# ASSESSMENT OF VERTEBRAL ARTERIES BLOOD FLOW SPECTRAL DOPPLER INDICES IN COMPARISON WITH INTERNAL AND COMMON CAROTID ARTERIES BLOOD FLOW SPECTRAL DOPPLER INDICES

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**Abstract-** Vertebrobasilar insufficiency is the cause of cerebrovascular accidents in 20% of cases. There are few reports regarding spectral Doppler indices (SDIs) of vertebral arteries (VAs) normal blood flow. The objective of this study was to provide basic reference data about SDIs of VAs normal blood flow separately and in comparison with internal carotid arteries (ICAs) and common carotid arteries (CCAs) normal blood flow SDIs. This cross-sectional study performed on 70 normal patients. Color Doppler sonography (CDS) and spectral Doppler sonography (SDS) of right and left VAs (RVA and LVA), right and left CCAs (RCCA and LCCA), and right and left ICAs (RICA and LICA) were performed. The mean peak systolic velocity (PSV), end-diastolic velocity (EDV), and resistive index (RI) values of RVA blood flow were 41.60 ± 9.6, 14.60 ± 3.7 and 0.65 ± 0.06, and the mean PSV, EDV and RI values of LVA blood flow were 42.20 ± 10.2, 15.20 ± 4.2 and 0.64 ± 0.05, respectively. There was not statistically significant difference between the mean PSV, EDV and RI values of RVA and LVA blood flows. The mean PSV and EDV values of VAs blood flows were significantly lower than the values of CCAs and ICCAs. The mean RI value of VAs blood flows was significantly lower than the mean RI value of CCAs, but there was not statistically significant difference between the mean RI value of VAs blood flows and the mean RI value of ICAs blood flows.



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**Key words**: Color Doppler sonography, spectral Doppler sonography, spectral Doppler indices, vertebral artery, common carotid artery, internal carotid artery

## INTRODUCTION

Vertebrobasilar insufficiency is the most important disorder of vertebral arteries (VAs) and the cause of cerebrovascular accidents (CVAs) in 20% of cases (1). Ultrasound assessment of the VAs, internal carotid arteries (ICAs) and common carotid arteries (CCAs) has become a widely available and reliable noninvasive tool in the diagnosis of cerebrovascular disorders (2-5).

With development of spectral Doppler sonography (SDS) and color Doppler sonography (CDS), immediate visualization of VAs and assessment of spectral Doppler indices (SDIs), consisted of peak systolic velocity (PSV), end-diastolic velocity (EDV) and resistive index (RI) values of VAs segments blood flows, has become possible (6). However, there are few reports regarding SDIs of VAs normal blood flow (3, 6).

VAs have five segments. The second one (V2 segment), passes through transverse processes foramina of the second to sixth cervical vertebrae (7-

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11) and is more accessible and feasible for SDS assessment.

The objective of this study was to provide basic reference data about SDIs of VAs V2 segment normal blood flow, separately and in comparison with ICAs and CCAs normal blood flow SDIs, for better and earlier detection of disordered SDIs of these arteries blood flow.

## MATERIALS AND METHODS

This cross-sectional study performed in Amir Aalam Hospital by three radiologists experienced in vascular color Doppler sonography (CDS) and spectral Doppler sonography (SDS), from February 2002 to March 2004, 150 apparently normal participants within the age range of 20-40 included in the study. Exclusion criteria consisted of: 1) age < 20 and > 40 years old, 2) known neurologic diseases, 3) known cardiac diseases, 4) hypertension (systolic blood pressure > 140 mmHg, diastolic blood pressure > 40 mmHg), 5) fasting blood sugar > 140 mg/dl, 6) cigarette smoking, 7) oral contraceptive consumption > 6 months, 8) carotid arteries with obstructed segments, significant segmental stenosis, and atheromatous plaques, and 9) VAs with caudal blood flow direction (see below). We obtained informed consent from all participants.

The sonography system was Aloka SSD-1700, made in Japan, and the transducers were 3.5 and 7.5 MHZ in frequency. All patients were in supine position and their necks hyperextended during examination. At first, gray-scale sonography of right internal carotid artery (RICA), left internal carotid artery (LICA), right common carotid artery (RCCA) and left common carotid artery (LCCA) were performed to detect calcified atheromatous plaques in the wall of these arteries. Then, for detection of obstructed segments and hypoechoic noncalcified atheromatous plaques CDS was performed.

Obstruction considered as nonvisualization of flow in the affected segment of these arteries. Arteries with atheromatous plaques and obstructed segments excluded from the study.

After then, RICA, LICA, RCCA and LCCA flows assessed by SDS, and SDIs of their blood flows which consisted of PSV, EDV and RI were measured to detect any significant segmental stenosis. PSV and EDV value units were centimeter/second (cm/s), which measured automatically by sonography system, and the RI value calculated based on known formula: RI = PSV-EDV/PSV. Insonation angle was in the range of 54-60 degrees during SDS. Significant segmental stenosis considered as stenosis more than 45% in the affected segment, if the calculated ratio of blood flow PSV in the stenotic segment to the blood flow PSV of prestenotic segment was more than 1.8, based on known standard Doppler indices nomogram. Carotid arteries with significant segmental stenosis excluded from the study.

The PSV, EDV, and RI of RCCA, LCCA, RICA and LICA blood flows were compared with each other, respectively. For detection of VAs during CDS of RCCA and LCCA blood flows, scanning plane slightly tilted laterally from the RCCA and LCCA bifurcation point until cervical spine transverse processes appeared, and after that, right vertebral artery (RVA) and left vertebral artery (LVA) blood flows (V2 segment), were observed running through these processes, respectively.

During the examination, normal blood flow direction in VAs was confirmed by comparison with blood flow direction in CCAs. Cephalic flow direction considered as normal VAs blood flow direction. VAs with caudal blood flow direction excluded from the study. After detection of VAs blood flows, SDS of RVA and LVA blood flows performed, and SDIs of their flows, consisted of PSV, EDV and RI, were measured. Insonation angle was in the range of 54-60 degrees during SDS. Then PSV, EDV, and RI of RVA and LVA flow compared with each other.

Finally, PSV, EDV, and RI of RVA blood flow, compared with the same blood flow SDIs of RICA and RCCA, and PSV, EDV and RI of LVA blood flow compared with the same flow SDIs of LICA and LCCA blood flows, respectively.

All data collected in SPSS version 12 software and analyzed by Student's *t* test. A value of $P \leq 0.05$ was considered statistically significant

# RESULTS

From the 70 patients whom included and assessed in this study, 35 were male and 35 were female. The age range was 20-40 years old.

In these 70 patients, the minimum PSV, EDV and RI values of RCCA blood flow were 44.30 cm/s, 13.60 cm/s and 0.62, respectively; the maximum PSV, EDV and RI values of RCCA blood flow were 102.40 cm/s, 34.6 cm/s and 0.80, respectively, and the mean PSV, EDV and RI values of RCCA blood flow were 70.20 ± 13.2 cm/s, 21.00 ± 4.8 cm/s and 0.70 ± 0.04, respectively (Table 1).

The minimum PSV, EDV and RI values of LCCA blood flow were 41.20 cm/s, 12.40 cm/s and 0.56, respectively; the maximum PSV, EDV and RI values of LCCA blood flow were 98.50 cm/s, 39.20 cm/s and 0.80, respectively, and the mean PSV, EDV, and RI values of LCCA blood flow were 70.50 ± 13.5 cm/s, 20.90 ± 4.7 cm/s and 0.70 ± 0.04, respectively (Table 1).

The minimum PSV, EDV, and RI values of RICA blood flow were 32.50 cm/s, 14.70 cm/s, and 0.45, respectively; the maximum PSV, EDV, and RI values of RICA blood flow were 77.50 cm/s, 38.40 cm/s, and 0.72, respectively, and the mean PSV, EDV, and RI values of RICA blood low were 66.00 ± 12.6 cm/s, 24.70 ± 5.3 cm/s and 0.63 ± 0.06, respectively (Table 1).

The minimum PSV, EDV, and RI values of LICA blood flow were 33.70 cm/s, 14.10 cm/s and 0.48, respectively; the maximum PSV, EDV, and RI values of LICA blood flow were 97.00 cm/s, 38.40 cm/s and 0.77, respectively, and the mean PSV, EDV, and RI values of LICA blood flow were 66.30 ± 13 cm/s, 24.90 ± 5.5 cm/s and 0.62 ± 0.05, respectively (Table 1).

The minimum PSV, EDV, and RI values of RVA blood flow were 15.30 cm/s, 5.30 cm/s and 0.50, respectively; the maximum PSV, EDV, and RI values of RVA blood flow were 63.10 cm/s, 24.40 cm/s and 0.79, respectively, and the mean PSV, EDV, and RI values of RVA blood flow were 41.60 ± 9.6 cm/s, 14.60 ± 3.7 cm/s, and 0.65 ± 0.06, respectively (Table 1).

The minimum PSV, EDV, and RI values of LVA blood flow were 20.80 cm/s, 6.90 cm/s and 0.47, respectively; the maximum PSV, EDV, and RI values of LVA blood flow were 64.60 cm/s, 31.60 cm/s, and 0.73, respectively, and the mean PSV, EDV, and RI values of LVA blood flow were 42.20 ± 10.2 cm/s, 15.20 ± 4.2 cm/s and 0.64 ± 0.05, respectively (Table 1).

There was not any significant difference between PSV, EDV and RI values of RCCA and LCCA, RICA and LICA, RVA and LVA blood flows, respectively ($P > 0.1$).

PSV, EDV and RI values of RVA and LVA blood flows were significantly lower than PSV, EDV, and RI values of RCCA and LCCA blood flows, respectively ($P$ value $< 0.001$). PSV and EDV values of RVA and LVA blood flows were significantly lower than PSV and EDV values of RICA and LICA blood flows, respectively ($P < 0.001$).

There was not any statistically significant difference between RI values of RVA and LVA blood flows and RI values of RICA and LICA blood flows, respectively ($P > 0.001$).

**Table 1.** Mean PSV, EDV, and RI values of RVA, LVA, RCCA, LCCA, RICA and LICA blood flows in this study*

| SDIs | RVA | LVA | RCCA | LCCA | RICA | LICA |
|---|---|---|---|---|---|---|
| **PSV** (cm/s) | 41.60 ± 9.6 | 42.20 ±10.2 | 70.20 ±13.2 | 70.50 ± 13.5 | 66.00 ±12.6 | 66.30 ± 13 |
| **EDV** (cm/s) | 14.60 ± 3.7 | 15.20 ± 4.2 | 21.00 ± 4.8 | 20.90 ± 4.7 | 24.70 ± 5.3 | 24.90 ± 5.5 |
| **RI** | 0.65 ± 0.06 | 0.64 ± 0.05 | 0.70 ± 0.04 | 0.70 ± 0.04 | 0.63 ± 0.06 | 0.62 ± 0.05 |

Abbreviations: RVA, right vertebral artery; LVA, left vertebral artery; LCCA, left common carotid artery; RCCA, right common carotid artery; RICA, right internal carotid artery; LICA, left internal carotid artery; SDIs, spectral Doppler indices; PSV, peak systolic velocity; EDV, end-diastolic velocity; RI, resistive index.

* Data are given as mean ± SD.

## DISCUSSION

In this study, the mean PSV, EDV, and RI values of RVA blood flow were as 41.60 ± 9.6 cm/s, 14.60 ± 3.7 cm/s and 0.65 ± 0.06, and the mean PSV, EDV and RI values of LVA Blood flow were as 42.20 ± 10.2 cm/s, 15.20 ± 4.2 cm/s, and 0.64 ± 0.05, respectively. There was not statistically significant difference between the mean PSV, EDV and RI values of RVA and LVA blood flows. The mean PSV and EDV values of RVA blood flow are 45.9 ± 11.1 cm/s and 13.8 ± 3.8 cm/s, and the mean PSV and EDV values of LVA blood flow are 51.5 ± 13.3 cm/s and 16.1 ± 5.8 cm/s, respectively (10). The mean PSV value of RVA blood flow is 48.3 ± 14.09 cm/s, and the mean PSV value of LVA blood flow is 48.9 ± 13.9 (11). The mean PSV value of VAs blood flows is 40 ± 10 cm/s (1). In one study the mean PSV and EDV values of VAs blood flows reported as 59 ± 17 cm/s and 19 ± 8 cm/s, respectively (5).

The mean PSV and EDV values of VAs blood flows are 56 ± 10.5 cm/s and 17 ± 4.3 cm/s, respectively (6). The mean PSV, EDV, and RI of VAs blood flows are 52 ± 6 cm/s, 17 ± 3 cm/s, and 0.68 ± 0.05, respectively (8). There is not any statistically significant difference between PSV, EDV and RI values of RVA and LVA blood flow (7, 8, 10). In this study, the mean PSV, EDV and RI values of RCCA blood flow were as 70.20 ± 13.2 cm/s, 21.00 ± 4.8 cm/s, and 0.70 ± 0.04, and the mean PSV, EDV, and RI values of LCCA blood flow were as 70.50 ± 13.5 cm/s, 20.90 ± 4.7 cm/s, and 0.70 ± 0.04, respectively. There was not statistically significant difference between the mean PSV, EDV, and RI values of RCCA and LCCA blood flows. The mean PSV, EDV, and RI values of CCAs blood flows are 101 ± 22cm/s, 25 ± 5 cm/s, and 0.74 ± 0.05, respectively (8). There is no statistically significant difference between the mean PSV, EDV, and RI values of RCCA and LCCA blood flows (7, 8, 10). The mean PSV, EDV, and RI values of RICA blood flow were as 66.00 ± 12.6 cm/s, 24.70 ± 5.3 cm/s, and 0.63 ± 0.06, and the mean PSV, EDV, and RI values of LICA blood flow were as 66.30 ± 13 cm/s, 24.90 ± 5.5 cm/s, and 0.62 ± 0.05, respectively, in this study. There was not statistically significant difference between the mean PSV, EDV, and RI values of RICA and LICA blood flows. The mean PSV, EDV and RI values of ICAs blood flows are 72 ± 18 cm/s, 26 ± 5 cm/s, and 0.62 ± 0.07, respectively (8). There is not statistically significant difference between the mean PSV, EDV, and RI values of RICA and LICA blood flows (7, 8, 10).

In conclusion, in this study, the mean PSV, and EDV values of VAs blood flows were significantly lower than the mean PSV, and EDV values of CCAs and ICCAs blood flows, respectively. The mean RI value of VAs blood flows was significantly lower than the mean RI value of CCAs blood flows, but there was not statistically significant difference between the mean RI value of VAs blood flows and the mean RI value of ICAs blood flows. There is not statistically significant difference between the mean RI value of VAs blood flows and ICAs blood flows (8, 9).

### Conflict of interests

We have no conflict of interests.

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