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STUDY ON THE IMPACT OF VARIATIONS IN THE CIRCLE OF WILLIS ON ISCHEMIC LESION PATTERNS IN 250 PATIENTS AT A TERTIARY HOSPITAL IN TAMIL NADU, SOUTHERN INDIA

Neurology

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ABSTRACT

Objective: To analyze the influence of anatomical variations in the Circle of Willis (CoW) on ischemic lesion patterns in 250 patients with acute ischemic stroke at a tertiary care hospital in Tamil Nadu, Southern India. **Methods:** A retrospective review of clinical and imaging data from 250 patients was conducted. Anatomical variations of the CoW were categorized using magnetic resonance angiography (MRA) and computed tomography angiography (CTA). The relationship between CoW variations and specific ischemic lesion patterns was assessed using statistical analysis. **Results:** Anatomical variations in the CoW were found in 58% of patients. The most common variations included hypoplasia or absence of the posterior communicating artery (PCoA) and fetal-type posterior cerebral artery (PCA). These variations were significantly associated with distinct ischemic lesion patterns, emphasizing the role of CoW configurations in influencing stroke outcomes. **Conclusion:** Variations in the CoW significantly affect the distribution and severity of ischemic lesions in stroke patients. Understanding these variations can enhance diagnostic accuracy and guide therapeutic interventions.

KEYWORDS

INTRODUCTION

The Circle of Willis (CoW) is a critical arterial anastomotic structure at the base of the brain, providing collateral circulation. Variations in the CoW can influence the hemodynamics and collateral potential during ischemic events, affecting the patterns and outcomes of ischemic strokes. This study aims to evaluate the impact of CoW variations on ischemic lesion patterns in patients treated for acute ischemic stroke at a tertiary hospital in Tamil Nadu, Southern India.

METHODS

Study Design

This retrospective cohort study included 250 patients diagnosed with acute ischemic stroke at a tertiary care hospital in Tamil Nadu from May 2021 to December 2023.

Data Collection

Data were collected from electronic medical records, including demographic information, stroke risk factors, clinical presentations, imaging findings (MRA and CTA), and treatment outcomes. Anatomical variations of the CoW were identified and categorized based on established criteria.

Classification of Circle of Willis Variations

CoW variations were classified into:

- Hypoplasia or absence of the anterior communicating artery (ACoA)
- Hypoplasia or absence of the posterior communicating artery (PCoA)
- Hypoplasia of the anterior cerebral artery (ACA)
- Fetal-type posterior cerebral artery (PCA)
- Other less common variations

Ischemic Lesion Patterns

Ischemic lesions were categorized as:

- Anterior circulation strokes (ACS): Involving the internal carotid artery (ICA), ACA, and middle cerebral artery (MCA) territories
- Posterior circulation strokes (PCS): Involving the vertebral arteries, basilar artery, and PCA territories
- Watershed infarcts: Border-zone infarcts between major cerebral arteries

Statistical Analysis

The correlation between CoW variations and ischemic lesion patterns was analyzed using chi-square tests and logistic regression. A p-value of less than 0.05 was considered statistically significant.

RESULTS

Demographics

- Age range: 40-82 years
- Gender distribution: 145 males (58%), 105 females (42%)
- Common risk factors: Hypertension (72%), diabetes (48%), hyperlipidemia (52%), and smoking (34%)

Variations in Circle of Willis

- Hypoplastic or absent ACoA: 30 patients (12%)
- Hypoplastic or absent PCoA: 85 patients (34%)
- Hypoplastic ACA: 18 patients (7%)
- Fetal-type PCA: 60 patients (24%)
- Other variations: 20 patients (8%)

Ischemic Lesion Patterns

- Anterior circulation strokes (ACS): 160 patients (64%)
- Posterior circulation strokes (PCS): 70 patients (28%)
- Watershed infarcts: 20 patients (8%)

Correlation Analysis

- Hypoplastic or absent ACoA: Associated with increased watershed infarcts ($p < 0.01$).
- Hypoplastic or absent PCoA: Significantly correlated with posterior circulation strokes ($p < 0.05$).
- Hypoplastic ACA: Linked to higher incidence of anterior circulation strokes, especially in ACA territory ($p < 0.05$).
- Fetal-type PCA: Associated with mixed distribution of ischemic lesions involving both anterior and posterior territories ($p < 0.05$).

DISCUSSION

This study highlights the significant influence of anatomical variations in the Circle of Willis (CoW) on ischemic lesion patterns in acute ischemic stroke. These findings underscore the importance of understanding vascular anatomy in stroke pathophysiology and the role of advanced imaging techniques in clinical decision-making.

The prevalence of CoW variations, particularly hypoplasia or absence of the posterior communicating artery (PCoA) and fetal-type posterior cerebral artery (PCA), observed in 58% of the study population, aligns with earlier research by Alpers et al. (1959)[1] and Fisher (1965)[2] which also documented a high occurrence of such anatomical deviations and their association with cerebrovascular disorders. Studies by Krabbe-Hartkamp et al. (1998)[3] further confirm that these variations can influence blood flow dynamics, particularly during ischemic events.

The association between hypoplastic PCoA and posterior circulation strokes observed in this study corroborates findings by van Raamt et al. (2006)[4] emphasizing the crucial role of the PCoA in sustaining blood flow to the posterior brain regions. Similarly, the increased susceptibility of anterior cerebral arteries (ACA) to ischemic events in cases of hypoplasia is supported by research from Hoksbergen et al. (2003)[5], which highlights the vulnerability of these arteries in proximal

occlusions. The occurrence of mixed ischemic lesion patterns in patients with fetal-type PCA reflects the hemodynamic complexities involved, as demonstrated by Kapoor et al. (2017)[6]and Chuang et al. (2020)[7]

Advanced imaging methods, such as magnetic resonance angiography (MRA) and computed tomography angiography (CTA), play a pivotal role in identifying these vascular anomalies. This is consistent with the utility of MRA in assessing collateral circulation as noted by Liebeskind (2003)[8] and Ringelstein et al. (1994)[9]. Similarly, the ability of CTA to detect anatomical variations is reinforced by the work of Saba et al. (2014)[10] Recognizing these variations before intervention could significantly inform tailored therapeutic strategies, as suggested by Ringleb et al. (2019)[11]

The study also advocates for a multidisciplinary approach that integrates expertise from neurology, radiology, and vascular surgery to optimize stroke care. This perspective aligns with the recommendations of Caplan et al. (2010)[12] and Campbell et al. (2015)[13], which stress the importance of collaborative care in achieving better outcomes for stroke patients.

However, the study has some limitations. As a retrospective analysis, it may be subject to selection bias, as highlighted by von Elm et al. (2007)[14]. Moreover, while this study establishes correlations between CoW variations and ischemic patterns, causality remains speculative. Advanced imaging techniques like perfusion MRI, as shown by Derdeyn et al. (2002)[15] and Parsons et al. (2005)[16] could provide further insights into these hemodynamic mechanisms. Larger prospective studies, such as those by Arenillas et al. (2001)[17], could also validate these findings.

CONCLUSION

In conclusion, the study underscores the importance of understanding CoW variations in influencing ischemic stroke patterns and calls for the integration of advanced imaging techniques into routine stroke care. Future research should focus on prospective designs with functional imaging to unravel the mechanisms linking CoW anatomy and ischemic dynamics, ultimately improving patient outcomes.

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