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Thoracic aorta emergencies: is the endovascular treatment the new gold standard?∗

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Abstract

Background: The endovascular treatment for acute traumatic aorta rupture has been proven to be safe in emergency. Technical aspects concerning the device fixation, the materials’ durability, and the patients’ selection criteria are still under discussion. We present our clinical experience and the mid-term follow-up. Methods: Between January 2001 and January 2005, twenty-five patients have been diagnosed with acute traumatic aorta wall rupture in our emergency department. An angio computed tomography scan (CT-scan) was performed to confirm the diagnosis and to localize the aortic lesions. Eighteen patients with isolated intimal lesion, aorta wall hematoma or aorta wall tear up to 1/3 of the circumference, received the endovascular treatment. The intravascular ultrasound (IVUS) and the fluoroscopy control were used routinely. The procedure was considered to have succeeded in the case of complete aortic wall tear occlusion. A CT-scan follow-up was organized 1 week and 1 year after the procedure. Results: Eighteen patients underwent endovascular treatment and 17 of these patients presented associated multiple injuries. The mean age was 40.7±12 years. The hospital mortality rate was 0%. In one patient the distal part of the graft was accidentally deployed into the brachiocephalic trunk and was surgically removed 8 weeks later. Two patients (11.1%) suffered from transitory neurological disturbances and 4 patients (22.2%) had the left subclavian artery ostia occluded by the graft, without developing symptoms. The mean follow-up time was 21±3 months: 1 patient (5.5%) died 1 month after the procedure for acute aortic rupture and no endoleaks were reported. Conclusions: The endovascular treatment for traumatic aortic rupture is an interesting alternative to conventional open surgery for a selected patient cohort. The stent graft material and the fixation to the normal aortic wall are safe and reliable in the mid-term. The results lead us to choose this approach as the treatment of choice in selected patients with traumatic aortic wall rupture.

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Keywords: Aortic rupture; Thoracic aorta; Vascular endoprosthesis; Intravascular ultrasound (IVUS)

1. Introduction

Thoracic aorta wall rupture after blunt thorax trauma is associated, if not treated, with a very poor outcome with an initial survival rate ranging from 10 to 30%. The hospital mortality rate is up to 32% during the first day, up to 61% within the first week and up to 74% after 2 weeks. Moreover, according to the literature patients surviving the acute phase without surgery could reach a 30% risk of late thoracic aorta aneurysm rupture [1]. Conventional open surgery for treatment of the thoracic aorta is also associated with a significant risk of postoperative mortality and morbidity. In emergencies, this risk is obviously higher [1–7]. During the past years, many efforts have been made to ameliorate the surgical techniques and to find new surgical approaches in order to reduce the risk of complications and guarantee the best patient outcomes. Reports recently published from the University of Stanford [2] indicate that the endovascular repair of the thoracic aorta in emergency is a quick and straightforward procedure, but still many questions remain open concerning the patient’s selection criteria, the durability of the stent-graft material, the device fixation to the aortic wall and the aorta remodelling. In this clinical study we describe our experience and we present a mid-term follow-up.

2. Methods

Between January 2001 and January 2005, all patients admitted to the emergency department with a recent history of acute deceleration shock, underwent an injected thoracic-abdominal computed tomography scan (CT-scan) according to the hospital’s guidelines. Twenty-five thoracic aorta ruptures were identified: they were classically located in the isthmus and a 3-dimensional reconstruction was performed to better evaluate the aorta diameters and the aortic wall tear extension. Patients were classified into three groups according to the following criteria: (1) patients with intimal tear <5 mm, were observed; (2) patients with isolated intimal lesion above 5 mm, or aortic wall hematoma without clear signs of rupture, or wall
rupture involving up to 1/3 of the aorta circumference, received an endovascular treatment; and (3) patients with aortic rupture bigger than 1/3 of the aorta circumference, underwent standard open surgery. The endovascular procedure was immediately performed in the operating theatre under general anesthesia once all life-threatening injuries were controlled. The femoral artery was prepared and all patients received a systemic low dose heparinization (100 U/kg of weight). To identify and localize the aortic wall tear and the collateral branches, an intravascular ultrasound (IVUS) coupled with a fluoroscopy control were performed routinely (Figs. 1 and 2). The optimal endoprosthesis ‘landing zone’ (at least 10 mm proximally to the aortic rupture) and the collateral branches were identified and marked using metallic instruments positioned under fluoroscopy control. Once the markers were positioned, the endoprosthesis (Medtronic Talent®, Minneapolis, MN) was gently deployed under fluoroscopic control (Fig. 3). The complete opening of the graft and the exclusion of the aortic lesion were assessed with IVUS (Fig. 4). When available, the transesophageal echography was used to double check the IVUS finding, and the procedure was considered successful when the thoracic aorta tear occlusion was achieved. A clinical evaluation and a thorax CT-scan were performed 1 week and 1 year after the procedure.

3. Results

Eighteen selected patients were referred for endovascular treatment immediately after the diagnosis. The mean age was 40.7±12 years. The aortic wall tears were always located in the aortic isthmus with different degrees of rupture: eight patients had an isolated intimal lesion, five patients had an aortic wall hematoma and five patients...
had an aortic wall rupture involving up to 1/3 of the aorta circumference. Seventeen patients presented concomitant major bone fractures and lung contusions as a consequence of the high-energy body trauma. Moreover, in the presence of major life-threatening injuries, the endovascular procedure was performed later, after having fixed the main problem (4 cases). All used endoprostheses were Medtronic Talent® polyester grafts with nitinol wires and bare proximal part and they were 15–20% oversized compared to the proximal aorta diameter. There were no conversions to conventional open surgery. The hospital mortality rate was 0%. Following the anatomical data coming from the IVUS and the fluoroscopic control, all stents, but one, were placed in the planned position without major problems. One patient (the first in our series) had the distal part of the graft accidentally deployed into the brachiocephalic trunk, without causing its occlusion. The patient remained totally asymptomatic and the prosthesis was removed 8 weeks later under open surgery. Two patients (11.1%) had transient asymptomatic neurological symptoms: one suffered of left hemiplegia and one had several episodes of amaurose fugax. To cover the intimal aortic wall tear, the origin of the left subclavian artery was occluded in 4 patients (22.2%): no one developed symptoms or required surgical revascularization. Eight patients (44%) were observed because of the increase of the blood inflammatory parameters one to five days after the procedure: this ‘inflammatory syndrome’ due to the presence of foreign graft material and major body injuries, disappeared spontaneously or under smooth anti-inflammatory therapy. Infections were not reported.

All 18 patients were followed-up and the mean follow-up time was 21 ± 3 months. One patient (5.5%) died 1 month after the procedure for acute aortic rupture likely due to the endoprosthesis displacement. The remodeling of the aorta around the injured region is probably due to the graft oversizing and appears as a ‘pseudoaneurysm’ of the endoprosthesis in the standard thorax radiogram. This finding has been found in three patients (Fig. 5) and they are now closely followed up with frequent CT scans. To date, no one underwent surgery.

In our series, no endoleaks were reported.

4. Discussion

The treatment of choice in the case of acute traumatic aortic wall rupture remains controversial. Regarding the pathological aspects, there are no clinical and technical methods able to differentiate, up to now, intimal injuries that will progress into aortic wall rupture from those with a more benign outcome. The risk of developing a free aortic rupture is estimated to be considerably lower in patients with a small and stable aortic lesion [8,9]. However, in case of active bleeding or obstruction of the aortic lumen, an emergency treatment must be immediately provided. If not treated, the patient’s outcome has been reported to be very poor but, on the other hand, patients undergoing standard open surgery have an early postoperative mortality rate ranging from 7.7 to 28% [4–6]. This mortality rate is often related to the use of cardiopulmonary bypass support which is associated with high-dose systemic blood heparinization (300 U/kg). Recently, use of left heart bypass and heparin-coated tubing reduced disadvantages coming from the systemic heparinization, but still the incidence of postoperative complications remains high. In particular, the presence of major bone injuries, cerebral traumas and/or abdominal traumas, could lead to potential mortal bleeding or severe neurological complications, and the presence of severe pulmonary traumas could end up with severe post-thoracotomy pulmonary insufficiency. Moreover, the extra-corporeal circulation induces a cascade of inflammatory responses that may have deleterious consequences when amplified by pre-existing injury-mediated inflammatory states. Major renal, pulmonary and cardiac complications together with neurological events after standard open surgery for traumatic aortic injury have unfortunately been frequently reported [4,7].

The significant lower morbidity and mortality rate after sub-acute or chronic aortic lesion stent-grafting shows the benefits and advantages offered by this intravascular and minimally-invasive approach [6,10–12]. During recent years, also the attitude in the case of acute blunt traumatic aortic rupture has changed. The recent literature reports a more frequent use of intra-vascular grafts to successfully treat emergency aortic ruptures, but still more data and more reports are necessary to assess the best treatment for this patient cohort [13–17].

The endoprosthesis versus the standard surgical treatment can help to reduce the mortality and morbidity rate in several ways: (1) reducing the low-dose systemic heparinization time; (2) avoiding the delay between the surgery for the aortic injury and other life-threatening surgical therapies; (3) avoiding bleeding and pulmonary complications related to the standard thoracic open surgery in patients otherwise already severely injured. In our experience, the stent graft implantation was frequently performed as the primary procedure, without significant delay for secondary therapies. On the other hand, in the case of life-threatening injuries treated previously, the stent graft implantation led to a faster and easier surgical turnover which was a consistent benefit for patients. In the reported series, the endovascular treatment for well-selected patients has been shown to be safe and effective, with an excellent operative mortality rate (0%).

![Fig. 5. The aortic wall remodelling as it appears in a thorax radiogram a few months after the procedure.](image-url)
Inclusion criteria are extremely important: we believe that limited intimal lesion, hematomas without clear signs of rupture and aortic wall tears up to 1/3 of the entire aorta’s circumference can accept the stent graft implantation. On the other hand, a bigger aortic wall rupture decreases the aorta rigidity and stability and the entire procedure can fail because of early or late endoprosthesis displacement. In our series, the patient who died 1 month after the procedure had two aortic lesions: one localized at the isthmus and a second one 2 cm distally, both involving <1/3 of the aortic circumference. However, these lesions had probably affected the axial stability of the endoprosthesis, causing its displacement.

Another important conclusion coming out from our experience is that the occlusion of the subclavian artery might be necessary to avoid endoleak. In our series, four patients having had the left subclavian artery overlapped by the graft did not develop early neurological symptoms or signs of carotid steal. At follow up, one patient developed a late complication related to the left arm hypo-perfusion and underwent a carotid-subclavian artery bypass.

As far as technical aspects are concerned, to guide and control the perfect graft positioning, we routinely used the intravascular ultrasound (IVUS). IVUS coupled with fluoroscopy control without nefro-toxic contrast meaning were performed for all 18 patients. In our experience, this technique is simple and feasible and helps to reduce the risk of renal failure in patients with multiple body injuries.

In one case, the patient was surgically treated after having the bare springs of the stent graft accidentally deployed into the brachiocephalic trunk, without causing its occlusion. This was the first case of our series and the misdeployment was mainly due to the position of the guidewire into the brachiocephalic trunk. Based on this experience, we now systematically place the guidewire into the ascending aorta.

Neurological complications are a major issue after surgery for thoracic aorta repair. In particular, open surgery for acute thoracic aorta rupture can cause up to 8% of neurological events and paraplegia apparently due to the aortic cross-clamping time and the distal hypo-perfusion [18,19]. Recently, the introduction of arterial-venous femoral perfusion has significantly reduced this risk. In our experience, and according to the recent literature, the use of endovascular stent-grafts for traumatic aortic rupture reduces even further the risk of paraplegia and neurological events [13–17]. None of the patients treated in emergency with endovascular procedures suffered of paraplegia or major neurological complications and this seems to be due to the aortic injury location: up to 70% of traumatic aortic transections affect the aortic isthmus, and only a few branches to the spinal cord are covered by implanted stent-graft. Therefore, minor neurological complications have been described in our patient cohort: two patients suffered of transient postoperative neurological disturbs: one suffered of left hemiplegia and one had several episodes of amaurose fugax.

At follow up, a pseudoaneurysm of the endoprosthesis due to the aortic wall remodelling under the effect of the oversized endoprosthesis was identified in three patients during the first 6 months (Fig. 5). These pseudoaneurysms did not show up signs of evolution and, even if we believe that there are no indications for surgical treatment so far, we do a close follow-up of these patients (quarterly CT-scan and checkups).

In conclusion, endovascular treatment for acute traumatic aortic rupture is feasible and represents a valid alternative to conventional open surgery in selected patients. Main advantages are the shorter time procedure and the lower operative risk. If the patient is not affected by other priority life-threatening injuries, the endovascular repair should be performed at first before any other surgical treatment in order to eliminate the risk of sudden aortic rupture. Another benefit coming from this technique is the absence of cardiopulmonary bypass and the low-dose systemic heparinization. Our results confirm the results coming from the recent literature and support the hypothesis that the stent graft material is durable and the device fixation to the aortic wall seems to be safe and reliable at mid-time follow-up, at least when the aortic tear involves <1/3 of the aorta circumference. In our experience the IVUS under fluoroscopy control is a helpful technical support which can substitute the angiographic control in order to avoid the use of nephro-toxic contrast medium.

Despite bigger reports and long-term follow ups which are necessary to confirm the worldwide enthusiasm for this procedure, we believe that the use of endovascular treatment in emergency should become the treatment of choice for well-selected patients.

References


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