Combined Open and Endovascular Techniques for the Treatment of Complex Vascular Disease

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Abstract

In an attempt to improve the outcome following aortic aneurysm repair, there has been an increased focus on endovascular technology as a minimally invasive means of treating various vascular pathologies. Stent-grafting of aortic aneurysms is an area where a less invasive approach may decrease the morbidity seen with conventional aneurysm repair. As with other technologies, increased experience and improvements in instrument design allow for applicability to a broader population of patients. However, despite such improvements, some patients' anatomic characteristics may make endovascular repair unsuitable or too risky. When complex anatomy prohibits repair by endovascular means alone, a combination of conventional surgery and endovascular therapy may be utilized in an effort to minimalize the invasiveness. Using adjunctive surgical procedures, complex anatomy may be modified to allow for a safe and successful endovascular aneurysm repair. In this paper, we describe the modification of access vessels as well as fixation sites to facilitate the endovascular treatment of aortic aneurysms.

Key Words: Endograft, aneurysm, open surgical reconstruction, endovascular techniques, thoracic aorta, iliac arteries.

Introduction

THE INTRODUCTION of endovascular technology has provided a minimally invasive means of treating various vascular pathologies. As with any technology, user experience as well as advances in instrument design have given an increasing number of patients the option of endovascular therapy. However, various anatomic characteristics might still render a patient unsuitable or at risk for complications following endovascular therapy. While future device modifications may provide all patients with a minimally invasive option, a variety of combined surgical and endovascular approaches can now provide benefits of minimal invasiveness to a patient with complex anatomy in situations which would otherwise require more traditional invasive procedures.

The treatment of aortic aneurysms provides an excellent example of complex anatomic characteristics that may make endografting unsuitable. However, the anatomy can be modified by adjunctive surgical procedures to permit a safe and successful endovascular aneurysm repair. The description of adjunctive procedures to modify access vessels as well as fixation sites in the treatment of aortic aneurysms is the focus of this paper.

Fixation Sites

Successful placement of an endograft requires adequate fixation of the endograft above and below the aneurysm at the proximal and distal necks (1–5). Factors such as adequate neck length and angulation as well as thrombus and calcifications have been described as potential detriments to adequate fixation. When faced with one or more of these factors, a more suitable fixation site can be achieved by extending the graft deployment across arterial branches. Moreover, the interruption of the renal and hypogastric arteries in the cases of infrarenal aortic aneurysms, or the subclavian and visceral vessels in the case of thoracic aortic aneurysm procedures, can have catastrophic conse-

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quences. Transposition and bypass of these critical vessels can safely provide an adequate fixation site for these more complex aneurysms.

Thoracic Aortic Aneurysms

Elephant Trunk

Aortic arch repair utilizes the elephant trunk technique, where the proximal graft replaces the ascending aorta, the mid-graft supplies the arch vessels, and the distal graft extends to the descending thoracic aorta (Fig. 1). Following such a repair, aneurysmal degeneration of the descending thoracic aorta can be approached endovascularly. The use of an "elephant trunk" graft as the proximal implantation site for an endograft has been described by Fann et al. (6). In these situations, the graft material from the previous reconstruction can be utilized as a proximal neck implantation site.

Subclavian Transposition / Bypass

Insufficient length for device implantation in the proximal neck of descending thoracic aneurysms may be managed by deploying the device across the origin of the left subclavian artery. Preservation of left upper extremity perfusion can be achieved by a transposition of the left subclavian artery to the left common carotid artery prior to endovascular treatment (Fig. 2). Prior to such a transposition or bypass, however, the presence of significant occlusive disease of the carotid artery must be excluded.

Infrarenal Aortic Aneurysms

Aortouni-iliac with Femoro-Femoral Bypass

Endovascular repair of infrarenal abdominal aortic aneurysms extending into the iliac arteries with inadequate distal neck in the com-

Fig. 1. (A) Angiogram demonstrating aortic arch aneurysm. **(B)** Aortic arch angiogram following elephant trunk reconstruction. The proximal graft begins at the aortic root. Arrow at left points to bifurcated graft originating from main aortic graft to revascularize the arch branches. Long arrows identify markers placed on distal end of graft within the aneurysmal proximal descending thoracic aorta. **(C)** Chest CT demonstrating aneurysmal descending thoracic aorta. **(D)** Aortic angiogram following stent-graft exclusion of a descending thoracic aortic aneurysm. Proximal stent-graft positioned within the previous elephant trunk graft.

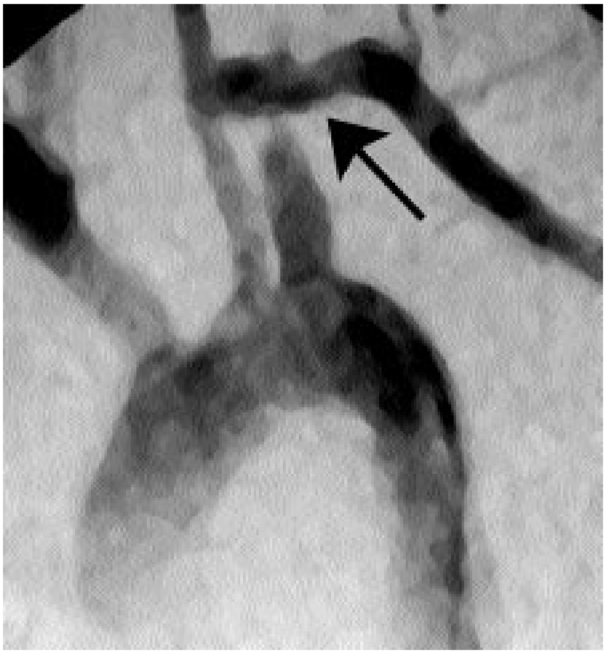

Fig. 2. Aortic arch angiogram demonstrating (arrow) left subclavian artery transposed to the left carotid artery.

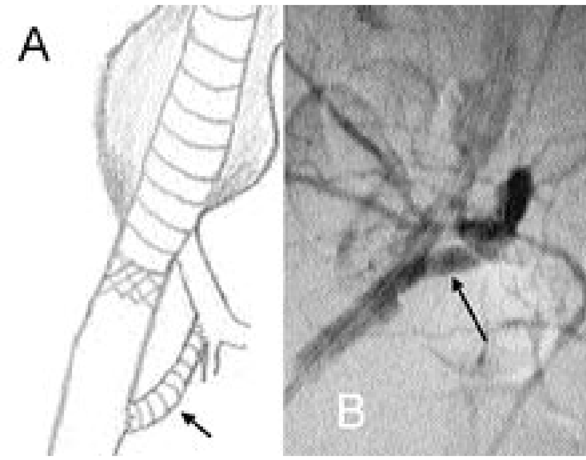

Fig. 3. (A) Diagram demonstrating stent-graft that extends through aneurysmal common iliac artery with planned fixation to the external iliac artery. Arrow demonstrates new anticipated position of hypogastric artery with origination from the external iliac artery. **(B)** Angiogram demonstrating hypogastric artery (arrow) being perfused by the external iliac artery following transposition.

mon iliac arteries, may be performed with an aortouni-iliac device extending to the external iliac artery after embolization of the hypogastric artery. Following placement of the uni-iliac graft, construction of a femoro-femoral bypass graft establishes circulation to the contralateral lower extremity. An occluder device is used to prevent aneurysm perfusion through the contralateral common iliac artery. This approach is not feasible when both common iliac arteries are aneurysmal. Due to concerns of pelvic ischemia, preservation of at least one of the internal iliac arteries, and thus pelvic circulation, is prudent.

Hypogastric Transposition / Bypass

Infrarenal aortic aneurysms that extend to and include common iliac artery aneurysms not only complicate the selection of an adequate implantation site, but also present a challenge to the preservation of the internal iliac arteries and pelvic vessels. A preferred method of preserving prograde pelvic arterial flow is by relocating the internal iliac artery inflow to a segment of the external iliac artery (Fig. 3), as described by Parodi and Ferreira (7).

Visceral and Renal Bypass

The various classes of thoracoabdominal aneurysms may be suitable for endovascular repair when more advanced branched endografts become available (8, 9). Alternatively, an extra-anatomic visceral vessel can be reconstructed to permit subsequent endovascular aortic grafting. As an example, extra-anatomic bypass to superior mesenteric and renal arteries can be performed. Following a brief period of recovery, the thoracoabdominal aneurysm can be excluded with a stent-graft, allowing continued perfusion of the renal and visceral vessels (Fig. 4).

Access Vessels

Passage of an endograft delivery system for aortic aneurysm repair routinely utilizes the iliac arteries. Despite improvement in devices, such as decreasing diameter and increasing flexibility, it is not uncommon to identify arteries that are stenotic, calcified and tortuous, thus restricting the passage of a device (1, 5, 10, 11). Occasionally, force utilized in overcoming these restrictions may result in arterial dissection, thrombosis, rupture, and failure to pass the device (12, 13). In such situations, alternative options may include endarterectomy, traction, and placement of a side arm conduit.

Endarterectomy

In focal, short segment, iliac artery stenosis, a simpler treatment modality is balloon angioplasty, which can sufficiently dilate the vessel to allow the device to safely traverse the lesion.

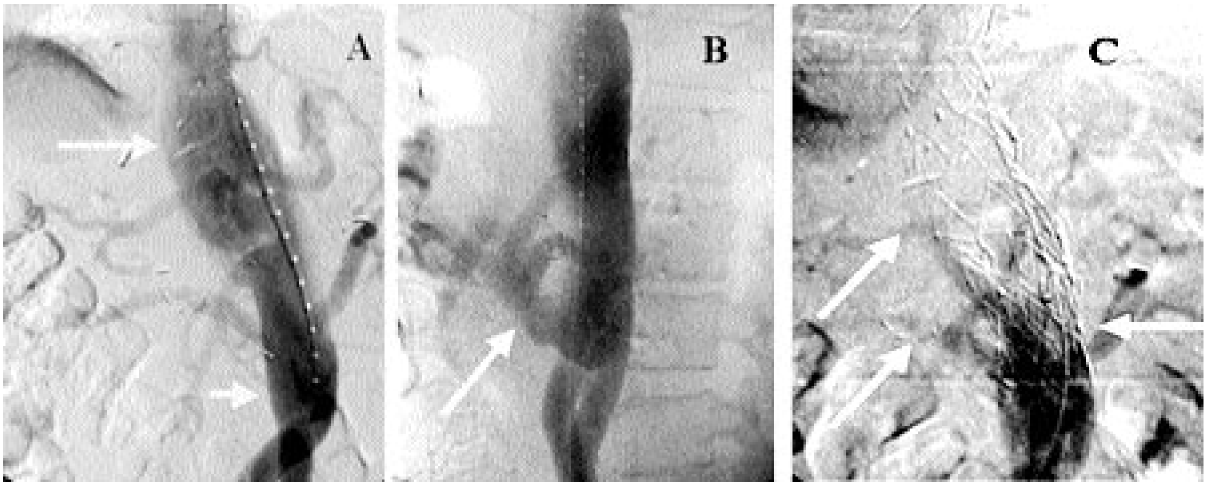

Fig. 4. (A) Aortic angiogram in a patient with previous infrarenal aortic aneurysm repair. Small arrow indicates previous infrarenal aortic graft. Large arrow indicates aneurysmal aorta within the visceral segment. **(B)** Angiogram of the same patient with arrow demonstrating a bifurcated graft with additional side branches originating from previous infrarenal graft, revascularizing bilateral renal arteries and superior mesenteric artery. **(C)** Angiogram revealing stent placed across the visceral segment, and visceral and renal branches perfused by graft.

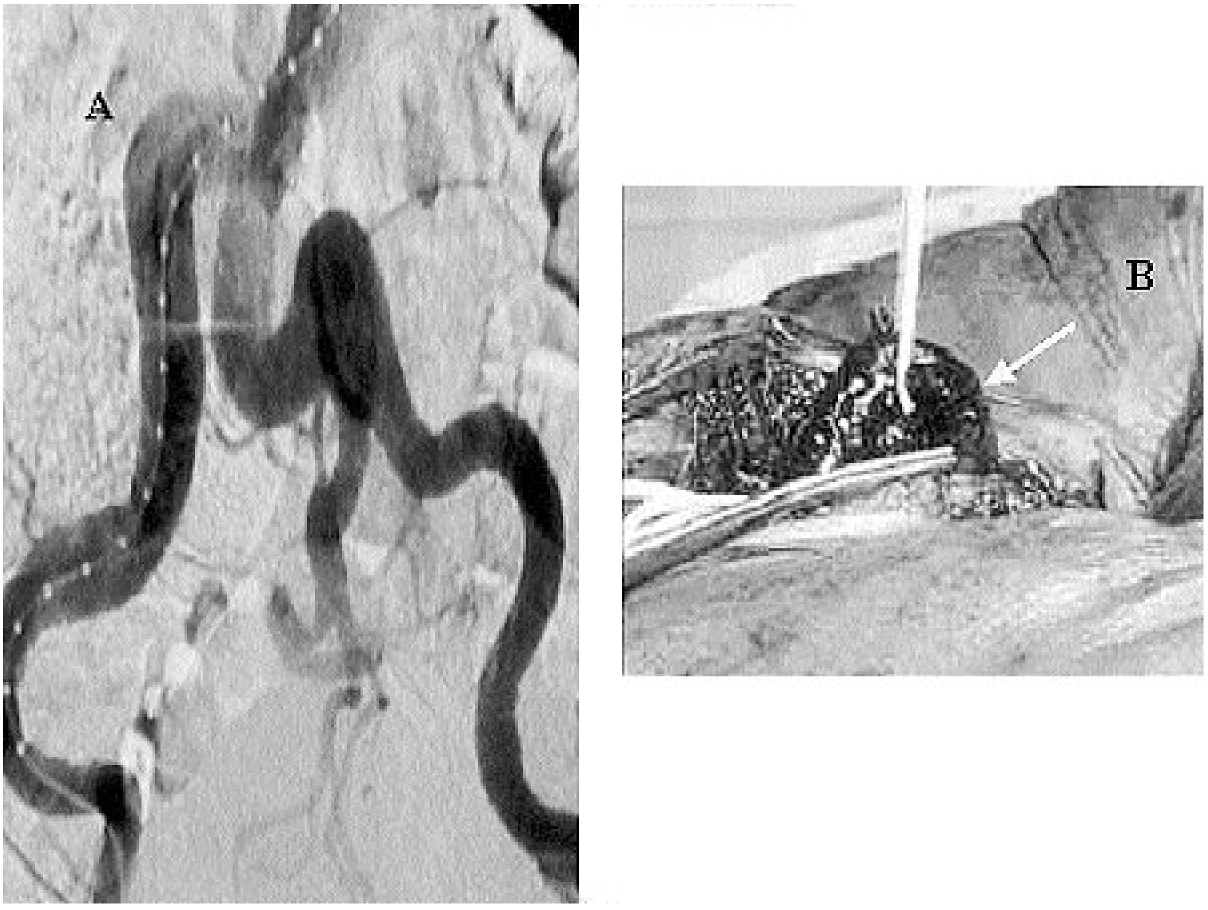

Fig 5. (A) Pelvic angiogram demonstrating tortuous iliac arteries. **(B)** Photo of groin dissection with arrow demonstrating external iliac artery, following its mobilization and traction to straighten vessel and facilitate device insertion.

Frequently, however, the iliac arteries are diffusely stenotic. In diffuse, multisegment, iliac artery stenosis, closed endarterectomy can be performed with multiple balloon dilations throughout the diseased segments. Atherosclerotic debris can then be withdrawn and extracted from the femoral arteriotomy site.

Endoluminal Conduits

Multisegment iliac artery stenosis with long, circumferential, nearly occlusive disease can benefit from intraluminal iliofemoral bypass grafts (14). These endoluminal conduits permit more aggressive dilation of a long stenotic segment of the iliac artery. This maneuver eliminates the risk of iliac artery rupture by aggressive angioplasty, because the intraluminal bypass graft protects the severely diseased vessel.

External Side Arm Conduit

The most serious disease of the iliac arteries is a combination of severe occlusive disease with calcifications and tortuosity. In these situations, the wiser choice may be avoidance of the entire diseased iliac segment. Navigation of the device can be accomplished via an extraluminal iliac side arm conduit originating from a proximal undiseased segment. This conduit can be constructed with a retroperitoneal approach. The bypass graft is then removed after endovascular aneurysm exclusion by the stent-graft.

Straightening / Traction

In calcified arteries with significant tortuosity, digital dissection allows full exposure and straightening of the redundant external iliac artery, thus decreasing the potential risk of perforation by the delivery system (Fig. 5). Once mobilized, the redundant and tortuous segment can be excised.

Summary

Combining surgical and endovascular techniques facilitates treatment of some aortic aneurysms with complex anatomy. Such an approach may also decrease possible iatrogenic injuries. Future device technology may allow some of the abnormalities to be managed solely by endovascular means.

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