Retrograde type A dissection after endovascular stenting of the descending thoracic aorta. Is the risk real? 

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Objective: Retrograde type A dissection during or after endoluminal graft repair of the descending thoracic aorta is a potentially lethal complication unique to thoracic endografting. Our aim is to increase its awareness and to review possible etiological factors.

Methods: Two hundred and eighty-seven patients with different thoracic aortic pathologies were treated with endovascular prostheses over the last 6 years (February 2000 to March 2006) under a single-site protocol. A retrospective review was conducted to identify any retrograde aortic dissections by both chart and film review. Factors that may have contributed to its formation were also documented. This population was analyzed for the complication of retrograde aortic dissection as well as the factors related to its occurrence.

Results: Seven patients (2.4%) with a gender distribution of three males and four females experienced a retrograde type A dissection within this sample at a median of 202 days. The mean age was 74 years (range 53–83). Aortic pathologies included aortic dissections (n = 6) and thoracic aortic aneurysm (n = 1). There were (n = 3) 43% retrograde type A dissections identified within the perioperative period. Balloon angioplasty was performed in 71.4% (n = 5). Two female patients (28.6%) had this event identified within their initial hospitalization with fatal consequences. Overall mortality was 57% (n = 4) with extension of dissection the primary cause of death (n = 3) and open surgical repair (n = 1) after an extension of retrograde dissection.

Conclusions: Female gender, use of stent-grafts for dissection and possible aggressive balloon angioplasty may play a role in the cause of retrograde type A dissection. A close surveillance program is recommended when using thoracic endografts outside the recommended device instructions for use.

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1. Introduction

Endovascular management of the thoracic aorta is increasingly being applied to treat various thoracic aortic pathologies ranging from thoracic aortic aneurysms, acute and chronic type B dissections, penetrating aortic ulcers, aortic transactions, and a host of other miscellaneous aortic pathologies.

Despite considerable interest in endoluminal graft therapy for treatment of various thoracic aortic pathologies, thoracic endoluminal graft (ELG) in the USA has been approved solely for the management of thoracic aortic aneurysms. In March 2005, the Gore TAG thoracic endoprosthesis (TAG; W.L. Gore and Associates, Flagstaff, AZ) became the first thoracic ELG to receive market approval for the treatment of thoracic aortic aneurysm by the Circulatory System Devices Panel of the United States Food and Drug Administration (FDA). The long-term efficacy of this approach in the prevention of thoracic aneurysm expansion or rupture in this setting has not been fully established. Although there have been no randomized studies to date, stent-graft implantation for Stanford type B dissections has been highly successful in technical implantation and is associated with shorter operating time, less blood loss, shorter hospital stay, avoidance of cardiopulmonary bypass and aortic cross-clamping, less risk of paraplegia and is associated with a lower morbidity and mortality when compared to historical controls. Retrograde type A dissection is a lethal complication of endovascular stent-graft therapy and has been increasingly associated with the endovascular management of type B dissections. Over the past 6 years we have treated
287 patients with an endoluminal stent-graft and seven patients have developed a retrograde type A dissection. The purpose of our retrospective study is to bring to the awareness of the aortic specialists the possible etiologic factors and mechanisms leading to this rare but lethal complication with the view of avoiding this potential complication especially when endovascular management of the thoracic aorta is performed for indications outside the indication for use specified by the FDA.

2. Materials and methods

2.1. Patients

From February 2000 to March 2006, 287 patients (males and females) with an average age were treated with a Gore TAG endoprosthesis (W.L. Gore and Associates, Flagstaff, AZ, USA) for various thoracic aortic pathologies under a single-site protocol. A retrospective review was conducted to identify any retrograde type A dissections by both chart and film review. Factors that may have contributed to its formation were also documented. This population was analyzed for the complication of retrograde aortic dissection as well as the factors related to its occurrence.

Patient data included demographics, comorbid factors, clinical symptoms, and anatomical details of pathology, procedural details, device characteristics, postoperative complications, secondary interventions and mortality and are summarized in Tables 1 and 2. All patients were enrolled with the provision of an FDA Investigational Devices Exemption for the Gore TAG device in a single center. This protocol was in compliance with the institutional review board of the Arizona Heart Hospital. The patients signed consents for the use of these investigational devices and all patients agreed to participate in the surveillance protocols following deployment of these devices.

All patients were of American Society of Anesthesiology classification III or IV, on the basis of their comorbid condition. In the retrograde type A dissection group and the non-retrograde dissection group of patients, hypertension and use of tobacco were the most predominant comorbidities, 85.7% and 75.7%, respectively (Table 1). The mean age was 74 years (range 53—83). Retrograde type A dissection was diagnosed at a median of 202 days with 43% of the retrograde type A dissections identified within the perioperative period. Out of the 287 patients with a thoracic stent-graft, 91 (n = 91) patients (31.7%) of the study patients were treated for a type B aortic dissection. Six (n = 6) of the seven patients who developed a retrograde type A dissection were treated for a type B dissection and one (n = 1) patient for a thoracic aortic aneurysm. Three (n = 3) out of the seven patients with a retrograde type A dissection had a bovine arch.

2.2. Preoperative examination

All patients were evaluated by a staff surgeon, and underwent preoperative chest roentgenography and contrast enhanced computed tomographic (CT) scanning before the procedure. The aortic measurements were made from the preoperative studies for determination of device diameter and length. All stent-grafts were oversized by 10—20% compared with the aortic neck diameter proximal to the entry point as determined by contrast enhanced CT or intravascular ultrasound. Lengths of the devices were chosen on the basis of the site of the proximal entry point and inclusion of a proximal and distal landing zone of at least 2 cm.

2.3. Device details

The TAG endoprosthesis by Gore was the only thoracic endograft used to treat our study population. The TAG endoprosthesis is a nitinol-supported expanded polytetrafluoroethylene (PTFE) endoluminal graft (ELG). The ELG is available in diameters of 26—40 mm and in 10, 15 and 20 cm lengths. The profile of the device depends on the diameter of the ELG, and requires a 20 French (F), 22 F or 24 F introducer sheath.

2.4. Stent-graft implantation

All thoracic endoluminal graft procedures were performed by cardiovascular surgeons using standard endovascular techniques under general anesthesia in our hybrid operating/endovascular suites equipped with fluoroscopic and angiographic equipment. Preoperative imaging included contrast enhanced CT of the chest, abdomen and pelvis. Contrast angiography or intravascular ultrasound (IVUS) was performed if CT images were of limited value or if no preoperative scans were available. IVUS was routinely used to position the guidewire into the true lumen, to identify entry point of dissection and to identify areas of fenestration as well as to determine proximal and distal landing zones.
The access site was determined based on the size of vessels and the degree of atherosclerosis in the vessel. One of the femoral vessels was usually surgically exposed for device delivery. Iliac vessel exposure was rarely carried out through a retroperitoneal approach if the size of the femoral vessel was <8 mm or iliac artery was severely angulated in which case a 10 mm polyester prosthesis was sown to the iliac vessel for graft deployment. The contra lateral vessel was percutaneously accessed. A 4 or 5 F pigtail catheter was placed in the left brachial artery to assist in accurate identification of the left subclavian artery in cases where we contemplated treating a type B dissection with a thoracic endoluminal graft. Arterial lines were routinely placed in both arms to detect any blood pressure difference that would arise from covering the left subclavian artery once the thoracic endograft was delivered. Systemic heparin 70 units/kg was routinely administered to keep an activated clotting time of greater than 200 s throughout the endovascular procedure prior to percutaneous access of groin vessels. Arteriography, transesophageal echocardiography (TEE), intravascular ultrasound (IVUS) and fluoroscopy were used to determine the diameter of the aorta, the precise dissection entry point, true and false lumen and the precise aortic landing zones prior to deploying an endoluminal graft. The device inventory included a variety of sizes that allowed selection of the appropriate graft on the basis of preoperative CT angiogram and IVUS measurements. After femoral or external iliac artery arteriotomy, the delivery system was advanced and guided into the thoracic aorta with the guidance of IVUS and aortogram. The appropriate size and length of graft was chosen and advanced into the delivery system. Blood pressure control with a vasodilator and transient cardiac arrest was achieved with adenosine in order to avoid misplacement and device migration. Delivery of the thoracic ELG was performed after the exact location of the great vessels, primary entry tear in cases of dissection, and/or aortic disease segment confirmation and achieved by a quick drawback of the outer sheath. To minimize having an endoleak and secure placement of ELG, proximal and distal landing zones of at least 2 cm was required. Whenever an endoleak was noticed on angiography, additional procedures including balloon dilation and additional stent-grafting were added.

2.5. Postoperative follow-up

All patients enrolled in the study were followed postoperatively in the intensive care unit for at least 12 h after ELG implantation. Hemodynamic parameters including pulse oximetry and continuous telemetry were monitored. Frequent neurologic examinations were performed to optimize spinal cord perfusion; systolic blood pressure was maintained above 140 mmHg for the first 48 h after ELG implantation. Cerebrospinal fluid drainage was reserved for patients who developed neurologic complications post ELG or in high risk patients such as those with prior abdominal aortic aneurysm repair as well as those needing ELG deployment below T8. CT scans of the chest abdomen and pelvis were obtained prior to discharge and at 1 and 6 months postoperatively and on an annual basis thereafter. Three-dimensional reconstructions were obtained on all CT scans performed with 2.5 mm cuts since December of 2003. An attending radiologist and staff surgeon independently reviewed imaging studies and all findings were subsequently independently confirmed at the time of data collection.

3. Results

Out of the 287 patients with a thoracic stent-graft, 91 (n = 91) patients (31.7%) of the study patients were treated for a type B aortic dissection. Six (n = 6) of the seven patients who developed a retrograde type A dissection were treated for a type B dissection and one (n = 1) patient for a thoracic aortic aneurysm. Three (n = 3) out of the seven patients with a retrograde type A dissection had a bovine type arch where the origin of the innominate and left common carotid artery originated from a single ostium. The overall mortality was 57% (n = 4) with extension of dissection the primary cause of death in 43% (n = 3) patients, and complications relating to open surgical repair in one patient (n = 1). Three of the deaths were within the perioperative period (Table 2). The three surviving patients were diagnosed at 1 month, 7 months and 19 months, respectively and all had an ascending aorta replacement with a tube graft. Two female patients, 28.6% (n = 2), had this event identified within their initial hospitalization with fatal consequences. The mortality rate for a retrograde type A dissection was 4/7, 57.1%, mostly as a result of complications. Balloon angioplasty of the stent-graft was performed in five patients (n = 5) 71.4%. Oversizing of the thoracic endograft outside the recommended indication for use occurred in two patients (Table 1).
the curved geometry of the aortic arch and to form a tight seal.

Formation of a new intimal tear leading to a dissection or a pseudoaneurysm may occur at the margin of a stent-graft [3,4]. The delay between stent-graft implantation and identification of a complicating intimal tear or dissection can vary from immediately postoperative deployment of stent-graft to 2 months after the procedure [5,6]. In a report by Won et al. [7], retrograde type A dissection was diagnosed 1–5 months post-procedure (mean 3.2 months). Rare proximal springs in the Talent and Cook thoracic devices have been reported [8,9] to cause intimal tear in the fragile thoracic aorta when subject to balloon angioplasty. This has been described in a couple of cases although in all our seven patients we used the Gore TAG device that has no proximal bare metal springs.

Oversizing of stent-grafts >10% results in a higher radial force against the aortic wall, with potential intimal injury and tears occurring if over sizing is >20% of indication for use (IFU) recommendations. In our series of seven patients who developed a retrograde type A dissection, oversizing of the endograft occurred in three patients. In one of our patients there was close to a 30% oversize of the endograft. And this was responsible for the death of a 78-year-old female with a 5.8 cm descending thoracic aortic aneurysm managed with an oversized endoluminal graft. The proximal neck was measured at 28 mm by CT scan but after using intravascular ultrasound a 37 mm × 20 cm TAG graft was deployed which represented a 27.6% oversizing which is outside the indication for use recommendations of maximum 20% oversize. The patient developed a retrograde type A dissection 7 months later and had an ascending tube graft replacement.

Progression of disease could potentially result in the formation of new intimal injuries and dissections at sites unrelated to the stent-graft procedure. Congenital weakness of the aortic wall must also be considered in patients who have no obvious cause for a dissection. Stent-graft implantation in such patients must be performed very cautiously. We suspect that the fragility of the aortic wall caused by this pathology can result in a retrograde type A dissection, which is triggered by stent-graft procedure. New intimal tears as a result of atherosclerotic disease of the arch and ascending aorta or progression of disease may develop and may be unrelated to the stent-graft procedure. Congenital weakness of the aortic wall must also be considered in patients who have no obvious cause of dissection. Stent-graft implantation in such patients must be performed very cautiously. Progression of disease was responsible for the death of a 60-year-old male who developed an acute type B dissection with the entry tear 4 cm distal to the left carotid artery. The patient was treated with an endoluminal graft with 10% oversize with coverage of the left subclavian artery, discharge CT scan demonstrated adequate deployment of endoluminal graft with no evidence of a retrograde type A dissection. He was followed up with serial CT scans per protocol with serial CT scans revealing a stable aorta. At 20 months follow-up upon developing back pain, a CT scan demonstrated a retrograde type A dissection which was treated with replacement of the ascending aorta with a tube graft; however the patient died 2 weeks postoperative from complications of the surgery. We believe the development of a retrograde dissection in this case scenario was related to progression of disease with a possible new intimal tear.

Persistent blood flow into the false lumen at the end of stent-graft procedure for the treatment of thoracic aortic dissection might also be a positive predictor for retrograde type A dissection. The influence of the different stent-grafts on intimal injury is questionable. Retrograde type A dissection has been reported in patients who were treated with a Talent endoprosthesis with a free flow design on the proximal cage, resulting in death. The cause may be related to the limited flexibility of the currently available devices that produce forced wall stress at the outer curvature leading to possible intimal injuries [5,10,11], although forced and repeated balloon dilation is an important etiologic factor that can contribute to intimal injuries. Careful balloon dilation is recommended since the self-expanding action of the stent-grafts also results in continuous expansion of the true lumen over time.

Possible etiologies for retrograde type A dissection that we knew of were possibly related to oversizing more than 20% the indication for use. The larger the stent-graft, the greater the radial force it gives to the aortic wall resulting in good apposition to the aortic wall. Occasionally oversizing has resulted in intimal injuries especially in fragile aortas. In the treatment of two patients oversizing of the aorta was responsible for retrograde type A dissection with two patients receiving an endograft that had been oversized by 21.4%. Incomplete seal of the entry tear of a type B dissection occurred in one patient with progression of disease of the aorta responsible in one patient diagnosed at 19 months previously stent-graft placement for a type B dissection.

In conclusion, retrograde type A dissection, a potentially lethal complication following endovascular stent-graft repair of thoracic aortic pathologies, may have an acute or delayed presentation. Better patient selection, precise stent-graft deployment, careful wire and sheath manipulation in the arch of the aorta, coverage of a large part of the descending aorta in the straight portion as opposed to the angled or curved part of the aorta and avoidance of aggressive balloononing of stent-grafts in the treatment of type B dissection can reduce the incidence of retrograde type A dissection. The inflexibility of current stent-grafts and pulsatile forces of the aorta have many adverse effects on an acutely dissected intima. The development of stent-grafts with smoother edges, stent-grafts specifically for the treatment of various thoracic aortic pathologies like thoracic dissections as well as stent-grafts with more flexible bodies [12] are able to adapt to the aortic conformation much more easily and the avoidance of stents with barbs at proximal ends that could potentially create new intimal tears could further help decrease this fatal complication of endoluminal stent-graft use especially in the treatment of type B dissection.

References

Appendix A. Conference discussion

**Dr M. Krasan (Zabrze, Poland):** What you lack in your presentation, the same as in the presentation from Dr Zipfel from Berlin, is the fact that you don’t show in the entire group data the stage of disease in the dissection group, that most of the patients are with dissection as the main cause of intervention, and you don’t show the stage, whether it is acute, chronic, what time after the onset of the disease it was. In our experience we did have one retrograde having over 70 procedures made. We did have one retrograde dissection, and it was an acute case a few years ago. So this might have been also an important issue. Can you comment on that?

**Dr Kpodonu:** Yes. I think it is pretty evident in my slide that I have shown exactly what times they have had their retrograde dissections. Three of those patients had those within 30 days and the other patients I listed the number of months after which they presented. So unlike the previous speaker who had six of his retrogrades within 30 days, we had three within 30 days and the other four showing up later, a couple of months later.

**Dr S. Schueler (Newcastle Upon Tyne, UK):** Maybe one more comment. I think you pointed this out and the previous speaker as well. It seems to be terribly important that we have to take a very strong standpoint in the way that we have to make sure these patients are treated primarily in centers where you have a surgical backup, where actually you have a team available who is able to treat these terrible complications. I think that has to be pointed out to not only we internally but also to the outside world where, as you know, many people are treating these patients without having any sort of safe network for these sort of complications.