Review

Utility of the Aortic Fenestration Technique in the Management of Acute Aortic Dissections

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Type B acute aortic dissection is not uncommonly encountered by cardiovascular and thoracic surgeons. However, the optimal treatment of patients, particularly those with visceral and renal vessel ischemia, is not well standardized. This is, in part, because of the high morbidity and mortality that continues to plague aortic replacement surgery in that setting. For this reason, other techniques have been investigated. Surgical aortic fenestration and percutaneous balloon fenestration are two attractive alternative solutions to this serious problem. We describe both procedures, illustrating their relative ease of performance, and review the most recent data regarding outcomes. Open surgical aortic fenestration is a quick and safe alternative to traditional operative strategies and has been shown to have both short-term and long-term effectiveness. Percutaneous balloon fenestration, although a more recent technique, appears to offer the same advantages as open fenestration with the added benefits of a minimally invasive approach. We believe that these two techniques can be safe and effective alternatives to medical management and aortic replacement surgery in properly selected patients. (Ann Thorac Cardiovasc Surg 2007; 13: 296–300)

Key words: type B aortic dissection, aortic fenestration, percutaneous balloon fenestration

Introduction

With a rupture rate twice that of aortic aneurysms, acute aortic dissection is a common aortic emergency with an estimated incidence of 2,000 cases per year in the United States.[1,2] If left untreated, acute aortic dissection (Type A) is associated with a mortality rate as high as 21% in the first 24 h of presentation.[3] Although the management of Stanford type A (DeBakey types 1 and 2) dissections is primarily surgery, the management of Stanford type B (DeBakey type 3) dissections remains somewhat undefined.[4,5] Most physicians agree that medical management is an adequate mode of therapy in stable patients with Type B dissections without evidence of complications (e.g., extension of dissection, aneurysmal aortic dilatation, rupture, or branch vessel occlusion resulting in end-organ failure).[6,7] Patients with acute descending aortic dissections incur a high surgical mortality rate. A report of the International Registry of Aortic Dissection (IRAD) noted an overall 12.8% in-hospital mortality rate. The mortality rate for surgically treated patients was 29.3% and 9.6% for those medically managed.[8,9] Furthermore, medically managed patients may have a long-term prognosis that is poor. In one study, the actuarial survival rates for medically managed patients at 1, 5, 10, and 15 years was 85%, 71%, 38%, and 20%. Twenty-seven percent of these patients had visceral ischemia, and peripheral vascular ischemia was present in 24%.[10]

Despite these unsettling numbers, medical management, "anti-impulse" therapy using beta-blockers and afterload-reducing medications[11,12] has been used for most patients with noncomplicated acute Type B dissections because surgical intervention with direct aortic replacement generally carries even higher rates of mortality and morbidity. Recent reports of surgical intervention for acute

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dissection demonstrate overall mortality rates of 28–65%. A third of the deaths occur from aortic bleeding.[13] Paraplegia, a devastating complication of the disease process and surgical repair, has been reported to be 30%–36% even in the most experienced hands.[14] The nature of this disease process and its poor outcomes have led physicians to seek alternative safe and effective methods of treatment.

Surgical Aortic Fenestration

The technique of aortic fenestration for acute aortic dissection was first described by Gurin in 1935.[15] A report by Shaw in 1955 details a successful restoration of limb perfusion after aortic fenestration. However, the patient ultimately succumbed to renal failure.[16] Since then, aortic fenestration has been used infrequently as aortic replacement techniques continue to improve. It is important, however, for this technique to be kept in every surgeon's repertoire.

Renewed interest in the use of aortic fenestration for dissection was championed by our group at Yale in the 1990s, wherein we first described a version of the technique depicted in Fig. 1. The infrarenal aorta is approached from a left flank retroperitoneal incision, and control is achieved below the renal arteries. The aorta is transected, and a generous portion of the proximal intimal flap is excised to allow the reentry of blood. The distal flap is sutured to the adventitia using full-thickness over-and-over bites circumferentially around the aorta. The aorta is then reanastomosed, and flow is restored.[17]

The effects of fenestration have also been examined in the lab. With a dog model used for acute aortic dissection, aortic fenestration has been shown to significantly increase pressures within the visceral and extremity vessels and to significantly increase blood flow rates. Moreover, the distensibility of the aorta, which decreased significantly with dissection, increased after fenestration.[18] These findings confirm the previously presumed hemodynamic changes expected after fenestration.

Aortic fenestration is a useful technique in patients with acute descending aortic dissections and impeding visceral or renal ischemia, often seen in combination with extremity ischemia.[17,19] Ideally, fenestration should occur within 24 to 48 h of dissection before thrombosis of the false lumen occurs. There are several advantages to using fenestration in cases of acute dissection: avoidance of thoracotomy, ease of aortic exposure and control, and avoidance of thoracic cross-clamping with resultant spinal cord, visceral, and renal ischemia.[18] The procedure can be done in a quick, safe fashion to rapidly restore blood flow to the viscera, kidneys, and extremities. Fenestration, however, should not be attempted in patients with aneurysmal disease or those with other indications for aortic replacement.[19]

Outcomes with Surgical Aortic Fenestration

Although acute descending aortic dissections occur not infrequently, experience with short- and long-term outcomes following fenestration is scant (Table 1). Our group reported the results of our first 12 patients, of which 11 regained distal aortic flow after fenestration. Ninety percent of the patients presenting with limb ischemia regained normal pulses postfenestration.[17] A long-term follow-up of 14 patients demonstrated a 3-year survival rate of 77% and a 5-year survival of 53%. None of the patients experienced late rupture.[20] Panneton et al. more recently described similar results. In patients with acute type B dissections, fenestration resulted in a 100% reperfusion rate. Perioperative mortality at 40% was high as a result of patients with anuria and treatment occurring more than 48 h after dissection. No late aneurysmal development was noted in the survivors.[19] The failure of successful reperfusion in the former series was also in a patient with a delay in diagnosis, reemphasizing the impact of early intervention on outcome.[17] Moreover, renal ischemia appears to be a strong predictor of clinical failure because others have noted a mortality rate of 50% in patients with acute dissection and renal ischemia.[6,7]

Percutaneous Aortic Fenestration

Since the initial description of a technique using percutaneous aortic fenestration to treat chronic type B dissection,[21] interest has been increasing in using this mode of therapy to rapidly reverse malperfusion in patients with acute presentation. A lab model examining gross and histological findings after balloon fenestration demonstrated the feasibility of such a procedure.[22] Peterson reported the first use of a percutaneous technique in a young patient with a traumatic dissection compromising the right renal artery.[23]

The technique of percutaneous aortic fenestration involves obtaining arterial access at the common femoral artery. Once the true lumen of the aorta is canalized, intravascular ultrasound (IVUS) or arteriography is used to establish the aortic branch anatomy. Fenestration is ac-

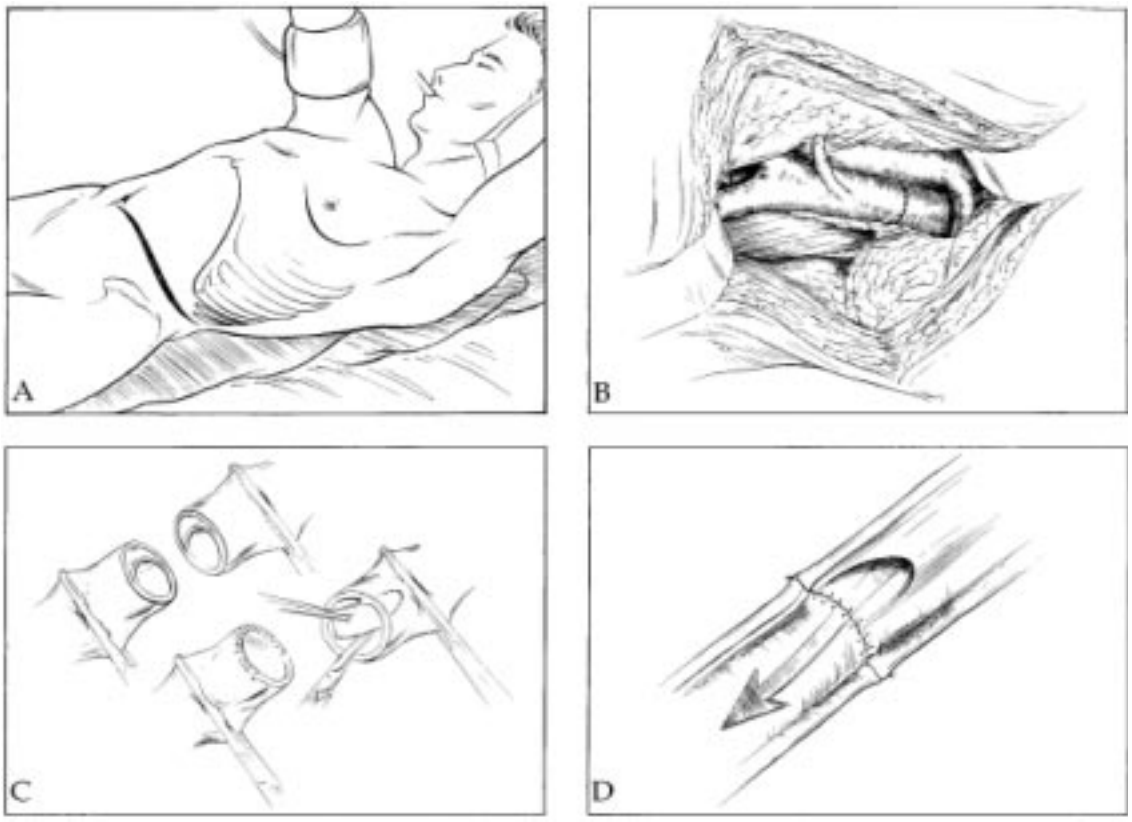

Fig. 1. Technique of aortic fenestration.
- **A:** A left flank incision is used to gain access to the retroperitoneum.
- **B:** Control of the infrarenal aorta is achieved.
- **C:** The transected aorta demonstrates the intimal flap caused by the dissection. A portion of proximal flap is resected to form a reentry point, and the distal flap is sutured to the adventitia circumferentially.
- **D:** The proximal aorta is then sutured to the reconstructed distal aortic lumen to reestablish continuity of flow.

complished by puncturing the intimal flap with an intravascular needle followed by balloon dilatation (at least a 15 mm balloon) of the flap over a guide wire (Fig. 2). Fenestration can be accomplished by serial dilatation of the flap at one location, or multiple fenestrations can be done along the dissection to achieve an equalization of pressures between the true and false lumens. Next, the degree of obstruction of the branch vessel ostia is examined, and stents may be added to optimize flow. A stent graft may or may not be required within the aorta.[24)]

Few data exist on the outcomes of percutaneous balloon fenestration for aortic dissection (Table 1). Although slightly more than 100 cases have been reported in the literature, no well-designed prospective studies are available that formalize outcomes.[24)] In general, the technical success of this procedure exceeds 90%, and it is unclear whether using stents as an adjunct is beneficial. Visceral vessel involvement, more so than the renal vessels, appears to have an adverse effect on the success of percutaneous fenestration.[25)]

Conclusion

Acute type B aortic dissection remains a serious cause of mortality and morbidity. Even with vast improvements in preoperative imaging, intraoperative treatment, and postoperative intensive care, surgical mortality remains high for those with visceral, renal, or extremity vessel involvement. For these patients, surgical aortic fenestration may provide a quick, safe, and effective option to treat the associated malperfusion. Percutaneous techniques may prove to be even more useful in expediting reperfusion to critical vascular beds; however, at the present time, there are insufficient data to justify their

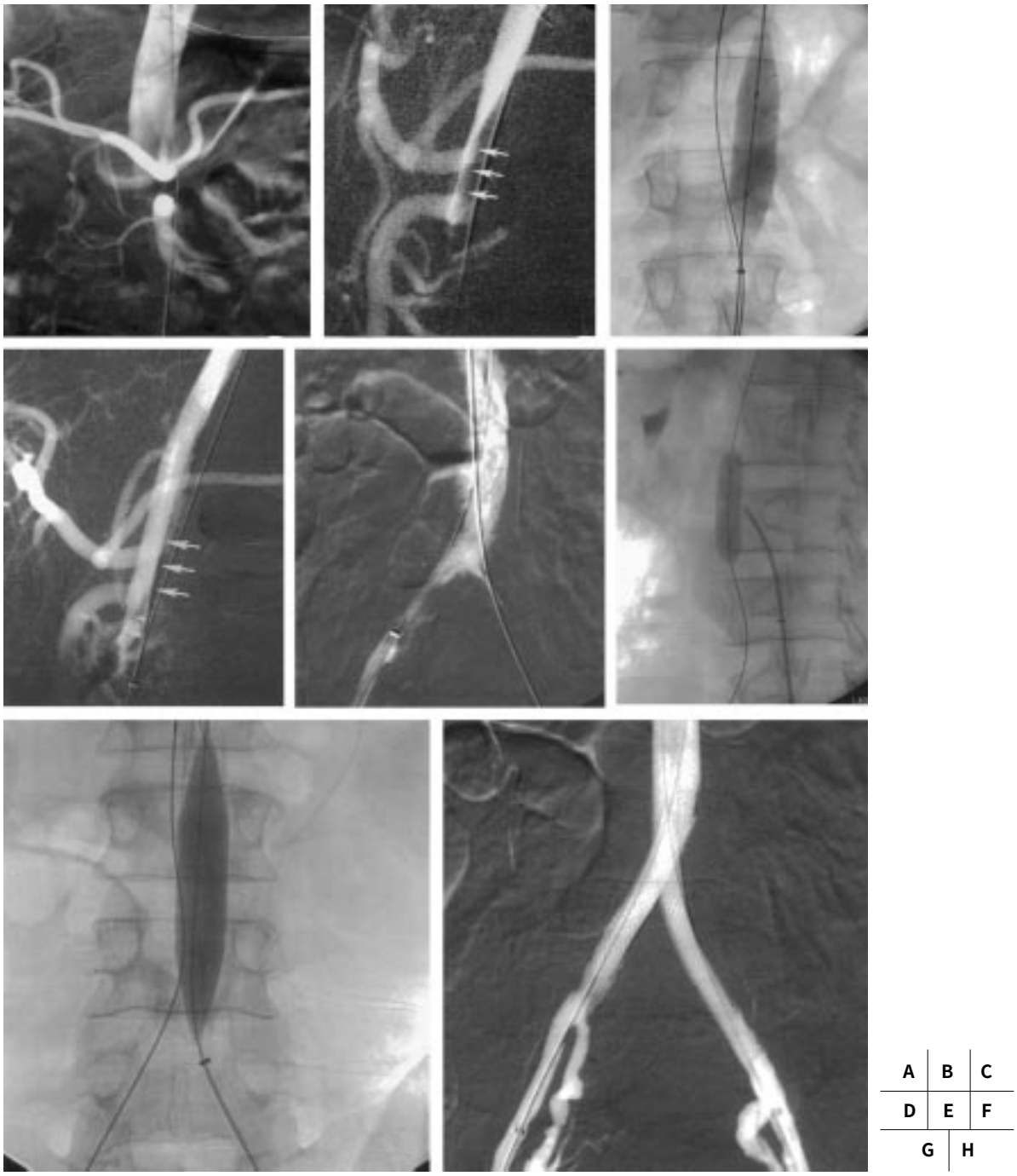

Fig. 2. Angiograms demonstrating the technique of percutaneous balloon fenestration.
Panel **A** demonstrates the "floating visceral sign" seen in this patient with acute type B aortic dissection and mesenteric, renal, and lower extremity ischemia. Panel **B** shows the narrowed true lumen from a lateral view. A guidewire is passed through an intravascular needle that is punctured through the dissection septum, and the fenestration is dilated with a 16 mm balloon (Panel **C**). The resultant increase in true lumen caliber is shown in Panel **D**. The extension of the dissection into the iliac arteries is treated similarly with cannulation of the false lumen, trans-septal cannulation into the true lumen, balloon dilatation of the fenestration, and, in this case, the placement of bilateral iliac "kissing" wall stents (Panels **E–H**). (Modified from Vedantham et al. *J Vasc Interv Radiol.* 2003; **14**: 181–94.)

Table 1. Summary of available data regarding the mortality and survival rates for the various modes of treatment for type B aortic dissection. Note that the clinical backgrounds of each group are heterogeneous; therefore, no direct comparisons between groups can be made.

	Hospital mortality	3-year survival	5-year survival
Medical management[8,9]	9.6%	78%	71%
Aortic replacement[9]	29.3%	82.8%	n/a
Aortic fenestration[20]	0%	77%	53%

routine use. We feel that for properly selected patients with acute type B aortic dissection, aortic fenestration techniques provide a safe, effective, and durable treatment alternative to aortic replacement.

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