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Case Report

# Neurovascular Neck-Bridging device in treatment of wide-necked splenic artery aneurysms

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ABSTRACT

We report the cases of 2 female patients, 45-year-old and 49-year-old, affected by wide-necked splenic aneurysm. We embolized the 2 lesions assisted by a new scaffolding neurovascular device, the Cascade Net, an innovative –occlusive remodeling device for temporary bridging in endovascular coil embolization of intracranial aneurysms. Visceral artery aneurysms are rare with an estimated prevalence of 2%-3% in imaging series and up to 10% in autopsy series. Most are asymptomatic and their diagnosis is occasionally. Aneurysm spontaneous rupture has been demonstrated in 2%-10% of cases and it can result in significant morbidity and mortality. Conservative management and open repair were the preferred treatment options for many years. Endovascular repair has been increasingly used since 2000; and the most widespread method of treatment has been coiling. Because of tortuosity of the parent artery, wide neck, and unfavorable locations at arterial branch points, 6% of Visceral and renal artery aneurysms VRAA cannot be adequately treated by simple coiling and requires parent artery remodeling through balloon occlusion, stent placement or parent vessel occlusion, leading to, in the latter situation, a compromised organ perfusion. Increasingly, balloon-assisted, and stent-assisted approaches as well as novel scaffolding neurovascular devices such as the Cascade Net, have allowed wide necked aneurysms to be bridged during endovascular treatment with smaller delivery system, averting parent artery occlusion and risk of distal embolization.



## Introduction

Visceral and renal artery aneurysms (VRAA), even if are more frequently detected with the increasing use of cross-sectional imaging, are rare with an estimated prevalence of 2%-3% in imaging series and up to 10% in autopsy series [1]. The VRAA may be dysplastic, atheromatous, infectious or congenital. Media degeneration induced by hormonal and hemodynamic changes during pregnancy appears to play a major role in splenic aneurysms in contrast to other visceral aneurysms whose atherosclerotic etiology is predominant. Most are asymptomatic, or present nonspecific symptoms and their diagnosis is often occasionally with a peak frequency

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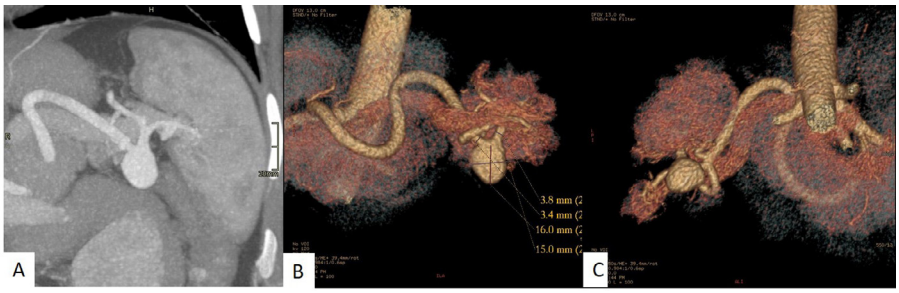


**Fig. 1 – Case 1, Diagnostic Angio-CT arterial phase. MIP (A) and 3D VR (B and C) reconstructions showing the wide-necked, 20 mm diameter splenic artery aneurysm in a 49-year-old female patient.**

around 60-year-old. In case of symptoms, they can be revealed by hemorrhagic shock due to rupture in the free peritoneum responsible for hemoperitoneum, or in the digestive tract with digestive hemorrhage. At the time of diagnosis, the splenic aneurysm is usually <3 cm, preferentially located at the distal third of the splenic artery, generally unique even though multiple aneurysms have been described too [ 2]. Symptomatic aneurysms require treatment, regardless of their size; spontaneous rupture has been demonstrated in 2%-10% of cases and it can result in significant morbidity and mortality, between 10% and 25%. Risk factors for rupture include rapid interval enlargement, size >2 cm, systemic hypertension, portal hypertension and hypersplenism, resulting in a chronic rise in splenic arterial flow and third trimester pregnancy, especially for hepatic and splenic artery aneurysms (SAA), the third most common intra-abdominal aneurysms. Similarly, pseudoaneurysms, which can be caused by trauma, intra-abdominal infection, and acute or chronic pancreatitis, because of the aggressive effect of pancreatic juices on the arterial wall, often continue to grow or subsequently rupture, and therefore also need to be treated [3,4]. Nearly 10% of pancreatitis is complicated by a pseudoaneurysm, this rate exceeds 40% in the presence of pseudo-cysts. Pseudoaneurysms are large, measuring on average nearly 5 cm at the time of their diagnosis, especially for those whose origin is post-pancreatic. The post-traumatic pseudoaneurysms are generally smaller in size, pain is almost constant but not specific. Hemorrhage when it occurs may be minor, limited to intracystic or major hemorrhage in the form of digestive hemorrhage, hematemesis and/or melena. Their overall rupture rate is estimated at 37% with a mortality rate close to 90% in the absence of treatment, mainly due to the parietal fragility of the psuedoaneurysms which no longer has a true arterial wall.

Conservative management and open repair were the preferred treatment options for many years. Endovascular repair (EV) of SAA has been increasingly used since 2000, and a recent extensive meta-analysis reported superior short-term outcomes for EV compared with open surgery [5,6]. EV approaches offer a minimally invasive first-line treatment of VRAA with significantly lower morbidity and mortality rate: 3.7% and 1.5% respectively [7].

The most widespread method of treatment is coiling; however, 6% of VRAA cannot be adequately treated by simple coiling. Tortuosity of the parent artery, wide neck and unfavorable locations at arterial branch anatomy, such as the splenic hilum, can be responsible for technical failure and often requires parent artery remodeling through balloon occlusion, covered stent placement or parent vessel occlusion, in order to exclude the aneurysm and to prevent recurrence [8]. Increasingly, balloon-assisted and stent-assisted approaches as well as novel scaffolding neurovascular devices have allowed wide-necked cerebral aneurysms to be bridged during endovascular treatment with smaller delivery system, averting parent artery occlusion and risk of distal embolization. Recently, these low-profile neuro-devices have found application in the peripheral aneurism's treatment; because of their flexibility they fit easily to the vessel wall, they can be manipulated to deploy better even in significantly tortuous anatomies, they can be re-sheathed up to 90% deployment and they have made it possible to treat complex aneurysms with unfavorable morphology safely and effectively. The disadvantage is that like all treatments with a stent, the patient should receive dual antiplatelet therapy for 6 months' and aspirin treatment continued thereafter. To overcome these challenges, the net-assisted remodeling technique has been proposed in which a braided net temporarily bridges the aneurysm neck to support coiling, without compromising flow in the parent artery [8].

We report our preliminary and novel experience using the Cascade Net – an innovative –occlusive remodeling device for temporary bridging in endovascular coil embolization of intracranial aneurysms- for SAA treatment.

## Case presentation 1

A wide-necked 20 mm diameter splenic aneurysm (Fig. 1A,B,C) in a 49-year-old female patient was treated in our department. Patients received 75 mg clopidogrel and 300 mg aspirin 1 week before the procedure. Antiplatelet response before the procedure was not checked. Procedure was performed by the right femoral artery under local anesthesia without sedation. Systemic anticoagulation was started after insertion of a femoral introducer sheath with a bolus dose of 5000 IU of intravenous heparin. The bolus dose was followed by a slow heparin infusion to maintain an activated clotting time 2-fold greater than the baseline value. The target visceral artery was catheterized

with a 7-F angled guiding catheter (ENVOY; Codman & Shurtleff, Inc, Raynham, Massachusetts) first (Fig. 2A). The parent artery was then catheterized with a 0.021-inch microcatheter, Headway-21 (MicroVention, Terumo, Japan) (Fig. 2B and 2C arrow) and another microcatheter was jailed into the aneurysm (Fig 2C arrow-head). The aneurysms had been coiled with bare platinum coils (1 POD and 2 Packing Coil by Penumbra, USA) (Fig. 2D, E). After the first or second loop of the coil, the Cascade Net stent (Perflow Medical, Israel), was partially and subsequently fully deployed to create a scaffold and bridge the neck. After sufficient coiling of the aneurysm with no significant contrast flow in the aneurysm sac, the mesh stent has been removed (Fig. 2E,F,G). The Cascade-Net L model has been chosen, with an effective braid diameter of 0.5-6 mm, recommended for vessel diameters of 4-6 mm. After endovascular treatment, intravenous heparin was administered by continuous infusion to keep the activated partial thromboplastin time 2 times greater than the baseline value for 24 hours. Angiography was immediately performed at the end of the endovascular procedures to evaluate parent artery patency and aneurysm occlusion (Fig. 2H). Primary technical success was defined as complete exclusion of the aneurysm after the procedure and on 6 months' CTA follow-up imaging (Fig. 3A,B,C). The procedure was technically successful with preserved flow to the splenic artery branches following endovascular coil occlusion. There were no coil herniations or entanglements during the procedures. Clots were not observed in the internal or external part of the device's net during post procedure angiographic examination or visual examination of the device on removal. There were no clinical or angiographic complications during treatment.

## Case presentation 2

A wide-necked 35 mm diameter splenic aneurysm (Fig. 4A,B,C) in a 45-year-old female patient was treated in our department. The patient received 75 mg clopidogrel and 300 mg aspirin 1 week before the procedure. Antiplatelet response before the procedure was not checked. After a first attempt from the right femoral artery, the procedure was performed through a left brachial access under local anesthesia without sedation. Systemic anticoagulation was started after insertion of a femoral introducer sheath with a bolus dose of 5000 IU of intravenous heparin. The bolus dose was followed by a slow heparin infusion to maintain an activated clotting time 2-fold greater than the baseline value. The target visceral artery was catheterized with a 7-F angled guiding catheter (ENVOY; Codman & Shurtleff, Inc, Raynham, Massachusetts) first. The parent artery was then catheterized with a 0.021-inch microcatheter, Headway-21 (MicroVention, Terumo, Japan) and another microcatheter was jailed into the aneurysm (Fig. 4D,E). The aneurysms had been coiled with bare platinum coils (1 POD and 2 Packing Coil by Penumbra, USA) (Fig. 4F). After the first or second loop of the coil, the Cascade Net L model stent (Perflow Medical, Israel), was partially, and subsequently fully deployed; after sufficient coiling of the aneurysm with no significant contrast flow in the aneurysm sac, the mesh stent has been removed. Intravenous heparin was administered by continuous infusion to keep the activated partial thromboplastin time 2 times greater than the baseline value for 24 hours. Procedure was technically successful with preserved flow to the splenic artery branches following endovascular coil occlusion. There were no coil herniations or entanglements during the procedures. Clots were not observed in the internal or external part of the device's net during post procedure angiographic examination or visual examination of the device on removal. There were no clinical or angiographic complications during treatment.

## Discussion

Conservative management and open repair (OR) were the preferred VRAA treatment options for many years. Endovascular (EV) repair has been increasingly used since last 2 decades; according to Pulli et al [9], open repair of VRAA was associated with a 30-day mortality rate of 1.8% and a morbidity rate of 5.4%, long-term follow-up revealed no aneurysm-related deaths. Other studies reported no significant differences in mortality and morbidity between EV and OR, although EV treatment shortened the hospital stay [10,11]. Recent studies reported a technical success rate of >94% for EV treatment of VRAA, with >99% visceral organ preservation and <4% complication. Therefore, EV repair is considered as the first-line treatment for VRAA [8].

Coiling is a widely used EV treatment method. However, conventional coil embolization of wide-necked aneurysms may result in migration of the coil, leading to difficulty in obtaining satisfactory results and complications such as infarction of the visceral organs; therefore, it is mainly used to treat saccular aneurysms with a narrow neck [12]. More specifically, conventional EV approaches involve selective catheterization of the parent artery and subsequent unassisted coiling, allowing for rapid thrombosis of the aneurysm and exclusion from the circulation. Additional endovascular approaches include the use of vascular plugs, front and back door parent artery embolization (where possible), liquid embolic agents such as n-butyl cyanoacrylate or ethylene vinyl copolymer (Onyx) and precipitating hydrophobic injectable liquid (PHIL) [7]. Parent artery sacrifice is also possible but is associated with the complications of end organ infarction and is not appropriate in many patients.

Preserving the parent artery with embolization of a VRAA is technically challenging because of the tortuosity of the vasculature or in wide-necked. For these kinds of aneurysms, besides coil packing, stent or balloon catheter–assisted remodeling technique can be required. These adjunctive tools consist of remodeling the artery by temporarily inflating a balloon or deploying a stent in front of the neck of the aneurysm (balloon- or stent-assisted coiling) during coil placement with a technical success rate of up to 96% and low complications rates reported. Balloon- or stent-assisted coiling technique creates temporary flow arrest in the parent artery, which may stress the clinician and potentially increase procedural risk for thromboembolic complications. Alternatively, a covered stent graft can be deployed to cover the wide neck maintaining flow within the parent artery. However, covered stent grafts

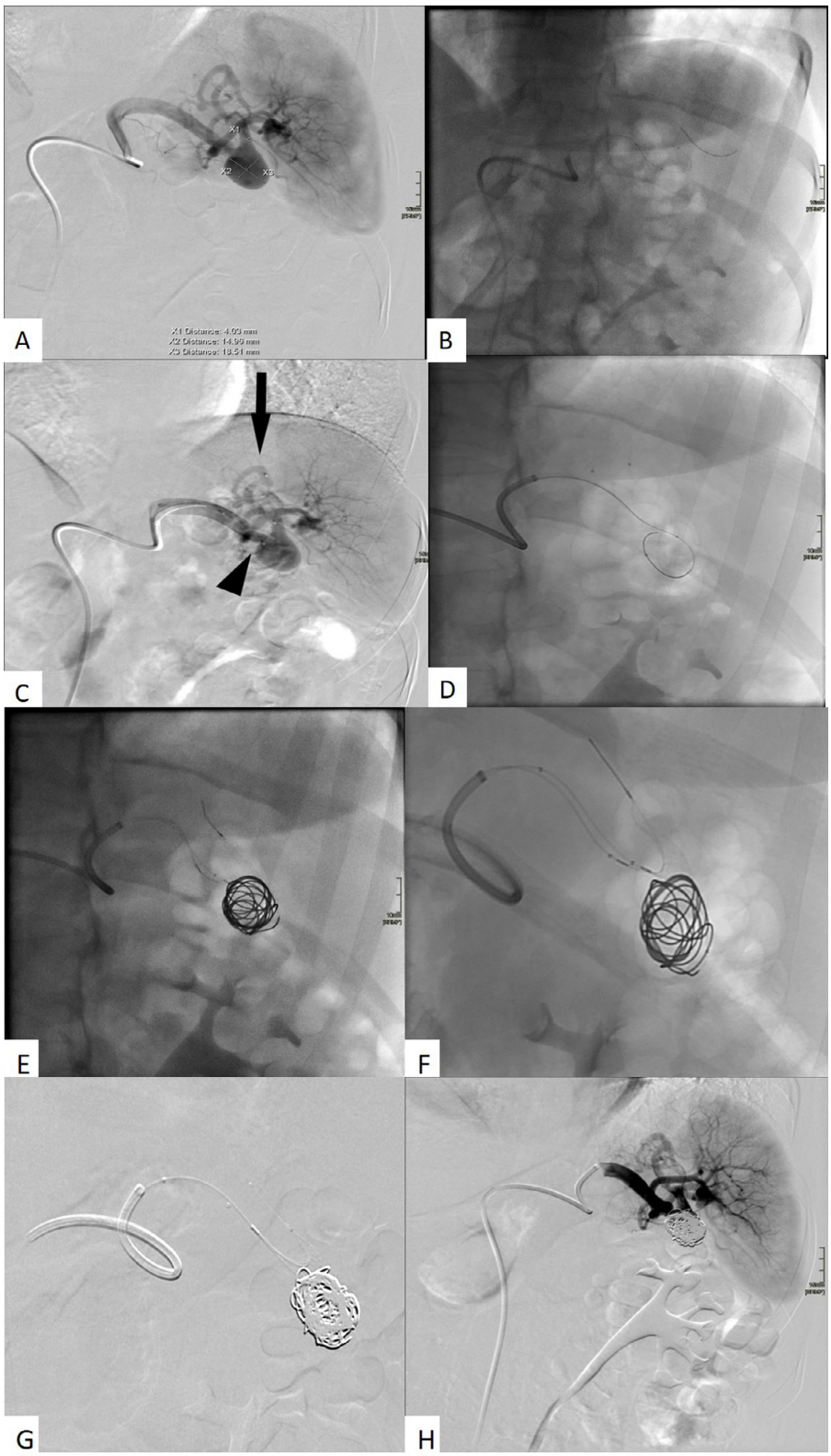


**Fig. 2 – Case 1, Endovascular procedure images. The target visceral artery catheterized with a 7-F angled guiding catheter (A). The parent artery catheterized with a 0.021-inch microcatheter (B and C-arrow). A second microcatheter jailed into the aneurysm (arrow-head) (C). Coiling with bare platinum coils (D and E). The Cascade Net stent partially and subsequently fully deployed after the first loops of the coil, to create a scaffold and bridge the neck. After sufficient coiling of the aneurysm with no significant contrast flow in the aneurysm sac, the mesh stent is removed (E,F,G). Angiography performed at the end of the procedure showing parent artery patency and aneurysm occlusion (H).**

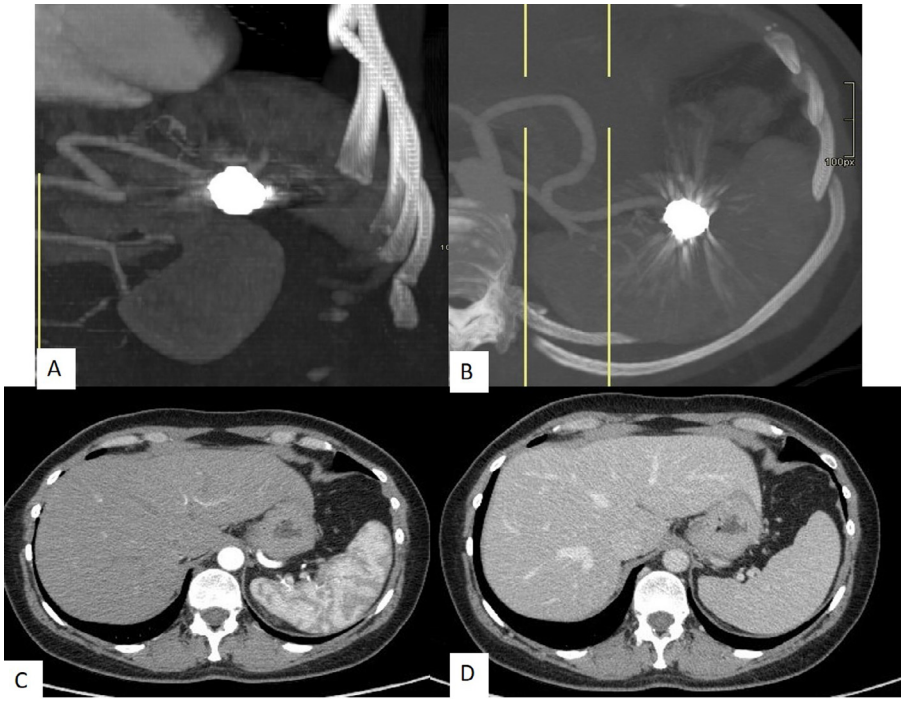


**Fig. 3 – Case 1, CTA 6 months' follow-up imaging. MIP reconstructions (A,B) and arterial phase acquisition image (C) showing a complete exclusion of the aneurysm, parent artery patency. CT portal phase showing any ischemic lesions of the splenic parenchyma (D).**

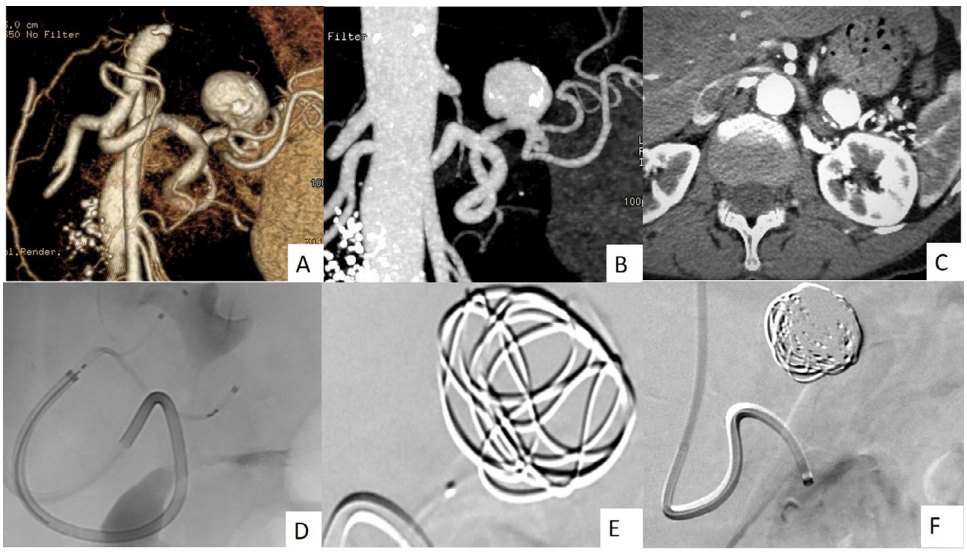


**Fig. 4 – Case 2, Diagnostic Angio-CT arterial phase and Endovascular procedure images. 3D VR (A), MIP (B) reconstructions and axial angio-TC arterial phase (C) showing the wide- necked, 35mm diameter splenic artery aneurysm in a 45-year-old female patient. The target visceral artery catheterized with a 7-F angled guiding catheter, parent artery catheterized with a 0.021-inch microcatheter and second microcatheter jailed into the aneurysm (D). Coiling with bare platinum coils (E,F).**

are limited by their physical properties including higher radial opening force and increased rigidity. As a result, they often force the parent artery to adapt to their shape resulting in loss of the natural arterial curvilinear course with potential end organ thromboembolic complications. Additionally, covered stents obstruct side branch perfusion and have a large profile making their use in smaller vessels potentially more difficult. Furthermore, covered stents or stent-assisted coiling could increase the risk of bleeding because continuous double antiplatelet therapy is required after the procedure [13] for 6 months' and aspirin treatment continued thereafter.

Neurointerventional lower profile stents can help to overcome these limits. They are more flexible, leading to an easier and safer assistance, and they fit more easily to the vessel wall. They can be manipulated to deploy better even in significantly tortuous anatomies, and they can be re-sheathed up to 90% deployment. Furthermore, they can be deployed from a microcatheter, and it is not necessary to put a stiff guide wire beyond the aneurysm to give support in a graft deployment. The disadvantage is that like all treatments with a stent, the patient should receive dual antiplatelet therapy for 6 months' and aspirin treatment continued thereafter.

To overcome these challenges, the net-assisted remodeling technique has been proposed in which a braided net temporarily bridges the aneurysm neck to support coil embolization without compromising flow in the parent artery. The first device created for this purpose was the Comaneci device (Rapid Medical, Yokneam, Israel). It is CE-marked but not FDA-approved, for treatment of wide-necked intracranial aneurysms. It is a retrievable compliant remodeling device composed of 12 nitinol wires mounted on a 182 cm core wire. The standard net length of the compliant remodeling segment is 32 mm with a diameter range of 1.5-4.5 mm. Smaller options of the device have a diameter of 1.5-3.5 respectively. The distal end consists of a 7-mm flexible tip allowing safe navigation and reducing the risk of endothelial injury. It permits long periods of temporary deployment and avoid the need of a balloon remodeling or of a permanent stent graft. Furthermore, need for a long-tern antiplatelet use is avoided and preclinical trials have failed to demonstrate a significant additional endothelial injury [8].

A limit of the Comaneci device is its variable cell size diameter 1.5-4.5 mm that would allow the entanglement of a small coil used in cerebral aneurysm embolization. In a retrospective study of 14 cerebral and carotid aneurysms treated with the Comaneci device, immediate, complete aneurysm occlusion was achieved in 64.3% of cases, whereas 35.7% had a remaining neck remnant. A follow-up of 11 cases (median 4.8 months') showed that 81.8% experienced complete occlusion and 18.2% achieved near-complete occlusion. [15,[16]]. On the other side, the device has been already successfully used in treatment of wide-necked visceral artery aneurysms as reported by Maingard et all, [8].

A new –occlusive net device, the Cascade-Net, leads to overcome these challenges because of a braided net with a cell size of 0.3 mm2, significantly smaller than the currently available coils used for intracranial aneurysm embolization. Cascade-Net is a CE-marked, radiopaque, adjustable braided net composed of nitinol and platinum wires which provides mechanical support during coil embolization and is fully removable at the end of the procedure. The device's architecture protects the parent artery during coil embolization without flow arrest in the distal vasculature, while avoiding the entanglement of coils. The diameter of the braided net ranges between 0.5 and 6 mm, with length measuring between markers of 37 mm when fully deflated and 10 mm when fully inflated. The diameter and length are adjustable by the operator via a handle that provides an expected straight foreshortening of the device and adaptation of the radial force in order to achieve optimal aneurysm neck coverage. Two models of the device are available: The M model has an effective braid diameter of 0.5-4 mm and is recommended for vessel diameters of 2-4 mm. The L model has an effective braid diameter of 0.5-6 mm and is recommended for vessel diameters of 4-6 mm. Both models are compatible with a 0.021-inch microcatheter and have a distal tip wire, allowing for gentle and safe navigation. The Cascade net device has several physical advantages compared to previous-generation devices. The responsive braided net provides excellent compliance with complex vessel geometry, allowing for superior aneurysm coverage even in challenging cases. The adjustable radial force permits a dynamic relationship between the intrasaccular microcatheter and the coils, making it possible to reorient the microcatheter as it is being stabilized, without blocking it. All of these features may have contributed to the high rate of complete occlusion of cerebral aneurysm (MRRC type I in 73.3% of cases) in the first and early multicenter experience [19].

Given the good results of balloon-assisted and stent-assisted approaches, of novel scaffolding low profile neurovascular devices as well as the new net-assisted remodeling technique in treatment of wide-necked aneurysms of visceral arteries, we have reported our preliminary and novel experience using the Cascade Net in treatment of 2 wide-necked aneurysms. The L model has been used, as it is recommended for vessel diameters of 4-6 mm. As told, in both cases, the device was successfully inserted by a 0.021-inch microcatheter, with no procedural complications, rupture or thromboembolic complications because of its –completely occlusive characteristics that allow for a continuous blood flow in the parent vessel during the procedure with no flow arrest and no add time pressure to the interventionalist during this rescue procedure. No coil mass prolapsed while the Cascade Net device was recaptured in the 2 cases. At 6 and 12 -months' CTA follow-up imaging the aneurysms were occluded, not residual contrast enhancement of the sac has been demonstrated and the parent artery is preserved.

Not many papers have been published yet and a preoperatively antiplatelet regimen in the absence of data has not been decided yet [19].

This is the reason why for these our first 2 patients, we judged to be reasonable to maintain postprocedural antithrombotic therapy according to the standard practice in our center after a coiling procedure, which takes into account the clinical characteristics of the patients.

## Conclusion

Our early experience suggests that the Cascade net device could be safe and effective for assisting endovascular coil embolization of splenic aneurysms, it reduces the risk of thromboembolism during the procedure, because of its compliance, it permits an optimal neck coverage and it is removable at the end of procedure.

Further larger randomized controlled studies are needed to confirm preliminary results and to test whether adjunctive antiplatelet therapy can be reduced in patients treated with the Cascade Net device to assist endovascular coil embolization, in order to reduce the risk of bleeding without an increased risk of thrombose.

## Patients consent

Written, informed consent for publication of their case was obtained from the 2 patients.

## Declaration of Competing Interest

No potential competing interest relevant to this article was reported.

REFERENCES


[1] Hossain A, Reis ED, Dave SP, Kerstein MD, Hollier LH. Visceral artery aneurysms: experience in a tertiary-care center. Am Surg 2001;67(5):432–7.

[2] Mailliard M, Novellas S, Baudin G, Benzaken T, Karimdjee BS, Anty R, et al. Anévrisme de l'artère splénique: diagnostic et thérapeutique endovasculaire. Journal de Radiologie 2010;91(11):1103–11.

[3] Belli AM, Markose G, Morgan R. The role of interventional radiology in the management of abdominal visceral artery aneurysms. Cardiovasc Intervent Radiol 2012;35:234–43.

[4] Carroccio A, Jacobs TS, Faries P, Ellozy SH, Teodorescu VJ, Ting W, et al. Endovascular treatment of visceral artery aneurysms. Vasc Endovascular Surg 2007;41:373–82.

[5] Hogendoorn W, Lavida A, Hunink MG, Moll FL, Geroulakos G, Muhs BE, et al. Cost-effectiveness of endovascular repair, open repair, and conservative management of splenic artery aneurysm. J Vas Surg 2015;61:1432–40.

[6] Hogendoorn W, Lavida A, Hunink GM, Moll FL, Geroulakos G, Muhs BE, et al. Open repair, endovascular repair, and conservative management of true splenic aneurysm. J Vas Surg 2014;60:1667–76.

[7] Kok HK, Asadi H, Sheehan M, Given MF, Lee MJ. Systematic review and single-center experience for endovascualr mengement of visceral adn renal artery aneurysms. J Vasc Inter Radiolg 2016;27(11):1630–41.

[8] Maingard J, Kok HP, Phelan E, Logan C, Ranatunga D, Brooks DM, et al. Endovascular treatment of wide necked visceral artery aneurysm using neurovascular comaneci neck-bridging device: a tecnical report. Cardiovasc Intervent Radiol 2017;40:1784–91.

[9] Pulli R, Dorigo W, Troisi N, Pratesi G, Innocenti AA, Pratesi C. Surgical treatment of visceral artery aneurysms: A 25-year experience. J Vasc Surg 2008;48:334–42.

[10] Ferrero E, Ferri M, Viazzo A, Robaldo A, Carbonatto P, Pecchio A, Chiecchio A, Nessi F, et al. Visceral artery aneurysms, an experience on 32 cases in a single center: treatment from surgery to multilayer stent. Ann Vasc Surg 2011;25(7):923–35.

[11] Sachdev U, Baril DT, Ellozy SH, Lookstein RA, Silverberg D, Jacobs TS, et al. Marin ML Management of aneurysms involving branches of the celiac and superior mesenteric arteries: a comparison of surgical and endovascular therapy. J Vasc Surg 2006;44(4):718–24.

[12] Lee BC, Kim JK, Yim NY, Kang YJ, Kim HO, Lee HK. Endovascular treatment of wide-necked aneurysms of the visceral and renal arteries using the double microcatheter technique via a single access route. Diagn Interv Radiol 2020;26(5):476–81.

[13] Onal Y, Acunas B, Samanci J, Ugurlucan M, Umutlu MR, Oztas DM. Alpagut U preliminary results of stent-assisted coiling of wide-necked visceral artery aneurysms via self-expandable neurointerventional stents. Vasc Interv Radiol 2019;30(1):49–53.

[15] Fischer S, Weber A, Carolus A, Drescher F, Götz F, Weber W. Coiling of wide-necked carotid artery aneurysms assisted by a temporary bridging device (Comaneci): preliminary experience. JNS 2017;9:1039–97.

[16] Gupta R, Kolodgie FD, Virmani R, Eckhouse R. Comaneci neck bridging device for the treatment of cerebral aneurysm. JNS 2016;8:181–5.

[19] Tomasello A, Hernandez D, Gramegna LL, Aixut S, Barranco Pons R, Jansen O, et al. Early experience with a novel net temporary bridging device (Cascade) to assist endovascular coil embolization of intracranial aneurysms. JNS 2021;134:591–9.