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Transvenous embolization of cavernous sinus dural arteriovenous fistulas using detachable coils and Glubran 2 acrylic glue via the inferior petrosal sinus approach

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Abstract *Objectives:* To describe the technique, efficacy, and safety of transvenous embolisation (TVE) of cavernous sinus arteriovenous fistulas (CSDAVFs) via the inferior petrosal sinus (IPS) with detachable coils and acrylic glue. *Methods:* Spontaneous unilateral CSDAVFs were confirmed by cerebral angiography in eight patients, with angiographic patency of the ipsilateral IPS in three and angiographic non-visualisation of the ipsilateral IPS in five. There were two patients with complete occlusion of the ipsilateral internal jugular vein (IJV). TVE with detachable coils and acrylic glue were performed through a femoral vein and an IPS approach. *Results:* TVE via ipsilateral IPS was successfully performed in all eight patients in our group. The number of detachable coils for each patient ranged from 2 to 8 (mean, 5.0). Angiography immediately after TVE showed complete occlusion of the CSCAVFs in seven patients and nearly complete occlusion in one. Complete recovery of clinical symptoms was achieved in all eight patients. No recurrence of clinical symptoms was observed at follow-up. *Conclusions:* Transvenous embolisation via an IPS approach is a highly efficient and safe treatment for CSDAVFs. Embolisation with a combination of coils and acrylic glue may help to achieve complete occlusion of fistulas with fewer coils.

Keywords Cavernous sinus · Dural arteriovenous fistulas · Radiology · Interventional · Embolization · Therapeutic · Glubran 2

Introduction

Cavernous sinus arteriovenous fistulas (CSDAVFs) are abnormal communications between dural branches of the internal carotid, external carotid, or both arteries, and the cavernous sinus (CS). CSDAVFs, which are also called indirect or dural carotid cavernous sinus fistulas, usually occur spontaneously in elderly women, but may present in other age and sex groups [1–4]. It is suggested that CSDAVFs are associated with various aetiological factors, which include venous outflow obstruction, trauma, pregnancy, previous surgery, sinusitis, or CS thrombosis.

The clinical presentation of CSDAVFs depends on the location of the shunt, the amount of shunted blood flow, and the pattern of venous drainage. In general, the initial symptoms and signs are mild and not life-threatening, because the shunt is usually low flow and low pressure. Reversed blood flow in the superior ophthalmic vein (SOV) will result in various ophthalmic symptoms such as proptosis, chemosis, retro-orbital pain, elevated intraocular pressure (IOP), diplopia, blepharoptosis, and diminished visual acuity. Spontaneous regression may occur in some cases, and manual compression of the carotid artery has also been reported to be effective in some patients [3]. On the other hand, CSDAVFs may cause serious morbidity including blindness, intolerable diplopia, severe headache, venous infarction of the brain, and intracranial haemorrhage, especially when associated with retrograde cortical venous drainage [5, 6]. In those patients with intractable or progressive symptoms or in the

presence of retrograde cortical venous drainage, more aggressive therapy is necessary [7, 8].

Management mainly depends on the symptoms and the patterns of venous drainage. Endovascular therapy has been widely accepted as the primary option for CSDAVFs. The key point of success is to obtain access to the CS and to obliterate completely the CS or occlude the fistulas. Although transarterial therapy is an option, transvenous embolisation of CSDAVFs is the primary approach because of its safety, ease of access, and high possibility of permanent occlusion [2, 9–12]. Among the various available materials, platinum coils are most commonly used for transvenous embolisation [2, 9, 13]. However, embolisation with platinum coils alone may fail to achieve complete obliteration of the sinus or of the fistulas in some cases, with persistence of fistulas and recurrence of symptoms [10, 14]. In addition to the use of coils, detachable balloons and particles, and liquid embolics have been used to fill the CS and achieve complete occlusion of the fistulas because of their penetration, adhesion, and solidification mechanism through either polymerisation or precipitation principles. Among the existing liquid embolics, cyanoacrylate glues that undergo polymerisation in the presence of blood have been widely used in the treatment of vascular diseases. Glubran 2 (GEM Srl, Viareggio, Italy) is an acrylic glue bearing a CE mark authorised for surgical and endovascular use in neuroradiology. Glubran 2 is a cyanoacrylate-based synthetic glue modified by the addition of a monomer of metacryloxysulpholane (MS, owned by GEM Srl). The addition of MS to the basic monomer allows the *n*-butyl-2-cyanoacrylate (*n*-BCA) to polymerise with an exothermic reaction at around 45°C, and with a slightly longer polymerisation time than Histoacryl, thereby reducing the toxicity of the basic monomer.

The current study evaluated the technique, efficacy and safety of transvenous embolisation of CSDAVFs via an inferior petrosal sinus (IPS) approach using a combination of detachable coils and Glubran 2. To our knowledge, this is the first report indicating transvenous embolisation of CSDAVFs via an ipsilateral IPS approach in two patients with occluded ipsilateral internal jugular veins (IJV).

Patients and methods

From May 2006 to June 2009, eight patients with CSDAVFs were treated in our hospital by transvenous embolisation with a combination of detachable coils and Glubran 2 via an IPS approach. The average age of the patients was 55 years (range, 30–79 years). Unilateral CSDAVFs were confirmed in all eight patients by cerebral angiography, with angiographic patency of ipsilateral IPS in three patients and angiographic non-visualisation of ipsilateral IPS in five patients. There were two patients who also had complete occlusion of the ipsilateral IJV.

This retrospective study was approved by the Institutional Review Board of our hospital, and signed informed consent for therapy was obtained from all of the patients and their family members according to hospital guidelines.

The clinical symptoms and physical findings included various ophthalmic symptoms such as proptosis, chemosis, ophthalmoplegia, diplopia, blepharoptosis, retro-orbital pain, elevated IOP, diminished visual acuity, and bruit. None of the patients had venous infarction or intracranial haemorrhage according to MRI/CT. Patients' general information, symptoms, locations of the fistulas, and angiographic characteristics in each case are summarised in Table 1.

All patients had ophthalmological and neurological examinations before and 1 week after endovascular treatment. Enhanced CT/MR and CTA/MRA are routinely performed before therapy. Cerebral angiography, including bilateral selective injection of contrast agent into the external and internal carotid arteries and at least one vertebral artery, was performed in all patients before embolisation.

Transvenous embolisation via a femoral vein-inferior petrosal sinus (FV-IPS) approach was performed in all eight patients. One patient presented with a recurrence of CSDAVFs after transarterial embolisation, and another two patients had had failed attempts at transvenous embolisation via a femoral vein-facial vein-SOV because of tortuosity of the angular vein. The procedures were performed under local anaesthesia, occasionally combined with sedation for patients when necessary. A 4F Ver 135 catheter (Cordis, Miami, FL) was positioned in the ipsilateral common carotid artery for roadmap visualisation of the venous pathway and to permit angiographic evaluation of the occlusion of the fistula. Appropriate IV heparinisation was used to avoid thrombosis in the drainage vein. Another 4F Ver 135 catheter used as a guiding catheter, or a 6F ENVOY guiding catheter (Cordis), was placed into the internal jugular vein bulb segment. We prefer to use a 4F Ver 135 catheter as a guiding catheter because it has a smaller calibre, and because it is more easily inserted into the IPS with less injury to the vein. Through the catheter, a 0.035-inch Radifocus guidewire (Terumo, Tokyo, Japan) was gently advanced into the IPS, and then the catheter was navigated into the IPS. In three patients with angiographic non-visualisation of the IPS, access was obtained by using a drilling action with a 0.035-inch Radifocus guidewire followed by stepwise advancement of a 4F glide catheter into the CS. The position of contralateral IPS displayed in cerebral angiography used as a comparison may be helpful for catheterising the ipsilateral IPS. A Progreat microcatheter with a microwire (Terumo) was navigated coaxially to the cavernous sinus via the IPS. In two patients in whom there was difficulty advancing the guiding catheter into the IPS, we attempted to directly navigate the Progreat microcatheter with the microwire into the IPS. Finally, the microcatheter was further navigated into the anterior cave of the CS and reached the posterior segment of the SOV. Microplex detachable

Table 1 Summary of patients information, clinical symptoms, and angiographic signs

No.	Age (years)/sex	Fistulas location	Clinical symptoms and signs	Brain angiography		
				Feeding artery origin	Main drainage vein	Non-visualisation of ipsilateral IJV
1	43/F	Left	Proptosis, chemosis	Ipsiateral ECA and ICA	SOV, IOV, IPS	NO
2	39/F	Right	Right headache and retro-orbital pain, proptosis, chemosis, bruit	Ipsilateral ECA and ICA	SOV, IOV, SPS	NO
3	66/M	Left	Retro-orbital pain, proptosis, chemosis, blepharoptosis ophthalmoplegia, diplopia, diminished visual acuity	Bilateral ICA and ipsilateral ECA	SOV, IOV, IPS	Yes
4	79/F	Right	Retro-orbital pain, proptosis, chemosis, diplopia, ophthalmoplegia and IOP	Ipsilateral ICA	SOV, IS, CV	Yes
5	55/F	Right	Retro-orbital pain, proptosis, chemosis, diplopia, ophthalmoplegia	Bilateral ICA and ipsilateral ECA	SOV, and CV	NO
6	59/F	Left	Headache, proptosis, chemosis, diplopia, ophthalmoplegia, diminished visual acuity, and IOP	Bilateral ICA	SOV, IPS	NO
7	71/F	Right	Right headache and retro-orbital pain, proptosis, chemosis, ophthalmoplegia, diplopia, and diminished visual acuity	Ipsilateral ICA and ECA	SOV, IOV	NO
8	30/M	Left	Right retro-orbital pain, proptosis, chemosis, diminished visual acuity, and IOP	Ipsilateral ICA and ECA	SOV, IOV	NO

Note: Superior ophthalmic vein (SOV), inferior ophthalmic vein (IOV), superior petrosal sinus (SPS), inferior petrosal sinus (IPS), intercavernous sinuses (IS), facial vein (FV), cortical venous (CV), internal jugular vein (IJV), elevated intraocular pressure (IOP), external carotid artery (ICA), internal carotid artery (ICA)

coils (MicroVention, Aliso Viejo, CA) were then deployed through the microcatheter to obstruct the posterior segment of the superior ophthalmic vein and to pack the cavernous sinus. In some instances it was difficult for the microcatheter to reach the inferior cava and ophthalmic vein because of the presence of cribriform foramina in the CS. A guide microwire such as Progreat microwire (Terumo) may make it much easier to pass through cribriform foramina and to reach the anterior cave of the CS and ophthalmic vein.

In order to completely pack the pathological CS and occlude the fistula, an additional infusion of Glubran 2 (GEM Srl, Viareggio, Italy) through the microcatheter was performed. The washout velocity of contrast material within the CS as seen on the transarterial angiogram or the venogram helped to prepare the appropriate Glubran 2/Ethiodol mixture for embolisation. The Glubran 2/Ethiodol mixture was varied according to the flow rate and anticipated needs in polymerisation times (31–33). Concentrations used included the following: 1:1, 1:2, and 1:3 (Glubran 2:Ethiodol, v/v). After rinsing the microcatheter with glucose solution to remove the saline flush solutions and blood, the Glubran mixture was slowly injected through the microcatheter in a continuous column monitored by fluoroscopy and guided by roadmap through the vein. During the injection, the microcatheter was gently withdrawn to prevent pressure build-up in the microcatheter and adhesion of the tip of the microcatheter. Intermittent angiography through the ipsilateral carotid artery was performed when the Glubran 2 infusion was briefly suspended to confirm progressive occlusion of the fistula. The infusion was stopped and the microcatheter removed when absolute occlusion of the sinus was achieved.

In two patients with an occlusion of the ipsilateral internal jugular vein (IJV), a 4F catheter with a guidewire was navigated through a transfemoral venous access into the contralateral IJV. The catheter reached the ipsilateral internal jugular vein through the sigmoid sinus, the transverse sinus and the confluens sinuum, respectively. After reaching the proximal segment of the ipsilateral internal jugular vein, we exchanged a long 0.035-inch Radifocus guidewire M (Terumo), passed it through the occluded segment of the ipsilateral IJV, and then to the femoral vein. Next, the long wire was pulled out using the snare technique, and a 6F guide catheter was successfully navigated into the ipsilateral IJV over this long wire. Subsequent transvenous embolisation via the ipsilateral IPS was successfully performed through the ipsilateral IJV access in these two patients (Figs. 1, 2).

The angiographic degrees of occlusion were defined as: (1) complete occlusion of the shunt, (2) nearly complete occlusion as a small residual stagnant shunt with occlusion of the SOV and cavernous sinus, (3) incomplete occlusion as shunt reduction less than 80%, and (4) failed attempt as residual filling of the SOV, deep venous system, or cortical vein. Complete and nearly complete occlusions were considered successful angiographic results.

Clinical improvement was defined as cure or improvement of the symptoms related to the lesion. No improvement was defined as no change or aggravation of symptoms, and recurrence was defined as newly developed symptoms related to the lesion during follow-up.

The patients were followed up by clinical evaluations from 6 months to 3 years with an average interval of 21 months. Additional imaging studies such as brain CT or MRI were performed during the follow-up period in

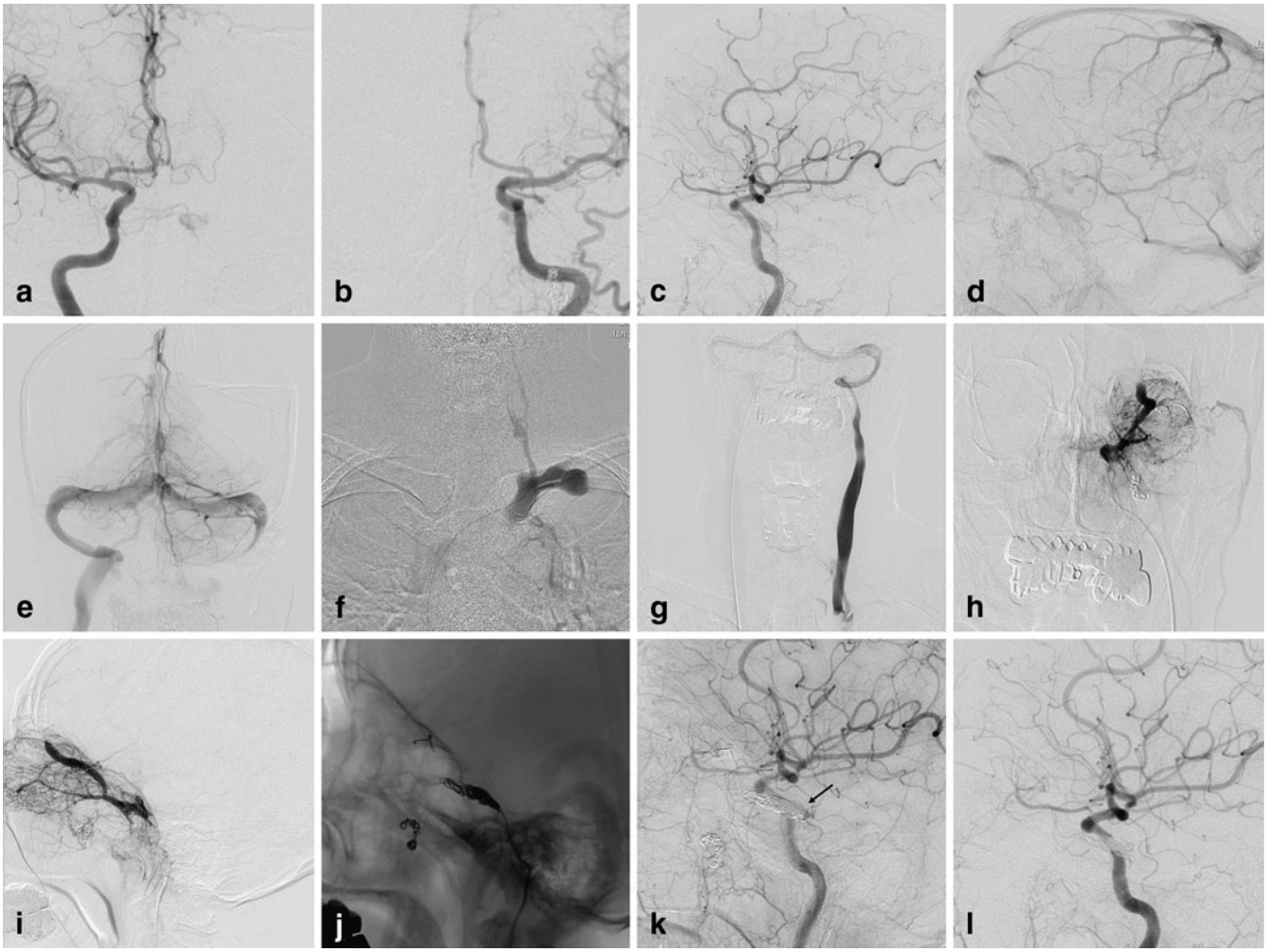

Fig. 1 Patient no. 3, left CSDAVFs with occlusion of the ipsilateral IJV. Symptoms recurred and were aggravated 3 months after transarterial embolisation of the feeding arterial branches from left ECA. **a-d** Angiography reveals the residual fistulas with feeding arterial branches originating from the bilateral ICAs. The main drainage veins include the ipsilateral SOV, IOV and IPS. **e-f** Angiography shows occlusion of the ipsilateral IJV. **g** Venography in the occluded left internal jugular vein after a 4F catheter with a long wire was navigated sequentially through the contralateral IJV, sigmoid sinus, transverse sinus and confluens sinuum, and finally reached the ipsilateral IJV. **h**, **i** After a long exchangeable wire passed through the occlusive segment of the ipsilateral IJV and was pulled out the femoral vein, a 4F catheter was successfully retrogradely navigated into the ipsilateral IJV over this long wire. Subsequently, a microcatheter was successfully drilled into the ipsilateral cavernous sinus. Angiography through the microcatheter reveals the dilated venous drainage, SOV and IOV. **j**, **k** Ipsilateral carotid arteriography reveals the residue of the fistulas (↙) after transvenous embolisation of the CS with coils. **l** After an additional injection of Glubran 2 through the microcatheter, ipsilateral carotid arteriography reveals complete occlusion of the cavernous sinus

patients with complicated CSDAVFs. Angiographic re-evaluation was performed in one patient with suspected recurrent CSDAVFs.

Results

Transvenous embolisation via ipsilateral IPS was successfully performed in all eight patients in our group, regardless of angiographic patency or non-visualisation of the ipsilateral IPS and occlusion of the ipsilateral internal jugular vein. For the first patients with occlusion of the ipsilateral internal jugular vein, it took us 195 min to find and catheterise through the IPS to CS. However, with the experience of success and increasing knowledge of the anatomical structure of the IPS, the mean duration of transvenous approaches in the subsequent six patients was 65 min, ranging from 45 to 110 min. A total of 40 MicroPlex detachable coils were used for transvenous embolisation through the microcatheter in eight patients. The number of detachable coils for each embolisation ranged from 2 to 8 (mean, 5.0). The volume of Glubran 2 used for embolisation mainly depended on the residual space of the dilated cavernous sinus after embolisation with coils and usually was no more than 1 ml. Equivalently, the total volume of mixture of Glubran and

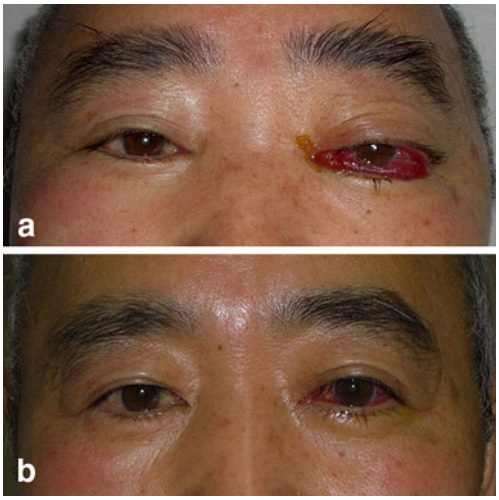

Fig. 2 **a**,**b**: Patient no. 3, photo before and 3 days after embolisation. The symptoms of left proptosis, chemosis and conjunctival congestion have disappeared

Ethiodol (1 :3, V/V) usually was no more than 4 ml. The duration of Glubran injection ranged from 20 s to 90 s.

Angiography immediately after transvenous embolisation showed a complete occlusion of fistulas in seven patients and nearly complete occlusion in one patient. Complete recovery (CR) of clinical symptoms was achieved in all patients, and no recurrence or aggravation of related symptoms was observed (Table 2).

The ocular pressure-related ophthalmic symptoms and signs such as proptosis, chemosis, retro-orbital pain, elevated IOP, and bruit were usually relieved immediately and eliminated 1 week after the transvenous embolisation. However, symptoms related to cranial nerve palsy such as visual acuity, blepharoptosis ophthalmoplegia, and diplopia improved slowly from 1 month to 3 months. There was transient aggravation of ocular symptoms and signs in one patient after embolisation (Figs. 3, 4), but the symptoms improved on the 3rd day after embolisation probably because of progressive thrombosis of the SOV, the cavernous sinuses, and their tributaries.

No symptomatic complications were observed in the patients. A few droplets of Glubran 2 drifted though the drainage vein and reached the lung in two patients, but there were no complaints of chest pain, chest distress, or shortness of breath. Oxygen saturation remained normal.

Discussion

Cavernous sinus arteriovenous fistulas (CSDAVFs) are abnormal communications between dural branches of the internal and/or external carotid arteries and the cavernous sinus. They differ from direct carotid cavernous sinus fistulas (CCF), which are usually due to trauma and are direct shunts between the internal carotid artery and cavernous sinus. CSDAVFs most commonly occur spontaneously in elderly women and are usually tiny shunts between dural branches of the internal and/or external carotid arteries and the cavernous sinus. Symptoms and signs of CSDAVF are often fewer and less severe than those of direct CCFs. The main clinical presentations of CSDAVFs include proptosis, chemosis, ophthalmoplegia, retro-orbital pain, elevated intraocular pressure (IOP), and diminished visual acuity, which are easily confused with other exophthalmia and ophthalmic symptoms due to endocrine, inflammatory, and infectious aetiologies. Imaging characteristics are very important for the diagnosis. Contrast agent concentration earlier in the arterial phase in the pathological cavernous sinus and distended SOV or other drainage veins observed in CT/CTA and MRI/MRA may imply the presence of CSDAVFs. The gold standard for the diagnosis is carotid angiography, which can reveal not only the fistulas, but also the cavernous sinus morphology, the feeding arterial branches, dilated drainage vein, and abnormally reversed venous blood flow.

An incidence of spontaneous regression of 10%-73% has been reported [15, 16]. Manual compression of the carotid artery has been reported to be effective in some patients [3, 17], but it may carry a risk of cerebral ischaemia and aggravation of symptoms in the event of incorrect compression of the internal jugular vein. On the other hand, CSDAVF may cause serious complications including blindness, seizures, stroke, and intracranial haemorrhage, especially when associated with retrograde cortical venous drainage [7–9]. In those patients with intractable or progressive symptoms or in the presence of retrograde cortical venous drainage, more aggressive therapy is needed.

Endovascular treatment has been commonly accepted to be the primary option for CSDAVFs. The key point of success is to gain access to the CS and completely obliterate the sinus or a segment that represents the venous outflow of the fistulas. CSDAVFs are usually low-flow fistulas, and the feeding dural artery branches are usually tiny, making impractical attempts at transarterial treatment using detachable balloons or coils. On the other hand, transarterial embolisation of the feeding arterial branches from ECA and ICA with polyvinyl alcohol (PVA) particles or injectable coils has a high rate of recanalisation and carries a high risk of cerebral infarction caused by non-target embolisation.

Transvenous embolisation for traumatic CCFs through an SOV approach was first reported by Uflacker et al. in 1986 [18]. In 1989, Halbach et al. reported a transvenous embolisation of CSDAVFs through the inferior petrosal sinus or basilar plexus [13]. With the improvement of materials and catheterisation technique, the rate of successful catheterisation of the CS lesion has significantly increased. Transvenous embolisation to occlude the CS and the fistulas has become the primary option because of its ease of access, higher clinical and anatomical cure rate, and a lower incidence of complications such as cerebral infarction caused by non-target embolisation.

Among all the available venous approaches, access through the inferior petrosal sinus (IPS) is the primary

Table 2 The approaches, materials, and results of transvenous embolisation

No.	Approaches	Embolisation materials	Angiography after embolisation		Symptoms
			Occlusion of Sinus	Fistulas	
1	Via IPS after failure via FV	6 MicroPlex coils+Glubran 2	Complete	Disappeared	CR
2	Via IPS after failure via FV	4 MicroPlex coils+Glubran 2	Complete	Disappeared	CR
3	Via IPS (recurrence after TAE)	5 MicroPlex coils+Glubran 2	Complete	Disappeared	CR
4	Via IPS	2 MicroPlex coils+Glubran 2	Near complete	Small residue	CR
5	Via IPS	2 MicroPlex coils+Glubran 2	Complete	Disappeared	CR
6	Via IPS	7 MicroPlex coils+Glubran 2	Complete	Disappeared	CR
7	Via IPS	8 MicroPlex coils+Glubran 2	Complete	Disappeared	CR
8	Via IPS	6 MicroPlex coils+Glubran 2	Complete	Disappeared	CR

Note: Inferior petrosal sinus (IPS), facial vein (FV), transcatheter arterial embolisation (TAE), complete recovery

option because of its ease, less invasion, and high success rate [13, 19–21], regardless of its angiographic patency or non-visualisation. Alternative venous approaches also include access through the superior ophthalmic vein (SOV) after surgical exposure [22–24] or direct puncture [25], and through the facial vein-SOV [2, 24, 26, 27]. Other less frequently used approaches, including the superior petrosal sinus [28], the frontal vein [29], direct

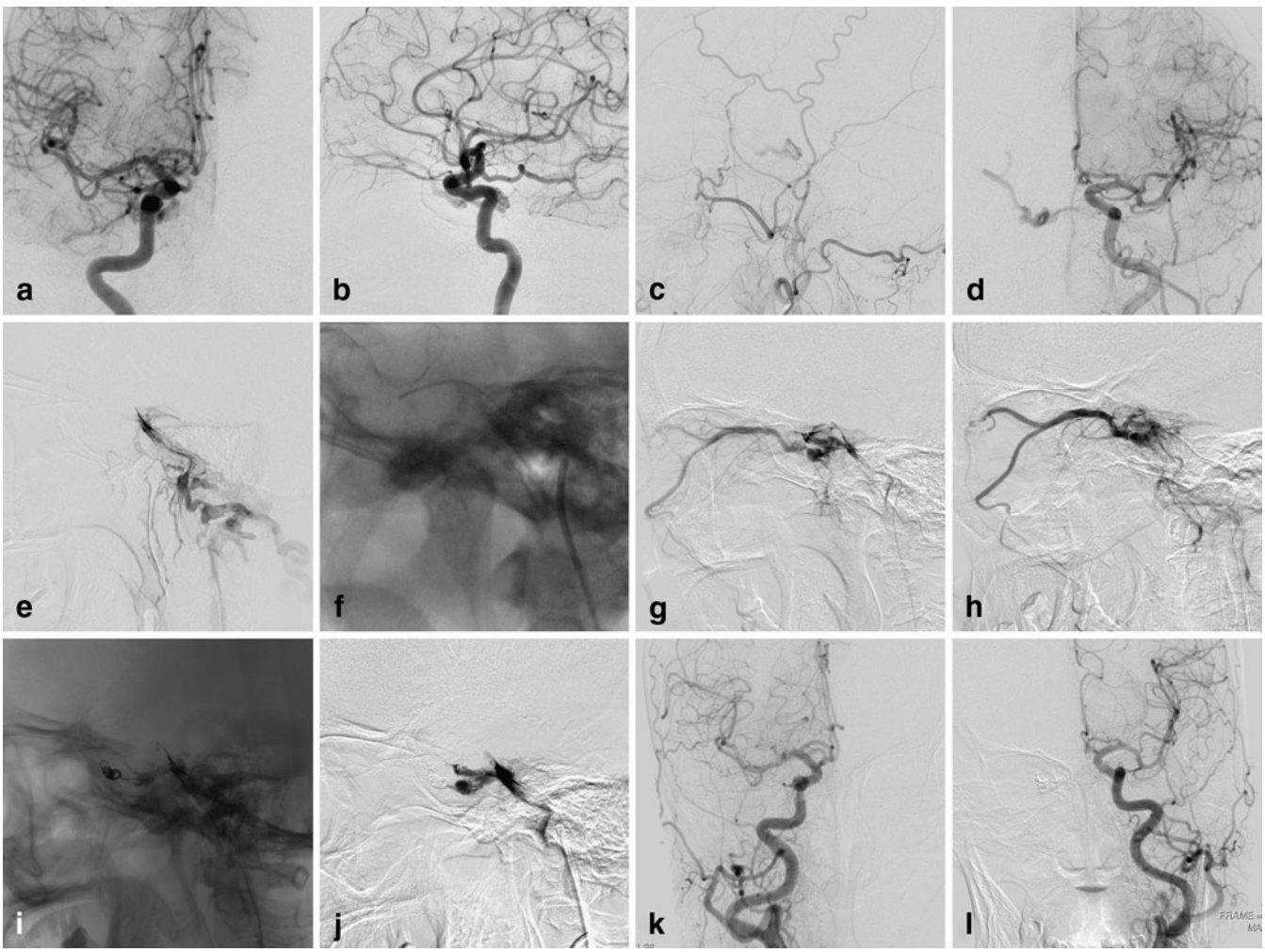

Fig. 3 Patient no. 5, right CSDAVFs with non-visualisation of the ipsilateral IPS. **a-d** Cerebral angiography reveals right CSDAVFs with feeding arterial branches originating from the bilateral ICAs and the ipsilateral ECA, non-visualisation of the ipsilateral IPS. The main drainage vein includes the ipsilateral SOV and IOV. **e-h** Lateral view. A 4F catheter drilled into the ipsilateral IPS, then a microcatheter was navigated into the CS and finally reached the anterior cave of CS and ophthalmic vein. Venography through the microcatheter shows the main drainage vein, SOV and IOV. **i**,**j** Venography through the microcatheter after embolisation with two coils deployed at the bifurcation of the ophthalmic vein reveals an irregular sinus with no filling of a dangerous drainage vein or reversal of flow into the ICA. **k**,**l** Cerebral angiography after an additional injection of Glubran 2 through the microcatheter shows complete occlusion of the fistulas

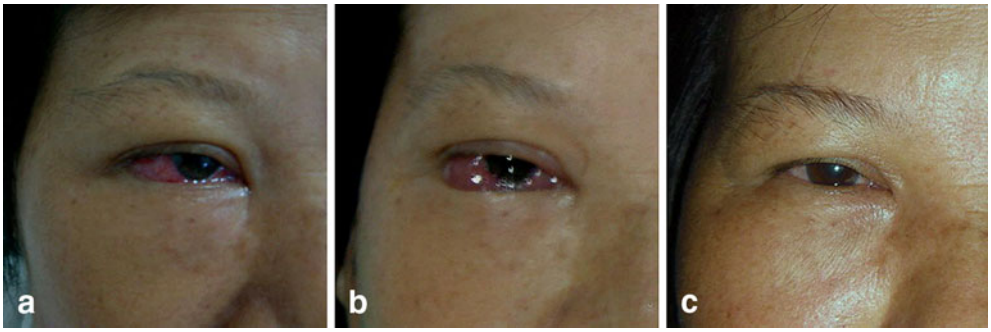

Fig. 4 **a-c** Patient no. 5, photo before embolisation and 1 day and 3 days after embolisation. Transient aggravation of ocular symptoms and signs occurred after embolisation, but were completely relieved by the 3rd day

percutaneous transorbital puncture [30], and the pterygoid plexus [31, 32], are rarely reported.

In this study, the transvenous approach via the IPS succeeded in all eight patients regardless of angiographic patency or non-visualisation of the ipsilateral IPS or occlusion of the ipsilateral internal jugular vein. The position of the contralateral IPS displayed on cerebral angiography used as a reference may be helpful. It is easier to catheterise through the IPS using a guidewire and reach the anterior cava through the cribriform foramina.

A detachable coil is the most commonly used embolic material because it is easy to control. However, it is difficult to achieve complete occlusion using only coils for embolisation [24, 33] because of the irregular morphology and septation structure in the CS. On the other hand, dense plugging of the CS may cause nerve root compression [19, 23, 34]. This disadvantage can be overcome by the use of liquid embolics because of their penetration, adhesion, and solidification mechanism through either polymerisation or precipitation principles. Among the existing liquid embolics, cyanoacrylate (CA) glues that undergo polymerisation in the presence of blood have been widely used in the treatment of vascular diseases.

GLUBRAN 2 is a synthetic cyanoacrylic surgical glue modified by the addition of a monomer synthesised by the manufacturer. The co-monomer of Glubran 2 comprises a monomer of NBCA and a monomer of MS (owned by GEM Srl). MS allows the monomer of NBCA to polymerise with a slightly longer polymerisation time, a lower exothermic reaction (approximately 45°C), and biotoxicity. This glue is officially authorised for surgical use and for "endovascular use in neuroradiology". The advantages of Glubran 2 include the injection of a uniform mixture, adjustable only in concentration, and the control of flow, making it an ideal material in the endovascular treatment of different brain and spine/spinal vascular diseases[35]. It polymerises rapidly in contact with living tissue and in moist environments. The polymerisation time depends on the type of tissue with which the glue comes into contact, the nature of the fluids present, and the amount of product applied. In embolisation procedures, the glue remains for a longer period of time. Compared with the monomer NBCA, Glubran 2 causes less pain to the patient and is associated with a lower risk of adherence of the catheter to the tissue, hence showing greater ease of use.

Coils combined with Glubran 2 help to achieve complete packing of the CS and occlusion of the fistulas with fewer coils [36]. The mean number of coils used for each patient (combined with Glubran 2) in this study is much lower than that (using coils only) reported by Kiyosue et al. [37]. Before the infusion of Glubran 2, a roadmap should be made through the microcatheter in order to evaluate the possible drainage pattern of Glubran 2 and to monitor the injection. The coils used before Glubran 2 in embolisation can slow down the blood flow and prevent Glubran 2 droplets from spillage into important inflowing draining veins such as the SOV or cortical veins.

In this study, complete occlusion of the fistulas was achieved in seven patients undergoing transvenous embolisation with detachable coils and Glubran 2. Paradoxical transient aggravation of ocular symptoms and signs occurred in one patient after the complete occlusion of the fistula. It is supposed that the reason may be the inflammatory effects of thrombosis in the highly innervated cavernous sinus or propagation of thrombus throughout the cavernous sinus extending into the superior ophthalmic vein [3]. A brief course of steroids may help to attenuate inflammation associated with acute thrombosis. No severe symptomatic complications were observed in patients with well-controlled injections of Glubran 2.

Consistent with our study, Arat et al. and Suzuki et al. also reported transvenous treatment of CSDAVFs using a combination of detachable coils and Onyx in four patients and achieved good results [38, 39]. As a non-adhesive embolic agent, Onyx is an alternative choice for transvenous embolisation. Its nonadhesive and cohesive properties make this agent suitable for transvenous casting of the cavernous sinus with significantly prolonged injections, better penetration, and decreased risk of catheter retention[38–44]. According to these few scattered reports, the duration of injection ranged from 6 min to 29 min, and the volume of Onyx for embolisation of the cavernous sinus ranged from 1.4 ml to 5 ml. The results and clinical effects of embolization with Onyx were similar to those of Glubran; however, its frequency of adverse events was a little higher than that of Glubran. The frequency of adverse events was reported to be up to 28.6%, and the long-term morbidity rate was about 5%. Common adverse events included reproducible bradycardia and cranial nerve palsy due to the angiotoxicity and

neurotoxicity raised from the DMSO within the Onyx. Reported complications have also included hemiplegia, tansient visual loss, and cranial nerve deficits, which may be associated with retrograde penetration into the feeding arterial vessels of the fistulas. In addition, it is expensive, and there are limited numbers of MSO-compatible delivery systems.

Conclusion

Transvenous embolisation via an IPS approach is a highly efficient and safe treatment for CSDAVFs. Embolisation with a combination of coils and Glubran 2 may help to achieve higher success rates of complete occlusion of fistulas with fewer coils.

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