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Evaluation by angiography of the lateral dominance of the drainage of the dural venous sinuses

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Summary. Venous drainage dominance of the dural venous sinuses may be defined as the drainage only or mainly into one of the transverse sinuses, as shown by bilateral carotid angiography. The aim of this study was to evaluate the venous drainage dominance in bilateral carotid angiograms of 189 cases retrospectively. Among these cases 41.3% showed drainage mainly to the right side, 37.6% showed equal drainage to each side, 18.5% showed drainage mainly to the left side, 2.1% showed drainage only to the right side and 0.53% showed drainage only to the left side. Cerebral venous drainage dominance is of great importance and should be considered before operations on patients for radical neck dissection, removal of tumors in the neck that invade the internal jugular vein or tumors of the glomus jugulare which may require ligation of the internal jugular vein.

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Evaluation angiographique de la prédominance du drainage veineux des sinus dure-mériens

Résumé. La prédominance angiographique du drainage des sinus veineux dure-mériens se traduit par le drainage de la substance radioopaque essentiellement ou uniquement par l'un des sinus transverses au cours d'angiographies carotidiennes bilatérales. Le but de ce travail est d'évaluer la prédominance du drainage veineux sur 189 angiographies carotidiennes bilatérales. Dans 41,3% des cas, on note une prédominance à droite. Dans 37,6% des cas, le drainage veineux s'effectue de façon égale des deux côtés. Dans 18,5% des cas, il y a prédominance à gauche. Dans 2,1% des cas le drainage est limité à droite et dans 0,53% des cas il est limité à gauche. La connaissance de cette prédominance du drainage veineux cérébral est capitale pour le chirurgien lors de curage cervical radical, lors d'intervention pour des tumeurs du cou envahissant la veine jugulaire interne ou pour des tumeurs du glomus jugulaire nécessitant la ligature de la veine jugulaire interne.

Key words : Cerebral angiography — Venous sinuse drainage — Radical neck dissection

The anatomy of the dural sinuses has been extensively studied [3, 4, 7, 12, 13] and recently reviewed by Huang [10] and by Lasjaunias [15]. After birth, the dural sinuses may retain some features of their embryologic plexiform pattern. The superior sagittal sinus empties into the confluence; typically, its drainage passes preferentially towards the right transverse sinus. The straight sinus also empties into the confluence; its drainage typically passes mainly into the left transverse sinus. The transverse sinuses connect the confluence to the sigmoid sinuses. Their initial posteromedial portions are variable and may be either atretic or absent; their lateral portions are more constant (Fig. 1A and B).

Venous drainage dominance of the dural venous sinuses generally implies the drainage of the blood mainly or only from one of the transverse sinuses. The great variations and various connections between the sinuses contributing to the

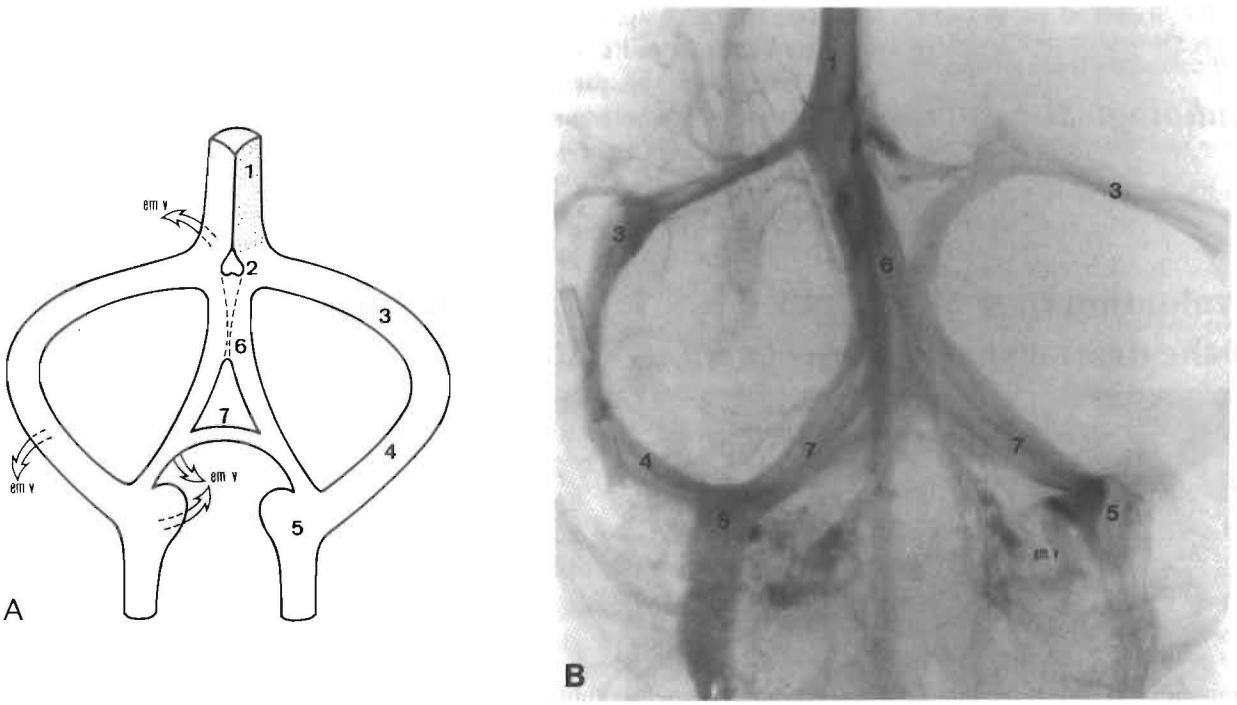


Fig. 1A, B

A Schematic representation of the confluence of the dural sinuses in frontal view. *1*, Superior sagittal sinus; *2*, straight sinus; *3*, lateral sinus; *4*, sigmoid sinus, *5*, jugular bulb; *6*, medial occipital sinus; *7*, marginal sinus; *em v*, emissary veins. **B** Late phase of a vertebral artery angiogram in frontal projection. Same legend as **A.** Figure reproduced from Lasjaunias P, Berenstein A (1990) Intracranial venous system. In: Surgical neuro-angiography. Springer, Berlin Heidelberg New York, p 260

A Représentation schématique du confluent des sinus. Vue frontale. *1*, Sinus sagittal superieur; *2*, sinus droit; *3*, sinus transverse; *4*, sinus sigmoïde, *5*, bulbe supèrieur de la v. jugulaire; *6*, sinus occipital; *7*, sinus marginal; *em v*, vv. émissaires. **B** Temps veineux d'une angiographie vertebrale. Vue frontale. Même légende que la Fig. **A.** Figure tirées de Lasjaunias P, Berenstein A (1990) Intracranial venous system. In: Surgical neuro-angiography. Springer, Berlin Heidelberg New York, p 260

formation of the confluence of sinuses have a significant effect on venous drainage dominance.

Variations of venous drainage dominance are of great importance and should be considered prior to extended craniectomy, radical neck dissection, removal of tumors in the neck that invade the internal jugular vein and tumors of the glomus jugulare that require ligation of the internal jugular vein.

Former studies of venous drainage dominance have been mainly limited to cadaver dissections [3, 4, 12, 22]. There have also been studies in which the evaluation of venous drainage dominance was made by angiography [6, 13]. In this study, bilateral carotid angiograms, without any diagnosed cerebral venous pathology, were evaluated for dominance.

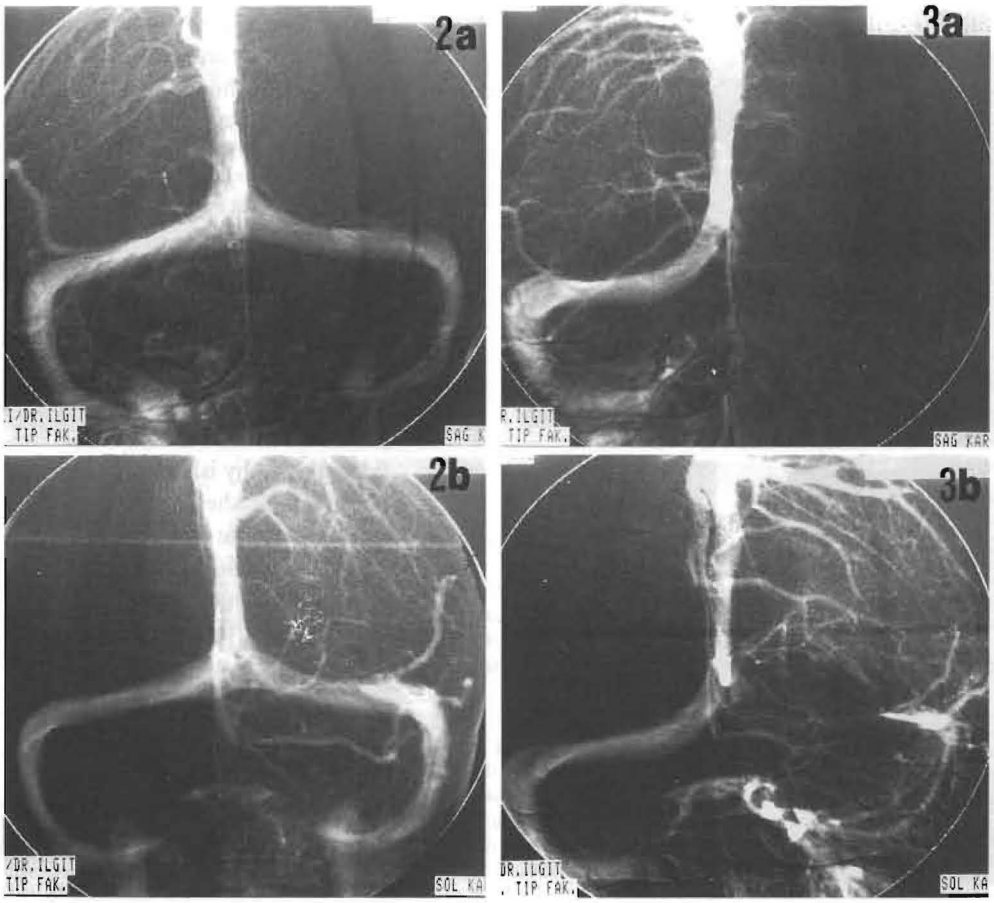
Material and methods

Cerebral angiograms of 206 cases, with no proven pathology in the dural venous system, were re-evaluated retrospectively. Cerebral angiography was performed by selective transfemoral catheterization of right and left internal carotid and vertebral arteries. All the angiograms were obtained using the DSA imaging system (Angioskop-C angiography unit and Digitron II digital imaging system). In all angiographies, 512 x 512 x 10 byte matrix, an image intensifier of 25 cm, and a focal spot size of 0.6 mm were used.

In carotid angiographies, 7 ml non-ionic contrast medium was injected at a rate of 4-5 ml/s into each internal carotid artery and images were acquired at a rate of 2 frames/s. Imaging was continued from the beginning of the arterial phase until the end of the venous phase. Opacification of the internal jugular veins was observed in all cases.

Seventeen of the 206 angiographies were found to be inappropriate for evaluation because of inadequate image quality or lack of standardized projections.

For the evaluation of venous drainage dominance with respect to the venous phase of each carotid angiography, a classification was made to describe drainage patterns, and five



Figs. 2a, b, 3a, b
2a Equal drainage in venous phase of right carotid angiography. **b** Equal drainage in venous phase of left carotid angiography. **3a** Drainage limited to the right side in venous phase of right carotid angiography. **b** Drainage limited to the right side in venous phase of left carotid angiography

2a Drainage symétrique lors du temps veineux d'une angiographie carotidienne droite. **b** Drainage symétrique lors du temps veineux d'une angiographie carotidienne gauche. **3 a** Drainage limité du côté droit lors du temps veineux d'une angiographie carotidienne droite. **b** Drainage limité du côté droit lors du temps veineux d'une angiographie carotidienne gauche

Table 1. Classification of venous drainage types
Classification des types de drainage veineux

Venous Drainage Types	Number of Cases	%
Equal Drainage	71	37.6
Drainage Limited to the Right Side	4	2.1
Drainage Limited to the Left Side	1	0.5
Drainage Mainly From Right Side	78	41.3
Drainage Mainly From Left Side	35	18.5
Total	100	100%

types were established as follows:

1) right=left: equal amount of drainage from right and left transverse sinuses.

2) ipsilateral only: the drainage is limited to the same side only.

3) contralateral only: the drainage is limited to the contralateral side only.

4) mainly ipsilateral: the drainage is mainly ipsilateral, but poor contralateral drainage also exists.

5) mainly contralateral: the drainage is mainly contralateral, but there is also poor ipsilateral drainage.

As bilateral carotid angiograms were used for the evaluation of dominance, two numbers were obtained for each case, such as 1/1, 2/5. The first number indicates the type of drainage during the venous phase of right carotid angiography while the second number indicates the type of drainage during the venous phase of left carotid angiography.

Results

Venous drainage patterns of bilateral carotid angiograms were assessed together and 5 different groups were obtained (Table 1):

A- Equal drainage: This group involves 1/1, 4/4 types of drainage patterns. Venous blood drains equally through the venous sinuses of each side and there is no dominance. 71 of the cases showed equal drainage and 68 of these were 1/1 type (Fig. 2a and 2b) and 3 were 4/4 type.

B- Drainage limited to the right side: This group involves 2/3 drainage pattern. In all of these cases the left transverse sinuses were not visualized and dominance was right sided. There were 4 cases in this group (Fig. 3a and 3b).

C- Drainage limited to the left side: This group involves 3/2 type

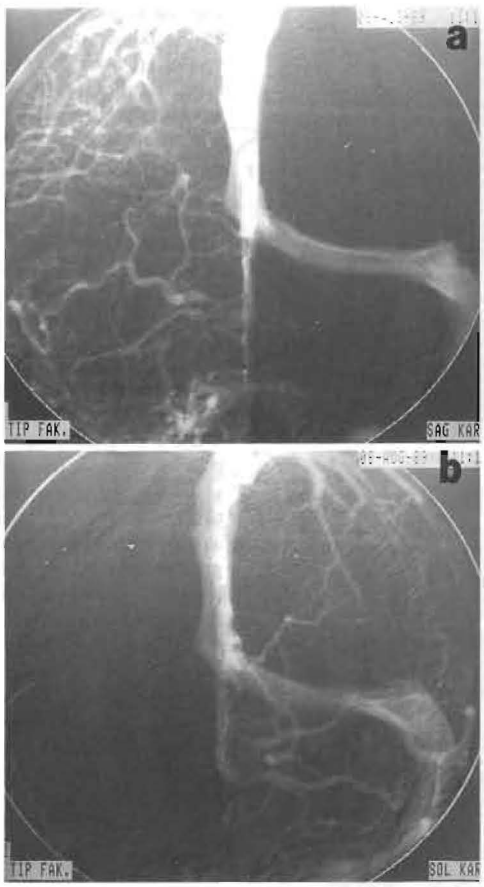


Fig. 4a, b
a Drainage limited to the left side in venous phase of right carotid angiography. **b** Drainage limited to the left side in venous phase of left carotid angiography

a Drainage limité du côté gauche lors du temps veineux d'une angiographie carotidienne droite. **b** Drainage limité du côté gauche lors du temps veineux d'une angiographie carotidienne gauche

of drainage pattern. In such a case the right transverse sinus was not visualized and dominance was left sided. There was only one case in this group (Fig. 4a and 4b).

D- Drainage mainly from the right and poorly from the left side: This group involves 2/5, 4/5, 2/1, 4/1 and 2/4 drainage patterns. In these cases there was either poor or no drainage from the left side in one of the right or left carotid angiographies and dominance was right sided. Seventy eight cases showed this type of drainage, where 44 of them were 2/5 type (Fig. 5a and 5b), 22 were 4/5 type, 8 were 2/1 type, 3 were 4/1 type and one was 2/4 type.

E- Drainage mainly from the left and poorly from the right side: This group involves 5/4, 5/2, 1/4, 1/2 and 4/2 drainage patterns. In these cases there was either poor or no drainage from the right side in one of the right or left carotid angiographies and dominance was left sided. Thirty five cases showed this type of drainage; 19 of them were 5/4 type, 9 were 5/2 type (Fig. 6a and 6b), 4 were 1/4 type, 2 were 1/2 type and one was 4/2 type.

Among the 189 cases, 82 (43.4%) showed right dominancy (B, D), 36 (19%) showed left dominancy (C, E) and 71 (37.6%) showed equal amount of drainage to each side (A) (Table 2).

Table 2. Distribution and percentages of venous drainage dominance
Distribution et pourcentages des prédominances de drainage veineux

Dominance	Number of Cases	%
Right	82	43.4
Left	36	19
Right=Left	71	37.6
Total	189	100%

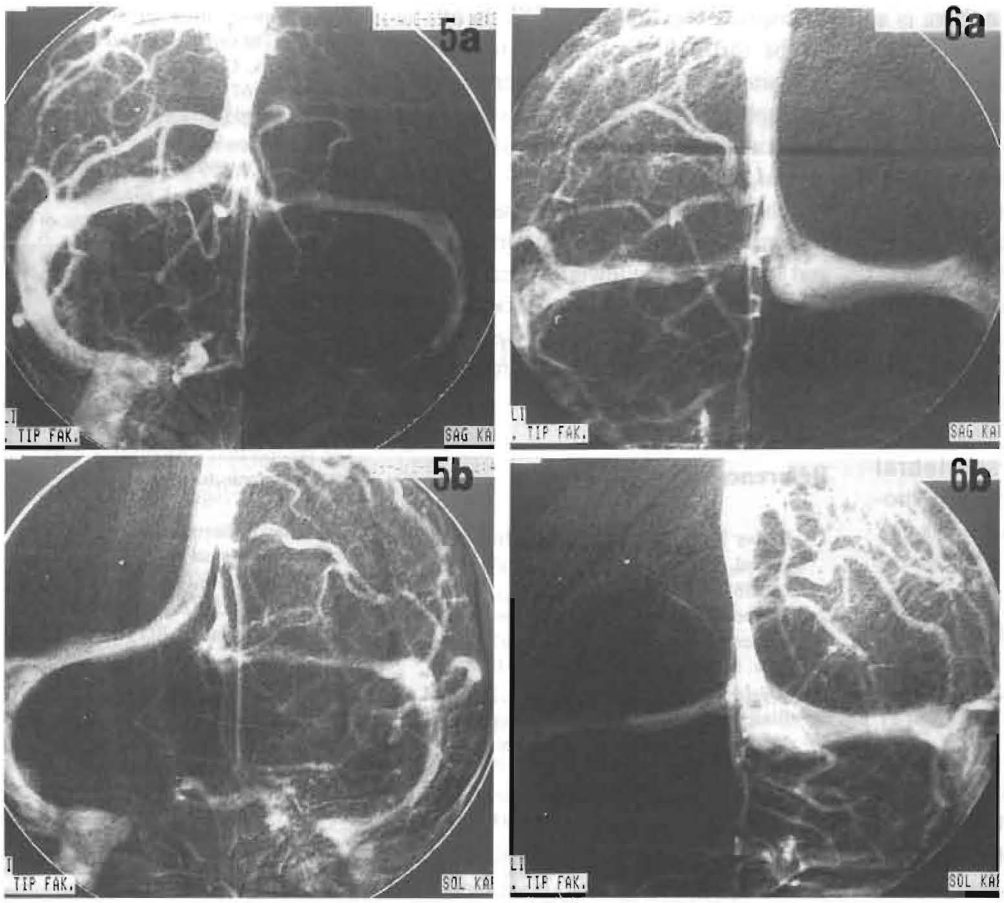
Discussion

Although the value of dissection studies on cadavers can not be disputed, we believe that bilateral carotid angiography is a better method to demonstrate the variations of the venous drainage dominance.

The venous drainage of the radiocontrast medium injected from one carotid artery may show differences when compared with the injection from the contralateral side. As it is thought that this might cause misleading findings. We studied the venous phase of both carotid angiographies during the evaluation of dominance.

Venous drainage dominance was analysed in 189 cases. In most of the symmetrical forms of confluence of sinuses the drainage patterns corresponded to A type (right=left). Moreover, in cases that had right or left dominance, the drainage type of confluence of sinuses showed deviation to the dominant side. The confluence of sinuses must not be regarded simply as the drainage site of the superior sagittal sinus and straight sinus or the origin of transverse sinuses but rather must be considered as a complex system of anastomosing sinuses [8,19]. The importance of this view point is shown by the formation of venous drainage patterns. Thus the drainage variations of dural venous sinuses into the confluence of sinuses is an important variable that determines the venous drainage dominance.

In this study the percentages of right and left dominancy was found



Figs. 5a, b, 6a, b
5a Drainage mainly from right side in venous phase of right carotid angiography. **b** Drainage mainly from right side in venous phase of left carotid angiography. **6a** Drainage mainly from left side in venous phase of right carotid angiography. **b** Drainage mainly from left side in venous phase of left carotid angiography

5a Drainage prédominant du côté droit lors du temps veineux d'une angiographie carotidienne droite. **b** Drainage prédominant du côté droit lors du temps veineux d'une angiographie carotidienne gauche. **6a** Drainage prédominant du côté gauche lors du temps veineux d'une angiographie carotidienne droite. **b** Drainage prédominant du côté gauche lors du temps veineux d'une angiographie carotidienne gauche

to be 43.4% and 19% respectively. 37.6% showed equal type of drainage (Table 1). Woodhall, in a postmortem study involving 100 cases, observed that the incidence of cases with right dominance was 39%, left dominance 13% and equal drainage 48% [22]. In another postmortem study of 100 cases, Browning found these percentages to be 51, 29 and 20 respectively [4]. In a study on 25 cadavers, Edwards gave his results as 50%, 42% and 8% [7]. Gibbs, in a study on 25 cadavers, gave the values as 52%, 24% and 24%. The findings of Edwards and Gibbs were not found to be statistically reliable by the authors [4]. Although our results are close to those of Woodhall, those of the latter two studies are controversial. Woodhall observed that the majority of the cases showed equal drainage to either side, whereas in our study, cases with right dominance constituted the largest group.

We have not found any report that classified the venous drainage dominance in the same way as in this study (Table 1). It seems that such a classification is more useful because of its surgical aspects.

Knowledge of variations of the venous drainage dominance has particular importance for the patients who will undergo a radical neck dissection. Furthermore, removal of the tumors in the neck that invade the internal jugular vein and tumors of the glomus jugulare that require ligation of the internal jugular vein on the dominant side may cause important complications. We think that such surgical approaches have a higher complication rate especially in patients with B or C types of venous drainage.

There are numerous studies in the literature concerning the postoperative complications of radical neck dissection. Marr reported that pseudotumor cerebri may be seen after the ligation of the internal jugular vein [16]. It is also reported that extensive edema and cyanosis of the head and neck regions, headache, pupilledema, blurred vision, blindness, loss of conciousness, confusion, convulsion and hemiparesis are other complications that may be observed after the ligation of the internal jugular vein [1, 5, 11, 12, 17, 20, 21]. Nagao, in an experi-

mental study, showed that there is a risk of transtentorial and/or tonsillar herniation if the pressure of intraventricular and cervical subarachnoid cerebrospinal fluid exceeds 10 mmHg [18]. There are controversial viewpoints among authors regarding the postoperative status after radical neck dissection. Some authors have proposed that adaptation to the new anatomical condition readily develops within a few days [2, 5, 9, 20]. Moreover, there are some cases in which sufficient venous drainage is provided through the vertebral venous plexus after bilateral removal of the internal jugular veins [1]. However, some authors support the idea that adaptation to the new venous drainage type depends greatly on the variations in the venous system and ligation of dominant or non-dominant sides [11, 12, 16, 17].

Some radical neck dissections require bilateral removal of the internal jugular veins. After bilateral removal development of postoperative complications is more frequent when compared with unilateral removal [17].

The findings of this study and a review of the literature reveal that there are many variations of venous drainage dominance. In some cases, specific intracranial venous channels may exhibit anomalies or lack of development which may not safely permit the ligation of internal jugular veins [17]. Sugarbaker reported a patient who underwent ligation of the internal jugular vein in which the right transverse sinus was found to be underdeveloped during the postmortem examination [20]. Unless venous drainage from the ipsilateral hemisphere can drain via the vein of Labbé through the torcular to the opposite jugular system, the cerebral hemisphere, especially the posterior temporal lobe, will be at risk of venous infarction [14].

The question of venous drainage dominance has clinical importance and should be reviewed especially prior to operations on patients who will undergo radical neck dissection and require ligation of the internal jugular vein.

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