INTRODUCTION

By the definition adopted at Ad Hoc Committee on Reporting Standards of Society for Vascular Surgery and North American Chapter of the International Society for Cardiovascular Surgery, an aneurysm is a localized or diffuse but permanent dilation of an artery with a diameter 50% bigger than the regular size of the artery.\(^1\)

**Classification**

Thoracic aneurysms (TAA) are subdivided into 3 groups depending on location:

- aneurysm of ascending aorta +/- valvular lesion named by Cooley anuloaortic ectasia (associated frequently with Marfan syndrome);
- aneurysm of aortic arch;
- aneurysm of descending thoracic aorta (the most frequent type).\(^2\)

Thoraco-abdominal aneurysms (TAAA) are classified by Crawford in 4 types:\(^3:\)

- Type I-aneurismal dilation affects the whole descending thoracic aorta beyond the left subclavian artery and the first part of abdominal aorta up to the origin of renal arteries;

**SUMMARY:**

The pathology of aortic aneurisms continues to represent a challenge for both cardiac and vascular surgeons as for those who practice endovascular procedures (radiologists, interventional cardiologists or in “developed” countries vascular surgeons). We present the case of a patient with a complex thoraco-abdominal aneurysm that underwent endovascular exclusion with visceral revascularization/visceral hybrid procedure (in Clinic of Thoracic and Cardio-Vascular Surgery Hospital “Saint Joseph” Marseille, France). A 65-year-old female patient, smoker with chronic obstructive pulmonary disease, hypertensive, totally asymptomatic was discovered at a routine chest X-ray exam with a large thoracoabdominal aneurysm. The Spiral CT Scan exam and the arteriography showed thoracoabdominal aneurysm (TAAA type I Crawford). The treatment consisted in a hybrid/combined vascular procedure. The transposition of the arteries emerging from the aneurismal part of aorta (left carotid artery, left subclavian artery, celiac trunk and superior mesenteric artery) was performed in open surgery on the first stage. In the second stage (endovascular procedure) a stent-graft was placed via femoral artery in the thoracic aorta and the first part of abdominal aorta. Both interventions were performed under local and general anaesthesia. The evolution was favourable postoperatively, the patient was discharged on the 8th day after the second intervention and was followed-up for 1, 3, 6, 12 months.

**Key Words:** thoracoabdominal aneurysm, visceral hybrid procedure, anterograde revascularization, stent graft.
Type II- the lesion characteristic for type I is present here too and the entire abdominal aorta and even the iliac arteries are affected by dilation;

Type III- the dilation affects the mid/distal part of descending thoracic aorta and the entire abdominal aorta up to the bifurcation;

Type IV- characterized by the dilation of the upper renal part associated or not with an infrarenal dilation.

Abdominal aortic aneurysms (AAA) affect the aorta under the origin of renal arteries (most frequent localization-95%).

Ethiology
The true etiology is probably multi factor and the disease develops in individuals presenting multiple risk factors such as: smoking, chronic obstructive pulmonary disease, hypertension, atherosclerosis and genetic disorders.

Clinics
Most of the patients with TAAA are asymptomatic, the aneurysm is found incidentally at a routine chest X-ray. Most of the patients are smokers, frequently presenting obstructive pulmonary disease and hypertension. The most frequent symptom is represented by the pain (acute in rupture and dissection or chronic caused by the distension and compression). The location of the pain could give some information regarding the segment of aorta involved in dilation (anterior chest pain- ascendant aorta, pain radiating in the neck- arch of aorta, interscapulae back pain-descending aorta, mid back and epigastric pain- aorta at the level of diaphragmatic hiatus). Other more rare symptoms due to the compression, erosion into surrounding structures, thromboses or peripheral embolisation could be: stridor, wheezing, cough, dysphagia, haemoptysis, hematemesing, or gastrointestinal bleeding, paraparesis or paraplegia, ischemia in visceral, renal or lower extremities.

Diagnosis
1. Suspicion: pulsating mass found at abdomen palpation or ultrasound exam- in TAAA type II, III, IV; a shadow positioned anterior and slightly to the left for arch aneurysms and posterior and to the left for descending thoracic aneurysms found at chest radiography.
2. Confirmation: imaging exams (computed tomography scan, magnetic resonance imaging, and aorta-angiography).

Indications/contraindications for surgery
1. Indication criteria are the size, the growth rate and the symptoms. For TAAA without Marfan disease or familial disorders a diameter >6,5cm and for those who present these anomalies or a dissection a diameter that exceeds 6cm represents a surgical indication. More accurate, in predicting complication, that absolute aortic size seems to be the relative aortic size reported to body surface (aortic size index<2.75 cm/m²- low risk, 2.75-4.24 cm/m²- moderate risk, >4.24 cm/m²- high risk for rupture). Also a growth rates average of 0.19 cm/y in the descending aorta and a growth rate of 1 cm/y or faster is an indication for elective surgical repair. The appearance of any of enumerated symptoms regardless the size of aneurysm represents an operating indication.
2. There are same individualized relative contraindications (the risk-to-benefit ratio), but there aren't any strict contraindications. For TAAA, endovascular stent grafting is a less invasive alternative to open repair for patients at high risk for complications of open repair, but also in patients who are not at high risk for complications.

Preoperative workup
Imaging Studies for evaluation of the aneurysm
1. Computed tomography scan (CT scan)
   - CT scan exam with contrast has become the most used diagnostic tool. It gives rapid and precise information about: the location, the size and the extent of the aneurysm, the relationship to major branch vessels and surrounding structures, the presence of dissection, mural thrombus, intramural haematoma, free rupture or contained rupture with haematoma. A spiral CT scan could obtain a 3-dimensional reconstruction. The endovascular procedures require three-dimensional reconstruction to determine the adequacy of the proximal landing zone, the fact that supraaortic branches are patent, as well as the feasibility of the common femoral artery access. This exam can be used even in instable patients suspected by rupture.
   - CT angiography may create multiplan reconstructions and cines. This requires nephrotoxic contrast and radiation, but the procedure is non-invasive.
2. Magnetic resonance imaging (MRI)

MRI with or without contrast (Gadolinium) has the advantage of avoiding nephrotoxic contrast and ionizing radiation, but is more time consuming, less readily available, and more expensive than CT scans. MRI and magnetic resonance angiography give information about the location, extent, size of the aneurysm and can differentiate between thrombosed and normal blood flow. It gives also relation about emerging branches and surrounding organs.

3. Aorto-angiography

Aortography is demanded especially for the evaluation of the coronary, epiaortic visceral and spinal arteries, but it does not help in defining the size of the aneurysm because the outer diameter is not measured. Disadvantages include the use of nephrotoxic contrast, radiation and the risk of embolization with a 1% stroke risk.

Other Tests for evaluating general estate of the patient

1. Screening for cardiac diseases

Baseline ECG, transthoracic echocardiograms for valvular abnormalities and cardiac function and even cardiac catheterization: in patients with a history of coronary artery disease or those older than 40 years should be performed.

2. Screening for carotid lesions

For all the patients proposed for cardio-vascular surgery a non-invasive carotid Echo Doppler ultrasound is needed.

3. Laboratory Studies

CBC count, electrolyte evaluation and creatinine value: (renal function), prothrombin time, international normalized ratio, and activated partial thromboplastin time, blood type and cross match, liver enzymes and amylase lactate values

4. Pulmonary function tests with spirometry and arterial blood gas determinations in patients with a smoking history and chronic obstructive pulmonary disease

Treatment

Medical Therapy

Strict control of hypertension in all patients, regardless of aortic aneurysm size, cessation of smoking and control of other risk factors for peripheral arterial obstructive disease is necessary.

Surgical Therapy

Descending thoracic aneurysms and TAAA (~10% of thoracic aneurysms) may be repaired with:

1. Open surgery

   - First reported resection with allograft replacement- 1951 by Lam and Aram.
   - The procedure may or may not need a partial bypass of the left atrium to the femoral artery.
   - Type I TAAA involves Dacron graft replacement of the aorta from the left subclavian artery to the visceral and renal arteries. Type II TAAA requires that the Dacron graft reaches the aortic bifurcation with reattachment of the intercostal arteries, visceral arteries, and renal arteries. Type III or IV TAAA repairs may be performed in a modified atrio-visceral and/or renal bypass. Prevention of paraplegia is one of the principal concerns and for this are used one of the following spinal protection: cerebrospinal fluid drainage, reimplantation of intercostal arteries, partial bypass, and mild hypothermia.

2. Endovascular stent grafting techniques

   - First reported endovascular thoracic aortic repair- 1994 by Dake et al
   - An appropriate anatomy (proximal neck of 2 cm prior to the aneurysm ideally beyond the left subclavian artery and distally, a sufficient landing zone of 2 cm prior to the celiac artery and appropriately sized femoral and iliac arteries- typically >8 mm in diameter without tortuosity and calcium) may permit the repair by endovascular stent grafts. The type of stents that may be used are specially designed for descending thoracic aneurysm repair (GORE TAG is an FDA–approved nitinol-based stent graft or custom-built fenestrated and branched stent grafts (still under investigational trials)

3. Visceral hybrid procedure

   - Recently developed, the procedure implies two stages: in the first stage, a revascularization of the visceral arteries and in the second stage an endovascular graft placement through the femoral artery, from the segment proximal to the aneurysm, above the origin of the visceral artery reconstructions, excluding the aneurysm from circulation. The two stages may be performed concomitant or the second stage may be delayed. Since now in the literature are listed only papers implying retrograde transposition of the visceral arteries. In our presentation the first stage of the procedure
consisted in an anterograde transposition of the visceral arteries.

**CASE STUDY**

A 65 years old female patient, smoker with chronic obstructive pulmonary disease, hypertensive, with ancient hysterectomy and appendectomy, totally asymptomatic was discovered at a routine chest X-ray exam with an enlargement of the mediastinal shadow, dislocation to the right of the trachea and down dislocation of the left main bronchia. (fig.1)

The CT angiography with multiplanar reconstructions (fig.2,3) showed a dilation of aorta beginning at the posterior part of the horizontal segment (arch) of the aorta, after the origin of left subclavian artery, affecting the entire descending thoracic part and ending before the origin of renal arteries (involves also the digestive branches: celiac trunk and superior mesenteric artery). This thoracoabdominal aneurysm (TAAA type I Crawford) with a maximum diameter of 65 mm was partially thrombosed and presented a “bi-locular” aspect (coexist an alveolar segmental syndrome in the middle lobe of right lung).

The aorto-coronarography (fig.4) showed the same aspects of the dilation (diameter of circulating channel ~50mm, estimated maximal diameter~75-80mm), the supra aortic trunks – normal aspect, without endoleak in the false channel, the coronary artery are normal.

The other preoperative workups made for evaluating general estate of the patient were in normal limits except: a slight increase of the creatinine and azothemie value (assumed to be determined by the nephrotoxic contrast injected at CT scan exam), modification of the results at

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**Fig.1.** Chest X-ray exam: enlargement of mediastinal shadow

**Fig.2.** CT angiography (classic images): thoracoabdominal aneurysm

**Fig.3.** CT angiography with multiplanar reconstructions: thoracoabdominal aneurysm

**Fig.4.** Aorto-coronarography: thoracoabdominal aneurysm, normal coronary artery.
spirometry and arterial blood gas determinations (characteristic in patients with chronic obstructive pulmonary disease) and a cardiac function with FE~60% (just at the limit) in the transthoracic cardiac ultrasonography.

The treatment options were: open surgery involving a high risk, endografting-impossible in this case due to missing of the inferior landing zone, and the hybrid/combined vascular procedure consisting in transfemoral stent repair with surgical revascularization of visceral arteries (the choice to make).

In the first stage in open surgery (mediastino-laparotomy), under regional and general anaesthesia, was performed the transposition of the arteries emerging from the aneurismal part of aorta. In our case the procedure consisted in an anterograde by-pass with Dacron hand made prosthesis in “Y” form (Ø=12mm and Ø=7mm, fig.5), of the left carotid artery (LCA), left subclavian artery (LSA), celiac trunk and superior mesenteric artery.

By anterograde by-pass we understand that the proximal end of the prosthesis was posted on the ascendant part of the aorta in a termino later anastomosis and his distal part was represented by a termino terminal anastomosis on the targeted artery (fig.6).

In addition a banding procedure was performed both at the level of ascending aorta and abdominal aorta just above the origin of the renal arteries (fig.7). At the proximal edge of the ascendant aorta band a steel wire was inserted, like a radiopaque marker for the next stage (the endovascular graft stent placement).

Postoperative (PO) care was performed at a Cardiac Intensive Care Unit (ICU) for 2 days with monitoring the haemodynamics standards (Hb=10.2). The PO treatments consisted in antibiotics, CALCIPARINE 0.3×3/day and painkillers. Due to a good evolution the patient was transferred in the clinic the third day PO. In the clinic the evolution was very slow but good, interrupted by some minor complications:

- in day 2 – left upper limb oedema appeared (Vascular Ultrasonography showed no sign of deep venous thrombosis) and therefore the manifestation was assumed to be of compressive cause (due to inraoperatory works on the left inominate venous trunk) and also a slight decrease of the Hb=11.3;

![Fig.5. Hand made “Y” form Dacron prosthesis.](image1)

![Fig.6. Anterograde transposition of LCA, LSA, celiac trunk and superior mesenteric artery.](image2)

![Fig.7. Banding of the ascendant aorta and radiopaque marker (steel wire) positioning.](image3)
in day 4 – same respiratory problems appeared, due to the ancient chronic obstructive pulmonary disease, also the red blood cell ratio continue to decrease (Hb=8.8) without any sign of active bleeding;

in day 5-7 – progressive bilateral lower limb oedema developed determining the initialization of a diuretic treatment, the patient become depressed;

in day 8-10 – bilateral lower limb oedema persists, also the decreasing of the red blood cell continued reaching a Hb of 7.7, in that point the patient was submitted to a 2 blood units perfusion followed in two days by an increase of Hb to 9.7;

in day 14 – due to increasing bilateral lower limb oedema and respiratory problems a cardiologic exam and Cardiac Ultrasonography is performed; the results showed no heart problems but the presence of a bilateral hydrothorax; after a chest radiograph which showed bilateral pleural liquid – in the left part - increased quantity (fig.8), a pleural puncture was performed with extraction of ~300ml of sero haematic liquid;

In day 17 the patient was submitted to the second intervention. The second stage/endovascular procedure consisted in graft stent placement via femoral artery in the thoracic aorta and the first part of abdominal aorta covering the anatomical origin of the left carotid and subclavian artery, and also of the celiac trunk and superior mesenteric artery. The surgical procedure to implant the device was performed under fluoroscopic guidance; anaesthesia was combined, regional and general, preceded by cerebrospinal fluid drainage, with continuous monitoring and systemic heparinization. Arterial approaches to perform the procedure were obtained through a right inguinal cross-sectional incision (fig.9).

The right femoral arteries was dissected, introduction and implantation of the endofit stent graft with a 20F calibre, was performed directly through the right common femoral artery, on a rigid Amplatz guide wire and under fluoroscopic guidance (fig.10).

After placing the stent graft a diagnostic 5F pig tail catheter was introduced and a panoramic aortography was performed revealing a slight narrowing of the aorta diameter in the distal part repaired with an Amplatz stent and a little type 1 endoleak which remained under postoperative surveillance (fig.11).

The duration of the second stage was about 60 minutes, with a total fluoroscopy time of about 20 minutes.

Postoperative the evolution was favorable under antibiotics, Calciparine and painkillers. Lab exams showed a slight decrease of the red blood cells, a slight increase of white blood cells, but a good renal function and a good state of coagulation.
The patient was discharged in the 8th days after the second intervention and remains in follow-up at 1, 3, 6, 12 months.

CONCLUSIONS

1. The endovascular treatment of arterial lesions is not new (Dotter in 1969 performed the first successful endovascular treatment in popliteal arteries of dogs), but only in 1991 Parodi reported the first successful endovascular treatment of infrarenal aortic aneurysm in humans.

2. Visceral hybrid procedure with the aim of minimizing the classic open procedure was recently developed in a few supper specialized hospitals like the Marseille “Saint Joseph” Clinic of Thoracic and Cardio-Vascular Surgery which is also one of the few “Centre de Reference des Anevrismes et Dissections de l’Aorte” from France.

3. Since now in the literature are listed only papers implying open abdominal access, allowing extra-anatomical by-passes/retrograde transposition for the visceral arteries. Therefore “Bergeron’s hybrid technique” the technique described in this paper represents an innovation in this very challenging area – aneurismal pathology of aorta.

4. The most recent advance procedure in the TAAA treatment is its repair exclusively by endovascular technique. For this kind of procedure to be performed, a special, branched and customized stent graft is necessary according to the anatomical characteristics of the patient’s aorta.

REFERENCES:


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