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*Review*

# Anatomy of the vertebral vein

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**Summary**

After a brief introduction about current anatomical terminology of the vertebral vein, different aspects of vertebral vein anatomy are considered, from basic anatomy, through the details about its specific parts (transverse and inferior parts) of the vertebral vein, to the ultrasonography data and their relationships to cerebral venous outflow. For transverse part controversial viewpoints are present regarding the position of the vertebral vein in relation to vertebral artery, the existence of one or more veins or of the venous plexus, including the findings that in this part, instead the venous vessels, there is a periosteal or dural sinus, like the cranial cavernous sinus. Also, the literature data about morphology and variations of inferior part (outside of transverse canal) of vertebral vein are reported. Only inferior part of vertebral vein is appropriately named, because of contradictory and different findings about its parts in transverse foramina and on atlas.

Useful but not always the same imaging and ultrasonographic data about diameter, cross sectional area and blood flow in vertebral vein are reviewed. The clinical significance of the vertebral vein related to catheter insertions, and to different surgical procedures is mentioned, as well as some ultrasonographic findings of specific relationships of the vertebral vein and the cerebral outflow. Finally, in conclusions open issues about anatomy of the vertebral veins are listed and the problems requiring further study are indicated.

**Key words:** vertebral vein, anatomy, transverse part, inferior part, ultrasonography

## Introduction

Contrary to the vertebral artery (VA), in human anatomy basic curricula the vertebral vein (VV) is more or less mentioned only as accompanying vessel of VA. In the professional literature, also contrary to the VA, which is a long time the subject of the numerous studies [for example see in 1, 2, 3], VV has not been so intensively studied. The interest in the precise VV anatomy and its variations has gradually increased in the last two decades after probably the first, report of VA examination with Duplex scanning, where also VV was identified as running lateral to the artery [4].

According to current Terminologia Neuroanatomica [5] topographical parts of extradural segment of VA are Pars prevertebralis (Segmentum V1), Pars cervicalis (Segmentum V2) and Pars transversaria (Pars atlantica or Segmentum V3). However, for the parts of VV there is not such division, but many authors use the same terms as of VA division (V1, V2 and V3) to mark the corresponding parts of VV. In the current anatomical terminologies [6, 7] Vena vertebralis, Vena occipitalis, Vena vertebralis anterior, Vena vertebralis accessoria, Plexus venosus suboccipitalis and Vena vertebralis profunda are listed, all in the column distinct from the column titled Venae columnae vertebralis.

Some controversies about VV terminologies remained historically, especially in clinical literature, even if current official anatomical terminologies are clear. For example, even in the paper describing vertebral venous plexus vertebral veins (included are internal vertebral venous plexus, basivertebral veins and external vertebral venous plexus) appears as one of key words [8] which can lead to misunderstanding. Additional caution is necessary because plexiform organization of the VV allowing to name them "vertebral plexus," or "vertebral sinus" [9], can suggest the uniform plexiform structure of VV and requires also certain care related to the term Plexus venosus vertebralis internus. Even this naming is not yet adopted in different nomenclatures; the "plexiform" terminology is already used in some old anatomy textbooks. In practice, the lack of standardized nomenclature (terminology) could bring about confusion [9]. The term "vertebral artery venous plexus" seems appropriate for the venous plexus surrounding VA [10] which displays communications with the internal vertebral venous plexus laterally [11]. The importance of standard anatomical terminology, the standard professional language in communication, and in data exchange in medicine is obvious. The appropriate anatomical terms also open insights into the concepts, facilitate learning, and unique terminology avoids arbitrary creation and use of names [12].

Clinical interest in VVs anatomy is related to possible penetrating or direct injuries of neck and cervical spine, arteriovenous and iatrogenic fistulas, iatrogenic VA injuries and to the orthopedic procedures [13, 14, 15]. Knowledge of the individual venous drainage patterns might be of clinical relevance. For example, extensive (radical) neck surgery may require the careful review of preoperative computed tomography scan on an individual basis as well as the analysis of alternative non-jugular drainage [15, 16]. Precise knowledge of the arrangement of the venous system within the transverse foramen is necessary in imaging when VA dissection is suspected, as well as in surgical approaches for the cervical spine [9].

During the insertions of central catheters, mechanical complications such as misplacement into VV are often related to the close anatomy of vessels in the area [17, 18]. Also, the puncture of VA adjacent to VV is well known to occur as a complication of central catheter insertion via the internal jugular vein (IJV) [17]. VV is a very small vessel located behind IJV, and inadverent catheterization of VV during central venous access is a rare occurrence except in cases of the excessive rotation of the patient's head to the opposite side what changes surface anatomy of IJV or if right VV is deeper than usual [19, 18]. The right IJV has been the preferred site for central venous cannulation [17, 20], and left IJV cannulation, compared with right IJV, was associated with a higher rate of catheter dysfunction. This complication is strongly correlated with the amplitude of the angle between the left IJV and the ipsilateral brachiocephalic vein axis on the frontal plane [21].

## *Vertebral vein anatomy*

A classic and concise description is that VV corresponds to the artery of the same name, but is significantly smaller in caliber and accompanies it only in its cervical part. It descends through the openings on the transverse processes of the cervical vertebrae, and after exiting the opening of the 6th or 7th cervical vertebra, VV abruptly turns forward and flows into the venous angle [22]. The other complementary description is that paired VV arises in occipital region of posterior circumference of foramen magnum, anastomoses with occipital vein, follows VA forming venous plexus around it, and receives blood from vertebral venous plexuses and deep cervical veins [23]. After exiting the transverse foramen of the 6th vertebra (in some cases C7), VV runs anterolateral to VA, continues anterior to the subclavian artery (SA), joins the deep cervical vein, descends laterally and posterior to IJV [17, 18, 23]. However, in specialized book about clinical neuroanatomy the existence of venous plexus around the vertical part of VV is clearly described, forming later a single vein [24]. The anatomy of VV still can be significantly different from the normal one thus affecting the method of calculations [25] and the angiographic and anatomical studies show a wide anatomical variability and varying degrees of jugular and non-jugular venous drainage [26].

The accessory VV also belongs to the system of VV, drains the vertebral venous plexuses and actually is doubling VV. It passes through foramina transversaria of all six cervical vertebrae and joins to the terminal part of VV [23]. It occasionally arises from a plexus formed around VA by VV, descends with VV and emerges from the C7 transverse foramen [27]. Other related vein, the deep cervical vein, descends winding between the deep muscles of the back of the neck, at the base of the neck it turns forward, and flows into the venous angle, either separately or as a common trunk with VV [22]. The accessory vertebral vein and the deep cervical vein should be considered also as related to the potential plexiform morphology of the transverse part or to the variability of inferior part of VV and can complicate related terminology and clinical findings.

## *Vertebral vein and transversal foramina*

VA in the transverse foramina covered by the intertransverse muscles is surrounded by a venous plexus, which unites to form VV and is accompanied by a plexus of nerves from the inferior sympathetic ganglion [15, 28]. At each level from C3 to C6, a venous plexus consisting of one to three dominant veins accompanies the artery. The diameter of foramina transversaria exceeds the diameter of VA proper by 1.5 to 2 mm, and this space was occupied by the VV [15]. The left foramina transversaria generally are larger than the corresponding foramina on the right side. C7 foramen transversarium is routinely smaller and more dorsally located than corresponding C6 foramen, and at C7 only venous structures have been identified in 15 from 16 specimens [15]. VA, located medially in the transverse canal, occupies only half of the canal [9].

However, the anatomical arrangement of the venous system within the transverse foramen is controversial; there is disagreement whether the anatomy consists of a single VV or a confluence of venous plexus [9]. Plexiform arrangement of VV begins at the upper part of the transverse canal before VV turns into a single vein running from the transverse foramen of C6. However, the vertebral venous system within the transverse foramen has shown a plexus arrangement in 80% of the cases, and a single vein in the other cases [9]. Observed plexus arrangement and exclusive ventrolateral position (to VA) of the venous system (VV) within the transverse foraminal canal [9] is similar to an early ultrasonographic study which identified VA as located medial to VV [4]. Opposite to this, by CT and dissections (C3 to C7) it has been found that VVs are typically located medially to the corresponding artery in the transverse foramen and will be injured more frequently than VA during surgery [15]. The segmental arrangement of the venous system at each vertebra (in most cases symmetrical) facilitates radiological readings. The suboccipital venous compartment cushioning the horizontal part of V3 continues below, gradually becoming the vertebral artery venous plexus around the vertical part of V3. This plexus, located predominantly at the medioposterior aspect, has a number of venous trunks (in average four, range three–six) mutually interconnected by venules and merging into one trunk that enters the brachiocephalic vein [10].

The traditional view of satellite vein alongside the artery in the transverse canal as incorrect has been challenged by the statement that there is no vein in the transverse canal, but the venous blood flows through a space formed by the periosteum without evidence of a vein [29]. Accordingly, the periosteum by the fibrous leaflets forms a network of compartments between the artery and periosteal sheath, without the differences between inter-foraminal and intra-foraminal regions. The presence of venous structure along the entire path of VV is not excluded, suggesting that the venous organization in the transverse canal is a set of successive venous structures (venous plexus, venous sinus, venous plexus, and vein). The venous system in the transverse canal presents itself as a sinus (called transversovertebral sinus) similar to the intracranial sinus structure and no sign of a satellite VV has ever been observed near the artery [29]. Histological study has confirmed the formation of a transverse vertebral venous sinus, and the fact that the venous plexus is surrounded by periosteum should be respected during the surgery to reduce the risk of VA injury [9].

To illustrate some inconsistencies, even between the two groups of authors both describing the presence of transversovertebral sinus and not of the vein, it can be mentioned that the classification of the venous organization in V2 part (single or double veins, venous plexus, and absence of vein) [30] one group of authors have considered as in accordance with their findings [29]. Also, they think that the type ''absence of vein'' should confirm the existence of the transversovertebral sinus they described [29]. Other group of authors in description of the transversovertebral sinus stated that reported equal ventrolateral or ventromedial positioning of VVs [30] was not consistent with their findings [9].

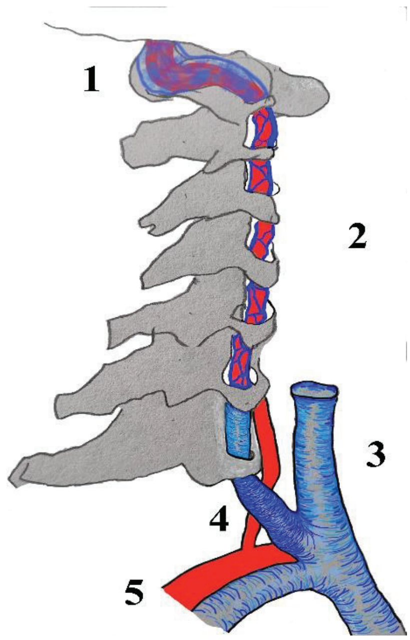


**Figure 1.** General summary view of human vertebral vein anatomy. 1. Suboccipital cavernous sinus; 2. Right transversovertebral venous plexus around V2 (or transversovertebral venous sinus or transverse vertebral venous sinus or vertebral artery venous plexus); 3. Right internal jugular vein; 4. Inferior part of the right vertebral vein (dark blue); 5. Right subclavian artery and vein. (drawing by the author according to 9, 10, and 29).

Finally, the "vertebral vein" terminology is appropriate only after the vessel exits the canal. The naming of "plexus" or "sinus" will be varied along the transverse canal height: it will be more sinusoidal on the top and plexiform on the bottom [9]. It seems that all reported differences in the number and location of VV or of venous plexus in V2 part, beside individual variability, are related to variable calibers, different number or variable position of the constituents of venous plexus or sinus, and to the cervical level studied.

These findings for the transverse part of VV correspond to still discussed structure of the intracranial cavernous sinus, where the existence of trabeculae is a particular point of contention. Structures within the intracranial cavernous sinus that would correspond to the venous plexuses described by some authors could not be demonstrated, while fibrous trabeculae are regularly found between the walls and the contents of the intracranial cavernous sinus [10, 31]. The suboccipital cavernous sinus surrounding horizontal V3 segment of VA shows striking similarities to the petrous -cavernous internal carotid artery venous cushioning [10]. More details about this question see in other papers [9, 10, 29, 30].

In any case, whether in transverse canal there are several VVs, the venous plexus or the venous sinus-like structure, possibly also variably related to different cervical levels, any of these facts may explain why the higher insonation levels frequently yield more than one venous signal [26].

The anastomoses between VV and ventral longitudinal veins are uniform and arranged segmentally at each vertebra, and several anastomoses, such as transverse plexuses, have been observed between left and right ventral longitudinal veins (not at any vertebra) and VV [9]. The vertebral artery venous plexus surrounding in transverse foramen VA communicates with the intraspinal epidural veins via an intervertebral vein and with the vertebral venous plexus and the suboccipital venous plexus [10, 27]. An original variant of the cervical venous plexus linking the transverse foramina, which anastomoses with VV at the same levels, is anomalous direct connection of the paraspinal venous plexus through the vertebral bodies. Authors have suggested that the cervical embryonic transverse intersegmental anastomosing veins do not always regress and may persist as VVs. Additionally, they have detected rare cylindrical VVs, whereas the more familiar structure was that of a periarterial venous plexus [32].

## *Inferior part of the vertebral vein*

Generally, the inferior part of VV corresponds to V1 segment of VA, but with the opposite direction of blood flow (BF), from its emergence at C6 foramen (usually) to its ostium in the region of venous angle. Because of its possible clinical significance during the insertion of central line catheters, this accessible portion of VV is here separately described. There are the valves on the opening of VV [23]. Some small veins are around IJV, including the vertebral, anterior vertebral, deep cervical, superior (sic!?) thyroid, and internal thoracic veins [33]. The first (V1) segment of VA, as well as VV which is more anteriorly positioned, is situated in a triangle of the vertebral artery, bound by the lateral edge of the longus cervicis muscle, the medial edge of the anterior scalene muscle, and the first part of SA. The V1 segment of VA is here situated behind IJV and VV, and just anterior to the transverse process of C7 vertebra [28]. After emergence from C6 or C7 transverse foramen, VV passes anterior to first part of SA, where it lies as the only vein posterior to IJV and drains into the upper (beginning) portion of the brachiocephalic vein [18, 23, 27, 34].

The VV receives flow from the plexus rising from the transverse foramen of C7 which is regarded as a venous sinus without muscularis interposition. At the emergence of C6 transverse foramina, VA is associated with a

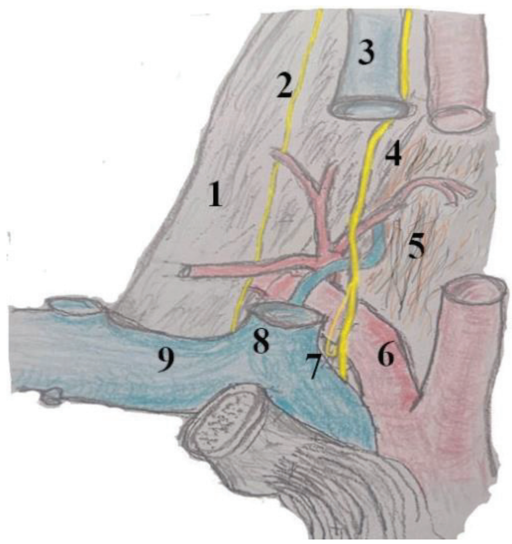


**Figure 2.** Inferior part of the right vertebral vein in vast majority of cases. 1. Anterior scalenus muscle; 2. Right phrenic nerve; 3. Right internal jugular vein; 4. Right vagus nerve; 5. Right vertebral vein; 6. Right subclavian artery; 7. Right recurrent laryngeal nerve; 8. Right venous angle; 9. Right subclavian vein. (drawing by the author)

satellite vein, which has, by definition, a muscularis layer [9].

In the extensive anatomical CT study [27] of the (inferior) portion of VV in the lower neck and thoracic inlet, the inferior part of VVs was classified into four types: type A (80.6 % of cases), with a single VV emerging from C5, C6, or C7 transverse foramen, descending ventral to SA and drained into the upper portion of the brachiocephalic vein; type B (5.8%) a single VV descending dorsal to SA and drained into the upper or the lower portion of the brachiocephalic vein. In this type single VV was more frequent than double VV and emerged from the one transverse foramen (C6 or C7) in 86.9%, or from two or more foramina (containing the seventh) in 13.0% of cases [27]; type C (8.3%), as a doubled VV crossing both sides of SA, forming a relatively short common trunk and drained into the upper portion of the brachiocephalic vein; type D (5.3%) was presented as one VV ventral to SA drained into the upper portion of the brachiocephalic vein, and as another VV dorsal to SA drained into the upper or the lower portion of the brachiocephalic vein [27]. Rarely VV can emerge from C6 or C7 transverse foramen, crosses the dorsal aspect of SA, rans down the trachea, and opens into the lower portion of the brachiocephalic vein [27].

It is important to emphasize that although sometimes it was difficult to differentiate between types C and D [27] in cited study [27] this issue was not widely discussed, as well as the presence of the accessory or deep cervical veins and the formation of their common trunks, especially in relation to the types C and D.

## *Vertebral vein and ultrasound*

In a very early ultrasonographic study [4] VA was identified by its location medial to VV, similar to some other findings [9], but opposite to the anatomical and CT findings of other authors [15]. However, VVs are generally difficult to identify with ultrasound [35] and VA in the segment between the transverse processes helps to visualize VV [36]. In V2 and V1 segments VV was over VA [37]. Visualization of the opening of VV into the brachiocephalic vein showed the two cusps and the motions (opening and closing) of the paired valve of VV, synchronized with the valves of IJV [38].

In supine position in rest, mean diameter of VV was 0.31 cm (± 0.09 cm) [39]. In healthy participants the diameters of VV bilaterally in segments V2 and V1 in rest were determined by ultrasound in supine position [37]. Diameter of VV in osseous canal (V2) was 0.17 cm (0.14–0.20 cm), and after exit from osseous canal (V1) it significantly increased to 0.25 cm (0.21-0.36 cm) with maximal size at ostium of 0.37 cm (0.33–0.40 cm). However, significantly different diameters between the right - 0.31cm (0.24–0.39 cm) and the left - 0.23 cm (0.14–0.26 cm) VV were found only in V1 segment [37].

Ultrasound assessment in healthy individuals revealed that the cross-sectional areas and the width of the jugular and VVs significantly varied depending on the patient's position. Depending of body elevation estimated cross-sectional area of VV was 10.6 to 11.9 mm2 [40]. By contrast with the jugular veins, which were completely closed or merely narrowed in sitting position, the cross-sectional area of VVs was greater in the sitting than in the supine position in a significant way [36]. Contrary to this, the cross-sectional area of the right VV (V1 segment) was 2 ± 1 mm2 (in both, supine and standing positions), and of left VV it was also 2 ± 1 mm2 in standing position. Only the left VV was larger in supine position (6 ± 25 mm2), and it was 3.6 times larger than of right VV at the same level [41]. The IJVs can show considerable asymmetry, while no statistically significant differences were observed between the cross-sectional areas of the left (mean 0.030 cm2; 0.008–0.096 cm2) and the right (mean 0.021 cm2; 0.005–0.053 cm2) VV [36].

In VV, BF was detected in all healthy subjects [35], but other authors found blood flow signal of VV in 68% subjects on both sides and in 28% persons on one side [26]. In healthy participants BF was registered in vertical position in 100% of cases and in horizontal position on right in 97% cases, and on left in 87.5% cases. In supine position maximal blood velocity in V1 was 28.4 cm/sec (18.8–41.3 cm/sec), in V2 it was 13.7 cm/sec (8.5–18), and in vertical position maximal blood velocity in VV was 29.7 cm/sec (20.7–46.0 cm/sec), meaning that practically it was doubled [37]. In VV, BF was characterized by the presence of reaction to hypercapnia, postural changes, synchrony with heart and respiration cycles. In persons with pathology of cervical region results were atypical [37]. In an ultrasonographic study bilateral manual compression of IJVs led to a significant increase of BF in VV [16], but in the sitting position on application of very low pressure to the skin with the sonography probe, IJVs rarely appeared to occlude [40].

Echo color Doppler of IJV and VV, bilaterally from their distal to the proximal part, showed that the blood outflow through VV and IJVs was more than twice the outflow in the sitting position (739.80 ± 326.32 versus 278.24 ± 207.94 mL/min) [40]. In upright sitting position flow decreased, both in VV and IJVs, as the total vessel area decreased (from 0.46 p ± 0.57 to 0.09 ± 0.08 cm2), even if the mean velocity increased. This reduced BF in VV with the body at 90° was explained by the different points of recording, because the diameter of elastic inferior part of VV (V1) was more likely to change than in the rigid V2 part. There was no significant side difference between the cross-sectional area and BF (for both IJV and VV) either in the supine or in the sitting positions [41]. Anatomy can participate in these upright/horizontal differences, since in horizontal position blood from neurocranium tends to flow more in occipital direction, but in this position this flow toward IJV can be probably slower because of slightly ascending flow through the sigmoid sinus.

Ultrasonography is a useful tool, not only for the easy confirmation of the puncture site, but it also provides real-time in plane and out-of-plane views to identify the needle position during the procedure [19]. Longitudinal view from the ultrasound is necessary to show wrong placement of the catheter passing the wall of IJV and proceeding deep in the small vein posterior to the right IJV, probably VV [17]. In one patient the transverse images of IJV showed the guidewire located within the right IJV lumen, but the longitudinal ultrasound images showed that it passed through the right IJV, penetrated its posterior wall, and its tip was placed in VV, the small vein posterior to the right IJV [33]. The vein initially punctured [19] was the right cervical VV, as a large vessel behind the common carotid artery and IJV, which was observed on longitudinal view. In this patient the cross-sectional area of left VV was 11.7 mm2, but it was 42.2 mm2 of right VV [19], which was approximately 20 times larger than the reported mean area of VV in the general population (2 ± 1mm2) [41].

The differences in reported results are related to an increased accuracy and sensibility of modern machines as compared with those used in the previous studies, to the technique used [41] and to the correction of angle error [37]. Additionally, the reduction of BF in VV with the body at 90° could be explained by the differences between the elastic V1 and the rigid V2 part, and by different regulation of the pulsed Doppler filter [41].

## Vertebral veins and cerebral venous outflow

The issue of cerebral venous outflow is not in the focus of this paper, but because it is related to clinical anatomy of VV, some facts will be mentioned here. Our current knowledge regarding the regulation of cerebral venous outflow is still very incomplete, but it should be suspected that jugular and vertebral outflow routes in many individuals are not properly interconnected. However, the most of the patients after radical surgery for neck cancers have not developed severe neurologic symptoms [42]. In some cases of radical neck surgery, the blood was returning to the heart by a route other than IJVs, probably the vertebral venous plexus. The anastomoses with external veins seemed most abundant in the cervical region with multiple connections to the deep cervical vein and VV [43]. In the supine position blood flows out mostly through IJVs, while in contrast, when the head is elevated the blood flows out primarily through VV and the spinal epidural plexus. The spinal epidural venous plexus and also, to some degree, VVs, do not collapse because of their localization within rigid osseous canals [42]. The calculations showed that the pressure gradients necessary to move blood from the brain toward the heart differed significantly between the supine and upright positions (0.21 mmHg and 0.80 mmHg, respectively) [42].

Schematically, two descending cerebral venous outflow tracks can be distinguished: IJVs anteriorly, and the vertebral venous system posteriorly which can be considered as belonging to non-jugular or extra-jugular system. The major alternative outflow track of cerebral venous drainage represents the internal and external vertebral venous systems [10]. Generally, vertebral venous system consists of four intercommunicating divisions: the central or internal network of the vessels surrounding the spinal dura mater, vessels within the bone of the vertebrae themselves, the plexuses external to and surrounding the vertebral column, and VV outside of transverse foramen [27]. In the cervical region, the vertebral venous system is mainly represented by the anterior internal vertebral venous plexus, the vertebral artery venous plexus, and the deep cervical veins. The anastomosis between anterior internal vertebral venous plexus and vertebral artery venous plexus was shown [11]. However, VVs, as important parts of the vertebral venous system are probably not the main non-jugular drainage pathway and the variably developed deep cervical veins as well as the intraspinal epidural venous system have to be considered [16]. The VV data themselves suggest that VV alone is not the main drainage pathway of cerebral blood under physiological circumstances [26].

The extra-jugular system consists of VVs and deep cervical veins [26, 38, 40]. Predominant jugular drainage has been found in 72% of all individuals, the predominantly non-jugular drainage pattern (as the principle path of cerebral venous outflow) in approximately 6% of subjects, and in 22% the jugular equals the extra-jugular drainage [26]. Interestingly, VV BF between the jugular and non-jugular drainage type did not show a significant difference (30 ± 25 ml/min vs. 42 ± 25 ml/min) [26].

Anatomical nomenclature of the extra-jugular venous system and its compartments is far less homogenous because of its more complex structure and a commonly problematic visualization on angiography and the classification of the extra-jugular venous system into an intra- and extraspinal compartment was proposed [26].

Using ultrasonography, the BFs were measured in the internal carotid artery (ICA), external carotid artery and VA, and in IJV and VV, before, and on days 30 and 57 of the long-term head down bed rest. Long-term head-down bed rest caused a heterogeneous cerebral BF response - the anterior cerebral arterial (ICA) and venous (IJV) BFs decreased, but posterior cerebral arterial (VA) and venous (VV) BFs were well maintained around the baseline values throughout two months. Authors suggested that a siphon (VV) supported the posterior cerebral circulation in maintaining VA BF during orthostatic stress [44]. Namely, if IJVs collapse, other veins may maintain the siphon, but if all veins draining the brain collapse in the upright position, the siphon does not support cerebral BF [45].

The dynamic supine exercise modifies the cerebral venous outflow, with the coupling between regulations of arterial inflow and venous outflow in both anterior and posterior cerebral circulation [39]. The change in ICA or VA mean BF velocity from baseline to exercise is significantly correlated with the change in IJV or VV BF, respectively. During dynamic exercise (workload) BFs in VA and VV increased. Both VV and external jugular veins progressively increased from basic values, and in contrast with IJV, VV was not constricted throughout the exercise [39]. This relative maintenance of posterior circulation (including VV) found in cited studies [39, 45] can be related to the vital importance of brain stem structures.

In the patients with multiple sclerosis, IJV stenosis, postural control reversal of the cerebral venous outflow pathways, and absence of flow in IJVs and/or VV were found in 4.5%, and 6.8% patients, respectively [35]. In the control group none of mentioned parameters were detected. In patients with multiple sclerosis, BF was not detected in VV by color Doppler while by spectral imaging it was found in 2.3% and 4.5% patients on the right and left sides, respectively. No significant difference in the cerebral venous drainage through IJV or VV was found between patients and healthy subjects within any of the investigated ultrasonographic parameters in the sitting or supine position and the role of abnormal cerebral venous drainage as an etiological factor of multiple sclerosis remained in doubt [35].

## Conclusions

Yet, there is not complete agreement about anatomy of the human vertebral veins having no consistently uniform morphology and structure. Only their inferior parts generally have appropriate names, in spite of their variability, as well as of the presence of accessory vertebral vein and of deep cervical vein. Therefore, the vertebral veins terminology requires further refinement and confirmation.

Potential differences of various vertebral veins studies can be related to the individual and ethnic morphological variability, differences in caliber of vessels studied, differences related to specific cervical levels, technical issues, and most probably, to the combination of all of these factors. Especially in the transverse part of the vein (V2) the differences found in location of vertebral veins or of plexus are related to the variability of calibers, the number or the position of constituents of venous plexus (or sinus).

Comparative analysis of results of structural (such as CT or MR) and of functional imaging studies (such as ultrasonography, some neuroradiological methods) are faced with the above-mentioned questions. Therefore, the imaging studies have not provided yet convincing details of vertebral veins specific level differences and morphological variability that can be related to the clinical findings.

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## Anatomija kičmene vene (v. vertebralis)

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Nakon kratkog uvoda u savremenu anatomsku terminologiju kičmene (vertebralne) vene (vena vertebralis), razmatraju se različiti aspekti anatomije vertebralne vene, od osnovne anatomije, preko detalja o specifičnim delovima (deo u transverznom kanalu i donji deo) kičmene vene, do podataka sa ultrazvuka, kao i o odnosu vertebralnnih vena i odvoda krvi iz mozga. Za njen deo u poprečnim otvorima vratnih pršljenova prikazana su kontroverzna gledišta o položaju vertebralne vene u odnosu na vertebralnu arteriju, o postojanju jedne ili više vena ili venskog pleksusa, uključujući i nalaze da se u ovom delu umesto venskih sudova nalazi periostalni ili duralni sinus, sličan kranijalnom kavernoznom sinusu. Takođe se navode podaci iz literature o morfologiji i varijacijama donjeg dela (van transverznog kanala) kičmene vene. Samo donji deo kičmene vene ima odgovarajući naziv, zbog protivurečnih i različitih nalaza u njenim delovima u poprečnim otvorima i na atlasu. Dat je pregled korisnih, ali ne i uvek jednakih ultrasonografskih podataka o prečniku, površini poprečnog preseka i o protoku krvi u vertebralnoj veni. Naveden je klinički značaj kičmene vene u vezi sa umetanjem katetera i različitim hirurškim zahvatima, kao i neki ultrazvučni nalazi specifičnih odnosa vertebralne vene i ukupnog venskog odliva krvi iz mozga. Na kraju, u zaključcima su navedena otvorena pitanja iz anatomije kičmenih vena i naznačeni problemi koji zahtevaju dalja proučavanja.

**Ključne reči:** vena vertebralis, anatomija, vertikalni (transverzni) deo, donji deo, ultrasonografija