Breath-Hold Task Using Arterial Spin Labeling

- Simultaneous measurement of cerebral blood flow and cerebrospinal fluid flow using pseudo-continuous arterial spin labeling
- Cerebrovascular Reactivity Mapping in Brain Tumors Based on a Breath-Hold Task Using Arterial Spin Labeling
- Enhanced parameter estimation in multiparametric arterial spin labeling using artificial neural networks
- Separating spin compartments in arterial spin labeling using delays alternating with nutation for tailored excitation (DANTE) pulse: A validation study using T(2) -relaxometry and application to arterial cerebral blood volume imaging
- Breath-Hold Induced Cerebrovascular Reactivity Measurements Using Optimized Pseudocontinuous Arterial Spin Labeling
- ICA-based denoising strategies in breath-hold induced cerebrovascular reactivity mapping with multi echo BOLD fMRI
- The effect of risperidone on reward-related brain activity is robust to drug-induced vascular changes
- Impaired cerebrovascular reactivity in obstructive sleep apnea: a case-control study

The **Breath-Hold Task Using Arterial Spin Labeling (ASL)** combines a simple physiological task, such as breath-holding, with a perfusion imaging modality based on ASL technology. This approach is used to evaluate changes in cerebral hemodynamics, including cerebral blood flow (CBF), cerebrovascular response, and vascular reserve.

Key Concepts

Breath-Hold Task:

1. A task where participants are instructed to hold their breath for a short period (typically 10–20 seconds) after a deep inhalation.
2. This induces a transient increase in carbon dioxide (CO_2) levels in the blood, causing cerebrovascular vasodilation and a corresponding increase in CBF.
3. The task serves as a functional stimulus to assess vascular reactivity and cerebrovascular reserve.

Application in Imaging:

1. ASL is performed before, during, and after the breath-hold task to measure the perfusion changes induced by the task.
2. Changes in CBF can provide insights into cerebrovascular health and the brain's ability to respond to physiological challenges.
3. Commonly used for studying conditions like stroke, traumatic brain injury, or neurodegenerative diseases where vascular dysfunction is suspected.

Advantages of ASL with Breath-Hold:

1. Non-invasive and does not require intravenous contrast agents, making it safe for repeated use.
2. Quantitative, allowing for precise measurements of changes in CBF.
3. Suitable for populations sensitive to contrast agents, such as children or patients with renal impairment.

Clinical and Research Relevance

- This method is increasingly used in studies of cerebrovascular reactivity (CVR) to detect early signs of vascular impairment or to evaluate therapeutic interventions. - It offers a cost-effective and accessible means to assess brain hemodynamics in both clinical and research settings.

Prospective observational diagnostic studies

Hemodynamic measurements such as cerebral blood flow (CBF) and cerebrovascular reactivity (CVR) can provide useful information for diagnosing and characterizing brain tumors. Previous work showed that arterial spin labeling (ASL) in combination with vasoactive stimulation enabled simultaneous non-invasive evaluation of both parameters, however, this approach had not been previously tested in tumors. This work aimed to investigate the application of this technique, using a pseudo-continuous ASL (PCASL) sequence combined with breath-holding at 3 T, to measure CBF and CVR in high-grade gliomas and metastatic lesions, and to explore differences across tumoral- - peritumoral regions and tumor types. To that end, 27 patients with brain tumors were studied. Baseline CBF and CVR were measured in the tumor, edema, and gray matter (GM) volumes of interest (VOIs). Peritumoral ipsilateral ring-shaped VOIs were also generated and mirrored to the contralateral hemisphere. Differences in baseline CBF and CVR were evaluated between contralateral and ipsilateral GM, contralateral and ipsilateral peritumoral rings, and among VOIs and tumor types. CBF in the tumor was higher in grade 4 gliomas than metastases. In grade 4 gliomas, edema had lower CBF than the tumor and contralateral GM. CVR values differed between grade 3 and grade 4 gliomas and between grade 4 and metastases. CVR values in the tumor were lower compared to the contralateral GM. Differences in CVR between contralateral and ipsilateral-ring VOIs were also found in grade 4 gliomas, presumably suggesting tumor infiltration within the peritumoral tissue. A cut-off value for CVR of 27.9%-signal-change is suggested to differentiate between grade 3 and grade 4 gliomas (specificity = 83.3%, sensitivity = 70.6%). In conclusion, CBF and CVR mapping with ASL offered insights into the perilesional environment that could help to detect infiltrative disease, particularly in grade 4 gliomas. CVR emerged as a potential biomarker to differentiate between WHO Grade 3 glioma and WHO Grade 4 glioma [1)]

This study presents an innovative approach to assessing hemodynamic parameters in brain tumors and highlights the potential of CVR as a diagnostic biomarker. While promising, limitations in sample size, patient variability, and lack of validation necessitate further research. With refinement and validation, PCASL-based CVR mapping could become a valuable tool for non-invasive tumor characterization, aiding in personalized treatment planning and prognosis.

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Calvo-Imirizaldu M, Solis-Barquero SM, Aramendía-Vidaurreta V, García de Eulate R, Domínguez P, Vidorreta M, Echeveste JI, Argueta A, Cacho-Asenjo E, Martinez-Simon A, Bejarano B, Fernández-Seara MA. Cerebrovascular Reactivity Mapping in Brain Tumors Based on a Breath-Hold Task Using Arterial Spin Labeling. NMR Biomed. 2025 Mar;38(3):e5317. doi: 10.1002/nbm.5317. PMID: 39844376.