Abdominal Aortic Aneurysms: The Magnitude of the Problem and its Natural History

Abdominal aortic aneurysm (AAA) is a balloon-like enlargement of the infrarenal aorta. Its pathogenesis is unclear and probably multifactorial, including atherosclerosis, familial clustering, and connective tissue disorders. Abdominal aortic aneurysms usually continue to enlarge and at some point may rupture. The death rate following rupture is 80–90% and the entity is responsible for 15,000 deaths in the United States annually. It is estimated that 2–3% of men over 50 years of age have an occult AAA and 200,000 new aneurysms are diagnosed each year in the USA. Moreover, the incidence of aneurysms appears to increase as the population ages.

The natural history of aneurysms is poor. In 2 landmark studies, the 5-year survival rates of patients with untreated aneurysms were 17% and 19%, with 63% and 35% of the deaths being due to aneurysmal rupture. However, among all factors, aneurysmal size (diameter) is the most important factor that determines the risk of rupture, and it increases in an exponential manner.

Pain is the chief symptom and is usually felt in the abdomen, back, flank or scrotum, although it may be in the chest. If the pain is truly due to the aneurysm, the rupture rate is as high as 50% within 3 months, and the aneurysm should be treated urgently. Indications for surgical replacement of aneurysms are determined by weighing the risk of rupture against the morbidity and mortality rates of surgery. Repair is generally indicated when the diameter of the aneurysm exceeds 5–5.5 cm, or the annual expansion rate exceeds 1.0 cm per year.

Key Words: Abdominal aortic aneurysms; Endovascular graft; Stent graft
year, or when it becomes symptomatic.1,2

Although some studies have suggested the efficacy of controlling hypertension and cessation of smoking in decelerating the growth rate of aneurysms, surgical replacement of the aneurysm with a prosthetic graft remains the only effective measure to prevent rupture.9–11

**Treatments for Abdominal Aortic Aneurysms**

**Gold Standard**

Standard surgical repair of AAAs is effective and relatively safe, with a perioperative mortality ranging between 1.4 and 6.5%.1 However, it is a highly invasive procedure and requires a long abdominal incision and extensive dissection (Fig 2). Surgical complication rates range between 24 and 39%.12,13 The procedure requires 2–3 weeks of hospital stay and 2–3 months for full physical and social recovery thereafter.14 In addition, some sick patients are deemed a prohibitive risk for such major surgery, and therefore, treatment may be deferred or they are considered untreatable. Although Hollier et al have reported excellent results, even in high-risk patients with severe comorbid conditions, the overall morbidity and mortality rates need to be decreased.15

**New Horizons: Endovascular Graft Repair**

To improve on the shortcomings of surgical repair, endovascular graft (EVG) repair has emerged as a potential alternative.16–28 EVG repair can be performed through small incisions in the groin and so the postoperative discomfort, length of hospital stay and the time to recover may be lessened substantially. In addition, it is hoped that EVG repair will decrease the morbidity and mortality rates in high-risk patients. Most importantly, it allows the treatment of sick patients with severe comorbid conditions, such as severe coronary artery disease or chronic obstructive pulmonary disease, who are deemed either inoperable or a prohibitive risk for standard surgical repair.

A possible weakness of EVG repair compared with the standard repair is that it may not be applicable to the majority of patients with AAAs, as it requires that AAAs possess certain anatomical criteria.17 Various authors have estimated that 10–50% of all AAAs may be treated endovascularly. Aorto-uni-iliac EVGs, in combination with femoro-femoral bypass, were first reported by Parodi et al.16 This procedure was designed to increase the applicability of aortic EVGs because the initial tube EVGs were only applicable to 10% of all AAAs. However, following the introduction of various bifurcated grafts (mainly industry-made), many thought that the role of unilateral aorto-iliac or aortofemoral EVGs would end. Aorto-uni-iliac EVGs have been regarded as an inferior option to tube or bifurcated grafts, because they do not mimic the normal anatomy or configuration. In addition, they require creation of a femoro-femoral bypass, which also has been viewed as a second-rate procedure. Finally, most unilateral aorto-iliac or aorto-femoral EVGs were ‘surgeon-made’, which also contributed to the notion that these grafts were inferior and should be abandoned.

We have been involved in a number of clinical trials to evaluate the feasibility and safety of industry-made devices, including the Vanguard (Boston Scientific Corp) the Talent (World Medical Corp), the Ancure (Guidant-EVT) and the Excluder (Gore-Tex) grafts. Despite the availability of these grafts, the role of an aorto-femoral EVG (Montefiore Endovascular Grafting Systems, MEGS) has not yet ended and there are still many patients who require grafts in this configuration. We describe the value and limitations of a surgeon-made aorto-unifemoral EVG (MEGS), and also present the case for a continuing role for such a ‘surgeon-made’ graft (Fig 3).

**The Montefiore Endovascular Grafting System**

The MEGS was derived from the Parodi graft, which was fabricated from a Palmaz stent and a Dacron graft.29 The current MEGS has undergone several modifications, which have increased its versatility and its ease of use and it now utilizes a PTFE graft instead of a Dacron graft (Fig 4). Originally the length of the graft needed to be...
measured accurately preoperatively so that the distal end could be fixed in the common or the external iliac artery by a second stent. This precise measurement was often difficult or impossible to make and added complexity to the procedure. The current MEGS graft is made long enough so that in each case, the distal end of the graft will emerge from the insertion site in the femoral artery. The graft is then cut to the appropriate length as it emerges from the artery and is anastomosed within the femoral artery by fashioning an endoluminal anastomosis. This greatly enhances the ease of the procedure, because by doing so, the difficult preoperative length measurement and a potential endoleak site at the distal attachment site are totally eliminated. In addition, the often encountered dissection of the external iliac artery secondary to insertion of a large introducer sheath can be repaired simultaneously, because the EVG covers the entire iliac system. Another modification has been the placement of the proximal bare portion of the stent above the orifice of the renal artery (Fig 3), which provides more secure fixation of the proximal stent even in those cases with necks shorter than 1.5 cm. Furthermore, the contralateral iliac artery outflow obstruction during stent deployment greatly increases the accuracy of EVG placement within the infrarenal aorta, which is of paramount importance in those cases with very short proximal infrarenal necks. With regard to the delivery system, we have been able to decrease the size of the introducer sheath from 22Fr to 16Fr (inner diameter). All these modification, along with some technical modifications such as the use of a through-and-through brachial wire into the femoral artery with tension on both ends to straighten tortuous iliac arteries, has allowed us to expand the anatomical indications for EVG repair.

Construction of the MEGS The MEGS device is constructed from 6-mm PTFE grafts (Impra, Tempe, AZ). The proximal 4-cm portion of each graft is expanded to 30 mm to accommodate the diameter of the proximal aortic neck (Fig 4). The graft is then sutured to a Palmaz stent (P-5014, Cordis, Warren, NJ, USA) with 4 ‘U’ stitches so as to overlap one-half the length of the stent. A metallic marker is sutured to the proximal end of the stent material so that the end of the PTFE covering can be seen fluoroscopically. The stent-graft is then crimped onto a 25-mm balloon (Maxi LD; Cordis) and loaded into a 16Fr sheath. The occluder device, which is placed in the contralateral iliac artery to prevent retrograde filling of the aneurysm, is also made from PTFE and a Palmaz stent (Fig 3). Two ligatures are used to occlude one end of the PTFE graft. A Palmaz stent (P-4014, or P-308) is attached to the other end of the PTFE graft. The occluder device is loaded onto an angioplasty balloon (15–20 mm, Maxi LD; Cordis) and then inserted into a 12–16Fr sheath.

Operative and Adjunctive Techniques

Coil Embolization of the Hypogastric Artery Coil embolization of the hypogastric artery ipsilateral to the graft insertion site is carried out if the distal landing zone is distal to the internal iliac artery orifice. Coil embolization (Gianturco coils; Cook, Inc. Indianapolis, IN, USA) is usually performed at the time of EVG insertion in the operating room, although it can be performed in the angio-suite if a preoperative angiogram is performed. Coil embolization has been routinely performed with all aorto-unifemoral MEGS. Serious complications, such as pelvic ischemia requiring surgery, have not been encountered from this maneuver, although buttock claudication may occur in 30% of cases. This claudication is self-limiting and usually resolves within 3–6 months.
Exposure of the Femoral Artery and Insertion of the Device

Bilateral surgical exposure of the common femoral arteries is followed by insertion of a diagnostic catheter into the aorta through one of these vessels. The locations of the renal artery, aortoiliac bifurcation and hypogastric arteries, as well as the site for proximal graft implantation, are identified. An Amplatz Super Stiff wire (260 cm long) (Medi-tech, Inc) is inserted to the thoracic aorta. A delivery sheath containing the endovascular graft is then advanced over the wire.

Deployment of the EVG

Following confirmation of the location of the lowest renal artery, the outer sheath is retracted and the proximal stent is deployed by inflating the balloon. The cephalad end of the graft material in the MEGS has a metallic marker for fluoroscopic visualization. The graft is deployed so that this marker is placed just below the lowest renal artery. The bare stent above the marker usually covers the orifice of the renal artery. The balloon is semi-compliant, ant its size can be modified by simply changing its inflation pressure (Fig 5). The balloon is generally oversized by 2 mm compared with the aortic neck diameter, which is measured from the preoperative computed tomography (CT) scan and intra-operative angiogram.

During proximal stent deployment, others have recommended that the patient’s blood pressure be lowered to a mean of 60–70 mmHg to minimize any caudal force being applied to the stent that might result in misdeployment. However, we have found that lowering the blood pressure had minimal effect on the stabilization of the proximal stent. Rather, eliminating iliac outflow has a major effect in reducing the caudal force applied to the proximal stent, thereby facilitating accurate stent deployment. Therefore, at present we occlude the outflow by applying a vascular clamp on the contralateral femoral artery or by placing an occlusion balloon in the contralateral common iliac artery (the ipsilateral iliac artery being completely occluded by the delivery device). We do not lower the blood pressure, which may be dangerous and time-consuming.

After the main EVG is deployed, the introducer sheath and the deployment balloon is retrieved. The MEGS is made long enough so that the distal end will emerge from the femoral arteriotomy site. A 9Fr sheath is then inserted into the distal end of the graft. Balloon angioplasty is performed throughout the entire length of the graft to ensure its full expansion and to eliminate any possible compression of the graft. Either an 8×80 mm Wallstent (Schneider, Inc, Minneapolis, MN, USA) or a SMART stent (Cordis) is usually placed in the common and external iliac artery. Initially, we performed completion intravascular ultrasound (IVUS) studies and placed these stents selectively. However, the IVUS studies were costly and time consuming. In addition, 55% of the MEGS grafts required the placement of a stent, which led us to use them routinely and to eliminate the need for IVUS in most cases.

Management of the Distal Anastomosis

In cases, where the distal end of the graft terminates in the common femoral artery, an endovascular anastomosis is performed (Fig 6). A surgical clamp is placed proximal to the arteriotomy site and the endograft is cut to the appropriate length as it emerges from the femoral artery. A running suture using 5-0 propylene is performed to securely attach the distal end to the native artery. If an aorto-uni-iliac graft is utilized, the distal end is secured by a second Palmaz stent. The distal end of the endograft is visualized by suturing a metallic marker. A loop suture may be useful to prevent migration of the distal end of the graft into the aneurysm when one passes the second stent into the graft prior to its deployment.

Occluder Device Deployment

Following deployment of the MEGS, an occluder device is placed in the contralateral common iliac artery. Placement of a standard femoro-femoral bypass using a ringed PTFE graft completes the procedure (Fig 3).

A completion arteriogram and pressure gradient study are performed to assure technical adequacy and the absence of an ‘endoleak’. Endoleaks are treated by one of the following techniques. If the leak is due to low deployment of the proximal stent, a PTFE-covered Palmaz stent is
deployed proximal to the previously deployed graft to seal the leakage. If the endoleak is due to under-deployment of the stent, further dilatation of the proximal stent is usually sufficient to seal the leakage. If the endoleak persists despite these additional maneuvers, then conversion to open surgical repair must be considered.

**Inclusion Criteria for the MEGS**

We have been involved in a number of clinical trials to evaluate the feasibility and safety of industry-made EVGs. Because these grafts do not require a femoro-femoral bypass, we have given these industry-made devices priority over the MEGS graft. Thus, we used the MEGS device only for those patients who were excluded from other industry-made device protocols (Table 1, Figs 7–9). Other general inclusion/exclusion criteria are described in detail elsewhere.

**Current Clinical Experience with the MEGS**

Between July 1997 and June 1998, 60 AAAs were treated at Montefiore medical center. Of these patients, most of whom were high risk, 26 received a MEGS graft.
despite the availability of multiple industry-made EVGs. Patient demographics and characteristics are shown in Table 2. By virtue of the inclusion criteria, the patients who received a MEGS graft were older and had more and worse comorbid conditions. The reasons for exclusion from other industry-made EVG protocols included a short proximal (<1.5 cm) or angulated neck (>60 degrees) (n=12), the lack of an acceptable distal landing zone due to enlarged or aneurysmal common iliac arteries (n=8), small diameter iliac arteries or iliac arteries with extensive occlusive disease (n=2), excessive tortuosity and calcification of the iliac system, (n=3) and/or a small distal aorta that could not accommodate a bifurcated graft (n=1). The details of the operation, the procedural morbidity and the 30-day mortality are shown in Tables 3 and 4. The time in the operating room may appear to be long; however, it is noteworthy that the majority of these patients did not have a preoperative angiogram, and therefore required thorough intra-operative Fig 9. A 76-year-old male was referred to Montefiore Medical Center after undergoing a failed open surgery attempt to repair his 8-cm abdominal aortic aneurysm. His open attempt was aborted due to desaturation and extensive bleeding, the former due to severe chronic obstructive pulmonary disease and the latter due to his complex vascular anatomy. He was intubated for 1 week and hospitalized for 3 weeks following this attempt. He was once told that there was no means to treat his aneurysm and that he had to wait until it ruptured. (A) Preoperative angiogram reveals (1) severely angulated (120 degrees) and short proximal neck (0.5 cm), (2) second neck distal to the first aneurysm, and (3) tortuous and small iliac artery (6 mm in diameter). The MEGS was the only device that could accommodate such anatomy and comorbid conditions. Metallic clips are proof of the previous open attempt. (B) Completion angiogram reveals complete exclusion of the aneurysm. O, occluder; C, embolization coils in the hypogastric artery. (C) Preoperative enhanced CT scan shows 8-cm aneurysm. (D) Postoperative enhanced CT confirms complete exclusion of the aneurysm with contrast confined to the endovascular graft. Due to the minimally invasive nature of the endovascular repair, this patient was discharged 2 days following surgery. (Reprinted from reference 48 with permission).

Table 2 Patient Demographics

| No. of cases | 26 |
| Age (years) | 79±6 |
| Sex (M/F) | 22/4 |
| Size of AAA (cm) | 6.4±0.9 |
| CAD | 13 (50) |
| CHF | 5 (19) |
| Hypertension | 11 (42) |
| Diabetes | 3 (12) |
| Renal insufficiency | 5 (19) |
| On dialysis | 1 (4) |
| COPD | 8 (31) |
| O2-dependent | 4 (15) |
| CVA | 8 (31) |
| Hostile abdomen | 8 (31) |
| ASA | |
| 1 | 0 (0) |
| 2 | 4 (15) |
| 3 | 11 (42) |
| 4 | 11 (42) |

MEGS, Montefiore endovascular grafting system, percentage*; maximum diameter; CAD, coronary artery disease; CHF, congestive heart disease; CVA, Cerebrovascular accident; ASA, American Society for Anesthesia Score.

Table 3 Operative Details and Length of Stay

| No. of cases | 26 |
| OR Time (h) | 6.7±1.8 |
| General anesthesia | 14 |
| Epidural anesthesia | 12 |
| EBL (ml) | 494±363 |
| Transfusion (units) | 1±1.8 |
| No. without transfusion | 16 (62%) |
| LOS (days) | 3.0±3.3 |

EBL, estimated blood loss; LOS, length of hospital stay; OR, operating room.

Table 4 Morbidity and Mortality Following MEGS Repair

| MI | 0 |
| CHF/arrhythmia | 1 |
| Pneumonia/atelectasis | 0 |
| Renal insufficiency (dialysis) | 1 |
| Graft thrombosis | 0 |
| Embolization (tissue loss) | 1 (0) |
| Leg weakness | 4 |
| Reoperation | 2 |
| Other | 0 |
| Morbidity rate | 35% |
| Mortality (%) | 1 (4%) |

MI, Myocardial infarction; CHF, congestive heart failure; MEGS, Montefiore endovascular grafting system.
angiography. In addition, coil embolization of one hypogastric artery and creation of the femoro-femoral artery bypass added to the time in the operating room. Although there were various complications following MEGS repair, none required conversion to open repair. Other outcome data are shown in Table 4. There was one (4%) type-1 endoleak and 2 type-2 (8%) endoleaks. The overall technical success for the MEGS was 96%. The patient who died following a MEGS graft had a successful repair without an endoleak and an uneventful postoperative course. The patient was discharged on the second postoperative day and was found dead at home 1 week later. Autopsy was refused and the cause of death remains unknown. There was one technical failure due to a proximal attachment site endoleak. A covered stent was placed, but failed to seal the leak. Because this patient had various comorbid conditions in addition to a history of an aborted attempt at open repair, we have not made further attempts to treat the leak.

**MEGS for Ruptured Aortoiliac Aneurysms**

The feasibility of EVG repair of ruptured aortoiliac aneurysms (AIAs) has yet to be demonstrated. There are inherent limitations to EVG repair, including the need for preoperative measurements of the aneurysm and adjacent arterial anatomy to determine the appropriate size and type of graft.

During the past 6 years, 9 ruptured AIAs were treated using the MEGS that facilitated intraoperative customization as previously described, thus eliminating the need for preoperative measurements. The age of the patients ranged between 48 and 85 years, and the mean size of the aneurysms was 7.4 cm (range, 3–8 cm). Preoperative symptoms, which were present in each case, included abdominal or back pain (n=7), syncope (n=1), and external bleeding (n=1). All patients were high surgical risks due to comorbid disease (n=8) and/or previous abdominal operations (n=4), and 6 experienced hypotension. All MEGS grafts

**Fig 10.** CT scan images of a ruptured abdominal aortic aneurysm (AAA). This 71-year-old male was admitted to another hospital for medical treatment of his pneumonia secondary to chemotherapy for leukemia. Other comorbid disease includes severe chronic obstructive pulmonary disease, requiring home oxygen, and congestive heart failure with an ejection fraction of 25%. The patient experienced sudden onset of severe abdominal pain, which was confirmed by CT scan to be a ruptured AAA. Due to his coexisting disease, standard repair was deemed impossible and he was transferred to our institution. On arrival, his systolic blood pressure was 75 mmHg and hematocrit was 18%. (A) Preoperative CT scan reveals possible rupture site (arrow) in the AAA. (B) Completion angiogram. The AAA is completely excluded without an endoleak. The bare portion of the proximal stent (S) was placed above the renal arteries and the cranial end of the graft, which is denoted by the gold marker (arrow), is placed immediately below the renal arteries. The right internal iliac artery is opacified by retrograde flow. C, embolization coils; O, occluder device; F, femoro-femoral bypass. (Reprinted from reference 37 with permission).

**Fig 11.** Intraoperative angiogram of the patient described in Fig 6. (A) Preoperative angiogram reveals large abdominal aortic aneurysm (AAA) and a small common iliac aneurysm. (B) Completion angiogram. The AAA is completely excluded without an endoleak. The bare portion of the proximal stent (S) was placed above the renal arteries and the cranial end of the graft, which is denoted by the gold marker (arrow), is placed immediately below the renal arteries. The right internal iliac artery is opacified by retrograde flow. C, embolization coils; O, occluder device; F, femoro-femoral bypass. (Reprinted from reference 37 with permission).
were successfully inserted and excluded the aneurysms from the circulation (Figs 10, 11). The mean operating time was 320 min, the mean blood loss was 900 ml, and the mean length of hospital stay was 7.4 days. There were 2 deaths (22%): one from the preexisting acute myocardial infarction 3 months after operation, and one from multiple organ failure. There were 2 minor complications (22%). In one patient, evacuation of an intra-abdominal hematoma from the initial rupture was required. All remaining grafts are functioning at a mean follow-up of 24 months.

Discussion

The feasibility of EVG repair in selected patients has been clearly shown, and encouraging early and mid-term results have been reported\(^1\),\(^2\),\(^7\),\(^1\) The current focus of research and development in EVG repair includes proving long-term durability, miniaturization of device delivery systems to facilitate introduction, and expanding the indications for EVG repair. In the early experience with EVG repairs, there were several factors that limited the proportion of patients who could be so treated. First, surgeons were limited to either tube or aorto-iliac grafts\(^1\),\(^6\),\(^2\),\(^0\),\(^0\),\(^3\),\(^7\),\(^1\) Second, the available devices required a large introducer sheath and the several, recently developed adjunctive techniques to facilitate these endovascular graft repairs had not been developed. Thus, in this early stage only 10–20% of aneurysms were thought to be amenable to EVG repair. With the introduction of bifurcated modular grafts and smaller introducer sheaths, the proportion of AAAs that could be treated endovascularly increased significantly. Various authors have speculated on what percent of AAAs can be treated in this fashion. However, most of these estimates were derived from theoretical analyses based on CT scans and not actual procedures performed\(^3\),\(^8\),\(^9\). In contrast, our recent experience defines the proportion of aortic aneurysm patients that can be managed endovascularly, based on our actual treatment of 60 consecutive patients undergoing repair of their AAA. This experience showed that approximately 80% of all AAAs could be treated endovascularly\(^0\),\(^5\) which is clearly higher than other reported recent percentages, which range between 30 and 55% of all cases\(^1\),\(^2\),\(^2\),\(^0\),\(^4\). Our ability to treat such a large percentage of patients with EVGs was facilitated not only by the opportunity to use various grafts, but also by the fact that we utilized the MEGS graft. For example, Harris et al analyzed 155 AAAs and found only 30% to be amenable to EVG repair utilizing a bifurcated graft\(^0\). The 3 common reasons for exclusion were too large, too angulated or too short a proximal neck, and the presence of aneurysmal iliac arteries. The MEGS graft, although it requires the creation of a femoro-femoral bypass, was useful for treating those patients who were not amenable to treatment with any of the industry-made devices. This advantage has also been observed by others using similar EVG systems\(^2\),\(^5\),\(^6\). The reasons for this are 3 fold. First, this graft is the only one that utilizes a balloon-expandable stent (Palmaz: Cordis, Johnson & Johnson, Warren, NJ, USA) for proximal graft attachment. This stent exerts the strongest radial force, which enables the treatment of AAAs with proximal neck angulations greater than 60 degrees. Second, this type of EVG can be delivered through a 16Fr sheath. This small profile allows for treatment of AAAs with diseased and/or small access vessels. The third reason is related to the aorto-uni-femoral configuration. By creating a hand-sewn endoluminal anastomosis within the femoral insertion site, the quality of the artery between the proximal neck and the femoral artery becomes irrelevant. Moreover, this type of EVG is useful in patients with very tortuous iliac arteries and, finally, accurate graft length measurements are unnecessary. In addition, our early experience demonstrated the feasibility of endovascular repair of ruptured AAAs using the MEGS. Although the vast majority of EVGs are used to treat elective AAAs and other vascular pathologies, their use in ruptured AIA may be the most valuable because the outcome of standard repair is dismal and there is certainly room for improvement. There are several potential advantages to EVG repair of ruptured aneurysms. EVGs can be inserted and deployed through a remote access site, thereby obviating the need for laparotomy and, more importantly, eliminating the technical difficulties that one encounters when performing a standard repair in this setting. The anatomy of the retroperitoneal structures is often distorted and obscured because of the large hematoma. This may lead not only to technical difficulties, but also to inadvertent injury of the inferior vena cava, the left renal vein or its genital branches. The iliac veins, inferior mesenteric vein, ureters or the duodenum can also be injured. These iatrogenic injuries have been the cause of significant operative mortality and morbidity following standard surgery for ruptured aneurysms\(^4\),\(^5\),\(^6\) In contrast, EVG repair is performed within the arterial tree, which is unaffected by the extravasated blood or previous operations (scar). Moreover, this approach completely eliminates the risk of inadvertent injuries to surrounding structures. Furthermore, in patients with hostile abdomens, we believe that proximal arterial control can often be achieved prior to EVG insertion more safely but also more rapidly than in a standard repair. In conclusion, despite the availability of various industry-made devices, there still remains a significant role for aorto-unifemoral or aortouni-iliac EVGs (MEGS). The main reason for this is its ability to treat a wider range of aneurysms, including ruptured aneurysms. Although the value of EVGs for good risk patients with AAA remains to be proven, it use already appears to be justified for those who are at high risk for standard repair.

Acknowledgments

Supported by grants from the Jikei University Visiting Scholar Fund, the James Hilton Manning and Emma Austin Manning Foundation, The Anna S. Brown Trust and the New York Institute for Vascular Studies.

References

33. Jenkins MP, Adiseshiah M: Aortomonoiliac endografting: it doesn’t have to be that difficult. J Endovasc Surg 1997; 4: 425–426