Covered Stents in Peripheral Vascular Aneurysms and Emergencies

Reviewing current covered stent selection and use through case study and discussion.

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The treatment of peripheral vascular disease has changed dramatically during the last decade, and a shift toward endovascular therapy can be observed. For the treatment of vascular injuries, life-threatening hemorrhage, and potentially lethal aneurysmal disease, several minimally invasive therapies are available. This article gives an overview of the currently available covered stents (excluding stent grafts used for aortic aneurysms) and provides guidelines for the choice of the type of covered stent. Four representative cases will be presented.

CASE 1: RIGHT COMMON CAROTID ARTERY FALSE ANEURYSM

A 58-year-old patient (on holiday in our region) was brought to our emergency department after recurrent hematemesis, in overt hemorrhagic shock (Figure 1). The clinical examination did not reveal any particular findings apart from two unsuspicious scars of the abdominal wall and on the right neck. The patient had a medical history of a right hemicolectomy 8 years earlier due to a poorly differentiated adenocarcinoma of the appendix vermiformis (pT3 pN1 yM0), followed by adjuvant chemotherapy. Two years later, the patient underwent open radiofrequency ablation of a hepatic metastasis, and then 3 years later, he underwent a right hemithyroidectomy with neck dissection for a malignant right recurrent nerve paresis. In addition, the patient was anticoagulated with low-molecular-weight heparin because of a recent deep vein thrombosis. After resuscitation, gastroscopy was immediately performed. During the examination, irregular

Figure 1. CT angiography. Volume-rendered image (A) and coronal MPR (B) showing a false aneurysm of the right common carotid artery (arrow). Roadmap image showing the false aneurysm (arrow) and the undeployed stent in place (C). Note the position of the tip of the stiff guidewire in the external carotid artery (arrowhead). Control angiography showing the deployed stent and full exclusion of the false aneurysm (D).

Figure 2. Axial CT image (A) showing an aneurysm of the left CIA (arrowheads). Note interruption of the calcific rim medially, indicative of a penetrating ulcer. Fusion image of live fluoroscopy and imported CT data showing the aneurysm (arrowhead) (B). Roadmap image showing position of the stent (arrowheads) between the aortic and left iliac bifurcation (C). Control angiography showing exclusion of the aneurysm and patency of the left internal iliac artery (D). MIP image of CT angiography performed 9 months after the stent placement showing complete exclusion of the aneurysm (E).

alterations of the upper esophageal mucosa on the right side were noted without any specific findings in the stomach and duodenum. High-resolution CT angiography of the supra-aortic vessels was therefore performed, which demonstrated active bleeding from a false aneurysm of the right common carotid artery.

Concerning the possible difficulties of an open approach in a hostile neck, we opted for exclusion of the lesion by stenting. After a right common femoral artery puncture, a 7-F introducer sheath was placed. The right common carotid artery was cannulated using a 4-F, headhunter-shape catheter, and the presence of the false aneurysm was confirmed. Subsequently, a 7- X 60-mm Fluency covered stent (Bard Peripheral Vascular, Inc., Tempe, AZ) was inserted under roadmap guidance. Control angiography demonstrated complete exclusion of the aneurysm. Hemostasis was achieved with an Angio-Seal closure device (St. Jude Medical, Inc., St. Paul, MN). After further hemodynamic stabilization, the patient was transferred to his county hospital where he eventually died from his end-stage malignant disease, without further episodes of bleeding.

CASE 2: LEFT COMMON ILIAC ARTERY ANEURYSM

A 61-year-old patient was brought to our attention for an accidentally found aneurysm of the left common iliac artery (CIA) (Figure 2). The patient had a history of type II diabetes mellitus. A clinical examination revealed no abnormalities. CT angiography (performed elsewhere) demonstrated a focal aneurysm of the left CIA with a diameter of 54 mm, starting 15 mm after the aortic bifurcation and extending until a point 30 mm proximal to the iliac bifurcation, where a normal diameter of the CIA was present. Given the morphology, a presumed diagnosis of a penetrating ulcer with (false) aneurysm formation was made. The distal segment of the CIA was slightly dilated but was not aneurysmal. Given the presence of a good proximal and distal landing zone, it was decided to treat the patient in an outpatient setting with a balloon-expandable stent. After puncture of the left common femoral artery, a 7-F introducer sheath was placed, and diagnostic angiography was performed. This confirmed the feasibility of an endovascular treatment, and subsequently, an 8-X 59-mm V12 balloon-expandable stent (Maquet Vascular Systems, Hudson, NH) was placed using a combination of two-dimensional roadmap and three-dimensional navigational tools (using the CT angiography data). The stent was dilated to a final diameter of 9 mm using a second 9- X 40-mm angioplasty balloon.

Control angiography demonstrated complete exclusion of the aneurysm, without protrusion of the stent into the aorta, and with good patency of the left internal iliac artery. Hemostasis was achieved with an Angio-Seal closure device. The postprocedural course was uneventful, and the patient was discharged the same day. A CT scan performed 6 months after the procedure demonstrated good patency of the covered stent and exclusion of the aneurysm.

CASE 3: CENTRAL VENOUS CATHETER PLACEMENT

A 59-year-old patient with end-stage renal disease because of IgA-positive glomerulonephritis was scheduled for placement of a temporary central venous dialysis catheter (Figure 3). Previous CT scan studies showed obstruction of the right internal jugular vein, so the right subclavian vein was chosen for the placement. The device used was an 11.5-F, dual-lumen central venous catheter. The operator noticed the intra-arterial placement but completed the procedure because of bleeding from the dilatating device. The patient was then presented to our service.

At clinical examination, the patient showed no signs of hemorrhagic shock, and there were no signs of peripheral ischemia or local expanding hematoma. CT angiography confirmed the intra-arterial placement of the catheter in

Figure 3. Coronal CT image showing intra-arterial position of the catheter in the right subclavian artery (A). Diagnostic angiography performed with injection of contrast medium through the catheter (open arrow); stent delivery system already in place (arrow) (B). Note position of right vertebral artery. Control angiography after withdrawal of the dialysis catheter showing patency of the vertebral artery (arrowhead) and absence of contrast extravasation (C).

the medial portion of the subclavian artery with an entry point 15 mm laterally from the ostium of the vertebral artery, leaving enough space to position a covered stent.

Treatment was performed the next day. The left common femoral artery was accessed by a single wall puncture, and a 10-F introducer sheath was placed. Subsequently, a 12- X 40-mm–shaft Fluency self-expandable covered stent was placed over the entry point of the catheter. The vertebral artery and the internal mammary artery were localized by diagnostic angiography. While deploying the stent graft, the dialysis catheter was removed. Control angiography confirmed proper placement of the covered stent, showed no signs of leakage or peripheral occlusion, and showed patency of both the vertebral and internal mammary arteries. An Angio-Seal closure device was used for hemostasis in the left groin. The postinterventional course was uneventful.

CASE 4: POPLITEAL ANEURYSM

An 86-year-old patient was referred to us for the presence of a left-sided popliteal aneurysm (Figure 4). The diameter of the aneurysm was 33 mm, and there was a substantial amount of circumferential, parietal thrombus. The diagnostic angiogram showed patency of the anterior tibial artery and signs of previous embolic occlusion of the posterior tibial and fibular artery. Given the age of the patient, endovascular repair using a Viabahn covered stent (Gore & Associates, Flagstaff, AZ) was planned. Sizing was performed with ultrasound. After local anesthesia and antegrade puncture of the left common femoral artery, a 9-F introducer sheath was inserted, and a 9- X 100-mm Viabahn was then placed.

Care was taken to salvage some of the small geniculate arteries that serve as collaterals for the lower leg in a patient with otherwise compromised tibial circulation. Control angiography demonstrated complete exclusion of the popliteal aneurysm and good distal patency. The postoperative course was uneventful.

DISCUSSION

The gold standard for treating arterial lacerations and peripheral aneurysmal disease has, until recently, been open surgical repair.

Covered stents have been successfully deployed in a large variety of vascular emergencies, ranging from gun and stab wounds to iatrogenic injuries. Trauma-related

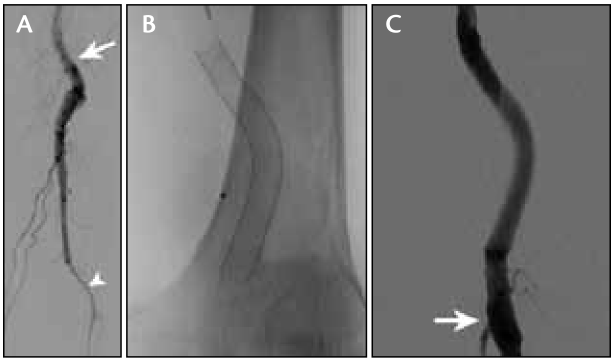

Figure 4. Angiographic image showing a popliteal aneurysm (arrow) (A). Note collaterals originating in the P2 segment and single-vessel runoff to anterior tibial artery (arrowhead). Fluoroscopic image demonstrating the expanded Viabahn covered stent (B). Angiographic image showing exclusion of the aneurysm and good patency of the collateral circulation (arrow) (C).

TECHNIQUES

TABLE 1. STENT GRAFTS AVAILABLE[a]

Company Name	Product Name	Materials Used	Introducer Size (F)	Endhole (inch)	Stent Diameter (mm)	Stent Length (mm)	Delivery System Length (cm)	CE Indications	FDA Indications
Abbott Vascular	Jostent GraftMaster OTW Coronary Stent Graft System[b]	316L stainless steel/ePTFE	7	0.015	3, 3.5, 4	12, 16, 19, 26	140	GraftMaster is indicated for use in the treatment of free perforations, defined as free contrast extravasation into the pericardium, in native coronary vessels or saphenous vein bypass grafts > 2.75 mm in diameter	Humanitarian Device Exemption for the use in the treatment of free perforations, defined as free contrast extravasation into the pericardium, in native coronary vessels or saphenous vein bypass grafts ≥ 2.75 mm in diameter
	GraftMaster RX Coronary Stent Graft System[b]		6 (for 2.8–4 mm), 7 (for 4.5–4.8 mm)		2.8, 3, 3.5, 4, 4.5, 4.8	16, 19, 26			
Bard Peripheral Vascular, Inc.	Flair Endovascular Stent Graft	Nitinol/ePTFE	9	0.035	6, 7, 8, 9	30, 40, 50	80	N/A	Stenosis at venous anastomosis of ePTFE or other synthetic AV grafts
	Fluency Plus		8–10	0.035	5, 6, 7, 8, 9, 10, 12, 13.5	20, 30, 40, 50, 60, 80, 100, 120	80, 117	Residual stenosis with impaired perfusion (pressure gradient) following balloon dilatation, especially in stages III and IV according to Fontaine; dissection; detached arteriosclerotic plaque material and luminal obstruction following balloon dilatation; occlusion after thrombolysis or after aspiration and before dilatation; restenosis or reocclusion	N/A
Gore & Associates	Gore Viabahn Endoprosthesis, Gore Viabahn Endoprosthesis With Propaten Bioactive Surface	Nitinol/ePTFE	6–12	0.014, 0.018, 0.035	5, 6, 7, 8, 9, 10, 11, 13	25, 50, 100, 150, 250	75, 120	The endovascular grafting of peripheral arteries	5–8 indicated for SFA; 5–13 indicated for iliac artery
	Gore Viabil Biliary Endoprosthesis		10 percutaneous, 8.5 endoscopic	0.035	8, 10	40, 60, 80, 100	40 percutaneous, 200 endoscopic	Malignant biliary strictures	Malignant biliary strictures
	Gore Viatorr TIPS Endoprosthesis		10	0.038	8, 10, 12	60, 70, 80, 90, 100	75	TIPS	TIPS
Maquet Vascular Systems	iCast Covered Stent	316L stainless steel PTFE covered stent	6, 7	0.035	5–12	16, 22, 38, 59	80, 120	N/A	Tracheobronchial
	V12 RX Vascular Covered Stent		5, 6	0.014	5, 6, 7	16, 21, 24	140	Renal, iliac	N/A
	V12 OTW Vascular Covered Stent		6, 7	0.035	5, 6, 7, 8, 9, 10	16, 22, 38, 59	80, 120	Renal, iliac	N/A
	V12 LD Vascular Covered Stent		9, 11	0.035	12, 14, 16	29, 41, 61	80, 120	Iliac	N/A

[a]*All device configurations may not be available in all markets.*
[b]*GraftMaster is not approved for aneurysms.*

TABLE 2. PROPERTIES OF COVERED STENTS	
Self-Expanding Covered Stents	**Balloon-Expandable Covered Stents**
Less accurate placement ("jumping")	Accurate placement
No foreshortening	Minor to moderate fore-shortening
Crush resistant	Not crush resistant
Flexible	Rigid
Conformable to vessel diameter (autotapering)	Little conformability, some tapering possible
Oversizing with respect to vessel diameter	Equal sizing (1:1) with respect to vessel diameter

vascular injuries constitute 3% of civilian trauma casualties, and 5% to 10% of all vascular traumas are carotid artery injuries that are usually attributed to direct-penetrating forces. Penetrating vascular injuries are associated with high morbidity and mortality rates. Open wound exploration and appropriate surgical repair has long been the treatment of choice for patients showing signs of peripheral vascular trauma. Surgical trauma, however, can increase the risk of morbidity in stable patients, and endovascular treatment has been notably beneficial in such cases. Given these advantages, the use of covered stents (stent grafts, endografts, and endoprostheses) in the treatment of peripheral aneurysmal arterial disease has evolved rapidly.

Over the past several years, several covered stents have become available (Table 1). Covered stents are composed of fabric or graft material, such as polytetrafluoroethylene (PTFE) or polyester (Dacron), covering a metal stent. The choice of the type of covered stent depends on target vessel diameter and target lesion length, as well as the anatomic location of the lesion. Like bare-metal stents, covered stents are available in self-expandable and balloon-expandable versions. Table 2 lists the properties of both types of covered stents.

In choosing the optimal type of stent for a lesion, the same principles apply as those with the use of bare stents for stenotic arterial disease. The use of balloon-expandable stents should be avoided in areas that are prone to external compression (eg, cervical carotid artery; Case 1), or where flexion of the artery can be anticipated (eg, distal external iliac artery and femoral artery), or in a combination of these factors (Case 3).

In general, the profile of the delivery system of the stent to be implanted plays a minor role in the choice of the device. With the introduction of endovascular treatment, the imaging workup has changed significantly in order to determine which patients are eligible for minimally invasive treatment. Proper patient selection and sizing of covered stents are mandatory to ensure success and to prevent failure of the treatment. The unwanted complications of undersizing speak for themselves (insufficient seal and migration), but also oversizing of the stent graft may have deleterious effects on the vessel wall. Wrinkling of the covering may occur because there is too much material for the vessel diameter. This wrinkling may cause a type I endoleak. For pre- or periprocedural stent sizing, a number of imaging modalities are available, including intravascular ultrasound, calibrated angiography, conventional or spiral CT, CT angiography, and MR imaging.

CONCLUSION

Covered stents can be used safely in patients with vascular trauma and peripheral arterial aneurysmal disease. Key points for success are proper preprocedural sizing and adequate choice of stent type, length, and diameter. ■

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