Leptomeningeal collateral status

- The Efficiency of FLAIR Images for Hemodynamic Change After STA-MCA Bypass with Moyamoya Disease and Symptomatic Steno-Occlusive Disorder
- Role of Endothelin-1 and Nitric Oxide in Acute Ischemic Stroke Leptomeningeal Collateral Activation
- Cerebral arterial collateral status, but not venous outflow profiles, modifies the effect of intravenous tissue plasminogen activator in acute ischemic stroke
- Collaterals and outcomes after endovascular treatment in acute large vessel occlusion: Disparity by stroke etiologies
- Direct endovascular treatment may be more appropriate for patients with good collateral circulation: a retrospective case-control study
- Correlation between P2-PCA Volume Flow Rate and BOLD Cerebrovascular Reactivity in Patients with Symptomatic Carotid Artery Occlusion
- Determinants of Leptomeningeal Collateral Status in Acute Ischemic Stroke: A Systematic Review and Meta-Analysis of Observational Studies
- Pre-Stroke Frailty Negatively Affects Leptomeningeal Collateral Flow in Proximal Middle Cerebral Artery Occlusion

Leptomeningeal collateral status refers to the condition and efficacy of the collateral circulation in the leptomeningeal (pia-arachnoid) arteries. These collateral pathways are vital in maintaining blood flow to brain tissue during ischemic events, such as an acute stroke caused by arterial occlusion. The status of these collaterals can significantly impact clinical outcomes and treatment decisions.

Definition

1. These are small arterial networks that connect branches of the anterior, middle, and posterior cerebral arteries.
2. They provide alternative routes for blood flow to ischemic regions when primary vessels are obstructed.

Assessment

1. **Imaging Techniques:**
    1. **CT Angiography (CTA):** Widely used to evaluate collateral flow visually based on vessel opacification and contrast delay.
    2. **MR Angiography (MRA):** Provides detailed vascular imaging without radiation exposure.
    3. **Digital Subtraction Angiography (DSA):** The gold standard for detailed visualization of collateral status.
2. **Collateral Grading Systems:** Various scales are used to quantify collateral status, such as ASITN/SIR (American Society of Interventional and Therapeutic Neuroradiology/Society of Interventional Radiology) or modified scales.

Clinical Relevance

1. **Acute Ischemic Stroke:**
    1. Good leptomeningeal collateral status can limit infarct size, reduce the extent of penumbral tissue progressing to infarction, and improve outcomes post-reperfusion therapy (e.g., thrombectomy or thrombolysis).
    2. Poor collateral status is associated with larger infarcts, poorer prognosis, and less favorable responses to treatment.
2. **Predictive Value:**
    1. Collateral status helps predict the success of reperfusion therapies and potential hemorrhagic transformation after intervention.

Factors Influencing Collateral Status

1. **Age:** Older patients tend to have poorer collateral circulation.
2. **Chronic Conditions:** Hypertension, diabetes, and atherosclerosis can impair the development and maintenance of collateral networks.
3. **Acute Stroke Dynamics:** The speed of occlusion development influences collateral recruitment.

Clinical Implications for Management

1. Patients with robust collateral status are often better candidates for endovascular therapies and have extended therapeutic windows.
2. In cases of poor collateral status, aggressive treatment may be reconsidered due to higher risks of complications.

Leptomeningeal collateral status plays a critical role in acute ischemic stroke management and prognosis. Advanced imaging techniques and collateral grading systems are essential for evaluating these pathways, guiding therapeutic decisions, and improving patient outcomes.

Modifiable risk factors

Leptomeningeal collateral (LMC) status is crucial in determining the outcome of ischemic stroke, especially in patients with large vessel occlusions. Several modifiable risk factors are associated with LMC status, as they influence the development and robustness of these collateral networks. Here are the key modifiable factors:

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1. Hypertension - Chronic hypertension negatively affects LMC status by causing arterial stiffness, endothelial dysfunction, and reduced angiogenesis. - **Management**: Controlling blood pressure through antihypertensive medications, diet (low sodium), and exercise can preserve or enhance collateral circulation.

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2. Diabetes Mellitus - Diabetes impairs LMC formation and function due to microvascular damage, chronic inflammation, and oxidative stress. - **Management**: Tight glycemic control via medication, diet, and physical activity can mitigate damage to the microvasculature.

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3. Smoking - Smoking reduces LMC efficacy by promoting atherosclerosis, endothelial dysfunction, and inflammation. - **Management**: Smoking cessation programs, nicotine replacement therapy, and counseling can improve vascular health.

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4. Hyperlipidemia - High levels of cholesterol and lipoproteins contribute to plaque formation and arterial narrowing, impairing collateral flow. - **Management**: Use of statins, dietary changes (low saturated fats), and regular exercise can improve lipid profiles and vascular function.

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5. Sedentary Lifestyle - Physical inactivity reduces angiogenesis and collateral circulation development. - **Management**: Regular aerobic exercise promotes angiogenesis and enhances LMC status.

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6. Obesity - Obesity is linked to systemic inflammation and metabolic syndrome, which negatively affect vascular health and collateral circulation. - **Management**: Weight loss through a combination of diet, exercise, and behavioral interventions improves overall vascular health.

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7. Alcohol Consumption - Excessive alcohol intake is associated with poor vascular health and collateral formation. - **Management**: Moderation or cessation of alcohol consumption can reduce vascular risk.

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8. Diet - Diets high in salt, sugar, and unhealthy fats can exacerbate hypertension, diabetes, and hyperlipidemia. - **Management**: Adopting a Mediterranean or DASH diet rich in fruits, vegetables, whole grains, and healthy fats supports vascular health.

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9. Stress - Chronic stress and its physiological impacts (e.g., elevated cortisol) impair vascular function. - **Management**: Stress-reduction techniques such as mindfulness, meditation, and counseling improve overall cardiovascular health.

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10. Inflammation - Chronic low-grade inflammation contributes to endothelial dysfunction and vascular disease. - **Management**: Anti-inflammatory interventions, including dietary changes (anti-inflammatory foods), physical activity, and medical treatment for underlying conditions, can support collateral health.

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11. Treatment of Atherosclerosis - Atherosclerosis directly affects the arteries supplying collateral flow. - **Management**: Use of antiplatelet agents, statins, and other treatments for atherosclerosis can preserve LMC function.

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By addressing these modifiable risk factors, it is possible to improve or preserve leptomeningeal collateral status, which is particularly important for ischemic stroke outcomes and overall cerebrovascular health.

Systematic reviews and meta-analysis

Li et al. conducted a comprehensive systematic review and meta-analysis to identify determinants associated with collateral status in patients with anterior circulation infarction.

The PubMed, EMBASE, Web of Science, and Cochrane Central Register of Controlled Trials databases were searched for studies that reported the determinants of leptomeningeal collateral status in acute ischemic stroke between January 2000 and June 2023. A random-effects meta-analysis model was used to pool the determinants of leptomeningeal collateral status. Eighty-one studies with 17 366 patients met the inclusion criteria. We analyzed 31 potential risk factors, and the results indicated that worse leptomeningeal collateral status was significantly associated with older age (weighted mean difference, 1.22 [95% CI, 0.69 to 1.76]), male sex (odds ratio [OR], 1.12 [95% CI, 1.02 to 1.23]), hypertension (OR, 1.27 [95% CI, 1.15 to 1.40]), diabetes (OR, 1.21 [95% CI, 1.10 to 1.33]), atrial fibrillation (OR, 1.26 [95% CI, 1.09 to 1.46]), cardioembolic stroke (OR, 1.27 [95% CI, 1.04 to 1.55]), internal carotid artery occlusion (OR, 1.84 [95% CI, 1.50 to 2.25]), and higher admission blood glucose (weighted mean difference, 8.74 [95% CI, 2.52 to 18.51]).

Hypertension and diabetes could be modifiable risk factors associated with leptomeningeal collateral status. Older age and male sex could be nonmodified risk factors. Further high-quality therapeutic studies focusing on controlling risk factors are needed to support our findings [1)]

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Li K, Jiang H, Yu J, Liu Y, Zhang L, Ma B, Zhu S, Qi Y, Li S, Huang Y, Yang Y, Xia X, Wen L. Determinants of Leptomeningeal Collateral Status in Acute Ischemic Stroke: A Systematic Review and Meta-Analysis of Observational Studies. J Am Heart Assoc. 2024 Nov 27:e034170. doi: 10.1161/JAHA.124.034170. Epub ahead of print. PMID: 39604037.