Use of a new low-profile coronary stent graft for the treatment of intracranial carotid blow-out

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INTRODUCTION

Stent graft placement is the most effective endovascular method for the treatment of vascular injuries while preserving arterial patency. However, issues with long-term patency of the stent graft as well as navigation issues in tortuous arterial anatomy preclude the widespread use of these devices particularly in the intracranial circulation. We present the endovascular treatment of a patient with carotid blowout using the latest-generation coronary stent graft, which has been used only for the treatment of extracranial endovascular treatments to date.

Carotid Blowout Syndrome (CBS) refers to a variety of clinical conditions leading to massive hemorrhage of the carotid arteries, necessitating prompt recognition and intervention due to the associated high mortality and morbidity. CBS is categorized into three types based on clinical progression: threatened, impending, and acute carotid hemorrhage. Threatened CBS presents with the carotid artery exposed to the outside through a skin defect. Impending CBS typically involves a past period of...
spontaneous bleeding with an underlying pseudoaneurysm. Early detection of impending CBS is crucial, since acute carotid hemorrhage is the most challenging clinical setting to control, with a significant risk factor being a history of radiation therapy and surgery. Patients with impending CBS often present with transient transcervical and transoral bleeding, hemoptysis, bleeding from the tracheostomy site, epistaxis, otorrhagia, bleeding neck mass, acute airway obstruction, or hematemesis. For patients with a suspected clinical diagnosis of impending CBS, a thorough examination of the head and neck region is essential. A head and neck computed tomography (CT) angiogram should be performed to identify necrosis, pseudoaneurysm, and contrast extravasation.\(^1\)\(^2\) Due to the grim prognosis and acute presentation of CBS, it is imperative that in acute cases and, as in our case, impending CBS, either a deconstructive approach or an endovascular approach aimed at treating the diseased arterial segment—not only the saccular component—is necessary. Such an endovascular strategy entails the use of intracranial stent grafts.

Stent grafts have been initially used for coronary lesions, particularly in coronary artery perforations (CAP), a serious complication of percutaneous coronary intervention (PCI). They have significantly improved the prognosis of CAP, reducing death rates, cardiac tamponade, and the need for emergency surgery. The PK Papyrus stent graft (BIOTRONIK, Bulach, Switzerland) has improved the safety and feasibility of coronary applications as it has a smaller profile than older coronary stent grafts. Since it is relatively new, data on its performance and long-term outcomes are currently limited.\(^3\)

To date, successful off-label use of the PK Papyrus stent graft for noncoronary pathologies has been reported in limited cases of visceral aneurysms as well as neurovascular lesions such as carotid artery cervical segment traumatic injuries. Our case represents the first report of successful endovascular embolization of an internal carotid artery pseudoaneurysm using the PK Papyrus stent graft, beyond the petrous segment, extending intradurally.

### CASE DESCRIPTION

A 50-year-old male with a history of transcranial surgery and subsequent radiotherapy for a pituitary adenoma presented to our emergency department with recurrent pulsatile nasal bleeding. On New Year’s Eve, 3 months before admission, he was awakened with a “pop” in his head and noted profuse bleeding from his nose, which recurred over 3 months, resulting in 8 emergency hospital admissions. He was repetitively treated with nasal packing, explored endoscopically, and transfused for decreased hemoglobin levels (decreasing to levels as low as 6-7 g/dL). During the last admission, after endoscopic exploration, a CT angiogram of the head was obtained and showed no evidence of active extravasation or a pseudoaneurysm. A cerebral angiogram demonstrated a right internal carotid artery (ICA) pseudoaneurysm of the cavernous segment (Fig. 1A, B). Subsequently, a balloon occlusion test was performed, but the patient did not tolerate ipsilateral carotid occlusion. An emergent multidisciplinary decision was made to treat the patient with a stent graft to promptly and effectively minimize the risk of re-rupture (i.e., to avoid intrasaccular manipulation of the pseudoaneurysm and the risk of recurrent hemorrhage after the procedure), a risk that is known to be associated with flow diverters in this setting.\(^1\)\(^2\)

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ophthalmic artery (Fig. 1D, E). To prevent thrombotic complications, a bolus dose of tirofiban (0.85 mg) was injected intravenously over 5 minutes after stent deployment, followed by a 0.075 mg/hour infusion. As the pseudoaneurysm demonstrated faint residual opacification, a 5 mm coronary angioplasty balloon (Apollo,
Schnell Medical, Switzerland) was used to perform post dilatation. At the end of the procedure, anticoagulation was completely reversed with protamine sulfate. The patient was awakened from general anesthesia and 60 mg of prasugrel was administered at 6 hours, the tirofiban infusion was then stopped. A multiplate test (Roche) at 48 hours showed hyperresponsiveness to prasugrel, so the patient was switched to 75 mg clopidogrel and 300 mg aspirin daily. The patient was discharged two weeks after the operation. One week, 3-month and 7-month follow-up cerebral angiograms all revealed no evidence of a residual aneurysm and patency of the internal carotid artery (Fig. 1F–H).

**DISCUSSION**

An intracranial pseudoaneurysm is a life-threatening condition due to the associated high risk of intracranial or nasopharyngeal bleeding. Pseudoaneurysms commonly result from trauma, iatrogenic causes, or arterial invasion by head and neck tumors.\(^\text{11}\) In our patient, a history of pituitary surgery and radiotherapy were among the predisposing factors. Commonly, there is no definable neck in pseudoaneurysms, and clipping is frequently not possible.\(^\text{14}\)

The treatment options for internal carotid artery pseudoaneurysms are either reconstructive or deconstructive. Deconstructive treatment options include parent artery sacrifice using coils or detachable balloons, while reconstructive treatment options are endovascular embolization with flow diverter stents or stent grafts. Parent artery occlusion is not the first-line endovascular treatment option due to significant risks such as stroke, infection, and peri-procedural death. However, it may be preferred over unsuccessful reconstructive treatment attempts in patients with documented sufficient collateral circulation during a balloon occlusion test.\(^\text{19}\)

Although endovascular embolization with stent grafts seems to be the definitive treatment of internal carotid artery pseudoaneurysms, it should be noted that the rigidity of the stent graft presents a challenge for the navigation of the system to the cavernous or supraclinoid segments, especially in cases with tortuous carotid siphons.

Chen et al. reported successful endovascular treatment of 6 cases with cavernous ICA injury with parent artery occlusion or coil embolization of the pseudoaneurysm with no clinical complication.\(^\text{3}\) Contrary to the stent grafts, flow diverter stents require a period of time to achieve complete occlusion of the pseudoaneurysm, and there still remains a risk of hemorrhage during that time period. In another case series, comprising 18 patients with internal carotid artery pseudoaneurysms, Chen et al. treated them with flow diverter stents. They achieved a complete obliteration rate of 78%, and 11% of the cases needed re-treatment.\(^\text{4}\)

Although parent artery occlusion after balloon test occlusion is technically easy and very effective\(^\text{19}\) our patient did not tolerate the test occlusion. Among the remaining endovascular treatment options are stent-assisted coiling, flow diversion and stent graft placement. It is known that excluding the defect in the vessel wall with a stent graft is a fast and reliable endovascular treatment method.\(^\text{6,17,19}\) On the other hand, flow diverters may be advantageous over stent grafts due to their navigability and pushability in tortuous arteries. In addition, the flow diverting stent is superior to the stent graft in the preservation of side branches such as the posterior communicating, ophthalmic, or anterior choroidal arteries.\(^\text{9}\) However, in carotid blowout, the immediate efficacy of flow diversion is lower than that of the stent graft and some authors suggest that flow diverters are to be avoided in this situation.\(^\text{17}\)

Significant perforator branches and major end arteries (such as the fetal-type PCA, PICA, anterior spinal artery, anterior choroidal artery) should be avoided, to the extent possible, during covered stent placement.\(^\text{19}\) It is likely preferable to protect other arteries as well, which have potentially robust distal collateral supply such as the ophthalmic artery or the hypoplastic variants of Pcom. Generally, patients tolerate the occlusion of the origin of these latter arteries acceptably well; however, respecting the patency of these arteries will minimize the risk of thromboembolic phenomena. Touze et
al. observed clinical complications such as transient visual symptoms (amaurosis fugax) and subclinical abnormalities (visual field defects) during follow-up after endovascular treatment of internal carotid artery ophthalmic segment aneurysms with flow diverter stents.\textsuperscript{16} Griessenauer et al. reported the clinical results of 160 ophthalmic segment aneurysms treated with flow diverter stents, finding that occlusion of the OA occurred in 7.1\% of the patients, whereas permanent morbidity occurred in only 3.1\% of the patients. Consequently, in our case, the ophthalmic artery origin was preserved to avoid these potential complications.\textsuperscript{8} One other option for our case would be the Willis stent graft (Microport Medical, Shanghai, China), which is dedicated to neurovascular applications, yet it is unavailable to us and many other countries.\textsuperscript{12,13} Although coronary stent grafts had been used frequently for intracranial aneurysms, pseudoaneurysms, and vascular injuries in the absence of flow diversion about 20 years ago, the unavailability of fast-acting parenteral antiplatelet medications and platelet reactivity testing at that time precluded their use for most of the acutely presenting patients. Other factors contributing to the fading enthusiasm for the stent grafts were the rigidity of the devices and the absence of distal access catheters at that time.

Although the Papyrus stent is relatively easy to navigate intracranially compared to higher-profile devices, navigating the distal access catheter distal to the arterial lesion may not always be straightforward. It may be necessary to ensure a higher technical success rate and deliverability by using multiaxial catheter systems (i.e., the sheath-6F distal catheter-4F inner distal access catheter and microcatheter system used in our case).

Although the Papyrus stent graft was manufactured for the coronary circulation,\textsuperscript{14} its use has also been reported in cervical\textsuperscript{9} and visceral arteries with small arterial diameters and tortuous arteries because it has a small profile (goes through 5F distal access catheters) and is flexible.\textsuperscript{10} Use of this stent graft in the intracranial circulation has not been reported in the literature previously. However, considering the paucity of endovascular options or devices for acute arterial injury in the intracranial circulation, it may become indispensable in selected cases. The advent of distal access catheters has revolutionized the endovascular treatment of acute ischemic stroke as well as flow diversion.\textsuperscript{15} We surmise that the availability of these catheters will be of critical value for the utility of new-generation, more flexible stent grafts for the treatment of acute intracranial arterial injury.

\section*{CONCLUSIONS}

The Papyrus stent graft was manufactured for use in tortuous arterial anatomy and through smaller guiding catheters compared to the older versions of stent grafts. The developments in intracranial access products and in the ability to evaluate the antiplatelet response of patients may favorably address the concerns of navigability and long-term patency of stent grafts, including the Papyrus stent. As such, it may provide a viable option in the treatment of acutely symptomatic intracranial dissecting aneurysms or pseudoaneurysms as well as the elective treatment of very large or giant aneurysms in which concerns exist for postoperative delayed rupture.

\section*{Disclosure}

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

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