

# **Assessment of Vertebrobasilar Insufficiency using duplex ultrasonography and neurophysiological tools**

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*To My Family*

## Abstract

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This study was carried on was conducted on two groups; 30 patients presenting with cerebrovascular insufficiency within the territory of the vertebrobasilar system and 20 normal control subjects. Of the patients group, 22 presented with established stroke and 8 with TIAs.

Duplex sonography showed positive findings in 60% of our patients. Color-coded ultrasonography allows detection of vertebral artery (VA) hypoplasia, site of occlusion and vertebrobasilar hemodynamic assessment. The extracranial VA was occluded in 26.7% and hypoplastic in 6.7 % of our patients. VA was occluded distally (intracranially) in 23.3 % of our patients.

Blink reflex and Brainstem auditory evoked potential studies have proved to be sensitive methods of detection of posterior circulation territory dysfunction, with 73.3% and 63.3% agreement with MRA respectively.

**Keywords:** vertebrobasilar insufficiency, color-coded duplex, TCCS, evoked potentials.

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## List of Abbreviations

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|          |                                                                 |
|----------|-----------------------------------------------------------------|
| A1:      | Pre-communicating segment of anterior cerebral artery           |
| A2:      | Post-communicating segment of anterior cerebral artery          |
| ACA:     | Anterior cerebral artery                                        |
| AcoA:    | Anterior communicating artery                                   |
| ADMA:    | Asymmetric dimethylarginine                                     |
| AICA:    | Anterior inferior cerebellar artery                             |
| ASICs :  | Acid-sensing ion channels                                       |
| AVMs:    | Arteriovenous malformations                                     |
| BA:      | Basilar artery                                                  |
| BAEPs:   | Brain-stem auditory evoked potentials                           |
| B mode:  | Brightness mode                                                 |
| BR:      | Blink reflex                                                    |
| CaMKII:  | Ca <sup>2+</sup> -calmodulin-dependent protein kinase II        |
| CAVATAS: | The Carotid And Vertebral Artery Transluminal Angioplasty Study |
| CBF:     | Cerebral blood flow                                             |
| CDU:     | Color doppler ultrasonography                                   |
| CI:      | First segment of internal carotid artery                        |
| CRP:     | C-reactive protien                                              |
| CT:      | Computed tomography                                             |
| CTA:     | Computed tomography angiography                                 |
| CVAs:    | Cerebral vascular accidents                                     |
| CW:      | Circle of Willis                                                |
| DESs:    | Drug-eluting stents                                             |
| DLPN:    | Dorsolateral pontine nucleus                                    |
| DSA:     | Digital subtraction angiography.                                |

|                  |                                                         |
|------------------|---------------------------------------------------------|
| ENG:             | Electronystagmography                                   |
| FTP:             | Fetal-type PCA                                          |
| FV:              | Flow volume                                             |
| I <sub>0</sub> : | Intensity threshold                                     |
| ICA:             | Internal carotid artery                                 |
| IL:              | Interleukin                                             |
| ICP:             | Intracranial pressure                                   |
| INO:             | Internuclear ophthalmoplegia                            |
| ISVT:            | Interstitial nucleus of the spinal trigeminal tract     |
| LDL:             | Low density lipoprotein                                 |
| LT:              | Left                                                    |
| LTM:             | Low-threshold mechanoreceptive                          |
| MCA:             | Middle cerebral artery                                  |
| MEPs:            | motor evoked potentials                                 |
| MHz:             | Motor hemiparesis                                       |
| MHz:             | Mega hertz                                              |
| MIR:             | Masseter inhibitory reflex                              |
| MLAEPs:          | Middle-latency auditory evoked potentials               |
| M mode:          | Motion mode                                             |
| MPO:             | Myeloperoxidase                                         |
| MRA:             | Magnetic resonance angiography                          |
| MRI:             | Magnetic resonance imaging                              |
| NMDA:            | N-methyl D- aspartate                                   |
| NS:              | Nociceptive-specific                                    |
| OA:              | Ophthalmic artery                                       |
| P1:              | Pre-communicating segment of posterior cerebral artery  |
| P2:              | Post-communicating segment of posterior cerebral artery |
| PAPP-A:          | Pregnancy-associated plasma protein A                   |



|         |                                                 |
|---------|-------------------------------------------------|
| PCA:    | Posterior cerebral artery                       |
| PoCA:   | Posterior communicating artery                  |
| PcTX:   | Picrotoxin                                      |
| PICA:   | Posterior inferior cerebellar artery            |
| PMD:    | Power motion mode Doppler                       |
| PPRF:   | Paramedian pontine reticular formation          |
| PSN:    | Principal sensory nucleus                       |
| PSV:    | Peak systolic velocity                          |
| PTX-3:  | Pentraxin 3                                     |
| R1:     | Early response of the blink reflex              |
| R2c:    | Contralateral late response of the blink reflex |
| R2i:    | Ipsilateral late response of the blink reflex   |
| RT:     | Right                                           |
| SA:     | Subarachnoid hemorrhage                         |
| SCA:    | Superior cerebellar artery                      |
| sCD40L: | Inflammatory cytokine soluble CD40L             |
| SD:     | Standard deviation                              |
| SEPs:   | Somatosensory evoked potentials                 |
| SP:     | Supression period                               |
| SP1:    | Early masseter inhibitory reflex                |
| SP2:    | Late masseter inhibitory reflex                 |
| STN:    | Spinal trigeminal nucleus                       |
| SNc:    | Subnucleus caudalis                             |
| SNi:    | Subnucleus interpolaris                         |
| SNo:    | Subnucleus oralis                               |
| TAV:    | Time-averaged velocity                          |
| TCCS:   | Transcranial color-coded sonography             |
| TCD:    | Transcranial doppler                            |

|          |                                                    |
|----------|----------------------------------------------------|
| TIAs:    | Transient ischemic attacks                         |
| TICA:    | Terminal internal carotid artery                   |
| TNF:     | Tumor necrosis factor                              |
| TSTN:    | Trigeminal spinal tract and nucleus                |
| US:      | Ultrasonography                                    |
| VA:      | Vertebral artery                                   |
| VAD:     | Vertebral arterial dissection                      |
| VBD:     | Vertebrobasilar disorders                          |
| VBI:     | Vertebrobasilar insufficiency                      |
| VICA:    | Velocity of internal carotid artery                |
| VMCA:    | Velocity of middle cerebral artery                 |
| VN sens: | Trigeminal sensory root                            |
| VN mot:  | Trigeminal motor root                              |
| VOR:     | Vestibulo-ocular reflex                            |
| VORC:    | Vestibulo-ocular reflex cancellation               |
| VSCIs:   | Very small cerebellar infarcts                     |
| WASID:   | Warfarin- Aspirin Symptomatic Intracranial Disease |
| WDR:     | Wide dynamic range                                 |

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## Introduction

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Cerebrovascular disease occupies second place amongst the causes of mortality in the world **(Yepes, 2001)**. Atherosclerotic occlusive disease of the vertebral artery affects a significant proportion of patients with cerebrovascular disease and can cause significant morbidity and mortality despite maximal medical therapy **(Wehman et al., 2004)**.

Approximately one-quarter of ischaemic strokes involve the posterior or vertebrobasilar circulation. Stenosis of the vertebral artery can occur in either its extra- or intracranial portions, and may account for up to 20% of posterior circulation ischaemic strokes. Stenotic lesions, particularly at the origin of the vertebral artery, are not uncommon **(Cloud and Markus, 2003)**. Obstructive lesions of proximal vertebral arteries probably occur in about 30% of stroke patients **(De Bray et al., 2001)**. The diagnosis of VBI is a clinical challenge because its manifestations are subjective and difficult to quantify **(Kizilkilic et al., 2004)**.

Sonography is a noninvasive technique; however the consequences of erroneous diagnosis must be taken into account. It could be argued that transcranial color-coded duplex sonography (TCCS) scanners are more expensive and less portable than conventional TCD scanners, but intensive care units are now equipped with sophisticated sonographic machines for general purposes, so adding transcranial probes increases the cost only a little **(Krejza and Baumgartner, 2004)**.

TCCS, in contrast to "blind" conventional transcranial Doppler sonography (TCD), enables a sonographer to outline the intracranial bony and parenchymal structures, visualize the basal cerebral arteries in color, and measure angle-

corrected blood flow velocities in a specific site of the artery in question. This makes measurements of flow velocity more valid than those obtained with conventional TCD (*Krejza, 2004*).

Simultaneous insonation of intracranial parenchymal structures by B-mode and cerebral artery blood flow by color-coded flow imaging allows visualization of vertebrobasilar arteries directly and continuously. Measurements of vessel length, as well as the hemodynamic assessment, are possible (*Schulte-Altedorneburg et al., 2000*).

Ultrasound of the extracranial vertebral artery (VA) is a valuable technique, providing direct or indirect evidence of abnormal VA circulation, including lesions that lie proximal or distal to the VA itself. It is possible to insonate the V1 and V2 sections of the VA with relative ease in most patients. Transcranial color-coded duplex US can confirm intracranial occlusion of the V4 segment (*Stolz et al., 2002*).

Transnuchal TCCS allows visualization of the proximal two thirds of the BA length. A tortuous BA might confound an accurate measurement, and variations of the superior bifurcation of BA may make it harder to identify distal segments of the BA transnuchally. This confirms a rule of sonography that the transtemporal insonation of the origin of both posterior cerebral arteries is an unavoidable step for a reliable judgment of the vertebrobasilar system (*Schulte-Altedorneburg et al., 2000*).

Evoked potentials have proved to be a sensitive method of detection of even slight cerebral dysfunction. Brainstem auditory evoked potentials (BAEPs) is a non-invasive and reliable electrophysiological method to assess the function of brainstem structures traversed by auditory pathways. BAEP data provide a functional evaluation of the brain-stem and some cranial nerves, which is lacking in imaging studies. Functional investigations may be useful in the long-term