Replacement of Neck Vessels and Endovascular Exclusion of Aortic Arch Dissections and Aneurysms

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ABSTRACT

Endovascular treatment of the descendant aorta is a safe and effective alternative to solve a severe condition in a selected group of high-risk patients.
In only 15% of patients the anatomical relations of the aneurysm neck with the left subclavian artery are adequate for the implant, and the incidence of arm ischemia, vertebrobasilar artery syndrome or leaks related to the left subclavian artery intentionally occluded reaches 30%. In addition, patients with compromise of the aortic arch (due to dissections or aneurysms of the aortic arch) are still a more selected high-risk population for surgical treatment.
Between November 2005 and December 2006 we included 10 patients with: 1) dissections with compromise of the left subclavian artery or dissections towards the aortic arch (n=7) and, 2) aneurysms of the aortic arch (n=3).
All patients had ASA class III or greater, and they were all treated during the acute phase (14 days).
A two-stage (surgical/endovascular) hybrid technique was performed during the same day. The surgical approach was carried out without the need for circulatory arrest, extracorporeal circulation, and deep hypothermia, but endovascular self-expanding stent-graft placement presented a few technical difficulties.
All procedures were technically successful.
Two patients died, one at day 1 (cardiac tamponade) and the other at day 27 (sepsis).
No neurologic or vascular complications were reported.
The procedure was feasible and effective, with morbidity and mortality rates according to the study population and similar to those reported in other studies performed on comparable patients.

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Key words > Aneurysm - Aorta - Dissection - Vascular Prosthesis - Chest Surgery

Abbreviations >

PTFE	Polytetrafluoroethylene	**BCT**	Brachiocephalic trunk
CT	Computed tomography		

BACKGROUND

Endovascular treatment of the descending aorta provides a safe and effective alternative treatment of a severe condition to a selected group of high-risk patients. (1, 2)

Patients are selected for this therapeutic option on the basis of computed tomography scans showing suitable anatomy features for stent-graft placement, that is to say, a normal aortic wall at the aneurysm neck. A proximal neck of 15 mm of normal aorta is needed for stent-graft implant; however, this requirement is fulfilled by only 5% to 15% of the dissections or aneurysms of the descending aorta and the "real world" is excluded from this treatment. (3, 4)

The intentional occlusion of the left subclavian artery during endoluminal deployment of stent-grafts in the thoracic aorta is a way of including more patients for endovascular repair; nevertheless, this procedure has an incidence of adverse events of at least 30%, and the most frequent complications are arm ischemia, leaks and vertebrobasilar artery syndrome due to subclavian steal phenomenon.

And on top of that, the aortic arch diseases are classically excluded from endovascular repair and

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need surgical repair with circulatory arrest, deep hypothermia and extracorporeal circulation.

Having this triad in mind (minority of patients with suitable anatomical features, a great number of complications related to the intentional occlusion of the left subclavian artery and compromise of the aortic arch), we decided to treat patients during the acute phase of the aortic syndrome (within the first 14 days since the diagnosis was performed) with a two-stage surgical/endovascular hybrid technique. The procedure was performed in the same day and was conceived as an alternative treatment to solve the aforementioned problem.

MATERIAL AND METHODS

Between November 2005 and December 2006 we treated 10 patients (9 men, mean age 58 years [42 to 73 years]). All patients had other comorbid factors, such as diffuse coronary artery disease with left ventricular dysfunction (n = 2), diabetes mellitus (n = 4), hypertension (n = 10), renal impairment not requiring hemodialysis, serum creatinine levels = 2 mg/dl) (n = 1) or chronic obstructive pulmonary disease (FEV_1 = 1 L) (n = 4). All patients had an anesthetic risk (ASA) class III or greater.

Patients with ASA class I or II, absence of cardiopulmonary risk and femoral arteries with a diameter less than 6 mm were excluded.

All patients were treated within the first 48 hours, during the first 14 days the condition was diagnosed (7).

The preoperative assessment consisted of contrast-enhanced computed tomography of the neck, chest and abdomen with cross-sectional cuts at 3-mm intervals.

The first seven patients presented type B dissections (three acute dissections with a patent false lumen and an aortic diameter greater than 4 cm, and 4 chronic dissections with acute exacerbations associated with aneurysms of 6 cm or greater) with retrograde dissection towards the aortic arch or with compromise of the left subclavian artery. In these patients, the neck was not suitable for stent-graft implant.

In these patients we performed a partial subclavian carotid transposition and bypass grafting followed by stent-graft placement immediately distal to the brachiocephalic trunk (zone 1). (5)

The remaining three patients with aneurysms of the aortic arch underwent a complete aortic arch branch transposition with a complex bypass graft from the ascending aorta and distal stent-graft deployment (zone 0). The surgical approach was carried out without the need for circulatory arrest, extracorporeal circulation, and deep hypothermia.

All the procedures were performed under general anesthesia.

Primary success was defined as the closure of the entry site in cases of dissections or complete exclusion of the aneurysm after stent-graft implantation, absence of leaks and patient's survival.

The follow-up protocol included clinical examination, helical CT at month 1, 6 and 12.

The absence of endoleaks, migration, kinking or thrombosis of the stent-graft were considered favorable findings; CT scan also ruled out aneurysm expansion and total or partial thrombosis of the false lumen in cases of dissections.

Transesophageal ultrasound was not routinely performed during the procedure, although we prefer to use it in cases of complete transposition to guide stent-graft deployment.

This two-stage hybrid procedure is described below.

Surgical stage (6-8) (Figure 1)

Total Replacement of the Aortic Arch

After a median sternotomy, the ascending aorta, the aortic arch and the vessels of the neck are exposed. The brachiocephalic trunk (BCT), the left carotid artery and the extrathoracic left subclavian artery are identified and preserved. After systemic heparinization, the ascending aorta is partially clamped and a proximal anastomosis is performed with a 10 to 12-mm precoagulated Dacron graft. The diameter of the graft depends on the caliber of the supra-aortic vessels.

After a total and brief clamp, an end-to-end anastomosis to the BCT is performed. In our series, the clamping time (which implies cerebral ischemia) does not exceed 5 minutes. Two 6 or 8-mm previously built up grafts emerge towards the left carotid artery and the homolateral subclavian artery. An end-to-end anastomosis to the carotid artery is performed and the left subclavian artery is anastomosed in an extra-thoracic end-to-side fashion after the first intercostal space.

Once this "new aortic arch" is built up, proximal ligation of the brachiocephalic trunk and the left carotid and subclavian arteries is performed.

The proximal anastomosis of the bypass graft of the neck vessels has radio-opaque markers with an O shape for visual guidance during deployment of the stent-graft (Figure 2).

Partial Replacement of the Aortic Arch

In this case, an extra-anatomical procedure is performed. Both axillary arteries are exposed via skin incisions between the pectoralis and deltoid muscles. After a left cervicotomy, the left carotid artery is exposed.

A 6 or 8 mm PTFE graft was tunneled beneath the pectoralis major muscle into the axilla to perform a bypass to both axillary arteries.

Finally, the graft is anastomosed to the left carotid artery in an end-to-end or end-to-side fashion by means of an inverted "Y" or "T"-shape bypass graft. The time of cerebral ischemia as well as proximal ligation of the left carotid and subclavian arteries should also be taken into account in this case.

Endovascular Stage (Figures 3 and 4)

The stent-grafts were introduced after the common femoral artery was dissected; an iliac access was not required in any of the cases. A marked pigtail catheter was advanced from the contralateral femoral region. This catheter served as reference points and was used to perform preoperative angiographies and final controls. The brachial access was not used for reference or verification.

After systemic heparinization with 80 UI/kg, an arteriotomy was performed and an angiography was carried out to verify the patency of the bypass-grafts. The device was then advanced under fluoroscopic guidance and the stent-graft was deployed in the site previously chosen with a mean pressure not greater than 60 mm Hg.

In all the cases, the stent-graft was advanced along a 0.035-inch Lunderquist extra-support wire until it reached the aortic valve plane. In the three cases of aneurysms of the aortic arch the wire and the stent-graft protruded towards the left ventricle because the device required a proximal positioning before deployment.

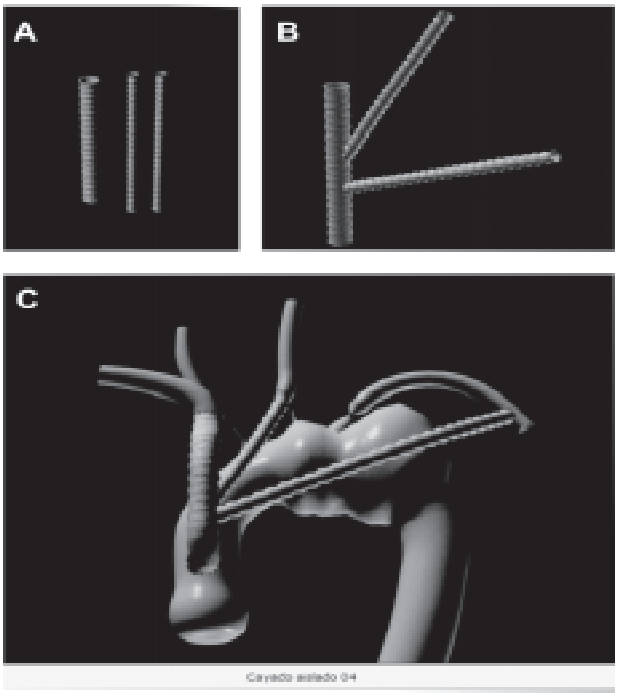

Fig.1. Diagram showing each graft individually (**A**), after the anastomosis (**B**) and, finally, *in situ* (**C**).

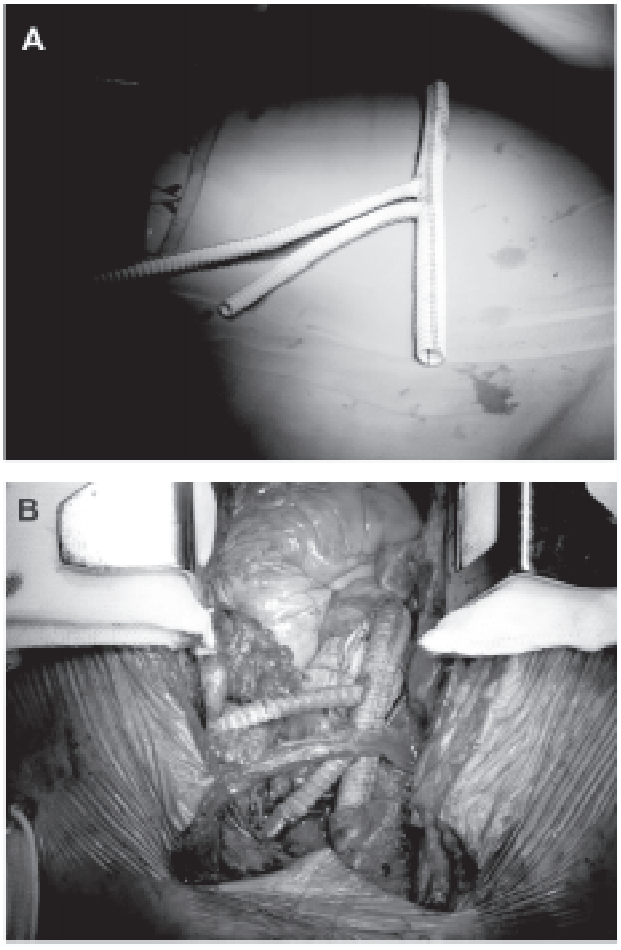

Fig.2. The built-up prosthesis **A.** Before the proximal and distal anastomosis. **B.** *In situ*.

A high degree of precision is demanded during the deployment of the endoprosthesis in all cases; nevertheless this issue is of vital importance in the cases of proximal compromise with complete replacement of the vessels to prevent an unnoticed occlusion of the bypass-graft at its origin. The radio-opaque ring that marked the proximal suture of the aortic bypass was extremely useful for us.

Twelve self-expanding stent-grafts were used: three Zenith TX1® (Cook) in the same patient (the first patient of the series), seven Valiant ® (Medtronic) and two Relay® (Bolton Medical).

RESULTS

Surgical Procedure

After the partial or total replacement of the neck vessels all patients recovered with no signs of transient or permanent cerebral ischemia.

There were no anastomosis-related complications.

Mechanical sternal dehiscences were not reported in the three patients who underwent median sternotomy.

Endovascular Procedure

Seven patients out of 10 received only one 200-mm long self-expanding stent-graft. Two patients received only one 250 mm-long endoprosthesis while another patient required 3 devices. In this patient - the first of the series - a type B dissection was treated with the conventional procedure, and the origin of the subclavian artery was successfully preserved. Fifteen days later the patient was readmitted with chest pain, hypertension and hemoptysis with a retrograde dissection towards the aortic arch that required a partial replacement of the neck vessels with implant of a third stent-graft.

All the implants were technically successful.

One patient with an acute dissection died during the first 24 hours after the intervention due to retrograde dissection towards the ascending aorta, with pericardial effusion and cardiac tamponade.

One patient with an aneurysm of the aortic arch died 27 days after the procedure of a pulmonary source of sepsis. The patient had a history of pulmonary obstructive lung disease and had been submitted to complete replacement with sternotomy.

The remaining patients (six with dissections and two with aneurysms) completed follow-up and were controlled with CT scans at 1, 6 and 12 months of postoperative. The longest follow-up lasted one year and a half and the shortest 6 months. No leaks or new corrections were reported during this interval. The two patients with aneurysms presented complete

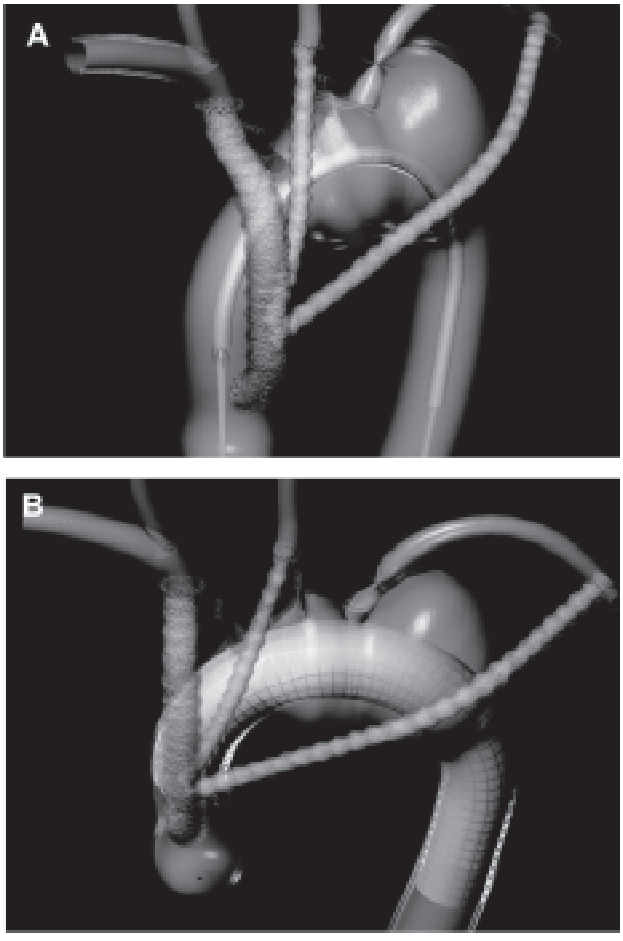

Fig. 3. Diagram that shows the grafts already anastomosed to the aorta and the neck vessels; the stent-graft is advanced from the femoral access (**A**), and the final deployment of the stent-graft (**B**).

thrombosis of the aneurysm at 6 months of follow-up, without changes in the diameters.

The two patients with non-dilated acute dissections presented complete thrombosis during follow-up. The other four dilated dissections presented partial thrombosis with no changes in the diameters compared to the preoperative values.

None of the patients required any additional surgical treatment.

DISCUSSION

Partial or total replacement of the neck vessels with stent-graft implant is a feasible and effective procedure to treat a group of highly selected patients.

Surgical repair of the aortic arch has high morbidity and mortality rates (9, 12) as well as unfavorable neurological outcomes despite the constant improvement of the technique. (13-15) The combination of 30-day stroke/death rate is 25.6% (mean 17.5%).

So far, the feasibility and effectiveness of this combined procedure has been reported in isolated cases or in small series of treatment, with a high incidence of technical success and favorable outcomes at mid-term follow-up. (16, 17)

We did not use brain monitoring during the global procedure as a complementary tool, and transesophageal ultrasound was only used in two out of three cases of complete replacement. This complementary diagnostic toll did not add any additional data useful to achieve a successful completeness of the procedure.

This endovascular technique is similar to the one used for diseases of the descending aorta; however, some special considerations are specific to the proximal aorta. The extra-support wire is placed on the sinus of Valsalva and, occasionally, it may enter the left ventricle.

The prosthetic appliance was originally designed for the treatment of the descending aorta, therefore the nose cone is too long and it may enter the left ventricle, with the subsequent risk of ventricular arrhythmias and mechanical complications due to rupture of the valvular or subvalvular apparatus, or to perforation of the left ventricle.

The development of the stent-grafts is crucial for generalizing endovascular procedures in the aortic arch (18) as they should have a specific design for this region, with shorter nose cones and more flexible bodies. In this sense, the best adapted endoprosthesis is the Relay Bolton Medical®. Its proximal cone is shorter; the deployment device uses a sheath that is positioned in the abdominal aorta and the uncovered stent-graft is advanced towards the desired site.

This method is less invasive and appears to be safer. Physicians associate this concept with a better prognosis. The prognosis of aneurysms and dissections of the aorta seems to be intimately related to comorbid factors (19-22) rather than to a lower risk of the procedure. Mid-term survival might be influenced by other variables that reflect the patient's general status and his/her life expectancy.

This paper was not designed to determine those sectors of a population who might gain greatest benefit from this procedure, whether uncomplicated low-risk patients or elder patients with associated comorbidities not eligible for conventional surgery. We still ignore which patients will benefit from the use of this technique (23, 24) and which is the situation of endovascular repair in the treatment of aneurysms and dissections of the aorta. Undoubtedly, this procedure has come to stay and its use in high-risk patients or in presence of complications (impending aneurysm rupture, visceral ischemia, and intractable hypertension) is accepted. The INSTEAD TRIAL has been designed to compare the usefulness of this strategy with medical treatment. Up to now, the patency of the false lumen and an aortic diameter greater then 4 cm are considered predictors of bad prognosis at mid-

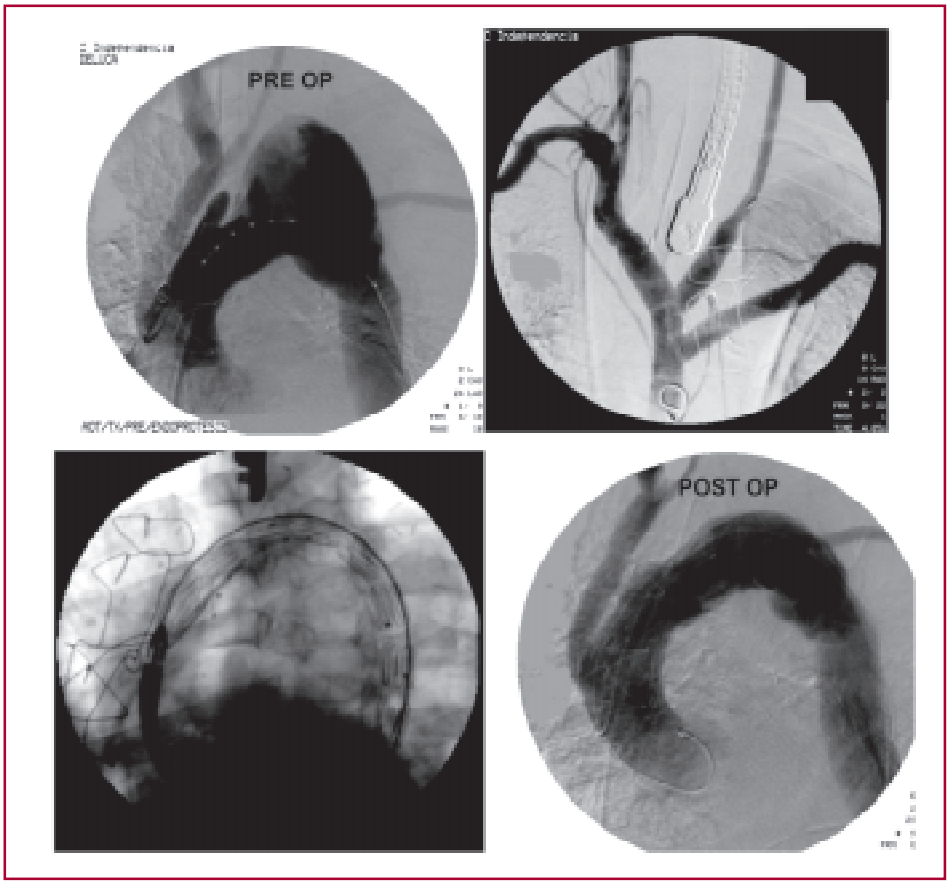

Fig. 4. The endovascular procedure, step by step.

term and long-term follow-up. (25, 26) This was our criterion for treatment in the three patients with uncomplicated acute dissections.

Finally, this new strategy has been developed to solve complex cases with high risk, and it should be carried out by a treating team with experience in emergencies, which should include technicians, nurses, vascular surgeons, interventional cardiologists, anesthesiologists and clinical cardiologists. In our case, we started to perform endovascular repair of the abdominal aorta in 1998, of the descending aorta in 2000, and since 2004 we have decided to perform endovascular repair in acute diseases of the aorta. The accomplishment of hybrid procedures is the corollary of a learning curve during several years, which included specific professional training to understand the clinical picture, the underlying anatomy, the selection of patients and the therapeutic options.

CONCLUSIONS

This combined therapy for dissections and aneurysms of the aortic arch with partial or total replacement of the neck vessels and stent-graft implant, which has been conceived as a two-stage procedure, has proved to be feasible and safe for the population included.

The outcomes at mid-term follow-up are encouraging and similar to other international series.

Yet, it is not clear in which clinical context this technique might be used or which patients might gain any benefit; the answer will depend on the results of ongoing trials.

This complex treatment needs a multidisciplinary team composed of interventional cardiologists and heart surgeons working in a tertiary medical center.

SUMMARY

Reubicación de los vasos del cuello y exclusión endovascular de las disecciones y los aneurismas del arco aórtico

El tratamiento endovascular de la aorta descendente le brinda a un grupo de pacientes seleccionados de alto riesgo una alternativa para resolver un problema grave de manera segura y efectiva.

Sólo el 15% de los enfermos tiene un cuello adecuado para el implante respetando la integridad de la arteria subclavia izquierda y su oclusión intencional origina en hasta un 30% isquemia del brazo, síndrome vertebrobasilar o *leaks*. Además, los pacientes que presentan compromiso del arco aórtico (extensión retrógrada de la disección, porque ésta se origina allí o por aneurisma de ese sector) constituyen una población aún más seleccionada y de mayor riesgo para el tratamiento quirúrgico habitual.

Entre noviembre de 2005 y diciembre de 2006 incluimos 10 pacientes que se presentaban con: 1) disecciones con compromiso de la arteria subclavia izquierda o retrodisecciones hacia el cayado aórtico (n = 7) y 2) aneurismas del cayado aórtico (n = 3).
Fueron tratados dentro del período agudo (14 días), todos con un puntaje de riesgo anestésico (ASA) igual a 3 o mayor. Se utilizó una técnica híbrida, de un solo acto en dos etapas (quirúrgica/endovascular) realizadas en el mismo día. En la fase quirúrgica no se requirió paro cardíaco, circulación extracorpórea ni hipotermia profunda y durante la etapa endovascular se utilizaron prótesis autoexpandibles y es aquí donde se notaron las dificultades técnicas que debieron sortearse para llevar adelante el implante.
Todos los procedimientos resultaron técnicamente exitosos. Dos pacientes fallecieron, uno en el primer día (taponamiento cardíaco) otro por sepsis en el día 27.
No se registraron complicaciones neurológicas ni vasculares. La técnica fue factible y efectiva, con una morbimortalidad adecuada para la población en estudio y similar a la de publicaciones con pacientes de las mismas características.

Palabras clave > Aneurisma - Aorta - Disección - Prótesis vascular - Cirugía torácica

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