Phylogeny of the cerebral venous system

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In phylogeny, lower vertebrates include fishes, amphibians, and reptiles while the higher ones include birds and mammals. The early embryological venous structures are relatively common across the vertebrates. Venous blood, which is collected from the three dural venous plexuses into the primary head sinuses, drains into the jugular veins and then into the anterior cardinal veins. The anterior and posterior cardinal veins connect to the common cardinal vein, which then connects to the heart. The cerebral venous system is classified into 4 venous systems based on the evolution of the meninges and structure of the brain vesicles: the dorsal, lateral, ventral, and ventricular systems [1-3]. **Figure 1.**

Dorsal venous system

Dorsal venous system is strongly related to the neopallium and neocerebellum and is a recent acquisition in the cerebral venous evolution. Thus, this system is related to the membranous neurocranium and includes superior sagittal sinus, inferior sagittal sinus, transverse sinus, falcine sinus, straight sinus, occipital sinus, and marginal sinus. Occipital and marginal sinuses may persist or regress spontaneously postnatally. Sigmoid sinus is not included in this system because this sinus is regarded simply as a conduit. Interestingly, sigmoid sinus drainage (to the internal jugular vein) without petrosquamous drainage (to the external jugular vein) is solely found in man.

Lateral venous system

Lateral venous system, i.e., venous system of the lateral cerebral surface, is related to paleopallium across the vertebrates. It includes middle cerebral vein, inferior ventricular vein, lateral mesencephalic vein, lateral pontine vein, lateral medullary vein, superior petrosal vein, and condylar vein. The superficial cerebral veins (embryological primitive tentorial sinus) drain to the transverse sinus, which is occluded subsequently. Superficial middle cerebral vein (Sylvian vein) is hemodynamically well balanced with the anastomotic veins of Trolard and Labbe. Sylvian vein may drain into the transverse sinus, superior petrosal sinus (sphenopetrosal vein), pterygoid venous plexus (sphenobasal vein), laterocavernous sinus and cavernous sinus (man only). These venous drainage patterns depend upon phylogenetic evolution. That is, drainage to the cavernous sinus, is the most advanced form phylogenetically, called “cavernous sinus capture”, which is believed to occur solely in man

postnatally. Medial drainage of the superior petrosal sinus to the cavernous sinus is also a late acquisition.

Ventral venous system

Ventral venous system is the latest acquisition evolutionally and only found in mammals. It is related to the late development of the following neural structures: basal ganglia, red nucleus, cerebral peduncle, and ventral pontine tegmentum. This system connects the lateral venous system longitudinally along the neuro-axis. Basal vein of Rosenthal develops lately after distal occlusion of the primitive tentorial sinus. Basal vein drains the venous flow from telencephalon, diencephalon, and mesencephalon, respectively. This vein is occasionally fragmented. The mesencephalic segment of the basal vein may drain into the vein of Galen, torcular Herophili, transverse sinus, and superior petrosal vein. Most advanced form of this drainage is draining to the vein of Galen commonly found in man.

Ventricular venous system

Ventricular venous system is defined as the venous system of the forerunner of median vein of prosencephalon of Markowski or primitive internal cerebral vein of Padget. Development of the dural venous system is phylogenetically related to the environments, which are either aqueous, transitional, and terrestrial. The lower vertebrates do not have dorsal dural venous sinus. Instead, they have dorsal sagittal “vein”, which runs in the subarachnoid space and drains to the internal jugular veins. This dorsal sagittal vein is phylogenetically homologous to the median vein of prosencephalon in man. Higher vertebrates have dural venous system, which drains into the external and/or internal jugular veins. Drainage to the external jugular vein is the petrosquamous sinus drainage through the postglenoid foramen.

Phylogenetic knowledge of the cerebral venous system helps understand the normal and pathological venous drainages and may contribute to better clinical outcome.

References

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Figure legend

Fig. 1. Four venous systems of the brain [1].

Venous System	Related area	Venous structures compare to man
Dorsal venous system	Neopallium	SSS, ISS, Str-S, FS, TS
Lateral-Ventral venous system	Paleopallium	Tentorial sinus (middle cerebral vein)
	Archipallium	Basal vein of Rosenthal
"Ventricular system"	lateral and 3rd ventricles	Tributaries of the forerunner of the median prosencephalic vein of Markowski

SSS, superior sagittal sinus; ISS, inferior sagittal sinus; Str-S, straight sinus; FS, falcine sinus; TS, transverse sinus; ICV, internal cerebral veins