DEVELOPMENTS AND IMPROVEMENTS continue in the hemodynamic and morphological study of cervical arteries by noninvasive methods using ultrasound. Duplex scanning is a new technique which has already been extensively applied to the study of carotid arteries.\(^1\) By contrast, there is, at present, no published study devoted to vertebral arteries.

We wish to report a prospective study of vertebral arteries by Duplex scanning in 50 subjects devoid of any history or sign of cerebrovascular disease.

**Materials and Methods**

**Subjects**

There were three main inclusion criteria: (1) no past history of cerebrovascular disease; (2) no physical sign pointing to lesions of cervical arteries, in particular no cervical bruit, no arm blood pressure asymmetry, and (3) normal continuous wave Doppler study.

Fifty subjects (20 males, 30 females) aged 12 to 79 (mean age 52) were studied. Most of them were referred for symptoms not related to ischemic cerebrovascular disease such as migraine, depression, anxiety, chronic memory disturbance, while some were referred because they had cardiac ischemic disease.

**Equipment**

The study was performed with duplex scanning equipment (Biosound) which includes, in the first place, a system for imaging arterial walls and their content (B. mode echo), and secondly, a pulsed Doppler with a sample volume of 1 mm\(^3\) for analysis of flow velocity wherever blood vessels are visualized.

This high resolution ultrasound duplex scanner utilized a transducer with an average frequency of 8 Megahertz.

The echographic image, obtained when the probe is placed over the artery, is viewed on a screen in real time, at a frequency of 50 images per second. Its size is 3 cm by 4. Axial resolution, improved by dynamic focusing of reflected ultrasounds, is approximately 0.3 mm. Recordings were obtained by direct polaroid photography of the screen and by video recording of selected sequences.

**Examination Procedure**

The examination procedure was identical for all subjects. The patients were all in supine position, head slightly turned away from the explored artery and shoulders kept down. Maximum forced expiration was requested of each patient.

The probe was first placed in the supraclavicular notch and adjusted laterally to detect the bifurcation of the brachiocephalic trunk, the subclavian artery, and the origin of the vertebral artery. The pre-transverse segment of the vertebral artery was followed up to its entry into the transverse canal. The probe was then directed...
Table 1

<table>
<thead>
<tr>
<th></th>
<th>Right vertebral artery (n=50)</th>
<th>Left vertebral artery (n=50)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ostium</td>
<td>47 (94%)</td>
<td>30 (60%)</td>
</tr>
<tr>
<td>Pretransverse</td>
<td>50 (100%)</td>
<td>50 (100%)</td>
</tr>
<tr>
<td>Intertransverse C6-C5</td>
<td>50 (100%)</td>
<td>50 (100%)</td>
</tr>
<tr>
<td>C5-C4</td>
<td>50 (100%)</td>
<td>50 (100%)</td>
</tr>
<tr>
<td>C4-C3</td>
<td>50 (100%)</td>
<td>45 (90%)</td>
</tr>
</tbody>
</table>

towards the cervical spine, in order to visualize the vertebral artery in the C6-C5, C5-C4 and C4-C3 vertebral interspaces.

Examination thus systematically explored in longitudinal sections, the morphology, caliber and systolic expansion of ostium, pretransverse and intertransverse C6-C5, C5-C4, C4-C3 segments of both vertebral arteries. Hemodynamic information was obtained concomitantly by pulsed Doppler recordings of all visualized arterial segments.

Results

One hundred vertebral arteries were examined and visualized to varying degrees in 50 subjects. Duration of the examination was 20 to 30 minutes.

Vertebral artery ostium was identified by its emergence from the subclavian artery, its Doppler characteristics which differentiate it from venous or nervous structures, and by the thickness, systolic expansion, and echogenic characteristics of its walls. It was visualized in 47 out of 50 cases (94%) on the right side and in 30 out of 50 (60%) on the left (table 1) (figs. 1 and 2).

A pre-transverse vertebral artery was easily identified. It is a straight, more often than sinuous, vertical segment directed towards the transverse process of C6, with the vertebral vein running lateral to the artery. It was readily visualized in 100% of cases on both sides. The vertebral artery entered the transverse canal at the C6 level in all cases (fig. 3).

An intertransverse vertebral artery was identified by its location medial to the vertebral vein, and anterior to the nerve root, by its Doppler characteristics and by the systolic expansion of its arterial walls. Segments C6-C5 and C5-C4, slightly concave medially, were visualized in 100% of cases on both sides. Segment C4-C3 was visualized in all cases on the right side and in 45 out of 50 (90%) on the left (fig. 4).

Caliber of the vertebral artery was measured in each visualized segment, and it remained constant throughout their trajectory; the mean caliber was 4 mm on both sides. However the left vertebral artery was dominant (difference of caliber of 1 mm or more) in 24 out of 50 cases (48%) and the right in 7 out of 50 cases (14%). In 3 cases (out of 50), one vertebral artery was hypoplastic, two on the left side and one on the right (diameter 3 mm).

Discussion

This seems to be the first report of vertebral artery examination with Duplex scanning. The technique allowed identification and visualization in vertebral arteries in all 50 subjects. Pretransverse and lower intertransverse segments were visualized in all cases on both sides, segment C4-C3 was obtained in all cases on the right and in 90% on the left. Ostium were found more difficult to examine and were visualized in 94% of cases on the right and in 60% on the left. The mere fact that all these segments could be visualized makes it possible to assess the hemodynamic behavior of these arteries.

Figure 1. Vertebral artery: ostium (o); common carotid artery (c.c.); and brachiocephalic trunk (b.c.t.).

Figure 2. Vertebral artery: ostium (o); subclavian artery (s.c.); and thyrobrachiocephalic arterial trunk (T.B.C.).

Figure 3. Vertebral artery: pretransverse (P.T.).
Duplex scanning superior to continuous wave Doppler which permits exploration of the vertebral arteries only at their origin and at their emergence from the transverse canal.

The quality of visualization was greatly influenced by the good positioning of subjects. Best visualization of the subclavian artery resulted with forced expiration, while the ostium was best viewed when shoulders were kept down. The vertebral artery on one side was best visualized in its entirety with the head turned towards the opposite side.

However, even with good positionings, there remain difficulties in imaging ostium of the vertebral artery. These difficulties are as follows: (1) The variations in echogenicity of tissue depends on (a) the individual subjects and more specifically (b) their age. (2) The depth of the structure examined in relation to the skin: it thus seems that the deeper and more posterior location of the left vertebral artery ostium explains its non-visualization in 40% of cases. Moreover, the quality of results is highly dependent on the experience of the examiner: this study was conducted by the first author following four years of practice.

In determining artery capacity Duplex scanning combines morphological and hemodynamic information. This is superior to continuous wave which does not permit differentiation between hypoplasia, agenesis and occlusion.

In conclusion, we have found Duplex scanning an easily performed noninvasive method to study morphological and hemodynamic characteristics of vertebral arteries from their origin to the C4-C3 level. We are currently using this technique to correlate Duplex scanning results with angiographic information in patients with vertebral artery stenosis and occlusions.

References
Duplex scanning of normal vertebral arteries.
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Stroke. 1986;17:921-923
doi: 10.1161/01.STR.17.5.921

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