Selective disconnection of cortical venous reflux as treatment for cranial dural arteriovenous fistulas


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Object. A single-institution series of 119 consecutive patients with a dural arteriovenous fistula (DAVF) and cortical venous reflux was reviewed to assess the overall clinical outcome of multidisciplinary management after long-term follow up. The selective disconnection of the cortical venous reflux compared with the obliteration of the entire DAVF was evaluated.

Methods. Dural arteriovenous fistulas in patients in this series were diagnosed between 1984 and 2001, and treatment was instituted in 102 of them. The outcome of adequately treated patients was compared with that of a control group consisting of those with persistent cortical venous reflux and with data found in the literature. In cases of combined dural sinus drainage and cortical venous reflux, a novel treatment concept of selective disconnection of the cortical venous reflux that left the sinus drainage intact, and thus converted the aggressive DAVF into a benign lesion, was evaluated.

Endovascular treatment, which was instituted initially in 78 patients, resulted in an obliteration or selective disconnection in 26 (25.5%) of 102 cases. In 70 cases (68.6%) the DAVFs were surgically obliterated or disconnected. In six cases (5.9%), patients were left with persistent cortical venous reflux. No lasting complications were noted in this series. Follow-up angiography confirmed a durable result in 94 (97.9%) of 96 adequately treated cases, at a mean follow up of 27.6 months (range 1.4–138.3 months).

Selective disconnection was performed in 23 DAVFs with combined sinus drainage and cortical venous reflux. These patients’ long-term outcomes were equal to those with obliterated DAVFs, and the complication rate was lower.

Conclusions. Considering the ominous course of DAVFs with patent cortical venous reflux, multidisciplinary treatment of these lesions is highly effective and the complication rate is low. Selective disconnection provides a valid treatment option of DAVFs with combined dural sinus drainage and cortical venous reflux, as has been shown in cranial DAVFs with direct cortical venous reflux.

Key Words • dural arteriovenous fistula • embolization • outcome • neurosurgery

Cranial DAVFs can be classified as aggressive based on the presence of cortical venous reflux on angiographic studies. Cranial DAVFs without cortical venous reflux are considered to be benign, with a clinical presentation characterized by the absence of aggressive clinical events such as ICH, nonhemorrhagic neurological deficits, and death.1,7 During follow up this benign clinical behavior is maintained in 98% of cases, justifying observational or at most palliative treatment measures.22 In contrast, cranial DAVFs with cortical venous reflux are well known for their aggressive clinical events, both at presentation1,4,9 and during their disease course.5,10,26 Cortical venous reflux, either untreated or persistent after partial treatment, is associated with an annual mortality rate of 10.4% and an annual morbidity rate of 15%.26 Hence, prompt diagnosis and treatment of the aggressive lesions is mandatory.

Treatment of aggressive cranial DAVFs, aimed at either obliteration of the lesion or selective disconnection of cortical venous reflux, can be performed neurosurgically or endovascularly. In this article the clinical features and management of the disease in 102 of an initial consecutive single-center cohort of 119 patients who had an aggressive cranial DAVF are reviewed, and the patients’ outcomes and complications are outlined. In a subgroup of patients who harbored a DAVF with combined dural sinus drainage and cortical venous reflux (Borden Type II, Cognard Type IIb and IIa + b), the long-term results of complete obliteration of the fistula were compared with a novel strategy of selective disconnection of the cortical venous reflux, leaving the sinus drainage intact and thus converting the aggressive DAVF into a benign lesion.

Clinical Material and Methods

Patient Population

Between June 1984 and August 2001, the University of Toronto Brain Vascular Malformation Study Group consecutively assessed 240 patients with a cranial DAVF (the Toronto Neurovascular Database). The period of time between 1984 and 1989 was reviewed retrospectively by using infor-
information from the clinical charts and radiological imaging. Since 1989 the data have been collected prospectively. All cases were evaluated in a multidisciplinary clinic at the Toronto Western Hospital, attended by neurosurgeons, interventional neuroradiologists, and radiation therapists. The initial assessment included a detailed medical history, a full neurological examination, and at least one digital subtraction cerebral angiogram.

The cohort of 119 patients was selected for the presence of cortical venous reflux on the initial angiogram (Borden, et al., Type II or III; Cognard, et al., Type IIb, IIa + b, III, or IV), reviewed by an experienced neuroradiologist. Seventeen patients were excluded from this study: three (2.5%) were lost to follow up directly after the initial assessment and 14 (11.8%) declined the initial treatment offer. The remaining 102 patients (85.7%) were treated and are evaluated in this study. Each treatment strategy was discussed in the multidisciplinary group and consisted of neurosurgery, endovascular embolization, or a combination of both. At regular intervals after discharge the patients were clinically evaluated in the multidisciplinary clinic at the Toronto Western Hospital. All treatment results were confirmed using (repeated) digital subtraction angiography.

Based on the pattern of venous drainage, the 102 treated patients were subdivided into two study groups. All 40 patients in Group A harbored cranial DAVFs with combined dural sinus drainage and cortical venous reflux (Fig. 1 upper: Borden Type II; Cognard Type IIb or IIa + b). Group B (62 patients) included patients with cranial DAVFs with direct cortical venous reflux (Fig. 1 lower: Borden Type III; Cognard Type III or IV). The treatment results in both Groups A and B were evaluated against the disease course of DAVFs with persistent cortical venous reflux, both from the Toronto Neurovascular Database and from the literature. Additionally, in Group A the novel treatment concept of selective disconnection of the cortical venous reflux, which left the dural sinus drainage intact and thus converted the aggressive DAVF into a benign one (Borden Type I; Cognard Type I or IIa), was evaluated and the outcome and complication rates associated with it were compared with those associated with obliteration of the whole fistula. For statistical analysis, the chi-square test was used.

**Clinical Features**

The mean patient age at clinical presentation was 54.8 ± 16.9 years (mean ± standard deviation), and male patients predominated (64:38 male/female patients). Within the group of DAVFs shunting directly into the cortical veins without dural sinus drainage (Group B) the preponderance of male patients was significant (55 male compared with 15 female patients, p < 0.001). In particular, all nine DAVFs with a direct shunt in the floor of the anterior fossa were found in male patients. All locations are outlined in Table 1; location was never an argument to choose between an obliteration procedure or a selective disconnection of cortical venous reflux, if both were feasible.

The clinical presentation was aggressive in 60 (58.8%) of 102 patients. An ICH was the main presentation feature in 25 patients. Nonhemorrhagic neurological deficit was the presenting feature in 34 patients; one presented with a seizure. Thirty-six patients (35.3%) had a more benign presentation, with chronic headache, pulsatile bruit, or orbital symptoms. Six patients (5.9%) were asymptomatic at presentation (Table 2).

**Treatment Modalities**

Endovascular embolization was primarily performed in 78 (76.5%) of 102 patients; in 24 (30.8%) of these multiple procedures were required. On average, 1.5 procedures per patient (range one–seven procedures) were performed to...
obtain an acceptable result, adding up to 120 embolization sessions. In 46 cases (59%) the endovascular treatment was followed by additional neurosurgical treatment.

Neurosurgical treatment was performed in 70 (68.6%) of 102 patients. Four patients underwent a second surgical procedure to obtain an adequate treatment, adding up to 74 surgical treatment sessions. In 21 (28.4%) of 74 cases a resection of the DAVF was achieved. In 53 (71.6%) of 74 sessions a selective disconnection procedure was performed. To disconnect the cortical venous reflux, the cortical veins involved were either occluded with an aneurysm clip (24 patients) or coagulated with bipolar forceps and divided (29 patients). In one patient the postoperative angiographic studies demonstrated residual cortical venous reflux after the disconnection procedure, which was followed by a complete resection of the DAVF. All treatment types have been summarized in Table 3.

**Results**

**Group A: DAVFs With Combined Dural Sinus Drainage and Cortical Venous Reflux**

This subgroup consisted of 40 patients harboring a DAVF with combined sinus drainage and cortical venous reflux. Thirty-six patients primarily underwent endovascular procedures, resulting in an acceptable result in 14 (38.9%) of 36 cases: obliteration of the entire DAVF in seven patients and a selective cortical venous reflux disconnection in seven. Thus, 22 patients were left with persistent cortical venous reflux following embolization; six of them declined subsequent surgical treatment. With the four who were primarily offered surgery, this adds up to 20 patients who underwent neurosurgical treatment: four of them were cured by an excision of the DAVF including the sinus, and in 16 patients the cortical venous reflux was successfully disconnected. The six partially treated patients who refused surgery after embolization were followed up and analyzed together with the previously mentioned 14 patients who refused any form of treatment. Together they acted as a control group, for which the results were published earlier.26

**Group B: DAVFs With Direct Cortical Venous Reflux**

This subgroup contained 62 patients who had a DAVF with direct cortical venous reflux (Fig. 1 lower). Forty-two patients (67.7%) were initially treated by endovascular means; of these the cortical venous reflux was disconnected in two patients and in 10 an obliteration of the entire DAVF was achieved. The 30 partially treated patients subsequently underwent surgical treatment, and 20 patients underwent surgery as a primary treatment. Selective disconnection was performed in 36 of 50 cases; the remaining 14 patients underwent a total excision of the DAVF.

**Clinical and Radiological Outcome**

The mean clinical follow up in Group A was 27.8 months (range 1.6–115.8 months). Both the 11 patients with obliterated DAVFs and the 23 with disconnected cortical venous reflux did well clinically. Whereas after obliteration a complete resolution of symptoms was achieved, after disconnection we encountered the benign signs and symptoms of a DAVF with solitary sinus drainage, which resulted in either a further spontaneous cure or a stable and well-tolerated disease. None of the patients in whom disconnection was performed complained of an incapacitating bruit. Any remaining orbital symptoms caused by cavernous sinus DAVFs could be medically managed by an ophthalmologist. Follow-up angiography was available in all 34 patients after a mean of 13.6 months (range 1 day–85.6 months), demonstrating a lasting result in all cases.

In Group B the mean clinical follow up was 27.5 months (range 1.4–138.3 months). After adequate treatment, both obliteration and disconnection, there was a 100% resolution
of the symptoms. Follow-up angiography was performed in 60 (96.8%) of 62 patients after a mean of 6.7 months (range 1 day–61.6 months), confirming the clinical result and demonstrating no recanalization or recurrence.

Complications of Treatment

Complications in both surgically and endovascularly treated patients were encountered in 16 (8.2%) of 194 procedures; all complications were transient. The most common complication was significant blood loss during a surgical procedure, none of which were selective disconnection procedures. No deaths or lasting complications due to the treatment were encountered (Table 4).

Discussion

Prompt treatment of an aggressive DAVF, that is, one accompanied by cortical venous reflux, is warranted because the Toronto Neurovascular Database has revealed an annual complication rate of 15% and an annual mortality rate of 10.4% in the natural course of the disease. In the past, obliteration of the entire DAVF including cortical venous reflux has been recommended; however, with recognition of the cortical venous reflux as the cause of complications, treatment can be more focused to selective disconnection of the reflux. This can be achieved using either surgical or endovascular methods, although, regardless of the anatomical location, no consideration should be given to the stereotactic radiotherapeutic (radiosurgery) treatment of aggressive DAVFs. Radiosurgery has been proposed in some case reports and small series; however, complete obliteration may take many years, during which time fatalities are to be expected as in the natural history.

Treatment procedures aimed at the disconnection of cortical venous reflux have been amply reported for DAVFs with direct cortical venous reflux without dural sinus drainage (Borden Type III, Cognard Types III and IV; Group B in this study). Pathophysiologically a DAVF is considered a venous disease and permanent cure of a cranial DAVF with direct cortical venous reflux can thus be obtained by a selective intradural division of the venous outlet of the fistula, analogous to the well-known treatment of a spinal DAVF. Primarily this procedure has been described as neurosurgical; however, with advances in interventional neuroradiology, the same result has been demonstrated with endovascular methods as well.

In case of combined dural sinus drainage and cortical venous reflux (Borden Type II; Cognard Type IIb or IIa + b; Group A in this series), the obliteration of the whole fistula including excision or packing of the involved dural sinus has been advocated. On the other hand, a drawback of permanent occlusion of an involved sinus might be that the venous drainage of the normal brain becomes impaired, resulting in venous infarction and hemorrhage or leading to long-term complications of venous hypertension (for example, dementia). In this regard, Mironov reported the treatment of two patients with combined dural sinus drainage and cortical venous reflux, in which he used endovascular methods to disconnect the cortical venous reflux selectively without influencing the venous drainage of the dural sinus. Although the fistula itself is not obliterated, by this method an aggressive DAVF is converted into a benign one. This is clinically important because, as has been demonstrated in the Toronto Neurovascular Database, benign DAVFs follow a disease course with no grave neurological events and in the majority of patients this is a self-limiting disease.

The surgical technique of selective cortical venous reflux disconnection, which leaves the actual fistula in the wall of the dural sinus untouched, is relatively simple and has the important advantage of a complete lack of major blood loss from the procedure, in comparison to the classic surgical obliteration of the DAVF. Simple coagulation and sharp division of the refluxing cortical veins as they enter the subarachnoid space is sufficient to convert the aggressive type of DAVF into a benign one. The permanent application of aneurysm clips has been increasingly avoided during the past decade, because of local distortions of the magnetic field in magnetic resonance imaging and magnetic resonance angiography.

The endovascular technique of selective cortical venous reflux disconnection can be more complex, because the involved sinus is usually partially thrombosed and a transfemoral route is difficult. This problem can be avoided by using a direct puncture of the dural sinus, or by moving the catheter transvenously “against the stream.”

In this study we have demonstrated that the concept of selective disconnection of cortical venous reflux is a safe and durable treatment option, not only in DAVFs with direct cortical venous reflux (Group B), but also in lesions with combined sinus drainage and cortical venous reflux (Group A). In experienced hands the endovascular disconnection technique was equal to surgical disconnection, both in effect and in complication rate.

Conclusions

Considering the ominous disease course of DAVFs with patent cortical venous reflux, multidisciplinary treatment is highly effective and carries a low complication rate. Selective disconnection has proven to be a valid treatment option in DAVFs with combined dural sinus drainage and reflux, as has already been shown in cranial DAVFs with direct cortical venous reflux.

References

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Manuscript received September 26, 2003. Accepted in final form March 12, 2004.

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