



Interhemispheric transcallosal approach: going further based on the vascular anatomy

Sorin Aldea¹ · Caroline Apra^{2,3,4} · Dorian Chauvet¹ · Caroline Le Guérinel¹ · Pierre Bourdillon¹

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Abstract

Preserving cortical frontal bridging veins draining into the superior sagittal sinus is a factor of good neurological outcome in anterior interhemispheric transcallosal approaches, classically performed to reach intraventricular tumors. Challenging the idea that veins are utterly variable, we propose a statistical analysis of 100 selective cerebral angiographies to determine where to place the craniotomy in order to expose the most probable vein-free area. The mean distance to the first pre-coronal vein was 6.66 cm (± 1.73 , 1.80 to 13.00) and to the first post-coronal vein 0.94 cm (± 0.92 , 0 to 3.00) ($p < 0.001$). The probability of absence of bridging veins was 92.0% at 4 cm anterior to the coronal suture versus 37.5% at 1 cm and 12.5% at 2 cm posteriorly. The length of the surgical corridor (distance between the first pre-coronal and post-coronal vein) was 7.60 cm (± 1.72 , 3.00 to 14.10). Overall, the ideal centering point of the craniotomy was 2.86 cm (± 1.08 , -0.65 to 6.50) ahead of the coronal suture. The mean number of veins within 6 cm behind the coronal suture was 8.47 (± 2.11 , from 3 to 15) versus 0.530 (± 0.82 , from 0 to 3) ahead of the coronal suture ($p < 0.001$). These findings support a purely pre-coronal 5 cm craniotomy for interhemispheric approaches.

Keywords Angiography · DSA · Veins · Coronal suture · Callosotomy · Parasagittal vein

Introduction

The anterior interhemispheric transcallosal approach is a very useful technique to resect intraventricular tumors, located in the frontal horn of the lateral ventricle or the anterior part of the third ventricle. The principle of this approach is to reach the ventricles without creating a corticectomy nor interrupting frontal white matter tracts, by following the natural interhemispheric space and using a minimal opening of the anterior part of the body of the corpus callosum. This aims at avoiding neurological deficits, in particular frontal symptoms and

epilepsy, and at giving anatomic access to the ventricles, even when they are not dilated. The first obstacles met in this approach are cortical frontal bridging veins that drain into the superior sagittal sinus.

Although sacrificing frontopolar cortical veins is theoretically possible and—fortunately—does not always have relevant clinical consequences [7], it should be avoided: surgical interruption of bridging veins during the approach has been shown to be a significant predictor of major neurological complications in patients operated through the transcallosal approach, both in adults and children [2, 5], and a significant factor of venous infarction, even though brain retraction can also cause it [16].

In this context, performing an adapted craniotomy is the first step towards a safe surgical resection. Most of the recent neurosurgical technique textbooks use the coronal suture as a bony landmark to locate the craniotomy but give heterogeneous advice: it is taught for instance to make the craniotomy halfway anterior and halfway posterior to the suture [6, 11]; or 4 cm anterior, 2 cm posterior to the suture [4]; 2/3 anterior, 1/3 posterior [14]; or 3–6 cm anterior, 1 cm posterior [1, 10].

Probably because of the idea that venous anatomy is highly variable, anatomical studies based on cadavers or imaging have been limited to small samples of patients, privileging

Sorin Aldea and Caroline Apra contributed equally to this work.

✉ Caroline Apra
caroline.apra@neurochirurgie.fr

¹ Department of Neurosurgery, Rothschild Foundation Hospital, Paris, France

² Department of Neurosurgery, Pitié Salpêtrière Hospital, 43-81, bd de l'Hôpital, 75013 Paris, France

³ Sorbonne Université, Paris, France

⁴ Brain and Spine Institute, INSERM U1127, CNRS, UMR7225, Paris, France

meticulous description rather than statistically reproducible patterns [3]. They mostly describe the location and dimension of veins in relation to the brain parenchyma. Using CT scan and arteriography, we chose to describe these veins in relation to the coronal suture, in order to get a schematic picture of the veins repartition in this area and to establish the most reproducible safe entry zone, if it exists.

Materials and methods

Data acquisition

One hundred selective cerebral angiographies free from any venous abnormalities and performed in patients who did not undergo cranial neurosurgery were extracted from the local anonymous database. Analyses of the angiographies with systematic concomitant CT scan were then performed to provide a description of the venous anatomy (SA & PB): number of veins in the zone extending 6 cm behind and 6 cm in front of the coronal suture; distance between the coronal suture and the first vein anteriorly; distance between the coronal suture and the first vein posteriorly. The coronal suture was visualized on CT scan and distances were measured by drawing a curved line on the skull. These analyses were performed separately for both sides of the sagittal sinus.

All patients gave their approval for the anonymous use of their selective cerebral angiography for research, according to the French law (n° 2012-300).

Data analysis and statistics

The distance between the first vein ahead and behind the coronal was analyzed through a survival analysis using Kaplan-Meier curves, the event being defined by the presence of a vein and the time replaced by the geometric distance from the coronal suture measured on the cerebral angiography. The comparison of the survival distributions of the two samples (pre- and post-coronal) was performed by using a logrank test. This comparison was done for both sides and the overall data separately.

The length of the surgical corridor for each patient was defined as the distance between the first pre-coronal and the first post-coronal vein. The ideal centering of the craniotomy was the middle of the surgical corridor. The left and right length of the surgical corridor was compared by using Welch's *t* test, as well as the left and right relative position of the ideal centering of the craniotomy in relation to the coronal suture.

All statistical analyses were performed with Matlab® R2017a v9.2.0.556344 (Copyright © 1984-2017, The MathWorks®, Natick, Massachusetts, USA) and Medistica.

pvalue.io, a Graphic User Interface to the R statistical analysis software for scientific medical publications 2019. Figures and artworks were performed with Glimpse Image Editor © 0.1.2.

Results

Among the 100 selective cerebral angiographies analyzed, the mean distance to the first pre-coronal vein was significantly higher than the one to the first post-coronal vein ($p < 0.001$). The mean distance to the first pre-coronal vein was 6.67 cm (± 1.77 , from 2.00 to 13.00) on the left-hand side and 6.66 cm (± 1.73 , from 1.80 to 13.00) on the right-hand side when the distance to the first post-coronal vein was 0.95 cm (± 1.08 , from 0 to 5.80) on the left-hand side and 0.94 cm (± 0.92 , from 0 to 3.00) on the right-hand side. The difference between left and right was not significant. It is worth noticing that while the probability of the absence of bridging veins is 37.5% at 1 cm and 12.5% at 2 cm posteriorly to the coronal suture, this probability is 92.0% at 4 cm anteriorly to the coronal suture (Fig. 1).

The mean length of the surgical corridor (defined by the distance between the first pre-coronal and the first post-coronal vein) was not significantly different ($p = 0.95$) between the left-hand side 7.62 cm (± 2.17 , from 2.40 to 14.70) and the right-hand side 7.60 cm (± 1.72 , from 3.00 to 14.10). Unsurprisingly, the ideal centering point of the craniotomy (defined as the center of the vein-free surgical corridor) in relation to the coronal suture was not significantly different ($p = 0.99$) between the left-hand side 2.86 cm (± 0.99 , from 2.34 to 3.51) and the right-hand side 2.86 cm (± 1.08 , from -0.65 to 6.50).

The mean number of veins (left and right) within 6 cm behind the coronal suture was 8.47 (± 2.11 , from 3 to 15) and was significantly higher than the mean number of veins within 6 cm ahead of the coronal suture, 0.530 (± 0.82 , from 0 to 3) ($p < 0.001$).

Discussion

Frontal cortical bridging veins drain not only the convexity of the frontal lobe but also the medial part in 47% of cases, and the basal surface in 21% [13]. Their interruption can lead to severe venous infarction or hemorrhage, with permanent or temporary neurological consequences in up to 44.5% of patients, and it is a significant predictor of increased incidence of major neurological complications in patients operated through this approach, both in adults and children [2, 5]. Consequently, their surgical sacrifice should be avoided whenever possible, making it crucial to describe and use a vein-free surgical corridor.

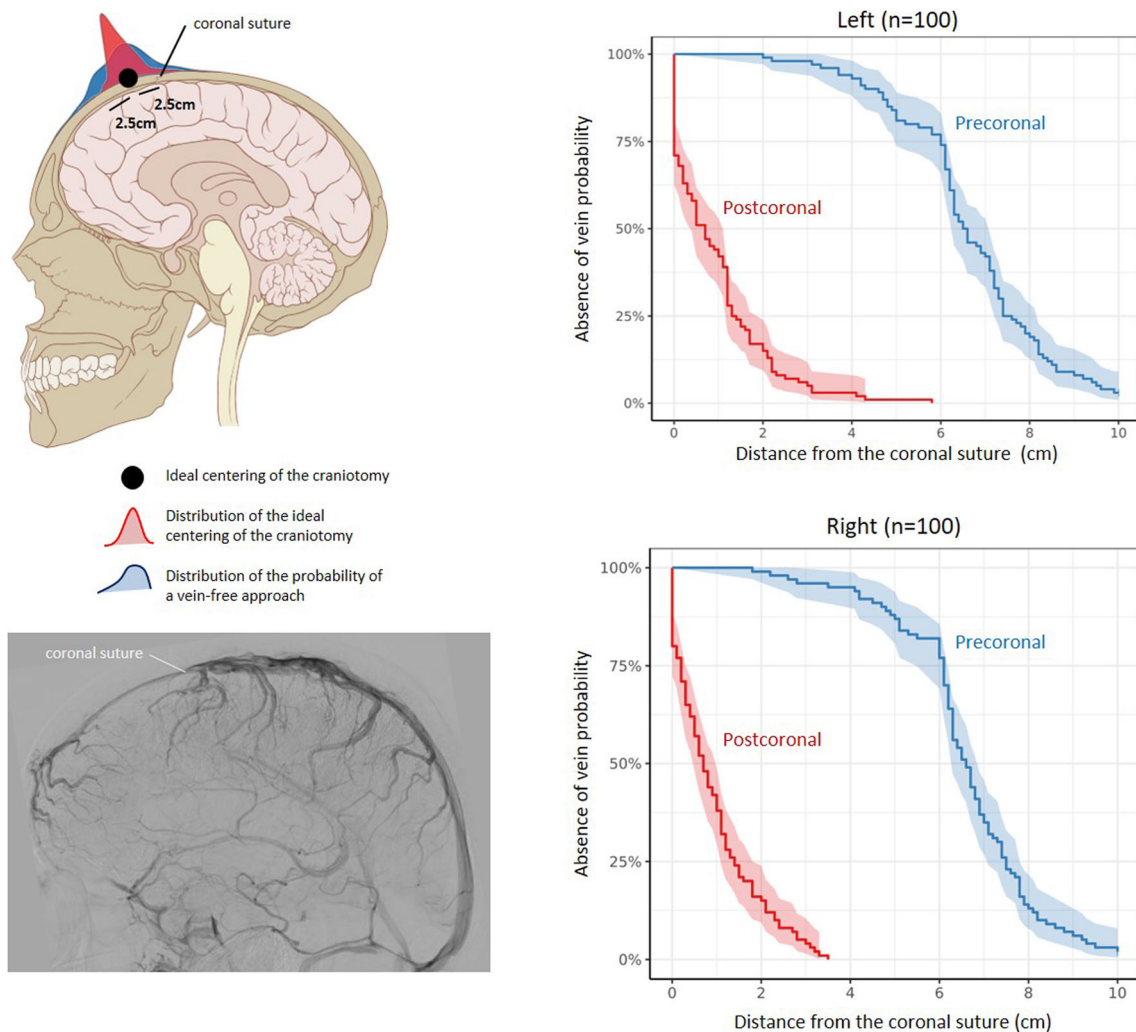


Fig. 1 On the top corner left: representation of the distribution of the probability of vein free approach (blue curve) and of the distribution of the position of the ideal centering of the craniotomy (red curve). The ideal centering of the craniotomy is marked by a black dot; on the bottom left: example of one of the 100 selective cerebral angiographies used for the

study, with MRI fusion available in this particular case, showing the relation to the corpus callosum and deep anatomical structures; on the right, Kaplan-Meier curves representing the absence of bridging veins according to the distance from the coronal suture

Anatomical cadaveric descriptions of frontal bridging veins have calculated the average distance between the frontal pole, defined as the most anterior point of the frontal lobe, and the bridging veins draining into the sagittal sinus. They include the frontopolar vein, located 2.5 cm (from 1.2 to 5.0) to 3.11 cm of the frontal pole [9, 13], the anterior frontal one (6.8 cm, from 3.2 to 9.6), the middle one (8.3 cm, from 4.0 to 11.8), and the posterior one (10.5 cm, from 9.0 to 12.5). The surgical corridor devoid of tributaries is located either between the anterior and the middle frontal vein or between the middle and the posterior one [9], which is congruent with our findings. However, the frontal pole cannot be used as a surgical landmark to predict the position of the veins.

Bony landmarks are the most reliable references neurosurgeons have per-operatively in this context, and, in the case of intraventricular lesions, the physiological anatomy of cortical

veins is unchanged, by the opposition for instance to meningiomas that modify the local superficial vasculature. We found that the coronal suture can be used as a very reliable landmark to position the craniotomy for an interhemispheric approach. While an extension of the craniotomy posterior to the coronal figure is frequently recommended in textbooks, the analysis of the anatomy of bridging veins reveals that a 1-cm extension is unusable in 62.5% of patients and a 2-cm extension in 87.5% of patients, making it controversial to perform such post-coronal extension (Fig. 2). Conversely, the probability of the presence of a bridging vein within the 4 cm anterior to the coronal suture is low (8.6%) and remains acceptable within 6 cm (22.5%). These findings encourage to propose to perform a purely pre-coronal craniotomy of 5 cm for the interhemispheric approach. In case a bridging vein is exposed by the craniotomy, it is also more

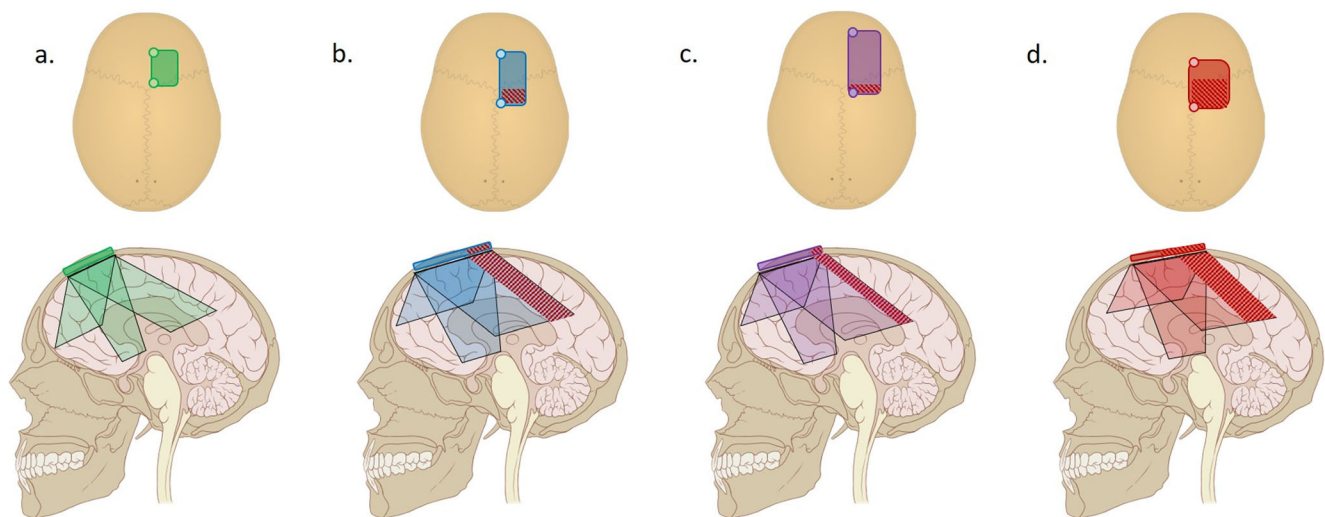


Fig. 2 Examples of craniotomies for interhemispheric approach. The crosshatched zones correspond to the region having a high probability to be inaccessible due to bridging veins. **a** Craniotomy anterior to the coronal suture, centered 2.5 cm ahead. The proposition made by the authors. **b** Craniotomy two-thirds anterior to the coronal suture [7, 8]. **c** Craniotomy 1 cm posterior to the coronal suture and 6 cm ahead [9, 10]. **d**

Craniotomy with the coronal suture at midway [5, 6]. To access the intracranial area exposed by the part of the craniotomy posterior to the coronal suture, the neurosurgeon will have to sacrifice bridging veins in 9.5% in case **a**, in 62.5% of patients in case **c**, and in 87.5% of patients in cases **b** and **d**

acceptable to sacrifice a bridging vein that drains into the anterior third of the superior sagittal sinus, which is thought to have less function than the middle or posterior third of the sinus.

This study does not replace a thorough preliminary analysis of venous anatomy on preoperative imaging, MRI, or CT scan with contrast. It aims at giving reliable landmarks that can be used in the majority of cases when no vascular particularity is observed. If a major vein is visible on the anterior frontal lobe and will presumably hinder the interhemispheric approach, a trans-frontal approach should be considered. If an interhemispheric approach is still performed, dissecting the bridging vein from the cortex is usually possible since the bridging segment, which includes the subarachnoid and subdural segments, is rarely less than 1.6 cm [13]. This will help minimizing the risk of thrombosis since retracting the veins leads to minimal damage compared to coagulation [12]. Some authors also propose to cut the vein from the sinus and anastomose it to a more posterior venous drainage, giving a large interhemispheric access [8, 15]. This approach is nevertheless technically demanding and its safety remains to be proven.

Authors contributions S.A. performed the analysis, drafted the manuscript, and approved the final version of the manuscript.

C.A. performed the analysis, drafted the manuscript, and approved the final version of the manuscript.

D.C. critically reviewed the manuscript and approved the final version of the manuscript.

C.L.G. critically reviewed the manuscript and approved the final version of the manuscript.

P.B. designed the study, performed the analysis, drafted the manuscript, and approved the final version of the manuscript.

Compliance with ethical standards

Ethics approval Local committee approval.

Informed consent Use of anonymized data, with patients' consents

Conflict of interest The authors declare no conflict of interest.

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