Ultrasound in Med. & Biol., Vol. ■■, No. ■■, pp. ■■–■■, 2017

0301-5629/$ - see front matter

https://doi.org/10.1016/j.ultrasmedbio.2017.11.002

● *Original Contribution*

DUPLEX SONOGRAPHY OF VERTEBRAL ARTERIES FOR EVALUATION OF PATIENTS WITH ACUTE VERTIGO

Peiman Nazerian,* Sofia Bigiarini,* Rudi Pecci,† Lucia Taurino,* Marco Moretti,‡ Andrea Pavellini,* Elisa Capretti,* Stefano Grifoni,* and Simone Vanni* on behalf of the Ultrasound Study Group of the Italian Society of Emergency Medicine (SIMEU)

* Department of Emergency Medicine, Careggi University Hospital, Firenze, Italy; † Otoneurology Clinic, Careggi University Hospital, Firenze, Italy; and ‡ Neuroradiology Unit, Careggi University Hospital, Firenze, Italy

(*Received* 19 *August* 2017; *revised* 30 *October* 2017; *in final form* 4 *November* 2017)

Abstract—We evaluated the role of vertebral artery extracranial color-coded duplex sonography (VAECCS) in predicting vertebrobasilar stroke in consecutive patients presenting to the emergency department with vertigo of suspected ischemic origin. The final diagnosis was established by a panel of experts consisting of an emergency physician, a neurologist, and an otoneurologist. Vertebrobasilar stroke was diagnosed when an acute brain ischemic lesion congruent with symptoms was detected by neuroimaging during the index visit or a stroke was diagnosed within a 3-mo period after emergency department presentation. Among 126 patients, 28 (22%) were diagnosed with vertebrobasilar stroke. Fifteen (75%) of 20 patients with abnormal VAECCS results and 13 (12%) of 106 with normal VAECCS results had a final diagnosis of vertebrobasilar stroke. The sensitivity and specificity of VAECCS were 53.6% and 94.9%, respectively. Detecting an abnormal flow pattern at VAECCS significantly increased the risk of vertebrobasilar stroke (odds ratio = 21.5). The flow patterns most frequently related to vertebrobasilar stroke were absence of flow and high resistance pattern velocity (odds ratio = 9.3 and 22.7, respectively). VAECCS predicts vertebrobasilar stroke and could be a useful bedside screening tool in patients with vertigo. (E-mail: pnazerian@hotmail.com)

Key Words: **Vertigo/dizziness, Duplex sonography, Stroke, Cerebrovascular disease, Vertebral artery.**

INTRODUCTION

Vertigo accounts for 1% to 3% of all presentations to emergency departments (EDs) (Crespi 2004). Most cases are caused by benign diseases of the inner ear (Herr et al. 1989). However, this symptom may be an indicator of more serious diseases of the central nervous system, with vertebrobasilar ischemia accounting for 3% to 5% of cases of vertigo presenting to EDs (Kerber et al. 2006; Lam et al. 2006). In patients with suspected central nervous system disease, the most frequently used first-line ED screening test is unenhanced head computed tomography (CT). In patients with vertigo, CT can identify rare causes of cerebral disease such as neoplasia and hemorrhages; however, its sensitivity in predicting vertebrobasilar stroke is low (Hwang et al. 2012; Ozono et al. 2014). Head magnetic resonance (MR) is more accurate, but is not available in the majority of EDs, and even MR can lead to false-negative results in the first hour after a vertebrobasilar stroke (Newman-Toker and Edlow 2015). Moreover, some studies have found that vertigo can be the only manifestation of transient ischemic attack (TIA), for which rapid access to secondary prevention can reduce the risk of early recurrent stroke (Hoshino et al. 2013; Paul et al. 2013; Rothwell et al. 2007). Therefore, the diagnosis of acute cerebrovascular disease in patients with vertigo is challenging.

Stenosis/occlusion of the proximal vertebral artery is present in 44% of patients with posterior circulation stroke, whereas a distal obstruction is present in 36% of stroke cases (Kim et al. 2005). Moreover, the presence of a vertebral artery stenosis/occlusion is a marker of poor prognosis in patients with vertebrobasilar stroke and is related to increased risk of consequent stroke in patients with TIA of the vertebrobasilar territory (Paul et al. 2013). Vertebral artery extracranial color-coded duplex sonography (VAECCS) can be a useful screening test in patients with

Address correspondence to: Peiman Nazerian, Emergency Department, Careggi University Hospital, Largo Brambilla 3, 50139, Firenze, Italy. E-mail: pnazerian@hotmail.com

suspected acute posterior circulation cerebrovascular disease, and although it is less accurate than angio-CT, angio-MR, or catheter angiography (Khan et al. 2007), it has some advantages such as low cost, no adverse effects and contraindications and ability to be performed at the bedside.

The role of VAECCS in patients presenting with vertigo is unknown. The aim of this prospective study is to evaluate the diagnostic accuracy of a standardized VAECCS examination as a screening test in patients presenting to the ED with vertigo and suspected vertebrobasilar ischemia.

METHODS

Study design and setting

For this single-center, non-profit, observational cohort study, study patients were recruited from May 2015 to January 2016 in the ED of an Italian university hospital with an annual census of 100,000 visits. The local ethics committee approved the study. Written informed consent was obtained for inclusion in the study.

Study population and management of patients

Consecutive adult patients presenting to the ED with vertigo or unsteadiness lasting no longer than 7 d were eligible for the study if an acute ischemic cerebrovascular disease was suspected. Suspicion of an ischemic cause was established by the attending physician after the initial standard evaluation, which included medical history, physical examination including a detailed neurologic examination, electrocardiogram, routine blood sample, unenhanced head CT and consultations with a neurologist or otoneurologist expert in vertigo evaluation. Attending physicians were trained to perform the "STANDING" approach, a four-step algorithm based on nystagmus observation and diagnostic maneuvers, to clinically differentiate suspected central versus peripheral vertigo (Vanni et al. 2015). "STANDING" includes discrimination between spontaneous and positional nystagmus, evaluation of the nystagmus direction, the head impulse test and evaluation of upright stance.

The attending physician notified the sonographer to perform a standardized VAECCS examination. Patients diagnosed with central vertigo from a non-ischemic cause after initial evaluation (*i.e.,* cerebral hemorrhage or neoplasia detected at unenhanced head CT) were excluded from the study. Patients who did not undergo VAECCS within 24 h of enrollment were also excluded. Decisions to perform further diagnostic tests and disposition for the patient's hospitalization or ED dismissal were determined by the attending physicians independent of participation in the study. All patients underwent a 3-mo follow-up (see below).

Vertebral artery extracranial color-coded duplex sonography

Vertebral artery extracranial color-coded duplex sonography examinations were performed by one of six sonographer investigators. They were three specialists in internal medicine with at least 5 y of experience in VAECCS and three residents (one in emergency medicine and two in internal medicine) with at least 2 y of experience in the methodology. Investigators were blinded to all diagnostic test results. VAECCS examinations were performed with the following multiprobe machines: two MyLab30 Gold, two MyLab alpha (Esaote, Genoa, Italy), one HD7 (Koninklijke Philips, Amsterdam, Netherlands) and one Vivid S5 (GE Healthcare, Wauwatosa, WI, USA), all equipped with a linear probe (4–8 MHz). VAECCS was performed according to a pre-defined ultrasound protocol. Patients were examined in the supine position. On both sides of the neck, the common carotid artery was first identified in B-mode in longitudinal scan. Then the probe was tilted to visualize the vertebral artery segments between the vertebral transverse processes in its long axis, moving caudocranially from C6 to C2 (V2 segment). After visualization of the vertebral artery in B-mode, color Doppler was applied and pulsed Doppler spectral analysis was performed to detect the presence of flow and its direction. Investigators were also asked to detect abnormalities of the waveform pattern and to measure peak systolic velocity (PSV). Long axis spectral Doppler velocity measurements were obtained with an angle correction between 45° and 60°.

The examination was considered normal when both vertebral arteries were visualized and flow had a normal direction, waveform and velocity (Fig. 1).

The examination was considered abnormal if at least one of the following alterations was detected in one or both vertebral arteries (Fig. 2): (i) Flow not present in a segment or in the entire vertebral artery (Fig. 2a). (ii) Flow was detected, but with an abnormal spectral waveform compared with contralateral vertebral arteries, defined as (i) focal high PSV (>60 cm/s) caused by a possible stenosis within the point of sampling (Fig. 2b); (ii) high-resistance-pattern velocity with a reduced or absent diastolic component caused by possible distal stenosis (Fig. 2c); (iii) low-velocity flow (PSV <20 cm/s) or post-stenotic flow pattern compared with the contralateral artery caused by possible proximal stenosis (Fig. 2d); or (iv) flow inversion caused by possible subclavian steal syndrome (Fig. 2e).

In the presence of hypoplasia of one or both vertebral arteries (diameter of vertebral artery <3 mm) without flow abnormalities, the examination was considered normal. After the completion of VAECCS, the investigators completed a standardized form (Supplementary Figure S1, online only, available at https://doi.org/10.1016/j.ultrasmedbio.2017.11.002).