VIA MEDICA

SHORT COMMUNICATION

Folia Morphol.
Vol. 62, No. 3, pp. 255–257

ISSN 0015–5659
www.fm.viamedica.pl

Morphology of the Willis chords in the superior sagittal sinus during various periods of life

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[Received 23 May 2003; Accepted 17 June 2003]

Numerous fibrous elements known as the Willis chords are situated in the light of the superior sagittal sinus. The paper is aimed at a comparative evaluation of the appearance of the Willis chords appearing in the superior sagittal sinus during various periods of human life and a determination of their role. The material comprises 200 brains at the foetal period as well as 200 adult and senile brains. The experimental methods include injection methods, infrared light, the Pickworth method and computer image analysis. During adulthood, various elements such as valvulae, divisions, plates, beams and arachnoidal granulation are situated in the light of superior sagittal sinus. The number of arachnoidal granulations increases continuously due to age, new ones appearing close to those already in existence and old granulation spreading. The superior sagittal sinus contains numerous valvulae similar to the feedback flaps typical for hydraulic systems. Divisions act as orifices which lead to a fall in pressure and induce blood into the sinus. Large differences between the cross-sections of meningeal veins and bridge veins were noticed, which resembles the structure of ejector. The blood flow in the bridge veins ending at the superior sagittal sinus is controlled by the valvulae and their geometrical form changes according to age. Conclusion: the Willis chords situated in the superior sagittal sinus may control the circulation. Their number grows with age and their morphology changes.

key words: Willis chords, superior sagittal sinus, brain vessels

INTRODUCTION

Numerous fibrous elements called by Schmutz [5] the Willis chords are situated in the light of the superior sagittal sinus. This author has made a classification of the Willis chords in the superior sagittal sinus and his has given descriptions of plates and beams reducing its light. Ogniew [3] has described the intersinus structures in the superior sagittal sinus in humans in adulthood. They include side lacunes, arachnoideal granulations, divisions, beams and transitionary forms between divisions and beams. He has discussed their functional significance and has depicted them in the role of controllers of circulation in the veins and sinuses. Balo [1] writes about the existence of "hole areas" in the back part of the superior sagittal sinus, reducing vein outflow and affecting the appearance of vein hyperaemia. It should also be determined to what degree elements existing in the superior sagittal sinus are remnants of the sinus marginalis. During the foetal period the superior sagittal sinus consists of two separate systems, the so-called "veines marginales", the term used by Paget [4]. The paper aims at a comparative evaluation of the Willis chords in the superior sagittal sinus during various periods of life and a determination of their role.

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MATERIAL AND METHODS

The material comprised 200 brains in the foetal period and 200 from the adult and senile periods. The experimental method included injection, vessels being filled with coloured mixtures of Polish latex LBS 3022, infrared treatment, the Pickworth method and computer image analysis.

RESULTS AND DISCUSSION

The superior sagittal sinus, together with its tributaries during the foetal, adult and senile periods, was evaluated in own research. The particular view of the superior sagittal sinus was observed during the 3rd and 4th months of life. It resembled an inverted letter Y, connecting to the transversal sinus with the help of the veines marginales. Both veines marginales are connected by a short vein running horizontally and forming a triangle of uneven size. Along with the growth of the hemispheres, both veines marginales changed their position from side to central so as to form the trunk of the superior sagittal sinus. The evolution of the brain falx and cerebellum tentorium plays an important role. During the first 4 months of foetal life the superior sagittal sinus is not well developed and the outflow of blood is directed towards the base. i.e. towards the sinus tentorium. During the 5th and 6th months it has a morphology close to that of adulthood. However, large individual scatter was observed and the degree of formation of the superior sagittal sinus was higher in some younger individuals than in older ones. Sometimes the vein linking both sinuses marginales was observed up to a late stage of the foetal period. The joining of both veines marginales brings about a large increase in the width of the superior sagittal sinus in its back part. The parasagittal area is characterised by a massive outflow of vein blood. For 3 months of life the veins of the brain were surrounded by a garland of meningeal veins with a diameter as large as the veins of the brain. The garland of vessels forms itself. In foetuses there are no lacuns laterals or arachnoidal granulation. These form during the last weeks of foetal life. The intradural segments of ultimate parts of the veins of the brain, characteristic of adults, are missing in foetuses. The bridge veins approach ends according to straight angle. Due to brain growth their length changes in the occipital section and the angle becomes more acute. A large number of arachnoideal granulations and numerous fibrous elements were noticed in the superior sagittal sinus. They took the form of valvulae, plates, divisions, beams and arachnoidal granulation which increased with age (Fig. 1).

The presence of division can be understood by the joining of the veines marginales, which are of great significance during the foetal period. The characteristic widening of the superior sagittal sinus in the back part resembles a diffuser. This form enables the same flow velocity to be maintained during the increase in the number of inflowing vessels and makes constant pressure along the sinus possible. The sinus contains valvulae which act in a way similar to the feedback flaps known from hydraulic systems. The valvulae, due to their elasticity, close the

Figure 1. Chordae Willisii as trabecular network.

inflow of the veins to the sinus at the moment of peak pressure. Numerous divisions, beams and narrowings were also observed. These resembled Venturi narrowings, jets and orifices. At places of narrowing the pressure is lower before and after. The inflow of liquid may be reduced in this place, which can be considered analogous to the situation taking place in the veins. The divisions observed may play the role of orifices leading to a localised fall in pressure and an inflow to the sinus below the divisions in veins. It should be noticed that in the cross-section of division, the flow velocity is higher compared with cross-sections without divisions. Large discrepancies in the diameters of meningeal veins were observed. This resembles the construction of ejector. The local reduction of pressure is observed in every narrowing, which entails an inflow of liquid into this cross-section. The correspondence between function and structure has been established. On the basis of the research performed it may be said that the feature common for all sinuses is the presence of bridge veins. Diameters, ultimate angles and the type of bridge vein were examined as well as their influence on the lowering of pressure in senility. An effect of the outgrowing of bridge veins to the superior sagittal sinus is that the greater diameter entails a smaller reduction in pressure and this diminishes energy expenditure. The effect of the size of the diameter is as follows: longer vessels, a greater fall in pressure and an increase in energy expenditure. During brain atrophy the diameter of bridge vessel becomes lower and increases in length. In effect we obtain a higher reduction of pressure and an increase in energy expenditure. The vessel is then subjected to the influence of the cerebrospinal fluid and this in turn elongates the vessel and in consequence glutting together. The form of bridge veins may also have an effect: the simper form corresponds to lower energy consumption. The type of bridge veins with common end and the construction of a knot of vessels gives rise to a tendency to glue during brain atrophy. An effect of an angle: lower angle measured according to blood flow corresponds to lower energy damping. Well-formed bridge veins appear at midway through the 4^{th} month of foetal life. They end in a straight angle and there are no branches. Initially their morphology is similar, they are the same length, they are single and they end in a straight angle. The growth of the brain involves some changes. The foetal sinus begins to vanish like the central and tentorium ones, the collapsing of veins marginalis becomes put forward ending at the superior sagittal sinus. The bridge veins join into common trunks which results in their ending at the sinuses. This gives variety of forms, bifurcations, bushes and fans. The description of the Willis chords in the superior sagittal sinus available in literature is very poor. The new result of this paper is the description of their behaviour during various periods of life, an attempt to evaluate their role and discussion as to whether they are only reminders of the foetal period or whether they play an important role as vein blood controllers. Divisions were observed during the foetal period. The appearance of various fibrous objects is accompanied by the ends of veins in the area close to the superior sagittal sinus. The parasagittal area is well developed from the foetal period. The results of the paper agree with information from other authors [3, 5]. It appears that the presence of numerous fibrous objects in the light of the superior sagittal sinus relates to blood circulation control. Our observations [2] have shown that the morphology of the superior sagittal sinus or is more complicated. The superior sagittal sinus is a dense net of meningeal inflows. The sinus contains valvulae which act in a way similar to feedback flaps known from hydraulic systems [6]. In conclusion, the Willis chords situated in the superior sagittal sinus may control the circulation. Their number grows according to age and their morphology changes.

REFERENCES

1. Balo (1950) The dural venous sinuses. Anat Rec, 106: 319–325.
2. Kędzia A (1992) Ocena morfologii układu żylnego człowieka w okresie płodowym, dojrzałym i starczym z uwzględnieniem aspektów klinicznych. Rozprawa habilitacyjna, Wrocław, tom 52.
3. Ognew B (1950) Krososawżenie centralnoj i perifeycznej nerwnoj sistemy czełowieka. Izdatielstwo Akademii Medicinskich Nauk, Moskwa.
4. Paget DH (1956) The central venous system in man references to development, adult configuration and relation to the arteries. Am J Anat, 98: 307–355.
5. Schmutz HK (1980) The chordae Willisi in the superior sagiital sinus: morphology and classification. Acta Anat, 108: 94–97.
6. Troskolański A (1954) Hydromechanika techniczna. Tom II. Hydraulika. PWT.