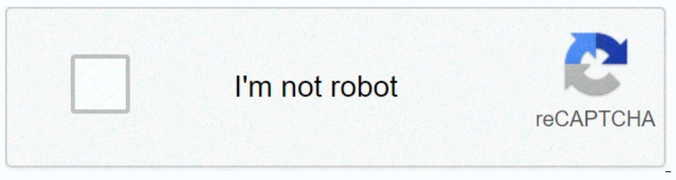

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Vertebral artery waveform ultrasound

Do you work off campus? Learn more about our remote access options Volume 29, Problem 8 objective. The appearance of the vertebral artery (VA) waveform on a pulsating Doppler study performed during standard carotid duplex ultrasonography (CDU) may decipher vertebrate disease. We tried to determine the radiographic meaning of high-resistive (HR) pulsed Doppler VA waveforms seen on the CDU. Methods. The noninvasive Vascular Laboratory database was queried about CDU studies that noted the HR VA Doppler signal. Studies with unilateral or bilateral HR and antegrade VA waveforms with correlative neuroimaging studies within 60 days were included. Image reports were reviewed to determine the following: (1) a normal VA; (2) at least moderately distal VA or basilar arteriestenosis, occlusion or dissection 3) an innate diminutive VA or (4) other abnormalities. Results. Out of 1338 studies with 1 or more HR VA waveforms, 79 studies met all inclusion criteria (n = 157 arteries) and had sufficient correlative neuroimaging. There were 90 HR ESLOG's, and HR waveforms were evenly distributed between the right and left sides. The average maximum systolic speed of HR versus low-resistive (LR) VAs was 51.7 versus 63.6 cm/s (P = 0.04); the average end-diastolic speed of HR versus LR VAs was 4.6 versus 17.3 cm/s (P< .001) and the resistive index for HR versus LR 0s was 0.92 versus 0.73 (P< .001). Of all HR Pa's, 18.9% were normal; 38.9% had distal vertebrobasilar stenosis or occlusion; 35.6% were congenital diminutive; and 6.7% had other abnormalities (proxima stenosis, excessive tortuosity, fibromuscular dysplasia and BA hypoplasia). Conclusions. The finding of an HR spectral Doppler signal in the VA was associated with major vertebrobasilar disease (46% of cases) and should prompt additional neuroimaging in the relevant clinical situation. BA basilar artery CDU carotis duplex ultrasonography CTA computed tomographic angiography EDV end-diastolic speed HR high-resistive LR low-resistive MRA magnetic resonance angiography PSV peak systolic speed RI resist Ive index VA vertebral artery Although standard duplex ultrasonography is not a comprehensive modality for the assessment of vertebral arteries (VAs), useful information can be obtained with limited interrogation of the impact assessments under carotid duplex ultrasonography (CDU). Determining the direction of blood flow (i.e. antegrade or retrograde) in impact assessments using color and pulsed Doppler waveforms can be particularly useful in assessing severe subclavia stenosis with vertebrale stealing phenomenon. In addition to directional information, the CDU of the Pa's can provide blood flow rates and allow for qualitative analysis of Doppler waveform properties. The normal VA has significant flow as it feeds low-resistance vascular bed of the circle of Willis and cerebral vasculature. A A (HR) vortex signal from cervical VA with loss of diastolic flow may indicate more cephalad vertebrobasilar disease (Figure 1.1 Limited pulsed Doppler interrogation of va's is a standard component of the CDU study. Complete evaluation of the CDU VPs is limited by its intraforaminal trajectory with significant acoustic shading and drop-off of the Doppler signal. Based on the Intersocietal Commission for the Accreditation of Vascular Laboratories standards for extracranial cerebrovascular testing, in addition to the evaluation of the common, internal and external carotid arteries, bilateral VAs are identified, and at a minimum, a single midartery Doppler signal is obtained for each cervical VA.2 Although an HR Doppler signal in the cervix VA may indicate disease located cephalad to the probe, ultrasonographic-angiographic correlation studies have been limited by a small number of angiographic correlations ,3 or by preselection of patients with neurological symptoms.4 Thus, the clinical importance of an HR-pulsed Doppler VA waveform in an unsized patient population presenting for routine carotid ultrasonography remains uncertain. Our institutional Noninvasive Vascular Laboratory database was queried for sequential CDU studies conducted between January 1, 2002, and December 31, 2007, regardless of the indication for ordering the survey. Study reports that noted antegrade HR (impaired or absent end-diastolic velocity) pulsed wave Doppler VA waveforms in one or both VAs were identified. The HR appearance of the VA waveform was introduced in the study report and database at the time of the ultrasonographic study and was based on qualitative interpretation by the vascular technologist and interpreter. The studies that had correlative neuroimaging performed within 60 days of ultrasonography were included in the analysis. Acceptable neuroimaging studies were catheter-based angiography, computed tomographic angiography (CTA), and magnetic resonance angiography (MRA). Studies were excluded if there was a documented neurological event between the dates of the CDU and correlative neuroimaging studies. Based on the intersocietal commission for accreditation of vascular laboratory standards,2 the complete CDU protocol in our laboratory includes spectral Doppler waveforms taken from proximal, middle, and distal parts of bilateral joint and internal carotid arteries and limited Doppler assessment of bilateral innominate, subclavia, external carotid arteries, and vertebrae arteries. VA is depicted in the center of the cervix segment (V2) with at least 1 pulsating Doppler waveform recorded from each side. A Doppler angle of 60° or less in terms of the direction of blood flow is maintained during the study. Two investigators independently reviewed the final reports on the neuroimaging studies that the vertebrobasilar system to one of the following: 1) a normal VA; (2) at least moderate distal VA or basilar artery stenosis, occlusion or dissection 3) an innate diminutive VA or (4) other vertimar abnormalities (proxima stenosis, excessive tortuosity, fibromusular dysplasia and BA hypoplasia). In the event of disagreement, a third investigator independently reviewed the neuroimaging reports and acted as a tie breaker. Left panel, Typically pulsating wave Doppler spectrum of a normal VA shows a systolic top with continuous flow in diastole. The than diastolic speed is 12.7 cm/s. This is a typical Doppler waveform of an arterial vessel delivering a low resistance bed, such as the brain. Right panel, Abnormal HR VA. There is a rapid rise to a sharp systolic peak followed by a rapid descent in flow speed back to baseline. There is no antegrade flow in the end diastole (end-diastolic speed is 0). Although this is a more typical Doppler

waveform of an artery delivering a high-resistance vascular bed, such as dormant limbs, it is a pathological finding in the evaluation of the VA and can indicate cephalad vertebrobasilar occlusive disease. All statistics were carried out using Stata software (StataCorp LP, College Station, TX).5 Resistive index (RIs) of HR and low-resistive (LR) VA waveforms were calculated by dividing the difference in peak systolic speed (PSV) and end-diastolic speed (EDV) of PSV [(PSV – EDV) /PSV].6 Mean speeds and RIs between HR and LR VA waveforms were compared using Student t test. The analysis of radiographic correlations according to the EDV of the Doppler waveforms (EDV of 0 or EDV >0) was carried out using χ2 tests. All statistical tests were performed with a significance level P = 0.05. 1338 studies with HR VA waveforms were noted. Of these, 86 studies met all inclusion criteria. Of the 172 possible VA's to be analysed in these 86 studies, 4 impact assessments were not able to be visualized during the ultrasonographic studies and 11 VA's were not adequately assessed by neuroimaging, resulting in 79 complete studies (n = 157 IMPACTANALYSIS). Of the 157 VA waveforms with correlative neuroimaging, none were repeated studies in the same patient. The average age of patients was 69.1 years and 66.6% were male. Correlative neuroimaging included catheter-based angiography (23.3%), TCL (16.3%), MRA (46.5%) or more than 1 modality (14.0%). Of the 157 VA waveforms in the 79 studies, 90 VA waveforms were HR; 13.9% of patients (n = 11) had bilateral HR waveforms. Ultrasonographic findings are shown in table . High-resistive VA waveforms were evenly distributed between the right and left sides (53.3% versus 46.7%, respectively; P not significant). The average EDV among HR VA waveforms was 4.6 / s (range, 0-89.0 cm / s). High-resistive VA waveforms had significantly lower average psvs and mean EDVs EDVs compared to LR VA waveforms. As expected, the average RI for HR Astas was significantly higher than for those with normal Doppler waveforms (0.92 versus 0.73; P < .001). Of all HR impact assessments with correlative neuroimaging studies, 18.9% were normal (falsely positive HR waveforms); 38.9% had at least moderate distal vertebrobasilar disease; 35.6% had congenital diminutive VAS; and 6.7% had other abnormalities (proximal VA stenosis, excessive tortuosity, fibromuscular dysplasia or BA hypoplasia). When categorized by EDV of 0 versus greater than 0 (average EDV 10.8 cm/s), HR Ba's with 0 end-diastolic flow were no more likely to be reflecting vertebrobasilar disease on neuroimaging (Table); however, the sample size of this provision was low. Although conventional angiography remains the reference standard for the assessment of vertebrobasilar circulation, it is invasive and reserved for patients for whom there is a strong neurological indication. Although previous studies have shown a link between the Doppler ultrasonography of PA's and angiographic results,1,3,4 to our knowledge, ours is the largest to investigate the correlation between a single Doppler waveform of the V2 segment of the VA and correlated neuroimaging in an unsized patient population mentioned for the CDU. Table 1. Hastigheder i UG'erne efter HR og LR Waveforms Parameter HR (n = 90) LR (n = 67) P Gennemsnitlig PSV (rækkevidde), cm/s 51,7 (15-180) 63,6 (19-276) .04 Gennemsnitlig EDV (rækkevidde), cm/s 4,6 (04 04 Mean EDV (rækkevidde), cm/s 4,6 (04 04 Mean EDV (rækkevidde), cm/s 4,6 (04 04 Mean EDV (rækkevidde), cm/s 4,6 (04, 6.6 (04 Mean EDV (range), cm/s 4,6 (04 Mean EDV (range), cm/s 4,6 (04 Mean EDV (range), cm/s 4,6 (04, 6.6 (04 Mean EDV (range), cm/s 4,6 (04 04 Mean EDV (range), cm/s 4,6 (04 04 Mean EDV (range0-89) 17,3 (0-120) <,001 Middel RI (interval) 0,92 (0,51-1,0) 0,73 (0,48-1,0) <,001 Sammenligning af gennemsnitlig PSV, EDV, og RI af HR- versus LR-optræder Doppler bølgeformer af dæmperne. Due to the different forms of neuroimaging we used as comparator studies (CTA, MRA, and angiography), the calculation of the sensitivity or specificity of a single VA waveform for the detection of vertiabililar disease was not performed. A previously published ultrasonic angiographic correlation study in 58 patients (116 VAs) of Nicolau et al4 showed that Doppler ultrasonography of the intertransverse V2 segment of the VA had a sensitivity of 90 %, specificity of 100 %, a positive predictive value of 100 % and a negative predictive value of 95 % for the detection of disease at any level of vertebrobasilar circulation. However, this study was limited to ultrasound examination of patients with stroke symptoms who were referred by general or stroke neurologists to assess the extracratic Although our study did not include as detailed an ultrasonic study of VAs as the study of Nicolau et al4 (a spectral Doppler waveform obtained at a site in the VA in our study compared to examining the course of va in the V2 segment by taking Doppler readings in several vertebrale interspaces in the study of Nicolau et al), we found that an HR appearance of a single VA Doppler Doppler in an unse select population was associated with documented vascular abnormalities on correlative neuroimaging in a significant proportion of cases (46%). Although not a pathological finding, innate insetoe dominance accounted for most of the remaining waveforms. The high false-positive rate of 18.9% may be due to several factors, including the qualitative assessment of VA Doppler waveforms in HR and LR categories and the lack of a single reference standard neuroimaging comparator (angiography). Further analyses could be performed using RI as a discriminator between HR and LR waveforms, but our laboratory has not validated RI standards for assessment of VA. Future correlation studies may also consider stratifying patients according to the indication for ordering the ultrasonographic study (neurological symptoms versus other causes) and using a quantitative definition of HR and LR waveforms in addition to qualitative assessment in an attempt to increase VA Doppler's waveform waveanalysis performance characteristics to demonstrate vertebrobasilar disease. Notable weaknesses in our study were reviewing neuroimaging study reports, rather than independent review of the actual images, and assessing VA Doppler waveforms only by the executive technologist and interpreting clinicians before entering the clinical database without an independent other physician review. Despite these limitations, we found that a significant proportion of VA's with an HR Doppler waveform at the CDU were associated with vertebrobasilar disease, and when accompanied by clinical findings, the presence of an HR VA Doppler waveform at the CDU may warrant further neuroimaging. These data underscore the importance of careful review of the VA Doppler waveform for its morphological properties as well as directionality of blood flow. Table 2. Radiographic Correlations of HR VA Doppler Signals Parameter Normal, n (%) Congenital Diminutiv, n (%) Vertebrobasilar occlusive disease, n (%)another abnormalities, n (%)b Total P LR (n = 67) 46 (68.7) 3 (4.5) 10 (14.9) 8 (11.9) <.001 HR (n = 90) 17 (18.9) 32 (35.6) 35 (38.9) 6 (6.7) EDV 0 cm/s (n = 51) 9 (17.6) 18 (35.3) 23 (45.1) 1 (1.96) .13 EDV >0 cm/s (n = 38) 8 (21.1) 14 (36.8) 11 (29.0) 5 (13.2) Findings of vertebrobasilar neuroimaging of EDV at CDU. High-resistive VAs with an EDV of 0 (no flow at the end diastole) were no more likely to have significant vertebrobasilar disease than those with an EDV of more than 0 cm/s (average EDV for HR Eslogas with an EDV>0 cm/s, 10.8 cm/s; P not significant). a Includes at least moderate distal VA or BA stenosis, occlusion or dissection. b Includes proximal stenosis, excessive tortuosity, fibromuscular dysplasia and BA hypoplasia. 1Biedert S, Winter R, Staudacher T, Betz H, Reuther R. Doppler sonography in basilar Occlusion. 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