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Endovascular Treatment of Intracranial Dural Arteriovenous Fistulas -Clinical and Radiographic Outcome Over A Long-Term Follow-Up

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Abstract

Background and Purpose: Dural arteriovenous fistulas (DAVFs) are pathologic shunts between dural arteries and dural venous sinuses, meningeal veins or cortical veins, representing 10%–15% of all intracranial vascular malformations. Although there are several treatment modalities such as surgical interruption of the fistula and stereotactic radiation therapy, endovascular embolization has recently become the most widely used one, but long-term follow-up data are not available in the literature.

Materials and Methods: We present a retrospective, single-center study of the long-term clinical and radiographic outcome of 32 patients who have undergone endovascular treatment of an intracranial DAVF with detachable coils and/or endovascular glue.

Results: There was no recurrence in the follow-up period (mean: 33 months, range 1-108 months) after complete occlusion with the treatment (n=19). Even in cases of incomplete occlusion (n=13), there was no aggravation of shunt flow and spontaneous complete occlusion was confirmed in almost 50% (n=6) in the follow-up period. Multi-session treatment was frequently needed for tentorial DAVF and complication rate was higher than other types.

Conclusion: In this study, there was no DAVF recurrence over an extended follow-up period (mean: 33 months, range: 1-108 months) after complete occlusion with the endovascular treatment and in nearly 50% of cases with incomplete occlusion, there was spontaneous complete occlusion during the follow-up period.

Keywords: Intracranial Dural Arteriovenous Fistula; Endovascular Treatment; Clinical Outcome; Radiographic Outcome; Recurrence

Abbreviations: DAVF: Dural Arteriovenous Fistula; TAE: Transarterial Embolization; TVE: Transvenous Embolization

Introduction

Dural arteriovenous fistulas (DAVFs) are pathologic shunts between dural arteries and dural venous sinuses, meningeal veins or cortical veins. Intracranial DAVFs represent 10%-15% of all intracranial vascular malformations and are more frequent among middle-aged and older patients, though children can also be affected [1]. Although DAVFs can occur anywhere in the dura mater covering the brain, they occur most frequently in the cavernous and transverse-sigmoid sinuses. Patients may be clinically asymptomatic or may experience a wide range of symptoms (mild symptoms to fatal hemorrhage), depending on the location (eg. cavernous sinus, transverse-sigmoid sinus, tentorium, superior sagittal sinus, anterior fossa) and venous drainage pattern of the DAVF. DAVFs draining into a dural sinus without recruitment of cortical veins are regarded as relatively benign lesions and treatment is advocated only if the patient is severely affected by the symptoms [2,3]. The traditional treatment of DAVFs was surgical disconnection of the pathologic arteriovenous communication and possible resection of the involved segment of the dural sinus [4]. Although stereotactic radiation therapy is, also demonstrating good results in an increasing number of cases and surgery is still the preferred option in some cases, recent developments in endovascular intervention now allow most patients to be treated with transcatheter embolization [5].

The purpose of our retrospective, single-center study was to determine the long-term clinical and radiographic outcome of patients who have undergone endovascular treatment of an intracranial DAVF with detachable coils and/or endovascular glue, since data from such an extended follow-up period is not available in the literature. We also examined epidemiologic characteristics of the patients and DAVF characteristics as possible prognostic factors of post-treatment clinical and radiographic outcome.

Materials and Method

All patients with intracranial DAVF who presented at our department between 2008 and 2014 and received endovascular treatment were included in the study. Evaluation was done by review of clinical records and radiographic imaging studies (conventional angiography, MRI and MRA). A total of 32 patients, 17 men and 15 women (mean age: 62,4 years, range: 38-81 years) with intracranial DAVF received endovascular treatment by transarterial (TAE) or transvenous (TVE) embolization with coils and/or glue. Before intervention, all cases were classified according to Cognard and Borden systems, on the basis of their arterial supply and venous drainage patterns.

In 6 patients DAVF diagnosis was made after a hemorrhagic event. Regarding the clinical symptom, most common one was tinnitus (n=15, mean duration: 10.3 months), followed by double vision (n=4) and motor disturbances (n=4). Other symptoms reported were headache (n=3), aphasia (n=2), conjunctiva hyperemia (n=1), loss of consciousness (n=1) and seizures (n=1), while in one patient it was discovered incidentally (Figure 1). Age, sex, classification and localization of the fistulas were examined as independent variables of clinical outcome (modified Rankin scale - mRS) and radiographic recurrence (angiography, MRA). Statistical analysis was performed using Student's t test and analysis of variance (ANOVA) and statistical significance (p) was set at 0.05.

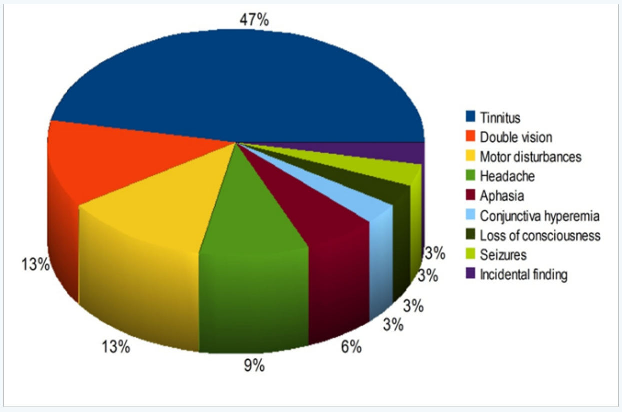

Figure1: Presenting symptom.

Results

Incidence and treatment results

The distribution of DAVFs was as follows: transverse sinus-sigmoid sinus (n=16), cavernous sinus (n=9), tentorial (n=4), sphenoid wing (n=1), craniocervical junction (n=1) and anterior condylar confluence (n=1). It is noteworthy that distribution was different between males and females (Figure 2). Based on DAVF localization and characteristics, TAE, TVE or combined approach was selected and embolization was conducted with detachable coils and/or endovascular glue. A total of 27 patients were treated in one session. Two sessions were needed in 3 patients, one patient required 5 sessions, while another patient after two sessions of endovascular treatment required two subsequent surgical operations for the complete obliteration of his DAVF. Nineteen patients (60%) had no residual flow immediately after treatment, while 13 patients (40%) had small residual flow at angiography (Table 1).

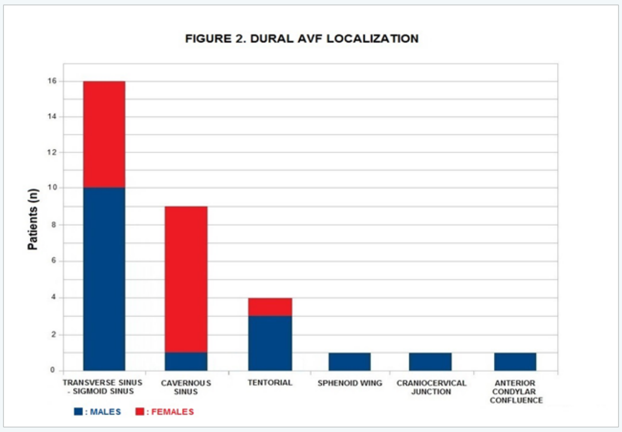

Figure 2: Dural AVF localization.

Complications

A 57-year-old male patient (case N:7) who presented with subarachnoid hemorrhage due to a ruptured tentorial DAVF (Borden:3, Cognard:IV), after two sessions of endovascular treatment, developed hydrocephalus due to intraventricular hemorrhage. He was surgically treated with bilateral external ventricular drainage placement, but nonetheless, he deteriorated and finally died two weeks later (mRS:6). A 62-year-old male patient (case N:9) who presented with subarachnoid hemorrhage due to a ruptured craniocervical junction DAVF, had a deterioration of his respiratory function after the endovascular treatment and required mechanical ventilation for two days. This patient on his 5-year follow up is fully functional, complaining only for intermittent headaches (mRS:1).

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Table 1: Patient data

S.No.	Age	Sex	Localisation	Classification	Approach	Complications	Pretreatment Mrs	Post-Treatment Mrs	Follow-Up Mrs	Post-Treatment Radiographic Evidence	Follow-Up Radiographic Evidence
1	68	F	Cavernous Sinus	Borden: 2, Cognard: IIB	TVE	None	2	2	0	Complete Obliteration	No Recanalization
2	71	M	Transverse-Sigmoid Sinus	Borden: 2, Cognard: III	TAE+TVE, TAE	None	0	0	0	Small Residual Flow	No Recanalization
3	69	M	Transverse-Sigmoid Sinus	Borden: 1, Cognard: IIA	TAE	None	1	0	1	Residual Flow	Small Residual Flow
4	56	F	Tentorial	Borden: 3, Cognard: IV	TAE+TVE, TVE	None	1	1	0	Residual Flow	No Recanalization
5	68	M	Transverse-Sigmoid Sinus	Borden: 2, Cognard: III	TAE, TVE, TAE, TAE, TAE+TVE	None	4	3	0	Residual Flow	Small Residual Flow
6	61	M	Transverse-Sigmoid Sinus	Borden: 3, Cognard: Iv	TAE	None	0	0	0	Small Residual Flow	No Recanalization
7	57	M	Tentorial	Borden: 3, Cognard: Iv	TAE, TAE+TVE	Intraventricular Hemorrhage, Hydrocephalus	2	5	6	Residual Flow	-
8	65	F	Cavernous Sinus	Borden: 2, Cognard: II A+B	TVE	None	2	2	2	Complete Obliteration	No Recanalization
9	62	M	Craniocervical Junction	Borden: 3, Cognard: III	TAE	Respiratory Deterioration, Mechanical Ventilation	1	1	1	Complete Obliteration	No Recanalization
10	78	M	Transverse-Sigmoid Sinus	Borden: 3, Cognard: Iv	TAE	None	3	3	3	Residual Flow	Small Residual Flow
11	75	M	Cavernous Sinus	Borden: 2, Cognard: IIB	TAE	None	2	1	0	Residual Flow	No Recanalization
12	46	F	Transverse-Sigmoid Sinus	Borden: 3, Cognard: III	TAE+TVE	None	2	2	1	Complete Obliteration	No Recanalization
13	56	M	Anterior Condyla Confluence	Borden: 2, Cognard: IIa	TVE	None	1	0	0	Complete Obliteration	No Recanalization
14	45	M	Transverse-Sigmoid Sinus	Borden: 1, Cognard: IIa	TAE	None	1	1	0	Residual Flow	Small Residual Flow
15	64	F	Cavernous Sinus	Borden: 1, Cognard: IIa	TAE+TVE	None	1	1	1	Complete Obliteration	No Recanalization

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16	69	F	Transverse-Sigmoid Sinus	Borden: 2, Cognard: IIB	TAE+TVE	None	3	2	3	Complete Obliteration	-
17	58	F	Transverse-Sigmoid Sinus	Borden: 1, Cognard: I	TAE	None	1	1	1	Complete Obliteration	No Recanalization
18	70	F	Cavernous Sinus	Borden: 1, Cognard: I	TAE	None	2	2	1	Residual Flow	Small Residual Flow
19	55	M	Tentorial	Borden: 3, Cognard: Iv.	TAE, TAE+TVE, Surgery, Surgery	Hydrocephalus	4	3	1	Residual Flow After Endovascular Tre-atment - Complete Obliteration After Surgery	No Recanalization
20	60	M	Tentorial	Borden: 3, Cognard: Iv	TAE+TVE	None	0	0	1	Residual Flow	Small Residual Flow
21	40	M	Transverse-Sigmoid Sinus	Borden: 1, Cognard: I	TAE	None	1	1	0	Complete Obliteration	No Recanalization
22	38	M	Sphenoid Wing	Borden: 1, Cognard: I	TAE	None	1	0	0	Complete Obliteration	No Recanalization
23	63	M	Transverse-Sigmoid Sinus	Borden: 3, Cognard: Iv	TAE	None	2	2	2	Complete Obliteration	No Recanalization
24	45	F	Transverse-Sigmoid Sinus	Borden: 3, Cognard: III	TAE	None	1	1	1	Complete Obliteration	No Recanalization
25	76	F	Cavernous Sinus	Borden: 2, Cognard: II A+B	TAE	None	2	2	2	Complete Obliteration	No Recanalization
26	80	F	Transverse-Sigmoid Sinus	Borden: 1, Cognard: I	TAE+TVE	None	1	1	1	Small Residual Flow	No Recanalization
27	77	F	Cavernous Sinus	Borden: 2, Cognard: II A+B	TVE	Abducens Nerve Paresis	1	2	2	Complete Obliteration	No Recanalization
28	71	F	Cavernous Sinus	Borden: 2, Cognard: II A+B	TVE	None	1	0	0	Complete Obliteration	No Recanalization
29	75	F	Cavernous Sinus	Borden: 2, Cognard: IIA	TVE	None	0	0	0	Complete Obliteration	No Recanalization
30	39	F	Transverse-Sigmoid Sinus	Borden: 1, Cognard: I	TAE	None	1	0	0	Complete Obliteration	No Recanalization
31	81	M	Transverse-Sigmoid Sinus	Borden: 2, Cognard: II A+B	TAE+TVE	None	1	1	0	Complete Obliteration	No Recanalization
32	61	M	Transverse-Sigmoid Sinus	Borden: 3, Cognard: III	TAE+Tve	None	0	0	1	Complete Obliteration	-

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A 55-year-old male patient (case N:19), presented with cerebellar hemorrhage due to a ruptured tentorial DAVF, rebled in the second session (TAE+TVE) and developed hydrocephalus which was treated with external ventricular drainage. The surgical obliteration of his DAVF was completed in two operations and the patient 4 years later has only slight remaining instability (mRS:1) with no remaining vascular malformation on MRA. A 77-year-old female patient (case N:27) with cavernous sinus DAVF presented post-embolization abducens nerve paresis which was efficiently treated with steroid administration. She has slight remaining diplopia on 1-year follow up, but no evidence of recanalization on MRA (mRS:2). Mortality rate in our series was 3% (1/32 patients), regarding a patient with an already ruptured DAVF before intervention (case N:8). Among the rest of the patients, overall complication rate was 9.3% (3/32 patients) and all three patients had mRS≤2, suggesting that endovascular treatment of DAVFs is not only an effective, but also a safe treatment modality.

Radiographic follow-up

Our protocol of follow-up consists of an angiography one year after the embolization and MRI/MRA scan at 1,3,6 and 12 months after the embolization and yearly thereafter. Mean radiographic follow-up period was 33 months (range 1-108 months). Two patients were lost in the follow-up period (cases N:16&32), while another (case N:7) died two weeks after embolization. Twenty-three patients (79%) had no signs of recanalization on follow-up MRA (mean follow-up period of 30 months), which is similar to other series of the literature [6]. Six patients (21%) had small residual flow diagnosed with MRA at a mean follow-up period of 48 months. Among patients to whom complete radiographic obliteration of their DAVF was achieved, none had recanalization at follow-up radiographic examination. Furthermore, half of the patients with residual flow after treatment had late occlusion with no signs of recanalization at follow-up (Figure 3).

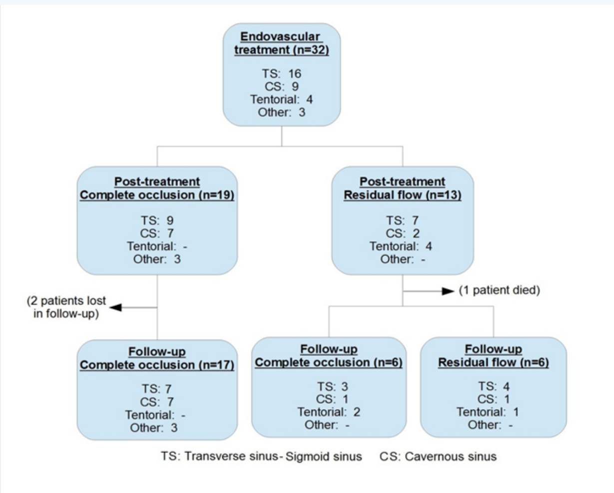

Figure3: Radiographic follow-up.

When patients where distributed to groups based on their age, there was no statistically significant difference between groups regarding their immediate post-treatment radiographic DAVF persistence or their radiographic recurrence after a mean follow-up period of 3 years. On the other hand, males had a greater likelihood of both immediate post-treatment radiographic DAVF persistence (P=0.02), as well as follow-up radiographic recurrence (P<0.05) compared to females, possibly due to the different distribution of DAVFs regarding localization that was observed among males and females. Regarding localization, tentorial DAVFs had statistically significantly higher rate of immediate post-treatment persistence (P=0.03), thus necessitating a repeat embolization, but there was no statistically significant difference on follow-up radiographic recurrence. Finally, there was no statistically significant difference regarding post-treatment radiographic persistence or follow-up recurrence based on Borden and Cognard classification systems.

Clinical outcome

In patients with DAVF, embolization with detachable coils and/or endovascular glue showed a high technical success rate. None of the patients presented with symptoms of cerebral infarction, in the follow-up examination. Mean duration of hospitalization among the 27 patients who were treated in one endovascular session was 12.4 days. Two of the three patients who were treated in two sessions (the third one died during his hospitalization) required 11.7 days/session (on average) until discharge, while the patient who was treated in five sessions required 16 days (on average) after each session until discharge. Finally, the patient who was treated with two sessions of endovascular treatment and two surgical operations was discharged after 39 days. Mean duration of hospitalization was 15.1 days after each endovascular treatment when TVE route was used and 12.4 days after each TAE embolization on average. When both TAE and TVE approaches were used mean duration of post-embolization hospitalization was 13.8 days.

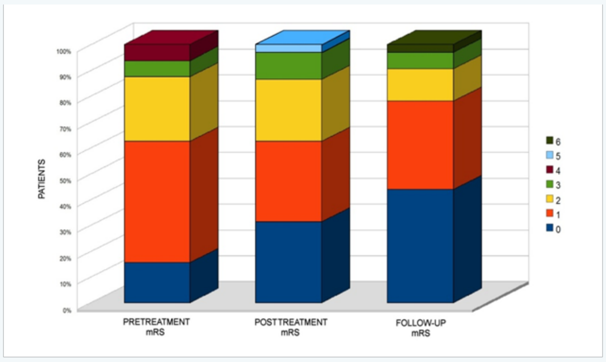

Figure 4: Clinical outcome - Modified Rankin Scale.

Compared to the pre-treatment mRS, nine patients had a one-degree improvement immediately post-treatment,

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twenty-one patients had no change in mRS score, one patient deteriorated by one degree and another one by three degrees. Regarding mRS at follow-up examination a score of 0 ("no symptoms at all") was attained by fourteen patients (43%), a score 1 ("no significant disability") was attained by eleven patients (34%), a score 2 ("slight disability") by four patients (13%), a score 3 ("moderate disability") by two patients (6%) and score 6 ("dead") was attained by one patient (3%)(Figure 4). When patients where distributed to groups based on their age, there was no statistically significant difference among groups regarding immediate post-treatment or follow-up clinical outcome (comparison of pretreatment and post-treatment or follow-up mRS scores, respectively). There was no statistically significant difference regarding clinical outcome (mRS score) between males and females, as well as, among groups based on DAVF localization or classification according to Borden and Cognard systems, either immediately post-treatment or at follow-up.

Discussion

The natural history of cranial DAVF is highly variable. Conventional angiography remains the gold standard for detection and classification of DAVFs [6]. Although several classification systems have been developed to grade the risks of DAVFs, those devised by Cognard et al. and Borden et al. are the most widely used [7,8]. Retrograde leptomeningeal venous drainage, variceal or aneurysmal venous dilations and galenic drainage correlate significantly with an aggressive neurologic presentation [9]. Therapeutic armamentarium for management of DAVFs includes conservative treatment, endovascular procedures, surgical treatment and radiation therapy. In view of the likelihood of an aggressive neurologic course, expectant therapy alone is rarely recommended [10]. DAVFs have been effectively treated by endovascular occlusion and/or surgical intervention. Regarding the endovascular treatment, TVE is preferred to TAE due to higher clinical and anatomical cure rates. In TVE, complete occlusion rate was reported in 80%–100% of cases [11], and incidence of complication was lower than TAE [12].

Though TVE by using coils has proved to be a reliable, effective and durable treatment for obliteration of DAVFs [13], there have been reports of up to a 44% rate of persistent cranial nerve deficits with disturbances of oculomotor and visual functions in cavernous sinus DAVFs [14]. This may be explained by the underlying fistula size itself and/or the space-occupying effect of the coils on cranial nerves running through the cavernous sinus. A disadvantage of coil embolization in the multi-compartmental space of the cavernous sinus is the duration of the intervention with long fluoroscopy times (procedures lasting several hours), the high costs for multiple coil implants and many DSA runs to control the degree of occlusion and the type of venous drainage [15]. The length of intervention and number of coils can be reduced by additional use of *n*-butyl-2-cyanoacrylate (n-BCA) or Onyx (ev3, Irvine, CA) [16,17]. However, liquid embolic agents are less controllable than coils and have an additional and permanent space-occupying effect on the cranial nerves. Faster occlusion may also be possible with the use of fibered or hydrogel-coated coils. Fibered coils increase thrombosis, which may extend into draining veins and become a source of complications.

TAE with n-BCA has been applied to complex DAVFs that are not accessible with percutaneous TVE catheterization. Although results are relatively good, TAE with n-BCA requires experience in using this material, and some authors have reported a 5%–20% complication rate [5,18]. In our series, seven patients were treated via TVE route alone, thirteen patients via the TAE route and twelve by combined TAE and TVE routes. No statistically significant difference was recognized in our series regarding duration of post-embolization hospitalization, clinical outcome or radiographic recurrence (both immediately post-treatment and at follow-up) according to the route used (TAE vs TVE). Deep-seated DAVFs involving the tentorium and posterior fossa, more often than not, do not drain directly into a venous sinus. They frequently feature leptomeningeal venous drainage, which often precludes embolization through the TVE route. TAE embolization alone is rarely successful because of too many small feeding arteries and the risk of infarction by occlusion of normal vessels [10,19]. In our series, multi sessions consisted of TVE, TAE and direct surgery were needed for tentorial DAVFs and the complication rate was higher than other locations.

In this study, our survey was especially focused on the change of radiographic features in the follow-up period after treatment. There was no recurrence in cases that complete occlusion had been achieved with the treatment. Even in cases of incomplete occlusion, there was no aggravation of shunt flow, and interestingly almost half of this group had complete spontaneous occlusion in the follow up period. Although localization of DAVF does not seem to correlate with the probability of radiographic recurrence over a long period of follow-up time in our series, tentorial DAVFs had statistically significantly higher rate of immediate post-treatment persistence. These results are in accordance with the fact that three of our four patients with tentorial DAVFs were treated in more than one sessions and via both routes (TAE & TVE). Moreover, men had a significantly higher chance of immediate post-treatment DAVF persistence and follow-up radiographic recurrence compared to women, possibly due to the different localization of DAVFs among males and females (tentorial DAVFs observed mostly in men).

Conclusions

In this study, there was no DAVF recurrence in the follow up period (mean: 33 months, range: 1-108 months) after complete occlusion with the endovascular treatment. Even in cases of incomplete occlusion, there was no aggravation of shunt flow and spontaneous complete occlusion was confirmed in almost 50% in the follow-up period.

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