Dynamic Susceptibility Weighted Contrast-Enhanced Perfusion Imaging

- The Significance of Relative Cerebral Blood Volume Index in Discriminating Glial Tumors from Brain Metastasis Using Perfusion Magnetic Resonance Imaging
- Combination of culprit plaque enhancement ratio and hypoperfusion contributes to short-term outcomes of patients with atherosclerotic stenosis in the middle cerebral artery
- Stroke Mechanism Subtypes and Prognosis in Patients With Symptomatic Intracranial Atherosclerosis Based on Multiparametric MRI
- Congress of neurological surgeons systematic review and evidence-based guidelines for the role of imaging in newly diagnosed WHO grade II diffuse glioma in adults: update
- Building a pre-surgical multiparametric-MRI-based morphologic, qualitative, semiquantitative, first and high-order radiomic predictive treatment response model for undifferentiated pleomorphic sarcoma to replace RECIST
- Differentiation between glioblastoma and solitary brain metastases using perfusion and amide proton transfer weighted MRI
- Routine and Advanced Neurologic Imaging at 0.55-T MRI: Opportunities and Challenges
- Diagnostic value and efficacy of multimodal magnetic resonance imaging in differentiating radiation necrosis from tumor recurrence in glioblastomas

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Dynamic Susceptibility refers to a phenomenon in magnetic resonance imaging (MRI) that involves changes in the magnetic susceptibility of tissues or contrast agents over time. This phenomenon is particularly relevant in the context of Dynamic Susceptibility Contrast-Enhanced Perfusion Imaging (DSC-MRI), which is a specialized MRI technique used to assess blood flow and perfusion in tissues, especially in the brain.

Dynamic Susceptibility Contrast-Enhanced Perfusion Imaging (DSC-MRI): Contrast Agent and Magnetic Susceptibility:

DSC-MRI involves the injection of a contrast agent, usually a gadolinium-based compound, into the bloodstream. The contrast agent alters the magnetic susceptibility of the blood, leading to changes in the local magnetic field within the imaging region. Signal Intensity Changes:

The altered magnetic susceptibility causes changes in the signal intensity of the MRI images. These changes are particularly pronounced in T2*-weighted or susceptibility-weighted imaging sequences. Dynamic Imaging:

Rapid and sequential MRI images are acquired to capture the passage of the contrast agent through the tissue of interest, such as brain tissue in the case of neuroimaging. Perfusion Analysis:

The dynamic data are then analyzed to derive perfusion parameters, including time to peak (TTP), mean transit time (MTT), and cerebral blood flow (CBF). Significance in Perfusion Imaging: Perfusion Parameters:

The dynamic susceptibility changes are directly related to the perfusion of blood in tissues. By analyzing the dynamic changes in signal intensity, clinicians can derive quantitative measures of blood flow and perfusion. Clinical Applications:

DSC-MRI is widely used in various clinical applications, including the assessment of stroke, brain tumors, vascular malformations, and neurodegenerative diseases. The technique provides valuable information about tissue vascularity and helps in the characterization of pathological conditions. Challenges and Considerations:

Proper acquisition and analysis techniques are crucial to obtaining reliable perfusion parameters. Factors like contrast agent concentration, bolus timing, and imaging parameters must be carefully controlled. In summary, dynamic susceptibility plays a central role in DSC-MRI, a technique used to study perfusion in tissues. By leveraging the changes in magnetic susceptibility induced by a contrast agent, this imaging method provides insights into blood flow dynamics, aiding in the diagnosis and management of various medical conditions.

Dynamic Susceptibility Weighted Contrast-Enhanced Perfusion Imaging (DSC-MRI) is a medical imaging technique used to assess cerebral blood flow and perfusion in the brain. It provides valuable information about the microcirculation and vascular properties of brain tissue. Here's an overview of how DSC-MRI works:

Principle of DSC-MRI: Contrast Agent Injection:

A contrast agent, often a gadolinium-based compound, is injected intravenously into the patient's bloodstream. Magnetic Susceptibility Effects:

The contrast agent alters the magnetic susceptibility of the blood, leading to changes in the local magnetic field. Signal Intensity Changes:

As the contrast agent passes through the brain vasculature, it causes changes in the signal intensity of the MRI images. Data Acquisition:

Rapid and sequential MRI images are acquired to capture the passage of the contrast agent through the brain. This is typically done with T2*-weighted or susceptibility-weighted imaging sequences. Perfusion Parameters:

DSC-MRI provides information about various perfusion parameters, including: Time to Peak (TTP): Time taken for the contrast agent to reach its maximum concentration in a particular region. Mean Transit Time (MTT): Average time taken by the contrast agent to pass through a given region. Cerebral Blood Flow (CBF): Blood flow to the brain tissue, often expressed in milliliters per 100 grams of tissue per minute. Data Analysis: Region of Interest (ROI):

Analysis is often performed by selecting specific regions of interest within the brain. Time-Intensity Curve:

The signal intensity changes over time are plotted to create a time-intensity curve for each region. Perfusion Maps:

Perfusion maps are generated based on the analysis, providing a visual representation of perfusion parameters across different brain regions. Clinical Applications: Stroke Assessment:

DSC-MRI is used to assess blood flow and detect abnormalities in stroke patients. It helps identify areas of decreased perfusion and ischemia. Tumor Characterization:

DSC-MRI is valuable in oncology for characterizing brain tumors. Tumors often exhibit increased blood volume, and DSC-MRI can help differentiate between tumor types and assess the effectiveness of treatments. Vascular Malformations:

It is useful in the evaluation of vascular malformations, such as arteriovenous malformations (AVMs) and aneurysms. Neurodegenerative Diseases:

DSC-MRI can provide insights into perfusion changes associated with neurodegenerative diseases, aiding in diagnosis and research. In summary, DSC-MRI is a powerful imaging technique that plays a crucial role in evaluating cerebral perfusion and is widely used in neuroimaging for various clinical applications.

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see also Relative cerebral blood volume from Dynamic susceptibility weighted contrast enhanced perfusion imaging.

Dynamic-susceptibility contrast (DSC) MRI, also known as bolus-tracking MRI, is a perfusion MRI method to measure perfusion and other related hemodynamic parameters.

It is shown that DSC-MRI is a very powerful technique that provides important information regarding cerebral hemodynamics.

Dynamic susceptibility weighted contrast enhanced perfusion imaging (DSC MRP) has been used to assess changes in cerebral perfusion attributable to vascular stenosis or occlusion that may predict stroke risk.

It is one of the most frequently used techniques for MRI perfusion, and relies on the susceptibility induced signal loss on T2* weighted sequences which results from a bolus of gadolinium-based contrast passing through a capillary bed. The most commonly calculated parameters are rCBV, rCBF and MTT.

The relatively high contrast-to-noise ratio, fast acquisition, and wealth of information available have made DSC-MRI the most commonly used MRI technique for the rapid assessment of the brain hemodynamics in clinical investigations. While very important advances have been achieved in the last 2 decades, there are still some remaining limitations that users should be aware of to avoid misinterpretation of the findings and to make the most of the invaluable information provided by perfusion MRI [1)].

Hilario et al retrospectively analyzed DSC perfusion MRI in 24 Glioblastoma recurrences treated with bevacizumab as second line chemotherapy. Leakage at baseline and changes in maximum leakage between baseline and the first follow-up after treatment were selected for quantitative analysis. Survival univariate analysis was made constructing survival curves using Kaplan-Meier method and comparing subgroups by log rank probability test.

Leakage reduction at 8 weeks after initiation of bevacizumab treatment had a significant influence on

overall survival (OS) and progression-free survival (PFS). Median OS and PFS were 2.4 and 2.8 months longer for patients with leakage reduction at the first follow-up. Higher leakage at baseline was associated with leakage reduction after treatment. Odds ratio of treatment response was 9 for patients with maximum leakage at baseline >5.

Leakage decrease may predict OS and PFS in Glioblastoma recurrences treated with bevacizumab. Leakage reduction postulates as a potential biomarker for treatment response evaluation. Leakage at baseline seems to predict response to treatment, but was not independently associated with survival [2)].

CNS toxoplasmosis and lymphoma are often indistinguishable by conventional contrast-enhanced MRI. There is limited literature on the diagnostic efficacy of dynamic susceptibility weighted contrast enhanced perfusion imaging for differentiating these entities. A study assesses the clinical utility of relative cerebral blood volume (rCBV) for making a diagnosis and determines rCBV thresholds for differentiation using contemporary DSC-MRI.

Thirteen patients with 25 lesions (13 toxoplasmosis and 12 lymphoma) and pre-treatment DSC-MRI were identified retrospectively. Volumetric regions of interest of segmented enhancement were used to extract mean rCBV normalized to normal-appearing white matter for each lesion.

They compared average mean rCBV between all toxoplasmosis and lymphoma lesions using a general mixed model. Three models were also compared for evaluating rCBV-based disease status in each patient: 1) mean rCBV of each lesion using a generalized estimating equation, 2) volume-weighted mean rCBV, and 3) maximum mean rCBV of all lesions using logistic regression.

The average mean rCBV for all toxoplasmosis lesions was 0.98 (95% CI 0.55-1.41) compared to 2.07 (95% CI 1.71-2.43) for all lymphoma lesions, a significant difference (1.09, 95% CI 0.53-1.65, p=0.0013). For the three models used to evaluate rCBV-based disease status in each patient, a significant relationship was observed, with an optimal rCBV threshold of approximately 1.5 for distinguishing lymphoma from toxoplasmosis in each model.

RCBV derived from contemporary DSC-MRI is helpful for distinguishing between cerebral toxoplasmosis and cerebral lymphoma on an individual patient basis and may facilitate more timely initiation of appropriate directed therapy [3)].

DTI, DCE-MRI are feasible tools for the assessment of peripheral nerve lesion [4)]

The method enables the analysis of blood vessels generated by a tumor.

Dynamic contrast enhanced magnetic resonance imaging and Dynamic susceptibility weighted contrast enhanced perfusion imaging represent a widely accepted method to assess glioblastoma microvasculature.

This method makes use of a contrast agent which is blocked by the regular brain-blood-barrier but is not blocked in the blood vessels generated by the tumor. In this method the images taken are MRI T1-

weighted after an intravenous injection of the contrast agent. The concentration of the contrast agent is measured, when it passes from the blood vessels to the extra-cellular space of the tissue (it cannot enter inside the cells) and whether it goes back to the blood vessels.

The contrast agents used are often gadolinium-based. Gadolinium injection causes the relaxation time to decrease, and therefore images done after gadolinium injection have higher contrast. First a regular T1-weighted MRI scan is done (with no gadolinium), then gadolinium is injected (usually dose of 0.05-0.1 mmol/kg) and another T1-weighted scan is done. By comparing the values of T1 in both scans, for each voxel, it is possible to identify permeable blood vessel and a tissue with active tumor. When there are many healthy cells in the tissue, the gadolinium gets back to the blood since it cannot enter the cells. If tissue is damaged and there are fewer cells, the gadolinium stays in the extracellular space of the tissue and gets out to the blood vessels very slowly.

To ascertain if the volume transfer constant (Ktrans) derived from T1 dynamic contrast-enhanced magnetic resonance imaging (DCE-MRI) correlates with the immunohistological markers of angiogenesis in high-grade gliomas.

Fifty-one image-guided biopsy specimens in 34 patients with newly presenting high-grade gliomas (grade III = 16; grade IV = 18) underwent preoperative imaging (conventional imaging and T1 DCE-MRI). We correlated vascular endothelial growth factor (VEGF) expression and the microvessel density (MVD) of MRI-guided biopsy specimens with the corresponding DCE-derived Ktrans . Histological sections were stained with VEGF and CD34, and examined under light microscopy. These histological and molecular markers of angiogenesis were correlated with the Ktrans of the region of interest corresponding to the biopsy specimen.

The Ktrans showed a significant positive correlation with VEGF expression ($\rho = 0.582$, $P = 0.001$) but not with MVD stained with CD34 antibody ($\rho = 0.328$, $P = 0.072$).

The Ktrans derived from DCE-MRI can reflect the VEGF expression of high-grade gliomas but not the MVD [5].

Spratt et al. report the first analysis on the utility of DCE-MRI for metastatic sarcoma spine metastases treated with SBRT. They demonstrate that early assessment at two months post-SBRT using size and subjective neuroradiology impressions is insufficient to judge ultimate disease progression, and that a combination of perfusion parameters provides excellent correlation to local control [6].

Dynamic Susceptibility Weighted Contrast-Enhanced Perfusion Imaging Indications

Dynamic Susceptibility Weighted Contrast-Enhanced (DSC) Perfusion Imaging is a magnetic resonance imaging (MRI) technique used to assess cerebral blood flow. It involves injecting a contrast agent into the bloodstream and tracking its passage through the brain to provide information about perfusion. Here are some common indications for DSC perfusion imaging:

Brain Tumor Evaluation:

Tumor Grading: DSC perfusion imaging helps in assessing the grade of brain tumors by providing information about vascularity and blood flow within the lesion. Tumor Angiogenesis: It can aid in evaluating angiogenesis, which is the formation of new blood vessels associated with tumor growth. Ischemic Stroke Assessment:

Assessment of Perfusion Deficits: DSC can identify regions with compromised blood flow, aiding in the evaluation of ischemic strokes. Identification of Penumbra: It can help identify the ischemic penumbra, the region of brain tissue with reduced blood flow but potentially salvageable. Vascular Malformations:

Cavernous Malformations: It can assist in assessing the perfusion patterns in cavernous malformations. Vasculitis:

Assessment of Vasculitis: DSC perfusion imaging can provide information about changes in cerebral blood flow associated with vasculitis. Pre-Surgical Planning:

Tumor Localization: Before brain tumor surgery, DSC can help identify the regions with increased blood flow, aiding in surgical planning. Mapping Functional Areas: It can be used in conjunction with other functional MRI techniques to map eloquent areas of the brain before surgery. Monitoring Treatment Response:

Evaluation of Treatment Effects: DSC can help assess the effects of treatments such as radiation therapy or anti-angiogenic therapies on tumor vascularity. Neurodegenerative Diseases:

Assessment in Dementia: DSC can be used to evaluate cerebral blood flow changes in neurodegenerative diseases, providing insights into disease progression. Epilepsy Evaluation:

Identification of Hypoperfused Areas: DSC can help identify areas of hypoperfusion associated with the epileptogenic focus. Traumatic Brain Injury (TBI):

Evaluation of Blood Flow Changes: DSC can assist in assessing blood flow changes in traumatic brain injury cases. Evaluation of Collateral Blood Flow:

Assessment of Collateral Circulation: It can be used to evaluate collateral blood flow in cases of arterial stenosis or occlusion. DSC perfusion imaging is a valuable tool in neuroimaging, providing crucial information for diagnosing and managing various neurological conditions. The specific indication may vary based on the clinical context and the information sought by the healthcare provider.

Dynamic Susceptibility Weighted Contrast-Enhanced Perfusion Imaging for Arteriovenous Malformation

Arteriovenous Malformations (AVMs): DSC imaging is useful in evaluating blood flow characteristics in AVMs.

Case series

performed conventional and dynamic susceptibility-contrast MRI imaging in 38 patients with brain tumours: 20 with metastases (breast carcinoma: two; renal carcinoma: five; colorectal carcinoma: one; lung carcinoma: seven; melanoma: five), and 18 with high-grade astrocytomas. We obtained cerebral blood volume (CBV) maps and calculated the relative CBV (rCBV) in different areas using the ratio between the CBV in the pathological area (CBVp) and in the contralateral white matter (CBVn). We calculated the maximum rCBV (rCBVmax) for each tumour and compared the mean rCBVmax in each group of tumours. The mean rCBV of melanoma metastases (5.35+/-2.32, range 3.14-9.23) and of renal carcinoma metastases (8.17+/-2.39, range 5.41-11.64) were significantly greater than those of high-grade astrocytomas (2.61+/-1.17, range 1.3-5.0) (P=0.002 and <0.001, respectively) and of lung carcinoma metastases (2.94+/-0.86, range 1.43-4.04) (P=0.003 and 0.002). There was no statistically significant difference between the mean rCBV of lung metastases and of high-grade astrocytomas (P=0.59). Large, solitary, necrotic metastases can be indistinguishable from high-grade astrocytomas using conventional MRI. Demonstration of an elevated rCBV which may suggest a hypervascular lesion such as renal carcinoma or melanoma [7].

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