CASE REPORT

Recanalization of acute carotid stent occlusion using Penumbra 4Max aspiration catheter: technical report and review of rescue strategies for acute carotid stent occlusion

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SUMMARY

Carotid artery stenting (CAS) has become a widely used treatment for carotid artery stenosis, especially in high-risk patients. Acute in-stent and distal protection device occlusion are potentially catastrophic complications of this procedure. Previously described rescue strategies have included administration of antiplatelet agents (eg, abciximab) with/without thrombolytics and removal of the filter. Here we describe the successful resolution of in-stent occlusion by mechanical thrombolysis using the Penumbra 4Max aspiration catheter. Distal flow was subsequently restored with minimal residual stenosis. The patient did not suffer any consequent neurological deficits. The different strategies that could be used in this critical situation are reviewed.

BACKGROUND

Carotid artery stenting (CAS) has become widely employed for the treatment of carotid artery stenosis, particularly in patients considered to have a high surgical risk.¹ Intraoperative in-stent or distal protection device occlusion may result in flow arrest and are recognized potential complications of CAS, with in-stent occlusion occurring in 0.5–2% of cases^{2–3} and distal protection device occlusion occurring in up to 30% of cases.^{4–6}

Administration of antiplatelet agents such as abciximab (glycoprotein IIb/IIIa antagonist) has recently been reported as an effective intervention in the setting of acute in-stent thrombosis.² Successful revascularization of acute stent thrombosis with ‘combined thrombolysis and dethrombolysis’ using locally administered intra-arterial tissue plasminogen activator (tPA), abciximab and heparin has been described.⁷ However, the literature remains sparse on effective and reliable treatment strategies should antiplatelet therapy fail. Open surgical thrombectomy and removal of the occluded stent may be an effective option for revascularization—albeit a significantly more invasive and less desirable one.⁸ In cases of distal protection device occlusion, a simple strategy to re-establish flow could be to retrieve the device. However, retrieval of the distal protection device could lead to thromboembolic complications attributed to release of embolic material within the device during retrieval.⁶

We present a case in which acute intraoperative in-stent thrombosis resistant to antiplatelet administration was successfully treated with mechanical thrombolysis using the Penumbra 4Max aspiration catheter (Penumbra, Alameda, California, USA). In addition, we review potential strategies in case of acute in-stent or distal protection device.

CASE PRESENTATION

A septuagenarian patient with hypertension and a prior history of oropharyngeal cancer treated with neck radiation presented to our institution with acute onset of slurred speech and right-sided hemiplegia. CT angiography of the neck showed approximately 90% stenosis of the left internal carotid artery (ICA) at the level of the cervical carotid bifurcation (figure 1). MRI of the brain could not be performed because the patient had a pacemaker. The cerebral blood volume component of the CT perfusion was consistent with a small left temporoparietal infarct (figure 2). Given the patient’s history of prior radiation to the mouth and neck, it was decided that carotid artery stenting would be a better option than carotid endarterectomy.

The procedure was performed on post-stroke day 3 following administration of 600 mg clopidogrel and 650 mg aspirin on the day prior to the procedure. Since the patient was agitated, the procedure was performed under general endotracheal anesthesia. After a diagnostic angiogram confirmed 90% left carotid stenosis (figure 3), the 6 Fr sheath and 5 Fr diagnostic catheter were exchanged for a Neuron Max guide catheter (Penumbra) which was positioned in the left common carotid artery. At this point 5000 units of intravenous heparin were administered, and 5 min after administration the activated clotting time was 305 s. A 5.5 mm Angioguard distal protection device (Cordis, Miami, Florida, USA) was deployed in the left ICA approximately 2 cm distal to the stenosis and a Precise carotid stent (Cordis) was deployed across the stenosis. Post-stent angioplasty was performed using a 5 mm Viatrac balloon catheter (Abbott Vascular, Abbott Park, Illinois, USA). The cervical carotid angiogram after balloon angioplasty demonstrated complete occlusion of the left ICA within the stent and distal to it (figure 4). An intra-arterial injection of 10 mg verapamil and 10 mg abciximab was unsuccessful in obtaining recanalization. Since

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Figure 1 (A) Lateral and (B) axial views of a CT angiogram of the neck demonstrating severe stenosis of the left internal carotid artery.

we were not sure if there was occlusion within the stent or due to debris within the distal protection device, we did not want simply to recapture the distal protection device. We therefore introduced a 4Max aspiration catheter over the existing Angioguard wire and across the in-stent thrombus to the level of the distal protection device (figure 5A). Thrombus was aspirated at the distal protection device and within the stent. Macroscopic inspection revealed that the aspirated contents from the stent were consistent with acute thrombus and not embolized plaque. A follow-up angiogram showed complete recanalization with restoration of blood flow. There was residual stenosis of approximately 25–30% (figure 5B) and no evidence of intracranial vessel occlusion. Following the procedure the aspirin and clopidogrel levels were confirmed to be therapeutic.

OUTCOME AND FOLLOW-UP

The patient suffered no new neurologic deficits following the procedure and was discharged to a rehabilitation facility.

DISCUSSION

Acute in-stent thrombosis and distal protection device occlusion are potentially devastating complications of CAS. Acute in-stent thrombosis is a relatively rare phenomenon, being reported in 0.5–2.0% of cases.^{2 3} On the other hand, distal protection device occlusion is much more common, occurring in as many as 30% of cases.^{4–6} Although described in the past as separate entities, we believe that these complications may be considered on a continuum of acute thrombotic complications that may occur during carotid stenting. They have been attributed to similar etiologies and similar rescue strategies have been described. Furthermore, occlusion at the level of the stent may prevent angiographic detection of occlusion at the level of the distal protection device.

Causes of these complications could be inadequate pretreatment with antiplatelet drugs, underdosing of heparin during the procedure, underlying hypercoagulable states, local factors (eg, vessel dissection, plaque protrusion) or technical factors (eg, underexpansion of the stent, inadequate angioplasty).^{5 9 10} Furthermore, deployment of the stent and balloon angioplasty ruptures the luminal plaque, exposing thrombogenic material, thereby potentially promoting thrombosis both locally within the stent and remotely at the distal protection device. The most likely cause of distal protection device occlusion is the debris burden in the filter which leads to stagnation of blood flow and

Figure 2 CT perfusion demonstrating an acute left temporoparietal infarct. (A) Cerebral blood flow map; (B) cerebral blood volume map; (C) mean transit time map.

Figure 3 (A) Lateral and (B) oblique projections of a cervical carotid angiogram demonstrating severe stenosis of the left internal carotid artery. A 'string sign' can be seen consistent with severe stenosis.

Figure 4 Lateral projection of a cervical carotid angiogram at the time of stent placement and subsequent acute thrombosis. Lack of flow is evident in the distal two-thirds of the stent and beyond. The distal protection device can be seen without evidence of blood flow.

eventually occlusion of the artery. In the case of either in-stent or distal protection device occlusion, efficient reopening of the artery in a timely manner is important. Delay in recanalization of the vessel or the incorrect technique could lead to ischemia and consequent complications.

It has been demonstrated that formation of acute in-stent thrombus and distal protection device occlusion is due primarily to platelet aggregation stimulated by exposure of thrombogenic material after plaque rupture.¹¹ This discovery has prompted the use of antiplatelet therapy as a rescue strategy in the face of intraoperative in-stent thrombosis and in cases of distal protection device occlusion due to debris. Tong *et al* have demonstrated effective dissolution of an in-stent thrombus with intravenous administration of abciximab which prevents platelet crosslinking and aggregation. In their report the patient was maintained on an abciximab infusion for 12 h postoperatively. While effective in terms of initially establishing stent patency, abciximab infusion may lead to potential hemorrhagic complications, particularly while heparin is pharmacologically active.^{12 13}

Steiner-Böker *et al* described 'facilitated thrombolysis' as a rescue therapy for in-stent thrombosis.⁷ In their case report they used locally administered intra-arterial tPA plus abciximab and additional heparin with restoration of blood flow occurring within 15 min. They argue that this method may provide a more rapid means to restore blood flow, thereby minimizing potential adverse neurologic sequelae.

Angioplasty is another potential intervention for the treatment of acute in-stent thrombosis. Although it may be employed relatively quickly, it risks showering distal emboli to an already hemodynamically compromised hemisphere. Furthermore, inflation of the balloon within the stent theoretically risks disrupting its construct and stability.

Surgical salvage procedures may be the most extreme and invasive interventions to address acute in-stent thrombosis. Stent retrieval has been described in cases of refractory in-stent thrombosis.^{8 14} In these cases the stent and associated thrombus are excised and an interposition graft is used to join the free

Figure 5 (A) Lateral projection of a cervical carotid angiogram at the time of aspiration with the Penumbra 4Max catheter. The aspiration catheter can be seen within the stent and blood flow can be seen distal to the site of occlusion in figure 4. (B) Successful revascularization following aspiration of the acute thrombus. Minimal residual stenosis is observed within the stent and good blood flow is observed distal to the stent and site of the distal protection device.

ends of the vessel. Various extracranial/intracranial bypasses have also been described. However, these procedures may be particularly risky in patients who had already been deemed poor surgical candidates to address their carotid disease.

In cases of distal protection device occlusion, the fastest and easiest option is to retrieve the occluded filter which will usually lead to re-establishment of the blood flow. Most recently, Kwon *et al* reported occlusion of the distal protection device in 6 of 61 patients (9.8%) who underwent carotid stenting. In all patients the capture of the device restored blood flow; however, in one case there was acute embolic M1 occlusion requiring administration of additional antiplatelet and thrombolytic agents. The authors caution that retrieval of a distal protection device that is full of debris could lead to distal emboli with resultant ischemic injury.

We feel that utilization of an aspiration catheter could be a viable option in both in-stent and distal protection device occlusion. In cases of protection device occlusion the use of an aspiration catheter to suction debris prior to filter retrieval may be a safer option as emptying the filter may prevent potential embolic phenomena. In cases of in-stent occlusion, the use of an aspirator catheter such as the Penumbra 4Max catheter could be more effective than infusion of antiplatelet or antithrombotic agents alone. This is the first report of the use of the Penumbra aspiration catheter, which is typically used in mechanical thrombolysis during acute stroke, as a rescue strategy for in-stent thrombosis during carotid stenting. The advantage of this microcatheter in this setting is that it fits over the 0.014 inch wire of the distal protection device which is already in place. This avoids the need for catheter exchange, thereby increasing the efficiency and decreasing the time to recanalization and blood flow restoration. While other aspiration catheters may be similarly effective, we believe that using a large enough catheter with sufficient suctioning capability is critical to this technique.

Although mechanical and pharmacologic thrombolysis of acute carotid in-stent thrombosis has been described, we describe a rescue strategy using the Penumbra 4Max aspiration catheter. This method of mechanical thrombolysis seems to be safe and

efficient, providing rapid restoration of blood flow. Although in this case we used this technique only after failure of pharmacotherapy, it is feasible that this strategy could be employed primarily and with the advantage of avoiding administration of thrombolytic agents and additional antiplatelet drugs. This method may serve to be particularly useful in patients who may be at increased risk of hemorrhagic complications.

Learning points

- ▶ Acute in-stent and distal protection device thrombosis are potential complications that may occur during carotid artery stenting.
- ▶ Effective treatment strategies for acute in-stent thrombosis are necessary to prevent devastating neurologic consequences.
- ▶ Mechanical thrombolysis using an aspiration catheter such as Penumbra 4Max may be a rapid and reliable approach when antiplatelet therapy fails or in patients in whom additional pharmacotherapy is contraindicated.

Contributors SM and RM were involved in the conception, creation and review of the manuscript and DL was involved in the review of the manuscript.

Competing interests None.

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