Journal of the Neurological Sciences 338 (2014) 142–147

Contents lists available at ScienceDirect

Journal of the Neurological Sciences

journal homepage: www.elsevier.com/locate/jns

Basilar artery bending length, vascular risk factors, and pontine infarction

Dao-pei Zhang [a,1], Shu-ling Zhang [a,1], Jie-wen Zhang [b,*], Hong-tao Zhang [a], Sheng-qi Fu [a], Meng Yu [a], Ya-fang Ren [a], Peng Ji [a]

[a] Department of Neurology, Zhengzhou People's Hospital, Zhengzhou 450003, China
[b] Department of Neurology, People's Hospital of Henan Province, Zhengzhou 450003, China

ARTICLE INFO

Article history:
Received 2 August 2013
Received in revised form 17 December 2013
Accepted 20 December 2013
Available online 31 December 2013

Keywords:
Basilar artery
Bending length
Pontine infarct
Vertebral arteries
Vascular risk factors
Magnetic resonance angiography

ABSTRACT

Background: Patients exhibiting basilar artery (BA) curvature (not dolichoectasia) are at an increased risk of posterior circulation ischemic stroke. In this study, pontine infarction patients were analyzed to assess the effect of BA bending length (BL) together with other vascular factors on pontine stroke risk.
Methods: Acute pontine infarction patients were divided into BA bending and non-BA bending groups by magnetic resonance angiography (MRA). Patients with BA bending who reported symptoms of dizziness or vertigo but who had not suffered brain infarction constituted the control group. The diameter of the vertebral artery (VA) and BL were measured using MRA. Based on the bilateral VA diameter data in vertebral artery-dominant (VAD) patients, the study participants were divided into three classes for VA diameter: class one, 0.30–0.80 mm (20 cases); class two, 0.81–1.37 mm (20 cases); and class three, 1.38–3.24 mm (20 cases). The measured BL in VAD cases allowed division of patients into three levels for BL: level one, 1.02–2.68 mm (21 cases); level two, 2.69–3.76 mm (20 cases); and level three, 3.77–7.25 mm (19 cases). Vascular risk factors were compared among the three groups. Correlations of BL and VA diameter differences were studied, and multivariate analysis was applied to search for predictors of ischemic stroke in BA bending patients.
Results: Among BA bending, non-BA bending, and control groups, VA dominance (VAD) proved to be a significant differentiator. For all three groups, a patient age of ≥65 years, the occurrence of hypertension, smoking, high homocysteine levels, high cholesterol, and a history of type 2 diabetes, were all statistically significant factors ($P < 0.05$). After adjusting for other relevant factors, multivariate analysis shows that BL of level 3 was an independent risk factor for pontine infarction (OR = 2.74; 95% CI, 1.27 to 4.48). Both BL and diameter differences between the VAs were positively correlated with risk with statistical significance ($r = 0.769$, $P < 0.001$).
Conclusions: Both BL and diameter differences between the VAs are positively correlated with the risk of pontine infarction. When BA bending was coupled with other vascular risk factors, the probability of pontine infarction increased. BA bending with a BL greater than 3.77 mm was an independent predictor of pontine infarction.

1. Introduction

Using the noninvasive cerebrovascular examination methods magnetic resonance angiography (MRA) and computed tomography angiography (CTA), it has been discovered that—by comparison to the standard picture of a straight-line vessel at the anatomical midline—basilar arteries (BAs) exhibit different degrees of bending in cerebrovascular disease patients and healthy subjects [1]. Furthermore, clinical and radiological physicians have, to a large extent, focused on vascular stenosis or occlusion while generally ignoring the presence of vascular curvature during the diagnosis and treatment of cerebrovascular diseases [2]. Because of the importance of the BA in supplying blood to the brain, and given that BA bending among the general populace is common, it has, therefore, been suggested that BA bending should be given more attention in dealing with cases of posterior circulation infarction [3,4]. However, the underlying reason for BA bending is unclear, and its association with atherosclerosis and ischemic stroke is controversial [5]. Recently, there has been a much greater concern among medical researchers with the occurrence of BA dolichoectasia (BAD), and the suggestion that BAD is related to posterior circulation ischemic stroke [6–8]; on the other hand, there are, many BA tortuosity cases that are not attributable to BAD. Unfortunately, BA bending, which is linked to ischemic cerebrovascular diseases, has been less well studied [1,3].

Previous studies on this topic have applied several methods for evaluating BA bending [9,10]. In this research, BA length (BAL) [1] and bending length (BL) were measured to investigate the relationships between age, gender, and vertebral artery (VA) dominance. BAL and BL were regarded as more convenient, reliable evaluators of BA bending. Based on these findings, it was reasonable to surmise that changes of BAL and BL contribute to posterior circulation infarction, especially of the

* Corresponding author. Tel.: +86 13607679900; fax: +86 371 65580014.
E-mail address: zhangjiewen9900@126.com (J. Zhang).
[1] Dao-pei Zhang & Shu-ling Zhang contributed equally to the study, and are co-first authors of the article.

0022-510X/$ – see front matter © 2013 Published by Elsevier B.V.
http://dx.doi.org/10.1016/j.jns.2013.12.037

pons. For the purpose of elucidating the relationship among BL, vascular risk factors, and pontine infarction, the present study was based on high-field-strength MRA to achieve reliably well-defined BA imaging. A cross-sectional, case–control study design was used to reveal the effect of BA bending together with vascular risk factors in patients with pontine infarction.

2. Methods

2.1. Patients

From June 2009 to October 2012, 217 acute pontine infarction patients admitted to the Department of Neurology of Zhengzhou People's Hospital (China) were identified; these patients had been diagnosed using magnetic resonance (MR) diffusion-weighted imaging (DWI). On the basis of the Chinese ischemic stroke subclassification (CISS), 97 of these patients were classified as having either small artery disease or infarcts of undetermined etiology [11]; ultimately, 88 of these 97 patients with complete data were selected as research subjects. Through the use of magnetic resonance angiography (MRA), pontine infarction patients were divided into BA bending and non-BA bending groups. The control group consisted of 38 patients aged ≥40 years who had been hospitalized during the same period for reported symptoms of dizziness or vertigo, and for whom head and neck magnetic resonance imaging data showed BA bending without brain infarction.

Utilizing a combination of vascular and cardiology study results together with CISS, the patients' stroke mechanisms were classified into six groups: 1. cardioembolism, 2. large artery atherosclerosis, 3. small artery disease, 4. other determined etiologies (e.g., vasculitis or dissection), 5. undetermined etiology, and 6. multiple coexisting etiologies. To identify the potential mechanism of brain infarct, a set of diagnostic tests was performed that included MRA, contrast-enhanced MRA (CEMRA), routine blood tests, and a cardiology workup (ECG and echocardiogram).

2.1.1. Enrollment and exclusion criteria

Patients in the experimental group were all aged ≥40 years and showed no significant VA or BA stenosis, thereby excluding patients with BAD and those with VA tortuosity. Also excluded were any patients with incomplete magnetic resonance scans. All patients had received a complete imaging examination within one week after stroke onset. The protocol for this cross-sectional study was approved by the Research Ethics Committee of Zhengzhou People's Hospital. All patients gave their full informed consent either directly or through a surrogate, when necessary.

Detailed records of patient demographic data (including gender and age) were obtained, as well as records indicating their vascular risk factors—history of diabetes mellitus, coronary artery disease, hypertension, previous stroke, high triglyceride (>1.71 mmol/L), high cholesterol (>5.17 mmol/L), high low-density lipoprotein cholesterol (>2.60 mmol/L), and high homocysteine (>15.0 μmol/L). All patients with vascular risk factors had been previously diagnosed as such and/or were already taking medications for these conditions (Table 1).

2.1.2. Alcohol consumption criteria

Patients classified as "drinkers in" Table 1 reported drinking at least once a week (1 standard alcohol consumption is equivalent to 120 mL of wine, 360 mL of beer, or 45 mL of distilled spirits).

2.1.3. Smoking criteria

To be classified as a "smoker," in Table 1, a study participant was someone who had continuously or cumulatively smoked for more than 6 months and who smoked at least 1 cigarette per day. "Never smoking" indicated a participant who had cumulatively smoked less than 6 months with a daily average of less than 1 cigarette. Smoking history includes both present consumption and that over the prior 6 months. Current smoking pattern must be consistent with that over the prior 30 days of smoking history.

Also, recorded in Table 1 is the score, upon admission, for the National Institutes of Health (USA) stroke scale (NIHSS) score in patients with cerebral infarction.

2.2. Imaging data

MRI and MRA were performed on all patients using a 3.0-T scanner (GE Medical, Piscataway, NJ, USA). Scanning was performed with a conventional T2-weighted MRI, and diffusion-weighted imaging was conducted in the axial plane with sections of 5 mm in thickness and 1 mm in length. Three-dimensional time-of-flight (TOF) MRA was performed, with a repetition time of 20 ms, echo time of 3.2 ms, and section thickness of 1.0 mm. Scanning results were obtained by re-creating the images with maximum intensity projection. Prior to neck CEMRA, patients were injected with gadopentetate dimeglumine (0.1 mmol/kg of body weight). All measurements of display data

Table 1
Baseline data for pontine infarction patients and control group.

	Pontine infarction patients		Control group(n = 38)	P value
	BA bending group (n = 46)	Non-BA bending group (n = 42)		
Sex (male) [n (%)]	29 (63.0)	27 (64.3)	23 (60.5)	0.548
Age (years)	61.73 ± 8.96	62.36 ± 10.07	61.21 ± 9.16	0.718
Hypertension [n (%)]	21 (45.7)	12 (28.6)	13 (34.2)	0.039
Diabetes mellitus [n (%)]	27 (58.7)	6 (14.3)	3 (7.9)	<0.001
Smoking [n (%)]	17 (36.9)	5 (11.9)	7 (18.4)	0.041
Stroke [n (%)]	10 (21.7)	7 (16.7)	6 (15.7)	0.612
High cholesterol [n (%)]	23 (50.0)	6 (14.3)	9 (23.7)	0.016
High homocysteine [n (%)]	15 (32.6)	7 (16.7)	3 (7.9)	0.038
High triglyceride [n (%)]	8 (17.4)	6 (14.3)	5 (13.2)	0.706
Coronary heart disease [n (%)]	8 (17.4)	9 (21.4)	8 (21.1)	0.773
Drinking [n (%)]	6 (13.0)	5 (11.9)	4 (10.5)	0.651
VAD [n (%)]	33 (71.7)	23 (54.8)	21 (55.2)	0.039
BAL (mm)	27.42 ± 2.66		23.12 ± 3.08	0.025
BL (mm)	5.54 ± 3.06		3.20 ± 1.44	0.031
BA diameter (mm)	3.98 ± 0.52	3.73 ± 0.61	3.82 ± 0.47	0.721
True length of BA (mm)	28.98 ± 3.12	27.48 ± 4.05	29.15 ± 4.36	0.614
NIHSS (scores)	3.4 ± 1.5	3.3 ± 1.6		0.642

Values are expressed as unadjusted means (standard deviation) or medians (interquartile range) unless otherwise indicated. P values were computed using analysis of variance and chi-square adjusted for age and gender except for age (only adjusted for gender) and gender (only adjusted for age); BL, BAL, and BA diameter were introduced as continuous variables.
BA = basilar artery, VAD = vertebral artery dominance, BAL = basilar artery length, BL = bending length, NIHSS = National Institutes of Health (USA) stroke scale.