Straight Artery Sign in Extracranial Carotid Artery Dissection

NIJASRI C. SUWANWELA, MD*,
KAMMANT PHANTHUMCHINDA, MD*,
NITAYA SUWANWELA, MD**

Abstract

Background and Purpose : Magnetic resonance imaging (MRI) has become generally accepted as a non-invasive method to provide the definitive diagnosis of cervicocerebral vessel dissection. The finding of an intramural hematoma on axial MR images is the characteristic sign of the disease. However, there has been no previous report of the characteristic magnetic resonance angiographic (MRA) findings.

Method : The authors retrospectively reviewed MRI and MRA findings of patients with spontaneous extracranial carotid dissection. The most striking finding on MRA was the straightness of the affected artery when compared to the non-affected side of the same patient. For quantitative measurement, "Carotid Straightness Index (CSI)" was developed to measure the straightness of the arteries and compared the indices of both extracranial internal carotid arteries in the same patient.

Results : The patients' age range was from 21-55 years (mean 38 years). There were 6 males and 3 females. All patients had the classical "Straight artery sign" on the MRA. The carotid straightness index was significantly higher in the affected artery when compared to the normal side of the same patient.

Conclusion : The straight artery sign and the carotid straightness index can be very useful for early detection of the extracranial carotid dissection. It can be found in early stage disease or in less severe forms of carotid dissection where significant narrowing is not demonstrated.

Key word : Carotid Dissection, MRA, Carotid Straightness Index

**SUWANWELA NC,
PHANTHUMCHINDA K, SUWANWELA N
J Med Assoc Thai 2003; 86 (Suppl 2): S490-S495**

* Neurological Unit, Department of Medicine,
** Department of Radiology, Faculty of Medicine, Chulalongkorn University, Bangkok 10330, Thailand.

Spontaneous carotid dissection is one of the major causes of ischemic stroke in middle aged adults. In the past, the diagnosis was generally based on the clinical picture and characteristic angiographic features[1]. However, improved diagnostic accuracy is currently obtained with magnetic resonance imaging (MRI) and magnetic resonance angiography (MRA). Magnetic resonance imaging (MRI) can demonstrate eccentric high signal intensity blood within the vessel wall, which is the gold standard for diagnosis. MRA usually demonstrates vascular stenosis or occlusion of the carotid artery above its origin[2-5]. Occasionally, a pseudoaneurysm can be demonstrated. To the authors' knowledge, there has been no report of any characteristic MRA findings in this disease. Several patients with carotid dissection who underwent MRI and MRA studies were observed. All of them had repeated transient ischemic attach (TIA) or ischemic stroke in the carotid artery distribution and classical intramural blood on MRI. However, some of these patients did not have evidence of significant carotid stenosis on MRA. Therefore, the MR studies of these patients were carefully reviewed in order to look for characteristic MRA findings and quantitatively measure the difference of the affected and non-affected arteries.

METHOD

The authors retrospectively reviewed MRI and MRA findings of patients who were diagnosed to have spontaneous extracranial carotid dissection during the past 3 years. These patients were previously healthy without any stroke risks. The MRI and MRA were performed by a Signa (GE Medical system) 1.5 Tesla. MRA was done using the 2D time-of-flight technique. Among the 12 cases reviewed, all had the classical picture of dissection demonstrated on the MRI axial T1 images. Three patients had severe stenosis or occlusion of the extracranial carotid artery with signal dropout on MRA and were excluded from the analysis. The other nine patients did not have signal dropout on their first MRA images. In one case, the dissection was evident on the second follow-up images. In order to make the diagnosis in these cases, the clinician had to specifically ask for axial T1 images to look for a characteristic crescent lesion of intramural hematoma.

By observation, the most striking finding on the MRA was the straightness of the affected internal carotid artery when compared to the non-affected side. Loss of the normal curvature was found throughout the entire length of the cervical internal carotid artery (ICA) in all nine cases. Nonetheless, the authors could not confidently draw such a conclusion without an objective measurement, as a result, "Carotid Straightness Index (CSI)" was developed to quantitatively measure the straightness of the arteries and compare the indices of both extracranial internal carotid arteries in the same patient.

Measurement of the carotid straightness index

Since 3-dimensional measurement of the 2-dimensional MRA pictures is not technically practical, the authors proposed a simple way to calculate Carotid Straightness Index (CSI) by projecting the ICA images (2-dimensional time-of-flight) onto two orthogonal planes (Fig. 1).

1. For each projected image, point A was defined at the middle entrance of the ICA origin, and point B, 6 cm distally on the centerline of the ICA. (Continuous line)

2. A curve was drawn along the centerline of the ICA. (Dotted curve)

3. The mean deviation distance between the continuous line and the dotted curve was then calculated by measuring the area between the line and the curve divided by A-B distance (6 cm). Such measurement was performed digitally using Adobe photoshop. This mean deviation physically indicated the curvature of the ICA, in other words, a true straight ICA would have zero deviation.

4. To calculate a dimensionless index for each projected plane, the authors proposed to divide the A-B distance (6 cm) by the mean deviation distance.

$$\text{Straightness Index } (SI_X) = \frac{\text{Distance from A to B}}{\text{Mean deviation}_X}$$

5. Since the projections were on orthogonal planes, the combined Carotid Straightness Index (CSI) was calculated by

$$\text{Carotid Straightness Index (CSI)} = \sqrt{(SI_X^2 + SI_Y^2)}$$

RESULTS

MRI and MRA findings of nine patients with carotid dissection in whom significant stenosis was not obviously seen on their first MRA images were carefully reviewed. The patients' ages ranged from 21-55 years (mean 38 years). There were 6 males

and 3 females, none of whom had vascular risk factors or a history of penetrating or blunt injury to the neck. However, trivial trauma was reported in 4 cases. All presented with stroke or transient ischemic attack in the carotid territory. The clinical findings of each patient are summarized in Table 1.

All patients were diagnosed to have unilateral extracranial carotid dissection based on clinical and classical MRI finding of intramural hematoma (Fig. 2). None of the patients demonstrated "string", or "pearl and string" signs which are angiographic features of patients with severe stenosis secondary to dissection. There was no evidence of pseudoaneurysm. Although significant narrowing of the vessel was not seen on the MRA, the authors found that all the patients had a remarkably similar MRA finding, which

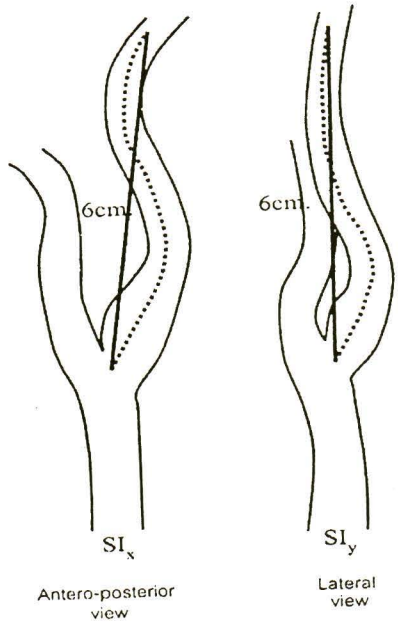

Fig. 1. Illustration of MRA images in two orthogonal planes and the measurement of carotid straightness index.

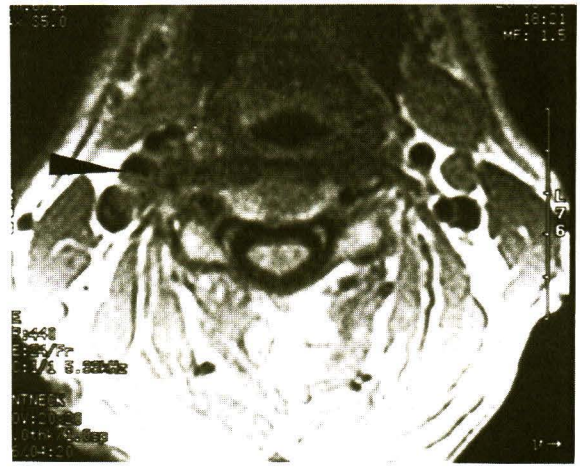

Fig. 2. Axial T1 weighted image of the neck demonstrates a characteristic crescent shaped intramural hematoma in the internal carotid artery.

Table 1. Clinical finding of patients with carotid dissection.

	Age y/sex	Affected side	Clinical	History of minor neck injury
Case 1	55/M	Lt	Transient speech arrest, right hemiparesis	Frequent golf player
Case 2	43/M	Rt	Sudden onset of mild left hemiparesis	Aggressive neck exercise
Case 3	31/M	Rt	Transient weakness of left arm x5	None
Case 4	40/M	Lt	Transient right hemiparesis with motor aphasia x2, sudden right arm weakness	Traditional neck massage
Case 5	21/F	Rt	Rt sided headache and transient left hemiparesis x2, Sudden left hemiplegia	None
Case 6	46/M	Lt	Transient right hemiparesis and aphasia	None
Case 7	29/F	Lt	Transient right hemiparesis x2, sudden right hemiparesis	Factory worker, carried 15 kg industrial parts more than 100 parts/day
Case 8	26/M	Rt	Sudden onset of left hemiparesis	None
Case 9	48/F	Lt	Transient right hemiparesis 4-5 times per day for 2 weeks	None

was the straightness of the affected artery (Fig. 3). As a result, this abnormality was described as the "Straight Artery Sign". The abnormality was obvious when compared to the non-affected side.

On quantitative measurement, the calculated carotid straightness index was significantly lower in the affected side. Marked difference of the carotid indices between the two sides were found ($p = 0.002$).

Fig. 3. Two dimensional time-of-flight MRA image of the neck vessels showing the straight artery sign in the right internal carotid artery.

In all cases, the CSI ratios of the normal and affected sides were more than 2. The difference of CSI and the CSI ratio in each patient are demonstrated in Table 2.

DISCUSSION

Cervicocerebral artery dissections are now recognized with increasing frequency. The most commonly involved artery is the extracranial segment of the internal carotid artery[6,7]. Dissection occurs when blood penetrates into the arterial wall and forms a false lumen. This may result from an intimal tear or rupture of vasa vasorum in the media[6]. The blood in the vessel wall usually dissects through the media leading to a long segment of intramural hematoma. The hematoma may then compress the true lumen resulting in elongated stenosis of the artery.

MRI and MRA play an increasingly important role in the diagnosis of extracranial arterial dissection. Their non-invasive nature offers a major advantage over conventional angiography. According to recent data, MRI and MRA can usually provide a definitive diagnosis of cervicocerebral vessel dissection[2-5]. A finding of intramural hematoma on axial MR images, with or without intimal flap, is characteristic of the disease. On MRA, evidence of arterial stenosis and at times pseudoaneurysm may be demonstrated. In the present report, the authors describe a new MRA finding in nine patients with spontaneous extracranial carotid dissection. All were definitely diagnosed by the characteristic intramural hematoma on MRI images. The striking MRA finding in these patients is the straightening of the affected

Table 2. Comparison of the carotid straightness index (CSI)) between the affected and normal sides.

	Carotid Straightness Index		
	Affected side	Normal side	CSI ratio between affected and normal sides
Case 1	114.81	22.47	5.11
Case 2	126.85	32.22	3.94
Case 3	79.51	12.44	6.39
Case 4	56.68	24.79	2.29
Case 5	102.53	20.52	5.00
Case 6	86.64	38.15	2.27
Case 7	57.93	14.75	3.93
Case 8	93.28	35.35	2.64
Case 9	89.54	29.65	3.02

$p = 0.002$ (Paired t-test)

artery which can be easily picked up on regular MR readings and can also be quantitatively measured by simple calculation. According to the presented data, when CSI of the normal side is more than two times greater than the affected side, straightening of the artery which may represent dissection is suggested. The straight artery sign and the carotid straigtness index may be useful for early detection of extracranial carotid dissection especially in young patients with ischemic stroke in whom significant stenosis can not be demonstrated on MRA. When extracranial carotid dissection is suspected, axial T1-weighted images of the neck should be obtained to look for the classical sign of intramural hematoma.

Two etiologic factors have been proposed in spontaneous carotid artery dissection[8]. First, an extrinsic factor or trivial injury of the neck. The type of injury is usually related to flexion, extension or rotation of the neck. Four of nine cases in the present series recalled a trivial and, in some cases, repeated injury to the neck. Another important etiology underlying dissection is an intrinsic factor related to arterial diseases that may predispose the vessel to dissection. Fibromuscular dysplasia is one of the known common etiologic factors and has been found in 12-15 per cent of patients with ICA dissections[9,10]. Other connective tissue diseases such as Marfan's syndrome, Ehlers-Danlos syndrome and osteogenesis imperfecta have been reported to be related to dissection[11-13]. However, none of the patients in the present study demonstrated obvious clinical signs or radiological features of these diseases. Some reports have suggested that dissection of the carotid artery is more common in redundant vessels which may be more susceptible to trivial trauma[14]. In contrast, the present findings demonstrated dissection in arteries that were straighter than those of the non-affected side. Since there is no proven data suggesting straightening of the artery as an indicator of a wall defect, the straight artery sign is likely to be the result rather than cause of the dissection. Blood in the arterial wall may act as a splint causing a more rigid wall. Therefore, the vessel loses its normal curvature.

SUMMARY

The "Straight Artery Sign" is a newly described MRA finding of extracranial carotid artery dissection. In contrast to the classical string sign, which is the angiographic feature of dissection with severe stenosis, the "Straight Artery Sign" is found in the early stage or less severe forms of carotid dissection where significant narrowing is not demonstrated.

ACKNOWLEDGEMENT

The authors wish to thank Jain Charnnarong, PhD for the measurement and calculation of the carotid straightness index.

(Received for publication on April 6, 2003)

REFERENCES

1. Hart RG, Easton JD. Dissections of cervical and cerebral arteries. Neurol Clin 1983; 1: 155-82.
2. Levy C, Laissy JP, Raveau V, et al. Carotid and vertebral artery dissections: Three-dimensional time-of-flight MR angiography and MR imaging *versus* conventional angiography. Radiology 1994; 190: 97-103.
3. Ozdoba C, Sturzenegger M, Schroth G. Internal carotid artery dissection: MR imaging features and clinical-radiologic correlation. Radiology 1996; 199: 191-8.
4. Bui LN, Brandt-Zawadzki M, Verchese P, Gillan G. Magnetic resonance angiography of cervicocranial dissection. Stroke 1993; 24: 126-31.
5. Provenzale J. Dissection of the internal cartoid and vertebral arteries: Imaging features. AJR 1995; 165: 1099-104.
6. Sasver JL, Easton JD, Hart RG. Dissection and trauma of cervicocerebral arteries. In "Stroke: Pathophysiology, diagnosis, and management" (Barnett HJM, Mohr JP, Stein BB and Yatsu FM, Eds), 2nd ed. New York: Churchill-Livingstone; 671-88.
7. Fisher CM, Ojemann RG, Robertson GH. Spontaneous dissection of cervico-cerebral arteries. Can J Neurol Sci 1978; 5: 9-19.
8. Mokri B. Spontaneous Dissections of cervicocephalic arteries. In "Primer on Cerebrovascular disease" (Welch KMA, Caplan LR, Reia DJ, Siesjp BK, Eds), San Diego: Academic Press; 1997: 390-6.
9. Collins GJ Jr, Rich NM, Clagett GP, Apebar MJ, Salander JM. Fibromuscular dysplasia of the internal carotid arteryies. Ann Surg 1981; 194: 89-96.

10. Bogousslavsky J, Despland PA, Regli F. Spontaneous carotid dissection with acute stroke. Arch Neurol 1987; 44: 137-40.
11. Austin MG, Schaefer RF. Marfan's syndrome, with unusual blood vessel manifestations. Arch Pathol 1957; 64: 205-9.
12. Lach B, Nair SG, Russel NA, Benoit BG. Spontaneous carotid-cavernous fistula and multiple arterial dissections in type IV Ehlers-Danlos syndrome: Case report. J Neurosurg 1987; 66: 462-7.
13. Schievink WI, Limburg M, Dorthuys JW, Oorthuys JW, Fleury P, Pope FM. Cerebrovascular disease in Ehlers-Danlos syndrome type IV. Stroke 1990; 21: 626-32.
14. Petro GR, Witwer GA, Cacayorin ED, et al. Spontaneous dissection of the cervical internal carotid artery : Correlation of arteriography, CT, and pathology. AJR 1987; 148: 393-8.

ความตรงของหลอดคาโรติดในผู้ที่มีโรคหลอดเลือดผิดปกติจากการมีเลือดเซาะในผนัง

นิจศรี สุวรรณเวลา, พบ,*
กัมมันต์ พันธุมจินดา, พบ, นิตยา สุวรรณเวลา, พบ***

ในปัจจุบันการตรวจโดยการใช้คลื่นสะท้อนในสนามแม่เหล็กถือเป็นการตรวจมาตรฐานที่ใช้ในการวินิจฉัยโรคหลอดเลือดคาโรติดผิดปกติจาการมีเลือดเซาะในผนัง ลักษณะเฉพาะที่จะพบในภาพตัดขวางของการตรวจคลื่นสะท้อนในสนามแม่เหล็กนี้ก็คือเห็นมีเลือดอยู่ในผนังของหลอดเลือดล้อมรอบส่วนที่ปกติ อย่างไรก็ตามยังไม่เคยมีรายงานที่กล่าวถึงลักษณะจำเพาะของโรคนี้ในการตรวจคลื่นสะท้อนในสนามแม่เหล็กเพื่อดูหลอดเลือดโดยตรง ในรายงานนี้ได้ศึกษาผู้ป่วยที่โรคหลอดเลือดผิดปกติจากการมีเลือดเซาะในผนังหลอดเลือดที่ไม่ได้เกิดจากอุบัติเหตุ ผลการศึกษาพบว่ามีผู้ป่วยจำนวน 9 ราย อายุระหว่าง 21–55 ปี ลักษณะเด่นที่พบจากการตรวจหลอดเลือดด้วยคลื่นสะท้อนในสนามแม่เหล็กก็คือหลอดเลือดคาโรติดที่ผิดปกติจะมีความตรงเพิ่มขึ้น นอกจากนี้ผู้ศึกษายังได้พัฒนาการวัดดัชนีความตรงของหลอดเลือด และนำไปเปรียบเทียบกับหลอดเลือดปกติ เมื่อคำนวนดัชนีความตรงของหลอดเลือดเทียบกับหลอดเลือดปกติด้านตรงข้าม พบว่ามีความแตกต่างกันอย่างมีนัยสำคัญทางสถิติ

คำสำคัญ : หลอดเลือดคาโรติด, การมีเลือดเซาะในผนัง, ความตรงของหลอดเลือด

นิจศรี สุวรรณเวลา, กัมมันต์ พันธุมจินดา, นิตยา สุวรรณเวลา
จดหมายเหตุทางแพทย์ ฯ 2546; 86 (ฉบับพิเศษ 2): S490–S495

* สาขาวิชาประสาทวิทยา, ภาควิชาอายุรศาสตร์,
** ภาควิชารังสีวิทยา, คณะแพทยศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย, กรุงเทพ ฯ 10330