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Etiological mechanisms of isolated pontine infarcts based on arterial territory involvement

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ABSTRACT

Background: Pontine infarcts can be classified into four regions based on the vascular anatomy: anteromedial, anterolateral, lateral and posterior. The purpose of this study was to determine if different etiological mechanisms are responsible for these four types of pontine infarcts.

Methods: We studied consecutive patients within 7 days of symptom onset who had isolated pontine infarcts on diffusion-weighted imaging. The factors associated with infarct topography were determined by multivariate logistic regression analysis.

Results: A total of 205 patients were enrolled (78 women; mean age, 72 ± 11 years). The distribution of the infarcts was anteromedial in 73%, anterolateral in 14%, lateral in 3% and posterior in 10%. In multivariate logistic regression analysis, major cardioembolic sources (odds ratio (OR), 4.17; 95% confidence interval (CI), 1.21–14.1) and previous ischemic stroke (OR, 2.92; 95% CI, 1.09–7.89) were positively associated with lateral or posterior infarcts compared with anteromedial infarcts. In contrast, advanced age (OR, 0.55; 95% CI, 0.35–0.81 per 10-year increase), diabetes mellitus (OR, 0.31; 95% CI, 0.11–0.80) and basilar artery disease (OR, 0.27; 95% CI, 0.08–0.75) were negatively associated with lateral or posterior pontine infarcts.

Conclusions: Baseline characteristics were significantly different among patients with isolated pontine infarcts in different topographic locations. Our results suggest that cardioembolism is relatively common in lateral or posterior pontine infarcts, whereas basilar artery atherosclerosis is more common in anteromedial infarcts.

1. Introduction

The clinico-topographic correlation of isolated pontine infarcts has been investigated [1–7]. However, the etiological mechanisms of isolated pontine infarcts based on arterial perfusion territories remain unclear. According to arterial anatomy, pontine perfusion territories can be categorized into four groups: anteromedial, anterolateral, lateral and posterior [8]. The anteromedial and anterolateral territories are supplied by basilar arterial branches; the lateral territory is supplied by long circumferential branches from the basilar artery, the anterior inferior cerebellar artery (AICA) and the superior cerebellar artery (SCA); and the posterior territory is supplied by only by the SCA [8,9]. Therefore, it is possible that there are some differences in underlying etiology of pontine stroke depending upon the artery involved.

There have been only a few studies on underlying mechanisms of isolated pontine infarcts based on arterial involvement [3,5]. Furthermore, all pontine infarcts in these previous studies were not identified by diffusion-weighted imaging (DWI). DWI seems superior to conventional imaging in selecting patients with acute isolated pontine infarcts because it can distinguish fresh infarcts from old ones and can accurately exclude concomitant extrapontine acute ischemic lesions such as small cortical infarcts.

The purposes of this study were to determine if stroke etiology in isolated pontine infarcts diagnosed by MRI including DWI depends upon the artery involved and to determine the clinical features in each pontine infarct.

2. Methods

2.1. Patient selection and evaluation

From a database of patients admitted to our department between January 2006 and June 2012, we retrospectively identified patients with an isolated pontine infarct within 7 days of symptom onset who underwent MRI and magnetic resonance angiography (MRA). The diagnosis of the isolated pontine infarct was based on DWI findings. Stroke subtypes were principally categorized by the Trial of Org 10172 in Acute Stroke Treatment (TOAST) criteria [10]. Electrocardiography, 24-hour electrocardiographic monitoring, and carotid ultrasound were performed on the first day of admission in all patients. Transthoracic echocardiogram was performed as a cardiac evaluation for most patients, while transesophageal echocardiogram was performed depending on

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the decision of attending neurologists. The hospital's ethics committee approved this study, which was based on a retrospective review of our stroke database.

2.2. MRI methods and analysis

MRI, including DWI and MRA, was performed at 1.5 T (Magnetom Vision; Siemens Medical Solutions, Erlangen, Germany). DWI was performed using the following parameters: repetition time, 4000 ms; echo time, 100 ms; matrix, 128 × 128; field of view, 23 cm; section thickness, 4 mm; intersection gap, 2 mm; and b values, 0 and 1000 s/mm^2. MRA was obtained using the following parameters: repetition time, 35 ms; echo time, 7.6 ms; flip angle, 20°; field of view, 200 mm; matrix, 224 × 512; and slice thickness, 0.6 mm.

Pontine lesions were estimated by two board-certified neurologists (J.K. and T.O.). The pontine infarcts were classified into four groups (anteromedial, anterolateral, lateral and posterior) according to the brain map of the arterial perfusion territories (Fig. 1) [8]. When the judgment of the two neurologists was inconsistent, a decision was made by discussion. Representative cases of isolated pontine infarcts are shown in Fig. 2.

Based on the results of basilar artery assessment, patients were categorized into three groups (normal, wall irregularity, >50% steno-occlusive lesion) [11]. Basilar artery disease was defined as the latter two pathologies at the level of pontine infarct. Old lacunar infarcts were defined as cavitated lesions (3–15 mm) in the territory of the deep perforating arteries on FLAIR imaging. White matter lesions were defined as a large confluent area in the deep white matter corresponding to grade 3 of the Fazekas criteria [12].

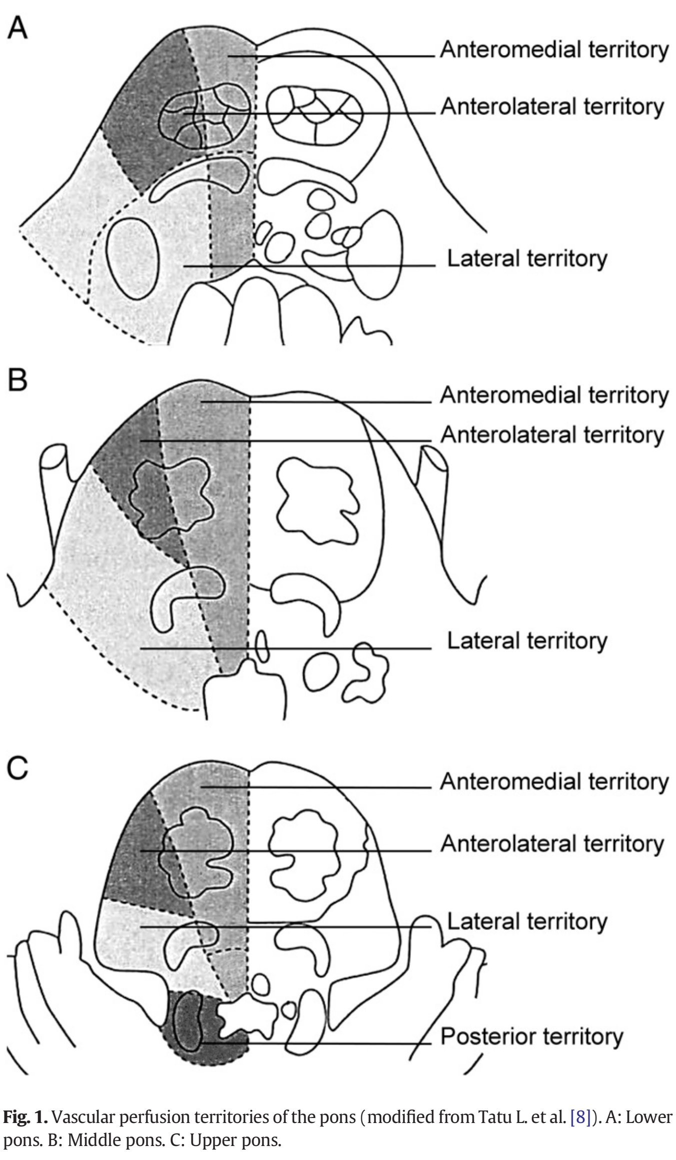

Fig. 1. Vascular perfusion territories of the pons (modified from Tatu L. et al. [8]). A: Lower pons. B: Middle pons. C: Upper pons.

2.3. Clinical characteristics

The patients' clinical characteristics, including sex, age and cardiovascular risk factors including diabetes mellitus, hypertension, dyslipidemia, smoking and alcohol consumption, were recorded. In addition, major cardioembolic sources of stroke including atrial fibrillation (AF), a previous history of ischemic stroke, coronary artery disease and peripheral artery disease were identified. Major cardioembolic sources were defined by high risk of cardioembolism in TOAST criteria [10]. AF was diagnosed based on either ECG recordings or a confirmed history of AF. Clinical findings, including hemiparesis, sensory disturbance and oculomotor disturbance, were also collected. The National Institutes of Health Stroke Scale (NIHSS) on admission and the modified Rankin Scale (mRS) scores at hospital discharge (median hospital stay, 18 days) were evaluated. A favorable outcome was defined as mRS scores of 0 to 1, and an unfavorable outcome as mRS scores of 2 to 6.

2.4. Statistical analysis

Differences in clinical features among the four groups were analyzed using the Kruskal–Wallis test for continuous values and Fisher's exact test for categorical variables. To identify variables in baseline characteristics and radiological findings associated with infarct topography, simple logistic regression analyses were performed. The lateral and posterior pontine infarcts were grouped together as a lateral-posterior (LP) group for the purpose of regression analysis, because both of these areas are mainly supplied by cerebellar arteries. The anterolateral and LP groups were compared with the anteromedial group serving as a reference. Multivariate logistic regression analyses were performed to determine the independent factors associated with infarct topography using all of the demographic, clinical and radiographic variables. A backward selection procedure was performed using $P > 0.10$ for the likelihood ratio test for exclusion of variables. A P value <0.05 was considered statistically significant. All statistical analyses were conducted using PASW for windows version 17.0 software (SPSS Inc., Chicago, IL, USA).

3. Results

A total of 3099 patients with acute ischemic stroke were admitted to our hospital during the study period. Among them, 231 (7.5%) consecutive patients had acute pontine infarcts (181 [78%] were admitted within 48 h of symptom onset). Finally, a total of 205 patients (78 women; mean age, 72 ± 11 years) with acute isolated pontine infarcts were enrolled in this study, excluding patients with contraindication for MRI by implanted cardiac devices ($n = 9$), pontine infarcts involving multiple vascular territories ($n = 16$), or lack of intracranial MRA study ($n = 1$). Of all isolated pontine infarcts, 149 (73%) belonged to the anteromedial group, 28 (14%) to the anterolateral group, 7 (3%) to the lateral group and 21 (10%) to the posterior group.

Clinical presentations are shown in Table 1. Pure motor hemiparesis ($P < 0.001$), sensory disturbance ($P = 0.004$), oculomotor disturbance ($P < 0.001$) and initial NIHSS score ($P < 0.001$) were significantly different among these four categories. Pure motor hemiparesis (PMH) was common in patients with an anteromedial pontine infarct, and sensory and oculomotor disturbances were common in patients with a lateral infarct. There were significant differences among the four groups in functional outcome at hospital discharge ($P < 0.001$). Patients with an anteromedial pontine infarct had a higher rate (67%) of unfavorable outcome (Fig. 3).