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Original Article

Effect of carotid artery aberrancy on the distance between the vessel and nasopharyngeal subsites

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Abstract

Background: Life-threatening hemorrhaging due to nasopharyngeal internal carotid artery (ICA) aberrancy may occur during routine nasopharyngeal surgery. To understand better the potential adverse effect of nasopharyngeal ICA aberrancy on routine nasopharyngeal surgery, we classified aberrant nasopharyngeal ICAs and analyzed the differences in mean distances from the ICA to nasopharyngeal subsites between aberrant and nonaberrant vessels.

Methods: The courses of nasopharyngeal ICAs were examined and classified for an aberrant pathway. Various distances were measured on magnetic resonance brain scans. The mean values of the measured variables were compared using an unpaired two-sample *t* test.

Results: The mean distances to the torus tubarius, the opening of Rosenmuller's fossa, and the posterior nasopharyngeal wall were 19.6 mm, 15.8 mm, and 16.7 mm, respectively, in the aberrant case group, and 23.1 mm ($p < 0.001$), 19.8 mm ($p < 0.001$), and 20.7 mm ($p < 0.001$) in the nonaberrant control group.

Conclusion: The mean distances between the ICA and nasopharyngeal subsites were significantly shortened (by 15–21%) in the presence of aberrant nasopharyngeal segments, which may increase the risk of severe complications in common and uncomplicated nasopharyngeal surgery, such as adenoidectomy, eustachian tuboplasty, and nasopharyngeal biopsies. However, the mean distances were not shortened by the severity (kinking and coiling) of the aberrant nasopharyngeal carotid arteries.

Keywords: aberrant internal carotid artery; cervical internal carotid artery; nasopharyngeal surgery; vascular anomaly

1. Introduction

Adenoidectomy, eustachian tuboplasty, and nasopharyngeal biopsies are common and unsophisticated nasopharyngeal surgeries. Catastrophic hemorrhaging due to an injury to an aberrant internal carotid artery (ICA) during routine nasopharyngeal surgery such as an adenoidectomy has been reported in the literature.[1–4] Eustachian tuboplasty has been a common endoscopic surgery of the nasopharyngeal portion of the eustachian tube (ET) using techniques of laser, microdebrider, or balloon dilation to improve the function of the ET in recent years.[5–7] During eustachian tuboplasty, serious complications have occurred by not appreciating the proximity of the ICA to the ET.[8,9] An ICA injury may be risked

Conflicts of interest: The authors declare that there are no conflicts of interest related to the subject matter or materials discussed in this article.

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either directly by laser or indirectly by thermal injury when performing endoscopic surgery of the nasopharyngeal portion of the ET.[8,10] Although many cases of aberrant cervical ICAs have been reported in recent decades,[11–20] only a few have provided practical clinical applications for routine nasopharyngeal surgery.[8,21,22] Severe complications may occur after common nasopharyngeal surgery; scant information on the distances from the ICA to nasopharyngeal subsites has been gleaned by studying computed tomography (CT) and magnetic resonance imaging (MRI) scans in recent years.[8,22] Some patients have close distances between the ICA and nasopharyngeal subsites, but because of the high price, it is difficult to arrange either CT or MRI scans preoperatively to evaluate the critical distances when performing these simple nasopharyngeal surgeries. In addition to experience and skills, severe complications due to an ICA injury may be prevented by further understanding the differences in distances from the ICA to nasopharyngeal subsites between aberrant and nonaberrant nasopharyngeal ICAs.

To understand better the potential adverse effect of nasopharyngeal ICA aberrancy on routine nasopharyngeal surgery, we classified aberrant nasopharyngeal ICAs and analyzed the differences in distances from the ICA to nasopharyngeal subsites between aberrant cases and nonaberrant controls.

2. Methods

2.1. Study participants

This retrospective study was conducted at Chi Mei Medical Center in Taiwan. Patients with MR brain scans and MR angiograms were identified from routine adult health examinations between February and September 2011. Scans with a motion artifact and scans that did not include the level of the ET (incomplete imaging) were excluded from analysis. Measurements were taken on both sides for independent analysis. The courses of nasopharyngeal ICAs were examined and classified for an aberrant pathway according to the criteria of Paulsen et al (Table 1).[13] The aberrant cervical ICAs in nasopharyngeal segments were included in the case group, and the nonaberrant cervical ICAs were included in the control group. Control-group participants were randomly selected from the same timeframe and were age-, sex-, and body-weight-matched with the case-group participants. The ratio of cases to controls was 1:3 (Table 2). The protocol was approved by the Internal Review Board of the Chi Mei Medical Center.

Table 1
The course of the nasopharyngeal internal carotid artery classified and modified according to the criteria of Paulsen et al.[13]

Type	Features
Straight	Deviation from the vertical is less than 15°
Curved	Deviation is greater than 15° and lower than 90°: S- or C-shaped elongation
Kinked	Deviation is between 90° and 180°
Coiled	A loop of 360° is visible

Table 2
Patient characteristics.

Characteristics	Cases (n = 39)	Controls (n = 117)	p
	Mean ± SD	Mean ± SD	
Age (y)	54.8 ± 9.6	54.5 ± 9.5	0.862
Body weight (kg)	64.3 ± 12.1	63.4 ± 13.4	0.716
Sex (M:F)	17:22	51:66	

Cases = aberrant nasopharyngeal internal carotid arteries (ICAs); Controls = nonaberrant nasopharyngeal ICAs.

2.2. Radiographic analyses

All scans were obtained using a 1.5 Tesla scanner (GE Medical Systems, Milwaukee, WI, USA). The MR images consisted of axial T1- and T2-weighted images, post-contrast T1-weighted images, and MR angiograms. The standard three-dimensional time-of-flight magnetic resonance angiography (MRA) protocol for ICA was as follows: repetition time, 6 milliseconds; echo time, 2 milliseconds; flip angle, 45°; field of view, 30 cm × 30 cm. We used a picture archiving and communication system (INFINITT Healthcare, Seoul, Korea) to evaluate the images.

In the present study, ICA variations were classified by evaluating the medial deviation of the nasopharyngeal ICA on the coronal view of three-dimensional time-of-flight MRA (Fig. 1A). When considering clinical applications and a few ventrodorsal deviations (only a 2.1% ventrodorsal curve was reported by Paulsen et al[13]), we only estimated the medial displacement of the ICA, but did not take ventral and dorsal folding into consideration. The transverse plane was used to measure the distance between the ICA and nasopharyngeal wall. The torus tubarius (TT) was used as a marker, and all parameters were measured on this plane, including the distances from the anterior margin of the TT (solid white line), the opening of Rosenmuller's fossa (RF; dashed white line), and the posterior nasopharyngeal wall (PW; solid white line) to the closest margin of the ICA (Fig. 1B). The midline was extended from the posterior septum, and the distance from the medial margin of the ICA to the midline (ML; solid black line) was measured. Nasopharyngeal ICA aberrations were distinguished from oropharyngeal aberrations by analyzing the coronal and transverse sections. A medial curving of the left ICA at the nasopharynx level (Fig. 2A), a kinking of the left ICA (Fig. 2B), and a coiling of the left ICA (Fig. 3) were demonstrated. With the aid of the crosshairs on these axial and coronal images for the localization, the intricate course of the ICA aberration could be clarified in detail (Fig. 3).

2.3. Statistical analysis

The numerical data are means ± standard deviation. All statistical analyses were done using Stata version 11.0 (StataCorp LP, College Station, TX, USA). Means of the numerical variables were compared with their control counterparts using an unpaired two-sample t test. The relationship between aberrant types and means of the numerical variables was predicted by a linear regression analysis. Significance was set at $p < 0.05$.

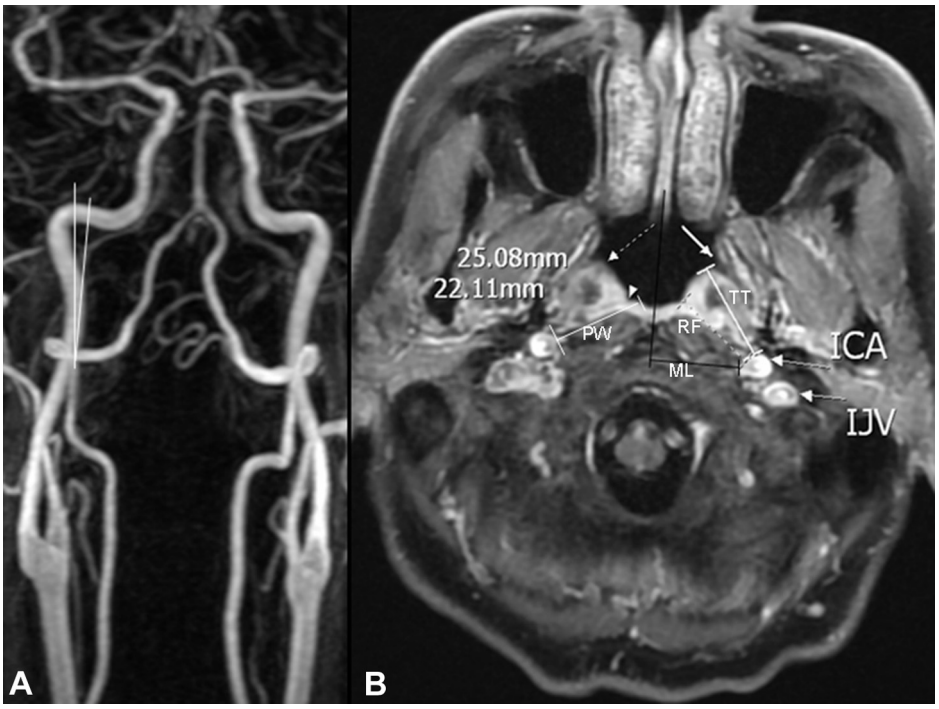

Fig. 1. (A) Magnetic resonance angiography shows bilateral nonaberrant nasopharyngeal internal carotid arteries. (B) Eustachian tube orifice (arrow), Rosenmuller's fossa (arrowhead), and torus tubarius (dashed arrow) are shown. ICA = internal carotid artery; IJV = internal jugular vein; ML = midline of posterior nasopharyngeal wall; PW = posterior nasopharyngeal wall; RF = Rosenmuller's fossa; TT = torus tubarius.

3. Results

Thirty-nine aberrant nasopharyngeal ICAs were included in the case group, and 117 nonaberrant nasopharyngeal ICAs were included in the control group. The mean age was 54.8 years in the case group and 54.5 years in the control group ($p = 0.862$) (Table 2). The mean distances to the TT, RF, PW, and ML were 19.6 mm, 15.8 mm, 16.7 mm, and 19.7 mm, respectively, in the case group, and 23.1 mm, 19.8 mm, 20.7 mm, and 23.6 mm, respectively, (all $p < 0.001$)

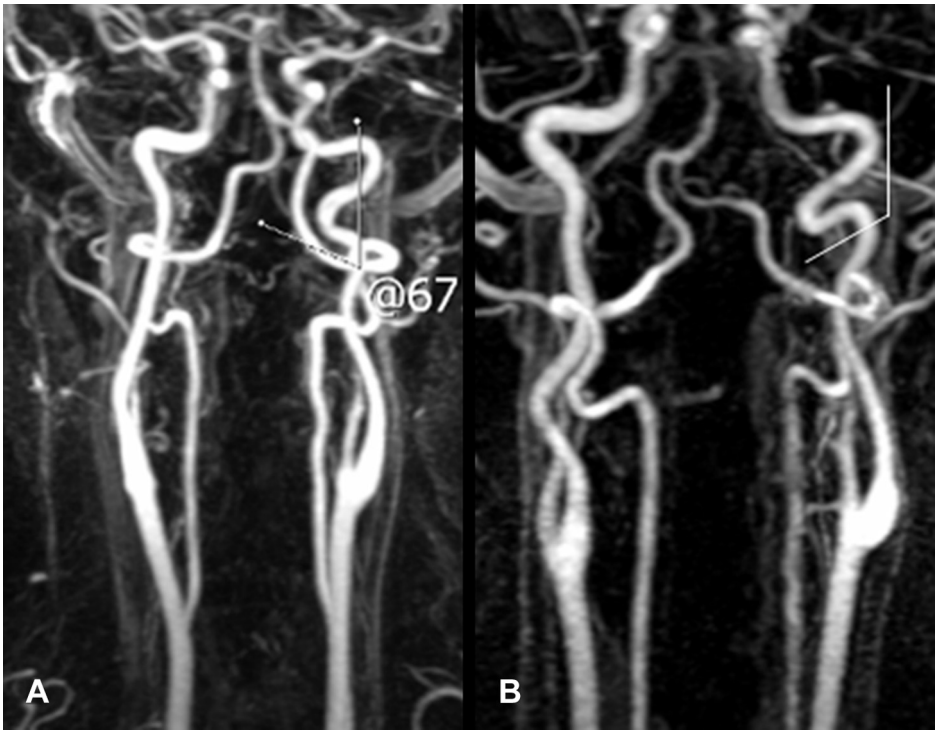

Fig. 2. (A) Magnetic resonance angiography reveals a medial curving and (B) a kinking of the left internal carotid artery at the nasopharyngeal level.

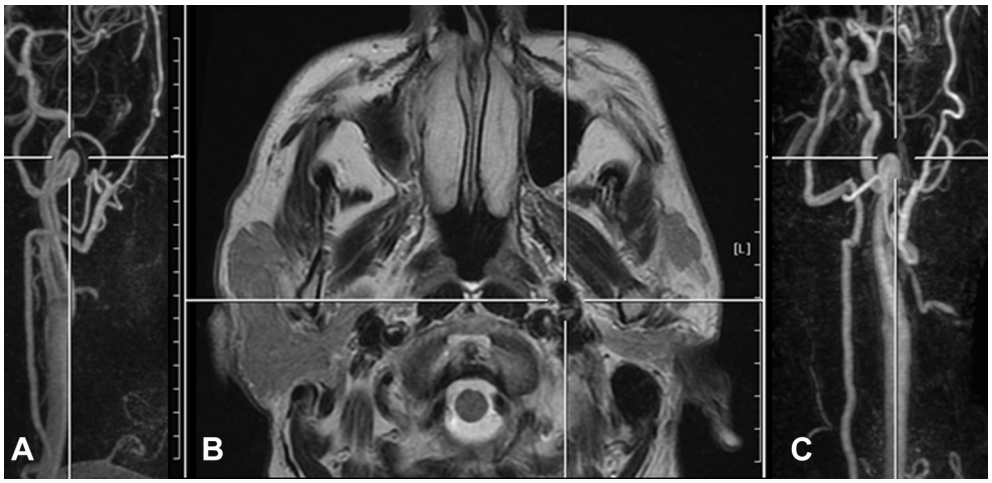

Fig. 3. (A) Left-sided coiled internal carotid artery is shown. (B) Axial section reveals the horizontal run (crosshair). (C) Oblique view is shown to help distinguish vessels.

in the control group. The minimum distances to the TT, RF, PW, and ML were 13 mm, 9 mm, 12 mm, and 14 mm, respectively, in the case group, and 14 mm, 11 mm, 11 mm, and 15 mm, respectively, in the control group (Table 3). The mean distances from the ICA to the TT, RF, PW, and ML in the case group were 15–21% shorter ($p < 0.001$) than those in the control group.

4. Discussion

In this study, we calculated the mean distances to the TT, RF, PW, and ML in patients with aberrant nasopharyngeal ICAs (case group) with age-, sex-, and body-weight-matched controls without aberrant nasopharyngeal ICAs (control group) and determined the relationships between them. We found that the mean distances in the case group were significantly shorter than the distances in the control group ($p < 0.001$). The mean distance to the TT was 20.0 mm and to the ML was 19.7 mm in aberrant ICAs, and 23.1 mm and 23.6 mm, respectively, in nonaberrant ICAs. The distances were shorter than those reported by Bergin et al,[8] who used the Weibel and Fields criteria and found that the mean distance to the TT was 22.5 mm and to the ML was 22.2 mm in aberrant ICAs, and 23.8 mm and 24.1 mm, respectively, in nonaberrant ICAs.[12] The longer distance indicates an ethnic difference (between New Zealand Caucasians and Taiwan Han Chinese). We also found that the severity (kinking and coiling) of nasopharyngeal ICA aberrations did not shorten the mean distances from the ICA to nasopharyngeal areas, which is consistent with another study.[21] Because only five severe aberrations (3 kinking and 2 coiling) were detected and only one of the nasopharyngeal levels was measured, the mean values could not be compared completely objectively in this study. In addition, we found only a few differences (<2 mm) in the minimum distances to the TT, RF, PW, and ML between the case and control groups. We consider the minimum distance to be an extreme value, not a mean value, and the value to be jointly determined by age, sex, weight, and nasopharyngeal ICA aberrancy.

Most ICA aberrations are medial deviations. If the ICA moves medially, the distances to the RF, PW, and ML will be shortened. Because ICA aberrations are postulated to be related to congenital anomalies,[20] aging,[12,13,19] or atherosclerotic change,[12,19] the distance may shorten in older age. We believe that sex and weight are associated with the distance from the ICA to the nasopharyngeal wall because both affect

Table 3
Nasopharyngeal internal carotid artery aberrations and associated carotid artery measurements.

	No. of ICAs	MD to TT (mm)	MD to RF (mm)	MD to PW (mm)	MD to ML (mm)
Nasopharynx					
Cases	39	19.6 ± 2.8	15.8 ± 3.1	16.7 ± 3.2	19.7 ± 2.5
Controls	117	23.1 ± 3.1	19.8 ± 3.4	20.7 ± 3.6	23.6 ± 2.8
p		<0.001	<0.001	<0.001	<0.001
Minimum distance					
Cases	39	13	9	12	14
Controls	117	14	11	11	15
Aberrant type					
Curved	34	19.4 ± 3.0	15.6 ± 3.2	16.6 ± 3.3	19.6 ± 2.5
Kinked	3	20.0 ± 1.7	16.3 ± 2.1	17.7 ± 2.5	20.0 ± 2.6
Coiled	2	21.0 ± 0.0	18.0 ± 1.4	18.5 ± 0.7	21.0 ± 2.8
p		0.428	0.248	0.278	0.630

MD = mean distance; ML = midline of posterior nasopharyngeal wall; PW = posterior nasopharyngeal wall; RF = orifice of Rosenmuller's fossa; TT = torus tubarius.

the amount of muscle and other tissue between the ICA and nasopharyngeal mucosa. Although many factors affect the distance between the ICA and nasopharyngeal wall, we hypothesize that ICA aberrancy is critical in determining the distance.

In conclusion, although the distance between the ICA and pharyngeal wall has been associated with age, sex, weight, and ICA aberrancy,[8,21,23] concrete data on the effect of aberrant nasopharyngeal ICAs on the distances between the ICA and nasopharyngeal subsites have never been published in the literature. We found that the distances between the ICA and nasopharyngeal subsites (TT, RF, PW, and ML) were significantly shortened (15−21%) in the presence of aberrant nasopharyngeal ICAs, which may increase the risk of severe complications in common and uncomplicated nasopharyngeal surgeries such as adenoidectomy, eustachian tuboplasty, and nasopharyngeal biopsies. However, the increased severity of nasopharyngeal ICA aberrancy did not shorten the distances between the ICA and nasopharyngeal subsites.

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