Quadruple coaxial catheter system on transvenous embolization for dural arteriovenous fistula

Kentaro Hayashi M.D., Nobutaka Horie M.D., Yoichi Morofuji M.D., Shuji Fukuda M.D., Susumu Yamaguchi M.D., Minoru Morikawa M.D.*

Department of Neurosurgery and Radiology*, Nagasaki University School of Medicine, JAPAN

Kentaro Hayashi
Department of Neurosurgery
Nagasaki University School of Medicine
Sakamoto 1-7-1, Nagasaki city, Nagasaki 852-8501, Japan
Tel: +81-95-819-7375
Fax: +81-95-819-7378
E-mail: kenkuni@nagasaki-u.ac.jp

Abstract

Background: Although transvenous embolization (TVE) is an effective method for treating dural arteriovenous fistula (AVF), directing the catheter to the lesion site is difficult.

Objective: We report on the utility of a quadruple coaxial catheter system for TVE.

Materials and Methods: The quadruple catheter system was comprised of a 6 Fr guiding sheath, 6 Fr guiding catheter, 4 Fr intermediate catheter, and a regular microcatheter. The system was utilized in 27 consecutive dural AVF cases treated with TVE. In this study, we reviewed our experience with this system, including the theory, method of use, and complications.

Results: Stenosis or obstruction of the vascular access was identified in 12 cases. The catheter could not reach to the lesion in three cases of cavernous sinus (7.4%); therefore, transarterial embolization was employed. Angiographic results revealed that the cases consist of total occlusion (n=16, 59.5%), subtotal (n=10, 37.0%), and partial occlusion (n=1, 3.7%). Complete resolution or improvement of symptoms was observed in 23 patients (85.2%), no improvement of symptoms was observed in three patients (7.4%), and deterioration of symptoms was observed in one patient (3.7%). Venous perforation occurred in one patient without any neurological deficit. The catheter system provided access to the lesion and provided stability during the mechanically demanding process navigating the catheter and placing the coils.

Conclusion: We determined that the quadruple coaxial system was safe and efficient for

TVE for dural AVF.

Key words; dural arteriovenous fistula, transvenous embolization, quadruple coaxial system

Running title; Quadruple system for neurointervention

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Introduction

Endovascular treatment is currently the first line of therapy for dural arteriovenous fistula (AVF) (1). Both transvenous and transarterial approaches have been reported, but transvenous embolization (TVE) is preferred because it has a higher clinical and anatomical cure rate, when the draining system can be safely and entirely occluded (2). Vascular access is required for any endovascular intervention. Traditionally, a guiding catheter and microcatheter, termed a double catheter system is used for TVE. However, this technique is technically difficult due to thrombosis or occlusion of the venous route, tortuous anatomy, and compartmentalization of the venous sinus, as well as the lack of support at the distal end during catheter manipulation. The intermediate catheter functions to bridge the gap between the guide and the microcatheter in a variety of settings, including the intracranial stenting, aneurysm coil embolization, and arteriovenous malformation embolization (3, 4). Furthermore, the tortuosity of proximal vessels may limit the ability to deliver the guide catheter distally in the vessel of interest. Another innovation is a guiding sheath, which provides a larger lumen and more proximal back up (5, 6). To overcome vascular access difficulties, we established a quadruple catheter system consisted of a 6 Fr guiding sheath, 6 Fr guiding catheter, 4 Fr intermediate catheter, and a regular microcatheter (Fig. 1 and Table 1). In this report, we review our experience with the quadruple catheter system, including the theory, method of use, and results and complications.

Materials and Methods

Clinical material

From 2007 to 2013, twenty-seven consecutive patients with a mean age of 69.4 years who suffered from dural AVF were treated with the quadruple catheter system. In 19 cases, the dural AVFs were located at the cavernous sinus (CS), seven cases at the transverse sinus-sigmoid sinus (TS-SS), and one case at the anterior condylar confluence (ACC). In all patients, transvenous approaches were performed by femoral vein access under general anesthesia. If the ipsilateral approach was not successful, the contralateral sinus and facial vein routes were used. The success rate of reaching the lesion site, angiographic degree of shunt occlusion, and subsequent changes in clinical symptom were evaluated. Catheter related complications were also recorded. Angiographic total occlusion was defined as complete occlusion of the shunt, subtotal occlusion was defined as a small residual stagnant shunt that was likely to thrombose, and partial occlusion was defined as the presence of a residual shunt. Clinical improvement was defined as a cure or improvement of symptoms related to the lesion, no improvement was defined as no changes or aggravation of symptoms, and deterioration was defined as newly developed symptoms related to the lesion during follow-up.

Catheterization technique

A standard unilateral femoral approach was performed with patients under general anesthesia. For systemic anticoagulation, periprocedural heparinization was accomplished via a bolus dose of 3000 IU followed by boluses of 1000 IU every 60 min thereafter. The goal of activated coagulation time was more than 200 seconds. We did not administer antiplatelet medication in cases where the quadruple coaxial catheter system was used. A diagnostic angiographic catheter was positioned in the common carotid artery to delineate the target site for occlusion using the road-mapping technique. All catheters used were connected to continuous high-pressure flush lines (500 ml saline mixed with 1000 IU heparin). First, the double coaxial system was assembled by connecting the outermost 6 Fr 90 cm long Shuttle sheath (Cook medical Inc., Bloomington, IN, USA) and 5 Fr CX catheter (Cathex, Tokyo, Japan). The system was then introduced into the internal jugular vein over a 0.035 inch Radifocus guidewire (Terumo, Tokyo, Japan). The CX catheter was advanced so there was a 5 to 10 cm distance between the tips of the two catheters. The CX catheter was then removed and replaced with the 6 Fr 100 cm long Envoy guiding catheter (Codman & Shurtleff, Inc., Raynham, MA, USA) to reach the target vessel (i.e., the sigmoid sinus). Then, using the conventional technique, a 4 Fr 125 cm long Cerulean G40 intermediate catheter (Medikit, Tokyo, Japan) was then advanced over the 0.035 inch wire in the target vessel such as the inferior petrosal sinus (IPS), transverse sinus, or facial vein, and it was followed by the Envoy guiding catheter or Shuttle sheath, always maintaining a certain distance between the catheter tips. Finally, the 0.035 inch wire was removed, and the microcatheter was navigated to the lesion site using a regular microwire. Regarding the hemostasis connecter, the T connecter is shorter than the Y connecter to avoid wasting the length of the coaxial catheter. As shown in Fig. 1, the T connecter was employed for the Shuttle sheath and the Envoy guiding catheter instead of the Y connecter. Embolization was performed with electrically detachable coils and /or fibered pushable coils using real-time digital subtraction fluoroscopic mapping.

Results

The catheter system provided access to the lesion and improved stability for the mechanically demanding manipulations required to navigate the catheter and place the coils. Stenosis or obstruction were identified in 4 case of CS, 7 cases of TS-SS, and 1 case of ACC. Target site access through any available venous rout was unsuccessful in 3 patients (7.4%) with CS dural AVF, so transarterial embolization was performed. Angiographic results indicated that patients presented with total occlusion (n=16, 59.5%), subtotal (n=10, 37.0%), and partial occlusion (n=1, 3.7%). Complete resolution or improvement of symptoms was observed in 23 patients (85.2%), no improvement of symptoms was observed in 3 patients (7.4%), and deterioration of symptoms was observed in 1 patient (3.7%). In this series, there was one complication (3.7%) related to the catheter system (venous sinus perforation), and this perforation occurred during insertion of the 0.035 inch wire into the occluded transverse sinus. The perforation site was managed by coil embolization with no significant neurological sequelae.

Illustrative case

A 76-year-old woman presented with chemosis with proptosis of her right eye. A magnetic resonance angiogram suggested the presence of a dural AVF at the CS. The digital subtraction angiogram (DSA) showed a dural AVF fed by the middle meningeal artery and accessory meningeal artery. Venous drainage occurred via the right superior ophthalmic vein (SOV) and the right IPS route was not visualized (Fig. 2A, B). The right femoral vein was cannulated using the Seldinger technique. A 6 Fr Shuttle sheath (Cook) was positioned in the right internal jugular vein, a 6 Fr Envoy guiding catheter (Cordis) was inserted near the sigmoid sinus, and the occluded IPS was searched with a 0.035 inch wire and a 4 Fr Cerulean G40 catheter (Medikit). The wire was inserted into the IPS and the Cerulean catheter was introduced into the middle portion of the IPS (Fig. 2C, D). The wire was withdrawn, and the Excelsior 1018 microcatheter (Boston Scientific, Natick, MA, USA) with microwire was introduced and navigated to the CS. Navigation was difficult due to compartmentalization and thrombosis of the CS. Finally, the microcatheter reached the outflow tract of the SOV (Fig. 2E, F), the SOV was obliterated with detachable coils and the catheter was withdrawn from the CS. The anterior compartment was loosely packed with coils, and the posterior compartment, which is shunt part, was tightly embolized. The post-coiling angiogram showed total occlusion of the right dural AVF (Fig. 2G, H). The post-operative course was uneventful and the patient’s symptoms were completely relieved.

Discussion

Stable access to the target lesion is fundamental to any endovascular intervention. The development of guiding catheters has produced a wide variety of access devices that offer various advantages with regard to trackability, distal and proximal support, and improved distal access. To supply distal support and stability, an intermediate catheter was developed and its efficacy in a triple coaxial catheter system was reported (3, 4). The intermediate catheter is useful for gaining access to the cerebral vasculature, especially in patients with significant tortuosity or when access to the distal vasculature is required multiple times (7, 8). We employed this system for the treatment of embolization of the cerebral aneurysm and arteriovenous malformation. The guiding sheath provides support for proximal back up (5, 6). Here, we combined these devices to develop a quadruple coaxial catheter system, and tested it for TVE for the treatment of dural AVF, because navigating the catheter to the compartmentalized or thrombosed lesion is extremely difficult (9, 10). Regarding the pathophisiology of the dural AVF, following occlusion of antegrade drainage (i.e., through the IPS), this condition will remain symptomatic due to retrograde drainage (i.e., through the SOV and sphenoparietal sinus) (11, 12). Therefore, catheterization of the occluded vessel or tortuous vessel is required in TVE.

Various transvenous routes are available for embolization of the dural AVF. In case of CS dural AVF, a catheter is first introduced into the ipsilateral IPS because this route is the shortest and most direct path to the target lesion. A 0.035 inch wire is relatively stiff, allowing it to penetrate the thrombosed, unviualized IPS more effectively than a microcatheter or microwire. Then, an intermediate catheter is introduced into the IPS. There are several compartments in the CS, so fine technique is required to navigate the microcatheter to the target lesion. If access via the IPS fails, the transfacial SOV approach can be used, but the navigation path is longer. In that case, the intermediate catheter is introduced into the facial vein as distal as possible to navigate the catheter to the tortuous angular vein at the orbital rim. TS-SS dural AVF, it usually accompanies occlusion of the unilateral sinus thrombosis and occasionally accompanies occlusion of the bilateral sinus, namely the isolated sinus. Thus, the occlusion makes it hard to navigate catheters due to the organization of the thrombus, a guiding sheath is required for proximal catheter back-up. A 0.035 inch wire and intermediate catheter are useful for penetrating the occlusion.

We experienced sinus perforation in one case of TS-SS dural AVF. Extreme care must be taken when directing the wire. The ratio of vessel perforation during TVE is approximately 5% and it is managed by coil embolization (11). Thus, TVE is not successful in approximately 10% of patient (13). Consistent with these statistics, we could not reach the lesion in three cases (7.4%) in this study.

Disadvantages of this system include the use of multiple coaxial access devices, which results in increased complexity of the procedure due to additional flush lines and the need for greater manual dexterity to manage each of the components. Knowledge of catheter compatibility is necessary, which has increased dramatically as the number of access devices and the differences in their lumen diameter, outer diameter, and lengths have increased. Length differences are the most critical physical property, as the intermediate catheter with a rotational hemostatic device may reduce the working catheter length of the inner microcatheter, rendering it unable to achieve distal access immediately adjacent to the target vessel. To maintain an effective catheter length, a T type hemostasis connecter was employed for the guiding sheath and guiding catheter instead of a Y type hemostasis connecter. Because we employ this system routinely for TVE for the treatment of dural AVF, our staff is familiar with this method.

A limitation of this report is the retrospective nature of this evaluation; it is impossible to assess how much benefit the quadruple coaxial system actually provides during any of the described procedures.

Conclusions

A quadruple coaxial catheter system is safe and effective for TVE for the treatment of dural AVF.

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Figure legends

Figure 1

1A: Photograph of the proximal connecters

1B: Photograph of the distal tip of the catheters

6Fr guiding sheath (black arrow)

6Fr guiding catheter (white arrow)

4Fr middle catheter (black arrowhead)

microcatheter (white arrowhead)

microguidewire (open arrow)

Figure 2 illustrative case

2A, 2B: Preoperative carotid angiogram shows the cavernous sinus (CS) dural arteriovenous fistula (AVF) fed by the branches of the external carotid artery. The draining vein is the superior ophthalmic vein (SOV). The inferior petrosal sinus (IPS) is obstructed (**2A**: A-P view, **2B**: lateral view).

2C, 2D: Intraoperative fluoroscopy image shows the introduction of the 0.035 inch wire and 4 Fr intermediate catheter into the right IPS through the 6Fr guiding sheath and 6 Fr guiding catheter (**2C**: A-P view, **2D**: lateral view).

2E, 2F: Intraoperative fluoroscopy image shows the introduction of the microcatheter and microwire into the SOV passing the CS (**2E**: A-P view, **2F**: lateral view).

2G, 2H: The SOV and shunt at the CS were obliterated with detachable coils. Postoperative control angiogram shows total occlusion of the AVF (**2G**: A-P view, **2H**: lateral view).

6Fr guiding sheath (black arrow)

6Fr guiding catheter (white arrow)

4Fr middle catheter (black arrowhead)

microcatheter (white arrowhead)

microguidewire (open arrow)

Fig. 1

1A

1B

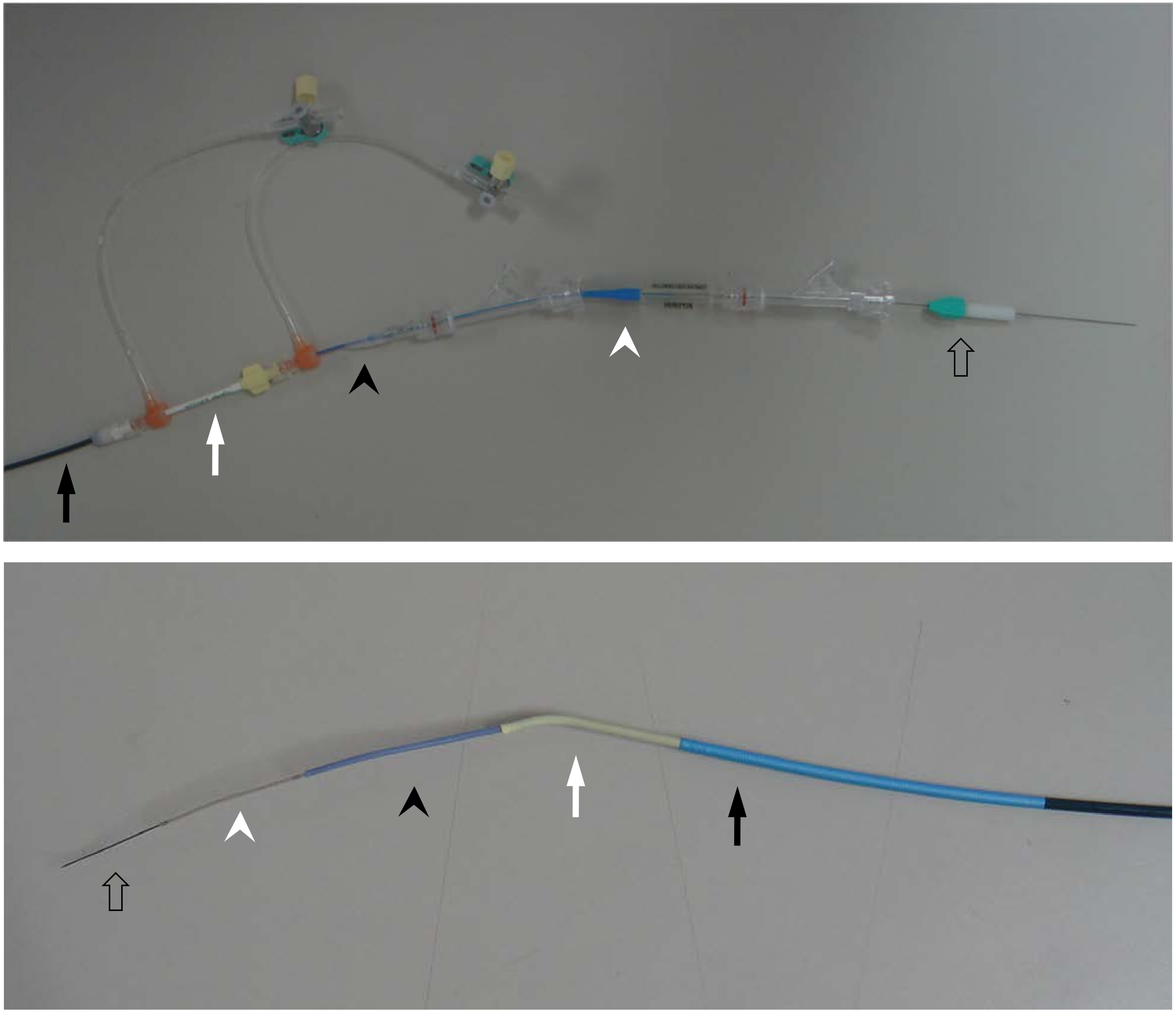


Fig. 2

2A

2B

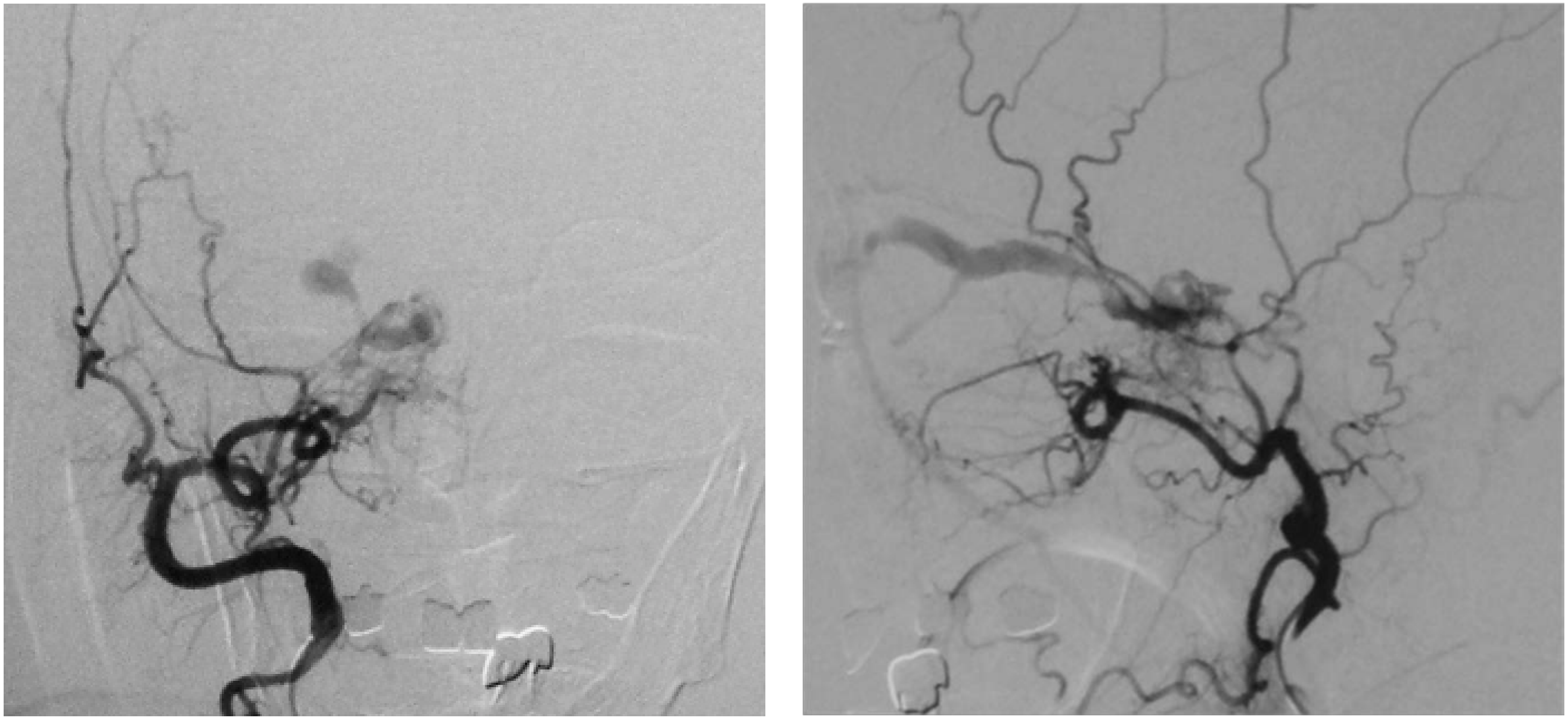
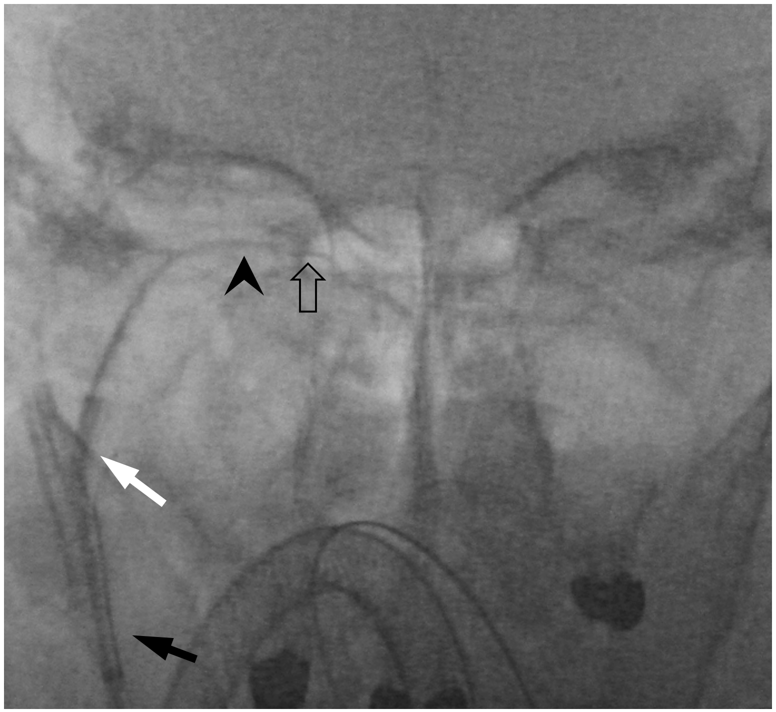


Fig. 2

2C



2D

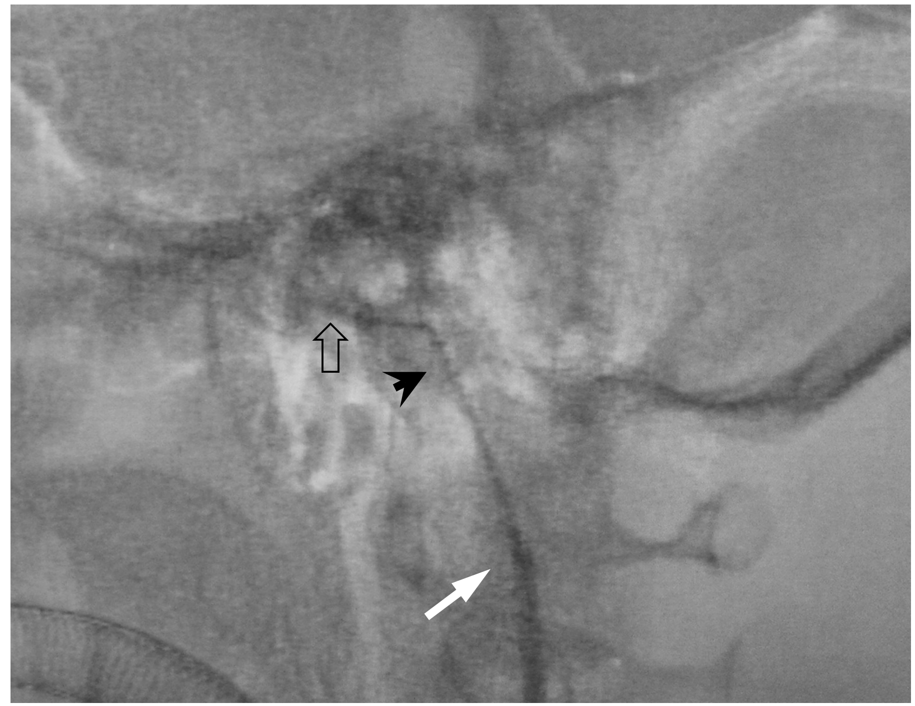


Fig. 2

2E 2F

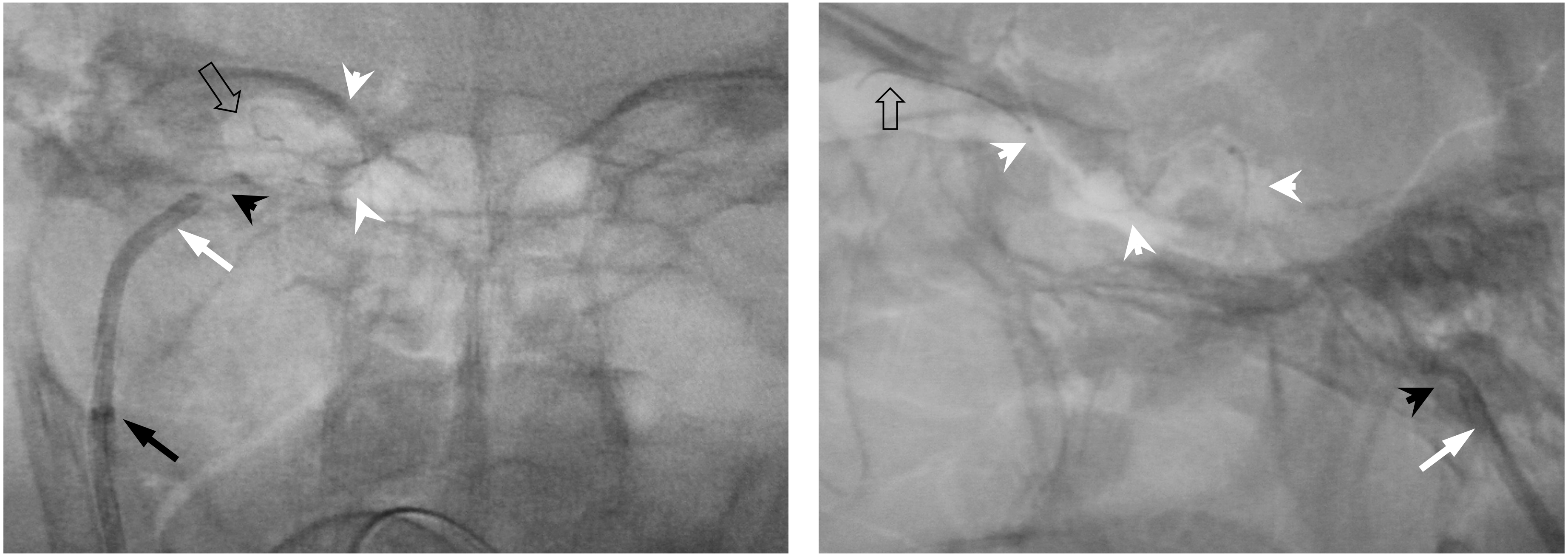


Fig. 2

2G 2H

Table 1 component of quadruple coaxial catheter system

	name of catheter	type of catheter	length	positioning	introduction device
4	Excelsior1018	mirocatheter	150 cm	target lesion, drainer	microwire
3	4 Fr Cerulean	intermadiate	125 cm	IPS, TS-SS, facial vein	0.035 inch wire
2	6 Fr Envoy	guiding catheter	100 cm	IJV, SS	0.035 inch wire
1	6 Fr Shuttle	guiding sheath	90 cm	IJV	CX catheter & 0.035 inch wire

IPS: inferior petrous sinus

TS: transverse sinus

SS: sigmoid sinus

IJV: internal jugular vein