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# Management of Ruptures Complicating Angioplasty and Stenting of Supraaortic Arteries: Report of Two Cases and a Review of the Literature

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**Summary:** Vessel rupture is a rare complication of angioplasty and stent placement of the supraaortic arteries occurring in two (1.1%) of 180 vessels treated at our institution. Many different approaches to the management of this complication have been proposed. In this report, we present our experience with conservative management in two cases in which vessel rupture occurred and review the relevant literature.

Options for treating the complication of supraaortic arterial rupture during angioplasty and stent placement include surgical grafting, stent placement with covered or uncovered stents, temporary balloon occlusion, vessel sacrifice, and conservative management. In this report, we describe our experience with conservative management in two patients.

## Case Reports

### Patient 1

A 72-year-old woman presented with a history of right carotid endarterectomy. Follow-up sonography indicated a high-grade stenosis of the right common carotid artery. Subsequent angiography revealed a 75% stenosis of the proximal right common carotid artery and a 90% stenosis of the right common carotid artery at the proximal end of the previous endarterectomy site (Fig 1A).

### Intervention

Intravenous heparin was administered to maintain the activated clotting time (ACT) at 250–300 s. The proximal lesion was treated first to provide access to the distal lesion. Using external calibrated markers, the common carotid artery was determined to be 9 mm in diameter, and a slightly oversized 10 mm × 20 mm self-expanding nitinol stent (SMART; Cordis Endovascular, Miami Lakes, FL) was chosen to assure apposition of the stent to the wall of the carotid artery. This stent was positioned at the level of the stenosis in the mid right common carotid artery but moved forward upon deployment and did not completely cover the stenosis. Angioplasty to six atmospheres was performed with an 8 mm × 40 mm noncompliant balloon (Olbert; Boston Scientific, Boston, MA) after stent placement, resulting in moderate improvement in the stenosis. To fully

cover the stenosis, a 10 mm × 20 mm self-expanding stainless steel stent (Wallstent; Schneider/Boston Scientific, Plymouth, MN), which would be slightly longer because it would not be completely unrestrained in the 9-mm carotid artery, was deployed more proximally. The distal portion of this second stent overlapped the proximal portion of the first stent (Fig 1B). Because there was residual stenosis after angioplasty with the 8-mm balloon and to appose the two stents as much as possible, an angioplasty was performed with a 10 × 20-mm balloon (Courier; Meditech/Boston Scientific, Natick, MA). The final angiogram demonstrated contrast material extravasation medial to the stent in the portion of the artery dilated after deployment of the two stents (Fig 1C). The patient remained hemodynamically stable and was discharged the next day.

### Follow-Up

The patient was placed on aspirin 325 mg and clopidogrel (Plavix; Sanofi Pharmaceuticals, New York, NY) 75 mg once daily. An angiogram 7 weeks later, at the time of distal lesion treatment, showed no evidence of vessel injury (Fig 1D). The stenosis at the proximal end of the previous endarterectomy site was treated with angioplasty and placement of a stent.

### Patient 2

A 72-year-old woman with a history of coronary artery disease and chronic obstructive pulmonary disease was referred from an outside hospital for symptoms of dizziness and right-hand weakness. She had been treated at another institution with a proximal right subclavian artery angioplasty and placement of a 6 × 16-mm stent (AVE; Medtronic, Santa Rosa, CA). A left vertebral artery angioplasty and placement of a 4 × 13-mm stent (Corinthian IQ; Cordis Endovascular), as well as a 4 × 18-mm stent (BX Velocity; Cordis Endovascular) was also performed 6 months before our procedure. Follow-up angiogram at the outside institution demonstrated occlusion of the previously stented left vertebral artery, severe restenosis of the stented right subclavian artery, and severe stenosis of the right vertebral artery origin. She was admitted to our institution 1 month later.

### Intervention

Arteriography confirmed occlusion of the left vertebral artery, tandem severe stenoses of the proximal and distal right subclavian artery, and stenosis of the right vertebral artery origin. (Fig 2A). The carotid arteries did not supply the posterior circulation.

Because the posterior circulation relied on the stenotic right vertebral artery, we opted to treat this vessel first and then address the subclavian stenoses.

The patient had received 325 mg of aspirin and 75 mg of clopidogrel (Plavix; Sanofi Pharmaceuticals) per day for 5 days before admission. A baseline ACT was obtained and heparin

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FIG 1. A 72-year-old woman who had undergone a prior right carotid endarterectomy. A, Right common carotid injection shows 75% stenosis of proximal right common carotid and 90% stenosis of the right internal carotid artery near the proximal endarterectomy site. B, Frontal view of overlapping 10 × 20-mm stents in the right common carotid artery. The SMART stent is more distal as compared with the Wallstent. C, Right common carotid arteriogram after stent placement shows contrast material extravasation medial to the stents. D, Arch angiogram obtained 7 weeks later shows no signs of vessel injury.

was administered to achieve a target ACT of 300 s. Our first goal was dilating the right vertebral origin stenosis, because this was most life threatening. If access to this vessel was precluded by the proximal right subclavian stenosis, the latter would have been treated first. If this had been necessary, we would have staged the procedure, because we prefer to allow the angioplasty site to heal before working across it. A 7F sheath (Shuttle SL Cook, Bloomington, IN) easily passed through the stenosis in the right subclavian stent and was positioned with the tip adjacent to the right vertebral artery origin. Using road mapping, a 4.5 × 13-mm (BX Velocity stent; Cordis Endovascular) was placed over a guidewire (Transend; Boston Scientific/Target, Fremont, CA) across the right vertebral stenosis. After the stent was deployed, an angiogram demonstrated minimal residual stenosis.

One approach would have been to perform the distal subclavian angioplasty, because the sheath was already across the proximal stenosis. Similar to the first patient, we chose to treat

the proximal right subclavian artery stenosis first because we believe that flow maintains patency and the now patent right vertebral artery provided outflow. The distal right subclavian artery stenosis would have been treated a month later to avoid crossing the acutely angioplastied proximal site. Consequently, the sheath was retracted proximal to the right subclavian stent. A 6 × 20-mm noncompliant balloon (Savvy; Cordis Endovascular) was positioned within the recurrent proximal stenosis, which was confined to the right subclavian stent. Angioplasty to 8 atmospheres was performed at the distal, central, and proximal aspects of the stent. Although this balloon positioning allowed the balloon to protrude beyond the length of the stent, the vessel was larger both proximal and distal to the stent. The balloon expanded to its nominal diameter, which was that of the stent. After the balloon was removed, digital subtraction angiography demonstrated little change in the right subclavian stenosis because of recoil.



FIG 2. A 72-year-old woman with recurrent stenosis after angioplasty and stent placement of a high-grade stenosis in the proximal right subclavian artery.

A, Injection of the guide catheter in the innominate artery before angioplasty of the right vertebral artery origin. The lumen of the stenotic segment is nearly the same diameter as that of the guide catheter. Another stenosis is in the right subclavian artery distal to the vertebral artery.

B, Innominate injection shows extravasation of contrast material after the second angioplasty of the right subclavian artery.

C, Arch aortogram the following day demonstrates a pseudoaneurysm.

The lumen of the innominate artery measured 12 mm, and the right subclavian artery distal to the stenosis measured 10 mm. Therefore, the Savvy balloon catheter was removed and replaced with a noncompliant  $8 \times 40$ -mm balloon (Diamond Ultra-Thin; Boston Scientific) inflated to 8 atmospheres to angioplasty the residual stenosis within the right subclavian stent. Although this balloon might be considered to be too long for this application, the artery proximal and distal was larger than the balloon's inflated diameter. The balloon was then deflated and withdrawn. Digital subtraction angiography demonstrated no residual stenosis, and contrast extravasated from the proximal portion of the artery containing the stent (Fig 2B). The heparin was discontinued. Mild hypotension occurred approximately 10 minutes later. A fluid bolus resulted in a return to normotensive parameters. Repeat angiography showed no active extravasation.

The patient was transferred for CT, which demonstrated a hematoma extending from C2 to the thoracic inlet crossing the midline from right to left and bilateral pleural effusions. The patient was admitted to the intensive care unit for observation. Approximately 36 hours later, the patient was intubated for hypoxia. A follow-up CT showed no change in the hematoma. A repeat angiogram at that time showed no active extravasation and a 1-cm pseudoaneurysm at the site of the right subclavian stent (Fig 2C).

Approximately 48 hours after the angioplasty procedure, the vascular surgery service elected to take the patient to the operating room for repair of the right subclavian artery with hematoma evacuation. This decision was based on uncertainty as to whether the patient's declining respiratory status was related to further bleeding into the mediastinum or compression of the lungs by pleural fluid.

A median sternotomy was performed, and a total of 1000 mL of bloody fluid was evacuated from the pleural spaces. There was no active bleeding. Following exposure, a 7-mm tear was identified in the proximal right subclavian artery allowing visualization of the stent. The portion of the subclavian artery involving the stent was resected, as was a diseased portion of the right common carotid back to the innominate artery. An 8-mm Dacron graft was then used for reconstruction of the subclavian artery. A graftotomy was then performed for end-to-side anastomosis of the carotid artery.

#### Follow-Up

The patient was neurologically stable after this operation. One month later, the patient expired following a protracted stay in the intensive care unit complicated by pancreatitis and multiple system organ failure.

#### Discussion

In patient 1, vessel rupture occurred following placement of two stents and successive angioplasties, the second with a slightly oversized balloon. In patient 2, vessel rupture occurred following repeat angioplasty within the right subclavian stent, with a balloon that was oversized in relation to the stent. This balloon was smaller than the artery proximal and distal to the angioplasty site. In both of our reported cases, the vessel rupture occurred within the stent. In the first patient, this occurred because the second balloon was slightly oversized in comparison to the vessel. In the second patient, the second balloon was oversized in relation to the stent. Previously, we believed that the stent reinforced the vessel walls, offering some protection for repeated angioplasty. The recoil in the carotid and subclavian vessels despite theoretically appropriate-sized angioplasty balloons led to overly zealous repeat angioplasty. In this second patient, the original placement of the undersized balloon-expandable stent probably prevented restoration of a normal lumen at this site. Rather than repeat angioplasty with a larger diameter balloon, placement of a 7-mm self-expanding stent at the site may have been adequate.

Angioplasty of atherosclerotic vessels requires use of noncompliant balloons that have the potential to cause rupture or tearing of the target vessel. This complication is uncommon and rarely reported. Consequently, there is little available data to guide man-

agement decisions when this complication occurs. Management alternatives for these injuries include: surgical repair or ligation, endovascular placement of a stent or graft, temporary balloon tamponade, permanent vessel occlusion, or conservative therapy with hemodynamic monitoring and follow-up imaging.

In this report, we present two cases that were managed conservatively, at least initially. The first patient clearly did well, with no significant clinical sequelae and a good outcome. The second patient remained stable for 48 hours and was taken for open surgical repair. At surgery there was no evidence of ongoing hemorrhage.

Angioplasty resulting in vessel rupture probably should be treated by placement of at least one stent, in our experience and that of others as detailed below. Vessel rupture after angioplasty of stented vessels may be treated conservatively or by placement of additional stents.

Statistics regarding the frequency of vessel rupture during angioplasty and stent placement of the brachiocephalic vessels are difficult to obtain. In our experience, this complication is rare—2 (1.1%) in 180 procedures. A similar statistic (1.6%) has been reported for vessel rupture during angioplasty or stent placement of the renal arteries. In a review of 308 renal arteries treated over a 5-year period with angioplasty or stent placement, Morris et al (1) reported five vessel ruptures that were successfully treated with balloon tamponade or placement of an additional stent or stent graft.

Owens et al (2) reviewed 22 carotid angioplasties with stent placement performed at their institution during a 5-year period. They treated two cases of ICA rupture—one referred from an outside hospital and one from their institution with removal of the stents followed by endarterectomy and suture repair of the vessel. One patient recovered uneventfully, whereas the second had fine motor deficits in the right hand after 6 months.

Warren et al (3) presented three cases where endovascular stent grafts were used to manage carotid “blowout.” Their conclusion stated that “acute carotid hemorrhage can be successfully managed with directed placement of endovascular grafts.”

Maskovic et al (4) reported treating a pseudoaneurysm of the subclavian artery secondary to a gunshot wound by placement of a Memotherm stent (Angiomed GmbH and Co., Karlsruhe, Germany). Follow-up angiography at 15 days and again at 12 months showed no pseudoaneurysm and no stenosis of the subclavian artery.

Arterial injuries due to angioplasty and stent placement are likely different from those due to carotid “blowouts” or gunshots, in that in the latter a portion of the vessel wall is absent. With angioplasty, the force is transmitted to the circumference of the vessel wall, with only the weakest portion failing. Speculatively, these are vertical or horizontal tears that may be reinforced by the placement of stents.

Kasirajan (5) reported treatment of a traumatic pseudoaneurysm of the subclavian artery secondary

to an attempted placement of a percutaneous dialysis catheter. Two Wallgraft (Boston Scientific) stents composed of polyethylene terephthalate material covering a standard Wallstent were used. The pseudoaneurysm continued to fill with contrast material in their patient despite covering of the neck. The pseudoaneurysm was then accessed percutaneously with 21-gauge needle by sonographic guidance and injected with 0.5 mL of 1:1000 thrombin. Sonography at 1 month showed persistent thrombosis of the pseudoaneurysm.

Smith et al (6) recently reported their experience treating three patients (four vessels treated) with pseudoaneurysms by using the Wallgraft (Boston Scientific). They achieved complete occlusion of the pseudoaneurysm with patency of the parent vessel in all cases; however, in a 12–18-month follow-up with either angiography or sonography, they noted 50–100% stenosis in three of four grafts. The high rate of severe stenosis or occlusion in this study makes treatment with currently available stent grafts a poor choice.

Liang et al (7) reported conservative management of a pseudoaneurysm and mediastinal hematoma complicating angioplasty of the aorta to treat coarctation in an infant. Follow-up imaging in this patient 10 weeks later revealed total resolution of the hematoma. The patient was asymptomatic throughout 12 months of follow-up.

Lin and colleagues (8) reported two cases of subclavian artery disruption related to endovascular intervention. One of their patients had contrast material extravasation after deployment of a balloon-expandable stent in a subclavian artery that was successfully treated with balloon tamponade. The second patient in their series had a large pseudoaneurysm 4 months after a balloon-expandable stent placement. This was eventually repaired with a prosthetic bypass graft.

In light of the reports in the literature of supra-aortic vessel rupture that have been treated successfully with a variety of nonsurgical approaches, we believe that surgery is not always indicated in this situation. Similar to the cases described in the literature, our patient 1 suffered no clinical effects from vessel rupture. Patient 2 in our series presented for endovascular management because of her high surgical risk. Unfortunately, these surgical risk factors made her a poor candidate for surgical management of the vessel rupture.

We suggest that management of brachiocephalic rupture complicating angioplasty and stent placement should follow a similar course to the same complication occurring in renal artery angioplasty and stent placement that was once managed surgically and is now treated conservatively. If balloon tamponade is feasible in the effected vessel, this could be undertaken to halt active extravasation and give the artery time to seal. Follow-up imaging with angiography and CT should be performed while monitoring and treating hypotension.

### Conclusion

Vessel rupture is a rare complication of angioplasty and stent placement of the brachiocephalic arteries. The small body of available literature supports our own experience that these patients may be managed conservatively with adjunctive endovascular techniques as needed. Surgery can be reserved for selected cases, which are not amenable to more conservative measures. Until further experience is available, however, the management of each case must be individualized.

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