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THREE DIMENSIONAL UTRASOUND OF THE VERTEBROBASILAR SYSTEM

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Summary

Background: Transcranial color-coded sonography (TCCS) and power Doppler imaging (PDI) are used for the evaluation of the vertebrobasilar (VB) system. Due to the unfavorable angle of the vertebral arteries' (VA) junction and angle of insonation, all three vessels can rarely be visualized at the same time. Three-dimensional ultrasound (3D US) enables volumetric reconstruction of the VB junction.

Methods: 2D TCCS and PD as well as 3D US were applied in 25 patients in order to visualize the intracranial part of the VB system.

Results: In TCCS mode it was not possible to obtain all three vessels at the same time, in PD mode it was possible in 6/25 patients, and in 3D PD method in 19/25 patients. In 6 patients the VB angle could not be visualized (2 VAs were occluded – confirmed by angiography, in 4 cases there was a suboptimal suboccipital window), and volumetric reconstruction was applied.

Conclusion: 3D US enabled better visualization of the VB junction due to the possibility of volumetric reconstructions.

Key words: Ultrasound, three dimensional ultrasound, vertebral arteries.

INTRODUCTION

Vertebrobasilar ischemia is certainly less common than internal carotid artery diseases, but it must be diagnosed appropriately because it is a treatable vasculopathy. The

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most common disease affecting vertebral arteries is atherosclerosis. Less common pathological processes include trauma, fibromuscular displasia, Takayasu disease, osteophyte compression, dissections, aneurysms, and other arteritides. Such pathological states can result in a transient "end-organ" (brainstem, cerebellum, and/or occipital lobes) hypoperfusion. A number of medical conditions may mimic vertebrobasilar ischemia – the inappropriate use of antihypertensive medications, cardiac arrhythmias, anemia, brain tumors, benign vertiginous states, basilar artery migraine, vertebral artery hypoplasia and postsubarachnoid hemorrhage vasospasm. Regardless of the specific pathology, patients usually demonstrate reproducible symptoms following postural or positional changes. In general, hypoperfusion attributable to hemodynamic causes rarely results in infarction. Patients typically present with repetitive, short-lived symptoms such as visual disturbance, drop attacks, unsteadiness or incoordination, weakness, confusion, headache, hearing loss, numbness, speech disturbance, abnormal noise in the ears, and numbness around the mouth. However, they can sustain traumatic injuries resulting from the loss of balance.

Introduction of the color Doppler flow imaging (CDFI), power Doppler imaging (PDI), transcranial Doppler (TCD) and transcranial color coded Doppler imaging (TCCD) into the everyday vascular workup of the VB system was a big improvement, but also, because of the unfavorable angle of insonation, in a big percentage of patients it was hard to evaluate the VB junction morphology and haemodynamics, so that 3D ultrasound evaluation and mathematical reconstruction of the VB junction gave new possibilities in the evaluation of such patients. Main advantage of such analysis is multiangular examination of the desired arterial segment including the intravascular approach, thus providing a greater spatial resolution.

Patients and methods

The technique was applied in 25 healthy volunteers in order to visualize the intracranial parts of both vertebral arteries (VA) and the basilar artery (BA), and to calculate the angle of the VB junction according to the direction of the blood vessels. Interactive 3D imaging software was integrated into the ultrasound platform (Aloka Prosound 5500). Data acquisition was performed using a 2,5 MHz sector transducer, freehanded in a fixed length of time (10 seconds), allowing PDI. The images were postprocessed (TomTec imaging system). Vertebral arteries were insonated at four different levels: the origin (ostium and proximal portion-V1), the intertransversal course (V2), the atlas loop (V3), by means of 2D US, while the intracranial portion (V4) was visualized by 2D US-Picture 1 and 3D US-Picture 2 by the suboccipital approach. An occlusion, stenosis or hypoplasia of the vertebral and carotid arteries, and pathological flow phenomena, such as

subclavian steal syndrome, were excluded according to the standardized criteria of the Cerebrovascular Laboratory of the Referral Center for Neurovascular Disorders of the Ministry of Health.

Results

There were 25 healthy volunteers (mean age 56 years, range 23-78 years), 15 women (mean age 62 years) and 10 men (mean age 59 years) – Table 1. In TCCS mode it was not possible to obtain all three vessels at the same time, while in PD mode we were able to obtain all three vessels at the same time in 6/25 patients. 3D PD method enabled visualization of all three vessels at the same time in 19/25 patients, while in 6 patients the angle between the VA and BA origin could not be adequately visualized (2 VAs were occluded – diagnose confirmed by angiography; in 4 cases there was a suboptimal suboccipital window), therefore, 3D mathematical reconstruction was applied – Table 2.

Table 1. General characteristics of the investigated population.

	number of individuals	mean age
men	10	59
women	15	62
pooled	25	56

Table 2. Number of patients in correlation to the number of vessels visualized at the same time by means of 2D TCCS, 2D PD, and 3D PD.

	2D TCCS	2D PD	3D PD
3 vessels	0	6	19+6*
1 or 2 vessels	25*	19*	0
Total	25	25	25

*2 VA were occluded – diagnose confirmed by angiography; in 4 cases suboptimal suboccipital window, 3D mathematical reconstruction was applied.

Discussion

The main advantage of the 3D analysis of the intracranial part of the circulation is a multiangular examination of the desired blood vessel including an intravascular approach with a greater spatial resolution than the standard ultrasound techniques. Other advantages are noninvasiveness, volumetric analysis, oblique planimetry with additional interpolation whenever a standard visualization does not suffice. 3D US has high

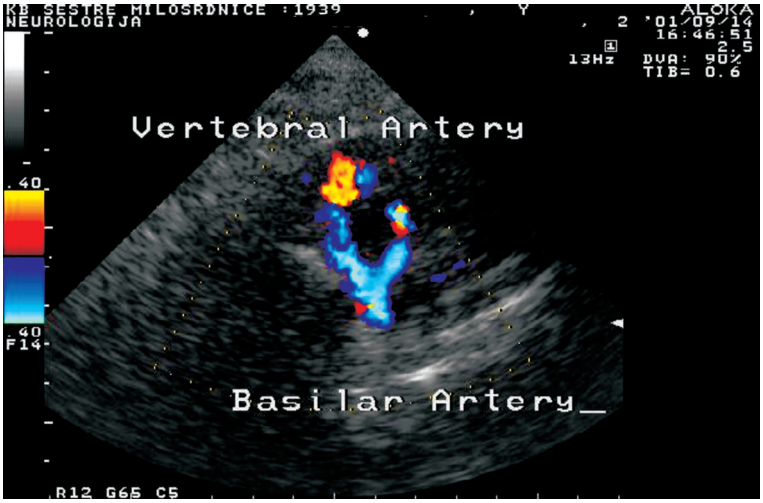

Figure 1. Color coded 2D ultrasound of the VB system.

levels of reproducibility, sensitivity and specificity in correlation with digital subtractional angiography (DSA) of the brain vessels (r=0,98). In comparison with magnetic resonance imaging (MRI), 3D also showed satisfactory results: transaxial resolution of 5

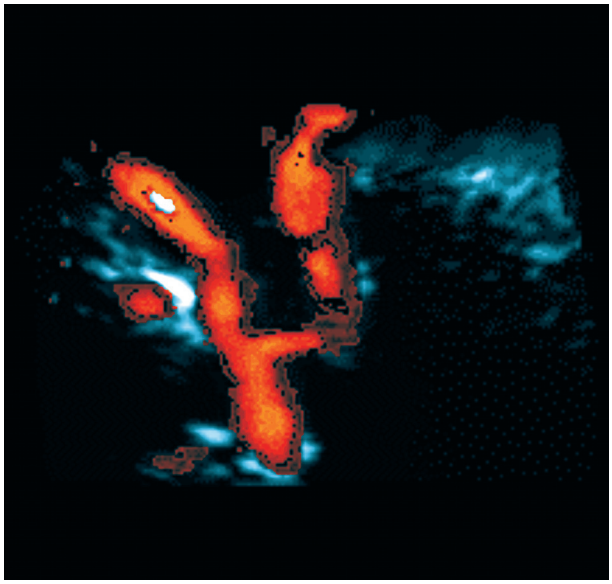

Figure 2. 3D ultrasound of the VB system.

mm, longitudinal resolution of 10 mm, and rotational resolution of 40°. Disadvantages of the 3D US are the lack of a proper differentiation between the periarterial and intraarterial tissue, which causes thresholding problems in tissue segmentation, higher costs as compared to conventional US examination, high operator skills and various artifacts (cardiac rhythm in cases without ECG synchronization, hand movement, swallowing or respiration).

This study showed that 3D US is better than 2D US in the visualization of the VB junction due to the multiangular examination and volumetric reconstruction possibility.

Further studies should be performed in order to evaluate the impact of 3D US of the VB junction hemodynamics in the differential diagnosis of the posterior fosse symptoms.

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Sažetak

Trodimenzionalni ultrazvuk vertebrobazilarnog sustava

Uvod: Transkranijska bojom kodirana sonografija (TCCS) i osnaženi dopler (PD) se upotrebljavaju za procjenu vertebrobazilarnog (VB) sustava. Zbog nepovoljnog kuta spoja vertebralnih arterija (VA) i kuta insonacije, rijetko se mogu prikazati sve tri žile istovremeno. Trodimenzionalni ultrazvuk (3D UZ) omogućava volumetrijsku rekonstrukciju VB spoja.

Metode: Primijenili smo 2D TCCS, PD i 3D UZ u 25 bolesnika kako bismo prikazali intrakranijski dio VB sustava.

Rezultati: Primjenom TCCS nije bilo moguće prikazati sve tri krvne žile istovremeno, primjenom PD to je bilo moguće u 6 od 25 bolesnika, a primjenom 3D PD u 19 od 25 bolesnika. U 6 bolesnika VB kut se nije mogao prikazati (2 VA su bile okludirane što je potvrđeno angiografijom, u 4 slučaja bio je suboptimalni okcipitalni prozor), pa je primijenjena volumetrijska rekonstrukcija.

Zaključak: 3D UZ omogućuje bolji prikaz VB spoja zbog mogućnosti volumetrijske rekonstrukcije.

Ključne riječi: Ultrazvuk, trodimenzionalni ultrazvuk, vertebralne arterije