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Ultrasound examination techniques of extra- and intracranial veins

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Summary While arterial ultrasonography is an established and widely used method, the venous side of circulation has long been neglected. Reasons for this late interest may be the relatively lower incidence of primary venous diseases.

It was not until the mid 1990s that venous transcranial ultrasound in adults was systematically developed. This paper reviews the extra- und intracranial examination techniques of the cranial venous outflow.

Examination of the internal jugular vein

The internal jugular vein (IJV) forms as an extension of the sigmoid sinus and leaves the cranial cavity through the jugular foramen. Similar to the distal part of the internal carotid artery, the slight dilatation at the origin of the IJV, called the superior bulb, and the proximal part of the vessel cannot be insonated due to lack of access because of the mandible. The IJV takes a course vertically down the side of the neck, lying at first lateral to the internal carotid artery, and then lateral to the common carotid. In the venous angle of the neck it unites with the subclavian vein to form the brachiocephalic vein. Above its termination it forms a second dilatation, the inferior bulb, in which on each side valves are present. While on the left side the valve is tricuspid in more than 60% of cases, it is bicuspid in approximately 50% and monocuspid in approximately 35% on the right side [1]. These anatomical differences are of importance because the right side is more frequently affected by incompetent valve closure than the left.

The ultrasound examination as such is not very demanding using the internal and common carotid artery as a landmark structure. The equipment and machine settings are similar to the examination of the carotid artery. However, the pulse repetition frequency (PRF) may need adjustment.

Care has to be taken because the vessel can easily be compressed even by applying slight pressure on the probe and hence mimic stenosis and induce changes of the Doppler waveform. On the other hand lack of compressibility is one of the diagnostic criteria for IJV thrombosis. Turning the head also leads to caliper changes mimicking stenosis [2]. Therefore, a fairly straight head position should be used to avoid artifacts and to increase reproducibility.

The walls of the vessel exhibit movements dependent on the respiration; the maximum extension occurs during expiration, the minimum during inspiration. On the respiratory wall movements faster wall movements caused by

Abbreviations: BV, basal vein; dMCV, deep middle cerebral vein; GCV, great cerebral vein; ICV, internal cerebral vein; IJV, internal jugular vein; MCA, middle cerebral artery; PCA, posterior cerebral artery; PRF, pulse repetition frequency; SPaS, sphenoparietal sinus; SPS, superior petrosal sinus; SRS, straight sinus; SSS, superior sagittal sinus; TCCS, transcranial color coded duplex sonography; TS, transverse sinus.

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the valves and by the right heart function are superimposed.

By following the IJV to the venous angle the valvular plane is reached. Movement of the valve leaflets can be observed in a longitudinal and transverse examination plane in B-mode (Fig. 1). The movement of the valve leaflets is heart circle dependent. The valve closes during diastole when the right atrium transmits pressure to the superior vena cava. During closure the valve bulges cranially into the lumen of the IJV causing a short transient spontaneous retrograde flow in the Doppler spectrum. Cranial to the valve plane the vessel is slightly dilated and flow is slow, so that cloud-like currents of slowly flowing venous blood can be observed on B-mode imaging without being pathological. Not in all persons the IJV valves can be imaged sufficiently because they may be located quite distally behind the clavicle. Of course, a trapezoid transducer design is of help.

Effect of body position on the extracranial venous system

The body position has a profound influence on the IJVs cross-sectional area and flow velocities [3]. In the supine position the IJVs constitute the major cranial venous outflow route, however, in sitting or standing position the IJVs collapse following the hydrostatic pressure drop [4]. Then cranial blood is drained predominantly via the vertebral venous plexus [5]. As a consequence, the cross-sectional area of the IJV decreases from the lying to the upright position.

Internal jugular vein valve incompetence

The strongest connection of IJV incompetence has so far been reported with transient global amnesia [6]. All methods for assessment of IJV valve competence have in common that valve function is examined using a short Valsalva maneuver. This has to be strong enough to induce a complete closure of the investigated valve. Sander et al. described a method which is based on the observation of retrograde flow in color-mode during a Valsalva maneuver [7]. A second method is based on the detection of air bubbles in the jugular vein that had been administered intravenously just prior to the maneuver by injecting agitated saline into an antecubital vein [8].

The most wide spread method utilizes the detection of a retrograde flow in the Doppler spectrum (Fig. 2) [9]. Even in competent valves, a Valsalva maneuver leads to a short reflux during valve closure (Fig. 2A). This physiological reflux, with a duration corresponding to the valve closing time, has to be differentiated from an ongoing retrograde flow component in insufficient valves. Nedelmann et al. evaluated a cut-off time of 0.88 ms which differentiates normal valve closure from valve incompetence with reflux with a sensitivity and specificity of 100% [9]. Using this method, care has also to be taken to increase the sample volume size to the size of the IJV because retrograde jet streams along the venous wall might otherwise be missed.

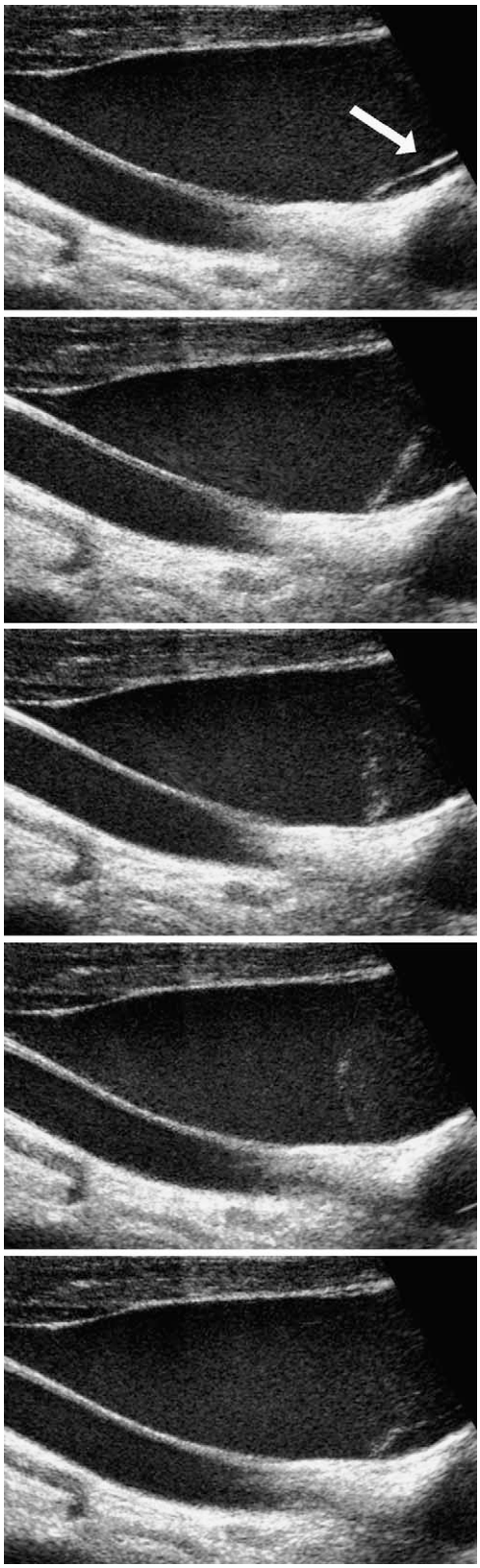

Figure 1 Movement of the internal jugular vein valve. The figure shows a movement sequence of a valve leaflet in the internal jugular vein. Please note the relatively large movement span.