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Value of external carotid artery resistive index for diagnosis of cavernous sinus dural arteriovenous fistula and determination of malignant type☆,☆☆

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ABSTRACT

Purpose: Cavernous sinus dural arteriovenous fistula (CSDAVF) causes hemodynamic disturbance in the arteries, which is detected by carotid Doppler sonography (CDS). The objective of the study was designed for validation of CDS in the diagnosis of CSDAVF.

Material and methods: 42 CSDAVF patients confirmed by angiography were enrolled. All patients were performed CDS before angiography. Evaluations of CDS parameters were compared with control subjects.

Results: The ECA resistive index (RI) shows the best performance. The highest yield shown on left ECA RI and increased from 78.6% to 91.7% on malignant-typed.

Conclusion: CDS may be beneficial as the screening tool for CSDAVF.

1. Introduction

Cavernous sinus dural arteriovenous fistula (CSDAVF) is arteriovenous communication, which is predominantly supplied by the meningeal branches of the external carotid artery (ECA) and drained into the cavernous sinus and its venous tributaries. Conventional cerebral catheter angiography remains the standard measure for the diagnosis.

According to Cognard classification, DAVF is divided into 5 categories. In term of prognosis, DAVF can be broadly divided into benign and malignant (aggressive) types. The Cognard classification types I and IIa are recognized as benign type, while the remaining (types IIb to V) are recognized as malignant (aggressive) type [1]. The malignant types have the combined annual risk of morbidity and mortality about 10–15% [2].

The pathologic consequence of arteriovenous shunts may cause hemodynamic disturbance in the feeding vessels, including a substantial reduction in the flow resistance and rising of flow velocity. Some investigators have described the effectiveness of carotid Doppler sonography (CDS) in the diagnosis of intracranial dural AVFs [3] [4] [5] [6]

Computed tomography angiography (CTA), or magnetic resonance angiography (MRA), has a high diagnostic performance but the CT has a risk of exposed radiation and contrast allergies. MRI's are not available from many health care providers and it is not economically friendly in low- and middle-income countries. As a matter of fact, many patients have to be scheduled for very long waiting periods for MRA or CTA, which probably delays the appropriate treatment of the patient, particularly in whom harbor cortical venous reflux exists. While the CDS may be an alternative diagnostic tool because of its availability, low cost and non-invasiveness. It has been no investigation emphasis on those CDS parameters in the diagnosis of cavernous sinus dural arteriovenous fistula or the prediction of the cortical venous reflux. The primary objective of this study was designed to validate the performance of the CDS in the diagnosis of CSDAVF. The secondary objectives were the performance of CDS in its ability to determine CSDAVF with cortical venous reflux and the primary side(s) of the cavernous arteriovenous shunt.

2. Material and methods

2.1. Patients

This study received approval from the institutional ethical review board. From January 2011 through September 2015, patients with clinical and imaging suspicion of CSDAVF were referred to our institute

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Table 1
Data of CDS parameters.

CDS parameters	Median (25%–75%)			
	Patients with CSDAVF		Reference control subjects	
	Right	Left	Right	Left
ECA PSV	70.9 (57.8–92.0)	72.0 (54.0–90.5)	71.8 (57.7–84.4)	72.1 (52.6–81.5)
ECA EDV	16.5 (11.1–22.6)	17.9 (13.8–26.4)	11.3 (7.7–15.2)	11.0 (8.6–14.7)
ECA RI	0.76 (0.71–0.83)	0.73 (0.66–0.78)	0.87 (0.80–0.89)	0.83 (0.79–0.89)
ICA PSV	64.1 (51.3–76.4)	69.2 (48.5–78.9)	63.8 (50.1–75.6)	58.9 (50.8–77.8)
ICA EDV	24.2 (18.2–31.0)	24.4 (18.8–31.3)	21.9 (14.0–27.6)	19.6 (17.7–26.3)
ICA RI	0.63 (0.55–0.66)	0.61 (0.55–0.66)	0.66 (0.60–0.71)	0.66 (0.61–0.69)
CCA PSV	69.8 (56.2–85.6)	80.0 (68.0–90.9)	73.3 (61.6–83.3)	76.8 (64.2–96.7)
CCA EDV	22.2 (17.0–26.5)	26.2 (21.3–33.4)	18.8 (14.5–23.7)	22.0 (14.1–29.5)
CCA RI	0.70 (0.62–0.74)	0.66 (0.61–0.73)	0.72 (0.67–0.80)	0.72 (0.66–0.79)

ECA = external carotid artery, ICA = internal carotid artery, CCA = common carotid artery, PSV = peak systolic velocity, EDV = end diastolic velocity, RI = resistive index, CSDAVF = cavernous sins dural arteriovenous fistula, CDS = carotid Doppler sonography.

Table 2
Diagnostic performance of CDS parameters associated with ECA.

CDS parameters		Cut point	Sensitivity	Specificity	PPV	NPV	Accuracy
Right	ECA PSV	70	57.1	46.3	52.2	51.4	51.8
	ECA EDV	15	57.1	70.7	66.7	61.7	63.9
	ECA RI	0.78	59.5	80.5	75.8	66	69.9
Left	ECA PSV	70	52.4	46.3	50	48.7	49.4
	ECA EDV	15	69	75.6	74.4	70.5	72.3
	ECA RI	0.78	78.6	75.6	76.7	77.5	77.1

ECA = external carotid artery, ICA = internal carotid artery, CCA = common carotid artery, PSV = peak systolic velocity, EDV = end diastolic velocity, RI = resistive index, CSDAVF = cavernous sins dural arteriovenous fistula, CDS = carotid Doppler sonography.

Table 3
Diagnostic performance of CDS parameters associated with ICA and CCA

CDS parameters		Cut point	Sensitivity	Specificity	PPV	NPV	Accuracy
Right	ICA PSV	60	57.1	43.9	51.1	50	50.6
	ICA EDV	25	50	65.9	60	56.3	57.8
	ICA RI	0.65	73.8	51.2	60.8	65.6	62.7
	CCA PSV	75	35.7	56.1	45.5	46	45.8
	CCA EDV	20	61.9	58.5	60.5	60	60.2
	CCA RI	0.7	57.1	58.5	58.5	57.1	57.8
Left	ICA PSV	60	57.1	53.7	55.8	55	55.4
	ICA EDV	25	47.6	70.7	62.5	56.9	59
	ICA RI	0.65	73.8	51.2	60.8	65.6	62.7
	CCA PSV	75	59.5	39	50	48.5	49.4
	CCA EDV	20	83.3	46.3	61.4	73.1	65.1
	CCA RI	0.7	66.7	58.5	62.2	63.2	62.7

ECA = external carotid artery, ICA = internal carotid artery, CCA = common carotid artery, PSV = peak systolic velocity, EDV = end diastolic velocity, RI = resistive index, CSDAVF = cavernous sins dural arteriovenous fistula, CDS = carotid Doppler sonography.

(Interventional neuroradiology division, department of Radiology, Ramathibodi hospital, Thailand). Patients were examined with the CDS by experienced radiologists within a month before diagnostic cerebral angiography. The subsequently angiography was done and interpreted by interventional neuroradiologists using standard methods (Digital subtraction angiography). Forty-two patients were met with the diagnostic confirmation. Patients with a negative angiography for CSDAVF were excluded from this study. Benign-typed CSDAVF is defined as any patients whose angiography demonstrated antegrade flow of vein downstream to the cavernous sinus, intercavernous to the contralateral side and/or ophthalmic venous drainage. Malignant-typed CSDAVF is defined as any patients who angiography demonstrated retrograde cortical venous reflux (Cognard IIb) [1]. The medical records of the patients were reviewed in detail retrospectively for the demographic data.

2.2. Carotid Doppler sonography

The carotid Doppler sonography was performed with the Philips IU-22 system containing a L12–5 broadband linear transducer. B-mode and pulse Doppler imaging of the distal common carotid artery, extracranial external carotid artery and extracranial internal carotid artery of each side were recorded. CDS data was obtained more than one time and chose by the observer based on optimization and appropriate Doppler sampling; such as centered luminal location and appropriate angle of insolation. The 3 major parameters of CDS including peak systolic velocity (PSV), end diastolic velocity (EDV), and resistive index (RI) were measured and recorded. The RI was defined as (PSV-EDV)/PSV.

2.3. Reference control subjects

The age-matched control subjects were collected by a retrospective data collection from the screening CDS for carotid diseases. Each subject underwent a complete CDS study with the same machines as those used in the study group. All subjects had no clinical suspicion for intracranial arteriovenous shunt. Forty-one patients with no carotid disease who were shown on the screening CDS were enrolled and used as reference control subjects.

2.4. Statistical analysis

The statistical analysis performed by using the SPSS version 17.0 (SPSS Inc., Chicago, IL). The CDS data of patient's group and reference control group were analyzed. Pearson's chi-square test was used to determine the difference of categorical data between the patient's group and reference control group. Each variable's CDS parameters were evaluated for the best cut of point to meet the highest diagnostic performance including sensitivity, specificity, accuracy, positive predictive value (PPV) and negative predictive value (NPV).

3. Results

Of the 42 patients with cavernous sinus dural arteriovenous fistulas who underwent CDS studies (9 males and 33 females). The patient's age ranged from 40 to 80 years. Feeders of CSDAVF included branches from the right ECA and right ICA in 28 patients (66.7%) and 29 patients (69%), respectively and from the left ECA and left ICA in 30 patients (71.4%) and 38 patients (90.5%), respectively. 17 patients (40.5%) and 16 patients (38.1%) had a location of shunt on the right and left sides, respectively. Bilateral shunts are observed in 9 patients (21.4%). The