differentiation from meningioma. This finding is very helpful to differentiate schwannoma from meningioma, in addition to other known features of conventional images.

**SS 15 NR-04**

08:50

Metabolite concentration in the optic radiation using proton MR spectroscopy (H-MRS) in primary open angle glaucoma

Sabrilhakim Sidek¹, Norlisa Ramli², Kartini Rahmat³, Norlina M. Ramli³, Fadzilina A. Rahman³, Tan Li Kuo³

¹Medical Imaging Unit, Faculty of Medicine, University Teknologi MARA, Selangor, Malaysia, ²Department of Biomedical Imaging, UMRIC, Faculty of Medicine, University Malaya, Kuala Lumpur, ³Department of Ophthalmology, Faculty of Medicine, University Malaya, Kuala Lumpur, Malaysia. bmhkim_7@hotmail.com

PURPOSE: Glaucoma is an irreversible neurodegenerative disease due to retinal ganglion cell (RGC) death and visual pathway axons degeneration. Few studies have documented the changes in the metabolite concentrations of the optic radiation due to glaucoma. However, the results remain debatable.

OBJECTIVES: To compare metabolite concentration in the optic radiation of glaucoma patients with healthy subjects using proton magnetic resonance spectroscopy (H-MRS).

MATERIALS AND METHODS: H-MRS was performed using 3-Tesla MRI on 45 optic radiations (15 normal, 15 mild glaucoma and 15 severe glaucoma). The categorization into mild and severe glaucoma was done using Hodapp-Parrish-Anderson (HPA) classification. Mean and multiple group comparisons for metabolite concentration ratio were performed between glaucoma grades and healthy subjects.

RESULTS: There was no significant difference (p > 0.05) between metabolite concentration and metabolite concentration ratio in the optic radiations of glaucoma patients and healthy subjects.

CONCLUSION: Glaucomas of different severity do not affect metabolite concentration in the optic radiations. This implies that there is preserved integrity and cellular function in the optic radiations of patients with glaucoma.
glioblastoma multiforme (GBM), four patients with anaplastic astrocytoma (AA), four patients with lymphoma and eleven patients with oligodendrogial tumors (OT) including mixed oligoastrocytomas were recruited in our study. First, voxel by voxel ADC value differences between $b = 1000$ and $b = 3000$ diffusion images were measured and calculated. Second, histogram analysis was performed and various parameters (mean, median, mode, skewness and kurtosis) were produced. Comparisons between various brain tumors (GBM vs. lymphoma, GBM vs. AA and GBM+AA vs. OT) were performed with using the parameters from ADC value differences histogram.

RESULTS: Of the various parameters, the mode (the most frequent value) was superior to other parameters to show significant differences in multiple comparisons of brain tumors. ADC value differences using the mode were significant in all above comparisons (450 vs. 237.5 $p < 0.01$ in GBM vs. lymphoma, 450 vs. 375 $p = 0.034$ in GBM vs. AA, 433.3 vs. 300 $p = 0.037$ in GBM+AA vs. OT, respectively).

CONCLUSION: Voxel by voxel analysis of ADC value differences between low and high b-value diffusion images are very useful in differentiating various brain tumors. Further investigation recruiting more brain tumors and more various brain diseases are needed to prove its usefulness for clinical practice.

SS 15 NR-07 09:20
Change of laterality of auditory network and its relative networks in tinnitus patients
Jung-Min Lee1, Chang-Woo Ryu1, Soochan Park1, Jae Yong Byun1, Moon Suh Park1, Geon-Ho Jahng1, David Salat6
1Kyung Hee University Hospital at Gangdong, Korea, 2Harvard University, USA.
md.cwryu@gmail.com

BACKGROUND: Tinnitus is defined as an auditory phantom percept without corresponding external sound source. One of potential mechanisms of tinnitus is suggested as the alteration of the perception in neural auditory pathway.

PURPOSE: To investigate difference of laterality in resting auditory connectivity and its relative networks between unilateral tinnitus (TI) and healthy controls (HC).

SUBJECT: Total of 83 subjects were enrolled this research. We included continuous and chronic tinnitus over six months and moderate degree. Nineteen right side tinnitus (R, TI) and 19 left side tinnitus (L, TI) were included. In addition, age and gender-matched 45 healthy controls were enrolled this study.

MATERIALS AND METHODS: Resting-state (rs) BOLD fMRI was acquired with a single-shot gradient-echo EPI sequence using a 3.0 Tesla MRI system. In addition, 3D T1-weighted images (3DT1WI) were also acquired. The rs-fMRI and 3DT1WI data were flipped. A bilateral symmetric template was made by combining native and flipped T1W images. Further post-processing steps were carried out using SPM8 software. Group independent component analysis (ICA) of native and flipped rs-fMRI was performed, and we selected auditory (AN), dorsal attention (DAN) and Salience networks (SAL) from 30 network components. Llaterity index (LI) was calculated by (L-R)/(LI+RI) from each network. The LI maps were compared between the groups, between the sides (left vs. right), and between the genders in the tinnitus group using the voxel-based analysis. Furthermore, regions-of-interest (ROIs) analyses driven from each network template were performed to compare volume of left lateralized regions (over SD) between the two groups.

RESULTS: Results of the voxel-based analysis showed significant difference of LI values between TI and HC in each network. LI within the AN cortex is higher in HC than in TI indicated more left lateralization in HC. LI within DAN cortex is higher in TI than in HC indicated more right lateralization in HC. LI within SAL was not significantly different between two groups. In ROI analysis, the volume of left lateralized regions of TI were significantly lower for AN, but higher for DAN and SAL compared with the HC group ($p < 0.0001$).

CONCLUSION: Lateralities of AN and DAN were altered in unilateral TI patients compared with HC subjects. This finding is helpful to understand network changes in TI patients.

SS 29 NR-01 09:50
Can FLAIR hyperintense vessel (FHV) signs be influenced by varying MR parameters and flow velocities? 
Sung Jun Ahn1, Sung Soo Ahn2, Bum-soo Kim3, Seung-Koo Lee2
1Gangnam Severance Hospital, 2Severance Hospital, 3The Catholic University of Korea, Seoul St. Mary’s Hospital, Korea.
aahng77@yuhs.ac

BACKGROUND: Fluid-attenuated inversion recovery (FLAIR) hyperintense vessels (FHVs) have been used to assess leptomeningeal collateral flow in acute ischemic stroke. However, prior FHVs studies showed inconsistent results, which may be ascribable to different MR parameters used.

PURPOSE: To evaluate whether FHVs could be influenced by varying MR parameters and flow velocities, using a flow phantom.

MATERIALS AND METHODS: A total of 512 sets of FLAIRs were performed with varying parameters and flow velocities, using a flow phantom. Flow phantom was manufactured with 3.5% agarose solution, an 8-mm-inner diameter silicone tube and non-pulsatile pump. Varying MR parameters were repetition time (TR)/inversion time (TI), echo time (TE), flip angle (FA) of refocusing pulse and periodically rotated overlapping parallel lines with enhanced reconstruction (PROPELLER). The signal...
intensity of flow were measured and regarded as the degree of FHVs. Simple and multiple linear regression analyses were applied to evaluate the association between the degree of FHVs and varying MR parameters as well as flow velocities

RESULTS: On univariate analysis, PROPELLER technique ($R^2 = 0.448$) demonstrated strongest correlation with the degree of FHV, followed by flow velocities ($R^2 = 0.204$), FA ($R^2 = 0.126$) and TE ($R^2 = 0.031$), whereas TR/TI showed no significant correlations. On multivariate analysis, TE, FA, PROPELLER technique and flow velocities were independent factors influencing the degree of FHVs ($< 0.001$).

CONCLUSION: Flow velocities, FA of refocusing pulse, TE and PROPELLER technique significantly affected the degree of FHVs. Optimized MR parameters should be used consistently in future studies, which may provide more reliable results.

**SS 29 NR-02 10:00**

Assessment of diffusion-weighted imaging-FLAIR mismatch: comparison between FLAIR (TR, 9000 ms) versus FLAIR (TR, 6000 ms) at 3T

Byong Ho Goh, Eung Yeop Kim
Gachon University Gil Medical Center, Korea.
eungyeop.kim@gmail.com

**PURPOSE:** FLAIR imaging helps to determine the age of infarct. There are a few ways to reduce its acquisition time. Of those, echo-planar imaging can be a good option, but images are susceptible to artifact, which could diminish its added value. FLAIR can be obtained faster with shorter repetition time (TR), but it is noiser. We hypothesized that shorter-TR FLAIR obtained at 3T with a 32-channel coil may be comparable to conventional FLAIR. The aim of this study was to compare the diagnostic value between FLAIR with TR of 9000 ms (FLAIR$_{9000}$) and FLAIR with TR of 6000 ms (FLAIR$_{6000}$) at 3T in patients with acute ischemic stroke.

**MATERIALS AND METHODS:** We retrospectively recruited 184 patients (103 male; mean age, 69.3 years) who had acute ischemic stroke (known [n = 121; 28 patients < 4.5 hours] and unknown [n = 63] symptom onset times) and had undergone 5-mm diffusion-weighted imaging (DWI) and two successive 5-mm FLAIR images at 3T with a 32-channel coil. FLAIR$_{9000}$ was obtained with the following parameters: TR/TE/TI = 9000/89/2500; in-plane resolution, 0.9 × 0.9 mm; no gap; reduction factor of three (acquisition time, 108 sec). FLAIR$_{6000}$ was obtained similarly except for TR of 6000 ms, TI of 2027 ms, and the reduction factor of three (acquisition time, 60 sec). Two radiologists independently reviewed paired imaging sets (DWI-FLAIR$_{9000}$ and DWI-FLAIR$_{6000}$) 2 weeks apart for the presence of matched hyperintense lesions (> 10 mm$^2$ on DWI) on each FLAIR imaging. The McNemar test was used for comparison between the two FLAIR images. Interobserver agreement was assessed by $\kappa$ coefficient.

**RESULTS:** DWI-FLAIR$_{9000}$ mismatch was present in 39 of 184 (21.2%) patients, which was perfectly the same on FLAIR$_{6000}$. DWI-FLAIR$_{9000}$ match (n = 145) was similarly observed on FLAIR$_{6000}$ except for three patients (2%), showing no significant difference ($p > 0.05$). Interobserver agreement was excellent for both DWI-FLAIR$_{9000}$ and DWI-FLAIR$_{6000}$ (Cohen’s kappa = 0.904 and 0.883, respectively).

**CONCLUSION:** For determination of mismatch or match between DWI and FLAIR imaging, there is no significant difference between FLAIR$_{9000}$ and FLAIR$_{6000}$ at 3T with a 32-channel coil.

**SS 29 NR-03 10:10**

Predicting leptomeningeal collateralization in acute ischemic stroke: comparison of SWI with FLAIR

Yunsup Hwang, Yeong-ju Kim, Yoodong Won, Yeil Kim, Ki Tae Kim
The Catholic University of Korea, Uijeongbu St. Mary’s Hospital, Korea.
violet2@catholic.ac.kr

**PURPOSE:** Assessing collateral status is important in acute ischemic stroke. The purpose of this study was to compare susceptibility weighted images (SWI) and fluid-attenuated inversion recovery (FLAIR) with digital subtraction angiography (DSA) in predicting leptomeningeal collateral flow in acute middle cerebral artery (MCA) infarction.

**MATERIALS AND METHODS:** We enrolled acute stroke patients due to thromboembolic M1 segment occlusion who underwent DSA and MRI including SWI and FLAIR. We reviewed the presence of prominent vessel signs (PVS) on SWI and vascular hyperintensity (FHV) on FLAIR and measured the extent of these finding to contra- lateral normal appearing areas. We graded the degree of PVS on SWI as four groups of none, mild, moderate, or extensive by the modified Alberta Stroke Program Early CT Scan (ASPECTS) system. FHV were classified into 4 grade in without FHV, FHV only within the sylvian fissure, extensive PVS on SWI in acute infarction were significantly lower for patients with better collateral grades than those with worse collateral scores ($p < 0.05$). There were no statistically significant association between FHV on FLAIR and collateral blood flow ($p = 0.05$). But both case of patient with FHV only within the sylvian fissure and...
patient without FVH were only observed in patients with poor collateral flow on DSA.

**CONCLUSION:** The grade of leptomeningeal collateralization correlates with the extent of PVS on SWI in acute ischemic stroke with M1 segment occlusion. The extent of FVH on FLAIR exhibits no relationship with respect to the degree of leptomeningeal collaterals. But absence of distal FVH could be useful finding of predicting the poor collateral flow in acute MCA infarction. SWI and FLAIR could assess non-invasively intracerebral collaterals in acute stroke patients.

**SS 29 NR-04  10:20**

**Evaluation of diagnostic feasibility of high-resolution MR imaging for posterior inferior cerebellar artery dissection**

Mirae Han, Jin Wook Choi, Sun Yong Kim, Jin Soo Lee

**Ajou University Hospital, Korea.**

**radjwchoi@gmail.com**

**PURPOSE:** To evaluate the feasibility of HR-MR imaging diagnosing posterior inferior cerebellar artery (PICA) dissection and to find most useful imaging findings suggesting dissection.

**MATERIALS AND METHODS:** We retrospectively reviewed 104 patients suspected of having arterial dissection involving posterior cerebral circulation and underwent HR-MR imaging between March 2012 and March 2015. 66 patients were diagnosed with arterial dissection involving posterior cerebral circulation and 16 patients among them (24.2%) were diagnosed with isolated PICA dissection by the consensus among neuroradiologists, neurointerventionist and neurologist after reviewing all clinical and paraclinical investigations available at hospital discharge (initial CT, MR, DSA images and etiologic work-ups) and follow up. Two neuroradiologists independently reviewed the HR-MR images of patients finally diagnosed as PICA dissection and looked for evidence of dissection (mural hematoma, dissection flap, outer diameter enlargement on T2WI) on each sequence of HR-MRI and CE-T1WI. Inter- and intraobserver agreement for detecting evidence of dissection was estimated using the Cohen’s kappa coefficient.

**RESULTS:** Dissection flaps were seen in all cases on T2WI (100%) and secondly on CE-T1WI (81.3%). Outer-diameter enlargement of the stenooclusive lesions on angiography was detected in most of cases (81.3%). A mural hematoma was best detected on CE-T1WI (50.0%). The two reviewers showed substantial to almost perfect agreement for detecting dissection signs on every sequence (Cohen’s kappa coefficient, 0.63–0.94)

**CONCLUSION:** HR-MR imaging could be a useful and non-invasive diagnostic tool for PICA dissection and dissection flap with outer wall enlargement on T2WI is most confident sign for suggesting dissection.

**SS 29 NR-05  10:30**

**Irregularity of intracranial arteries on TOF-MRA - relation with atherosclerosis and small vessel disease**

Hokayun Byun¹, Jinhee Jang¹, Jinkyung Sung², Lee Song³, Hyun Seok Choi¹, So-Lyung Jung¹, Kook-Jin Ahn¹, Bum-soo Kim¹

¹The Catholic University of Korea, Seoul St. Mary’s Hospital, ²The Catholic University of Korea, St. Vincent’s Hospital, Korea.

**znee@catholic.ac.kr**

**PURPOSE:** It has been suggested that there could be correlation between atherosclerotic disease of relatively large vessel and that of smaller arteries or arterioles. However, stenosis which is the main feature of atherosclerosis in large artery, cannot be observed on MR angiography unless the degree of atherosclerotic change is definite and localized. However, other visual characteristics such as irregularity of vessel contour or signal heterogeneity of vessel on MR angiography are not evaluated. The purpose of this study is to explore the value of the texture property of intracranial arteries on MR angiography in acute ischemic stroke patients and control groups. We also explore the correlation between texture property of known atherosclerosis risk factors and MR findings of small vessel diseases.

**MATERIALS AND METHODS:** 31 Patients with acute ischemic stroke and 35 control patients were included in this study. Patient’s medical history regarding risk factors of atherosclerosis was reviewed. On axial T2-weighted images, white matter hyperintensity (WMH) was scored according to modified Fazekas score. Also, presence of lacunes was assessed. On susceptibility-weighted images, presence of microbleeds was assessed. On maximal intensity projection (MIP) images of time-of-flight MR angiography (TOF-MRA), a neuroradiologist graded the visual texture score using a 4-point scale according to the degree of irregularity of vessel contour and heterogeneity of signal intensity of the vessel.

**RESULTS:** Visual texture score shows significant positive correlation with age, presence of hypertension, previous history of stroke. Patients with acute ischemic stroke shows significantly higher visual texture scores than control groups (Chi-square test, p < 0.030) Visual texture score are associated with modified Fazekas score of both deep WHM grading (p < 0.001, Kendal’s tau = 0.423) and subcortical WMH grading (p = 0.003, tau = 0.346). And it also was related to presence of lacunes (p= 0.001, tau = 0.384). Partial correlation analysis was also done to exclude effect of age and hypertension, and it revealed same results.

**CONCLUSION:** Visual texture score of MIP of TOF-MRA was significantly higher in patients with acute ischemic stroke than control group. Visual texture score of MIP of TOF-MRA showed significant correlation with atherosclerotic risk factors. It also showed positive correlation with surrogate markers of small vessel disease, WMH and lacunes, but not microbleeds.
Which evaluation should we take among various infarct core volume measurement methods?

Miran Han, Jin Wook Choi, Sun Yong Kim, Jin Soo Lee, Kyu Sun Lee
Ajou University Hospital, Korea. rajwchoi@gmail.com

PURPOSE: To evaluate the predicting power of various infarct core volume measurement methods for clinical outcomes in patients treated with intraarterial thrombectomy.

MATERIALS AND METHODS: We retrospectively selected 79 patients with acute ischemic stroke in unilateral anterior circulation territory and treated with intraarterial thrombectomy. For assessing infarct core volume, Alberta Stroke Program Early Computed Tomography Score (ASPECTS) was scored based on non-contrast CT (NCCT), post-contrast CT (PCCT) and DWI by one neuroradiologist and one neuroradiologist, independently. Infarct core volume was also quantitatively measured with the manually outlined hyperintense lesion on DWI by two independent readers and calculated with the multiple margin thresholds of ADC value as $500 \pm 10$, $550 \pm 10$, $600 \pm 10$, $650 \pm 10$ mm$^2$/s, and $700 \pm 10$ mm$^2$/s. Intraclass correlation coefficients (ICC) were estimated to assess inter-reader reliability for ASPECTS scoring and quantitative infarct core volume measurement. ROC curve analyses were performed with each evaluation method to predict subsequent parenchymal hematoma formation (PH1, PH2), good outcome (mRS 0–2), futile outcome (mRS 5, 6) and mortality, respectively.

RESULTS: The mean age of the 79 patients was 65.1 ± 15.7 years (range, 39–81 years). The average time from stroke onset to CTA was 1.9 ± 1.0 hours and to MRI was 2.8 ± 1.0 hours. 54 patients were treated with Solitaire, 13 patients with Penumbra and 14 patients with combination of these devices. A total of 55 of 79 patients (69.6%) demonstrated successful revascularization after intraarterial thrombectomy. Interreader agreement between neurologist and neuroradiologist was excellent for measuring the infarct core volume (ICC, 0.973) and scoring ASPECTS based on DWI (ICC, 0.940). Interrater reliability for scoring ASPECTS was decreased based on CT (ICC on NCCT, 0.694; ICC on PCCT, 0.859). There were no statistically significant difference among CT ASPECTS, MRI ASPECTS and MRI infarct core volume for predicting subsequent hematoma formation and good outcome. ASPECTS based on NCCT showed significantly smaller AUC (p < 0.05) for predicting futile prognosis and mortality (Table 1).

CONCLUSION: Assessing infarct core volume based on MRI was more predictive for clinical outcome after intraarterial thrombectomy, especially for futile outcome and more reliable.

Carotid MPRAGE sequence added to routine contrast-enhanced carotid MR angiography: detection of intraplaque hemorrhage

Hye-Jin Yang, Hyo-Sung Kwak, Gyung-Ho Chung, Seung-Bae Hwang
Chonbuk National University Hospital, Korea. kwak8140@jbnu.ac.kr

PURPOSE: To assess the usefulness of carotid MPRAGE sequence added to routine contrast-enhanced carotid MR angiography for detection of carotid IPH.

MATERIALS AND METHODS: From November 2012 to November 2014, 1,537 patients (M:F = 751:786; age range 31–95; median age, 66 years) with carotid MPRAGE sequence and carotid contrast-enhanced MR angiography at 3.0-T were identified. Carotid plaque with high signal intensity on MPRAGE of > 200% that of adjacent muscle was defined as IPH. We analyzed the prevalence of IPH based on degree of carotid stenosis (normal, 0%; mild, 1–50%; moderate, 51–90%; severe, > 90%) carotid contrast-enhanced MR angiography. ROC curve analyses were performed with each evaluation method to predict subsequent carotid IPH.

RESULTS: MPRAGE-predicted IPH was found in 146 carotid arteries (4.2%) of 118 patients (6.8%) included 28 with bilateral IPH. Of 146 carotid IPH, 42 (28.8%) had a normal finding on carotid contrast-enhanced MR angiography. Interreader agreement between neuroradiologist and neuroradiologist was excellent for measuring the infarct core volume (ICC, 0.973) and scoring ASPECTS based on DWI (ICC, 0.940). Interrater reliability for scoring ASPECTS was decreased based on CT (ICC on NCCT, 0.694; ICC on PCCT, 0.859). There were no statistically significant difference among CT ASPECTS, MRI ASPECTS and MRI infarct core volume for predicting subsequent hematoma formation and good outcome. ASPECTS based on NCCT showed significantly smaller AUC (p < 0.05) for predicting futile prognosis and mortality (Table 1).

CONCLUSION: Assessing infarct core volume based on MRI was more predictive for clinical outcome after intraarterial thrombectomy, especially for futile outcome and more reliable.

Table 1. The area under the ROC curve analysis for predicting outcome of endovascular treatment

<table>
<thead>
<tr>
<th>Imaging protocol</th>
<th>Parenchymal hematoma</th>
<th>Good outcome (mRS 0–2)</th>
<th>Futility outcome (mRS 5, 6)</th>
<th>Mortality</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>AUC</td>
<td>95% CI</td>
<td>AUC</td>
<td>95% CI</td>
</tr>
<tr>
<td>NCCT ASPECTS</td>
<td>0.647</td>
<td>0.531–0.751</td>
<td>0.617</td>
<td>0.501–0.724</td>
</tr>
<tr>
<td>PCCT ASPECTS</td>
<td>0.712</td>
<td>0.599–0.808</td>
<td>0.646</td>
<td>0.531–0.751</td>
</tr>
<tr>
<td>DWI ASPECTS</td>
<td>0.726</td>
<td>0.614–0.820</td>
<td>0.672</td>
<td>0.557–0.774</td>
</tr>
<tr>
<td>MRI infarct core volume by ADC 550 x10^-6 mm^2/s</td>
<td>0.769</td>
<td>0.661–0.857</td>
<td>0.692</td>
<td>0.578–0.791</td>
</tr>
<tr>
<td>MRI infarct core volume by ADC 650 x10^-6 mm^2/s</td>
<td>0.758</td>
<td>0.649–0.847</td>
<td>0.675</td>
<td>0.560–0.776</td>
</tr>
<tr>
<td>MRI infarct core volume by manually measured</td>
<td>0.751</td>
<td>0.641–0.842</td>
<td>0.692</td>
<td>0.578–0.791</td>
</tr>
</tbody>
</table>

* AUC of ASPECTS based on NCCT are significantly smaller than that of ASPECTS on PCCT (p<0.029), DWI (p<0.029) and quantitatively measured infarction volume by ADC 550 x10^-6 mm^2/s (p<0.016), by ADC 650 x10^-6 mm^2/s (p<0.023), by manually measured (p<0.023) for predicting futile outcomes.
† AUC of ASPECTS based on NCCT are significantly smaller than that of ASPECTS on DWI (p<0.001) and quantitatively measured infarction volume by ADC 550 x10^-6 mm^2/s (p<0.005), by ADC 650 x10^-6 mm^2/s (p<0.007), by manually measured (p<0.004) for predicting mortality.
(CCA) was significantly higher in no stenotic or mild stenotic group (p < 0.01).

CONCLUSION: MPRAGE sequence can be detected a carotid IPH in no stenotic group on carotid contrast-enhanced MR angiography. Carotid IPH of CCA is more frequently found in no stenotic or mild stenotic group.

**SS 29 NR-08**

**11:00**

**High-resolution MR (HR-MR) findings of intracranial artery dissection based on quantitative analysis**

Nam Joo Lee, Seung Chai Jung, Ho Sung Kim, Choong-Gon Choi, Sang Joon Kim, Deok Hee Lee, Dae Chul Suh

*Asan Medical Center, Korea.*

dynamics79@gmail.com

**PURPOSE:** High-resolution magnetic resonance (HR-MR) is reported to be helpful in the diagnosis of spontaneous intracranial artery dissection (SID). Quantitative radiologic findings and qualitative dissection findings using HR-MR were compared in patients with SID lesions in the anterior cerebral artery (ACA), middle cerebral artery (MCA), and vertebral artery (VA).

**MATERIALS AND METHODS:** This study included 26 patients (M:F = 17:9; mean age, 47 years; range, 32–74 years) presumpatively diagnosed with SID based on clinical features, luminal angiography, and HR-MR. Lesions were located in the ACA (n = 6), MCA (n = 4), and VA (n = 16). HR-MR was performed within 1 month of SID onset. Radiological indices of aneurysmal dilatation, including maximal outer diameter/area, remodeling index/modified remodeling index, and signal intensities of intramural hematoma were assessed using HR-MR. Qualitative findings, including intimal flap, double lumen, intramural hematoma, aneurysmal dilatation, and periaxial enhancement, were assessed using HR-MR and luminal angiography. Results were compared among the cerebral arteries.

**RESULTS:** Maximal outer diameter/area, remodeling index/modified remodeling index, wall thickness index, and length differed significantly in the anterior and posterior circulation (p < 0.05). Mean relative hypo-, iso-, and hyperintensity signal intensities of intramural hematomas were 0.73, 1.00, and 1.46, respectively, on T1-weighted, and 0.60, 0.99, and 2.76, respectively, on T2-weighted, imaging. Qualitative findings differed among cerebral arteries.

**CONCLUSION:** Radiological indices of aneurysmal dilatation differed between the anterior and posterior circulation. Signal intensities of intramural hematomas were varied but consistent regardless of the cerebral artery. Qualitative analysis may complement qualitative findings in the evaluation of SID.

**SS 29 NR-09**

**11:10**

**3D-CE-T1-weighted FSE black-blood MRI using a single and double dose of gadolinium: preliminary study for gadolinium dose optimization for the evaluation of atherosclerotic plaque**

Aleum Lee, Kee-hyun Chang

*Soonchunhyang University Bucheon Hospital, Korea.*

alearad@gmail.com

**PURPOSE:** The purpose of this prospective, preliminary study was to compare the efficacy of a single dose (SD) and double dose (DD) of gadolinium (Gd) for the evaluation of plaque using HR MR vessel wall imaging (VWI) and to develop a useful strategy for conducting clinical trials on VWI by establishing the best trade-off in terms of dose.

**MATERIALS AND METHODS:** Institutional Review Board (IRB) approval and written informed consent from all patients were obtained before study initiation. From June 2013 to March 2015, we performed 3T HR-MR VWI for 45 consecutive patients (M:F = 29:16) with carotid and intracranial artery stenosis. DD-enhanced scans were obtained 10 min after the injection of an SD of Gd (0.2 mmol/kg). For SI comparison, reconstructed 0.5-mm-thick isotropic FSE-CUBE images were assessed for SNRwall and CNRwall-lumen on SD- and DD-enhanced T1-WI. Quantitative measurements were performed using FuncTool II software from a Sun ADW4.3 workstation (GE Healthcare), with 400% zooming. Wall thickness, vessel area (VA), and lumen area (LA) on a cross-sectional image of the target vessel were manually measured by two neuroradiologists. Visual assessment for image quality and additional findings on DD-scan were recorded. Inter- and intraobserver variabilities were assessed using intraclass correlation coefficients (ICCs). The Mann-Whitney U test and the Wilcoxon two-sample test were used for statistical comparison.

**RESULTS:** The DD-enhanced images resulted in a 24% and 13% improvement in SNRwall and CNRwall-lumen, relative to SD, although the difference was not statistically significant (p = 0.06). Inter-(ICC: 0.91, 0.92, and 0.90, respectively) and intraobserver (0.92, 0.88, and 0.93, respectively) reliabilities for measurements of wall thickness, VA, and LA were good. On visual assessment, DD-enhanced scan showed better image quality, relative to SD with statistical significance (p < 0.05).

**CONCLUSION:** The results of this study suggest that a DD of Gd might be helpful to delineate plaque enhancement, intramural hematoma and to measure stenosis, although larger cohorts study will be necessary.