The marginal sinus

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Object. Descriptions of the marginal venous sinus are lacking in the extant medical literature. The aim of this study was to characterize the anatomy of this intracranial venous sinus.

Methods. The authors examined the marginal sinuses in 15 adult cadavers following the injection of latex into the intracranial venous system. The maximal vertical height of the sinuses, which ranged from 7 to 15 mm (mean 10 mm), was located at the lateral aspect of the foramen magnum at or near the region at which the spinal accessory nerve crossed en route to the jugular foramen. In all specimens the sinus tapered as it traveled both anteriorly and posteriorly. Ninety-three percent of the specimens demonstrated significant drainage into the veins of the hypoglossal canal. The hypoglossal nerve rootlets pierced the sinus and its tributaries in 11 (73%) of 15 specimens. The marginal sinus communicated with the basilar venous plexus in 12 (80%) of 15 specimens and with the occipital sinus in all specimens (100%). There was venous communication with the sigmoid sinus in all specimens. The vertebral artery coursed through the marginal sinus as it pierced the posterior atlantooccipital membrane in all left sides and in 87% of the right sides.

Conclusions. These quantitative data will be useful to the neurosurgeon who operates in the region of the marginal sinus.

Key Words • posterior fossa • dural venous sinus • foramen magnum • neurosurgery • anatomical study

Reports on the marginal sinus have been scanty, and most standard anatomy texts mention merely that it is found in the vicinity of the foramen magnum. This dural venous sinus lies between the layers of the dura mater and more or less rims the internal aspect of the foramen magnum. It communicates anteriorly with the basilar venous plexus on the superior surface of the inferior clivus, and posteriorly with the occipital sinus (Fig. 1). The marginal sinuses may also join the distal portions of the sigmoid sinuses via small connections that pass across the intracranial surface of, and communicate with, the veins of the hypoglossal canal. Distally, the marginal sinus drains freely into the vertebral venous plexus. The occipital sinus begins at the junction of the left and right posterior parts of the marginal sinus, although the former sinus may not connect to the latter. In the present study, we sought to elucidate further the anatomy of this intracranial venous sinus.

Materials and Methods

Fifteen formalin-fixed adult cadavers (nine male and six female patients who had a mean age of 61 years [range 50–74 years] at the time of death) were dissected, and marginal sinuses were measured. Dissections were performed following the injection of blue latex into the left and right internal jugular veins. Specimens were allowed to cure for 48 hours prior to dissection. The calvaria in each specimen was removed using a bone saw, and the brain and brainstem were removed. The dimensions of each marginal sinus were measured, and the connections and relationships to surrounding sinuses were observed. All measurements were obtained using calipers.

Results

No specimen demonstrated evidence of prior surgical intervention in the posterior cranial fossa. All specimens had marginal sinuses, which lay between the layers of the dura mater at the superior margin of the foramen magnum in all. The maximal vertical height of the sinuses, which ranged from 7 to 15 mm (mean 10 mm), was located at or near the foramen magnum where the spinal accessory nerve crossed en route to the jugular foramen in all specimens (Figs. 2 and 3). The sinus tapered to 3 to 5 mm as it traveled both anteriorly and posteriorly toward the basion and opisthion in all specimens. The marginal sinus communicated with the basilar venous plexus in 12 (80%) of 15 specimens and with the occipital sinus in all specimens (100%). Fourteen (93%) of 15 specimens exhibited significant drainage into the veins of the hypoglossal canal. The hypoglossal nerve rootlets pierced the sinus and its tributaries in 11 (73%) of 15 specimens. Venous communication with the sigmoid sinus was seen in all specimens. The VA coursed through the margin-
al sinus as it pierced the posterior atlantooccipital membrane in all left sides and in 13 (87%) of 15 right sides.

Discussion

Using injected fetal brains, Okudera, et al., have shown that the marked increase in venous flow from the rapidly growing cerebral hemispheres leads to ballooning of the transverse sinuses in the absence of an increase in the inner diameters of the sigmoid and jugular sinuses. This ballooning also results in the formation of the occipital and marginal sinuses.

The cephalic venous drainage system in the early human embryo arises from three dural venous plexuses (anterior, middle, and posterior). In the adult human the marginal sinus constitutes an inconstant remnant of the embryonic posterior venous plexus that anastomoses with the distal part of the sigmoid sinus, thus communicating with the internal jugular system. The occipital and marginal sinuses are established as concomitants of the caudal expansion of the cerebrum over the midbrain and cerebellum during fetal growth. The marginal sinus is already developed by the 6th fetal month; prior to this time during the 3rd and 4th months, it and the occipital sinus are plexiform in nature and extend from the tentorium cerebelli inferiorly toward the foramen magnum. The marginal sinus tends to be enlarged in cases of large occipital sinuses. Some authors have considered these instances of enlarged marginal and occipital sinuses as persistence of the fetal prototype of posterior venous sinus formation. Interestingly, some have reported that the occipital and marginal sinus system in the human neonate has a capacity equivalent to that of the transverse sinuses.

Falk has studied ancient hominid skulls and found that those in the early bipeds (Australopithecus afarensis) and robust australopithecines were characterized by enlarged occipital and marginal sinus systems. This author has suggested that selection for bipedalism initially resulted in epigenetic adaptations for routes to deliver blood to the vertebral plexus, including an enlarged marginal sinus, but that the pressures underlying these adaptations relaxed as bipedalism became established. Other routes for delivering blood to the vertebral plexus of veins were either directly or indirectly selected for, perhaps in conjunction with the changing architecture of the skull. The specimens examined by Falk were also found to have marginal sinus and occipital sinus bony grooves that were much larger than the grooves for the transverse and sigmoid sinuses, thus presumably usurping the role of the sinuses as the main venous outflow of the cranium.

In modern adult humans compared with developing fetuses, the marginal sinus does not provide the main venous outflow of the cranium but rather serves as an alternate route for venous drainage to occur, particularly in cases of internal jugular vein obstruction, whether positional or pathological. However, some authors have posited that this sinus, coupled with the vertebral venous plexus, provides most of the cranial venous drainage in species with an upright posture such as monkeys and humans.

Caruso, et al., have reported on marginal sinuses with a mean diameter of 2 mm in 14 patients who had undergone magnetic resonance imaging. We found that the maximal vertical height was 7 to 15 mm (mean 10 mm) and that this height was at or near the lateral aspect of the foramen magnum where the spinal accessory nerve crossed it. In our study, there was, in general, significant communication between the marginal sinus and the veins of the hypoglossal canal. Interestingly, in many of our specimens the marginal sinus or its tributaries were pierced by the rootlets of the hypoglossal nerve, which is reminiscent of the cranial nerves as they traverse the cavernous sinus. Furthermore, the VA...
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was noted to pierce this venous sinus in the majority of specimens, as does the internal carotid artery within the cavernous sinus.

Clinically, dural arteriovenous fistulas involving the marginal sinus have been reported. These fistulas are often found following basilar skull fractures and may involve the occipital, posterior meningeal, or posterior auricular arteries. McDougall, et al., found that the ascending pharyngeal artery was most often involved by fistulas involving the marginal sinus. Furthermore, these authors prescribed great care when treating these fistulas to avoid occlusion of the arterial supply to the lower cranial nerves; one of their patients incurred transient hypoglossal nerve palsy following an embolization procedure. Surgically, entrance into the subdural space deep to the foramen magnum necessitates traversing the marginal sinus, as in posterior cranial fossa decompression for Chiari I malformations or posterior fossa tumors. Knowledge of the anatomy of the marginal sinus as described in our study is therefore of surgical importance.

Conclusions

The marginal sinus may be encountered in approaches to the posterior cranial fossa and may be enlarged in children. Results of our study in adult cadavers revealed that this sinus is greatest in size laterally in the foramen magnum and usually has significant connections to the veins of the hypoglossal canal. In fact, in many of our specimens the rootlets of the hypoglossal nerve pierced this sinus or its tributaries. We also have found that the marginal sinus is often pierced by the VA, an arrangement that is comparable to the internal carotid artery piercing the cavernous sinus. Additional knowledge of this sinus may be useful to the neurosurgeon who operates in this region.

References


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