

SSG11

Neuroradiology (Stroke Imaging)

Tuesday, Nov. 29 10:30AM - 12:00PM Room: N227B



AMA PRA Category 1 Credits™: 1.50
ARRT Category A+ Credits: 1.50

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Sub-Events**SSG11-01 Magnetization Transfer and Relaxation-normalized Amide Proton Transfer (MRAPT) MRI Enables Automatic Segmentation of Graded Tissue Acidification**

Tuesday, Nov. 29 10:30AM - 10:40AM Room: N227B

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PURPOSE

pH-sensitive amide proton transfer (APT) MRI provides a surrogate metabolic biomarker that complements the widely-used perfusion and diffusion imaging. However, endogenous APT MRI relies on the asymmetry analysis (MTRasym), which is susceptible to an asymmetry shift due to concomitant semisolid magnetization transfer (MT) and nuclear overhauser (NOE) effects, resulting in intrinsic non-pH contrast between white and gray matters. Our study evaluated MT and relaxation-normalized APT (MRAPT) MRI in a rat model of acute ischemic stroke that enabled automatic segmentation of graded ischemic tissue injury.

METHOD AND MATERIALS

Normal and stroke rats (MCAO) were imaged at 4.7T. Multi-parametric MRI including diffusion, perfusion MRI, T1, T2 mapping and pH-weighted APT MRI was performed. Ischemic lesion was automatically defined using a K-means clustering-based algorithm.

RESULTS

We found that the heterogeneous MTRasym shift not related to pH highly correlates with mean MT ratio (MMTR) and longitudinal relaxation rate R1w, which can be largely corrected using the multiple regression analysis (Fig.1). We further evaluated MRAPT MRI in an animal model of acute stroke for lesion segmentation (Fig. 2). Given little MT and R1w change during acute stroke, the MRAPT analysis substantially increased its specificity to ischemia-induced acidosis than the routine MTRasym image, hence enabling automatic lesion segmentation of acidic lesion. We found significant differences in perfusion, pH and diffusion lesion volumes ($P < 0.001$, ANOVA). Furthermore, MRAPT MRI depicted heterogeneous ischemic acidosis, with the most severe acidosis in the diffusion lesion, moderate acidification within the pH/diffusion mismatch (metabolic penumbra) and little pH change in the perfusion/pH mismatch (benign oligemia), providing refined stratification of ischemic injury.

CONCLUSION

Multivariate regression analysis enables substantial reduction of intrinsic non-pH heterogeneity in pH-weighted APT MRI. The MRAPT approach enables automatic lesion segmentation, demonstrating graded tissue acidification in the acute stroke setting for refined tissue classification.

CLINICAL RELEVANCE/APPLICATION

Multivariate regression analysis substantially reduces intrinsic non-pH heterogeneity in pH-weighted APT MRI, enabling automatic segmentation of graded tissue acidification in acute stroke setting.

SSG11-02 The Importance of Differentiating Between Lacunes and Perivascular Spaces in Cerebral Small Vessel Disease

Tuesday, Nov. 29 10:40AM - 10:50AM Room: N227B

Philip Benjamin, MBBS, London, United Kingdom (*Presenter*) Nothing to Disclose**PURPOSE**

Cerebral small vessel disease (SVD) is a major cause of cognitive impairment in the elderly. Perivascular spaces (PvS) are an important disease feature but their relationship to cognitive impairment remains controversial. One reason for this may be due to the difficulty in distinguishing between lacunes and PvS. We determined the relationship between baseline PvS score and PvS volume with change in cognition over a 5 year follow-up period. We compared this to the relationship between baseline lacune count and total lacune volume with cognition.

METHOD AND MATERIALS

Data from the prospective SCANS (St Georges Cognition And Neuroimaging in Stroke) study of patients with symptomatic lacunar stroke and confluent leukoaraiosis were used (n=121). Multimodal MRI and neuropsychological testing was performed annually over 5 years. Lacunes were manually identified and carefully distinguished from PvS. PvS were rated using a validated visual rating scale and PvS volumes calculated using T1-weighted images. Linear mixed effect models were used to determine the impact of baseline PvS and lacunes on cognition while adjusting for brain volume, T2 White Matter Hyperintensities (WMH) volume and microbleeds.

RESULTS

Baseline PvS showed no association with cognitive indices. Lacunes however, had a significant effect on all cognitive indices in the same cohort and were the only MRI marker in SVD at baseline which had an independent effect on cognitive decline over a 5 year follow-up period ($p=0.007$).

CONCLUSION

Lacunes were the only conventional MRI marker at baseline which were associated with a decline in cognition over a 5 year follow-up period. This study underlines the importance of carefully differentiating between lacunes and PvS in studies investigating vascular cognitive impairment.

CLINICAL RELEVANCE/APPLICATION

Lacunes although often overlooked, are the only conventional MRI marker at baseline which are associated with a longitudinal decline in cognition. Neuropathological studies also suggest that patients with subcortical lacunes have a higher prevalence of clinical dementia than those without. It is therefore important to develop treatment strategies aimed at preventing lacunar infarcts through clinical trials. This study underlines the importance of carefully differentiating between lacunes and PvS in studies investigating vascular cognitive impairment. PvS, although a feature of SVD are not associated with cognitive decline.

SSG11-03 Patient Outcomes and Recurrent Artery of Heubner Infarction after Ruptured Anterior Communicating Artery Aneurysm Treatment

Tuesday, Nov. 29 10:50AM - 11:00AM Room: N227B

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PURPOSE

Anterior communicating artery aneurysm (AcomA) rupture and treatment is associated with cognitive and behavioral deficits after recovery, but the cause of these deficits remains uncertain. Surgical clipping of AcomA has been associated with more severe cognitive and behavioral deficits when compared to endovascular coil embolization. We characterized patterns of cerebral ischemic injury and patient outcomes following treatment of ruptured AcomA by clipping or coiling.

METHOD AND MATERIALS

We retrospectively reviewed 100 consecutively treated patients with ruptured AcomA (50 clipped and 50 coiled) presenting to our neurovascular center. Patient demographic, treatment, and outcome data were determined by electronic medical record review. Neuroimaging was reviewed for aneurysm characteristics and associated hemorrhagic, ischemic, and vasospasm related cerebral injury.

RESULTS

Coiled patients were older (mean age 56 years versus 51; $p=0.04$) and presented with a worse clinical status (60% with Hunt and Hess Score >2 versus 34% in clipping group; $p=0.009$). Frontal lobe cerebral infarction (30% versus 4%; $p=0.001$) and cerebral infarction in the territory of the recurrent artery of Heubner (RAH) (33% versus 2%; $p=0.0005$) were more common in clipped patients. There was no difference in the frequency of frontal lobe hemorrhagic infarction, punctate embolic infarction, or infarction secondary to vasospasm between clipped and coiled patients. In a multivariate analysis, poor outcome (mRS greater than 2) was associated with diabetes mellitus ($p=0.04$), presentation with Hunt and Hess greater than 2 ($p=0.02$), age over 55 years ($p=0.004$), and the development of cerebral arterial vasospasm ($p=0.0001$). No differences in mortality, discharge modified Rankin score (mRS), or 3-month follow-up mRS were detected between the two groups.

CONCLUSION

Frontal lobe and RAH infarction were more common after surgical clipping of ruptured AcomA, but this increased infarct burden did not result in poorer outcomes as assessed by mortality or mRS.

CLINICAL RELEVANCE/APPLICATION

Further studies are warranted to determine if post-surgical frontal lobe and RAH infarctions contribute to cognitive and behavioral deficits after ruptured AcomA treatment.

SSG11-04 Disrupted Functional Connectivity within the Default-mode Network in Brainstem Ischemic Stroke Patients with Cognitive Impairment

Tuesday, Nov. 29 11:00AM - 11:10AM Room: N227B

Cheng-Yu Peng, Nanjing, China (*Presenter*) Nothing to Disclose
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PURPOSE

The purpose of the current research is to explore the disrupted functional connectivity within the default-mode network (DMN) in brainstem ischemic stroke patients with cognitive impairment and whether the decreased connectivity is correlated with

neurocognitive performance and the serum total homocysteine (tHcy) level.

METHOD AND MATERIALS

Thirty-two brainstem ischemic stroke patients and 34 well-matched healthy controls were included and underwent resting-state functional MRI. Independent component analysis was adopted to extract the DMN, including its anterior and posterior components. Z-maps of both sub-networks were compared between the two groups and correlated with each clinical variable.

RESULTS

Post-stroke patients showed decreased connectivity around the middle frontal cortex in the anterior sub-network and the posterior cingulate cortex in the posterior sub-network. The decreased connectivity in the posterior part was significantly correlated with the score on Auditory Verbal Learning Test -delay recall test ($r = 0.532$, $P = 0.006$), the Complex Figure Test-delay recall test ($r = 0.494$, $P = 0.012$), and the tHcy level ($r = -0.555$, $P = 0.007$).

CONCLUSION

Decreased connectivity within the DMN was found in brainstem ischemic stroke patients, which might provide powerful new insights into the neural mechanisms that underlie the post-stroke cognitive decline.

CLINICAL RELEVANCE/APPLICATION

The connectivity of the posterior cingulate cortex within the DMN revealed by the fMRI can be an indicator to assess the post-stroke cognitive impairment.

SSG11-05 Where Are the Cerebral Regions Saved by Successful Recanalization of M1 Occlusion?

Tuesday, Nov. 29 11:10AM - 11:20AM Room: N227B

Seyedmehdi Payabvash, MD, San Francisco, CA (*Presenter*) Nothing to Disclose
Shayandokht Taleb, Minneapolis, MN (*Abstract Co-Author*) Nothing to Disclose
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PURPOSE

To determine the distribution of cerebral regions that can potentially be saved by successful recanalization of acute M1 occlusion in stroke patients.

METHOD AND MATERIALS

47 patients with acute unilateral M1 occlusion who underwent endovascular treatment were included. Final infarct volumes were segmented on follow-up MRI/CT scans obtained 2-7 days post symptom onset, and then coregistered on standard brain map. Voxel-based analysis was performed to determine the topology of infarct lesions associated with successful versus unsuccessful recanalization, and disability/death. Successful recanalization was defined by a modified Thrombolysis in Cerebral Infarction (mTICI) score of 2b/3. Favorable outcome was defined by a 3-month modified Rankin Scale score ≤ 2 ; and disability/death by a score > 2 .

RESULTS

Successful recanalization of M1 was achieved in 26/47 (55%) patients, which was associated with higher rate of favorable outcome (54% versus 9%, $p=0.002$) and smaller final infarct volume (34.3 ± 43.7 mL versus 98.1 ± 47.7 mL, $p < 0.001$). Voxel-based analysis showed that patients with successful recanalization had lower rate of infarction in precentral gyrus and posterior insular ribbon compared to those with unsuccessful recanalization. Similarly, higher grades of recanalization were associated with lower rates of ischemic infarct in aforementioned regions. Favorable outcome was achieved in 16 (34%) patients, who were younger (62.2 ± 13.9 years versus 70.9 ± 13.9 years, $p=0.048$), had higher rate of successful recanalization (88% versus 39%, $p=0.002$), and smaller infarct volume (25.2 ± 23.6 mL versus 82.2 ± 57.1 mL, $p < 0.001$) compared to those with disability/death. In voxel-based analysis, infarction of the insular ribbon, precentral gyrus, middle centrum semiovale and corona radiata were associated with disability/death.

CONCLUSION

Successful recanalization of acute M1 occlusion tends to save the precentral gyrus and posterior insular ribbon from infarction in stroke patients; however, preservation of more anterior cerebral regions like anterior insular ribbon, middle centrum semiovale and coronal radiata can potentially further improve the outcome of endovascular treatment.

CLINICAL RELEVANCE/APPLICATION

Knowing the topographic distribution of salvageable cerebral regions with successful endovascular treatment can potentially guide patient selection based on the **location** of tissue at risk in acute phase stroke imaging.

SSG11-06 Stroke Assessment with Monoexponential, Biexponential, Stretched Exponential Diffusion Weighted MR Imaging and Diffusion Kurtosis MR Imaging

Tuesday, Nov. 29 11:20AM - 11:30AM Room: N227B

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PURPOSE

To investigate the concomitant change of multi model diffusion and kurtosis metrics in stroke patients and screen for difference among patients with different subtypes of potential etiology in all studied parameters.

METHOD AND MATERIALS

84 patients with acute stroke underwent multi b diffusion and kurtosis scan. ROI analysis was performed in metrics of monoexponential, biexponential, stretched exponential model and kurtosis imaging between ischemic tissue and contralateral hemisphere. Correlation between monoexponential apparent diffusion coefficient (mADC) and the other parameters was evaluated.

Multiple comparisons of all parameters among patients with different potential etiologies were performed.

RESULTS

All 14 parameters exhibit significant difference between stroke and contralateral ROIs except pseudo-diffusion coefficient (Dfast) (P=0.342). Correlations between mADC and mean diffusion (MD), diffusion coefficient (Dslow), distributed diffusion coefficient (DDC) are fairly good in ischemic area (0.807, 0.698, 0.756, all P<0.05). Kurtosis metrics (mean kurtosis MK, axial kurtosis Ka, radial kurtosis Kr) are negatively correlated with mADC (rs =-0.505, -0.749, -0.430; all P<0.05). There is no significant correlation between mADC and perfusion metrics (Dfast, perfusion factor f and f·Dfast), neither between mADC and stretching parameter (α) (P=0.666, 0.232, 0.066, 0.871). Significant differences are observed between groups of cardioembolism and undetermined etiology in fractional anisotropy (FA), MK, Kr and α obtained from stroke tissue, while the differences also exist in contralateral MK and Kr (All P<0.05, SNK corrected). No significant difference is detected between groups of large artery atherosclerosis and cardioembolism or between groups of cardioembolism and undetermined etiology either in stroke or contralateral hemisphere (all P>0.05).

CONCLUSION

Diffusion and kurtosis change in stroke indicates disturbance of water microenvironment in different scales, together with diffusion derived perfusion information, yield a more comprehensive stroke assessment. In particular, inhomogeneity manifested by FA and α could potentially assist in clarifying stroke etiology despite its complexity, while kurtosis seems to be more relevant to stroke distribution.

CLINICAL RELEVANCE/APPLICATION

Multi model diffusion and kurtosis imaging provide biophysical and hemodynamic information in ischemic brain and thus a more comprehensive stroke assessment.

SSG11-07 Additional Value of Brain CT Perfusion in The Detection of Intracranial Vessel Occlusion in Acute Ischemic Stroke: A (Multi Experience Level) Inter-Observer Study

Tuesday, Nov. 29 11:30AM - 11:40AM Room: N227B

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Rashindra Manniesing, PhD, Nijmegen, Netherlands (*Abstract Co-Author*) Research funded, Toshiba Corporation
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Stefan Steens, MD, PhD, Leiden, Netherlands (*Abstract Co-Author*) Nothing to Disclose
Ewoud J. Smit, MD, Nijmegen, Netherlands (*Abstract Co-Author*) Speakers Bureau, Toshiba Corporation; Research Grant, Toshiba Corporation
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Mathias Prokop, PhD, Nijmegen, Netherlands (*Abstract Co-Author*) Speakers Bureau, Bayer AG Speakers Bureau, Bracco Group
Speakers Bureau, Toshiba Corporation Speakers Bureau, Koninklijke Philips NV Research Grant, Toshiba Corporation
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PURPOSE

We aimed to evaluate the additional value of brain CT perfusion (CTP) for intracranial vessel occlusion detection in acute ischemic stroke for observers with different levels of experience.

METHOD AND MATERIALS

We retrospectively included all patients with symptoms of acute ischemic stroke (onset of less than 9 hours) who were scanned with non-enhanced CT (NECT), CT angiography (CTA) and CTP in the year 2015. Four observers with different levels of experience (neuroradiologist, non-neuroradiologist, two radiology residents) evaluated the imaging data with 2 imaging strategies. Method 1 included NECT and CTA. For method 2, additional CTP maps were provided for the evaluation of intracranial vessel occlusion on CTA. The observers were blinded to patient identity and clinical outcome. Receiver operating characteristic (ROC) was used for the evaluation of accuracy in intracranial vessel occlusion detection. The reference standard of vessel occlusion was set based on the evaluation by the four observers, and the judgment of an independent neuroradiologist serving as a referee in case of discrepancy.

RESULTS

In total 110 patients were included, preliminary analyses included 94 patients. There was an increase of AUC in the overall detection of intracranial vessel occlusion for observer 1, 3 and 4, though only for observer 1 the increase in AUC was statistically significant (p=0.041). Increase of intracranial vessel occlusion detection mainly concerned distal vessel occlusions. No significant added value of CTP was found for proximal vessel occlusions, with already a high accuracy based on NECT and CTA for all experience levels with sensitivity ranging between 86-94% and specificity between 92-100%.

CONCLUSION

Our study demonstrates that the use of CTP can aid in the detection of distal intracranial vessel occlusions on CTA in case CTP is integrated in the reading strategy. It is also demonstrated that CTP was not of added value for the detection of proximal intracranial vessel occlusions. Finally, there was no major difference in the diagnostic accuracy of intracranial vessel occlusion detection for the different levels in experience of the observers.

CLINICAL RELEVANCE/APPLICATION

Our study demonstrated that brain CT perfusion can aid in the detection of distal intracranial vessel occlusions, which is clinically relevant for optimizing the imaging strategy in acute ischemic stroke.

SSG11-08 Detection of Elevated Whole-Brain Oxygen Extraction Fraction (OEF) in Patients with Intracranial Stenosis Using Non-Invasive MRI

Tuesday, Nov. 29 11:40AM - 11:50AM Room: N227B

Awards

Trainee Research Prize - Medical Student

Jennifer M. Watchmaker, Nashville, TN (*Presenter*) Nothing to Disclose
Meher R. Juttukonda, PhD, Chapel Hill, NC (*Abstract Co-Author*) Nothing to Disclose
Lori Jordan, MD, Baltimore, MD (*Abstract Co-Author*) Nothing to Disclose
Larry T. Davis, MD, Nashville, TN (*Abstract Co-Author*) Nothing to Disclose
Melissa C. Gindville, Nashville, TN (*Abstract Co-Author*) Nothing to Disclose
Allison Scott, Nashville, TN (*Abstract Co-Author*) Nothing to Disclose
Manus Donahue, PhD, Nashville, TN (*Abstract Co-Author*) Nothing to Disclose

PURPOSE

The purpose of this work is to incorporate novel and noninvasive whole-brain MRI measures of cerebral oxygen extraction fraction (OEF; ratio of oxygen consumed to oxygen delivered) to test fundamental hypotheses regarding elevated OEF and its concordance with clinical radiological measures of impairment in patients with intracranial (IC) arterial stenosis at high risk of recurrent stroke. Elevated OEF is hypothesized to be driven by reduced oxygen carrying capacity, as in the case of hemoglobinopathies such as sickle cell anemia (SCA), or by reduced cerebral blood flow (CBF) as in the case of IC steno-occlusive disease. Unfortunately, tools capable of recording OEF routinely in clinical settings are limited. Here, we apply a novel whole-brain OEF MRI method in sequence with CBF and structural imaging.

METHOD AND MATERIALS

CBF and whole-brain OEF MRI were performed using pseudo-continuous arterial-spin labeling (pCASL) and T2-Relaxation-Under-Spin-Tagging (TRUST), respectively, in participants with IC stenosis (n=21), SCA (n=20), and age-matched (n=45) control participants. TRUST provided a venous blood water T2, which was converted to blood oxygenation level and OEF by utilizing the measured hematocrit and arterial oxygenation.

RESULTS

OEF was elevated in participants with IC stenosis (IQR = 0.38 - 0.45) and SCA (IQR = 0.37 - 0.45) compared to controls (IQR = 0.29 - 0.38). CBF was inversely correlated with OEF in IC stenosis participants (Spearman test; $r = -0.42, p = 0.03$), but not in control participants ($r = -0.07, p = 0.33$) or participants with SCA ($r = -0.28, p = 0.12$).

CONCLUSION

These results (i) are consistent with non-invasive MRI being able to quickly detect elevated OEF in multiple cases of reduced oxygen delivery to tissue, (ii) provide insights regarding differing pathological hemodynamic compensation mechanisms, and (iii) suggest that extreme hypoperfusion corresponds to elevated OEF in IC stenosis, which may be indicative of widespread, advanced disease and elevated stroke risk.

CLINICAL RELEVANCE/APPLICATION

Patients with symptomatic intracranial atherosclerotic stenosis have an unacceptably high 14-16% 1-year risk of recurrent stroke even on standard-of-care aggressive medical management; elevated cerebral oxygen extraction fraction (OEF), which can be quantified in approximately 1-minute with noninvasive MRI, may provide a new biomarker of stroke risk, which could guide personalized stroke prevention therapies.

SSG11-09 Collateral Assessment With Multi-Phase CTA In Thrombectomy Candidates in the Borderline ASPECTS Subgroup

Tuesday, Nov. 29 11:50AM - 12:00PM Room: N227B

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John Thornton, Dublin, Ireland (*Abstract Co-Author*) Nothing to Disclose
Seamus Looby, FRCR, MBBCh, Dublin, Ireland (*Abstract Co-Author*) Nothing to Disclose
Paul Brennan, Dublin, Ireland (*Abstract Co-Author*) Nothing to Disclose
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PURPOSE

Collateral blood supply an important factor in determining the extent of ischaemia in stroke (1). Good collaterals are an important predictor of good outcome from endovascular treatment of stroke (3). In cases of large vessel occlusion of the anterior circulation and early ischaemic changes or no established ischaemia, patients may be eligible for thrombectomy. CT is used to quantify established infarction according to the Alberta stroke score (4). Multiphase CT angiography is used for collateral assessment in our center (5). This study aims to assess if three-phase CTA assessment of collaterals is predictive of outcome in patients who had borderline ASPECTS scores and who subsequently went on to have mechanical thrombectomy.

METHOD AND MATERIALS

A retrospective analysis of 184 thrombectomy patients over a two year period with a proximal vessel occlusion in the anterior circulation was carried out. Patients with an ASPECTS score of 5/6/7, indicating early ischaemic change were selected. ASPECTS scores were assigned in the original report and subsequently by a neuroradiology interventionalist, blinded to the original report. Assessment of collaterals with three-phase CTA assigned a value of >50% or <50%. Success of mechanical thrombectomy and favourable outcome (as measured by a reduction in 90 day NIHSS or MRS).

RESULTS

184 patients had mechanical thrombectomy over a 12 month period. 26 patients were identified with ASPECTS score of 5/6/7, 19 with good collaterals, 7 with poor collaterals. In the good collaterals group there was an 84% recanalization rate, 85% in the poor collateral group. There was favourable 90 day outcome in 63% of the good collaterals group and 14% of the poor collateral group. Mortality in the good collateral group at 90 days was 31% and 57% in the poor collaterals group.

CONCLUSION

Linear regression analysis identified a statistically significant association between good collaterals and a reduction in disability at 90 days in the borderline ASPECTS subgroup with a P value = 0.012.

CLINICAL RELEVANCE/APPLICATION

Collateral assessment with three phase CT angiogram is an good predictor of outcome in thrombectomy candidates with large vessel occlusion who have evidence of early established ischemia and should be used as the standard imaging protocol in this group.