The eJournal of the European Society of Minimally Invasive Neurological Therapy

Balloon-assisted flow-diverter deployment for the treatment of a giant intracranial aneurysm

EJMINT Technical Note, 2014: **1432000147** (4th August 2014)

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Abstract

Endovascular reconstruction of the parent artery of wide neck, or large, intracranial aneurysms is a feasible treatment strategy. Although several techniques of microcatheter navigation across the aneurysm's neck have been described, these techniques do not predict how to stabilize the microcatheter in a straightened conformation during flow-diverter deployment. We describe a technique to stabilize the microcatheter during flow-diverter deployment. A compliant balloon is first inflated in the parent artery distal to the aneurysm's neck, trapping the microcatheter against the artery wall to avoid microcatheter recoil. The flow diverter is slowly advanced, while the microcatheter, which is anchored by the balloon, is gently pulled back. This maneuver allows the flow-diverter device to reach the distal branch of the parent artery. With the increasing use of flow diverters to treat intracranial aneurysms, our technical proposal may be useful for treating challenging aneurysms.

Keywords: intracranial aneurysms, flow diverter, pipeline embolisation device, balloon-assisted, stability

Introduction

Wide-neck intracranial aneurysms are usually challenging lesions if an endovascular approach is utilized [1]. When an intracranial aneurysm displays an “ultra-wide neck” or circumferential involvement of the parent artery, endovascular reconstruction of the affected artery is a feasible treatment strategy [2, 3]. However, for some of theses aneurysms, navigating the microcatheter distally to the aneurysm may become very difficult due to the complex anatomies of these aneurysms. To address this problem, some techniques have been proposed to facilitate microcatheter navigation across the aneurysm’s neck [4-9]. However, these techniques do not predict, once the microcatheter is positioned distally to the aneurysm, how to stabilize the microcatheter in a straightened conformation ready for flow-diverter deployment.

Technique

A 54-year-old woman, presenting with a giant unruptured intracranial aneurysm in the right internal carotid artery, was admitted to our institution for endovascular treatment. The patient signed a written informed consent form approved by the institutional review boards. The aneurysm measured 25 × 17 mm and the neck presented a complex anatomical configuration (Figure 1). Because the patient did not support the therapeutic occlusion of the right internal carotid artery, the proposed endovascular strategy

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was a parent artery reconstruction with the pipeline embolisation device (Covidien Vascular Therapies, Mansfield, MA, USA) associated with coiling.

The procedure was performed, through bilateral femoral artery access under general anesthesia. The antiplatelet regimen recommended was aspirin (300 mg daily) and clopidogrel (75 mg daily) 7 days before the procedure. Standard heparin was administered immediately after bilateral femoral puncture at an infusion rate to maintain an activated clotting time between 2.0 and 2.5 times the baseline value. A 6F introducer sheath (Pinnacle Destination: Terumo, Tokyo, Japan) was placed proximally in the right carotid artery. Next, a 6Fguiding catheter (Neuron: Penumbra, Alameda, CA, USA) was conducted through the introducer sheath and positioned in the right internal carotid artery. A 6F guide catheter (Envoy: Cordis Neurovascular, Miami Lakes, FL, USA) was introduced through the left femoral artery and placed into the right internal carotid artery. A microcatheter Excelsior SL-10 (Stryker, Natick, MA, USA) was navigated over a 0.014 in microwire Syncro (Stryker) to bypass the aneurysm's neck. This step was achieved only after looping the microwire into the aneurysm's dome (Figure 1). Attempts to unwind the loop and straighten the microcatheter across the aneurysm neck failed, resulting in repeated herniation into the aneurysm sac. Therefore, a HyperGlide balloon catheter 4×10 mm (Covidien, Irvine, CA, USA) was navigated along the same artery harboring the microcatheter - also by means of a loop inside the aneurysm's dome - and was positioned distally from the aneurysm (Figure 1). The balloon was inflated in a segment of the parent artery right after the aneurysm's neck; the microcatheter and the balloon were then gently pulled back to unwind the loops. After deflating the balloon, the microcatheter's microwire was replaced by a 0.014 in, 300 cm exchange microwire (Transend, Stryker). Then, the Excelsior SL-10 microcatheter was retrieved and a microcatheter Marksman (Covidien) was navigated over the exchange wire distally to the aneurysm's neck (Figure 1). The Pipeline device (Covidien) was advanced through the microcatheter marksman. When the Pipeline reached the aneurysm's neck, the microcatheter prolapsed into the aneurysmal sac. Then, the HyperGlide balloon was slightly overinflated, trapping the microcatheter against the carotid wall. The Pipeline was slowly advanced, while the microcatheter, anchored by the balloon, was gently pulled back. Once the pipeline reached the distal segment of the microcatheter, the balloon was deflated and retrieved. If this strategy had failed, a "Plan B" would have been to inflate another HyperGlide balloon proximal to the neck, aiming to improve support and stabilisation of the microcatheter.

An Excelsior 10-18 microcatheter over a 0.014 in microwire Syncro (both by Stryker) was used to catheterise the aneurysmal sac. The Pipeline was deployed into the parent artery - covering the aneurysm's neck - and endovascular coiling was performed. Immediate angiograms showed contrast stagnation in the remnant aneurysmal sac (Figure 2). The procedure was accomplished with no technical or clinical complications. The patient was discharged after 48 h, presenting no neurological symptoms or deficits.

Discussion

Large or wide-neck intracranial aneurysms make endovascular parent artery reconstruction an attractive strategy, because circulation can be excluded in the aneurysm while preserving the parent artery flow. Stent-assisted coiling and, most recently, flow-diverting stents, have been used to reconstruct the parent artery of wide-neck or giant intracranial aneurysms [3, 4]. When a reconstruction strategy is chosen, a stent delivery microcatheter needs to be placed across the parent artery, distal to the aneurysm neck as straight as possible, to allow a safe stent deployment. However, some aneurysms are characterised by complex anatomical configuration of their necks, with acute curves and angles between the inflow and outflow vessels. These geometries make a distal parent artery catheterisation a very difficult procedural step. For such situations, looping the microcatheter is often a necessary step to reach the outflow vessel. Once the microcatheter is placed distally to the neck, the looping can be unwound by pulling back on the microcatheter. However, this maneuver is often not feasible due to a lack of distal stability of the microcatheter. Previously reported techniques have been proposed to unwind the loop and place the microcatheter straight across the aneurysm's neck. These techniques were previously described as the "balloon anchor," "double wire," "stent anchor," "sea anchor" and "neck-sealing" techniques [5-9]. Although these techniques allow for catheterisation of the distal parent artery, they do not predict how to stabilise a microcatheter in an environment of significant stent deployment instability.

Important stent deployment instabilities may occur with flow diverter devices because compared with low-profile stents designed for stent-assisted coiling, flow-diverting stents experience increased friction against the inner wall of the microcatheter. This friction may increase the instability of the delivery system, which may lead to microcatheter prolapse into the aneurysmal sac, causing the recoil of the microcatheter distal tip and loss of its optimal deployment position. In addition, even if the distal tip of the microcatheter is advanced far from the aneurysm's neck segment, a stent deployment maneuver with a prolapsed microcatheter may lead to hazardous forces against the aneurysm's sac walls, increasing its risk of rupture. Moreover, even if the flow diverter can be placed distal to the aneurysm's neck without forcing the inner walls of the sac, maneuvers to open the flow diverter across the parent artery are difficult with a herniated microcatheter in the aneurysm.

Distinct from previous studies, our new concept uses a compliant balloon not only to catheterise the parent artery but also to stabilise the microcatheter during the flow diverter deployment maneuver to avoid the potential complications discussed above. Another potential advantage of the balloon is its ability to be inflated inside the flow diverter after its total deployment. The flow diverters may not completely open or the proximal segment may not perfectly attach to the parent artery wall. For such situations, a compliant balloon can be used to fully open the flow diverter or to attach its proximal segment in the parent artery wall. Therefore, the balloon can additionally improve the angiographic results and potentially reduce future clinical complications associated with inadequate flow diverter deployment.

With the increasing use of flow diverters to treat intracranial aneurysms, our technical proposal may be useful to treat challenging aneurysms. However this technique may have potential complications such as dissection or rupture of the parent artery by a balloon overinflation and also increase the procedure time and thromboembolic complications. The methodological limitations of this study are its limited sample size and the lack of a control group. Additionally, because experienced operators performed the procedure, extrapolation of our results to general clinical practice should be considered with caution.

Conflict of interest

We declare that we have no conflict of interest.

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Figures

Figure 1 - (a) Digital subtracted angiography (DSA) of the right common carotid artery (CCA), frontal view, shows a giant unruptured internal carotid artery (ICA) aneurysm; (b) DSA with 3D reconstruction of the right ICA, left oblique view, shows the aneurysm neck; (c, d, e, f) X-rays, right oblique view, demonstrating the catheterisation of the aneurysm's outflow vessel and (c) the positioning of the microcatheter 10 - 18, over the microwire Syncro in the right middle cerebral artery (MCA), forming a loop inside the aneurysmal sac (arrow); (d) distal tip of the microcatheter 10 - 18 placed in the right MCA (arrow) and the balloon HyperGlide 4 x 10 mm inflated in the right ICA (arrow head) (e) distal tip of the microcatheter 10 - 18 placed in the right MCA (bold white arrow) over a 0.010 in 300 cm exchange microwire Transend (thin white arrow) and the deflated balloon HyperGlide 4 x 10 mm (arrow head) (f) distal tip of the microcatheter Marksman placed in the M2 segment of the right MCA (thin white arrow) with the pipeline stent (bold white arrow) and the deflated balloon HyperGlide 4 x 10 mm in the right ICA (arrow head).

Figure 2 - X-rays taken during the Pipeline stent deployment and endovascular coiling of the aneurysm and the final DSA: (a) distal tip of the microcatheter Marksman placed in the M2 segment of the right MCA (thin white arrow) with the Pipeline stent (arrow head) and the deflated balloon HyperGlide 4 x 10 mm positioned in the right ICA (bold white arrow); (b, c, d) balloon HyperGlide 4 x 10 mm inflated in the right ICA trapping the microcatheter Marksman (bold white arrows); pipeline stent (arrow heads) crossing the aneurysm's neck through the microcatheter whose distal tip rests in the right MCA (thin white arrows); (e) catheterisation of the aneurysmal sac with the microcatheter 10 - 18 and the microwire Syncro (arrow), the pipeline stent within the microcatheter Marksman across the aneurysm's neck (arrow heads); (f, g) the microcatheter 10 - 18 over the microwire Syncro inside the aneurysmal sac (arrow); (f) beginning of the Pipeline stent deployment (arrow head) and (g) the Pipeline stent fully deployed (arrow heads); (h) the coil mesh and the Pipeline stent in place; (i) DSA of the right ICA, frontal view, shows no embolic or haemorrhagic complications at the end of the procedure.