

Intentional Occlusion of the Left Subclavian Artery during Endovascular Repair of Descending Thoracic Aorta

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SUMMARY

Background

The safety and efficacy of endovascular repair of descending thoracic aorta depends on certain anatomical conditions, in particular the presence of a healthy segment of the aorta (proximal neck). In a significant proportion of patients, the proximal neck is inadequate or non-existent. A bypass or transposition of the left subclavian artery would maintain an adequate perfusion of the left arm after stent-graft implantation. However, this surgical approach is not always feasible in unstable patients who are treated urgently or that have multiple comorbidities.

Objective

Evaluate the clinical and neurological consequences of intentional occlusion of the left subclavian artery during endovascular repair of descending thoracic aorta.

Material and Methods

Between August 1999 and February 2010, 136 patients were consecutively treated with implantation of self-expandable stent-grafts. In 29 patients (21%) with absence of an adequate proximal neck (healthy aorta sector \geq 15mm in length), it had to be intentionally covered the origin of the left subclavian artery. In all cases, before procedure it was carried out a selective angiography of the right vertebral artery in order to confirm the permeability of this and the conformation of the vertebrobasilar circulation.

Results

A total of 20 men and 9 women were treated, whose mean age was 62 (49-72) years. The basic pathology was acute type B aortic dissection (n = 4), chronic type B aortic dissection (n = 14), intramural hematoma (n = 1), true aneurysm (n = 7), aortic ulcer (n = 1) and traumatic pseudoaneurysm (n = 2). The device implantation was successful in all the patients. There were no clinical or neurological complications to median follow up of 29 months (13-50).

Conclusions

The use of strict selection criteria allows intentional occlusion of left subclavian artery during endovascular repair of descending thoracic aorta, without increasing the incidence of higher complications. Thus, surgical revascularization is reserved for patients with severe symptoms of ischemia during follow-up.

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Key words

> Aorta - Endovascular - Stent-grafts - Subclavian artery

Abbreviations

> LCCA	Family History of Sudden Death	TBAD	Secondary prevention
LSA	Automatic Implantable Cardioverter Defibrillator		

BACKGROUND

The treatment of various pathologies of the thoracic aorta with stent-graft implantation may be carried out safely and effectively as long as certain

anatomical conditions are kept. In particular, the presence of a healthy aorta segment of at least 15mm distal length to the origin of the left subclavian artery (LSA) allows us to fix properly the device,

which reduces the possibility of migration and the development of endoleaks.

In a significant proportion of patients, this proximal neck is inadequate or non-existent. The carrying out of a bypass or transposition of the LSA would allow us to maintain a proper perfusion of the left arm after stent-graft implantation. However, this surgical approach is not always feasible in unstable patients who are treated urgently or that have multiple comorbidities.

In this work we evaluate the clinical and neurological consequences of intentional occlusion of the LSA in a series of patients with pathologies of the descending thoracic aorta treated by endovascular surgery.

MATERIAL AND METHODS

Between August 1999 and February 2010, we consecutively treated 136 patients with aortic arch and / or descending thoracic aorta pathology with an implantation of self-expandable stent-grafts. In 29 patients (21%) in the absence of an adequate proximal neck we should intentionally cover the origin of the LSA with the stent-graft (Figure 1). All demographic, clinical, angiographic and follow-up data was prospectively recorded.

All procedures were carried out under general anesthesia

and invasive monitoring of blood pressure. In one patient underwent drainage of cerebrospinal fluid (1) by history of surgery for abdominal aortic aneurysm.

We used TALENT® or VALIANT® self-expandable stent-grafts (Medtronic, USA), which have free-graft proximal segment of 15mm in length, which allows the attachment of the device to the wall of the aorta. The release of the stent-grafts was carried out under controlled systemic hypotension (mean arterial pressure \leq 70mm Hg).

Before device implantation, in all the cases underwent a selective angiography of the right vertebral artery, in order to confirm its permeability and assess the conformation of the vertebrobasilar circulation.

Surgery was carried out to revascularize the left subclavian artery in patients with a dominant left vertebral artery, obstructive disease of the right vertebral artery or bilateral carotid, left mammary-coronary bypass, dialysis fistula of the left arm, anatomical variations of aortic arch (abnormal right subclavian) or with extensive compromise of the thoracoabdominal aorta. (2)

A patient, who required an axillosubclavian bypass with reimplantation of the left common carotid artery and a stent-graft from the brachiocephalic trunk, was included in the control group. Two other patients with stent-graft implantation from the brachiocephalic trunk required a carotid-carotid bypass before the procedure. These patients were part of the study, since it was not revascularized left subclavian artery.

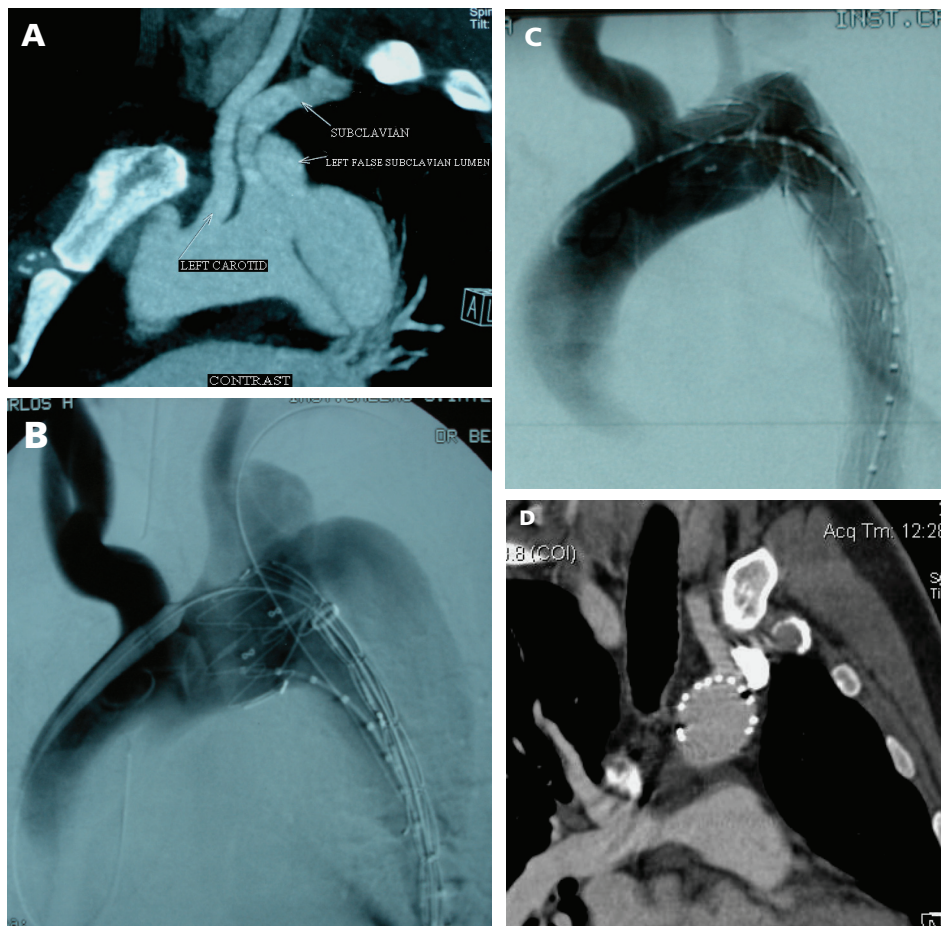


Fig 1.

A. Coronal reconstruction of multislice CAT before the procedure.

B. Release of the stent-graft. Guide place from LSA. to the descending aorta to use as a reference during the procedure.

C. Immediate angiographic control that shows absence of LSA blood circulation (arrow).

D. Control CT at 24 months that shows normal permeability of the left carotid artery (arrow).

Definitions

Severe hypertension: requirement of antihypertensive treatment by intravenous line at the time of procedure.

Obesity: Body mass index (BMI) ≥ 30 (ratio between weight in kilograms to the square of height in meters).

Chronic renal failure: history of normal serum creatinine $\geq 1.5\text{mg/dl}$.

Follow up

All patients were followed up by multislice computerized tomography with three-dimensional reconstruction of the aortic arch level at 1. 6 and 12 months during the first year and annually thereafter.

Between December 2009 and February 2010, a cardiologist of the group carried out a clinical assessment of patients, which included measurement of blood pressure in both upper limbs. In the first 20 patients enrolled, this was supplemented with an assessment by a neurologist.

Statistical analysis

Continuous variables are presented as median and interquartile interval (25-75), while categorical variables are expressed as a percentage along with their absolute value. Differences between variables were assessed with the Mann-Whitney test or the Fisher test as they were continuous or categorical.

The difference in free survival of major events (mortality, rupture or endoleak intervention) was assessed by the Kaplan-Meier and Wilcoxon log-rank methods.

Statistical analysis was carried out using StatsDirect programme.

RESULTS

Characteristics of the global population

The clinical and angiographic characteristics of patients with or without intentional occlusion of the subclavian artery were similar, except for the proximal neck length [0 (0-0) versus. 20 (13-50), $p < 0.0001$] and for the length of implanted stent-grafts [150 (130-200) versus. 150 (130-200), $P < 0.05$].

There were no differences in the incidence of death, rupture or endoleak treatment between both groups (82.8% versus. 87.9%, $p = 0.48$) (Figure 2).

Patients with subclavian artery occlusion

In total there were treated 20 men and 9 women, the median time of follow-up was 29 months (13-50).

Table 1 shows the demographic and clinical characteristics of patients. The aortic pathology of base was: acute type B aortic dissection (BAD) (n = 4; 13.8%), chronic BAD (n = 14; 48.3%), intramural hematoma (n = 1; 3.4%), true aneurysm (n = 7; 24.1%), aortic ulcer (n = 1; 3.4%) and traumatic pseudoaneurysm (n = 2; 6.8%). The device implantation was successful in all cases, they were required a proximal and 12 distal extensions. In 12 patients the aorta was covered below the diaphragmatic hiatus, with no paraplegia observed in any case.

There were two deaths during the perioperative period. A patient with Marfan disease and cronic BAD had symptoms of mesenteric ischemia within the first 24 hours by occlusion of the superior mesenteric

Fig 2. Survival free of death, rupture or endoleak intervention.

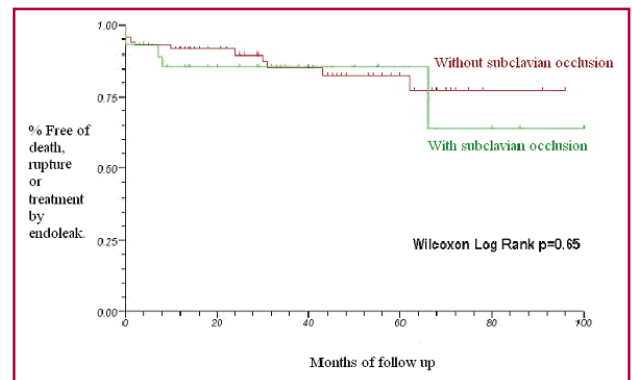


Table 1. Clinical characteristics and demographic factors

Variables	
Age, years	62 (49-72)
Male, % (n)	69.0 (20)
Severe AHT, % (n)	37.9 (11)
Active tobacco addiction, % (n)	17.2 (5)
Dyslipidemia, % (n)	48.3 (14)
Diabetes, % (n)	17.2 (5)
Obesity, % (n)	41.4 (12)
Coronary artery disease, % (n)	17.2 (5)
Peripheric vascular disease, % (n)	3.4 (1)
Chronic obstructive pulmonary disease, % (n)	34.5 (10)
Chronic renal failure, % (n)	10.3 (3)
ASA -fitness level	
I, % (n)	6.9 (2)
II, % (n)	58.6 (17)
III, % (n)	31.0 (9)
IV, % (n)	3.4 (1)

ASA: American Society of Anesthesiology.

artery, due to an extension of the dissection after releasing the stent-graft at the level of the descending thoracic aorta. The other patient underwent surgery for a thoracic aneurysm rupture, had a picture of multiorganic failure on the fourth day after surgery.

Two patients died at 7 and 8 months of follow-up. The first presented a low digestive hemorrhage and the second, an acute myocardial infarction. One patient was lost at the fifth year of follow up.

There was an *early endoleak* by filtration through the device and one proximal late by migration of the device. The first one was resolved spontaneously during follow-up, while in the second one, a proximal extension was implanted without complications.

Clinical consequences of subclavian occlusion

Three patients had paresthesia and left upper limb claudication during three months after the procedure; these symptoms were temporary and they did not require any treatment.

The final clinical assessment was carried out in 24 patients. One of them showed claudication of the left arm, while the remainders were clinically and neurologically asymptomatic. The mean systolic pressure was 130mm Hg (127.5 to 156.3) for the right arm and 95mm Hg (87.5 to 102.5) for the left one.

DISCUSSION

The safety and efficacy of endovascular repair of descending thoracic aorta depends on certain anatomical conditions. The presence of a healthy segment of the aorta of at least 15mm in length (proximal neck or landing zone) assures a proper fixation of the stent-graft to the aortic wall and a circumferential sealing, thereby preventing migrations and leakages. In order to provide adequate radial force, devices with a diameter greater than 10-20% of the proximal neck are used. (3)

The systematic screening of anomalies of the supra-aortic vessels by non-invasive methods (multislice CT, MRI, or Doppler of the neck vessels) prevents complications related with the procedure. However, in complex or emergency situations, the angiographic assessment of aortic arch and neck vessels allows us to obtain accurate and detailed anatomical information.

In patients with inadequate proximal neck, one alternative is the implantation of the distal device to the origin of the left common carotid artery (LCCA) intentionally occluding the LSA. In our series, this situation took place in 21% of patients without causing early nor remote major complications.

However, a recent meta-analysis about this technique showed a higher frequency of vertebrobasilar ischemia and of the left arm, as well as a tendency to the occurrence of medullary and forebrain ischemia, without differences in other major events (death, myocardial infarction or transient cerebral ischemia). Its authors emphasize the poor quality of the analyzed studies, which is why it could not be determined whether those findings were merely a reflection of the basic aortic pathology. (4)

The reverse of the left vertebral artery flow from the right vertebral artery is usually sufficient as to maintain perfusion and functionality of the left upper limb after occlusion of the LSA. This phenomenon of adaptation may require several months, as it is suggested by the outcome of three patients in our series that initially presented paraesthesias and left arm claudication. (5)

Thus, the reported frequency of symptoms attributable to subclavian hypoflow is 10-15% and revascularization procedures are required in 4-5% of patients. (6, 7) The difference in blood pressure found during neurological assessment between the two arms is consistent with that reported by other groups (between 36 and 48mm Hg). (8)

In any case, we carried out embolization or occlusion of the origin of the LSA prior stent-graft

implantation. The persistence of retrograde flow through the LSA to false lumen or aneurysmal sac after implanting the stent-graft involves to a potential risk of late rupture. This situation is unusual, as we have observed in our series, the incidence found in the bibliography is 1.2%. (8) In these cases, occlusion of the LSA can be achieved as endovascular (embolization with coils or with a *vascular plug* by brachial or radial via) or surgical (binding or transposition of the LSA) way. (9)

Surgical revascularization options (before or after implantation of the stent-graft) are the transposition of the LSA to LCCA or left carotid subclavian bypass. Although both procedures are technically simple in experienced hands are not free of complications, including death (1-2%), CVA (4-6%) and nerve injury (9-12%). (10) Experience in obstructive pathology shows that faraway permeability and resolution of symptoms are better in those treated with transposition of the LSA. (11).

Using criteria of strict selection, surgical revascularization of supra-aortic vessels would be reserved for patients with an inadequate anatomy, (12) severe symptoms of ischemia during follow-up or with need to extend the proximal neck to the origin of LCCA or the brachiocephalic trunk.

Future developments, such as procedures for fenestration (13) or stent-grafts with branches, (14, 15) will have an important role in handling these situations with no easy solution.

Limitations

Our study has certain limitations that deserve to be commented. First, the size of the population is poor. However, our results are consistent with those reported by other authors.

Second, the decision to cover the origin of the LSA with the stent-graft was only based on anatomical criteria, without carrying out, for example, tolerance test by occlusion with balloon. The usefulness and reliability of this type of moves are not established yet and the opinions are controversial. (6, 16)

Third, the presence of ischemic sequelae (cerebral or posterior fossa) was not systematically evaluated after the intervention by CT or MRI.

Finally, the presence of claudication of the left arm during the neurological assessment was only based on the interview and physical examination, without performing an objective functional assessment.

RESUMEN

Oclusión intencional de la arteria subclavia izquierda durante el tratamiento endovascular de la aorta torácica descendente

Introducción

La seguridad y la eficacia del tratamiento endovascular de la aorta torácica descendente dependen de ciertas

condiciones anatómicas, en particular de la presencia de un segmento sano de aorta (cuello proximal). En una proporción importante de pacientes, este cuello proximal es insuficiente o inexistente. Un bypass o transposición de la arteria subclavia izquierda permitiría mantener una perfusión adecuada del brazo izquierdo luego del implante de la endoprótesis. Sin embargo, este abordaje quirúrgico no siempre es factible en pacientes inestables, tratados de forma urgente o que presentan múltiples comorbilidades.

Objetivo

Evaluar las consecuencias clínicas y neurológicas de la oclusión intencional de la arteria subclavia izquierda durante el tratamiento endovascular de la aorta torácica descendente.

Material y métodos

Entre agosto de 1999 y febrero de 2010, 136 pacientes fueron tratados consecutivamente con implante de endoprótesis autoexpandibles. En 29 pacientes (21%) con ausencia de un cuello proximal adecuado (sector sano de aorta ≥ 15 mm de longitud) se debió cubrir intencionalmente el origen de la arteria subclavia izquierda. En todos los casos, previo al tratamiento se realizó una angiografía selectiva de la arteria vertebral derecha con el objetivo de confirmar la permeabilidad de ésta y la conformación de la circulación vertebrobasilar.

Resultados

Se trataron 20 hombres y 9 mujeres, cuya edad media fue de 62 (49-72) años. La patología de base fue disección aórtica tipo B aguda ($n = 4$), disección aórtica tipo B crónica ($n = 14$), hematoma intramural ($n = 1$), aneurisma verdadero ($n = 7$), úlcera aórtica ($n = 1$) y pseudoaneurisma traumático ($n = 2$). El implante del dispositivo fue exitoso en todos los pacientes. No se registraron complicaciones clínicas ni neurológicas a 29 (13-50) meses de seguimiento medio.

Conclusiones

La utilización de criterios de selección estrictos permite la oclusión intencional de la arteria subclavia izquierda durante el tratamiento endovascular de la aorta torácica descendente, sin aumentar la incidencia de complicaciones mayores. Así, la revascularización quirúrgica queda reservada para pacientes con síntomas graves de isquemia durante el seguimiento.

Palabras clave > Aorta - Endovascular - Stents - Arteria subclavia

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