Angioscopy as a supplement to frozen elephant trunk treatment

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Introduction

The frozen elephant trunk (FET) approach to treatment of the descending aorta is performed without any visual control through the opened aortic arch, based only on preoperative imaging. The current video demonstrates the feasibility of angioscopy for evaluation of the descending aortic disease during the operation, while simultaneously allowing control of stent-graft deployment (*Video 1*). The procedure, illustrated step-by-step, for acute and chronic aortic diseases, involves:

(I) Visualization of the downstream aortic disease;

(II) Identification of the distal landing zone;

(III) Control of stent-graft deployment;

(IV) Guidance of additional endovascular procedures, if required.

The angioscope is a flexible autoclavable videoscope (Olympus®, BF type Q180-AC) with a working length of 60 cm and an outer diameter of 5.5 mm (1). The flexible tip has a total angulation range of 310° and allows guidance even through sharp angles of the aorta. We routinely use the videoscope only for the angioscopy of aortic diseases and the instrument is always kept sterilized in the operative theater for immediate use. The additional armamentarium consists of a video control panel and cardiopulmonary bypass suction. The procedure is performed after establishment of selective cerebral perfusion and under hypothermic circulatory arrest distally.

Surgical techniques

Cannulation of the right subclavian/axillary artery is used for continuous cerebral perfusion during the arch repair. After arch resection and during unilateral cerebral perfusion, the perfusion of the left carotid artery is initiated antegradely using a flexible balloon catheter connected as a side arm to the arterial driveline. If possible, additional cannulation and perfusion of the left subclavian artery is used (2). Alternatively, in acute aortic dissection with unstable hemodynamics, direct cannulation of the true lumen is used after aortic incision and true lumen identification (3). In this case, the epiaortic vessels are cannulated separately with balloon catheters. Hypothermic arrest is performed at 25 ℃ bladder temperature and selective cerebral perfusion at 18-20 ℃ blood temperature, while arterial pressure is maintained at 50-60 mmHg pressure measured at the right subclavian arterial cannula and the cannula tip in the left carotid artery. For FET placement and fixation, the arch is resected at Zone 2 or Zone 3.

Angioscopic procedure

After arch resection, the flexible cardiopulmonary suction is inserted into the downstream aorta to achieve a bloodless operative field. With suction in place, the angioscope is inserted into the aorta. The position of potential intima findings or lesions is noted according to the distance to the aortic rim. In the case when the collateralized blood flow disturbs the optical field under the perfusion of the supra-aortic arteries, the pump flow can be adjusted to reduce the retrograde bleeding of the intercostal arteries if required. The length of the angioscope tip to the aortic rim is used to calculate the distance to the selected landing zone. In FET procedures, we use the E-vita open stentgraft (Jotec GmbH, Hechingen, Germany) with a length of 130 mm. In the case of more distal lesions (>130 mm), the design of the stent-graft allows coverage of such distal lesions by deeper deployment. The proximal aorta close to the aortic rim is covered by the integrated vascular prosthesis, similarly to the classic elephant trunk technique, and the stent-graft covers the distal aortic part. Deployment of the stent-graft is controlled angioscopically, while a gentle balloon-induced dilatation can be performed during incomplete deployment, especially in chronic atherosclerotic disease.

Association of angioscopy with echocardiographic findings

A fully active 55-year-old male patient was treated for progressive dyspnea and cardiac failure in an external clinic for 3 days. Computed tomography (CT) revealed an unknown chronic type I aortic dissection with a primary entry in the distal arch and pleural effusion. Transesophageal echocardiography (TEE) demonstrated a left ventricular fraction less than 20% combined with moderate mitral valve regurgitation, and thus concomitant coronary artery disease was ruled out. Angiography confirmed the position of the primary entry in the arch and true lumen collapse distally. Three re-entries were identified echocardiographically within the descending aorta 30-40 cm distal of teeth row according to the TEE tube. Due to cardiac failure, surgery was focused on minimizing the duration of cardiac arrest time. Artery cannulation was performed via the right subclavian artery and left femoral artery. During the cooling of the bladder to 28 ℃, the arch branches were mobilized and the left subclavian artery and the left carotid artery were debranched using an 8 mm vascular prosthesis. The left subclavian artery orifice was closed by suture in order to prepare Zone 2 for proximal fixation of the E-vita open stent-graft. After initiation of cardioplegic arrest, during lower body hypothermic circulatory arrest and ongoing perfusion of the three epiaortic vessels, a pump sucker and angioscope were inserted into the descending aorta for visualization of the disease. The suspended intima completely constricted the true lumen. The first re-entry was identified approximately 4 cm distal to the aortic rim and originated from false lumen margin. Due to its round shape and smooth margin, we considered this re-entry to be a disrupted intercostal artery. In contrast, two intact intercostal arteries originated from the non-dissected aortic side distally. The visualization was susceptible to disturbance by the collateralized blood flow, which can be controlled by reducing cerebral perfusion flow if necessary. At the level of the landing zone, approximately 13 cm distal of Zone 2, no intima defect was identified. A 24 mm × 130 mm E-vita open prosthesis was deployed and fixed by continuous 3-0 polypropylene suture and the incorporated vascular prosthesis was released back to the arch position for proximal replacement. Control-angioscopy demonstrated a partial folding of the distal stent-graft section, which is usual in a non-perfused situation. A spurting arterial hemorrhage distal to the deployed stent-graft was identified, which represents the position of the distal re-entries described by echocardiography. After retrograde de-airing, the vascular prosthesis was clamped and visceral perfusion was started after 35 min of hypothermic arrest time. Upon completion of the anastomosis between the vascular prosthesis and the ascending aorta, retrograde cardiac reperfusion was started after a cardioplegic arrest time of 60 min and followed by implantation of the three supra-aortic vessels separately. The intraoperative control TEE demonstrated exclusion of the false lumen and thrombosis after protamine sulfate administration. One year follow-up echocardiography demonstrated improved myocardial function (ejection fraction more than 40%) with mild mitral valve regurgitation. The false lumen along the stent-grafted aorta remained thrombosed and shrunk over the time.

Identification of aortic pathology and landing zone

A 69-year-old male patient with an acute aortic dissection complicated by malperfusion of the superior mesenteric artery was admitted to our hybrid operation 6 hours after onset of symptoms. Echocardiography and angiography demonstrated the position of the primary entry within the distal arch. The ascending aorta was dissected in a retrograde fashion and a true lumen collapse was observed in the descending and abdominal aorta. Due to its complete collapse, a selective endovascular intubation of the mesenteric artery was impossible. In addition, the celiac trunk was observed to originate from the lumen, and immediate surgery followed. Angioscopy demonstrated a transverse intimal injury in the distal arch. An intercostal artery originated from the dissected aortic site distal to the left subclavian artery, where the aortic wall was severely atherosclerotic. In the middle part of the descending aorta and proximal to the kinking neck, a bleeding plaque rupture was identified as an additional entry, which was located approximately 15 cm from Zone 2. Furthermore, the true lumen was narrowed at the kinking. In order to stabilize the perfusion of true lumen, we decided to implant an E-vita open hybrid stent-graft. Due to the risk associated with the celiac trunk originating from the false lumen, the landing zone was planned at the level of the plaque rupture. Our intention was to exclude the ruptured plaque from antegrade blood flow by partial overlapping with the graft, thus allowing retrograde perfusion of the entry for feeding of the false lumen. Angioscopy confirmed the position of the stent-graft over the plaque, while bleeding of the entry confirms the partial covering at the stent-graft end. Otherwise, repositioning of the stent-graft by back retraction before starting the anastomosis can be performed. The intraoperative angiography demonstrated expansion of the true lumen with restoration of the dissected mesenteric artery perfusion, while a retrograde perfusion of the coeliac trunk via collaterals was also demonstrated. The postoperative CT presents the exclusion and thrombosis of

the false lumen up the stent-graft end, with the coeliac trunk perfused and the partial covered entry opened.

Securing of FET procedure

A 35-year-old male patient with Marfan's disease presented with progressive false lumen enlargement in the descending aorta, 9 months after isolated proximal aortic replacement for acute type I aortic dissection. CT demonstrated an aneurysm in the proximal descending aorta and a narrowed true lumen. In order to secure the E-vita open hybrid stent-graft placement into the true lumen, a stiff guide wire was placed via the femoral artery. The guide wire was no longer visible through the opened arch after arch resection, thus blocking advancement of the wire and trapping it in the aneurysm as shown by angioscopy. Guided by the angioscope, a surgical clamp was inserted and the wire was harvested. This was followed by stent-graft placement into the true lumen using the over-the-wire technique. Postoperative CT examination demonstrated exclusion of the aneurysm and thrombosis of the excluded false lumen. Thoracoabdominal replacement was performed 3 years later, using the E-vita open stent-graft end for the proximal anastomosis.

Comments

Angioscopy overcomes the optical barrier of the sharp angle from the arch to the downstream aorta via median sternotomy. Visualization of distal aortic pathologies provides the surgeon the option to control the stent-graft placement and treatment. In our clinic, angioscopy represents an indispensable tool for descending aorta treatment through the opened arch.

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