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REVIEW

Evolving Experience of Percutaneous Management of Type B Aortic Dissection

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Introduction

Aortic dissection is a life-threatening condition characterised by high early mortality. While general consensus exists regarding the need of immediate surgical repair for patients with acute ascending aortic dissection, the optimal treatment strategy for type B aortic dissection continues to be a matter of debate. It has been generally advocated that patients who have type B aortic dissection without complications should be treated with medical therapy, historically based on the Wheat's concept of antiimpulse therapy,[1] decreasing the force of cardiac contraction and systolic blood pressure acting upon the weaker aortic wall. With aggressive antihypertensive therapy up to 85% of patients may survive their initial hospital stay. However, about 30% of acute type B dissections at clinical presentation are complicated by peripheral vascular ischemia or hemodynamic instability, which results in high risk of spontaneous death.

The perception that prognosis of type B dissection is better with medical management mostly derives from the negative results for descending aorta surgery.[2–14] Direct aortic replacement for acute aortic dissection showed significant mortality and paraplegia rate, even in the outstanding Crawford–Svennson data,[5,6] reporting 30–36% of paraplegia for extensive aortic replacement for dissection. Long-term follow-up of patients with type B dissection showed unsatisfactory outcome even after successful initial stabilization and optimal medical therapy. Mortality is related either to retrograde progression of dissection with involvement of the proximal aorta or to expansion of the false lumen and formation of a thoracic aneurysm. Several reports in the literature analysed long-term outcome in patients with type B dissection, comparing medical with surgical therapy without evidence of a significant difference between the two groups.[1–14] A large retrospective analysis of Umana and colleagues[4] has recently focused on long-term outcome comparison (36 years) between medical and surgical therapy in 189 patients after acute type B dissection. The actuarial survival estimates for all patients were 71, 60, 35, and 17% at 1, 5, 10, and 15 years, respectively, and were similar for the medical and surgical patients, indicating that medical therapy appears to confer some survival advantage only in the short term but fails to demonstrate any significant advantage in the long term.

These suboptimal results have prompted the need of investigation for alternative procedures, which could combine low invasiveness and durable results.

Rationale and Early Results of Endovascular Treatment of Aortic Dissection

The rationale of endovascular treatment of aortic dissection was originally based on evidence in the literature[15,16] of protective effect of false lumen thrombosis against false lumen (FL) expansion and on the clinical observation that patients in the rare instance of spontaneous thrombosis of the FL have a better long-term prognosis than without it. Conversely, persistent perfusion of the FL has been identified as an independent predictor of progressive aortic enlargement and adverse long-term outcome.[17]

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Closure of the entry tear of a type B dissection may promote both depressurisation and shrinkage of the false lumen, with subsequent thrombosis, fibrous transformation, remodelling and stabilization of the aorta (Fig. 1).

Using the terms aorta, type B dissection, and stent-graft, a comprehensive search of the English-language literature from January 1999 to July 2005 was performed, using the Medline database. All studies focused on endovascular stent-graft treatment of aortic dissection were considered in order evaluate current results with respect to complications and outcome (Table 1). The first report on stent-graft treatment in type B aortic dissection appeared in 1999, in two different series of acute and chronic patients. Dake *et al.*[18] reported a series of 19 patients with acute dissections treated with homemade devices. Technical success was achieved in all cases. The 30-day mortality rate was 13%. Serious morbidity occurred in three (20%) of these 15 patients. Three patients had persistent flow in the false lumen that had resolved at the 1-month CT scan. All dynamic branch vessel occlusions were corrected by endograft coverage of the proximal entry tear. No subsequent deaths or aneurysm ruptures occurred in a follow-up of 13 months. Nienaber *et al.*[19] compared 12 patients with chronic type B dissection and aneurismal degeneration ($>$ 5.5 cm) treated with commercial available stent-graft device to 12 concurrent patients treated with conventional open surgical repair. Technical success was 100% in the endovascular group, with 10 of 12 patients having immediate thrombosis of the false lumen on intraoperative transesophageal echocardiography (TEE). No patient in the endovascular group died during the 12-month study there was not a single instance of spinal cord ischemia, whereas 33% of the surgical patients died. After this initial experience, several single-center reports have shown technical feasibility and clinical safety of endovascular techniques in type B dissection.[20–41]

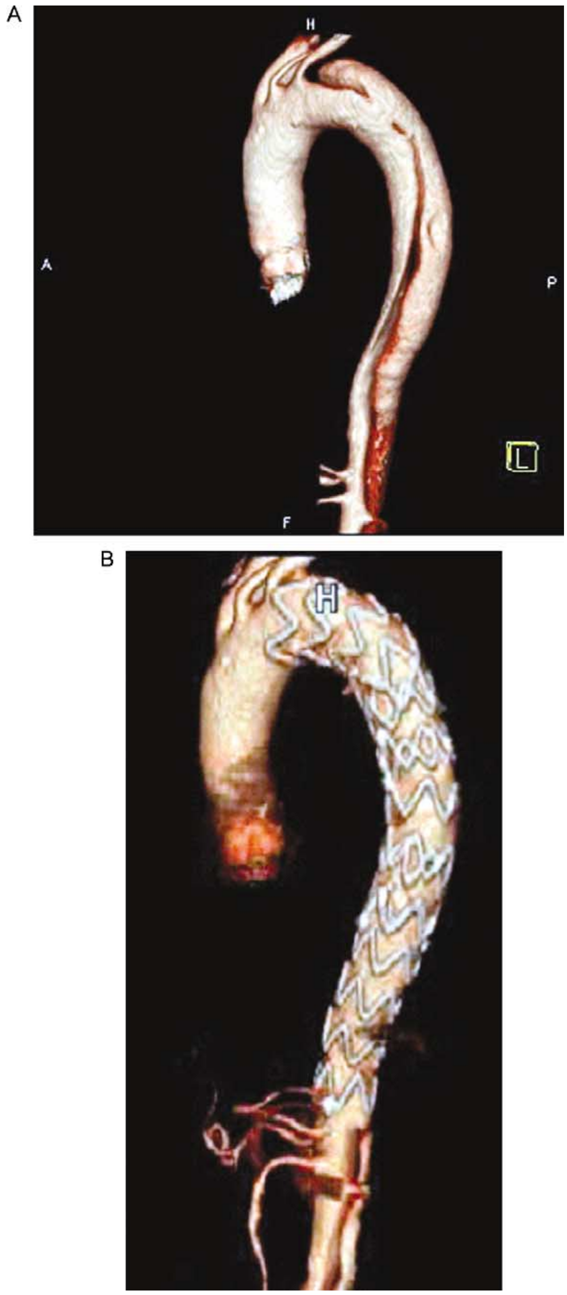

Fig. 1. (A) and (B) MDCT images of type B aortic dissection. The entry site is visible in the volume rendering reformation (B) 2 cm below the left subclavian artery.

The widest published series is the combined experience of EUROSTAR registry (European Collaborators on Stent Graft Techniques for Thoracic Aortic Aneurysm and Dissection Repair) and the United Kingdom Thoracic Endograft registry.[40] The initial and 1-year outcome of endovascular treatment of 443 patients is reported and among them, 131 had aortic dissection. Sixty-two of them were treated under emergency conditions and 42% were at high risk for conventional open surgery. Primary technical success was achieved in 89% of patients; the remaining 11% had either incomplete covering of the entry tear, persistent flow without thrombosis of the largest portion of the false lumen, no expansion of the true lumen, or endoleak. Neurological complications consisted of paraplegia in one patient who underwent emergency repair, and stroke in two patients who underwent elective procedures. The overall 30-day mortality rate was 8.4%. One year after treatment 94% of patients followed up during this interval (67 patients) had satisfactory findings at CT examination. New endoleaks were observed in 2.8% of patients.

Table 1. Endovascular treatment of Type B aortic dissection: results in the literature

Author	Year	Pts	Technical success	Emergency conversion	Complications: overall	Complications: stroke	Complications: paraplegia	30-day mortality	Late surgical conversion	Late aortic rupture
Dake[18]	1999	19	19	0	4	0	0	3	0	0
Nienaber[19]	1999	12	12	0	0	0	0	0	0	0
Czermak[20]	2000	7	6	0	2	0	0	0	1	0
Hausegger[21]	2001	5	5	0	1	0	0	0	0	0
Kang[22]	2001	6	6	0	0	0	0	0	0	0
Sailer[23]	2001	7	7	0	n.a.	0	0	0	0	0
Tiesenhausen[24]	2001	4	4	0	0	0	0	0	0	0
Bortone[25]	2002	12	12	0	1	0	0	1	0	0
Herold[28]	2002	18	18	0	3	0	0	1	0	2
Hutschala[27]	2002	9	9	0	1	1	1	0	0	0
Kato[26]	2002	38	38	0	9	1	0	2	2	1
Nienaber[29]	2002	127	127	0	4	2	1	2	n.a.	3
Palma[30]	2002	58	65	2	n.a.	2	0	4	3	2
Pamler[31]	2002	14	14	2	4	1	1	0	0	0
Quinn[32]	2002	15	15	0	3	0	0	4	0	0
Rousseau[33]	2002	20	20	1	2	1	0	2	1	1
Shim[34]	2002	15	14	0	0	0	0	1	2	0
Beregi[35]	2003	12	11	0	4	1	0	2	0	1
Lonn[36]	2003	20	20	0	10	5	1	3	0	0
Lopera[37]	2003	10	9	0	2	1	0	0	0	2
Dialetto[38]	2004	28	28	0	1	0	0	3	0	0
EUROSTAR/UKTE registries[40]	2004	131	117	0	n.a.	2	1	1	1	0
Nathanson[41]	2005	40	38	0	15	1	1	1	0	0
Eggebrecht[39]	2005	38	38	0	4	0	0	4	1	3
Total		665	652	5	70	18	6	34	9	12
%			98	0.7	18.9	2.7	0.9	5.1	1.3	1.8

Table 2. Anatomic details of aortic dissection with the different imaging modalities

	Non-invasive-ness	Measurements	Entry site	Arch anatomy	TL/VL, visceral vessels	Iliac access
CT (standard)	++−−	++−−	+−−−	+−−−	++−−	+++−
MDCT	−+++	++++	++++	++++	++++	++++
MRI	++++	++++	+++−	++++	++++	+++−
ANGIO	−−−−	+−−−	+++−	++++	++++	++++
TEE	++−−	++−−	++++	++−−	−−−−	−−−−

Late death occurred in 1.5% of patients, and the cumulative survival rate after 1 year was 90%.

The talent thoracic retrospective registry (TTR) analysed data on patients who underwent endovascular treatment of the thoracic aorta in seven European referral centers with the Talent device (unpublished data). Four hundred and fifty seven patients have been enrolled and among them 180 had type B dissection. The in-hospital mortality did not differ between patients with dissection as compared to other aortic diseases: there was 5% of mortality for the whole group and 4.5% in-hospital mortality for patients with type B dissection. Of note, the only two patients of the entire series who died during the interventional procedure were type B dissection patients treated under emergency conditions. During the follow-up, which has been complete in 422 patients (mean 24 months ranging from 1 to 85 months), no statistical difference was observed in long term mortality and outcome between patients treated with endovascular stent-graft for aortic dissection or for other thoracic aortic diseases.

The INSTEAD trial was designed as a multicenter, randomized trial that is ongoing in Europe.[42] The purpose of the study is to compare the outcomes of type B aortic dissection subjected to interventional thoracic stent grafting combined as an adjunct with tailored antihypertensive treatment (stent-graft group) to those of tailored antihypertensive treatment alone (medical treatment group). Acute cases are excluded as well as chronic long-standing aortic dissection (>24 months from initial clinical presentation). Results from INSTEAD trial are expected in 2006.

Published data confirm the technical feasibility and a relative low rate of complications with respect to surgical repair (Table 1). However, long-term follow-up and outcome information, in order to document the sustained benefit of endovascular repair, are still limited. With growing experience in endovascular stent-graft treatment the spectrum of acute and midterm complications has broadened to include potentially disastrous events. Late aneurismal degeneration of the thrombosed false lumen has been reported by Kato *et al.*,[43] and also several case reports have highlighted the risk of retrograde extension of the dissection into the ascending aorta, potentially caused by stent-graft induced intimal injury.[44] Even though extension of dissection is known event in the course of type B dissection disease, wire or sheath manipulation during the endovascular procedure could increase the risk of this dreadful complication. Continuous progress in stent-graft technology, improving morphology and flexibility, may lead to more suitable stent-graft configuration for aortic dissection. However, these unexpected complications underline the particular fragility of the aortic wall and the need of careful selection criteria and rigorous follow-up.

Imaging Evaluation Before Endovascular Treatment

Knowledge regarding the extent and specific pathophysiology and anatomy of each dissection is critical prior to intervention. In the diagnostic work up of patients candidate to endovascular treatment of type B dissection, high resolution imaging modalities such as MRI and MDCT, are fundamental in order to define the essential anatomic characteristics and are on the basis of procedural success.[45–47] The identification of the entry and re-entry tears, the relationship between true and false lumen and visceral vessels, the iliac arteries involvement, are all crucial information for patient selection and stent-graft design, which can be assessed non-invasively. Therefore, catheter angiography should be reserved only in patients in whom the other modalities have been unable to identify the necessary anatomic details (Table 2).

The Role of Transesophageal Echocardiography (TEE)

TEE can be highly useful in the operating room to guide a correct stent positioning in type B aortic dissection, visualizing a safe advancement of stent-graft device in the true lumen and its position in front of the entry site. The support of color-Doppler, differentiating true lumen from false lumen, as well as the entry sites, can accurately display flow dynamics. Stent deployment can be monitored by fluoroscopy using the TEE probe as a marker facing the selected area, avoiding the need of repeated contrast medium injections. Because TEE offers multiple angulations images, accurate measurements can be assessed in order to select the optimal size of the stent-graft. This attribute is particularly useful in emergency procedures, in which the risk of rupture may not allow to perform CT or MRI evaluation before the procedure. After stent deployment, TEE with color-Doppler is more sensitive than angiography in identifying endoleak (usually velocity $\geq$100 cm/s). Endoleak due to incomplete stent-graft apposition to the aortic neck or at segment junction can be resolved by balloon inflation. Again TEE guidance of balloon inflation can detect complete balloon expansion, avoiding overstretching and potential damage of the aortic wall.[48] It is also important to recognize thoracic re-entries, detectable only after stent implantation after the closure of the main entry site, in order to avoid false lumen reperfusion by retrograde flow. Monitoring of thrombus formation with successful sealing of entries is due to the sensitivity of TEE for slow flow as an early sign of clot formation in the false lumen after aortic stent-graft placement and direct sign of the success of the procedure.

Imaging Follow-up After Stent-graft Placement

The goal of endovascular treatment in type B dissection is to provide false lumen thrombosis and aortic remodelling with false lumen expansion. Thrombosis of the false lumen in the thoracic aorta should be rather immediate after stent-graft closure of the thoracic entry and re-entry sites, while aortic remodelling is a slow process, which typically needs several days or months. After treatment, a strict imaging follow-up is mandatory, because endoleak may cause false lumen expansion and increase the risk of aortic rupture.[49] Both MRI and CT are reliable techniques, even if CT scan has the advantage of being able to depict the stent-graft material with high accuracy, while on MRI the metallic component of the stent-graft provides artefacts, thus limiting the evaluation of aortic wall conditions and peri-graft zone. It is important to remind that slow flow endoleak can be missed by the short acquisition time of both CT and MR angiography. Therefore, a second delayed acquisition (30–60 s) after the arterial phase should be performed, in order to exclude any residual flow in the false lumen.[50] Accurate measurement of true and false lumen dimension are also important for indirect assessment of procedural success, because aortic remodelling with false lumen shrinkage and true lumen expansion is frequent in the absence of endoleak.

Percutaneous Management of Malperfusion

Aortic branch-vessel obstruction is one of the most important causes of morbidity and mortality in type B dissection and constitutes a challenge for medical and surgical treatment of the disease. The incidence of aortic branch vessels compromise in association with aortic dissection ranges from 25 to 50%.[51] Ischemic complications can arise when the dissection compromises blood flow, by either extrinsic compression of the true lumen by the false channel or an intimal flap occluding the orifice of a branch artery. Immediate correction of these abnormalities is necessary to preserve end-organ function. Surgical fenestration, first successfully performed by DeBakey in 1955, has spread out in the 90s with large series reported by Elefteriades *et al.* and Cambria *et al.*[52–55] To this day, aortic fenestration is still a rarely performed procedure, and surgical series have remained limited. The advantage of surgical fenestration is to be a durable procedure with no late recurrence of malperfusion. However, despite a wide array of operative strategies, the operative mortality rate for patients with acute aortic dissection complicated by renal ischemia has been upwards of 50% and as high as 88% when mesenteric perfusion is impaired.

Williams *et al.* first described percutaneous technique of aortic fenestration in 1990[56] reporting successful resolution of mesenteric ischemia from subacute aortic dissection by percutaneous balloon fenestration. However, despite the reperfusion success, the dissected aorta showed progressive enlargement, necessitating thoracoabdominal aortic replacement 6 weeks later. Since then, several small series has been reported using a variety of techniques in different indications.[57–61] Slonim *et al.*[57] reported results of 6 years experience of percutaneous fenestration on 40 patients. Successful revascularization was achieved in 93%. However, 30-day mortality was 25% due to multiorgan failure or aortic rupture. Williams *et al.*[59] recently reported their endovascular experience with 24 patients with peripheral vascular complications from aortic dissection. They reported a 92% success rate at restoring flow into compromised branch vessels. However, they had a 25% 30-day mortality rate and had an immediate ischemic recurrence rate of 8% (2/24). After aortic balloon fenestration, four patients had significant complications from the false lumen such as rupture, false lumen expansion and paraplegia from retrograde thrombosis.

The purpose of percutaneous balloon fenestration is to create a communication between the two aortic lumens homogenizing the pressure and the flow in both the lumens and in branch vessels. A curved, hollow metal needle is employed, introduced into the sheath over a stiff guide wire and advanced above the level to be punctured, under intravascular ultrasound (US) guidance, usually in the infrarenal aorta or the iliac bifurcation. The metal stylet, with a coaxially mounted 5-F catheter, is inserted to just inside the needle tip. After the puncture the stylet is removed and the 5-F catheter left in position across the flap. With an over-the wire exchange technique, an appropriate-sized (15–25-mm), low profile balloon is inserted through the sheath and positioned across the flap and inflated. Pressure measurement attesting no gradient between the two lumens assesses the efficacy of fenestration. On the basis of successful aortic fenestration is an accurate imaging evaluation before the procedure. Identification of the dissection anatomy and extension, position and size of lumens, assessment of branch vessel perfusion from true and false lumen, the cause and degree of obstruction of the involved branch vessels such as flap prolapse into the vessel, are essential information.

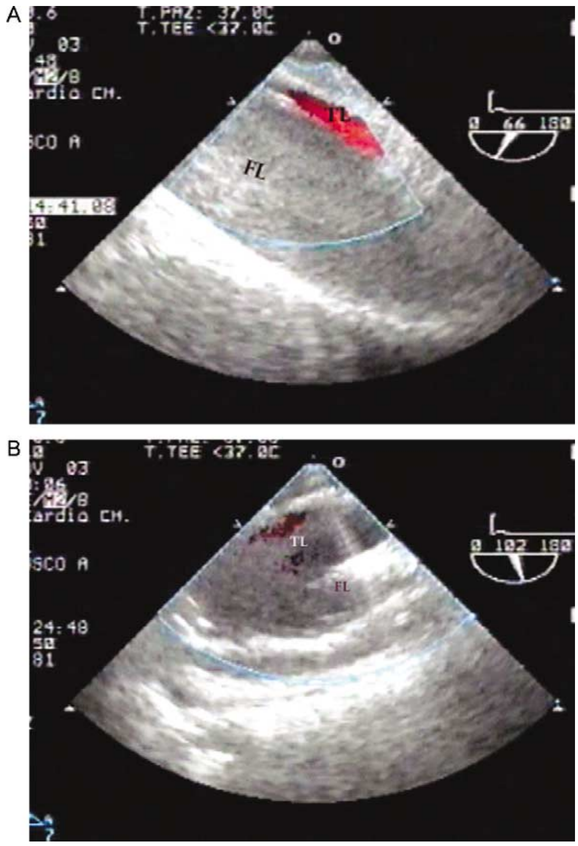

Fig. 2. (A) and (B) MDCT images after stent-graft treatment: complete thrombosis of the false lumen and aortic remodelling with true lumen expansion and FL shrinkage. (A) Transesophageal echocardiography image of a patient with acute type B dissection and malperfusion syndrome. The false lumen is enlarged and compresses the true lumen. There is a slow flow in both true lumen and false lumen (smoking effect). (B) After stent deployment: immediate normalization of flow with true lumen expansion.

Overall technical success in revascularization exceeds 90%. Rupture of the dissected aorta, although a real risk, seems to be an uncommon procedural complication, but there is still potential for extension of the dissection in spite of fenestration. Percutaneous transluminal balloon angioplasty with intravascular stent may be sometimes necessary in cases of localized fibrous stenosis in major aortic tributaries or prolapse mechanism of the intimal flap. The role of fenestration the era of stent-graft placement is also unclear. Usually, the stent-graft occlusion of the entry site results in thrombosis of the false channel and flow increase in the true lumen, therefore, normalizing the vessel perfusion and restoring branch vessels patency (Fig. 2). Therefore, immediate relief of malperfusion syndrome may be the first results of endovascular stent-graft treatment of aortic dissection.

Conclusion

In the difficult management of descending aortic dissection endovascular treatment represents a promising alternative to medical therapy and surgical repair, with the prospective of better long-term survival. Understanding of the pathologic condition, careful attention to the dissection anatomy and progress in stent-graft technology, will be essential in improving technical skill and procedural results. Until the results of randomized comparative trial of medical *versus* endovascular therapy will be available, indication to endovascular repair of type B dissection should be considered the same applied to surgical repair, namely acute unstable cases or chronic aneurysmal expansion (usually >5.5 cm). At present long term follow-up data are scarsely reported. As yet, no literature data support the expansion of stent-graft treatment in asymptomatic, stable patients with type B dissection, until a clear survival benefit will be proved. The risk of unexpected complications and the potential need for reinterventions underline the importance of rigorous selection criteria and strict lifelong surveillance.

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