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Correlation between Regional Leptomeningeal Collateral Score by MR Angiography and Clinical Outcome in Patients with Acute Ischemic Stroke

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1. Introduction

The therapeutic decision-making in patients presenting with acute ischemic stroke (AIS) is greatly influenced by ascertainment of prognosis, which, in turn, depends on the vulnerability of the brain tissue to ischemia. This decision-making is based on information obtained from clinical and radiologic assessments. Status of collateral blood vessels is one such important radiological parameter. Following the onset of ischemic stroke, survival of the brain tissue distal to an arterial occlusion is dependent on the status of leptomeningeal collateral (LMC) pathways.

- These are small arteriolar connections between the terminal branches of larger cerebral vessels which open up following any proximal occlusion.
- It has been postulated that for any occlusion distal to the circle of Willis, tissue viability is dependent on blood flow via LMC pathways. [1, 2] A regional LMC score (rLMC score) has been devised based on the findings derived from multi-phase computed M R angiography.

The rLMC score is a semi-quantitative system of scoring the pial collaterals, which is based on the major anatomic regions of anterior circulation of the brain, which have been delineated in accordance with the Alberta stroke programme early CT score (ASPECTS) method of scoring head CT.[3,4,5] AIS interventions, either pharmacological or mechanical, have become a standard form of treatment in ischemic stroke patients within 6–8 h (extendable up to 24 h) of ictus. The need for several invasive interventions will depend on the perceived outcome, and the degree of collateral circulation is an important factor which determines this.

2. Objectives

1) The objective of this study is to correlate the rLMC score with the 3-month clinical outcome (modified Rankin Scale [mRS]) in patients with middle cerebral artery (MCA) and/or internal carotid artery (ICA) occlusion in AIS.
2) To evaluate the factors associated with baseline rLMC scores in AIS in the study population and the need to standardize rLMC scoring system to determine its association with the outcome of stroke.

3. Methods

The study population consisted of patients of age >18 years with AIS who are diagnosed to have MCA and/or ICA occlusion on multi-phase MR angiography within 24 hours of the episode and who came for clinical follow-up for 3 months.

Collateral status on TOF-MRA was graded by the regional leptomeningeal collateral (rLMC) score on MR angiography. We analyzed the relationship between rLMC score on TOF-MRA and patient characteristics, collateral flow grade, and good clinical outcome.

For CE-MRA, a single echo 3D RF-spoiled gradient echo sequence was used to image the neck and head with the following parameters: TR/TE 3.34/1.31 ms; FA: 25◦; FOV: 320 × 230 mm2; matrix: 576 × 478 mm2, 120 slices × 1 mm thick. Parallel imaging with an acceleration factor of 3 was applied. With these settings, a 3D volume with a voxel-size of 0.67 × 0.56 × 1 mm3 was obtained for a combined neck-brain coverage during a 26 s acquisition. Multislab TOF-MRA of the brain was performed with 5 axial slabs of 30 slices per slab, each 1 mm thick, with the following parameters: TR/TE: 25/3.86 ms; FA: 20◦; matrix: 512 × 332 mm2; FOV: 210 × 184 mm2; and parallel imaging with an acceleration factor of 2 resulting in the acquisition of a 3D voxel-sizes of 0.41 × 0.55 × 1 mm3 during a 6-min 10-s acquisition.

4. Analysis

RLMC score was trichotomized as poor (0–10), medium (11–16), and good (17–20), according to the study conducted by Menon et al.[4] The ASPECT[3] score was categorized as low (0–7) and high (7–10). The mRS score was categorized as good (mRS 0–2) and poor outcome (mRS 3–6). The BI was categorized as total dependence (0–20), severe dependence (21–60), moderate dependence (61–90), and slight dependence (91–100).[6] Inter-rater reliability in the assessment of rLMC scores was analyzed using Kappa statistics.

Spearman's correlation was used for exploring associations

between rLMC score, ASPECTS score, mRS, and BI. P < 0.05 was considered statistically significant. Univariate analysis was done to look for any association between confounding demographic parameters and stroke risk factors and rLMC scores.

5. Result

A total of 38 patients (aged 71.7 ± 10.3 years; men, 71%;) were included. Collateral grade on angiography was 0 to 1 in 10 (26%) patients, 2 in 6 (15%), 3 in 19 (50%), and 4 in 3 (7%), which was correlated to rLMC score on TOF-MRA (p < 0.001).

All patients with high rLMC score (15-20) demonstrated mRS 0-2 at 90 days, whereas 69% of those with medium rLMC score (8-14) and 31% of those with low rLMC score did. In multivariate analysis, both rLMC score on TOF-MRA (OR, 1.5 per 1 point; p = 0.009) and reperfusion (TICI 2b/3 reperfusion; OR, 49.9; p < 0.001) were independent predictors of mRS 0-2 at 90 days.

6. Discussion

Modern imaging modalities such as conventional cerebral angiography, CTA, and magnetic resonance imaging have given us considerable insight regarding the role of LMCs in preserving brain tissue until recanalization is achieved. Like other collaterals, these vessels are dormant under physiological conditions when there is unimpeded blood flow from all major cerebral arteries, but are recruited when any one major artery is either chronically or acutely occluded. LMCs of varying numbers have been noted in nearly 80% of the patients with acute MCA occlusion in CTA images obtained within few hours of stroke.

- In humans, LMCs have been found to show considerable variation in their distribution, size, number, and compensatory capacity in ischemic stroke.[10] Taking into account the inter-individual variability in the magnitude of collaterals, multiple collateral scoring systems have been devised
- These LMC scoring systems have been calculated based on CTA, and they have shown potential in predicting clinical outcomes. One major limitation of these scoring systems is that they do not consider into account the considerable regional variability in the presence of these intercommunicating arteries.
- Furthermore, there is nonuniformity in the CTA-based imaging protocols used in various studies.[4] Hence, with a robust scoring system and optimal imaging protocols, it is possible to achieve standardization in the assessment of LMCs. This will lead to better understanding of the physiology of LMCs in AIS related to their mechanism of action and temporal profile of the development and enhance our existing knowledge regarding th preferable modes of delivery of thrombolytic drugs.

7. Conclusion

1) rLMC score on TOF-MRA is a noninvasive and feasible parameter of collateral flow status and related to clinical outcome in patients with AIS.
2) TOF-MRA might be a useful non-invasive imaging method to select candidates for invasive therapy.

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