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Emissary veins and foramina: topography, incidence, and clinical significance

Abstract

Emissary veins are valveless veins which pass through skull foramina connecting the intracranial dural venous sinuses to the extracranial veins. They equalize the venous pressure on both sides of the cranium, cool the brain, and may transmit extracranial infection to intracranial structures. Parietal, mastoid, sphenoidal and occipital emissary foramina and veins proved to be of great clinical significance. Petro-squamosal sinus and mastoid emissary vein may cause excessive bleeding during skull base and middle ear surgeries. Venous anomalies of some emissary veins could be a rare cause of tinnitus. Their incidence, morphology and course must be determined preoperatively to avoid interventional complications.

Keywords: emissary, vein, foramen, parietal, mastoidal, occipital, sphenoidal

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Introduction

Emissary veins are small venous channels that connect the extracranial veins of the head to the intracranial dural venous sinuses and diploic veins. Not all of emissary veins are present in all individuals. Being valveless, they allow flow of blood on both directions of the cranium, helping to equalize intracranial tension and to cool the brain. They may provide a route of extension of extracranial infection to precious intracranial structures and may be a source of haemorrhages and thrombosis in operations around the head.[1] The hypothesis of selective brain cooling function of the emissary veins in hyperthermia was confirmed by observing rapid flowing of blood, in the parietal and mastoid emissary veins, from skin to brain. During hypothermia there was either no flow or slow flow of blood from brain to skin.[2] The emissary veins connected to the scalp lie, together with nerves and arteries, in the loose connective tissue between the epicranial aponeurosis (galea aponeurotica) and the pericranium.[3] Subgaleal haemorrhage is an uncommon but potentially fatal birth trauma that may result from rupture of the emissary veins connected to veins of the scalp, usually during instrumental vaginal deliveries or sometimes spontaneously suggesting congenital bleeding diathesis.[4–6] Recognition of the morphological and morphometric features of emissary veins is important in the operation room to avoid unnecessary blood loss.

Parietal emissary foramen

The parietal emissary foramina are small inconstant foramina that may be present in the middle or posterior one-third of the parietal bone of the skull; one on each side of the sagittal suture. They transmit emissary veins that connect the superior sagittal venous sinus to the scalp veins. In a study of 100 dry adult skulls, the parietal foramen was bilateral in 32%, unilateral in 35%, located on the sagittal suture in 5% of calvaria. It had a mean diameter of 1.55 mm and was located at a mean distance of 9.02 mm lateral to the sagittal suture.[7] Enlarged parietal foramina may be identified in addition to the ordinarily sized and positioned parietal emissary foramina.[8] In South Indian skulls, the parietal emissary foramen was present at the junction of middle and posterior thirds of the parietal bone in 71.5% of skulls, at a mean distance of 6.7 mm (right) and 6.8 mm (left} lateral to the sagittal suture: solitary in 62.9%, double in 6.9%, triple in 1.7%, unilaterally absent in 32.7%, and bilaterally absent in 12.1% of skulls.[9]

Mastoid temporal emissary foramen

The mastoid emissary foramen transmits an emissary vein that connects the sigmoid venous sinus to the suboccipital venous plexus which lies between the muscle layers of the back of neck. On dissection of 15 silicon-injected human cadaveric specimens, the mean diameter of the mastoid foramen was 2.15 mm, and it was located at a mean distance of 21.14 mm from the asterion and of 33.65 mm from the mastoid tip. The suboccipital venous plexus and its connections are potential source of excessive bleeding and air embolism during posterior cranial fossa surgical approaches.[10] In dry skulls there was at least one mastoid emissary foramen in 83.7% of specimens with a mean diameter of 1.64 mm and the largest foramen measured 7 mm.[11]A case was reported with a giant mastoid emissary vein which was injured during a mastoid operation leading to profuse bleeding that was only controlled by surgical pack.[12] In another study, the mastoid emissary foramen was present in 91.7% of 48 adult human skulls: single in 62.5%, double in 22.9%, and triple in 6.2%. It was observed that the accessory mastoid emissary foramina were present in 29.1% of cases.[13] A radiological study of patients determined a mastoid emissary connection in 92.3% and the mean diameter of mastoid foramen was 1.92 mm on the right and 1.84 mm on the left, and on both sides the number of the mastoid foramina varied from absent to triple. The authors decided that preoperative detection of mastoid emissary veins, before the operation, is necessary.[14] In surgical approaches through the mastoid process, to reach pathologies in the pontocerebellar angle, mastoid emissary vein may be a source of profuse bleeding. In a study of 295 skulls, the mean diameter of the external opening of the mastoid emissary foramen was 1.3 mm with predominance of types I and II (by Louis) in women and types III and IV in men.[15]

It was also added that radiological identification of venous variations in head and neck may prevent complications during surgeries. In a case, the left sigmoid sinus was noticed to be drained by a dilated mastoid emissary vein that continued as posterior auricular and posterior external jugular veins, of which the latter drained into the subclavian vein.[16] In MRI study of 96 patients, the mastoid emissary veins were bilateral in 59.3 % and unilateral in 29.2 % of patients. They arose from the posterior wall of the sigmoid venous sinus, most frequently from the lower third of the sinus. They had a

straight, curved, or tortuous course inside the bone, with the straight course was the most frequent. Two patients had two mastoid emissary veins on the same side.[17]

The association of large mastoid emissary veins and pulsatile tinnitus has been investigated with limited therapeutic solutions for this condition.[18] A case of endovascular coiling of a large mastoid emissary vein was diagnosed in a patient suffering from severe pulsatile tinnitus.[19] In a different case of tinnitus, CT and MRI revealed a dilated left mastoid emissary vein, bilateral petro-squamosal sinuses, posterior condylar veins, occipital emissary veins, intrapetrous venule and major anomalies of posterior cranial fossa venous sinuses.[20] Also, it has been noticed that the emissary veins, like the petro-squamosal sinus, are residual valveless veins which rarely may cause pulsatile tinnitus.[21] A rare case of audible pulsatile tinnitus, in a middle-aged female, was reported to be due to a large mastoid emissary vein. The tinnitus was intermittent, and the patient adapted herself to the condition without the necessity of any surgical intervention.[22] Preoperative thin-slice CT is recommended in posterior cranial fossa approaches to identify the presence and course of mastoid emissary vein and to avoid complications during and after surgery.[23] Moreover, mastoid emissary canals may be wider in diameter in patients with chronic otitis media. These canals in these patients must be CT-assessed before surgery in the mastoid region.[24]

Venous abnormalities in the region of the temporal bone as large emissary veins, ipsilateral hypoplastic sigmoid venous sinus or jugular foramen, aberrant petrosal sinuses, and jugular bulb abnormalities are common features in CHARGE syndrome. Recognition of these abnormal venous structures during ear surgeries is crucial to avoid fatal bleeding.[25]

In paediatric cochlear implant subjects, vascular canal anomalies were recognized in the form of high riding jugular bulb, dehiscent jugular bulb, jugular bulb diverticulum, bulging of sigmoid sinus, mastoid emissary vein, carotid canal dehiscence, and aberrant internal carotid canal.[26] These variations should be assessed before surgery.

Occipital emissary foramen

It is a small foramen in the squamous part of the occipital bone just behind the foramen magnum on one or both sides of the external occipital crest. It is also named the "posterior condylar canal or condylar emissary foramen". In some study, it was seen in one skull only, and its emissary vein probably connected the occipital venous sinus with the suboccipital venous plexus.[27,28] In another study, the occipital emissary foramen was observed in 14.1% of dry adult skulls: on the left side in 6.4%, on right-side in 5.1%, and median in 2.6% of skulls. It was located close to the posterior margin of foramen magnum. It transmits the occipital emissary vein which surgeons should be aware of to avoid profuse bleeding during suboccipital craniotomies.[29]

Recently, cerebral angiography demonstrated an abnormally large central occipital emissary vein, in a middle-aged female, passing through the skull and draining into the suboccipital venous plexus.[30] Preoperative findings of computed tomography (CT) and CT venography (CTV) were compared with the intraoperative findings regarding the drainage patterns of the posterior condylar emissary vein. Five types were demonstrated: the sigmoid sinus, jugular bulb, occipital sinus, anterior condylar emissary vein, and marginal sinus. Preoperative CT and CTV findings correlated well with the intraoperative findings.[31]

The anatomy of the posterior condylar canals and posterior condylar emissary veins was studied using cadaveric specimens, dry skulls, and CT images. The posterior condylar canals were recognized in 36 of 50 sides in dry skulls and 82 of 100 sides in CT. They had a mean diameter of 3.5 mm and a mean length 6.8 mm. They were classified, according to their intracranial openings. into four types: the sigmoid sinus type, the jugular bulb type, the occipital sinus type, and the anterior condylar emissary vein type. This knowledge is essential, during skull base surgery, to avoid unnecessary injury of the nearby structures.[32,33] It has been also mentioned that occipital emissary veins serve as collateral venous pathway in transverse venous sinus stenosis. They are larger and more frequent in patients with pseudotumor cerebri syndrome. Prominent occipital emissary vein, in images, is considered as a sign of suspicion of pseudotumor cerebri syndrome.[34]

Posterior cranial fossa emissary veins include the mastoid emissary vein, condylar emissary veins, occipital emissary vein, and petro-squamosal sinus. They must be preoperatively assessed using computed tomography (CT), CT angiography, and cerebral magnetic resonance venography.[35] On CT angiography of 182 patients, the mastoid emissary vein was not identified in 22.3% of patients, the posterior condylar emissary vein was absent in 23.5%, while the petro-squamosal sinus was only identified on the left side one patient (0.6%) and the occipital venous sinus was present in two patients (1.2%).[36] In another preoperative MR imaging of posterior fossa emissary veins, the occipital emissary vein was present in 28.6% of patients as assessed by the first radiologist, and 27.7% by the second radiologist with the conclusion that MRI is essential to demonstrate major emissary veins and sinuses before operation.[37] Venous anomalies are identified by imaging as common cause of pulse- synchronous tinnitus. They include transverse and sigmoid sinus stenosis, jugular bulb anomalies, and prominent posterior fossa emissary veins.[38]

Foramen ovale and sphenoidal emissary foramen (foramen of vesalius)

The foramen of Vesalius lies in the floor of middle cranial fossa between the foramina rotundum and ovale. It transmits emissary veins which connect the cavernous sinus with the pterygoid venous plexus that lies on the lateral pterygoid muscle. This foramen was observed in 60% of total skulls studied; being unilateral (35.56%) or bilateral (32.23%) with a mean diameter of 0.9 mm (on right side) and 1.12 mm (on left side).[39] Foramen ovale is always present in the greater wing of sphenoid bone in the floor of the middle cranial fossa. It transmits a vein, two veins, a venous plexus, or a dural sinus between the cavernous venous sinus and pterygoid venous plexus on both sides of the head.[40] In a thin-sliced contrast MRI, the emissary veins of the foramen ovale were well observed in 100% of sagittal and 97% of coronal images. On the sagittal images, these emissary veins were classified into lateral, medial, and perineural types in relation to the mandibular division of the trigeminal nerve inside the foramen ovale.[41] Emissary sinus of foramen ovale was always bilaterally present, and its inferior end passed through the foramen ovale in front of the mandibular branch of trigeminal nerve. It was microscopically observed to be constituted of layers of dura mater.

Conclusion

Emissary veins pass through emissary foramina in the skull bones. They connect dural venous sinuses inside the skull with veins outside the skull. Not all of emissary veins are present in all individuals. Normally they have good functions but abnormally they may be a source of trouble in infections and during surgeries.

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Conflicts of interest

The author declares no conflicts of interest.

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