

## Original Article

# Application of stent-graft is the optimal therapy for traumatic internal carotid artery pseudoaneurysms

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**Abstract:** Background: Traumatic pseudoaneurysm of the internal carotid artery (ICA) is an uncommon but serious complication, and difficult to repair surgically. Minimally invasive endovascular treatment of traumatic injuries of the ICA with a stent graft has become increasingly popular over the past decade. The efficacy of the stent graft appears satisfactory, but most if not all reported studies have involved small patient cohorts (less than 10) with short follow-up periods (less than 3 years). Methods: In this prospective study, 13 patients with traumatic pseudoaneurysm of the ICA were recruited from June 2008 to June 2012. All the patients were examined using whole-brain cerebral angiography and followed up for as long as five years. Willis intracranial vascular stent grafts, manufactured by Shanghai Microport, were chosen as embolism material. Results: All 13 patients achieved good clinical outcome. Pseudoaneurysm recurred in one patient and this patient was treated by balloon occlusion of the parent artery. No patient suffered recurrent bleeding or death. Conclusion: Based on the outcomes of this relatively large cohort and long follow-up period, we believe that stent graft is an optimal therapy for patients with traumatic pseudoaneurysms of the ICA.

**Keywords:** Pseudoaneurysms, endovascular therapy, stent-graft, trauma, internal carotid artery

## Introduction

A pseudoaneurysm forms as the result of a leaking hole in an artery. While contained by surrounding tissues, it still communicates with the artery [1]. This can occur at any artery in the body [2, 3]. Two major causes of pseudoaneurysm are catheterization and trauma [4, 5]. In the adult population, traumatic pseudoaneurysm of the internal carotid artery (ICA) is rare and accounts for less than 1% of all cerebral aneurysms [6, 7]. However, complications can be disastrous and may include regrowth, ischemia, compression symptoms, thromboembolism, or eventually, rupture [8]. Therefore, early diagnosis and optimal treatment of traumatic pseudoaneurysms of the ICA is quite important.

Many options exist for the treatment of pseudoaneurysms, and in the past surgery was the gold standard. Several less invasive treatment options are more popular today, including cov-

ered stent, ultrasound probe compression, and ultrasound-guided thrombin injection [9-11]. However, these new treatments, especially covered stent, are still not universally accepted.

A stent graft is a tube of fabric supported by metal mesh, which can support weak points in blood vessels and keep blood flow unobstructed [11, 12]. Recently, stent grafts have been used in the treatment of traumatic pseudoaneurysms of the ICA. By placing stent grafts across the hole of an ICA pseudoaneurysm, we can thrombose the pseudoaneurysm immediately and simultaneously preserve or reconstruct the parent vessel. Although studies have supported the safety and efficacy of stent grafts for treating traumatic pseudoaneurysms of the ICA, they have been limited by small cohorts and short follow-up periods [8, 13, 14].

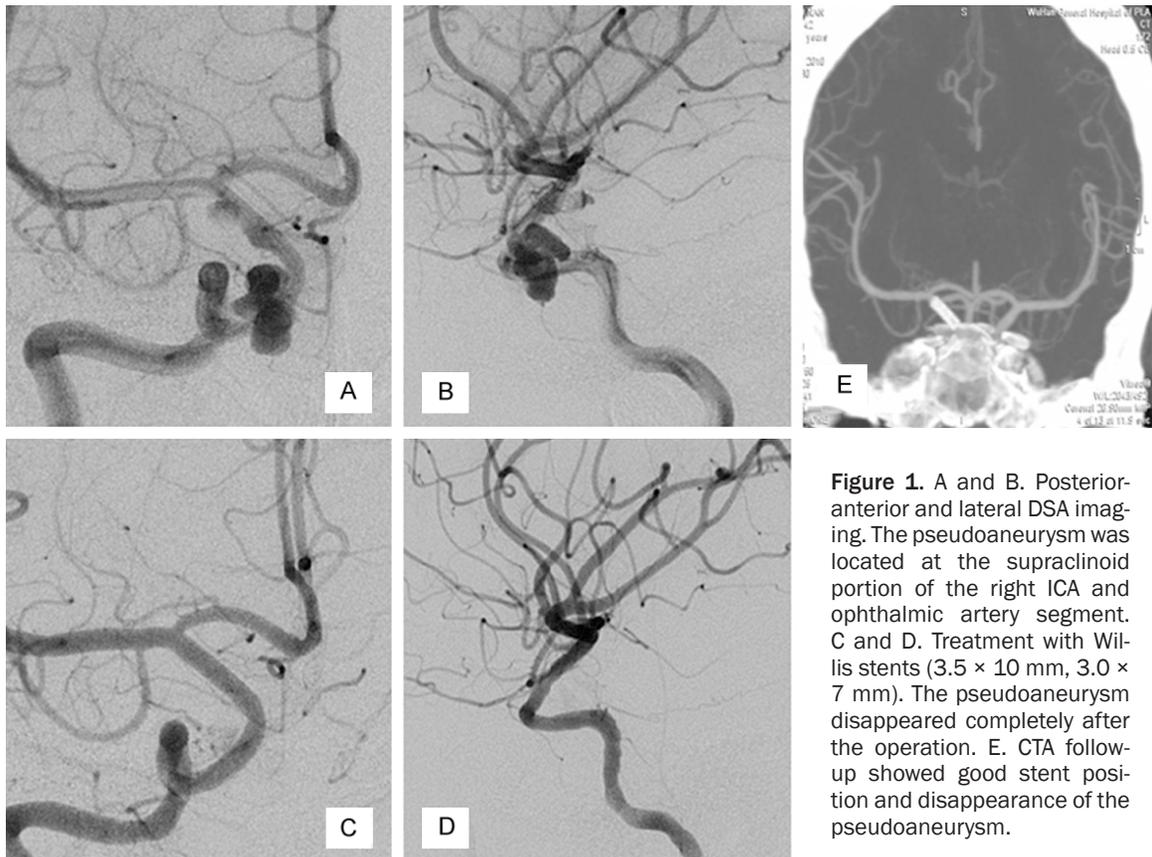
Herein, we describe 13 patients with traumatic pseudoaneurysms of the ICA treated by stent graft and their five-year follow-up.

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**Table 1.** Summary of the information and outcomes from 13 patients\*

Case	Age, y	Gender	Cause of injury	Outcome	Follow-up (months)
1	37	M	Traffic accident	Without pseudoaneurysm development at 12 months	12
2	38	M	Traffic accident	Without pseudoaneurysm development at 24 months	24
3	15	F	Fall from third floor	Multiple pseudoaneurysm stable at 24 months	24
4	30	M	Traffic accident	Multiple pseudoaneurysm stable at 36 months	36
5	28	M	Fall from second floor	Without pseudoaneurysm development at 30 months	30
6	6	F	Fall from standing position	Stable at 15 months	15
7	30	M	Traffic accident	Without pseudoaneurysm development at 48 months	48
8	29	M	Beaten with heavy object	Without pseudoaneurysm development at 3 months	3
9	38	M	Traffic accident	Stable at 30 months	30
10	19	M	Traffic accident	Without pseudoaneurysm development at 12 months	12
11	16	M	Traffic accident	Without pseudoaneurysm development at 6 months	6
12	20	M	Stabbing wounds	Without pseudoaneurysm development at 36 months	36
13	30	M	Beaten with beer bottle	Stable at 18 months	18

\*Pseudoaneurysms were located in the ICA in all cases.



**Figure 1.** A and B. Posterior-anterior and lateral DSA imaging. The pseudoaneurysm was located at the supraclinoid portion of the right ICA and ophthalmic artery segment. C and D. Treatment with Willis stents (3.5 × 10 mm, 3.0 × 7 mm). The pseudoaneurysm disappeared completely after the operation. E. CTA follow-up showed good stent position and disappearance of the pseudoaneurysm.

### Materials and methods

#### Study subjects

In this prospective study, 13 patients (11 males) with traumatic pseudoaneurysm of the ICA

were recruited from June 2008 to June 2012 (Table 1). Their ages ranged from 15 to 38 years with an average of 28.9 years. All diagnoses were based on solid clinical presentation and images. In all cases, the time from injury to pseudoaneurysm development is between 3

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**Figure 2.** Imaging of the pseudoaneurysm before and during treatment, and at follow-up. A. CTA indicated traumatic ICA pseudoaneurysm. B. DSA-lateral showed that the Willis stent accurately covered the pseudoaneurysm. C. One week after the operation, CTA showed complete occlusion of the pseudoaneurysm with good stent position and shape. D. Three months after the operation, CTA indicated that the position of the Willis stent graft was good and the pseudoaneurysm disappeared.

hours to 48 hours. The Ethics Committee of Wuhan General Hospital of Guangzhou Command reviewed and approved this study. All patients agreed to participate in this study and provided a signed informed consent form.

### *Clinical manifestations*

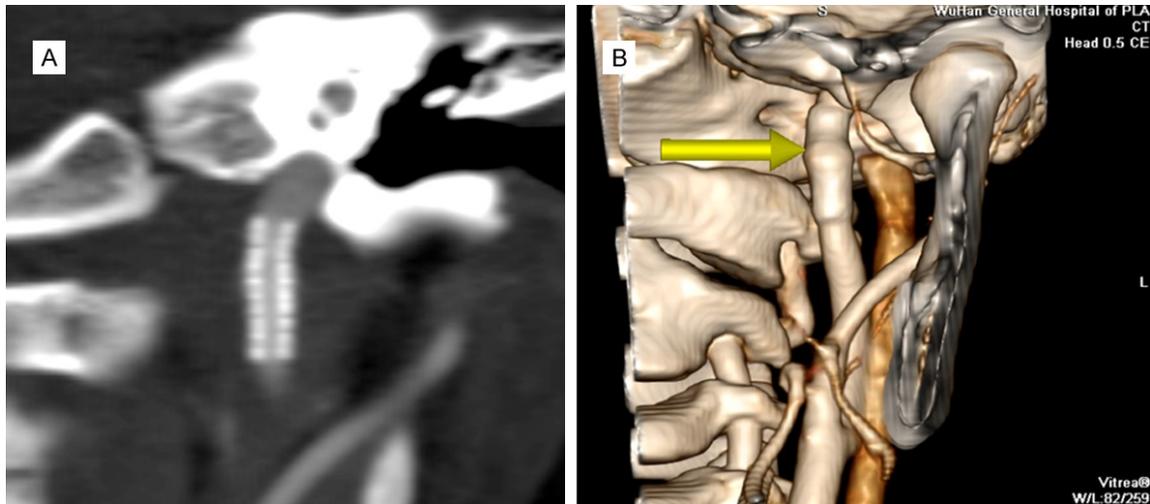
All the 13 patients had definite head and neck trauma. Five had repeated excessive epistaxis, which is not due to issues of *external carotid*

*branch in our study*, 4 suffered from headache and subarachnoid hemorrhage, 1 had intracranial hematoma, 2 developed intracranial vascular murmur, and 1 had a local pulsatile mass that continued to enlarge. GCS Scores are from 7 to 14.

### *Radiographic inspection*

All the patients underwent digital subtraction angiography (DSA). In 2, 3, 3, and 6 cases the

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**Figure 3.** Representative CTA images 15 months after surgery.

ICA pseudoaneurysms were in the internal carotid petrous, cavernous, ophthalmic, and communicating segments, respectively. There were 2 cases of multiple ICA pseudoaneurysms, 2 with internal carotid cavernous sinus fistula, and one with an ICA dissecting aneurysm.

### *Treatment*

All the patients were inspected using whole-brain cerebral angiography to study the site, size, shape, and relationship with the parent artery of the pseudoaneurysm and the collateral circulation of the circle of Willis. Based on these images, endovascular interventional treatments were determined and performed. Willis intracranial vascular stent grafts, manufactured by Shanghai Microport, were chosen as embolism material.

After interventional treatment, all patients routinely took clopidogrel bisulfate (Plavix) for 6 months (75 mg per day) and aspirin for 12 months (100 mg per day). At months 1, 3, 6, and 12 of the treatment course, coagulation and platelet activation were measured and the drug dose was adjusted accordingly.

### **Results**

#### *General patient outcomes*

All 13 patients underwent stent graft treatment (**Table 1**), but one patient was administered a parental artery balloon occlusion due to a huge ICA pseudoaneurysm and the absence of an

appropriately sized stent graft. The remaining 12 patients were cured by stent graft and maintained a stable condition. Several patients were followed up by DSA and computed tomography angiogram (CTA). The stent graft was shown to be normal in shape and position in all patients. The artery previously bearing the pseudoaneurysm was patent, and the previous pseudoaneurysm had disappeared. The follow-up period for several patients lasted 4 years.

#### *Detailed presentation of two patients from diagnosis to cure*

One patient showed pseudoaneurysm at the supraclinoid portion of the right ICA and the ophthalmic artery segment (**Figure 1**). Willis stent grafts were applied in this case and the pseudoaneurysm completely disappeared after the operation. After two months, at follow-up the stent was positioned well, without pseudoaneurysm.

For another patient we successfully covered the pseudoaneurysm using a Willis stent graft. One week after the surgery, the pseudoaneurysm was blocked and the stent was in good position and shape. This patient was followed for 15 months. The CTA showed that the Willis stent graft was well positioned and the pseudoaneurysm was gone (**Figures 2 and 3**)

### **Discussion**

Traumatic ICA pseudoaneurysm is an uncommon disease and diagnosis is often delayed.

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Nevertheless, at times there are severe complications [14-18]. In the past, surgery was the gold standard treatment for traumatic ICA pseudoaneurysm, but current management strategies are controversial, including endovascular treatment with covered stents. The results of all reported cases highly suggest that the stent graft is the optimal therapy for traumatic ICA pseudoaneurysms, but the number of treated patients in each study have been relatively small and the follow-up periods have been short [14-18]. Here, we summarize our results for 13 patients who were followed for up to four years. Consistent with previous reports, our results clearly show that patients with traumatic ICA pseudoaneurysms can be successfully treated by stent graft and sustain good long-term outcomes. The information provided here has significance for the clinical management of patients with traumatic ICA pseudoaneurysms.

In 1998, two groups reported the first successful treatment of traumatic extracranial ICA pseudoaneurysms using polytetrafluoroethylene (PTFE) or autologous vein-covered stents [19, 20]. Subsequent studies of the treatment of traumatic ICA pseudoaneurysms with covered stents or stent grafts have been mainly case reports with few patients [14-18]. Although almost all the reported cases showed positive results with the application of stent grafts, the overall number is still very limited. In addition, more than 43 cases of traumatic ICA pseudoaneurysms have been treated with various covered stents [14, 21-23] but in almost all the follow-up time was less than two years. In our study, the follow-up time in five patients was more than 2 years and up to four years (The median is 24 months and the range is 45 months) (**Table 1**). Therefore, our results are a valuable contribution toward information regarding the application of stent graft for treatment of traumatic ICA pseudoaneurysms.

A recent report concerning the treatment of traumatic ICA pseudoaneurysms also had a relatively large number of patients [8], in which 14 pseudoaneurysms were treated in 13 patients. The initial angiographic results showed complete exclusion in 9 patients and incomplete exclusion in 4, and the follow-up angiographic findings revealed complete exclusion in 12 patients and an incomplete exclusion in 1 patient. At the end of follow-up, all patients had demonstrated patency of the ICA.

Among the 13 patients in our study, a pseudoaneurysm recurred in one patient, and this patient was treated by balloon occlusion of the parent artery. The remaining 12 patients were cured by stent grafts. Postoperative DSA indicated a disappearing pseudoaneurysm in 11 patients. Another pseudoaneurysm developed after release of the stent graft, and showed no change on repeated angiography after 2 days. Hence after the strict balloon occlusion test, the aneurysm and parental artery were occluded simultaneously. Taken together, more than 80% of the patients with traumatic ICA pseudoaneurysm were treated successfully with one application of the stent graft. Our results clearly show that stent graft is an optimal therapy for traumatic ICA pseudoaneurysms.

### Disclosure of conflict of interest

None.

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