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Case study

Embolization of cranial dural arteriovenous fistulas in the liquid embolic era: A Sydney experience

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ABSTRACT

Endovascular management of dural arteriovenous fistulas has become a mainstay of treatment. In particular, modern techniques have allowed greater fistula penetration and likelihood of complete obliteration. However, the efficacy of newer agents has not been quantified outside of predominantly small case reports and case series. Furthermore, the Australian experience with fistula embolization has yet to be reported in the literature. To this aim, we performed a retrospective review of our endovascular management of a large cohort of cranial dural arteriovenous fistulas in the liquid embolic era. This retrospective case series included ninety-six consecutive patients of any Cognard grade, treated between 2005 and 2016. Liquid embolic agents were used exclusively in eighty-three cases. The overall complete obliteration rate was 89.6% with a residual fistula rate of 2%, and complication rate of 8.3%. This Sydney, Australia cohort demonstrates excellent treatment effect and safety outcomes and thus supports the primary treatment of this condition by endovascular means.

1. Introduction

Dural arteriovenous fistulae (dAVF) are vascular malformations, which represent 10–15% of all intracranial arteriovenous malformations (AVMs). These acquired malformations are abnormal arteriovenous connections that lie within the dura. Clinical presentation varies from asymptomatic or minimally symptomatic, to sequelae of devastating intracranial haemorrhage, which are generally associated with high-grade lesions with pressurization of cortical veins. Two grading systems, that of Cognard, and Borden, are currently in use and categorize the fistula based on its venous drainage pattern.

Currently the three main modalities of treatment include surgery, endovascular treatment, and radiosurgery, in isolation or combination. Although now commonly used, large case series and long term data regarding the use of liquid embolic agents in neurointerventional treatment of cranial dAVFs is not well represented in the literature. We propose that this is one of the largest case series to date evaluating the use of liquid embolic agents for the management of these uncommon, but often complex lesions.

2. Materials and methods

2.1. Patient population

A retrospective analysis of a prospectively collected database of patients who were treated in one of three major tertiary referral hospitals between March 2005 and 2016 was performed. Consecutive patients whom underwent endovascular treatment for cranial dAVFs were included, without age discrimination, or exclusion based on fistula location or presentation. Patients who had failed surgical treatment, or required other therapeutic options were also included.

2.2. Endovascular procedure

All procedures were performed in a uniplane or biplane angiographic suite (Allura Xper FD20/Allura Xper FD20/20, Philips Healthcare, Best, Netherlands, Artis Zee Biplane, Seimens Healthcare, Erlangen, Germany) under general anaesthesia. Patients were not routinely systemically heparinized. Depending on operator preference, transarterial or transvenous access was obtained to

Abbreviations: dAVF/s, dural arteriovenous fistula/s; TV, transvenous; TA, transarterial; TO, transorbital.

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the fistula, with arterial or venous balloon occlusion as desired. The preferred transarterial access pedicle was chosen on the likelihood of achieving a final position as close to the fistula point as possible, whilst avoiding critical vascular territories and minimizing likelihood of embolization of non-target territories. Minimisation of cranial nerve injury was pursued by careful consideration of the vascular anatomy of the transarterial access pedicle prior to embolization, and minimisation of unwanted embolysate reflux. A double-lumen balloon catheter was used for transarterial embolization wherever possible as this improved the ability to minimise retrograde reflux and improved the confidence of antegrade flow of embolysate. Temporary transvenous balloon occlusion was utilised to protect the patency of a venous sinus when it was felt loss of embolysate into a dural sinus was likely, especially if it was shared for brain parenchymal drainage.

Liquid embolics used include Onyx-18 and Onyx-34 (ethylene vinyl alcohol dissolved in DMSO, Medtronic, Irvine, CA, USA), PHIL (Hydroxyethyl methacrylate dissolved in DMSO, Precipitating Hydrophobic Injectable Liquid, Microvention Terumo, Tustin, CA, USA) 25%, 30% and 35%, SQUID (ethylene vinyl alcohol copolymer dissolved in DMSO, Emboflu, Gland, Switzerland) and Histoacryl (n-BCA; B Braun Surgical, Rubi, Spain) combined with Lipiodol Ultra-Fluid (Guerbet, Aulnay-sous-Bois, France). Immediate post treatment angiographic results were classified as angiographic cure, or residual fistula.

2.3. Follow-up

Follow-up scheduling was at the discretion of the operator and or referring specialist. All patients had clinical follow-up scheduled at the approximate 3 month post procedure mark. There was often, but not always a view to repeat cerebral imaging within twelve months post embolization depending on the individual fistula, the complexity of the procedure and patient factors. This was adhered to more toward the end of the recruitment period, when practise protocols were better established.

2.4. Data collection

Information regarding each case was collated from review of patient medical records, radiological imaging and clinical correspondence. Demographics obtained included age at treatment, sex, and presenting symptoms. Pertaining to the fistula itself, we used the Cognard classification, as well as the anatomical location of the fistula, specifically the Lawton classification for tentorial dAVFs. The modified Rankin score (mRS) was recorded for patients immediately prior to discharge and included in our analysis.

3. Results

3.1. Demographics

96 patients with endovascularly managed cranial dAVFs were included ranging from 1 to 91 years of age. Excluding the single paediatric outlier, the age range was 25–91, with a mean age of 61 years, and a median age of 64 years. There were 55 males and 41 females included. The most frequent grade in our cohort was IIA + B, comprising 30% of patients. 'Aggressive' fistulas, that is those with leptomeningeal venous drainage, comprised 76% of cases (Table 1).

The most common presenting complaint was proptosis, chemosis or other visual disturbance. Table 2 demonstrates the breakdown of presenting symptomatology. The most common fistula location in our series was in the cavernous sinus (27 patients), followed by the transverse or sigmoid sinus (26 patients), then the superior sagittal sinus (10 patients) (Table 3).

Table 1
Patient and dAVF demographics.

Characteristic	Number of Patients (%)
Age	
Mean	61
Median	63
(range)	(1–91)
Sex	
Male	55 (57%)
Female	41 (43%)
Cognard Grade	
I	11
IIA	12
IIB	1
IIA + B	29
III	19
IV	21
V	3

Table 2
Patient presenting complaints.

Symptom	Number of Patients
Proptosis, chemosis or other visual disturbance	27
Pulsatile tinnitus	26
Haemorrhage	17
Parenchymal	13
Subarachnoid	2
Brainstem	1
Intraventricular	1
Headache	7
Asymptomatic	6
Seizure	4
Myelopathy	3
Altered level of consciousness	3
Neuralgia	1
Retroauricular mass	1
Weakness of extremity	1

Table 3
Fistula topography.

Location	Number of Patients
CS	27
TS or SS	26
SSS	10
Convexity	9
Posterior Fossa/Tentorium	21
Galenic	*1*
Straight Sinus	*3*
Torcula	*4*
Tentorial Sinus	*9*
Superior Petrosal Sinus	*4*
Incisural	–
Cribriform	2
Other	1

3.2. Transvascular approach and embolic agent

Transarterial (TA) approaches were the most common (61 patients) with transvenous (TV) approaches in isolation used in only 10 patients. 10 patients had a combination of approaches (Table 4). The majority of TA approaches utilised a single vascular pedicle, and the majority of cases required only one angiographic session. Non-adhesive liquid embolic agents were used as the main embolysate in 83 cases (86%), of which Onyx was the main agent (78%). PHIL and SQUID were the alternatives in 15 and 3 cases respectively. Histoacryl, referred to as an adhesive liquid embolic

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