Editorial Commentary

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Spinal radiculomedullary vein and bridging vein

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"The antireflux mechanism – angiographic anatomy and clinical implications"[1] authored by Dr. Philippe Gailloud is very interesting because not only of beautiful illustration by Dr. Lydia Gregg and precise spinal angiograms, but of the way to prove the anti-reflux mechanism (ARM) by clinical images of the spinal cord veins in the normal and pathological conditions. He showed the ARM at the dural exit of **radioculomedullary vein (RMV)** coursing from perimedullary to epidural venous systems radio-anatomically. I would like to comment on this article, especially focusing on anatomical nomenclature of RMV and its roles in the normal and pathological circumstances.

Radiculomedullary vein and bridging vein

Some may call all spinal draining veins RMVs in the broad sense of the term irrespective of locations of the dural exits.[1] Total number of these draining veins amounts to 30–70, with an average of over 50 per spinal cord.[2] However, differentiation between radicular veins and RMVs is not straightforward. If the possible radicular veins are excluded, the numbers of anterior and posterior RMVs remain 6–11 and 5–10, respectively.[2] Others may differentiate the spinal draining veins by their dural exit.[3] The draining veins exiting at the level between intervertebral foramina are called **bridging veins (BVs)** and those draining at the level of intervertebral foramina are called **RMVs** in the narrow sense of the term (Figure 1(a)).

It is reported that 60% of the draining veins from the spinal cord exit at the level of intervertebral foramina along the nerve roots while the remaining 40% exit at the level between the intervertebral foramina.[4] Thron A et al.[5] reported the topical relationship between the draining veins and nerve roots are jointed in 22%, close to each other (<1 mm) but separate in 47%, and distant to each other in 31%. These can be summarized that the draining veins and nerve roots are in close vicinity in approximately 60-70%, and they are separate in approximately 30–40%.

In this commentary, I would like to use RMV in the narrow sense in order to discuss RMV and BV as different structures. Personally, I have wrongly taken it for granted that RMVs and BVs are completely different embryologically and anatomically for a long time because I thought that RMVs of the narrow sense are in metameric disposition similar to **radiculomedullary arteries (RMAs)** while BVs are not in metameric disposition. However, this idea is not the case.

Difference between RMV and BV

It is apparent that both RMVs and BVs have the role to drain perimedullary venous blood to epidural veins (internal vertebral venous plexus). Tadié et al.[6] established the concept of the ARM, which is functional and important for the entire spinal cord. Although the ARM should be equipped to both RMVs and BVs, it is not clear whether they have the other functions furthermore.[5]

There are two structures of venous exits through the dura mater: **slit type** and **bulge or nodular type**. Neither has a valve-like structure as previously thought. Thron A, et al [5] reported that 60% of the specimen studied were slit type and 35% were bulge or nodular type. The remaining 5% could not be assigned to either type. Slit type is regularly observed in the vicinity of nerve roots. Bulge or nodular type is mainly observed with vessels crossing the dura at some distance from nerve roots.[2] This means that slit type is common for RMVs and bulge or nodular type is common for BVs.

Spinal radicular arteries and RMAs are metameric embryologically and accompanied by the nerve roots at each spinal level. Each RMA runs through the intervertebral foramen. Although radicular veins are metameric, RMVs are not metameric and do not

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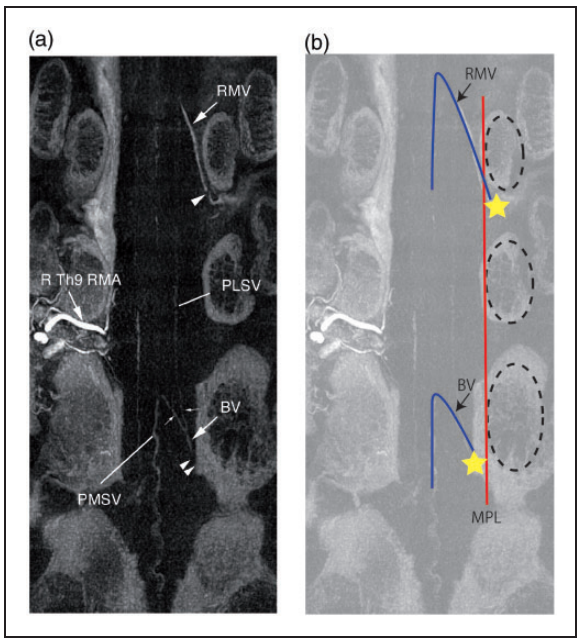

Figure 1. Spinal radiculomedullary vein and bridging vein. (a) Radiculomedullary vein and bridging vein in the normal circumstances. This radiculomedullary vein is connected to anteromedial spinal vein (not visualized). This bridging vein with dual rooted structure (small arrows) is connected to left posterolateral spinal vein. Single arrowhead indicates the slit type and double arrowheads point to the bulge or nodular type antireflux mechanisms. Coronal reconstruction image of 3D-rotational angiography of right Th9 injection.(b) Shunting points in dural arteriovenous fistulas and their relationship to medial interpedicular line (red line: MPL) is shown. Stars (yellow) indicate the shunt points. The exit of bridging vein to dorsal epidural veins is located medial to the medial interpedicular line. The exit of radiculomedullary vein in its narrow sense is located lateral to this line. Bridging vein and radiculomedullary vein have the same embryological dispositions and they do not follow the metameric dispositions. BV: bridging vein, PLSV: posterolateral spinal vein, PMSV: posteromedial spinal vein, RMA: radiculomedullary artery, and RMV: radiculomedullary vein.

follow the nerve roots.[2,7] This means that both RMV and BV are embryologically the same spinal draining veins and their difference is only the fortuitous levels of dural exits.

Roles of RMV and BV in pathological conditions

Irrespective of the different types of ARMs, RMV and BV have the same roles of spinal venous drainage and the ARM in the normal conditions. In dural AVFs, more than one radiculomeningeal artery make AV shunts on the inner dural surface after piercing the dura mater from outside.[3,8] Then, venous reflux is directed to perimedullary veins through either RMV or BV. The shunting points of dural AVFs are classified by Kiyosue et al.[3] as follows: (1) Lateral to the medial interpedicular line, which is the tangent line connecting the most medial point of pedicular circles between the upper and lower levels on AP view, suggestive of location on the dural nerve sleeve, thus drainage is through RMV and (2) Medial to this line, suggestive of location on the spinal dura mater (thecal sac), thus drainage is through BV. They reported using this classification that the drainage routes in dural AVFs are through BVs in 77% of cases and RMV drains only in 5%.[3] In the remaining 18%, it was not decisive whether the draining veins were RMV or BV because AV shunts were located just on the medial interpedicular line (Figure 1(b)).

Arrow-tipped loop or anastomosis is known to be the result of distal thrombotic occlusion of spinal draining veins with dual or multiple rooted structure.[9,10] If dual- or multi-rooted venous structure is more frequently associated with BV than with RMV, higher incidence of dural AVF in association with BV could be explained by this anatomical disposition and possible pathogenesis of venous thrombosis in dural AVFs. This speculation should be validated by the future study.

In epidural AVFs, feeding arteries are mostly epidural arteries, especially dorsal somatic branches. Ventral epidural AVF with perimedullary drainage shows a characteristic J turn consisting of the epidural venous pouch and RMV.[3] Thus, it is concievable that the slit type ARM is predominantly related to the pathogenesis of epidual AVF with perimedullary drainage, and the bulge or nodular type ARM is related to that of dural AVF.

In conclusion, RMV in the narrow sense and BV have two common functional roles with the same embryological dispositions such as perimedullary venous drainage and the ARM in the normal conditions. In the presence of AV shunts, they can be the routes for retrograde venous reflux. In dural AVF, reflux is more preferentially drained by BVs and in epidural AVFs it is more preferentially drained by RMVs. Although it is not clear that the difference of venous reflux routes is related to the structure of the ARM, I believe that the architectures of RMV and BV likely influences development and clinical manifestations of the dural and epidual AVFs.

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References

1. Gailloud P. The antireflux mechanism – angiographic anatomy and clinical implications. *Interv Neuroradiol*. EPub ahead print 14 July 2020. DOI:10.1177/1591019920941309.
2. Thron A. *Vascular anatomy of the spinal cord: basic radioanatomy for diagnostic imaging and spinal cord interventions*. New York, NY: Springer Berlin Heidelberg, 2016.
3. Kiyosue H, Matsumaru Y, Niimi Y, JSNET Spinal AV Shunts Study Group, et al. Angiographic and clinical characteristics of thoracolumbar spinal epidural and dural arteriovenous fistulas. ***Stroke*** 2017; 48: 3215–3222.
4. Die Blutgefäße des Rückenmarks. Untersuchungen über ihre vergleichende Anatomie and Entwicklungsgeschichte. *Anat Hefte* 1904; 24: 1–364.
5. Thron A, Krings T, Otto J, et al. The transdural course of radicular spinal cord veins – a microangiographical and microscopical study. ***Clin Neuroradiol*** 2015; 25: 361–369.
6. Tadié M, Hemet J, Freger P, et al. Morphological and functional anatomy of spinal cord veins. *J Neuroradiol* 1985; 12: 3–20.
7. Lasjaunias P, Berenstein A and Ter Brugge K. *Spinal vein. Surgical neuroangiography*. Heidelberg: Springer Science & Business Media, 2013, pp. 146–158.
8. Takai K, Komori T and Taniguchi M. Microvascular anatomy of spinal dural arteriovenous fistulas: arteriovenous connections and their relationships with the dura mater. ***J Neurosurg Spine*** 2015; 23: 526–533.
9. Crock HV and Yoshizawa H. *The blood supply of the vertebral column and spinal cord in man*. New York: Springer-Verlag, 1977.
10. Gailloud P. The arrow-tipped loop is a marker of radiculomedullary vein thrombosis linked to the anti-reflux mechanism – angiographic anatomy and clinical implications. ***Neuroradiology*** 2014; 56: 859–864.