Endovascular management of iliac rupture during endovascular aneurysm repair: A single-center experience

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Background: Inadequate iliac artery diameter, calcification, and tortuosity are associated with increased incidence of iliac injury during abdominal (EVAR) and thoracic endovascular aneurysm repair (TEVAR). Despite careful preoperative assessment and use of iliac conduits, inadvertent iliac rupture is a source of morbidity and mortality. This report details our single-center, 10-year experience with intraoperative iliac artery rupture and describes a successful endovascular salvage technique.

Methods: All patients undergoing EVAR and TEVAR between August 1997 and June 2008 were reviewed. Computed tomography (CT) measurements of access vessels were obtained for all patients. The smallest diameter of the external or common iliac artery was used to determine suitability for access based on the instructions for use for each device. Patients who underwent repair of a procedure-related iliac artery rupture were identified. Outcomes among patients who did not have an access vessel rupture (nonruptured group) and those who did (ruptured group) were compared. Patency of the endovascular iliac repair is reported.

Results: During the study period, 369 EVARs and 67 TEVARs were performed. Eleven iliac conduits were used, all during TEVAR (16%). There were 18 ruptured iliac arteries in 17 patients; 11 EVAR patients (2.98%) sustained iliac rupture vs six TEVAR patients (8.9%). One EVAR patient was converted to open repair. Seventeen ruptures in 16 patients were successfully treated with endovascular stent graft placement. Iliac rupture was more likely to occur during TEVAR (8.9%) than EVAR (2.98%; P = .0239, Fisher exact test). Significantly more women were in the ruptured group (76% vs 19%; P < .0001, Fisher Exact Test). Patients in the ruptured group had longer lengths of stay (7.6 vs 5.1 days; P = .0895, t test), no 30-day mortality, but a procedure-related mortality of 11.8%. In the nonrupture group, 30-day mortality was 6.6% (4 of 61) and 2.8% (10 of 358) for TEVAR and EVAR, respectively, and procedure-related mortality was 9.8% (6 of 61) and 3.1% (11 of 358). For endovascular repair of iliac rupture, primary and primary-assisted patency was 88.2% and 94.1%, respectively, with median follow-up of 40 months (range 10-115 months).

Conclusion: Iliac rupture during EVAR or TEVAR can be successfully managed with endovascular stent grafting. Higher mortality and length of stay associated with iliac artery rupture confirm that there is no substitute for prevention. Access vessels of all patients undergoing EVAR should be examined closely for suitability. The threshold for using an iliac conduit, especially in women undergoing TEVAR, should be low. (J Vasc Surg 2009;xx:xxxx.)

One of the keys to successful endovascular repair of aneurysms of the thoracic and abdominal aorta is adequate vascular access through the femoral and iliac arteries. Current delivery systems have improved dramatically compared with first-generation devices, with improved tapered tips, trackability, and hydrophilic-coated surfaces. Nevertheless, the advent of larger diameter endografts requires larger delivery catheters and places greater demands on access vessels.¹

To prevent iliac artery injury, special attention must be paid to evaluating the adequacy of access vessels. Calcification, diminished diameter, and severe tortuosity of the iliac arteries have been associated with an increased incidence of iliac injury during abdominal endovascular aneurysm repair (EVAR) and thoracic endovascular aneurysm repair (TEVAR).²-⁴ Even after careful preoperative assessment, inadvertent iliac rupture may be a source of morbidity and death.⁵ Despite the importance of access vessel suitability for EVAR, few data are available concerning incidence, risk factors, management, and outcomes of iliac artery rupture. Our single-center experience with ruptured iliac arteries during EVAR is reviewed, and our management algorithm is described. The durability of endovascular repair of a ruptured iliac artery is also reported.

METHODS

Study population. All endovascular aneurysm repairs performed by one surgeon (H. E. G.) between August 1997 and June 2008 were retrospectively reviewed. Demographic, procedural, and outcome data were collected from the inpatient and outpatient records including age, gender,
device type, use of conduit, death, presence of iliac artery rupture, type of repair, length of stay, and patency (for ruptures). Indications for intervention included (1) saccular aneurysms, (2) symptomatic aneurysms, (3) asymptomatic fusiform aneurysms with a diameter of ≥5 cm (6 cm for thoracic aneurysms) or more than twice the size of the normal adjacent aorta, and (4) asymptomatic fusiform aneurysms with a growth rate >0.5 cm in 6 months.

**Access vessel compatibility.** During the study period, preoperative computed tomography (CT) measurements of access vessels were obtained on all patients. The smallest diameter of the external or common iliac artery by axial CT images was used to determine suitability based on the instructions for use for each device. If the iliac artery and graft delivery device were not compatible, a 10-mm Dacron common iliac artery conduit was used from a retroperitoneal flank approach. Owing to the retrospective nature of this study, multiple types of imaging analysis were used to assess the vessel diameters. Three-dimensional (3D) reconstructions were used for preoperative planning in 18 of 67 thoracic stent patients.

**Repair of aneurysm.** Thoracic and abdominal aortic stent graft placement was performed using standard techniques. All patients underwent general anesthesia and intraarterial blood pressure monitoring. Bilateral open common femoral access was obtained in patients undergoing EVAR. Unilateral open femoral access with additional percutaneous access at another site was used for TEVAR.

Weight-based intravenous heparin doses were administered at the time of initial arterial access and at hourly intervals throughout the procedure to maintain adequate anticoagulation. Protamine was administered selectively according to the degree of hemostasis at the time of wound closure.

Adjunctive intravascular ultrasound (IVUS) was used to accurately determine the device size in all patients and to visualize the quality and length of landing zones. No patients were excluded from EVAR or TEVAR on the basis of IVUS measurements. After stent graft deployment, satisfactory exclusion of the aneurysm was documented angiographically, and additional iliac views were obtained by withdrawing the sheath distal to the level of the hypogastric artery over a stiff wire. In all TEVAR cases and selective EVAR cases, a retrograde arteriogram was performed to exclude iliac arterial injury, including dissection or rupture. Iliac artery rupture was defined as extravasation of contrast medium on this injection. Injuries not associated with extraluminal contrast (eg, dissection) were not studied in this series.

**Repair of ruptured iliac artery.** In patients with hemodynamic compromise or evidence of extravasation (Fig, A), a Coda (Cook, Bloomington, Ind) or Reliant (Medtronic, Santa Rosa, Calif) endovascular aortic occlusion balloon was introduced into the distal aorta through the contralateral access site. After balloon occlusion through the contralateral sheath (Fig, B), a stent graft was chosen to repair the ruptured artery. In the case of TEVAR, ipsilateral balloon occlusion was obtained while surgical exposure of the contralateral femoral artery was performed if not already exposed. A second occlusion balloon was introduced through the contralateral side to allow endovascular repair of the ruptured iliac artery through the ipsilateral access (Fig, C).

During EVAR, a limb of the endograft currently being used for the aneurysm repair was used to repair the rupture. During TEVAR, the existing hospital inventory determined the stent graft that was used for repair. Endovascular repair of the iliac injury required appropriate proximal graft overlap (>2 cm) and adequate extension beyond the site of injury (>2 cm). Completion angiography confirmed exclusion of the injury and absence of extravasation (Fig, D).

**Outcomes.** Primary end points were 30-day and procedure-related death. Secondary end points were length of stay and primary and secondary patency of the iliac repair. Patients who sustained iliac rupture were identified and compared with patients whose iliac artery did not rupture during the study period.

The operative techniques and preoperative CT findings for each ruptured iliac artery were reviewed. Calcification and tortuosity of the ruptured iliac vessels were assessed. The durability of endovascular repair of a ruptured iliac artery was also assessed. Most patients underwent surveillance CT ≤1 month after implant, then at 6 months, 1 year, and annually thereafter. Each CT scan was accompanied by an outpatient clinic visit, including interval history and physical examination. Detected endoleaks were monitored every 3 to 6 months until resolved or treated. Patency of the iliac artery repair was assessed by history and physical examination findings in addition to CT imaging.

**Statistical analysis.** Descriptive statistics are reported as frequency distributions for continuous factors and counts and percentages for categoric factors. Inferential statistics included Fisher exact test and χ² analysis for categoric data and the t test with heterogenous variance for continuous variables. Statistical significance was assessed at the α = 0.05 level.

**RESULTS**

During the study period, 436 endovascular repairs were performed, including 369 infrarenal aneurysms (EVAR) and 67 thoracic aneurysms (TEVAR). TEVAR was performed using the TAG device (W. L. Gore & Associates, Flagstaff, Ariz) in 55 patients and the Talent Thoracic Graft (Medtronic, Santa Rosa, Calif) in 12. Abdominal repairs used 183 AneuRx (Medtronic), 26 Excluder (W. L. Gore & Associates), 98 Zenith (Cook, Bloomington, Ind), 47 Vanguard (Boston Scientific, Natick, Mass), 9 AnCure (Guidant, Indianapolis, Ind), 5 PowerLink (Endologix Inc, Irvine, Calif), and 1 Talent abdominal (Medtronic) device. There were 18 ruptured iliac arteries in 17 patients. The combined EVAR and TEVAR incidence of iliac rupture was 8.9%. Of these, 11 of the 369 EVAR patients (2.9%) sustained iliac rupture compared with six of the 67 TEVAR patients (8.9%), which is a statistically significant difference (P = .0239 Fisher exact test; Table I).
No EVAR patients deemed to have inadequate access vessels were treated with an iliac conduit, but underwent open repair instead. In the 11 patients undergoing EVAR whose iliac artery ruptured, eight (73%) were women. Seven patients were implanted with an AneuRx graft, three with a Zenith graft, and one with an Ancure graft.

For repair of iliac rupture, endograft type was chosen by availability of inventory. The diameters and lengths of endografts used to repair iliac ruptures were based on intraoperative arteriography of the ruptured iliac artery once hemodynamic control was obtained using occlusion balloons. AneuRx limbs were favored because they are available as nontapered grafts in multiple sizes. Other companies offer limbs that are tapered proximally, which is a disadvantage when the proximal end of the stent graft begins within the common iliac artery.

Fig. A, A retrograde angiogram demonstrates iliac rupture during thoracic endovascular aneurysm repair. B, Ipsilateral balloon occlusion is obtained due to single-sided access. C, Contralateral balloon occlusion is obtained after large-bore access is obtained to allow for repair. D, Completion arteriogram after endografting.
All ruptures were early in our experience with each graft, except for two patients treated with a Zenith graft. In one of these patients, the introduction and removal of the delivery system was uneventful, but iliac rupture occurred from over-aggressive balloon dilatation at the conclusion of the procedure. Intraoperative hypotension was documented in four patients. The other patients were hemodynamically stable, with extravasation noted on the arteriogram.

One patient with iliac rupture required conversion to open repair because of a persistent large type I proximal endoleak that could not be repaired by endovascular means. One patient died on postoperative day 33 of aspiration pneumonia when the family requested withdrawal of further support.

In the six TEVAR patients who sustained iliac rupture, five (83%) were women. All were treated with TAG grafts. Paraplegia developed in one patient. One patient required a femoral-femoral graft for occlusion of the stent graft used for endovascular repair of the ruptured iliac artery. This patient returned 2 months later with an infected graft, which ultimately resulted in multisystem organ failure and death.

A retroperitoneal approach was used in 11 of 67 patients (16%) for implantation of an iliac conduit because their access vessels were deemed inadequate. Iliac rupture rates differed by graft type. Rupture rates were higher in thoracic than in abdominal endografting; (Table II). All ruptures occurred with delivery systems of ≥20F.

Lengths of stay were 7.6 days for patients in the ruptured group and 5.1 days for nonruptured patients (P = 0.0895, t test with heterogeneous variance). The median length of stay was 2 days for nonruptured EVAR and 5 days for TEVAR. Although not reaching statistical significance, there was a clear trend toward higher procedure-related mortality of 11.8% in the ruptured group vs 4.06% (P = 0.1657 Fisher exact test) in the nonruptured group (Table III).

In the two groups were similar in age, with a mean age of 74.3 years in the ruptured group vs 72.3 years in the nonruptured group (P = .55 by t test with heterogeneous variance). Significantly more women were in the ruptured group, 76% vs 19% (P < .0001 Fisher Exact Test). Women comprised 26% of the TEVAR nonruptured group (16 of 61) vs 83% in the ruptured group (5 of 6) and 14% of the EVAR nonruptured group (51 of 358) vs 73% of the ruptured group (8 of 11).

Technical success was 94% (17 of 18) for all attempted endovascular repairs of ruptured iliac vessels. All ruptures occurred at or near the internal iliac artery. Iliac stenting to the external iliac was adequate in all but one patient. In this group.

### Table I. Patients who sustained iliac rupture during endovascular aneurysm repair

<table>
<thead>
<tr>
<th>Patient</th>
<th>Age</th>
<th>Sex</th>
<th>Aneurysm</th>
<th>Endograft</th>
<th>Sheath size, F</th>
<th>Procedure-related death</th>
<th>Stent graft used for repair</th>
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<tbody>
<tr>
<td>1</td>
<td>56</td>
<td>M</td>
<td>Abdominal</td>
<td>Ancure</td>
<td>23.5</td>
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<td>WallGraft</td>
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<td>2</td>
<td>77</td>
<td>F</td>
<td>Abdominal</td>
<td>Zenith</td>
<td>20</td>
<td>Yes</td>
<td>AneuRx/Excluder</td>
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<tr>
<td>3</td>
<td>66</td>
<td>F</td>
<td>Abdominal</td>
<td>Zenith</td>
<td>20</td>
<td>No</td>
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</tr>
<tr>
<td>4</td>
<td>77</td>
<td>M</td>
<td>Abdominal</td>
<td>Zenith</td>
<td>20</td>
<td>No</td>
<td>Zenith</td>
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<tr>
<td>5</td>
<td>86</td>
<td>M</td>
<td>Abdominal</td>
<td>AneuRx</td>
<td>21</td>
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<td>6</td>
<td>87</td>
<td>F</td>
<td>Abdominal</td>
<td>AneuRx</td>
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<td>No</td>
<td>AneuRx</td>
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<td>8</td>
<td>63</td>
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<tr>
<td>9</td>
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<td>10</td>
<td>69</td>
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<td>AneuRx</td>
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<tr>
<td>11</td>
<td>85</td>
<td>F</td>
<td>Abdominal</td>
<td>AneuRx</td>
<td>21</td>
<td>No</td>
<td>Converted to open</td>
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<tr>
<td>12</td>
<td>75</td>
<td>F</td>
<td>Thoracic</td>
<td>TAG</td>
<td>22</td>
<td>No</td>
<td>AneuRx</td>
</tr>
<tr>
<td>13</td>
<td>75</td>
<td>F</td>
<td>Thoracic</td>
<td>TAG</td>
<td>24</td>
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<td>AneuRx</td>
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<tr>
<td>14</td>
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<td>TAG</td>
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<tr>
<td>15</td>
<td>74</td>
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<tr>
<td>16</td>
<td>73</td>
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<td>TAG</td>
<td>24</td>
<td>No</td>
<td>AneuRx &amp; Zenith</td>
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<tr>
<td>17</td>
<td>85</td>
<td>M</td>
<td>Thoracic</td>
<td>TAG</td>
<td>22</td>
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<td>Excluder</td>
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</table>

### Table II. Incidence of rupture by device type

<table>
<thead>
<tr>
<th>Type</th>
<th>Ruptured no.</th>
<th>Nonruptured no.</th>
<th>Incidence %</th>
</tr>
</thead>
<tbody>
<tr>
<td>AneuRx</td>
<td>7</td>
<td>176</td>
<td>3.83</td>
</tr>
<tr>
<td>Ancure</td>
<td>1</td>
<td>8</td>
<td>11.11</td>
</tr>
<tr>
<td>Endoglix</td>
<td>0</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>Excluder</td>
<td>0</td>
<td>26</td>
<td>0</td>
</tr>
<tr>
<td>Vanguard</td>
<td>0</td>
<td>47</td>
<td>0</td>
</tr>
<tr>
<td>Zenith</td>
<td>3</td>
<td>95</td>
<td>3.06</td>
</tr>
<tr>
<td>Talent abdominal</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>TAG</td>
<td>6</td>
<td>49</td>
<td>10.91</td>
</tr>
<tr>
<td>Talent thoracic</td>
<td>0</td>
<td>12</td>
<td>0</td>
</tr>
<tr>
<td>Overall</td>
<td>17</td>
<td>419</td>
<td>3.90</td>
</tr>
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</table>

### Table III. Comparison of ruptured and unruptured groups

<table>
<thead>
<tr>
<th>Variable</th>
<th>Ruptured</th>
<th>Nonruptured</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, y</td>
<td>74.3</td>
<td>72.3</td>
<td>.5536</td>
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<tr>
<td>Female sex, %</td>
<td>76.47</td>
<td>19.09</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>TEVAR, %</td>
<td>35.29</td>
<td>14.56</td>
<td>.0325</td>
</tr>
<tr>
<td>Length of stay, d</td>
<td>7.60</td>
<td>5.10</td>
<td>.0895</td>
</tr>
<tr>
<td>Procedure-related mortality, %</td>
<td>11.76</td>
<td>4.06</td>
<td>.1657</td>
</tr>
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</table>

TEVAR, Thoracic endovascular aneurysm repair.
case in which the external iliac artery was removed with the delivery sheath, extension to the femoral artery was necessary. The stent graft was sutured circumferentially to the proximal common femoral artery. No patients underwent exploration due to persistent bleeding after the initial repair or to evacuate a large hematoma. As previously stated, one patient required immediate open conversion due to an unrepaired proximal type 1 endoleak.

Calcification and tortuosity of ruptured and nonruptured iliac arteries in TEVAR patients were evaluated with 3D CT reconstructions. For only a small number of infra-renal aneurysm patients were 3D CT reconstructions available for review. The 11 patients who required an iliac conduit due to small iliac diameter were excluded from this analysis.

Standard measurements of angulation from 3D reconstructions were obtained from centerline imaging between the aorta and common iliac artery, within the common iliac artery, at the origin of the internal iliac artery, and within the external iliac artery. Calculation was as a percentage of the circumference at the vertex of each angle measured using centerline imaging. Of the 56 thoracic stent graft patients, 3D reconstruction imaging was available in 17 (30%), three of which had sustained ruptured iliac vessels. Table IV lists the angles of centerline tortuosity and percentage of circumferential calcification found along the iliac arteries. Statistical analysis could not be performed due to the small sample size.

Two of the ruptured iliac vessels had 100% calcification within the common iliac artery and >50° of angulation between the aorta and the common iliac artery. The ruptures occurred just distal to the origin of the internal iliac artery. The third ruptured iliac artery had 30% calcification and 44° of angulation between the external and common iliac arteries. Of the unruptured iliac vessels, the mean calcification was 26.5% in common iliac and 18.5% in the external iliac. The mean angulation of the common iliac artery was 32°, common to external iliac artery was 4°, and external iliac artery was 36°. The mean diameter of the ruptured iliac arteries was 8.0 mm compared with 8.9 mm in the unruptured group.

Patients were monitored using standard protocols for surveillance of endovascular aneurysm repair, with median follow-up of 20 months for the entire cohort. After endovascular repair of an iliac rupture, the primary and primary-assisted patency was 88.2% and 94.1%, respectively, with a median follow-up of 40 months (range, 10-115 months). Immediate thrombosis of the iliac endograft in one patient was treated with femoral-femoral bypass. A pseudoaneurysm formed at the distal end of the endograft repair site in another patient 32 months after implant. This may have represented incomplete coverage of the injured external iliac artery. Endograft repair of the pseudoaneurysm remains patent at 42 months since the initial injury. The nonrupture cohort experienced 1.3% limb occlusions (9 of 716; 6 Aneurx, 2 Zenith, and 1 Vanguard).

### DISCUSSION

Iliac artery injury can be a highly morbid complication of surgical interventions. Iatrogenic iliac injuries have been reported during endovascular, laparoscopic, orthopedic, neurosurgical, and open pelvic procedures. A unique aspect of endovascular injury is that vascular access and wire or catheter placement is already established, making prompt diagnosis and endovascular salvage possible. Early reports of endovascular stent grafting for iatrogenic iliac ruptures originated from percutaneous balloon angioplasty for occlusive disease, which carries a rupture risk of one per 200 procedures. Stent graft repair of these injuries
endovascular repair, including dissection, rupture, and several types of vascular injury have been reported during necessary devices must be readily available. Although the own method of treatment for arterial rupture; however, the necessity devices must be readily available. Although several types of vascular injury have been reported during endovascular repair, including dissection, rupture, and thrombosis, the incidence, management and outcomes for salvage endografting specifically for iliac rupture have not been previously reported, to our knowledge.

Several factors contributed to the incidence of iliac artery disruption during EVAR in this series. First, iliac artery injuries are more common in thoracic than abdomino-endograft placement because of the larger percentage of women treated and the larger graft sizes used. In this series, patients undergoing TEVAR had an 8.9% vs. 2.98% (P = .0239) incidence of rupture compared with patients who underwent EVAR, despite use of iliac conduits in 16% of TEVAR cases. Others have reported an incidence of iliac rupture of 0.5% to 1.5% with endograft repair of abdominal aneurysms.

Women were at higher risk for rupture (76% vs 19%; P < .0001). All ruptures occurred during the use of devices with a ≥20F delivery system.

Although no definitive conclusion could be drawn about the risk of iliac rupture related to calcification and tortuosity, a combination of calcification, tortuosity, and diminished caliber contributes to the risk of iliac rupture even when the iliac diameter is acceptable. Owing to the small sample size, a statistical analysis could not be performed. Nevertheless, calcification and angulation of the iliac artery inhibit straightening of the artery with a stiff guidewire, which provides a second point of fixation in addition to the internal iliac artery. Although specific predictors of iliac rupture could not be ascertained, patients with rupture displayed greater angulation (aorta to common iliac 45° vs 32°, calcification (common iliac, 66% vs 26.5%), and diminished caliber (external iliac, 8.0 vs 8.9 mm).

The endovascular repair strategy used in this study prevented any intraoperative deaths. To successfully perform an endovascular repair of an iliac rupture, several steps were taken prophylactically. Intraoperative arterial blood pressure monitoring was used in all patients. A stiff wire capable of tracking a stent graft through tortuous iliac arteries was maintained. An aortic occlusion balloon and an inventory of iliac extension grafts were readily available. A high index of suspicion, hemodynamic monitoring, and radiographic interrogation of the access vessels while withdrawing the sheaths were also critical.

Although persistent retroperitoneal bleeding through the ipsilateral hypogastric artery or other type II endoleak is possible, such bleeding has not occurred in our experience. In most patients with small external iliac arteries at risk for rupture, the orifice of the hypogastric artery is sealed against the outer wall of the stent graft. Nevertheless, the possibility of persistent bleeding through a type II endoleak must be considered, although this may be difficult to demonstrate angiographically.

Ultimately, the prevention of rupture is the best management. The liberal use of iliac conduits and use of small-diameter sheaths may be the best preventive strategy. During this study period, 11 iliac conduits (16%) were used during TEVAR, but none were used during EVAR. Some patients were not candidates for an iliac conduit due to previous iliac stenting or concurrent iliac aneurysmal disease. Patients with an abdominal aortic aneurysm with inadequate access vessels on axial CT imaging underwent open repair rather than endovascular repair with an iliac conduit. Peterson and Matsumura have described an alternative technique of “internal endoconduit” in which a controlled rupture is performed after endografting of the external iliac as an alternative to an iliac conduit. No endoconduits (internal conduits) were performed during this study period. The more liberal use of 3D reconstructions may have better helped identify the patients with worse tortuosity and calcification, and also identify areas of stenosis not evident on axial imaging.

Patency rates for the endovascular repair of ruptured iliac arteries in this series were excellent. Only one iliac occlusion occurred in the 17 iliac arteries that were successfully endografted during a median of 40 months. The 88.2% primary and 94.1% primary-assisted patency rates are similar to the 87% primary and 100% secondary rates reported by Schienert et al in which 47 patients with occlusive disease were treated with covered stents for catheter-induced iliac injury.

Surveillance of the iliac repair is included with the routine endovascular repair surveillance protocol. There was a nonstatistically significant trend toward a higher mortality rate and longer length of stay in the ruptured group. The two deaths that occurred in the ruptured group were directly attributable to consequences of the rupture, although neither death occurred intraoperatively. Alternatively, conversion to open aortic and iliac repair has been associated with higher mortality rates of 11% to 22% in other reports.

Given this disparity, endovascular repair should be the preferred approach to iliac artery rupture during EVAR, especially when prerequisite preparations have been made.

CONCLUSION

Although prevention of iliac rupture during EVAR is the best strategy, the surgeon must be prepared to deal with an unexpected injury. Intraoperative invasive arterial blood pressure monitoring, maintenance of stiff wire access, readily available intra-aortic occlusion balloons, and an inventory of iliac stent grafts are prerequisites for timely endovascular management of a ruptured iliac artery during EVAR. Given the excellent durability and the low morbidity and mortality of this repair, endovascular repair should be the preferred approach to inadvertent rupture of an iliac artery during aortic endograft placement. The higher mortality rate and length of stay associated with inadvertent iliac...
artery rupture testifies to the fact that there is no substitute for prevention. The access vessels of all patients undergoing EVAR should be examined for compatibility with the anticipated device. This is especially true for women being considered for TEVAR.

AUTHOR CONTRIBUTIONS

Conception and design: JF, HG
Analysis and interpretation: JF, HG, JC
Data collection: JC, SB
Writing the article: JF, JC
Critical revision of the article: JF, HG
Final approval of the article: JF, HG
Statistical analysis: AB

REFERENCES


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DISCUSSION

Dr. W. Todd Bohannon (Temple, Tex). I would like to thank the Southern Association for Vascular Surgery for the opportunity to discuss this paper regarding the endovascular management of iliac artery rupture during endovascular aneurysm repair. Also, I congratulate Dr. Fernandez on a fine presentation and thank the authors for providing me with the manuscript in a timely fashion.

Iliac rupture can be a devastating complication of the endovascular management of aortic aneurysms. Dr. Fernandez and colleagues have reported their experience with endovascular aneurysm repair and iliac artery rupture over a 9-year period. They have provided a good description of the challenging iliac anatomy that is encountered when treating aortic aneurysms and the intraoperative management when a rupture is encountered. Appropriately, they have pointed out the importance of a close preoperative assessment of the iliac anatomy before the endograft procedure to limit the associated morbidity of a ruptured iliac vessel.

I have several questions for the authors. First, do you routinely balloon dilate the iliac limbs, and what type of balloon do you use? Do you use the same compliant balloon used to treat the aortic neck, or do you use a smaller noncompliant balloon that approximates the size of the iliac arteries. How do you decide when to use intravascular ultrasound (IVUS)? In our institution, we utilize IVUS in treatment of both occlusive and aneurysmal disease of the aorta and iliac vessels. It is another modality to evaluate the diameters and atherosclerotic plaque of the iliac arteries. Also, after endograft deployment, IVUS can assess the lumen of the graft and the need for postdeployment angioplasty. I note that you were placing iliac conduits, primarily for thoracic endograft procedures, during the time of this review. How has this review changed your practice? Have you lowered your threshold for placing iliac conduits or have you altered your endograft choices?

Dr. Joss D. Fernandez. Thank you for your comments. The first question is about balloon dilation. All but one of these ruptures occurred due to the sheath, not to the post-deployment balloon dilation. We use the same type of balloon, a Cook Codad Medtronic Reliant, to post-dilate the iliacs and the aortic neck routinely. Whether or not that is necessary, we don’t know. We make sure the balloon is well within the iliac limb when we dilate, and we have had only one rupture from that standpoint. It has really been the sheath itself, placing it, having successful endograft
deployment then removing it and having the actual rupture occur. When there is stenosis of the iliac limbs, we will use a noncompliant balloon or a secondary stent. We have a low threshold for using noncompliant balloons within the endograft itself, and for stenting distal to the endograft limbs when there is injury such as a dissection.

We do use IVUS on all our endograft cases. Our group has previously published both in thoracic and abdominal aneurysms the accuracy of IVUS. We feel that IVUS provides important measurements that may not be obtained with CT alone, and does occasionally change our graft selection. In our view, the IVUS often shows 1 to 2 mm smaller size than the CT measurements. We are very strong advocates of IVUS. We use IVUS, of course, for endografting of dissections and that type of thing, and if there is any questionable anatomy.

Will this review change our practice? Certainly. We feel that diameter alone does not mean that you have adequate access. If you have a calcified or tortuous vessel, even though the diameter is adequate, there is a risk of rupture so we have a lower threshold for iliac conduits during EVAR repair. That does change our mindset. We don’t just look at diameter anymore. There is more to it than that, especially in females.