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Clinical Study

Radiographic and clinical outcomes in cavernous carotid fistula with special focus on alternative transvenous access techniques

Ryan P. Morton [a,*], Farzana Tariq [a], Michael R. Levitt [a], John D. Nerva [a], Mahmud Mossa-Basha [b], Laligam N. Sekhar [a], Louis J. Kim [a,b], Danial K. Hallam [a,b], Basavaraj V. Ghodke [a,b]

[a] Department of Neurological Surgery, University of Washington at Harborview Medical Center, Box 359766, 325 9th Avenue, Seattle, WA 98104, USA
[b] Department of Radiology, University of Washington at Harborview Medical Center, Seattle, WA, USA

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ABSTRACT

Carotid cavernous fistulae (CCF) are dangerous entities that may cause progressive cranial neuropathy, headache and blindness. Endovascular therapy for CCF is the treatment of choice and can be accomplished with minimal morbidity, but optimal treatment strategies vary according to CCF anatomy. We aimed to define a tailored endovascular treatment algorithm for CCF with a focus on traditional and aberrant venous anatomy. Retrospective cohort analysis of data for 57 patients (age range, 18–90 years, mean 53 years) with CCF (35 direct, 22 indirect) was performed. Treatment was transarterial (n = 31), transvenous (n = 18), combined (n = 2), or observation (n = 6). Non-conventional transvenous access (that is, via the facial vein, pterygoid plexus, or via direct puncture of the inferior ophthalmic or frontal vein) was employed in five patients. Mean follow-up period was 12 months. Radiographic cure rate in treated CCF was 96%. Forty-five patients presented with ophthalmic symptoms (chemosis, proptosis, eye pain); all resolved within 6 weeks of successful treatment. Forty-three patients presented with cranial nerve III, IV and/or VI palsy; complete recovery was seen in 54% and partial recovery in 18%. Five patients presented with blindness and five with declining visual acuity. No patient with blindness regained sight after treatment, but all five patients with declining vision recovered some visual acuity. The complication rate was 10.6% (one transient abducens nerve palsy, two symptomatic cerebral infarctions, and three groin hematomas). The permanent complication rate was 3.5%. Multimodal treatment of CCF, including non-traditional routes of transvenous access, results in excellent outcomes and low morbidity.

1. Introduction

Carotid cavernous fistulae (CCF) are abnormal arteriovenous connections between the carotid artery (internal [ICA], external [ECA], or both) and the cavernous sinus. CCF can be classified on the basis of hemodynamics (high-flow *versus* low-flow), etiology (spontaneous *versus* traumatic), or anatomy (ICA *versus* ECA feeding vessels) [1]. The severity and acuity of CCF clinical presentation is related to the type and degree of flow between the arterial and venous circulations, with high-flow/direct fistulae (dCCF) presenting more severely than low-flow/indirect fistuale (iCCF). Endovascular treatment strategies (transarterial, transvenous, or other) must be tailored to individual CCF anatomy to maximize the potential for angiographic cure and resolution of symptoms. Occasionally, non-traditional transvenous routes must be employed to achieve access and treat CCF.

Here we present our radiographic results and clinical outcomes, with a sharp focus on and discussion of alternative transvenous access and technique.

2. Methods

This study was approved by the relevant Institutional Review Board. We retrospectively examined all cerebral angiograms at an academic tertiary referral center between January 2000 and July 2012 to identify a cohort of patients with CCF. Relevant demographic, clinical and radiographic data were recorded, and immediate and 1 year outcome data were assessed.

All endovascular procedures were performed under general anesthesia in a biplane angiographic suite with three-dimensional rotational angiographic capability (Philips Medical Systems, Best, The Netherlands). Bifemoral access was obtained with 6-French

* Corresponding author. Tel.: +1 206 744 9330; fax: +1 206 744 9944.
E-mail address: rymorton@uw.edu (R.P. Morton).

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sheaths in the common femoral artery on the right side and (in the case of anticipated transvenous treatment) the femoral vein on the left. Selective diagnostic angiography of the ICA, ECA and vertebral arteries was obtained. The treatment strategy including route (transarterial, transvenous, or other) and embolic material selection were made on the basis of fistula type and individual patient anatomy. All patients were heparinized with a targeted activated clotting time of 2–3 times that of normal throughout the case. After intervention, femoral artery access was removed either with a vascular closure device (Angioseal; St. Jude Medical, St Paul, MN, USA) or manual pressure, either immediately after heparin reversal or 12–24 hours post-procedure. Patients underwent non-contrast head CT scan and were observed in the intensive care unit with hourly neurological examinations for at least 24 hours.

3. Results

3.1. Demographics

Fifty-seven patients with CCF were evaluated during the 12.5 year study period. The male to female ratio was 1.5:1, with a mean age of 53 years (range 18–90 years). Thirty-five (61%) fistulae were dCCF (Barrow type A) and 22 (39%) were iCCF (four type B, nine type C and nine type D). The etiology of the CCF is displayed in Table 1. The majority of dCCF were the result of trauma, while most iCCF were spontaneous.

3.2. Treatment approach

Table 2 displays our treatment approach for each type of CCF. Transarterial treatment was the method of choice for most dCCF. None were treated using direct percutaneous puncture, and four received observation only. In cases of iCCF, the transvenous approach was most common; five of 22 patients were treated via non-traditional transvenous routes. Of the four iCCF treated via the transarterial route, all had dilated ECA feeders amenable to direct catheterization. Of the 51 treated patients, coil embolization alone was performed in 36 (70%); detachable balloon occlusion in nine (17.5%); with one case each of stent-assisted coil embolization, n-butyl-2-cyanoacrylate (n-BCA) liquid embolization, and Onyx (ev3 Endovascular, Plymouth, MN, USA) embolization; and a combination of Onyx and coil embolization in three cases.

3.3. Radiographic outcome

The radiographic cure rate was 96% (49 of 51 treated patients). Immediate radiographic cure after a single treatment session was achieved in 43 patients (84%). The mean follow-up period was 12 months. Five patients (one dCCF and four iCCF) with small and sluggish residual filling after a single treatment session had complete spontaneous angiographic cure at 3 month follow-up on CT angiography or angiogram. One iCCF patient required three treatment sessions before radiographic cure was achieved. Of the two persistent cases, one patient with a partially-treated dCCF died of severe penetrating systemic injuries prior to additional treatment attempts, and one iCCF patient's small residual fistula was asymptomatic and unchanged on 1 year follow-up angiography. Among the six untreated cases (four dCCF and two iCCF), four spontaneously thrombosed on 3 month follow-up angiography, one patient died of systemic trauma shortly after admission and one was lost to follow-up.

Table 1
Etiology of direct (n = 35) and indirect (n = 22) carotid cavernous fistulae.

Etiology	dCCF n (%)	iCCF n (%)
Blunt trauma	19 (54.3)	2 (9.1)
Penetrating trauma	6 (17.1)	2 (9.1)
Spontaneous	10 (28.5)	18 (81.8)

dCCF = direct carotid cavernous fistulae, iCCF = indirect carotid cavernous fistulae.

Table 2
Treatment approach to direct (n = 35) and indirect (n = 22) carotid cavernous fistulae.

Endovascular approach	dCCF n (%)	iCCF n (%)	Total n (%)
Transarterial only	27 (77.1)	4 (18.2)	31 (54.4)
Transvenous only	2 (5.7)	16 (72.7)	18 (31.6)
Non-traditional route	0 (0)	5 (22.7)	5 (8.8)
Combined transarterial/transvenous	2 (5.7)	0 (0)	2 (3.5)
Observation	4 (11.4)	2 (9.1)	6 (10.5)

dCCF = direct carotid cavernous fistulae, iCCF = indirect carotid cavernous fistulae.

3.4. Clinical outcome

Forty-five (79%) patients presented with ophthalmic symptoms of chemosis, proptosis and eye pain. All symptoms resolved within 6 weeks of successful treatment. Forty-three (75%) patients presented with cranial nerve III, IV and/or VI palsy. After treatment, cranial neuropathy resolved completely in 54% and partially in 18% of patients. Twelve patients (28%) had persistent deficit. Ten patients presented with visual decline (five with monocular blindness and five with decreased visual acuity). No patient with complete vision loss improved despite radiographic cure, while all patients with partial vision loss recovered, albeit incompletely.

3.5. Complications

The overall procedure-related complication rate was 10.6%, with a permanent complication rate of 3.5%. One patient (1.8%) with a dCCF developed a new abducens nerve palsy after endovascular coil embolization. Oral glucocorticoids were administered for 2 weeks, with complete resolution 4 weeks later. Groin hematoma not requiring further intervention was reported three patients (5.3%). Two patients (3.5%) suffered symptomatic cerebral infarction (one after detachable balloon occlusion and one after coil embolization of dCCF). Both patients had recovered at 3 months and were living independently.

4. Discussion

Our series highlights the advantages of tailored multimodal endovascular treatment of CCF, including a high radiographic cure rate (96%) and low permanent complication rate (3.5%), similar to or better than other contemporary series [2,3]. Clinical improvement was seen in the majority of patients with the exception of monocular blindness, which did not improve despite radiographic cure. Tailored treatment strategies are required based on the anatomic and physiologic particulars of CCF.

4.1. Transarterial approach

The transarterial approach is ideal for most dCCF, with coils as the embolic material of choice. In these cases, the delineation of a single, high-flow fistulous connection (typically aided by three-dimensional rotational angiography) is critical for success. Notably, we typically deployed coils with the assistance of a Hyperform or Hyperglide balloon (ev3 Endovascular) to prevent coil herniation into the ICA lumen. The transarterial approach to dCCF has been reported by others [4–8], with most using detachable balloons before March 2004 and coils thereafter when detachable balloons