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Differentiation Between High-Grade Glioma and Brain Metastasis Using Cerebral Perfusion-Related Parameters (Cerebral Blood Volume and Cerebral Blood Flow): A Systematic Review and Meta-Analysis of Perfusion-weighted MRI Techniques

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Abstract

Background: Distinguishing high-grade gliomas (HGGs) from brain metastases (BMs) using perfusion-weighted imaging (PWI) remains challenging. PWI offers quantitative measurements of cerebral blood flow (CBF) and cerebral blood volume (CBV), but optimal PWI parameters for differentiation are unclear.

Purpose: To compare CBF and CBV derived from PWIs in HGGs and BMs, and to identify the most effective PWI parameters and techniques for differentiation.

Study type: Systematic review and meta-analysis.

Population: Twenty-four studies compared CBF and CBV between HGGs (n = 704) and BMs (n = 488).

Field strength/sequence: Arterial spin labeling (ASL), dynamic susceptibility contrast (DSC), dynamic contrast-enhanced (DCE), and dynamic susceptibility contrast-enhanced (DSCE) sequences at 1.5 T and 3.0 T.

Assessment: Following the PRISMA guidelines, four major databases were searched from 2000 to 2024 for studies evaluating CBF or CBV using PWI in HGGs and BMs.

Statistical tests: Standardized mean difference (SMD) with 95% CIs was used. Risk of bias (ROB) and publication bias were assessed, and I^2 statistic was used to assess statistical heterogeneity. A P-value < 0.05 was considered significant.

Results: HGGs showed a significant modest increase in CBF (SMD = 0.37, 95% CI: 0.05-0.69) and CBV (SMD = 0.26, 95% CI: 0.01-0.51) compared with BMs. Subgroup analysis based on region, sequence, ROB, and field strength for CBF (HGGs: 375 and BMs: 222) and CBV (HGGs: 493 and BMs: 378) values were conducted. ASL showed a considerable moderate increase (50% overlapping CI) in CBF for HGGs compared with BMs. However, no significant difference was found between ASL and DSC (P = 0.08).

Data conclusion: ASL-derived CBF may be more useful than DSC-derived CBF in differentiating HGGs from BMs. This suggests that ASL may be used as an alternative to DSC when contrast medium is contraindicated or when intravenous injection is not feasible.

Technical efficacy: Stage 2.

Keywords: arterial spin labeling; brain metastasis; cerebral blood flow; cerebral blood volume; dynamic susceptibility contrast; high-grade glioma.