Visceral embolus protection by catheters with balloon-inflatable tips during hybrid repair of thoracoabdominal aortic aneurysm

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Thoracoabdominal aortic aneurysms (TAAA) are associated with high rupture rates and poor outcome in patients who do not have surgical repair. Endovascular and hybrid techniques have gained increasing acceptance for the treatment of TAAA in patients with multiple comorbidities and an increased anesthetic risk. One of the complications of endovascular repair in TAAA is procedurally related embolism to visceral vessels. Visceral embolism causes bowel ischemia and is a potentially lethal complication. This report illustrates the intermittent use of catheters with balloon-inflatable tips as visceral embolus protection systems. These catheters are easy to apply and demonstrated perfect prevention of visceral embolization. To date, 10 patients have undergone operations at our clinic using this protection system, and no embolic complications were observed at the visceral vessels. Therefore, catheters with balloon-inflatable tips for visceral embolous protection should be considered in patients undergoing a two-stage hybrid TAAA repair to avoid embolus-associated morbidity and mortality. (J Vasc Surg 2009;50:442-6.)

The prevalence of thoracoabdominal aortic aneurysms (TAAA) is still unknown, and has a poor outcome and a high rupture in patients who do not have surgical repair. Despite distinct technical improvement in the therapy for TAAA in recent years, the mortality rates are still as high as 20%.[1-3]

Endovascular and hybrid techniques have gained increasing acceptance for the treatment of TAAA in patients with multiple comorbidities and an increased anesthetic risk. However, several periprocedurally related complications such as strokes, distal embolic events, and renal and bowel infarctions have been reported.[4,5]

Bowel ischemia, especially, is a potentially lethal complication after open or endovascular abdominal aortic aneurysm repair. The incidence of bowel ischemia has been well documented in open procedures; however, its incidence and severity remain poorly documented in endovascular procedures. Different etiologies have been described for the development of bowel ischemia, including hypotension, interruption of the corresponding arteries, reperfusion injury, and mainly, embolization.[5,6]

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To date, no protection system is available to prevent embolization, and as a result, bowel infarction, with an increased risk of death. In this preliminary report, we demonstrate our experience with intermittent blockade of the debranching bypass by catheters with balloon-inflatable tips in patients undergoing hybrid repair of TAAA (Fig 1) in a two-stage procedure.

OPERATIVE PROCEDURE

During the first stage of the operation, general anesthesia was initiated and a debranching operation of the renal and visceral arteries was performed. A bilateral subcostal incision was made 5 cm below the costal margin, extending from one anterior axillary line to the other. Both renal arteries and the root of the superior mesenteric artery were exposed anteriorly. Next, a retractor was placed to facilitate exposure, and the small bowel was retracted to the patient's right side.

The left renal artery was identified, and a suitable length was dissected free to create enough space for the anastomosis and a vascular clamp. A comparable length of the right renal artery was dissected free posterior to the left renal vein and vena cava. Then the superior mesenteric artery was dissected free for a suitable length.

Exposure of the celiac trunk and the common hepatic artery was performed by opening the lesser omentum and dissecting the common hepatic artery at the upper edge of the pancreas. A tunnel was created deep to the pancreas using finger dissection for passage of the celiac limb of the

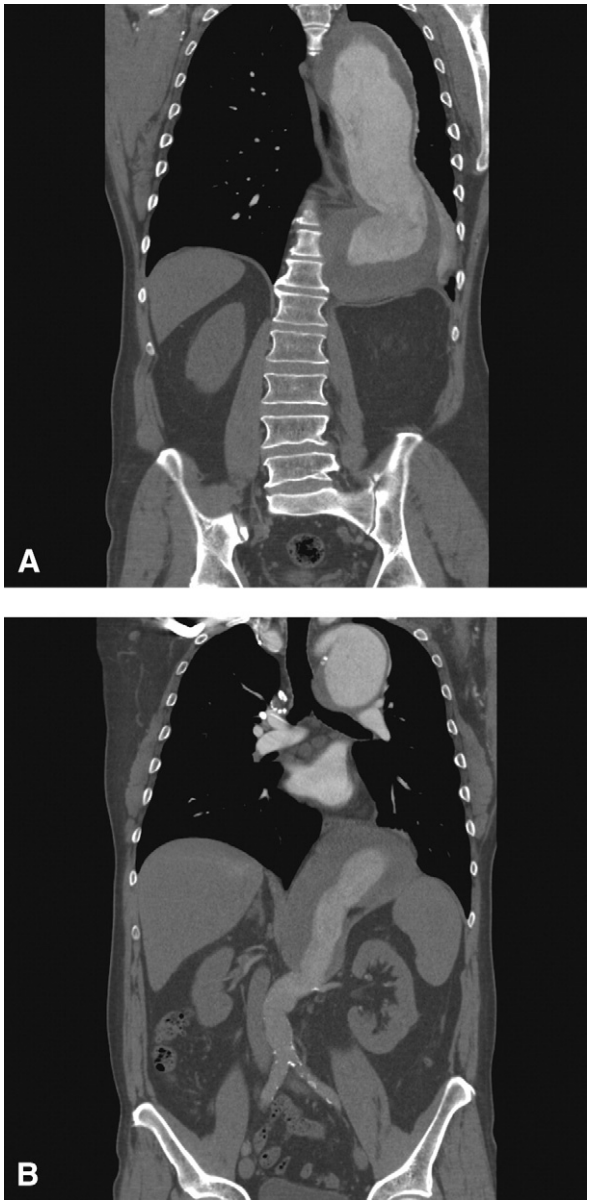

Fig 1. A and B, Preoperative computed tomography scans show a thoracoabdominal aortic aneurysm.

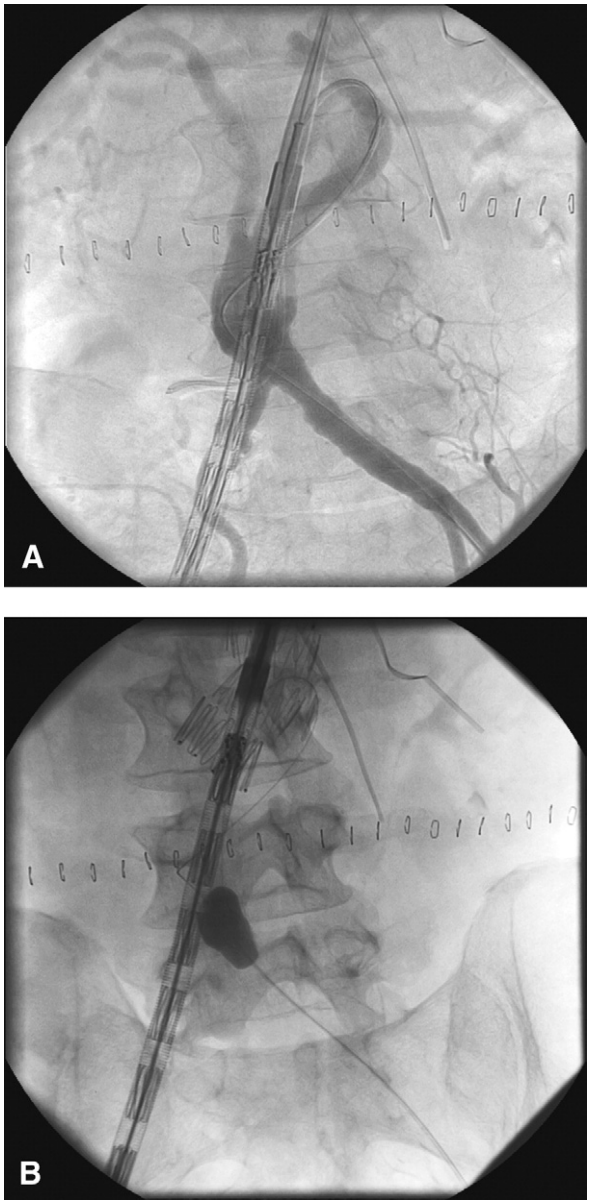

Fig 2. Intraoperative angiography is used to visualize the placement of the catheter with a balloon-inflatable tip **(A)** before and **(B)** after blocking the trifurcated Dacron graft.

graft. The choice of the inflow site for the retrograde bypass to the visceral and renal arteries was determined individually by the extent of the distal aortic pathology.

Before the anastomosis of the graft at the inflow site was started, 7500 IU of heparin and 80 mL of mannitol 20% were administered. The inflow anastomosis was performed at the distal edge of the abdominal aorta using a trifurcated Dacron graft with a main body of 14 mm and three limbs of 7 mm each. Afterwards, the right renal artery was squeezed (the kidney was flushed with iced lactated Ringer's solution) and the anastomosis was performed in an end-to-side fashion using one limb of the trifurcated graft.

After the anastomosis was tested, the renal artery was ligated near its origin. The second limb of the graft was used for the anastomosis with the superior mesenteric artery. This anastomosis was performed, similarly to the renal artery, in an end-to-side fashion. After this anastomosis was tested, the mesenteric artery was ligated at the base. The third limb of the graft was first used for an end-to-side anastomosis with the left renal (the kidney was also flushed with iced lactated Ringer's solution). The same limb was then passed through the previously created retropancreatic tunnel, and an end-to-side anastomosis was performed at

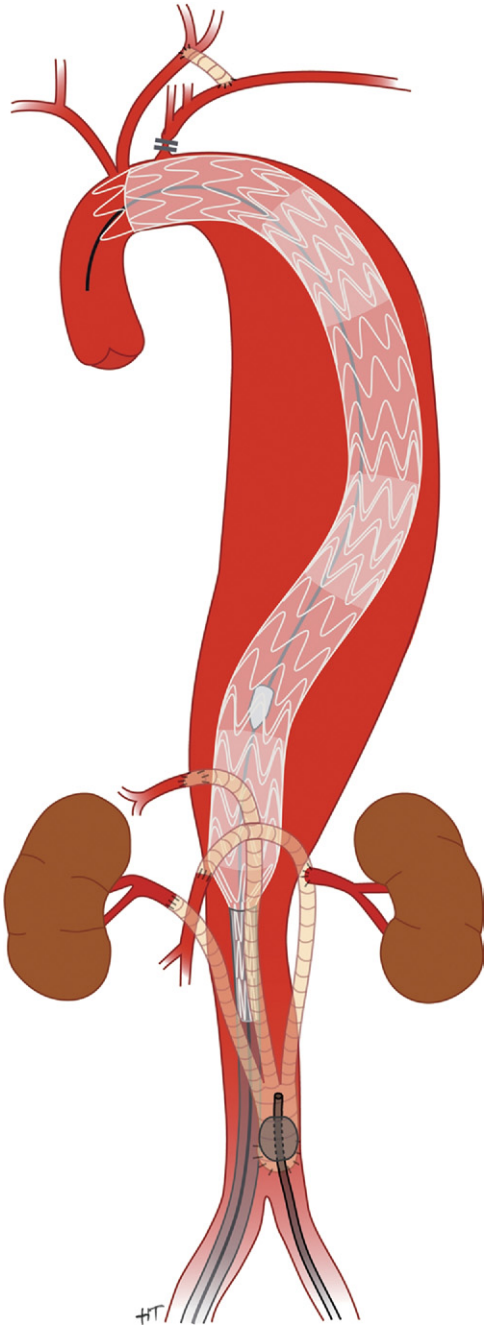

Fig 3. Illustration shows catheter placement at the base of the trifurcated graft.

the proximal common hepatic artery. The final the anastomosis was tested, and the original vessels were ligated at their origin.

Continuous wave Doppler imaging was used to confirm visceral and renal perfusion. The viscera were returned to their anatomic position, and the omentum was used to cover the prosthetic graft material.

Because patients with TAAA often have severe comorbid disease with an increased anesthetic risk and because of the length of the operation, we prefer a two-stage procedure. Therefore, the patients were transferred to the intensive care unit after reno-visceral debranching operation until the next day.

Fig 4. The endograft is placed at the distal aortic arch during drug-induced cardiac arrest.

Then, the second stage of this procedure, endovascular aneurysm repair of the thoracic and abdominal aorta was performed with the patient under general anesthesia. Spinal drainage was not routinely used. For exact visualization of the landing zones, the patient was positioned with both arms fixed beside the body on a carbon table in our endovascular suite. To increase the length of the landing zone for the endovascular graft and to secure the spinal perfusion through the left vertebral artery and the anterior spinal artery, a carotid-to-subclavian bypass was implanted using a 8-mm polytetrafluoroethylene graft, followed by ligation of the proximal edge of the subclavian artery. Afterwards, the right femoral artery was dissected, a 7F sheath was inserted, a guidewire (Terumo, Frankfurt, Germany) was brought in, and 5000 IU of heparin was given.

For the next step, the guidewire was changed to a calibrated pigtail angiography catheter. Digital subtraction angiography was done, using 20 mL of nonionic contrast medium (Peritrast, Dr. Franz Koehler Chemie GmbH, Alsbach-Haehnlein, Germany). The pigtail angiography catheter was placed in the aortic arch, and anchoring zones were marked. To prevent embolism of the visceral revascularization, a 10F catheter catheter with a balloon-inflatable tip (Coda Ballon Catheter 10.0-35-120-40, William Cook Europe ApS; Bjaerverskov, Denmark) was introduced by direct puncture of the left femoral artery and placed at the base of the trifurcated graft (Figs 2 and 3). Every time a new endovascular stent graft was introduced, the balloon at the tip of this catheter was filled and sealed the trifurcated graft.

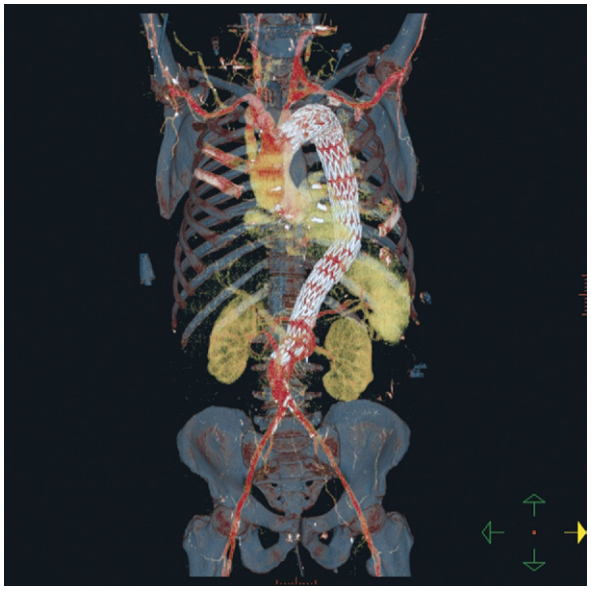

Fig 5. Postoperative computed tomography scan reconstruction of the aorta shows the trifurcated Dacron graft (with good visceral revascularization) and the endovascular stents.

To prevent coagulation and thrombosis during the short period of blocking (<3 minutes), saline 0.9% and 5000 IU of heparin were continuously perfused (84 mL/h) through the catheter.

The endovascular procedure was performed in a reversed trombone technique starting infrarenal, with the first graft (Zenith TX2, William Cook Europe, Bjaeverskov, Denmark) showing the smallest diameter, and continued with larger diameters sequentially to the aortic arch. Drug-induced cardiac arrest with adenosine (0.2-0.5 mg) was used for precise endograft placement at the distal aortic arch (Fig 4). The diameter and length of the endovascular stent depended on the patient's anatomy. At the completion of the procedure, the circulation of the renal and visceral arteries was accomplished with angiography. Routine postoperative CT scanning (Fig 5) should be performed before hospital discharge, and at 3, 6, and 12 months, and yearly thereafter.

DISCUSSION

Open repair of TAAA is associated with high morbidity and mortality rates. Most complications related to TAAA reconstruction result from ischemic damage to the viscera, kidneys, and spinal cord. Catheter techniques and endovascular procedures have changed the spectrum of modern vascular surgery. The hybrid repair of these aneurysms is associated with reduced access-related trauma and it is also tolerated much better in higher-risk patients. It may extend the indications for patients previously considered prohibitive from a medical or anatomic condition.[5,7]

Several disadvantages may still limit its application, however:

1. The visceral revascularization is a major, technically challenging procedure.
2. The time for this operation is very long, and the overall number of steps and anastomoses are considerable and add to the likelihood of technical errors.
3. Lee et al[8] reported about comparable morbidity and mortality rates of hybrid and open TAAA repair.
4. Patients need long-term follow-up to assess the status of the aneurysm and the integrity of the graft.
5. A major complication of endovascular repair in TAAA is procedurally related embolism.[7,8]

The embolism is most likely caused by endovascular manipulations such as advancement of the delivery system and deployment of the stent graft. These manipulations may lead to rupture of atheromatous material from the proximal abdominal or thoracic aorta and result in embolic complication. Other authors have described the incidence of procedurally related embolic complications in >3% of patients.[9,10] According to the varying degrees of severity, the patients can present different clinical presentations. Most will have abdominal pain; other symptoms include diarrhea, melena, or rectal bleeding. In some of patients with milder forms, no signs develop. Laboratory findings may also be nonspecific and include increased serum lactate levels, metabolic acidosis, and increased white blood cell count. Diagnosis is often delayed in these patients because of an altered mental status, peridural anesthesia, or sedation; therefore, the mortality rate in these patients is high.[11]

Protection of the visceral vessels remains difficult, especially in patients undergoing a two-stage procedure. Within this preliminary report, we present a visceral embolus protection system that uses a catheter with a balloon-inflatable tip. The balloon catheter seals the base of the trifurcated graft in a perfect manner and prevents embolization of the visceral vessels. Additional administration of saline 0.9% and heparin through this catheter helps to reduce the risk of coagulation and thrombosis. To date, 10 patients have undergone operations at our clinic using this visceral embolous protection system, and no embolic complications were observed at the visceral vessels. Postoperative laboratory findings showed normal ranges of serum lactate and pH in all patients, and additional CT scanning failed to show infarction of bowel, kidney, or liver. Therefore, a visceral embolus protection system using a catheter with a balloon-inflatable tip seems to be a helpful method to prevent visceral infarction and death in patients undergoing a two-stage procedure.

As do other centers, we also perform the endovascular portion of the hybrid repair as a separate procedure. The endovascular procedure is technically simpler and faster than open reno-visceral revascularization and offers several advantages:

1. The endovascular procedure adds a minimum of another hour to the anesthetic time.
2. Staging allows the endovascular component of the procedure to be performed at our endovascular suite with superior imaging.

3. The introducer sheaths and devices are not being passed through relatively fresh sutured incisions, with an increased risk of rupture and bleeding.
4. It avoids the added risk of renal injury from contrast nephrotoxicity that was already exposed to ischemia.

A two-stage procedure also contains two disadvantages: the risk of a second anaesthetic procedure and a potential rupture risk of the aneurysm. But the rupture risk of the aneurysm on a per-day basis is quite low and does not necessarily justify a single-stage procedure.[8]

The technique used in this report does have two important limitations. First, the technique is not inevitably necessary in a single-stage approach. In this case, visceral embolic protection can be easily done by gently squeezing the trifurcated graft. Second, our technique does not protect against embolic complications to the lower extremities. But the lower extremities are more easily accessed, and embolization or acute ischemia of the lower extremities can be detected more easily than ischemia to the visceral organs. Although the symptoms can be variable, a cold, pale, and pulseless leg during clinical examination and pulselessness during Doppler ultrasound imaging lead to the correct diagnosis, followed by quick operative embolectomy.

CONCLUSIONS

Embolic complication due to endovascular TAAA repair is a serious complication associated with morbidity and death. A visceral embolus protection system using catheters with balloon-inflatable tips is an easy and useful tool to prevent visceral embolization and ischemia in a two-stage hybrid procedure. Therefore, it should considered to avoid embolus associated morbidity and mortality.[11]

AUTHOR CONTRIBUTIONS

Conception and design: MS, JH
Analysis and interpretation: MS, MT, BS, JH
Data collection: MS, MT, BS, JH
Writing the article: MS, JH
Critical revision of the article: MT, BS
Final approval of the article: MS, MT, BS, JH
Statistical analysis: Not applicable
Obtained funding: Not applicable
Overall responsibility: MS, JH

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