Combined Surgery and Endovascular Treatment of Complicated Traumatic Carotid-Cavernous Fistulas: Results and Illustrated Cases

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ABSTRACT

Objective: To review Siriraj Hospital's experiences with direct surgical treatment of complicated traumatic carotid-cavernous fistulas (CCFs) in the context of multidisciplinary approach.

Methods: This study is a retrospective review of complicated direct carotid cavernous fistulas (CCFs) that had opened surgery after failure of detachable balloon embolization. Data were collected from medical records, radio-angiographic records, and follow-up results of combinations of treatment.

Results: From 1993- April 2003, we have total 25 cases of combined surgery and endovascular treatment of traumatic carotid-cavernous fistulas (CCFs). Causes of unsuccessful balloon embolization are small-hole fistula, deflation of the balloon, difficult position of fistula, false aneurysm, risk of intracavernous internal carotid artery (ICA) occlusion, and tortuosity of ICA and draining veins. Various procedures were performed and all patients have good results with completed resolution of clinical triad symptoms. On follow-up cerebral angiography of 16 patients that received cavernous sinus packing, we could preserve the patency of ICA in 8 patients but 5 patients had thrombosis of ICA without ischemic events. In 3 patients, an operation to occlude the ICA was performed after failure of cavernus sinus packing.

Conclusions: The standard treatment of carotid cavernous fistula is endovascular balloon embolization. When the endovascular treatment fails, surgical packing of cavernous sinus is immediately considered an alternative way to cure the CCFs and to offer additional technique to help increase the patency of ICA.

Keywords: Balloon embolization; Carotid cavernous fistulas; Cavernous sinus packing; Endovascular treatment

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Traumatic carotid-cavernous sinus fistulas (CCFs) are serious vascular abnormalities which may develop following a craniofacial trauma to the skull base. These vascular anomalies are rare in the western countries but frequently seen in Thailand. At Siriraj Hospital, we have more than 300 case-experiences for the treatment of these cases.[1] Head trauma from motor vehicle accident is the common cause of carotid-cavernous fistulas in Thailand due to drunken drivers and motorcycle riders without helmet.

Pathophysiology of carotid cavernous fistulae is well known after pathological examination of patients with CCFs. It is an abnormally created communication between the carotid artery system and the venous channels of the cavernous sinus. Parkinson gave the definition of a traumatic CCF that the typical anatomical nature is a short endothelial opening between the ICA and any one of the adjacent variable lateral sella venous channels.[2] Traumatic carotid cavernous fistulas are classified by Barrow as type A (direct) shunt between the ICA and cavernous sinus.[3] This is a high flow shunt that produce the symptoms due to the high pressure in cavernous sinus refluxed to ophthalmic veins and pressure may reflux to leptomeningeal veins causing cortical venous hypertension.

Clinical triad of CCF is pulsatile exophthalmos, chemosis and bruit.[4,6] In patients with leptomeningeal venous congestion, focal neurological deficit may develop. The goals of treatment are: obliteration of the fistulae, preservation of blood flow via ICA and restoration of neurological and ophthalmologic functions. To date, the treatment of choice is mainly

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endovascular techniques (detachable balloon occlusion of the fistula with preservation of carotid flow). Balloon sacrifice of ICA can cure the fistulas in case of adequate collateral blood flow but it does not preserve the normal anatomy of ICA. In order to restore cerebral blood flow trough ICA, surgery is indicated for patients who are treated unsuccessfully with embolization instead of ICA sacrifice.

MATERIALS AND METHODS

We retrospectively reviewed the cases of traumatic carotid cavernous fistulas (CCFs) admitted at Siriraj Hospital between 1993 and 2003. The patients were classified as type A (direct) CCF according to Barrow's classification.[3] Transarterial balloon embolization or other form of embolization, such as transvenous embolization, was chosen as an initial treatment with an effort to preserve the patency of ICA in all patients. In one patient, the initial treatment was considered surgical direct packing of the cavernous sinus. In 23 patients, endovascular treatment failed to occlude the fistulas; the patients underwent direct cavernous sinus packing to seal of the fistula. One patient underwent emergency endovascular sacrifice of ICA due to massive nasal bleeding from false aneurysm in sphenoid sinus. The patients were operated by the staff of the Neurosurgery Division, Department of Surgery, Faculty of Medicine Siriraj Hospital.

Clinical follow ups included outpatient clinic, telephone contact with the patient and an immediate relative or chart review. Any brain imaging (computed tomography of the head and cerebral angiography) examination performed subsequent to treatment was analyzed, and magnetic resonance (MR) angiography was offered to some patients. Data were collected and analyzed from medical record, radio-angiographic record, and follow-up results of the combination of treatment.

Standard detachable balloon technique for the treatment of CCFs begins with systemic heparization (3,000 unit). An 8 Fr. guiding catheter positioning in the ICA is used followed by mounting a gold valve detachable balloon (Nycomed) on a Minitorquer CIFN. The Goldvalve is a detachable balloon with integrated valve. The Goldvalve balloons are made from latex with a leak-proof valve and a radiopaque gold marker. They can be tested and mounted with the blunt needle included in the package. The balloons are designed to be mounted easily and precisely with optimal safety. The Minitorquer CIFN is a microcatheter that is used as a carrier catheter. The Goldvalve detachable balloons must be mounted on specific catheters. These carrier catheters allow balloon navigation within the vasculature, its inflation and final detachment. After entering the cavernous sinus, the balloon is slowly inflated until the fistula is completely occluded. To adjust the volume of the balloon, injection through the guiding catheter is tested before detachment. In many patients, more than one balloon might be required to obliterate the fistulae.[5]

When arterial sacrifice is being considered as a therapy for traumatic CCF, balloon occlusion test is used to determine if the patient can hemodynamically tolerlate arterial sacrifice. It evaluates the adequacy of collateral flow, primarily through the circle of Willis. The test requires the use of temporary balloon occlusion of arteries with concomitant electroencephalographic (EEG) and clinical assessment of brain functions. If the patient tolerates the temporary balloon occlusion for 30 minutes or more, the parent artery is then permanently occluded with detachable balloon or coils. If the patient fails this functional test, an external carotid-internal carotid (EC-IC) bypass preceeded the permanent arterial occlusion.

Surgical technique of the surgical packing of the cavernous sinus is started by frontotemporal craniotomy with head rotate 30 degree toward the contralateral side. In addition to routine intraoperative monitoring, a Doppler ultrasound transducer is fixed extracranially on the orbit to record the bruit. Proximal control of the cervical common carotid artery (CCA), internal carotid artery (ICA) and external carotid artery (ECA) is secure and surrounded by an elastic band to allow later temporary occlusion. A combined extradural-intradural approach to the cavernous sinus, as described by Dolenc,[13,14] is applied in direct surgical packing of cavernous sinus. Extradural removal of the sphenoid ridge and the anterior clinoid process with intradural unroofing the bone of optic canal are done subsequently. The ICA is dissected from the ophthalmic artery backward, along the sella turcica. Partial opening of anterior carvernous sinus through Dolenc triangle is done. Packing of anterior carvernous sinus through the anteromedial triangle (Dolenc triangle) is done. Packing of the cavernous sinus with thrombogenic materials (7-10 small pieces of muscle and SurgicelR) along the medial aspect of the ICA is performed gently with Doppler monitoring during the entire procedure until the sound of fistulae was silence.

The other rout to enter the cavernous sinus is Parkinson's triangular area (formed by the third and fourth cranial nerves running together within the dural roof of the cavernous sinus toward the superior orbital fissure and the ophthalmic division of the fifth cranial nerve in the inferior lateral dural wall).[2,11,12] It is safe to open the caver-nous sinus without these nerves injury if the incision is carried parallel to and beneath the point of entry of third nerve.

If arterial bleeding should occur, the blood flow can easily be interrupted by placing temporary clips on cervical ICA and distal control at the clinoidal segment of ICA proximal to the origin of ophthalmic artery to avoid the possibility of visual loss. The proximal ICA is not occluded until distal occlusion is also possible to avoid retrograde vascular steal and possible distal circulation ischemia. The time for temporary occlusion of ICA during packing the cavernous sinus varies from 15 to 30 minutes.

RESULTS

From 1993- April 2003 we have total 25 cases of combined surgery and endovascular treatment of complicated carotid cavernous fistula. The ratio of male and female is 20: 5, as men have more exposure to accident, especially motor vehicle accidents. Interestingly, bilateral CCF was noted in three cases.

The onset of the symptoms was 1 day to 4 months after injury. Surprisingly, 1 case developed chronic CCF more than 20 years after injury. Reviewing the causes of trauma, we found the following: 21 cases were motor vehicle accidents, 2 cases car accidents and 2 cases direct blunt injuries. We analyzed the angiographic findings to identify the cause of unsuccessful treatment by detachable balloon embolization. As described in Table 1, most common causes of failure of embolization were, namely: small-hole fistula (9 cases), early deflation of balloon (9 cases) and difficult position of fistulae (3 cases).

Twenty-three patients were operated by cavernous sinus packing techniques. As seen in Table 2 and Fig 1, there are four cases of failed packing of cavernous sinus (case No. 16, 17, 21, and 24). Three of four of the cases, ICA were occluded by balloon occlusion and surgical tapping of ICA without neurological deterioration from ischemic event. We have one CCF patient who was decided to be operated by packing the cavernous sinus because angiographic machine was unavailable at that time and rapid progressive visual loss (case 24). At first, the surgical packing of cavernous sinus failed, but attempt endovascular embolization of the CCF was subsequently successful. In two patients, bypass

TABLE 1. Causes of unsuccessful balloon embolization

Small hole fistula	9	cases
Early deflation of balloon	9	cases
Difficult position of fistula	3	cases
False aneurysm	2	cases
Risk of intracavernous ICA occlusion	1	case
Tortuosity of the ICA and draining veins	1	case
Total	25	cases

TABLE 2. Summary outcome of the treatment of complicated CCFs

Pt. No.	Sex/Age (yr)	Side	Clinical Manifestations	Endovascular Treatment	Causes of Unsuccessful	Surgery	Neurological function	Fistula closure	Patency of ICA
1	F/43	R	Eye symptoms	Failed balloon	Small hole /hole site	Packing	Good	Complete	Yes
2	F/39	L	Eye symptoms	Failed balloon	Small hole	Packing	Good	Complete	Yes
3	F/32	R	Eye symptoms	Failed balloon x2	Small hole	Packing	Good	Complete	Yes
4	M/42	L	Eye symptoms >20 yr +SAH	Balloon x3	Early deflation	Packing	Good	Complete	Yes
5	M/47	L	Eye symptoms	Failed balloon & transvenous coilling	Kinging Lt ICA & small inferior petrosal sinus	Packing	Good	Complete	Narrow
6	M/25	R	Eye symptoms	Failed balloon	Eearly deflation	Packing	Good	Complete	Narrow
7	M/32	L	Eye symptoms	Balloon x2	Early deflation	Packing	Good	80%	Yes
8	M/40	L	Eye symptoms	Failed balloon	Small hole	Packing	Good	Complete	Thrombosis
9	M/29	L	Eye symptoms	Failed balloon (transarterial & transvenous)	Small hole & small inferior petrosal sinus	Packing x2	Good (mild symptoms)	Residual	Thrombosis
10	M/21	R	Eye symptoms	Balloon x1	Early deflation	Packing	Good	Complete	Thrombosis
11	M/30	R	Eye symptoms	Failed balloon	Small hole	Packing	Good	?	?
12	M/21	R	Eye symptoms	Failed balloon	Hole site	Packing	Good	?	?
13	F/15	R	Eye symptoms	Failed balloon	Small hole	Packing	Good	?	?
14	M/28	L	Eye symptoms	Balloon x1	Early deflation	Packing	Good	?	?
15	M/20	L	Eye symptoms	Failed balloon x2 & transvenous coilling (retained coil in ICA)	hole site + small hole	Packing & Coil Removal	Good	Complete	Thrombosis
16	M/27	R	Eye symptoms	Partial balloon embolization	Compromised ICA	Failed Packing	Good	Complete	Surgical trapping
17	M/23	R	Eye symptoms	Balloon x2 & transarterial glue emb	Deflation + Indirect CCF (type C)	Failed Packing	Good	Complete	Balloon sacrifice of ICA, Rt.
18	M/45	R	Eye & Massive epistaxis due to false aneurysm in sphenoid sinus	Emergency balloon sacrifice of ICARt.	Life threatening	Bypass ECA-MCA Rt.	Good	Complete	Balloon Sacrifice of ICA, Rt.
19	M/19	L	Eye + CSF rhinorrhea	Balloon x1	Early deflation	Packing	Good	?	?
20	M/57	L	Eye symptoms	Failed balloon	Hole site	Packing	Good	?	?
21	M/24	Bilat	Eye symptoms Lt > Rt	Balloon x3 Lt.	Early Deflation Rt.	Failed Packing, Rt.	Good	Complete	Balloon sacrifice of Rt. ICA
22	M/65	Bilat	Eye symptoms Lt.	Failed balloon	Small hole, Rt	Packing, Rt	Good	Complete	Thrombosis Rt ICA
23	M/41	Bilat	Eye symptoms	Balloon x1 Rt.	Early deflation Rt & false aneurysm Lt	Bypass Rt ECA-MCA	Good	Complete	Surgical trapping Lt ICA
24	F/40	L	Eye symptoms	Successful balloon embolization	-	Failed Packing(1st)	Good	Complete	Yes
25	M/15	R	Eye symptoms	Failed balloon	False aneurysm	Packing	Good	?	?

Balloon x1 or x2 or x3 = successful balloon embolozation in one, two or three times
? = postoperative angiography was not performed

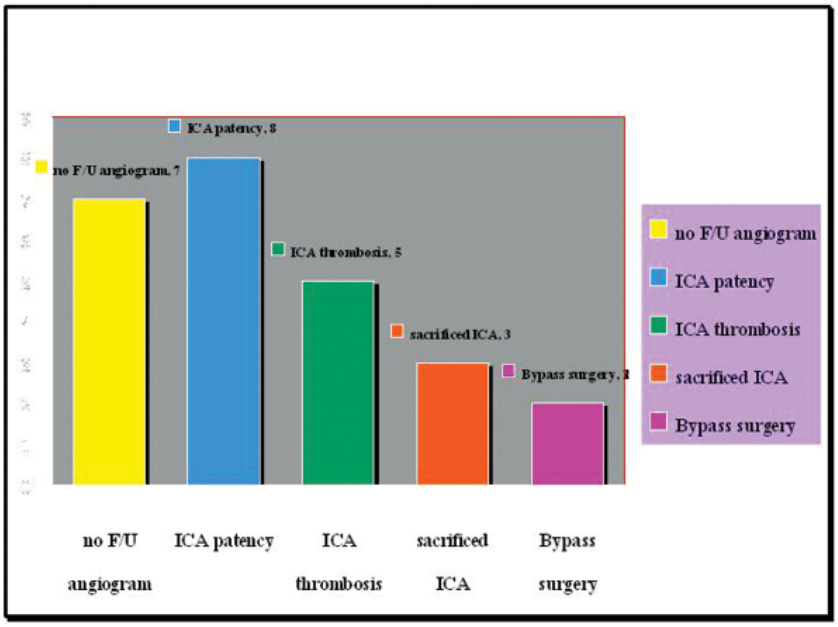

Fig 1. Angiographic results of 25 patients

operation had to be performed due to false aneurysm and ischemic neurological deficits (case 18 and 23). In case 18, the patient went into coma due to a massive nasal bleeding from false aneurysm into sphenoid sinus. Because of emergency situation, balloon sacrifice of right cavernous ICA was performed in order to save life. One week after, he developed left-side weakness after recovering from the coma. The bypass operation (right cervical ECA to supraclinoid ICA) was selected to augment the cerebral blood flow. In case 23, the patient had bilateral traumatic CCF and false aneurysm of left cavernous ICA projecting superiorly with tendency of rupture. Firstly, right balloon embolization was attempted to cure right CCF and to preserve right ICA and left ICA sacrifice was planned to cure the CCF and false aneurysm after balloon occlusion test of left side had been successful. Unfortunately, the right CCF was came again after early deflation of balloon. So, the bilateral ICA was surgically trapped after bypass surgery between right cervical ECA and supraclinoid ICA had been done successfully. These two patients withbypass surgery were no further neurological deficit after complete treatment.

All 25 patients had good results with completed resolution of clinical triad symptoms, obliteration of fistula in 23 of patients, partial obliteration of fistula in 2 patients. By follow-up cerebral angiography of 16 patients performedcavernous sinus packing, we could preserve the patency of ICA in 8 patients but 5 patients had thrombosis of ICA without ischemic events. In 3 patients (case No. 16, 17, and 21), an operation to occlude the ICA after failure of cavernous sinus packing was performed. There was no immediate neurological deficit with absent of CCF. Anyway, the long-term MRI study of patient No. 15 who had thrombosis of left ICA had shown atrophy of left cerebral hemisphere without motor deficit or dysphasia.

Illustrate cases

Case 1

A 43-years-old Thai female had right chemosis, proptosis, and bruit in the right eye after a head trauma. Right CCF was diagnosed by an ophthal-mologist. Head CT showed enlarged cavernous sinus after contrast enhancement (Fig 2A). Definite diagnosis of CCF was confirmed by cerebral angiography that revealed a small-hole fistula at the junction of C4 and C5 portion of ICA and narrowing of inferior petrosal sinus (Fig 2B). Accordingly, the microcatheter could not be passed through the hole of fistula due to its difficult position (Fig 3A). Right craniotomy for cavernous sinus packing was performed after a failed balloon embolization. Postoperatively, eye symptoms and signs were subsiding immediately and MR imaging and angiography demonstrated no residual CCF and the patency of ICA lumen was maintained (Fig 3B).

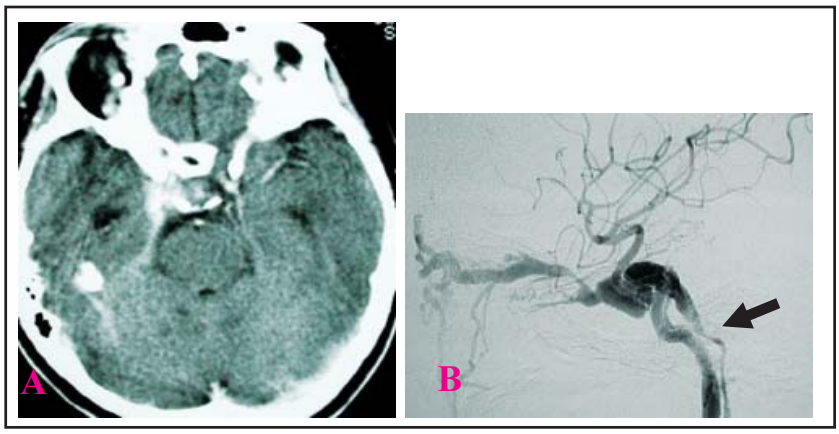

Fig 2. (A) Enhanced enlarged right cavernous sinus compares to the left was seen in contrast CT (arrow). (B) Four-vessel digital subtraction cerebral angiogram demon strates a unilateral carotid-cavernous fistula with ophthalmic venous drainage (white arrow) and narrow inferior petrosal sinus (black arrow).

Case 3

A 32-years-old Thai female developed right CCF early as two weeks after the car accident. She had right chemosis, proptosis, and bruit in the right eye. Surprisingly, there are spontaneous regressions of proptosis and chemosis but still bruit. Cerebral angiography showed a smallhole fistula at dorsal aspect of C3-C4 portion of the ICA without ophthalmic venous drainage which explain the regression of eye sign (Fig 4A). Balloon embolization was planning to obliterate the fistula. fortunately, both of transarterial and transvenous balloon embolization were unsuccessful because the hole of fistula was too small and the catheter could not pass through a narrow petrosal sinus (Fig 4B). Cavernous sinus packing with small pieces

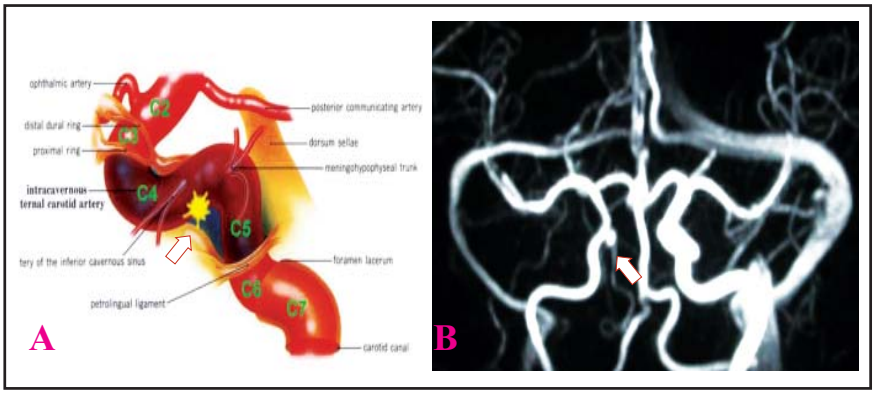

Fig 3. (A) Picture diagram showed fistula hole (arrow) at inferomedial part of C4 and C5 junction of ICA.(adapted picture of intrcavernous ICA from Kanno T, et al. Cadaveric dissection workshop 2003, Indonesia) (B) Postoperative MR angiography demonstrated patency of ICA and residual venous pouch (arrow).

of muscle and Sugicel[R] was done with the technique of extradural Dolenc approach using intraoperative angiography. Postoperative cerebral angiography revealed patency of cavernous sinus ICA and complete obliteration of the fistula (Fig 4C).

Case 9

A 29-year-old man was brought to the hospital due to alteration of consciousness. On examination, he had the clinical triad of left eye. Head CT revealed diffuse subarachnoid hemorrhage and intraventricular hemorrhage. The diagnosis was made after cerebral angiography had been done (Fig 5A). Surprisingly, a left small aneurysm proximal to the junction of posterior cerebral artery and posterior communicating artery was seen (Fig 5B) with the present of left CCF. After he was recover from subarachnoid hemorrhage, detachable balloon embolization was performed using 3 balloons. The patient was immediately relieved from symptoms. Two days later, he felt the previous symptoms again. Due to early deflation of the balloon, direct surgical packing of the cavernous sinus was attempted. But the fistula had been persisting after the operation. Successful second balloon embolization was done using 4 balloons. Postembolization cerebral angiography was done 1 month later. The CCF was cure with small venous pouch and a small aneurysm could not be seen anymore (Fig 5C).

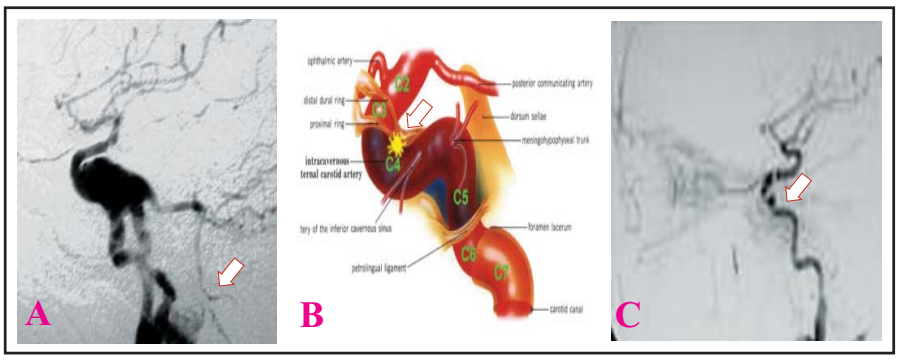

Fig 4. (A) Selective cerebral angiography of right ICA reveals carotid cavernous fistula without ophthalmic venous drainage. Segmental narrowing of right superior and inferior petrosal sinus were noted (arrow) (B) Picture diagram showes a small hole fistula at dorsal aspect of C3-C4 portion of the ICA. (Adapted picture of intrcavernous ICA from Kanno T, et al. Cadaveric dissection workshop 2003, Indonesia) (C) Postoperative digital subtraction cerebral angiography of right ICA revealed a patency of ICA with a small residual venous pouch (arrow).

DISCUSSION

Anatomy and pathophysiology of the traumatic carotid carvernous fistulas (CCFs)

Cavernous sinuses are a paired venous structure in the anterior portion of the middle cranial fossa. They located on either side of the sella turcica and the pituitary gland received blood supply from the superior and inferior ophthalmic veins and sphenoparietal sinuses. The venous drainage from the cavernous sinuses enters the superior and inferior petrosal sinuses and eventually drains into the transverse sinus. The paired dural venous structure connected via small venous channels as known as inter-cavernous sinuses.[6,7] Fractures or the shearing forces of severe head trauma may cause weakness of the of the ICA or cause an actual laceration producing a vascular shunt from a high-flow arterial system into a low-flow venous sinus, resulting in CCFs.[8] The high venous pressure causes a "back-up" pressure to the venous drainage of the cavernous sinus resulting in orbital triad symptoms (proptosis, chemosis and bruit).[6] In case of aggressive type of carotid cavernous fistulas, there are retrograde venous refluxes to the cortical venous system. Accordingly, they may cause cerebral venous ischemia from retrograde venous hypertension and congestion.

Anatomy of internal carotid artery and approaches to the cavernous sinus

Fischer assigned the classiification of ICA using the carotid bifurcation as the starting point. Most distal portion (C6) is defined as the intrapetrous portion of the internal carotid artery. The C5 portion is short segment between the fibrous ring and the posterior bend of the vessel. The junction of the C4 and C5 segments is the meningohy pophyseal trunk. The C4 segment of the artery is horizontal toward the superior orbital fissure and exits the cavernous sinus by piercing the caroticooculomotor membrane to enter the epidural space under the anterior clinoid process. The C3 segment, also known as the "siphon" or "clinoid segment", bends posterior and superior to penetrate the dura.

History of the treatment of carotid cavernous fistula (CCF)

Traumatic carotid cavernous fistulas (CCFs) are the neurosurgical disease. In the past, definitive treatment of CCFs was usually performed by neurosurgeons. The treat-ment of CCF has undergone

Fig 5. (A) Cerebral angiography of left ICA can diagnosed left CCF with ophthalmic and inferior petrosal venous drainage. (B) Vertebral artery injection demonstrated an aneurysm of distal posterior communicating artery (arrow). (C) After complete treatment, the CCF was cure with small venous pouch and obliteration of an aneurysm (arrow).

a dramatic evolution from a wholly surgical approach to one that now uses embolization techniques initially and reserves surgery for cases in which intravascular method fail.

The pathological entity was first described 200 years ago. In 1809, Travers treated this lesion by ligating the common carotid artery for pulsatile exophthalmos in a 34-year-old pregnant woman.[6] In 31, Brooks embolized a piece of muscle into a CCF via the ICA. In 1964, Hamby used a combination of embination of muscle and intracranial ICA ligation to close CCFs.[9]

In 1965, Parkinson pioneered direct surgical exposure of the intracavernous ICA through the lateral wall of the cavernous sinus (Parkinson's triangle) with the aid of hypothermic cardiac arrest.[2] In 1974, Mullan introduced hemostatic agents, such as gelfoam and o xidized cellulose, directly into the exposed cavernous sinus through its draining veins.[10] In 1983, Dolenc described his approach to expose of the entire cavernous sinus for the treatment of direct CCF.[13,14]

Serbinenko revolutionized the therapy for CCF in the 1970s by introducing detachable intravascular balloons.[15] Endovascular detachable balloon occlusion of CCF introduced through a transfemoral access allows preservation of the distal aspect of the ICA. This method is the current standard therapy in most cases of CCF.[16-19] In addition to the transfemoral detachable balloon embolization, several other modalities have been deemed useful in the treatment of CCFs in recent years. Transvenous embolization via the superior ophthalmic vein, the double-balloon embolization technique, and coil embolization modalities have been used with various success rates.[20,21,22] In fact, some clinicians believe that unless urgent treatment is indicated (i.e., rapid loss of vision, progressive hemiplegia, herniation of cavernous sinus into the sphenoid sinus), 6-week delay and a repeat angiogram may be prudent before embarking on an intervention.[23]

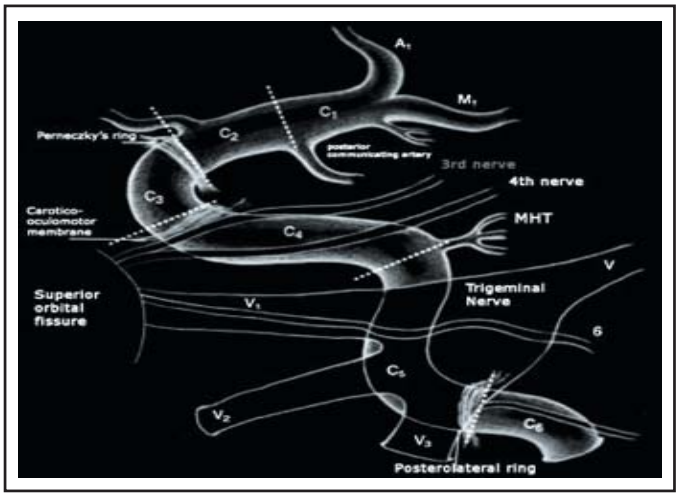

Fig 6. Classification of the intracavernous carotid artery. C1, segment from PCOM to bifurca-tion; C2, ophthalmic segment; C3, siphon or clinoid segment; MHT, meningohypophyseal trunk; C4, horizontal segment; C5, segment from MHT to posterolateral ring; C6, intrape-trous segment. (Adapted from Fischer, E.: Die Lageabweichungen der vorderen Hirnarterie in Gef[1]ssbild. Zentralb. Neurochir, 1938;3:300-12).

Results and complication of detachable balloon embolization

However, failure to embolize the CCF may occur on a few occasions, such as when the balloon cannot pass through the fistula into the cavernous sinus by blood flow, or when the inflated balloon in the cavernous sinus retracts to the carotid artery. Under these circumstances, the ICA may have to be sacrificed in order to treat the CCF.[23,24] Complications associated with endovascular therapy (e.g., thromboembolic and ischemic events, pseudoaneurysm formation, and alteration of arterial flow resulting in hemorrhage, edema, or worsening of ocular symptoms) are not frequent.[25] Hantson P, et al. reported one patient who developed brain edema leading to death after detachable balloon embolization of bilateral CCF. They postulated that reestablishment of normal cerebral perfusion after abrupt closure of the fistulas might have played a deleterious role.[26] Senser S and colleague reported diplopia associated with balloon migration on the venous side of the treated CCF.[27]

Surgical Strategy for the treatment of the traumatic CCFs

The treatment modalities for traumatic CCFs included ligation or trapping of the carotid artery, muscle embolization via cervical exposure of the carotid system, and balloon embolization combined with carotid artery ligation and direct surgical intervention. Thanapura C reported 12 patients of traumatic CCFs who were cured under circumstances such as the lack of angiography, poor socio-economic status, or patients wanting to be treated close to home.[28] All of the patients were treated by muscle embolization only; muscle embolization with internal carotid ligation (Brooks technique); muscle embolization with trapping (Jaeger-Hamby procedure); or muscle embolization

with trapping and external carotid ligation. However, the problems of these treatments are, namely: risks of ischemia from ICA occlusion, visual loss and recurrent of the fistula. To date, dramatic treatment of CCF has changed with the evolution of interventional radiography.

Neuroangiographic studies of the CCF are completed before the operation. In case of total steal of ICA blood flow should predict the tolerances after ICA sacrifice. Balloon occlusion test (BOT) was not performed in all patients. Failure to pass the BOT when ICA occlusion is required for CCFs control which may need an extracranial-to-intracranial bypass surgery. Despite a negative preoperative test occlusion, neurological deficits can occur after endovascular sacrifice of the ICA, the rate of permanent post-procedural neurological deficits varies from 0% to 10%.[29,30] Moreover, the goal of treatment of traumatic CCFs should cure the fistula, preserve the patency of blood flow via the ICA and restore neurological function.

Tu YK, et al. reported a series of direct surgery of carotid cavernous fistulae and dural arteriovenous malformations of the cavernous sinus. The patients had embolization problems such as large fistula, tiny fistula, multiple fistulae, site of fistula which difficult to thread the catheter, several recurrences and acute bleeding of a false aneurysm. Sixteen patients with type A or direct carotid cavernous fistula underwent direct intracavernous repair of carotid cavernous fistulae. Half of the patients (8/16) were treated by sinus packing, one patient underwent sinus packing and intracranial-intracranial (IC-IC) bypass operation, two patients underwent IC-IC bypass operation, three patients were treated by sealing the fistulae with fascia and acrylate glue and one patient with multiple fistulae underwent suture and clipping operation. They found that one-fourth (4/16) of the patients had ICA thrombosis. As compared to our series, we have one-fifth (5/25) of the patients who had ICA thrombosis. But the incident of ICA thrombosis in our series should be more than 5 patients because 7 patients did not have the postoperative angiography. The etiology of ICA thrombosis after packing cavernous sinus may be compromise the ICA patency by over-packing of the cavernous sinus.[31]

CONCLUSION

The standard treatment of carotid cavernous fistula is endovascular treatment, in which balloon embolization is the most successful method. Alternative endovascular treatment is transvenous coil embolization. Our retro-spective analysis demonstrated the alternative treatment by surgical packing of cavernous sinus to cure the CCFs and to possibly save the patency of ICA if endovascular treatments fail. The indications for direct surgery for the treatment of CCFs include failure of transarterial and/or transvenous approach, recurrence of CCFs after successful endovascular treatment due to rapid balloon deflation, false aneurysm associated with CCFs, and compromised arterial patency. In emergency situations such as massive nasal bleeding from false aneurysm extend to sphenoid sinus, balloon sacrifice of ICA is done, followed by a bypass surgery if any sign of cerebral ischemia is present.

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บทคัดย่อ

Combined Surgery and Endovascular Treatment of Complicated Traumatic Carotid-Cavernous Fistula: ผลการรักษาและตัวอย่างผู้ป่วย

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วัตถุประสงค์: เพื่อทบทวนประสบการณ์ของโรงพยาบาลศิริราชในการผ่าตัดรักษาโรค carotid-cavernous fistula จากอุบัติเหตุในรายที่ไม่สามารถรักษาได้ด้วยการสวนหลอดเลือดแดงใหญ่และอุดรอยรั่วด้วยลูกโป่ง (detachable balloon embolization) เพียงอย่างเดียว

วิธีการ: เป็นการศึกษาแบบพรรณนา โดยทบทวนประวัติผู้ป่วยย้อนหลัง 25 ราย ที่วินิจฉัยว่าเป็น traumatic carotid-cavernous fistula ซึ่งไม่สามารถทำการรักษาด้วยวิธีมาตรฐานโดยการสวนหลอดเลือดแดงสมองฉีดสีเพื่ออุดรูรั่วด้วยลูกโป่งได้ ผู้ป่วย 23 รายได้รับการผ่าตัดรักษาเปิดโพรงเลือดดำ cavernous และใช้กล้ามเนื้อชิ้นเล็ก ๆ และวัสดุห้ามเลือด Surgicel® หลายชิ้นยัดใส่เข้าไปในโพรงเลือดดำ cavernous เพื่ออุดรูรั่วของหลอดเลือดแดง ผู้ป่วย 2 รายได้รับการตัดต่อหลอดเลือดแดงส่วนคอไปยังหลอดเลือดแดงในสมองหลังจากทำการอุดหลอดเลือดแดงแคโรติดเพื่อรักษาโรคในกรณีที่มีเลือดไปเลี้ยงสมองไม่เพียงพอ

ผลการศึกษา: จากการทบทวนผู้ป่วยในโรงพยาบาลศิริราชตั้งแต่ปี พ.ศ. 2538 ถึงปี พ.ศ. 2548 มีผู้ป่วย 25 รายได้รับการรักษาโรค traumatic carotid-cavernous fistula ที่มีปัญหาซับซ้อน ซึ่งได้รับการผ่าตัดหลังจากไม่สามารถอุดรอยรั่วด้วยลูกโป่งได้ อันเนื่องมาจากสาเหตุต่าง ๆ ได้แก่ รูรั่วเล็กเกินกว่าขนาดลูกโป่ง 9 ราย กรณีลูกโป่งยุบตัวเร็วกว่าปกติทำให้เกิดเป็นโรคซ้ำ 9 ราย ตำแหน่งรูรั่วยากต่อการใส่ลูกโป่ง 3ราย มี false aneurysm 2ราย กรณีมีความเสี่ยงต่อการอุดตันของหลอดเลือดแดงแคโรติด 1 ราย และ 1 รายที่มีการคดงอหรือตีบแคบของหลอดเลือดแดงแคโรติดหรือหลอดเลือดดำที่เข้าโพรงเลือดดำ cavernous ผู้ป่วยทั้งหมด 25 รายไม่สามารถรักษาโดยวิธีปกติซึ่งใส่สายสวนหลอดเลือดแดงและอุดรอยรั่วด้วยลูกโป่ง การรักษาร่วมโดยการทำผ่าตัดเปิดกะโหลกศีรษะเพื่ออุดรอยรั่วในโพรงเลือดดำ cavernous หรือตัดต่อหลอดเลือดแดงที่คอไปยังหลอดเลือดแดงในสมอง หลังจากการอุดรูรั่วและมีการอุดตันของหลอดเลือดแดงแคโรติดหรือภายหลังการทำหัตถการอุดหลอดเลือดแดงแคโรติดโดยการผ่าตัดหนีบหลอดเลือดแดงแคโรติดหรืออุดหลอดเลือดแดงแคโรติดด้วยบอลลูนแล้วสมองเกิดภาวะขาดเลือด จากการ รักษาพบว่าผู้ป่วยจำนวน 25 ราย ผู้ป่วยทั้งหมดหายจากอาการของโรคคือ ตาโปน ตาแดง และฟังได้ยินเสียงฟู่ในหู และจากการติดตามตรวจรังสีเส้นเลือดสมองผู้ป่วย 18 รายจาก 23 ราย ที่ผ่าตัดเปิดโพรงเลือดดำ cavernous เพื่ออุดรูรั่ว พบว่าสามารถรักษาการไหลเวียนเลือดผ่านหลอดเลือดแดงแคโรติดได้ 8 ราย มีการอุดตันของหลอดเลือดแดงแคโรติด 5 ราย ผู้ป่วยอีก 3 รายจำเป็นต้องทำหัตถการอุดหลอดเลือดแดงแคโรติดเนื่องจากยังมีอาการหลังผ่าตัดเปิดกะโหลกศีรษะเพื่ออุดรอยรั่วในโพรงเลือดดำ cavernous

สรุป: การรักษาโรค traumatic carotid-cavernous fistula ที่เป็นมาตรฐานในปัจจุบันคือการใช้วิธีทางรังสีรักษาโดยการอุดรูรั่วด้วยลูกโป่งผ่านทางหลอดเลือดแดงใหญ่ ปัจจุบันยังสามารถอุดรูรั่วผ่านทางหลอดเลือดดำหรือโพรงเลือดดำที่ต่อกับโพรง cavernous ได้แต่ในรายที่มีความซับซ้อนจากเหตุต่าง ๆ ส่วนการผ่าตัดเป็นการรักษาอีกวิธีหนึ่งซึ่งทำให้อาการจากรอยรั่วผิดปกตินั้นหายไป และอาจช่วยในการรักษาการไหลเวียนเลือดในสมองให้ใกล้เคียงภาวะปกติได้