Neuroradiology (2001) 43: 139–143

P. Gailloud
M. Muster
N. Khaw
J. B. Martin
K. J. Murphy
J. H. D. Fasel
D. A. Rüfenacht

Anatomic relationship between arachnoid granulations in the transverse sinus and the termination of the vein of Labbé: an angiographic study

Received: 21 January 2000
Accepted: 21 July 2000

Philippe Gailloud, MD (✉)
Interventional Neuroradiology,
Department of Radiology and
Radiological Sciences,
The Johns Hopkins Hospital,
600 North Wolfe Street Baltimore,
MD 21287
Tel.: (410) 955-7433
Fax: (410) 955-0962
E-mail: gailloud@rad.jhu.edu

P. Gailloud · M. Muster · N. Khaw ·
J. B. Martin · K. J. Murphy ·
D. A. Rüfenacht
Department of Radiology,
Geneva University Hospital,
1211 Geneva 14, Switzerland

J. H. D. Fasel
Department of Morphology,
University of Geneva/CMU,
1211 Geneva 4, Switzerland

P. Gailloud · K. J. Murphy
Present address: Interventional
Neuroradiology, Department of Radiology
and Radiological Sciences, The Johns
Hopkins Hospital, Baltimore, MD 21287

Present address:
[3] Interventional Neuroradiology,
Department of Radiology and
Radiological Sciences,
The Johns Hopkins Hospital,
Baltimore, MD 21287

Abstract We studied the anatomic relationship between arachnoid granulations in the transverse sinus and the termination of the vein of Labbé in 57 consecutive angiograms. Patients with pathology in intracranial venous structures or with inadequate image quality of the venous system were excluded. Arachnoid granulations were found in 12 of the 57 patients (21.1 %), always at the junction of the vein of Labbé and the transverse sinus; the vein of Labbé was present in 55 patients (96.5 %), most often without associated arachnoid granulations; the latter, however, were not observed in the absence of a vein of Labbé. This study confirms the close, constant anatomic relationship between arachnoid granulations in the transverse sinus and the termination of the vein of Labbé. This observation may help to differentiate arachnoid granulations from pathologic conditions involving the transverse sinus such as dural sinus thrombosis. The constant character of this relationship suggests a developmental role of afferent veins in the formation of arachnoid granulations.

Key words Vein of Labbé · Granulations, arachnoid · Angiography

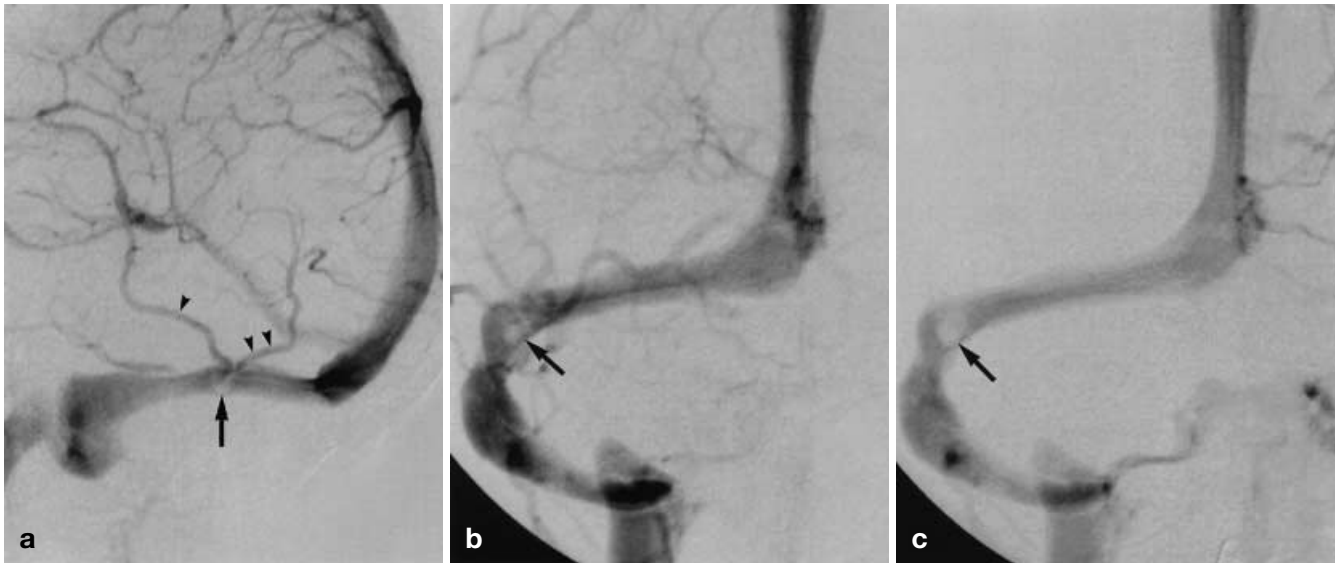

Fig. 1 a–c Case 5. Digital subraction angiography, venous phases, illustrating the criteria used to characterize an arachnoid granulation (AG). This AG of the right transverse sinus (TS) *(arrow)* was detected on three different projections as a stable intraluminal defect visible throughout the venous phase. Both a vein of Labbé (VL) *(single arrowhead)* and an inferior temporal vein *(double arrowheads)* are seen to terminate in the AG. **a, b** Right carotid injection, lateral and anteroposterior projections **c** left carotid injection, anteroposterior projection

Introduction

Fortuitous observations made during routine cerebral angiograms suggest a frequent, close anatomic relationship between arachnoid granulations (AG) in the transverse sinus (TS) and the termination of the vein of Labbé (VL). Studies based on CT and MRI and classical anatomic investigations have previously reported a topographic association, but have shown variations in the frequency and degree of anatomic proximity [1–4]. Recognition of AG in the TS may be challenging, in particular in patients investigated for suspected dural sinus thrombosis. A topographic relationship between the AG and the VL might be a useful diagnostic clue. The present study was conceived in order to explore this anatomic relationship using digital substraction angiography (DSA).

Methods

The cerebral angiograms of consecutive patients were studied. Patients presenting with pathology involving the intracranial venous system, subarachnoid hemorrhage and no angiographically proven aneurysm, or other intracranial hemorrhage were excluded, and only patients with a TS clearly delineated on both sides were recorded. We found 57 diagnostic angiograms satisfying these criteria. They were of 18 females (31.6%), 39 males (68.4%), mean age 60.4 years (range 16–87 years). The angiograms were performed for investigation of cervicocranial atheromatous disease (70.2%), subarachnoid hemorrhage (24.6%) and skull base tumors (nasal angiofibroma, sphenoid wing meningioma) (5.3%). All were performed according to a standard protocol. We defined AG as intraluminal defects visible throughout the venous phase on both anteroposterior and lateral projections (Fig. 1). Defects detectable in one plane only or not seen constantly during the whole length of the venous phase were not recorded as AG. VL were also sought and documented. When both an AG and a VL were observed, particular attention was directed to their anatomic relationship.

Table 1 Characteristics of 12 individuals with an arachnoid granulation in the transverse sinus

Case	Age (years), sex	Side	Vein of Labbé present	Diagnosis
1	57, F	Left	Yes	Atheroma
2	70, F	Left	Yes	Atheroma
3	62, F	Left	Yes	Aneurysm
4	64, F	Left	Yes	Aneurysm
5	71, M	Right	Yes	Atheroma
6	66, M	Left	Yes	Atheroma
7	73, M	Right	Yes	Atheroma
8	71, M	Right	Yes	Atheroma
9	87, M	Right	Yes	Atheroma
10	70, M	Right	Yes	Aneurysm
11	51, M	Right	Yes	Aneurysm
12	81, M	Right	Yes	Atheroma

Results

The 57 patients satisfying the inclusion criteria were considered free of dural sinus pathology. AG were found in 12 (21.1%) (Table 1). All were exactly at the

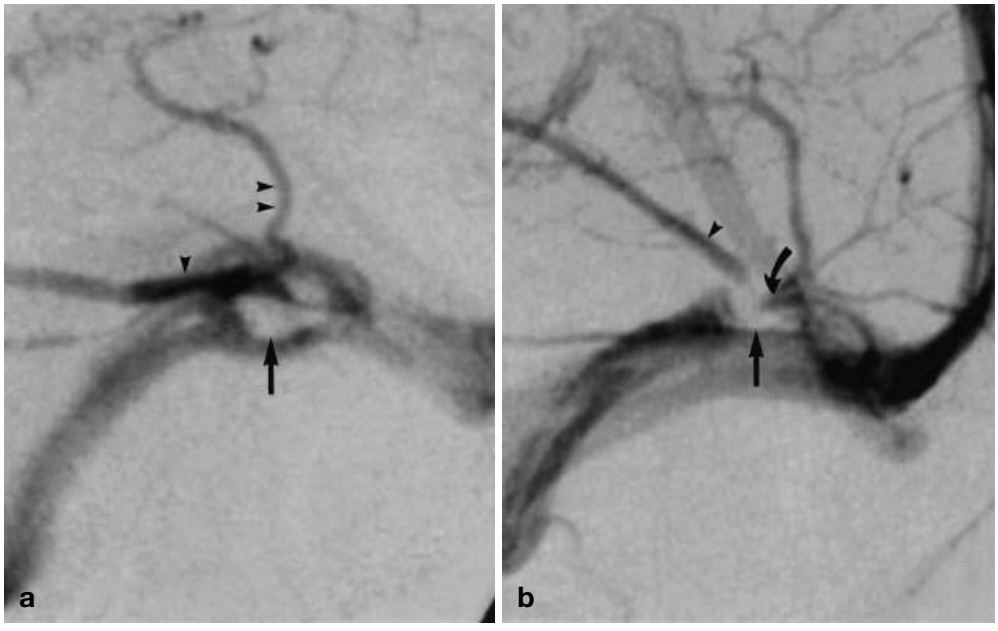

Fig. 2 a, b Cases 9, 11. DSA, venous phase, lateral projections, showing examples of AG in the TS. In **a** an inferior temporal vein *(double arrowheads)* joins the VL *(single arrowhead)* as it terminates at the AG *(arrow),* while in **b** the VL and several temporal and occipital veins end separately in the AG

Fig. 3 – DSA, venous phase, oblique projection, showing an AG *(arrow)* in the distal superior sagittal sinus. Cortical veins *(arrowhead)* may be seen entering the AG. This example suggests that our observations concerning AG in the TS might be extapolated to AG in other sites

termination of a VL at the TS (Figs. 1 and 2). VL were present in 93 % of the TS (4 not seen in 57 individuals), most often without associated AG. AG were, however, not observed in the absence of a VL. Patients with AG (eight male, four female) were older than those without (68.6 vs 60.5 yrs). No gender predominance for AG occurence or any association with pathology condition was observed. AG were found on the left in all four of the female patients and on the right seven of eight males. We saw no bilateral AG. In 11 of the 12 individuals with AG, one or more temporal or occipital veins were seen to join the VL as it emptied into the AG (5 cases) or to terminate in the AG independently (6 cases). In the remaining case, inferior temporal veins were present but their exact course could not be traced. In addition to the 12 AG in the TS, 3 AG were observed at other sites, two in the posterior part of the superior sagittal sinus (Fig. 3) and one in the torcular region.

Discussion

Local filling defects observed incidentally during diagnostic imaging within TS of patients with no suspected venous sinus disease are usually assumed to be AG. Tokiguchi et al. [5] examined a typical filling defect observed on contrast-enhanced CT and proved it histologically to be an AG. Several studies have since shown that AG within the TS are not infrequent and should be considered normal variants [2–4].

We took special care to overcome the absence of anatomic correlation. Patients with visible anomalies of the venous system, even if not directly related to the dural sinuses, were excluded, as were those with pathology potentially related to a dural sinus anomaly (such as subarachnoid hemorrhage with no angiographically demonstrated aneurysm, or intracranial hemorrhage). Since hemodynamic artefacts may mimic an AG within the TS [6], we chose strict criteria for AG: they had to be visible on at least two projections and to

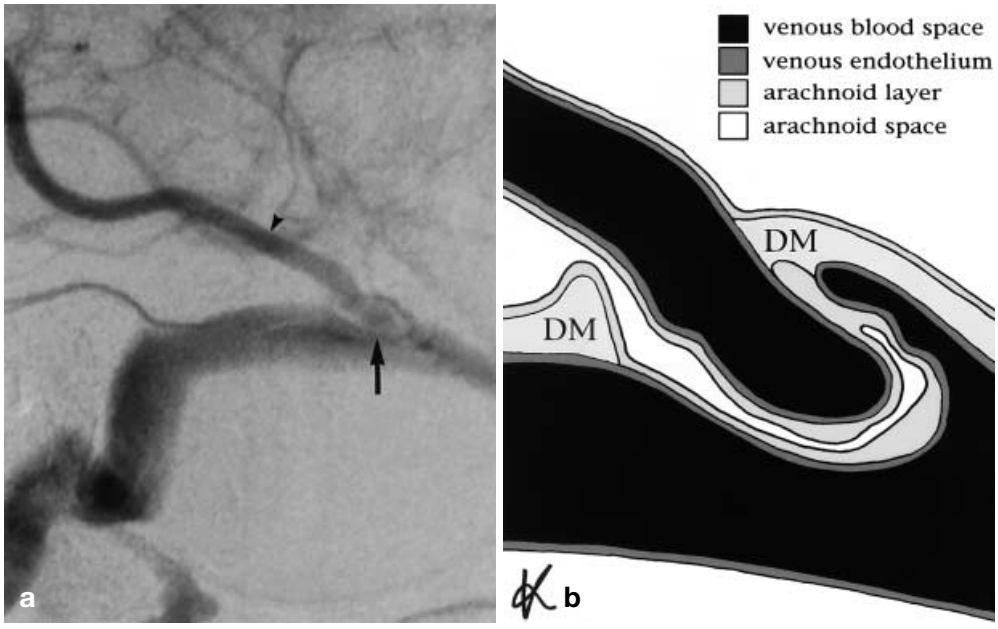

Fig. 4a,b Case 4. **a** DSA, venous phase, lateral projection, showing the termination of a VL *(arrowhead)* in an AG *(arrow)* (left side). **b** Diagram of the relationship between the VL and the AG. The ultrastructural findings of Krisch [8] are adapted to the particular anatomic situation observed on the angiogram. The AG is formed by the protrusion of the afferent vein perivascular arachnoid layer into the lumen of the sinus. The AG contains a fluid space in continuity with the subarachnoid space. *DM* dura mater

be unchanged in size and shape during the whole length of the venous phase.

The frequency with which AG are observed within a TS is strongly dependent on technique. Frequencies derived from anatomic investigations range from 8.4 % (32 of 380 specimens) [1] to 66 % (19 of 29) [3]. However, this variation seems to be explained by differences in size (3–24 mm in the first study and 1–8 mm in the second). Imaging studies also depend on the modality used. AG were observed in 13 % of MRI and 24 % of CT reviewed by Leach et al. [3]. The frequencies of 0.3 % (CT) to 1 % (MRI) reported by Roche and Warner [4] seems to be an underestimate due to suboptimal technique. AG were found in 21.1 % of cases in our study, using DSA. Although this is probably a slight underestimate because of our inclusion criteria, it correlates well with the findings of Leach et al. [3]. Our patients with AG seems to be slightly older than these without (68.6 vs 60.5 yrs), and no AG were observed in patients under 50 years of age. These findings are consistent with the concept that, although they may be found in all age groups [1, 3], AG enlarge with age [3, 7]. There was no sex predominence, but left side predominence observed by Browder et al. [1] (right: 13 %, left: 87 %) and Leach et al. [3] (right: 43 %, left: 57 % in imaging studies; right: 29 %, left: 71 % in anatomic investigation) was found in our female patients while the males exhibited a right predominence.

The existence of a topographic relationship between veins (mainly the VL) and AG within the TS was noted in several previous studies [1, 3, 4]. Here again, the technique greatly influences the frequency of this finding. Of the 41 AG observed by Roche and Warner [4], 16 (39 %) showed a close relationship with a vein, but vein could be traced into the AG in only four. Leach et al. [3] observed AG to be directly adjacent to a vein entry site in 62 % of cases on CT and 85 % of cases on MR. They also noted this relationship to be frequent in their anatomical study (no percentage given). Browder et al. [1] reported that AG were at the termination of the VL at the TS in 21 of 23 cases (91 %). In our study, AG within the TS were exactly at the termination of the VL in all cases. These angiographic observations correlate well with the ultrastructural studies of Krisch [8], who demonstrated that AG are formed where an afferent vein penetrates the dura mater of the sinus by the intraluminal protrusion of the venous perivascular leptomeningeal layer (Fig. 4). Our findings may therefore probably be extrapolated to AG in other dural sinuses (Fig. 3).

Our angiographic observations may be important from a diagnostic point of view, since the constant relationship between AG in the TS and the VL may help differentiating these normal variants from various dural sinus diseases appearing as intraluminal filling defects. In particular, where thrombosis of a TS is suspected, the presence of a patent vein coursing toward the filling defect should raise the possibility of an AG.

Acknowledgements We express their thanks to Kristin A. Cook Gailloud for preparation of the artwork.

References

1. Browder J, Kaplan HA, Howard EM (1973) Hyperplasia of pacchionian granulations. Arch Pathol 95: 315–317
2. Mamourian AC, Towfighi J (1995) MR of giant arachnoid granulation, a normal variant presenting as a mass within the dural venous sinus. AJNR 16: 901–904
3. Leach JL, Jones BV, Tomsick TA, Stewart CA, Balko MG (1996) Normal appearance of arachnoid granulations on contrast-enhanced CT and MR of the brain: differentiation from dural sinus disease. AJNR 17: 1523–1532
4. Roche J, Warner D (1996) Arachnoid granulations in the transverse and sigmoid sinuses: CT, MR, and MR angiographic appearance of a normal anatomic variation. AJNR 17: 677–683
5. Tokiguchi S, Hayashi S, Takahashi H, Okamoto K, Ho J (1993) CT of the pacchionian body. Neuroradiology 35: 347–348
6. Hacker H (1974) Normal supratentorial veins and dural sinuses. In: Newton TH, Potts DG (eds) Radiology of the skull and brain. Vol 2, Book 3. Mosby, Saint Louis, p. 1869
7. Le Gros Clark WE (1920) On the pacchionian bodies. J Anat 55: 40–48
8. Krisch B (1988) Ultrastructure of the meninges at the site of penetration of veins through the dura mater, with particular reference to Pacchionian granulations. Cell Tissue Res 251: 621–631