Mechanical revascularization of acute iatrogenic anterior cerebral artery occlusions: use of a new coaxial dual-lumen balloon catheter results in rapid access and flow restoration

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SUMMARY

Acute iatrogenic occlusion of cerebral vessels is a risk during the performance of neuroendovascular procedures. Most commonly this is a result of thrombus formation within the vessel, thromboembolism or an acute vasospastic response. There are several options for flow restoration including pharmacological, mechanical and microsurgical. Mechanical flow restoration, usually by thrombectomy, is typically performed in large cerebral vessels. Current mechanical thrombectomy devices have limited utility in smaller vessels that are more difficult to access, such as the anterior cerebral artery (ACA). We present two cases where successful flow restoration of an intraoperative acutely occluded or thrombotic ACA was rapidly achieved by balloon dilation using a new coaxial dual-lumen balloon catheter. The time elapsed from the decision to use the balloon catheter until revascularization for each patient was 5 min and 46 s (case 1) and 10 min and 25 s (case 2).

BACKGROUND

Neuroendovascular procedures carry a risk for acute thrombosis and occlusive complications. Pharmacological rescue therapy using glycoprotein IIb/IIIa inhibitors has been shown to be an effective treatment in some patients.^{1 2} When pharmacological rescue fails, mechanical flow restoration attempts can be useful.³ Balloon catheter disruption of thrombus with mechanical revascularization has been reported to be effective in patients with acute ischemic stroke, but little has been reported on its usefulness as a rescue therapy during neuroendovascular procedures.^{4 5} Recently, new coaxial dual-lumen cerebral balloon catheters compatible with 0.014 inch guidewires have been developed to improve steerability and trackability while maintaining excellent balloon inflation compliance.^{6–9} They may improve access to challenging cerebral vascular anatomy commonly encountered with some anterior cerebral arteries (ACAs). We report two cases of rescue therapy using a new dual-lumen balloon catheter that was navigated into acutely occluded or thrombotic ACAs resulting in excellent and immediate flow restoration.

CASE PRESENTATION

Case 1

A 57-year-old woman presented with a spontaneous subarachnoid hemorrhage (SAH) consistent with aneurysm rupture. A new left-sided superior hypophyseal artery aneurysm was identified and

treated with coil embolization. Severe radiographic cerebral vasospasm was identified 9 days after the ictus of the SAH and the patient was taken for endovascular treatment.

Angiography revealed cerebral vasospasm of the left internal carotid artery (ICA) terminus and the A1 segment of the left ACA (figure 1A). The patient was heparinized and a therapeutic activated clotting time (ACT) was confirmed. An Echelon-10 microcatheter (Covidien-eV3 Neurovascular, Irvine, California, USA) was advanced over a microguide-wire to the carotid terminus. Intra-arterial infusion of 20 mg verapamil was performed for the next 30 min without any improvement. The microcatheter was then navigated over a wire into the left ACA origin so that verapamil could be infused directly into the ACA. A control angiogram revealed complete occlusion of the left ACA distal to the tip of the microcatheter. The microcatheter was then pulled back proximally to see if this would restore flow into the left ACA without success (figure 1B). We then prepared a newly available Scepter C 4 mm×10 mm coaxial dual-lumen balloon catheter (MicroVention, Tustin, California, USA) with a 50:50 contrast to saline mixture. The balloon was advanced over a 0.014 inch Synchro 2 microwire (Stryker Neurovascular, Fremont, California, USA) into the A1 segment of the ACA with ease. The balloon was underinflated within the A1 segment of the left ACA and the left ICA carotid terminus. After deflation of the balloon, an angiogram demonstrated restoration of flow to the entire left ACA distribution and the previously identified severe vasospasm of the left ACA and left ICA terminus had resolved (figure 1C). The total time elapsed while performing mechanical revascularization including device preparation was 5 min and 46 s.

Case 2

A 45-year-old woman with three known cerebral aneurysms had elective coiling of an anterior communicating artery aneurysm. Heparinization with a therapeutic ACT was confirmed. On the final control angiogram, evidence of thrombus was seen within the parent vessel adjacent to the aneurysm coils at the left A1–A2 junction (figure 2A). This caused a significant delay in contrast filling of the ACA distal to the thrombus. A 0.25 mg/kg bolus of abciximab was given intravenously without evidence of improvement on delayed angiography. We then attempted mechanical revascularization. A 4 mm×10 mm

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Figure 1 Case 1. (A) Catheter-based digital subtraction angiography (DSA) of the left internal carotid artery (ICA) demonstrating severe vasospasm of the left ICA terminus and A1 segment of the left anterior cerebral artery (ACA). (B) DSA demonstrating occlusion of the left ACA just distal to the origin of the A1 segment after the infusion microcatheter has been removed. (C) DSA demonstrating the Scepter C balloon catheter within the left ACA immediately after inflation resulting in flow restoration of the left ACA and improvement in previously identified vasospasm.

Scepter C balloon catheter was advanced over a 0.014 inch Traxcess EX microwire (MicroVention), easily selecting the ACA. The catheter was carefully advanced through the thrombus. It was underinflated to approximately 80% of the vessel diameter. The balloon was then deflated immediately and a control angiogram revealed improved coil position at the neck of the aneurysm and complete flow restoration without any evidence of residual thrombus or distal embolus (figure 2B). The total time elapsed while performing mechanical revascularization including device preparation was 10 min and 25 s. A 12 h intravenous infusion of abciximab was started after the procedure. The patient developed a retroperitoneal hematoma that was determined to be stable. The patient was loaded with clopidogrel and discharged home with a prescription for clopidogrel.

Outcome and follow-up

Both patients had excellent outcomes without focal neurological deficits and modified Rankin scale scores of 0.

DISCUSSION

Reports have shown that dual-lumen balloon catheters have been used safely as solitary devices during aneurysm

embolization with balloon remodeling^{6–8} and as assist devices during cerebral arteriovenous malformation embolization,⁹ but there have been no reports of their use for mechanical disruption of acute thrombus or in cerebral vasospasm. We present two cases where a new coaxial dual-lumen balloon catheter was safely and quickly navigated into occluded and nearly occluded ACAs with very effective flow restoration after balloon inflation and no evidence of distal thrombus migration. Most currently approved mechanical thrombectomy devices are difficult or unsafe to navigate into smaller distal tortuous cerebral anatomy. While the ACA anatomy of the two cases presented here was not extremely challenging for navigation with standard cerebral microcatheters, navigating the larger microcatheters necessary for deployment of traditional mechanical thrombectomy devices may have proved difficult. Mechanical disruption of intraluminal thrombus using more navigable balloon catheters may be a reasonable treatment alternative when pharmacological therapy fails or is contraindicated, and when the anatomy precludes the use of traditional mechanical thrombectomy devices.

Balloon angioplasty for vasospasm or thrombus disruption within the cerebral vasculature is performed almost exclusively with Hyperform or Hyperglide balloon catheters (Covidien-eV3

Figure 2 Case 2. (A) Digital subtraction angiography of the left internal carotid artery. Long arrow shows intraluminal thrombus at the left A1–A2 junction adjacent to the coil mass interface at the neck of the aneurysm. Short arrow shows delayed filling of the distal left anterior cerebral artery (ACA) with near complete occlusion. (B) Complete flow restoration of the left ACA with resolution of intraluminal thrombus and improvement in coil position at the neck of the aneurysm.

Neurovascular). However, these 0.010 inch guidewire-compatible balloon catheters can be so difficult to navigate into distal tortuous anatomy that some operators give up any attempt at direct navigation and immediately turn to an exchange technique.¹⁰ The use of a new coaxial dual-lumen balloon catheter that accommodates guidewires up to 0.014 inch in diameter has avoided many common problems encountered with single-lumen balloon catheters. First, by having a separate lumen for the guidewire, this lumen can be connected to heparinized saline flush, does not have any contrast within it and therefore prevents issues with friction or binding of the guidewire while increasing trackability. The other lumen, devoted to the balloon, is more reliable to retain the initial contrast concentration and maintain its visibility when inflated and avoids being contaminated with blood. Additionally, the ability to use a 0.014 inch microguidewire improves the ability to select difficult anatomy by the superior steering and tracking ability of these guidewires compared with 0.010 inch wires.

The Scepter C balloon catheter used in our cases was a 4 mm diameter balloon that has excellent balloon compliance allowing for slow volume inflation as contrast is infused into the balloon port. This allows for maximal control of the increasing balloon diameter during inflation within small arteries <4 mm. Paradoxically, the firmness of the underinflated balloon was sufficient in case 1 to allow for a significant improvement in SAH-induced cerebral vasospasm.

CONCLUSION

Our case report is the first to demonstrate the safe, rapid and successful use of the Scepter C coaxial dual-lumen balloon catheter as a potential device to aid in flow restoration for the treatment of iatrogenic acutely occluded or vasospastic ACAs. This technique may be particularly useful when pharmacological therapy fails or is contraindicated and in areas of difficult cerebral anatomy that make the use of traditional mechanical thrombectomy devices ill-advised. We consider that the new features inherent to its design as a dual-lumen balloon catheter make it superior to the more traditional 0.010 inch guidewire-compatible balloon catheters commonly used.

Learning points

- ▶ Iatrogenic occlusion of cerebral arteries as a complication of neuroendovascular procedures can be difficult to treat if pharmacological therapy fails and if the anatomy is too challenging or distal to use traditional mechanical thrombectomy devices.
- ▶ Balloon disruption of the intraluminal thrombus as a means to restore blood flow can be a safe reasonable alternative but, in the past, its success has been limited by the inherent difficulties with older 0.010 inch guidewire-compatible single-lumen balloon catheters.
- ▶ Balloon disruption of the intraluminal thrombus using newer dual-lumen balloon catheters compatible with 0.014 inch guidewires is an option for rapid flow restoration that overcomes the limitations of the older single-lumen balloon catheters. Their use results in improved access to difficult anatomy while maintaining safety with excellent balloon inflation compliance.

Contributors RFJ is responsible for writing the majority of the manuscript, the study concept, performance of the procedures, editing the manuscript and supervision of the project. JRL assisted in writing portions of the manuscript, including preparing the figures. HAK assisted with helpful critique and editing the manuscript.

Competing interests None.

Patient consent Obtained.

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