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Transcranial doppler findings in basilar artery dolichoectasia: a case control study

Zaid Ali Hussein[1], Haider N. Al-Tameemi *[2], Hayder Kadhum Hassoun [2], Ahmed MH Almudhafar [2]

Abstract

Basilar artery dolichoectasia (BAD) is a disorder characterized by dilatation, elongation and tortuosity of the basilar artery. Transcranial Doppler ultrasound (TCD) is a useful tool that can detect blood flow in intracranial vessels including basilar artery (BA). Few studies have been conducted on blood flow changes in BAD. This study was conducted to evaluate the Doppler parameters in dolichoectatic BA and to assess if there is any difference in TCD findings between stroke and non-stroke BAD patients. A case-control study was conducted on 35 patients diagnosed with BAD (26 male, 9 female) and 35 age- and gender-matched control group (without BAD) at the Middle Euphrates Neuroscience Center, Al-Sader Medical City, Al-Najaf, Iraq. Dolichoectasia was diagnosed on non-enhanced brain CT scan using established imaging criteria according to Dan Deng et al criteria. Doppler flow for control and stroke cases was recorded. The parameters measured on TCD were peak systolic velocity (PSV), end diastolic velocity (EDV) mean blood velocity (MBV), pulsatility index (PI) and resistive index (RI). After logistic regression for adjustment for the significant confounders, there was statistically significant difference in Doppler parameters between both groups including decrease in each of PSV, EDV and MBV while both PI and RI weren't statistically significant. Among BAD patients, there was statistically significant difference in all TCD parameters between stroke and non-stroke patients (PSV EDV, MBV, PI and RI). BAD was associated with a decrease in flow velocities as measured by TCD. Furthermore, among BAD patients, those with stroke had lower values for all Doppler parameters than non-stroke patients.

Keywords: Basilar artery, Dolichoectasia, Transcranial Doppler, stroke, Computed tomography

*Corresponding author email: haidern.altameemi@uokufa.edu.iq
[1]Middle Euphrates Neuroscience Center, Al-Najaf health directorate, Iraq
[2]Middle Euphrates Neuroscience Center and Faculty of Medicine/ University of Kufa, Iraq
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Introduction

Basilar artery (BA) dolichoectasia as a part of vertebrobasilar dolichoectasia (VBD) is a term derives from the Greek words: dolichos, meaning elongation, and ectasia, meaning dilatation of the vertebrobasilar arteries [1] and was first described in 1761 [2-4]. The estimated prevalence of VBD ranges between 0.2 and 4.4% [5-7]. Etiology of VBD is variable and is commonly seen in elderly hypertensive male patients [8]. The data suggest that the occurrence of VBD may be due to the combined effect of congenital and acquired factors [9, 10, 11, 12].

Most patients with VBD are asymptomatic and this dolichoectasia is detected incidentally. However, it can present clinically with variable manifestation, with ischemic stroke being the most common [10]. Other manifestations include intracranial hemorrhage [13, 14], cranial nerve compression [15, 16, 17, 18, 19, 20] brain stem compression [21, 22].

Radiological diagnosis of VBD can be achieved using different imaging modalities with the conventional angiography being the reference standard [23]. Conventional magnetic resonance imaging (MRI), magnetic resonance angiography (MRA) [24, 25], computerized tomography CT (24, 26) and computerized tomography angiography (CTA) [2, 23] all provide non-invasive, safer and reliable diagnostic alternatives.

Transcranial Doppler (TCD) ultrasonography provides a relatively inexpensive, noninvasive and real-time measurement of blood flow characteristics of the BA with continuous increase in the clinical and research applications in the cerebrovascular disorders [27]. TCD can show hemodynamic changes in the BA that could not be shown by other imaging methods, but is less often used in BAD [28]. The primary aim of this study is to evaluate the TCD patterns and parameters of dolichoectatic basilar arteries and in comparison with non-dolichoectatic control cases. Secondary aim is to study the difference of TCD findings between stroke and non-stroke patients with basilar artery dolichoectasia (BAD).

Patients and Method

A case-control study was conducted on 35 BAD patients (26 male, 9 female) and age- and gender-matched 35 control patients (without BAD) at Middle Euphrates Neuroscience Centre of Al-Sader Medical City, Al-Najaf, Iraq along ten months period.

Study population: A total of seventy patients (48male, 23 female) were included in the study: cases group (35 patients, 26 male, 9 female) and control group (35 patients, 21 male, 14 female).

Inclusion and exclusion criteria: Patients were included as cases if they were older than 18 years and their brain CT scans showed features BAD. Cases in the control group were age- and gender-matched referred for brain CT scan because of different clinical indications other than

stroke and their CT scans did not show any findings of stroke with normal diameter, length and course of basilar artery.

Patients were excluded from the study when they were younger than 18 years old, had any vascular variation or malformation related to the vertebrobasilar circulation, had any space occupying lesions that may distort the anatomy related to basilar artery or had history of trauma, skull surgery or radiotherapy.

The study was approved by regional Intuitional Review Committee and consents were taken from all patients in both groups to participate in the study.

Radiological evaluation

Patients were examined by either of two CT scanners: multidetector 64 slices, Brilliance (Philips Medical System, 2010) or multidetector 64 slices Somatom Definition (Siemens 2013). Brain CT scan parameters were identical in both devices, including: 100 KV, 450 mAs, 3mm slice thickness, gantry tilt that made axial sections were parallel to the base of skull and the examinations done in craniocaudal direction.

Measurements of basilar artery on brain CT scan

The diameter, length and laterality of BA were assessed on 3 mm-slice thickness non-contrast enhanced CT images using brain window settings. Diameter is the transverse distance of the BA at mid-pons level in axial images, where the fourth ventricle and middle cerebellar peduncles were seen. (figure 1, A); Length is measured in coronal oblique images, from its origin to bifurcation using freehand calipers (figure 1, B) and laterality which was measured in coronal oblique images by drawing an imaginary line from the origin to the bifurcation of BA then another line was drawn perpendicular to the first line at the point of the greatest bending of the BA and measuring this line length (figure 1, C).

Patients were classified as BAD (cases group) using Dan Deng et al criteria (29), where ectasia of the basilar artery was defined as arterial diameter greater than 4 mm in the female or 4.2mm in the male at mid-pons level. BA length more than 29.5 mm and lateral deviation greater than 10 mm perpendicular to a straight line joining the BA origin to its bifurcation were considered as BAD [1, 29].

All cases were examined by the same TCD device (EZ-DOP / DWL 2011 Compumedics Germany, using 2 MHz probe. For both groups, TCD examinations were done by a clinical neurophysiologist (with 8-year experience in TCD work) using 2 MHz dedicated probe. Patient was in supine position and with hyperflextion of the neck. The examination was performed through the transforaminal window and made at different depths (60-90 mm) with fine angulations of the probe until finding the best proper spectral wave of basilar artery. Spectral Doppler wave was recorded and different spectral parameters were calculated automatically including peak

systolic velocity (PSV), end diastolic velocity (EDV), mean blood velocity (MBV), pulsatility index (PI) and resistive index (RI) (FIG 23).

Statistical analysis

Data of the studied groups were analyzed using the SPSS version 24, IBM, USA, 2015. Chi square test was used to compare categorical variables; Fisher's exact test was used as an alternative when chi square was inapplicable. Student's t test (independent 2 sample model) was used to compare mean Doppler parameters between patients and controls, and also between stroke patients and non-stroke patients, Partial correlation analysis was used to assess the correlation between dolichoectasia and Doppler parameters after controlling the effect of significant confounders. A P-value of ≤ 0.05 was considered as significant.

Results

A total of seventy patients (48male, 23 female) aged 35-75 years (mean age=56.8 years) were included in the study and the demographic characteristics are demonstrated in table 1.

Table 1.

Demographic characteristics of the studied groups

		Patients		Control		P. value
		No.	%	No.	%	
Age (years)	≤ 40	1	2.9	2	5.7	0.52
	41 - 50	7	20.0	9	25.7	
	51 - 60	10	28.6	13	37.1	
	> 60	17	48.6	11	31.4	
	mean (SD)	57.9 (8.7)		55.7 (11.4)		
Gender	Male	26	74.3	21	60.0	0.31
	Female	9	25.7	14	40.0	
BMI	Normal	9	25.7	11	31.4	0.86
	Overweight	21	60.0	19	54.3	
	Obese	5	14.3	5	14.3	
Smoking		13	37.1	8	22.9	0.30
Family history of stroke		1	2.9	0	0.0	0.50

Table 2.

Co-morbidities of the studied groups

	Group				P. value
	Patients		Control		
	No.	%	No.	%	
Hypertension	19	54.3	7	20.0	0.003
Medications used	6	17.1	2	5.7	0.13
DM	16	45.7	5	14.3	0.004
Hyperlipidemia	10	28.6	1	2.9	0.003
Arrhythmia	3	8.6	0	0.0	0.077
Other chronic illnesses	4	11.4	6	17.1	0.49

The difference between BAD patients and control groups was not significant regarding medications, history of arrhythmia and other chronic illness (table 2) while significant regarding hypertension, hyperlipidemia and DM the difference was significant and more in BAD patients than control group.

In BAD patients, there was statistically significant decrease in mean PSV (40 vs 52 cm/sec; P value< 0.001), mean EDV (15 vs 21 cm/sec; P value< 0.001), mean MBV (26 vs 36 cm/sec; P value< 0.001) and significant increase in both PI (P value= 0.006) and RI values (P value= 0.020).

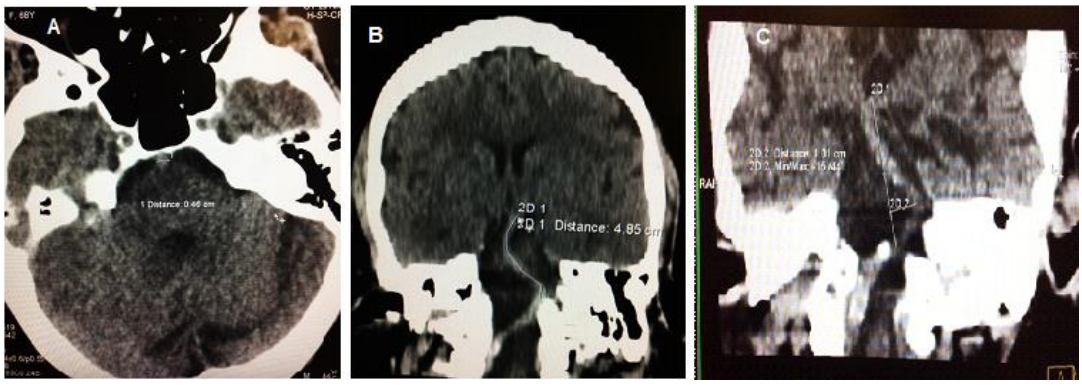

Figure 1.

Measurement of basilar artery dimensions for diagnosis of dolichoectasia. Transverse diameter measured on axial (A), the length (B) and the laterality (C) measured on coronal CT sections.

Table 3.

Comparison of Doppler parameters among the studied groups

	BAD Patients		Control		P value
	Mean	SD	Mean	SD	
PSV	40	12	52	9	< 0.001
EDV	15	5	21	6	<0.001
MBV	26	7	36	7	< 0.001
PI	1.15	0.50	0.88	0.22	0.006
RI	0.70	0.18	0.61	0.11	0.020

** (BAD= basilar artery dolichoectasia, PSV= peak systolic velocity, EDV= end diastolic velocity, PI= pulsatility index, RI= resistive index).*

After logistic regression to adjust the effect of significant confounders (hypertension, hyperlipidemia and DM) on Doppler parameters, the decrease in each of PSV, EDV and MBV was still significant (P values 0.010, .031 and 0.002 respectively), while the increase in both PI and RI was not significant (P. values 0.071 and 0.085 respectively).

Table 4.

Correlation between BAD patients and Doppler parameters after adjustment for confounders

	R	P value
PSV	0.32	0.01
EDV	0.27	0.031
MBV	0.373	0.002
PI	0.223	0.071
RI	0.213	0.085

To assess a possible effect of the selection bias that may result from exclusion of stroke in control cases, sensitivity analysis was conducted after inclusion of non-stroke BAD patients only in the statistical analysis. The results showed significant difference in all Doppler parameters including PSV, EDV, MBV, RI and PI (table 5).

Table 5.

Comparison of TCD findings of basilar artery among stroke and non-stroke patients

Parameter	Stroke		Non-stroke		P value
	Mean	SD	Mean	SD	
PSV	38	13	48	10	0.001
EDV	13	4	20	6	< 0.001
MBV	23	6	33	7	< 0.001
PI	1.26	0.49	0.94	0.34	0.004
RI	0.72	0.18	0.63	0.14	0.039

Discussion

BAD patients and control cases in this study were not significantly different regarding BMI, smoking and family history of stroke (Table 1). This disagreed with Ken Ikeda et al Japanese study [3] as these comorbidities appeared significantly among VBD patients in comparison with non VBD patients. The much higher number of the control non VBD cases (5000 cases) versus only 96 of VBD patients may explain this disagreement. Hypertension, hyperlipidemia and DM represented significant confounders that may affect Doppler parameters in our study which was in agreement with Ken Ikeda et al [3] and Dziewasa R. et al [8], the later has proposed a hypothesis stating that hypertension induced by atherosclerosis is a major contributing factor to VBD. On the other hand, Pico et al [30] found no correlation between atherosclerosis and intracranial arterial dolichoectasia.

All measured Doppler parameters were significantly different between both study groups in BAD patients, but after logistic regression, only the decrease in PSV, EDV and MBV values persisted. This reflects that the reduction in PSV, EDV and MBV BAD are associated with BAD, while increment in both PI and RI might be due to the effect of hypertension, hyperlipidemia and DM as according to Dikanovic M et al [31], the PI was significantly higher in diabetic patients than in healthy controls.

The reported marked reduction in flow rate using TCD but with normal morphology and pulsation in Egido JA et al [28] van also support our finding. Furthermore, Babikian et al [32] found that flow velocities were moderately to severely reduce in the dolichoectatic arterial segments, and were frequently less than two standard deviations below the mean control values while they found normal PI and RI. This reduction of main velocity parameters is very important regarding risk of cerebral ischemia and can explain one of the important reported consequences secondary to VBD [10].

Normal resistivity and pulsatility indices have been reported in the dolichoectatic arteries including VBD (33) which suggest normal peripheral resistance [34] and arterial compliance [35] in these arteries which can explain the lack of significant difference between patients with BAD and control groups regarding PI and RI in our study. On other hand, Mehdi F et al [36] in their study of the effect of hypercholesterolemia on Doppler parameters of intracranial arteries found that MBV, PI and RI of the intracranial arteries were not significantly different between the hypercholesterolemia and normal control groups which disagrees with our result.

The results of sensitivity analysis (by assessing the correlation after inclusion of only non-stroke BAD patients) showed that the reduction in PSV, EDV and MBV and increment in both PI and RI remained statistically significant. The significant difference in the Doppler parameters between stroke and non-stroke patients is consistent with Kumral E et al study [37] and supports the evidence that flow turbulence in dolichoectatic BA plays an important role in the pathogenesis of the posterior circulation stroke. Rautenberg W et al [12] has found that the reduced antegrade flow with decreased peak and mean systolic velocities measured played a role in the development of ischemic stroke in dolichoectatic patients.

We think that the main results of this study emphasize the significant role of flow turbulence in BA in patients with dolichoectasia and consequent complication of cerebral ischemia. Therefore, radiologists should pay attention to presence of the BAD during evaluation of brain imaging examination, and to mention the findings in the reports as it may increase the risk of ischemic stroke. Moreover, being a risk factor for posterior circulation infarcts, presence of BAD may alerts the neurologist to consider more specific preventive measures to reduce the future risk of serious posterior circulation ischemic events according to patient's clinical state including the appropriate use of anticoagulation as which has been suggested to be beneficial [12] in such cases.

This study has some limitations. Firstly, although non-enhanced CT is a good method for BA examination and for measuring length, width and tortuosity, it cannot exclude intraluminal stenosis that may subsequently affect Doppler examination results. Another, limitation is inherent to the sonographic examination (TCD) is being operator-dependent. In addition, there is a lack of well-developed protocols in dealing with patients of VBD regarding the equipment used like CT, CT angiography and TCD, which may affect the proper way of diagnosis and assessment in this study.

Conclusions

The data of this study has significant reduction in blood flow velocities was seen in dolichoectatic BA as measured by TCD in comparison to normal population. Among BAD patients, those with stroke had significant Doppler changes (decrease PSV, EDV, MBV; increase PI and RI) in comparison to non-stroke BAD patients. Nevertheless, considering limited number of the current

sample size further studies with larger sample and cohort studies correlating TCD findings in VBD patients regarding different types of management and follow up are suggested.

Competing interests

The authors declare that they have no competing interests.

Ethical Committee

This work was approved by Middle Euphrates Neuroscience Center, and Faculty of Medicine/ University of Kufa.

Authors' contributions

All authors participated in the conception and design of the study, collected and analyzed the data, read and reviewed the final manuscript.

List of abbreviations

BA: Basilar artery; BAD: Basilar artery dolichoectasia; TCD: Transcranial Doppler

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