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Treatment of ruptured blood blister-like aneurysms of the internal carotid artery with flow-diverting stents: Case report and review of pharmacological management

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ABSTRACT

Background: Rupture of a blood-blister like aneurysm (BBLA) of the internal carotid artery (ICA) is a rare etiology of subarachnoid hemorrhage (SAH). Historically, BBLAs have been difficult to treat. Open surgical clipping and endovascular coiling techniques have both had high rates of failure. Recently, flow-diverting stents (FDS) have been used to treat BBLAs with success, but concerns exist regarding the need for dual anti-platelet therapy, the delayed occlusion of the aneurysm that occurs with flow-diversion, and the potential difficulty of treating cerebral vasospasm and hydrocephalus.

Methods: Clinical data and imaging from the index case were reviewed, and a systematic review of the medical literature was performed. Medical databases including PubMed and Medline were searched using multiple combinations of keywords. The bibliographies of each result were then used to identify additional publications. Only English language case reports of ruptured, intracranial ICA blood blister-like aneurysms treated exclusively with flow-diverting stents were included.

Results: Given the results from our literature search and this patient's characteristics, we chose to treat her ruptured BBLA with a FDS. Although the FDS was deployed successfully, her clinical course was complicated by cerebral vasospasm, which was managed with induced hypertension. Subsequently, she developed hydrocephalus and underwent successful placement of a ventriculoperitoneal shunt while on dual antiplatelet therapy, which was briefly held. She had no operative complications and made an excellent recovery. Follow-up angiography performed at 3 and 6 months confirmed total occlusion of the aneurysm.

Conclusions: A literature review revealed numerous successful treatments of ruptured BBLA with FDS monotherapy. A variety of different pharmacological treatment adjuncts were used; oral aspirin and clopidogrel being the most common. Overall, patients with ruptured BBLAs of the ICA treated only with FDS monotherapy had superior outcomes when compared to patients with ruptured BBLAs treated with open microsurgical clipping or endovascular coiling alone.

1. Introduction

Blood blister-like aneurysms (BBLAs) of the internal carotid artery (ICA) are an uncommon cause of subarachnoid hemorrhage (SAH). They are identified by their dome-like shape, their origin away from a branch point, and their dorsal projection [36]. The fragility of the vessel wall in the area of the aneurysm presents special challenges for open surgical clip reconstruction techniques as the ICA may tear during manipulation requiring vessel sacrifice [1]. Even with successful clip ligation or wrapping, the aneurysm may recur with the need for further procedures [2]. Coil embolization with and without stent-assistance also has a high failure rate secondary to intraoperative rupture or

Abbreviations: ACT, activated clotting time; ADL, activities of daily living; ASA, aspirin; BBLA, blood blister-like aneurysm; CLO, clopidogrel; CT, computed tomography; DSA, digital subtraction angiography; DAT, dual anti-platelet therapy; EEG, electroencephalography; EVD, external ventricular drain; F, fisher score; FDS, flow-diverting stent; HH, Hunt Hess score; ICA, internal carotid artery; ICP, intracranial pressure; IPH, intraparenchymal hemorrhage; mo, month; mRS, modified rankin scale; MR, magnetic resonance; Neuro, neurological; SAC, stent-assisted coiling; SAH, subarachnoid hemorrhage; SSEP, somatosensory evoked potentials; TIC, ticagrelor; Unk, unknown; VP, ventriculoperitoneal

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aneurysm recurrence [3].

Recently, flow-diverting stents (FDS) have provided a novel way to treat these lesions by providing a scaffold for the vessel to heal while causing the aneurysm to thrombose [1, 3, 4–20]. Aneurysm occlusion, however, typically occurs in a delayed fashion during which time the patient is maintained on dual antiplatelet therapy to prevent thrombosis or embolization. Delayed aneurysm occlusion and the need for dual anti-platelet therapy raise concerns in the setting of a ruptured aneurysm and SAH. In addition, cerebral vasospasm, a relatively common occurrence following SAH, is typically treated with induced hypertension, which may be risky in the setting of an unsecured aneurysm. Hydrocephalus is also a common occurrence following SAH and may require a surgical procedure for treatment in the setting of dual anti-platelet therapy. We describe a case in which all of these clinical problems were encountered and successfully managed. Furthermore, we review the current literature on treatment of BBLAs with FDS with regard to outcome, complications, and pharmacological management.

2. Methods

We reviewed the chart of our patient after receiving consent. We also reviewed the literature on treatment of BBLAs with flow-diverting stents and by other methods. Specifically, medical databases including PubMed and Medline were searched using the following terms: “ruptured,” “blister,” “aneurysm,” and “endovascular.” We reviewed the bibliographies of each result to identify additional publications and continued this method of research until the process was exhausted. Only English language case reports of ruptured, intracranial ICA blood blister-like aneurysms treated exclusively with flow-diverting stents were included (Table 1). Patients treated with a FDS in conjunction with open surgery, stenting, coiling, or vascular bypass surgery were not included in this study.

3. Case description

A 45-year old woman with no past medical history presented with a severe headache and hypotension after being found unresponsive by her family (Hunt and Hess grade 4). A computed tomography (CT) head scan revealed diffuse, thick SAH (Fisher grade 3) (Fig. 1A). CT angiography of the head suggested a small, wide-necked, superiorly projecting aneurysm of the distal right paraophthalmic segment of the ICA. Digital subtraction angiography (DSA) confirmed a ruptured 2.5 mm × 2.5 mm × 2.5 mm BBLA of the right ICA (Fig. 1B).

On post-bleed day 3, the patient was brought to the angiography suite, and after induction of general anesthesia, she was given 650 mg aspirin and 180 mg of ticagrelor via a nasogastric tube. She was set up for somatosensory evoked potentials (SSEP) and electroencephalography (EEG) monitoring throughout the case. After confirmation of the aneurysm with standard angiography, a coaxial system of a Neuron Max 088 catheter (Penumbra, Inc., Alameda, CA) and a Navien 058 catheter (Medtronic, Inc., Minneapolis MN) was used to access the right ICA. The patient was bolused with intravenous heparin (70 units/kg) and the activated clotting time (ACT) was maintained at twice control. The patient was then given a single loading dose of 180 μg/kg eptifibatide (Merck & Co., Inc., Kenilworth, NJ), and an infusion was started at 2 μg/kg/min for 10 min prior to deployment of the flow-diverting stent.

Under roadmap views, a Marksman catheter (Medtronic, Inc.) was used to deliver a 4.25 × 12 mm Pipeline Flex FDS (Medtronic, Inc.). Excellent placement of the stent was seen across the aneurysm with good apposition to the carotid artery wall (Fig. 2). SSEP and EEG monitoring remained stable at baseline. The femoral artery sheath was secured and left in place while the eptifibatide drip was continued for 12 h and the effects of the heparin wore off. The sheath was then removed without difficulty. Forty-eight hours after the procedure, platelet response testing (VerifyNow, Accriva Diagnostics, Inc., Bedford, MA) was used to document adequate response to aspirin and ticagrelor (Aspirin response < 500, P2Y12 response < 194).

On post-bleed day 7, the patient developed vasospasm on CT angiography and transcranial Doppler (Fig. 3A). She was treated with induced hypertension to keep systolic blood pressure between 160 and 200 mm Hg for approximately 7 days. CT angiography at this time also demonstrated that the aneurysm had not yet occluded (Fig. 3A). In fact, it appeared to have slightly enlarged. Following a 21-day course in the hospital, the patient was discharged home with no neurological deficits.

She was followed up in clinic approximately 10 days after the discharge (post op day 28) for complaints of visual obscurations and mild lethargy. A non-contrast CT scan demonstrated hydrocephalus (Fig. 3B). Two doses of ticagrelor were held, and she underwent placement of a ventriculoperitoneal (VP) shunt without complication on post op day 30). She was again seen at a 6-month post-operative visit, and she was neurologically intact. Follow-up magnetic resonance (MR) angiography and DSA at that time showed occlusion of her right ICA blister aneurysm with no evidence of residual or recurrent aneurysm (Fig. 4).

4. Discussion

Blood blister-like aneurysms (BBLA) are small, wide neck lesions created from defects in the vascular wall, most commonly on distal unbranched segments of the ICA [11]. Disruption of the internal elastic lamina and media of the vascular wall lead to aneurysmal outpouchings separated from the subarachnoid space by only a thin layer of blood clot and adventitia [17]. BBLA domes lack collagen in the wall, leading to a weak, fragile aneurysm not well-suited to typical microsurgical or endovascular treatments [2]. BBLAs are an uncommon etiology of aneurysmal subarachnoid hemorrhage, accounting for < 2% of ruptured intracranial aneurysms [3, 22]. When SAH is discovered on routine CT head, it is not uncommon for the initial CT angiogram, MR angiogram, or even DSA to miss a BBLA, prompting a second DSA study if clinical suspicion is high [12, 23]. Microsurgical treatments of BBLA have traditionally been challenging and associated with poor outcomes given the high rate of intra-operative rupture and parent vessel damage [13, 24]. Conventional coiling or stent-assisted coiling (SAC) of a ruptured BBLA has also led to many complications, including intra-operative aneurysm rupture given the weak non-collagenous aneurysm wall and embolization of coil material given the wide neck of the aneurysm [3].

Flow-diverting stents (FDS) offer a new way to treat ruptured BBLA, as this technology allows endoluminal reconstruction of the parent vessel without entering the weak aneurysm dome [3]. A FDS commonly used in the United States is the Pipeline Embolization Device (Medtronic, Inc.). It is a flexible construct composed of cobalt, chromium, and platinum that provides 30–35% metal surface coverage area inside of a vessel [25]. Reconstruction of the parent vessel begins from the moment the FDS is deployed. Although a FDS is a porous construct, the inflow of blood into the aneurysm is reduced due to physical obstruction from the stent itself. Over a period of days to weeks, the aneurysm begins to thrombose, with eventual endothelialization of the parent vessel, thus completely excluding the aneurysm from the circulation [26]. Registries and trials of the Pipeline device demonstrated an occlusion rate of 74% at 6 months and almost 90% at 1-year post-embolization [27].

The Pipeline FDS has been approved by the United States Food and Drug Administration for unruptured aneurysms since 2011. On-label uses include the treatment of large, wide-necked aneurysms of the cavernous and ophthalmic segments of the internal carotid artery. Treatment of BBLAs with Pipeline is off-label and published experience is limited for this indication [25]. Although a FDS may seem to be an ideal way to treat a ruptured BBLA, there are many factors to consider, including the risk of rebleeding as aneurysm occlusion does not occur immediately. Furthermore, the need for dual antiplatelet therapy in the