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The diagnostic value of the resistivity index of the common carotid arteries in severe internal carotid artery stenosis

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Duplex ultrasound is currently used both for screening and for preoperative assessment of the carotid arteries and has completely replaced carotid angiography for the latter purpose in many institutions. The study aimed to identify resistivity index abnormalities in the common carotid arteries in patients with occluded or severely stenosed internal carotid arteries. Sixteen patients with severe internal carotid artery stenosis or occlusion over a twelve-month period were studied by duplex ultrasonography. The resistivity index in the common carotid artery was 0.85 ± 0.03 on the stenotic side compared to 0.74 ± 0.04 on the opposite side ($p < 0.05$). There was no side difference regarding flow velocity. In patients with occluded or severely stenosed internal carotid arteries compensatory vasodilation occurs in cerebral vessels on the same side, and this is also significant, resulting in a decrease in the resistivity index in the common carotid artery of the opposite side. (Folia Morphol 2008; 67: 175–178)

Key words: internal carotid artery, common carotid artery, stenosis, duplex sonography, peak systolic velocity

INTRODUCTION

Doppler sonography is widely used today as a safe and non-invasive method of assessment of the carotid arteries. In addition to its usage in screening subjects suspected of having cerebrovascular disease, it has replaced carotid angiography with catheter in the preoperative evaluation of endarterectomy [3, 5, 7, 8].

Although numerous studies have been conducted to assess normal or stenotic carotid arteries by Doppler sonography [1, 6], variations in vascular resistivity in haemodynamic stenotic carotid arteries are not yet truly understood [4]. The presence of severe (over 70%) stenosis in the brain vasculature leads to uncompensated blood supply and subsequent arterial aneurysms. Moreover, collateral arteries begin to become too dilated to supply the pathological region and prevent ischaemia and cellular necrosis [9]. We assumed that the development of unilateral haemodynamic stenosis in the internal carotid artery leads to dilation of the vasculature of the brain in the same hemisphere and a subsequent decline in vascular resistivity. On the other hand, collateral compensation via the circle of Willis and association of the carotid arteries of the two cerebral hemispheres via the anterior communicating artery leads to a decline in vascular resistance in the non-stenotic internal carotid artery. For this reason we wanted to assess variations in the vascular resistance of the common carotid arteries (the resistivity

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Table 1. Pathological findings in the internal carotid arteries

Pathology	Right internal carotid artery	Left internal carotid artery
Stenosis (70% to 90%)	3 cases (18.8%)	1 case (6.3%)
Stenosis (90% to 99%)	4 cases (25.0%)	2 cases (12.5%)
Complete stenosis	4 cases (25.0%)	2 cases (12.5%)

Table 2. Resistivity indices and peak systolic velocities of the common carotid arteries in the case and control groups

	Case group		Control group	
	Stenotic side	Normal side	Left side	Right side
Resistivity index	0.85 ± 0.03	0.74 ± 0.04	0.81 ± 0.04	0.79 ± 0.04
Peak systolic velocity	41.5 ± 17.0	59.5 ± 22.0	55.1 ± 16.5	55.0 ± 14.6

Data are expressed as means ± SD; the unit of peak systolic velocity was considered to be cm per second

index) in patients with severe (over 70%) internal carotid artery stenosis.

MATERIAL AND METHODS

This study was conducted over the year from April 2005 to March 2006 in Imam Hospital, Tabriz University of Medical Sciences, Tabriz, Iran. Of the 115 patients referred to the radiology section of Imam Hospital, Tabriz, Iran for duplex sonography, 16 had over 70% stenosis and were therefore included in this research. A control group consisting of 16 patients without clear haemodynamic stenosis in the carotid arteries was selected for the purpose of the study.

Duplex sonography was performed using a Hitachi EUB-525 device and a 5 to 10 MHz multi-frequency linear probe in a comfortable room at a convenient temperature and with the patient in a prone position. The common carotid arteries, the bifurcation site, the internal carotid arteries, the external carotid arteries and the vertebral arteries were investigated by colour Doppler and simple sonography. Their waves were recorded and all haemodynamic parameters measured at a site 2 cm proximal to the bifurcation of the common carotid arteries of both sides. The Doppler angle was considered as 60° in all cases and the parameters measured were peak systolic velocity and resistivity index. The Doppler studies were performed for all the subjects of both case and control groups by the same radiologist.

Data were analysed by SPSS 13.0 software using descriptive statistics and an independent t-test.

This study was approved by the Ethics Committee of Tabriz University of Medical Sciences, Tabriz, Iran.

RESULTS

Of the 115 patients who underwent colour Doppler sonography of the carotid arteries of both sides, 16 had stenosis of more than 70% and/or occlusion in one of the internal carotid arteries. All 16 patients were male and their ages ranged between 60 and 82 (73.37 ± 7.67). Table 1 illustrates the pathological findings of the internal carotid arteries of the patients referred to. The other group of 16 subjects, chosen as the control group and with the same mean age (73.37 ± 7.67), had no evident stenosis of the carotids in colour Doppler sonography (Table 1).

The resistivity index of the common carotid artery of the case subjects was lower on the stenotic side than that on the normal side ($p < 0.05$), while there was no significant difference in the resistivity index of the right and left sides of the control subjects (Table 2). Peak systolic velocity did not show any significant difference between the stenotic and normal sides of case subjects. In addition, there was no significant difference in peak systolic volume between the right and left sides of the control subjects (Table 2).

A comparison of resistivity indices in the control and case groups showed the difference between the control group and the stenotic side of the case group was not statistically significant, while the difference between the control group and the normal side of the case group was statistically significant ($p < 0.05$). Peak systolic velocity did differ significantly between the control group and either side of the case group.

DISCUSSION

Occlusion or evident haemodynamic stenosis (more than 70%) in the peripheral arteries leads to an increase in vascular resistance in prestenotic or preoccluded sites, which is of potential diagnostic value. Severe stenosis or occlusion of the internal carotid artery would therefore be likely to have a wave of low resistance to a high resistance pattern [10]. Occlusion or severe stenosis leads to changes in the shape of the wave in the poststenotic parts and would create a damped-down shape pattern. This is one of the characteristics of a decrease in vascular resistance. The other reason for lowered vascular resistance is widening of the vascular beds in parts which are supplied by the stenosed artery, as the distal ischaemic tissues cause the blood to circulate during the diastole by their secondary widening and so compensate to some extent for decreased blood delivery [2, 10]. Thus in severe stenosis of the internal carotid artery the wave becomes of low resistance in its poststenotic parts, because the capillary beds of the same side tend to be secondarily widened to compensate for decreased blood delivery. The internal carotid arteries are anastomised within the skull via the circle of Willis and are communicated by the anterior communicating artery. This anastomosis is of critical significance in the collateral intracranial circulation. In a normal state a small amount of blood is transmitted by the anterior and posterior communicating arteries, while this communication plays a more potential role and serves as the main collateral circulation [10].

In the light of these considerations, we assumed that in patients with severe stenosis of one of the internal carotid arteries or with an occluded one the vascular resistance is decreased owing to secondary widening of the vascular bed. The resistivity index is then decreased on the opposite side, the normal side, because of the increase in blood flow on the normal side via the anterior communicating route and its collateral circulation. In our study the resistivity index was 0.85 in the stenosed side compared to 0.74 on the normal side, which confirms the assumption ($p < 0.05$). In addition, a comparison of the resistivity index of the normal side in the patients and in the controls showed a significant 0.07 difference, which further confirms our theory. Thus we conclude that in severe stenosis or occlusion of one of internal carotid arteries, a compensatory widening occurs on the stenotic side, which leads to a fall in the resistivity index of the opposite side. This maintains the blood circulation in the diastolic phase and prevents irreversible cerebral injury. The collateral system is also potentially activated to regulate the decrease in vascular resistance. In addition, it is concluded that the presence of a difference of more than 0.1 in the resistivity index of the common carotid arteries of the two sides in duplex sonography indicates a severe stenosed or occluded internal carotid artery in the side with the lower resistivity index.

The results of this study are of potential clinical interest for clinical anatomists, radiologists, vascular surgeons and neurological surgeons. We understand that measuring the resistivity index of the common carotid arteries can be a safe and reliable method in the diagnosis of severe internal carotid artery stenosis or its occlusion. Duplex sonography may thus be a potential screening test and can also replace invasive angiographic studies for diagnostic purposes in severe stenosis or occlusion of the internal carotid arteries.

The limitations of this study are the limited number of patients, exclusion of female patients and restriction to the specific age range of 60 to 82 years old. Other studies with large numbers of samples, wide age ranges and a balance between the sexes are necessary for further support of the diagnostic and screening value of the common carotid artery resistivity index in patients with severe stenotic or occluded internal carotid arteries.

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