Aortic dissection with acute malperfusion syndrome: Endovascular fenestration via the funnel technique

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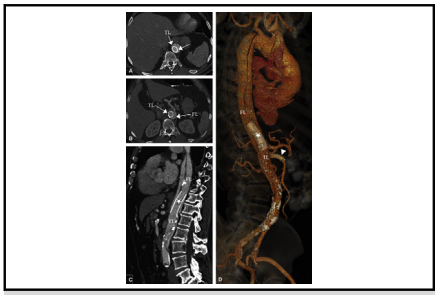
ABSTRACT

Objective: To analyze the short- and long-term results of an original aortic fenestration method using the funnel technique during aortic dissection complicated by malperfusion syndrome.

Methods: The funnel technique consists of deployment of an uncovered aortic stent graft placed from the false to the right lumen through an intimal flap aortic fenestration made by balloon angioplasty. Twenty-eight patients presenting with an aortic dissection (type A, n = 19; type B, n = 9) were treated for malperfusion syndrome owing to dynamic compression (16 renal, 17 bowel, and 13 lower limb ischemia) using the aforementioned technique, and had follow-up evaluation at short term (30 days) and long term (mean: 55 ± 40 months). Eight patients had severe ischemia on arrival (6 bowel, 7 renal, 3 lower limb).

Results: Technical success was achieved in 27 of 28 patients (96%), and ischemic symptoms had disappeared in 25 of 28 patients (89%) at short-term follow up. Five patients presented postprocedure complications: 4 minor and 1 major with arterial thrombosis which caused technical failure (3.6%). The 30-day mortality rate was 7% (n = 2), related to bowel ischemia complications. At long-term follow up, 21 patients had a stable thoracic aortic diameter (91%).

Conclusions: The funnel technique, in cases of malperfusion syndrome after aortic dissection, safely improves short- and long-term clinical outcome, and could represent an interesting alternative in the management of patients. The hemodynamic efficiency of this technique may account for a lower mortality in our series. (J Thorac Cardiovasc Surg 2015;150:108-15)



The funnel technique: An uncovered aortic stent graft is used between the false and the true lumen.

Central Message

The funnel technique is a novel aortic fenestration method (clinical success rate here: 89%), using a stent graft through the intimal flap, for patients with malperfusion syndrome.

Perspective

The funnel technique, versus other techniques to treat malperfusion syndrome during aortic dissection, has better efficacy and a lower rate of morbidity. As an alternative to covering the primary entry tear, when this is unfeasible, it protects against short-term ischemic recurrence. Long term, it permits a decrease in pressure in the false lumen, protecting against potential thoracic aortic dilatation, which occurs in 20% to 50% of cases.

See Editorial Commentary page 116.

Acute aortic dissection (AD) is a rare, but serious, disease[1] that induces a high mortality rate (50%) at 48 hours.[2,3] The Stanford classification of AD[4] differentiates type A, which requires surgical management,[5] from type B, which is treated medically.[6]

Malperfusion syndrome (MPS), caused by reduced flow in the aortic branch vessels, is the second most common complication (20%-50%) of AD,[7] after cardiac complications,[8] and causes higher mortality (51% vs 29% in survivors of AD).[9-11] Two ischemic mechanisms have been described[12]: dynamic compression due to an aortic true lumen collapse; and static compression related to direct extension of AD into an aortic branch.

In cases of dynamic compression MPS, closing the primary entry tear of the dissection, by using a covered stent, is the recommended treatment.[13-16] When this method is unfeasible, aortic fenestration (AF) has been proposed as an alternative technique[17-20]; however, high postprocedural

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Abbreviations and Acronyms
AD = aortic dissection
AF = aortic fenestration
CT = computed tomography
MPS = malperfusion syndrome

complications (11%-20%) and mortality rates (17%-34%) have been reported.

In our center, a new and original AF technique, consisting of an uncovered aortic stent graft, inserted between the false and the right lumen, was performed on selected patients. The aim of this study was to assess the safety and efficacy of this technique, known as the "funnel technique," at short- and long-term follow-up evaluation.

METHODS

Study Design

The local institutional review board (No. 5891) approved this retrospective study. Relevant and follow-up data were collected and reviewed, using the medical files and imaging exams of included patients. From January 1, 2000 to December 31, 2013, all consecutive patients admitted to our center and presenting with renal, digestive, and/or lower limb ischemia, owing to dynamic compression MPS, after type A or type B AD, was treated with this new procedure. These patients could not be treated with a thoracic aortic stent graft, because of anatomic constraints, as they had an entry tear either in the aortic segment II or next to the supra aortic trunks.

Diagnosis of MPS was based on clinical, biologic, and/or radiologic features, according to the following criteria:

- Renal ischemia: uncontrolled arterial hypertension, defined as blood systolic pressure >120 mm Hg, despite 2 doses of intravenous antihypertensive therapy; variation of serum creatinine $\geq$44 μmol/L; or decreased glomerular filtration rate of >25%[21]; evidence of renal malperfusion on CT scan in nonsevere forms; anuria in severe forms.
- Lower limb ischemia: absent pulse, claudication, cool limb, low flow in the iliac arteries in nonsevere forms; sensorimotor deficit in severe forms.
- Bowel ischemia: abdominal pain and diarrhea in nonsevere forms; bowel tract bleeding, high lactate levels, and/or lack of enhancement of bowel wall on CT scan in severe forms.

The preoperative CT scan additionally confirmed the dynamic compression, with the collapse of the true lumen, and the absence of concomitant disease, which could explain the symptoms. These types of ischemia and their severity are described in Table 1. Depending on the patient, MPS occurred during the dissection, postoperatively, or later. The time from diagnosis to treatment varied from 3 to 72 hours.

Procedure

A preprocedure contrast-enhanced CT scan was systematically performed, to determine the orientation of the intimal flap and the fenestration target, located 4 cm above the celiac trunk. All procedures were performed by 2 interventional radiologists with >10 years of experience, under fluoroscopic guidance. The initial anteroposterior and lateral angiography in the true lumen was first done under local anesthesia, through a femoral sheath, to confirm the dynamic compression and identify the flap orientation. In a curved 5F catheter, positioned 4 cm above the celiac trunk facing the intima, a rigid 0.014-inch Spartacore guidewire (Abbott Vascular, Santa Clara, Calif) was introduced in the reverse position (hard end first), pushed through the flap, and advanced into the false lumen.

The fenestration opening was enlarged by using an 18-mm–diameter balloon (Boston Scientific, Natick, Mass) after changing the introducer for a 10F sheath and replacing the guidewire with a 0.035-inch guidewire (Terumo, Yamanashi, Japan). An uncovered self-expanding steel stent (Wallstent, Boston Scientific, Natick, Mass), or a nitinol stent (Memotherm, Bard Angiomed, Wachhausstrasse, Germany) of 18 to 24 mm in diameter and 40 to 60 mm long, was deployed from the false lumen toward the true lumen through the opening created, with its distal end placed above the ostium of the celiac trunk.

The final angiography was performed in the false lumen, above the fenestration, and had to confirm satisfactory flow in the true lumen (increased caliber, rapid and intense enhancement) and the aortic branches. Upstream of the stent, the true aortic lumen was expected to be collapsed by the stent (Figures 1-4). If the angiographic result was inadequate, an additional subrenal fenestration without stenting or peripheral stenting of side branches was discussed. For the following 6 months, patients received an antiplatelet treatment, except those treated with oral anticoagulants.

Definitions

Technical success was defined as a normal blood flow velocity in the stent, the true lumen, and the aortic branches, with a normal perfusion of end-organs on the final angiogram, in either a single procedure (primary technical success) or 2 procedures, whether or not simultaneous (secondary technical success). Clinical success was defined as clinical symptoms having disappeared, and biologic parameters having normalized between day + 1 and day + 30. The main evaluation criterion was clinical success. The secondary evaluation criteria were mortality and complication rate in the short term (between day + 1 and day + 30); and onset of late complications and evolution of thoracic aorta diameter in the long term.

Patients were followed up, with magnetic resonance imaging or CT, at day + 10; 6 months; 12 months; and every 2 years thereafter. The mean duration of the follow-up period was defined as the time between the initial imaging study and the last available images. The thoracic aorta was measured on the same levels in the axial plane. Increased aortic diameter was defined as a diameter >60 mm, or progressing >4 mm/year. Data were summarized using the mean and the median (25%-75% interquartile range). The Kaplan-Meier technique was used to create a survival curve. Growth rates for aortic diameter were estimated with linear regression, using a linear, mixed-effects model. Linear, mixed-effect regression analysis was carried out, using follow-up time, the localization of the primary entry tear, the involvement of the ascending aorta, age, and pre-existing hypertension.

RESULTS

Population

Within 13 years, 379 patients were admitted to our center for AD (type A, n = 259; type B, n = 120). Among patients presenting with type A, 247 of 259 (95.4%) underwent surgical aortic replacement, and 12 of 259 (4.6%) died before the surgery. All patients with type B AD were treated medically. Sixty-nine of 379 patients (18.2%) presented dynamic compression MPS, and were treated with either thoracic endovascular aortic repair (n = 41) or AF, by the funnel technique (n = 28).

Of the 28 treated by the funnel technique, 19 patients presented type A AD and underwent emergency cardiac