Aortic Paraprosthetic-colonic Fistulae: A Review of the Literature

L.R. Leon Jr.,1,2* J.L. Mills Sr.,1,2 S.B. Psalms,1 J. Kasher,3 J. Kim3 and D.M. Ihnat1,2

1Southern Arizona Veteran Affairs Health Care System (SAVAHCS) — Vascular Surgery Section, Tucson, Arizona, USA, 2University of Arizona Health Science Center (AHSC) — Division of Vascular Surgery, Tucson, Arizona, USA, and 3Southern Arizona Veteran Affairs Health Care System (SAVAHCS) — Gastroenterology Section, Tucson, Arizona, USA

Background. Aortic graft-colonic fistulae are a rare complication of aortic reconstructive surgery. We performed an exhaustive literature review of this entity.

Methods and findings. A comprehensive review of this entity was performed based on the available literature from 1950 until 2006. Available reports were analyzed with respect to demographics, prior surgical intervention and its indication, prosthetic material used during the initial intervention, clinical presentation, the time interval in between the initial operation and symptoms, the method of treatment of the aortic graft-colonic fistula and its outcome.

Results of Literature Review

Incidence

Aortic reconstruction has been performed for aortoiliac occlusive or aneurysmal disease for >50 years, with excellent results in terms of patency, morbidity and mortality.46,47 Kalman et al.46 studied 94 patients after non-ruptured abdominal aortic aneurysm (AAA) repair with CT scans obtained 8 to 9 years after repair. Abnormal findings were frequent, but were mostly clinically insignificant (65% of patients had evidence of aneurysmal dilatation, but in only 14% was surgical repair a consideration). Hallett et al.48
analyzed 307 AAA operations over 33 years for graft-related complications. At a mean follow-up of 6 years (range: <1 month-36 years), 9% of patients had a graft-related complication.

Gastrointestinal (GI) tract erosion by an adjacent vascular prosthesis is a rare complication of aortic reconstruction, known as SAEF. Cases of erosion of a native vessel and the bowel (without prosthesis) are classified as primary aortoenteric fistulae. Some have made a distinction between SAEF, which is a true fistulous tract from the proximal suture line to the bowel lumen, and a paraprosthetic enteric fistula (PEF), also known as prosthetic or aortoenteric erosion, which is a communication between the GI tract and the external prosthetic graft body surface without actual fistulization into the lumen. Brock first described a case of SAEF to the duodenum that was identified 6 months after implantation of an aortic homograft. In 1958, Mackenzie et al. successfully treated a patient with a SAEF after AAA homograft replacement.

The pathogenesis of colonic SAEF rather than small bowel involvement remains speculative. Erosion into the adjacent colon is thought to result from pressure necrosis due to constant graft pulsation eventuating in graft body erosion into the bowel. This may be facilitated by the lack of interposed tissue or excessive pulsation of redundantly placed or kinked grafts. Indolent graft infections may promote inflammatory adherence and subsequent erosion into the bowel wall. Additionally, retroperitoneal infectious processes (i.e. diverticular abscess or pancreatic pseudocysts) may predispose to graft erosion into the bowel wall. Our review identified colonic involvement almost exclusively after aortic reconstructions using bifurcated prosthetic grafts and rarely after the use of tube grafts.

The incidence of SAEF involving any enteric segment ranges from 0.4–1.6%. The overwhelming majority involve the 3rd and 4th portions of the duodenum. Kalman et al. noted that bowel was found to be intimately associated with the prosthetic graft in 7% (which did not imply a true fistulous connection). Hallett et al. identified graft-enteric erosion/fistula in 1.6% of cases after AAA repair, with a median follow-up of 4.3 years. With regard to colonic involvement, Bergqvist analyzed 631 cases of SAEFs, reporting sigmoid involvement in 2.4% of cases and appendix-colon (colon site not further specified) involvement in 4.2%. We were unable to precisely define the prevalence of SAEFs involving the colon given the paucity of large series and the multitude of case reports. We identified 53 colonic PEF cases (12.3%) among 430 reported PEFs involving all bowel segments. Affected patients tended to be elderly (mean age = 65 years; range 47–83; age unknown in 19 cases) with strong male gender predilection (4.8:1; unknown in 18 cases), reflecting the patient population undergoing open aortic reconstruction.

**Intestinal site of involvement**

The most frequent site of SAEF is the duodenum, related to its proximity to the infrarenal aorta. Other segments have been infrequently reported. Aorto-colonic erosions are especially uncommon. O'Mara and Imbembo only identified 1/21 patients with sigmoid involvement in their SAEF review. Among cases of colonic SAEF in our review, 3/4 cases involved the sigmoid (39/53; 73.6%); the transverse colon was involved in 4 cases (7.6%), whereas the ascending colon and a rectal stump were involved in one instance each (1.9% each). The site of involvement was not reported in 8 cases (15.1%).

**Indication for initial operation**

The initial indication for aortic reconstruction was equally divided between occlusive and aneurysmal disease with 15 cases each (11 intact and 4 ruptures; one of the 4 ruptured cases was associated with an aortocaval fistula). Several papers have reported that SAEF are more likely to occur after surgery for ruptured AAA than for elective AAA and almost insignificant when the graft is placed for aortoiliac occlusive disease. This statement seems to arise from observations made by Elliott et al., based on their reported series of 17 PEF cases, 14 of which developed after AAA repair. This assertion has not been universally confirmed. Although Armstrong et al. concurred with Elliott’s observations (identifying as the indication for aortic reconstruction an aneurysm in 72% of their patients (21) with SAEFs, and aortoiliac occlusive disease in 28%). Vollmar and Kogel found a higher incidence of SAEFs after reconstruction for occlusive disease (1.1% vs. 0.2% for aneurysms). Six of Vollmar’s initial procedures for aneurysms were performed for rupture AAA, while 15 were elective. Kuestner et al. noted that >50% of the patients with SAEF in their series had occlusive disease as the indication for the original operation. O’Mara found that among 21 cases of PEF, AAA had been the indication in 14 (6 ruptured and 8 elective) and the remaining 7 followed therapy for aortoiliac occlusive disease. Our review of aorto-colonic fistulae identified an equal proportion of cases recognized after operations for occlusive disease and AAA.
<table>
<thead>
<tr>
<th>Paper</th>
<th>Age</th>
<th>Sex</th>
<th>Number/total PEF number</th>
<th>Follow-up (months)</th>
<th>Prior surgery</th>
<th>Indication</th>
<th>Presentation/time between 1st surgery and PEF diagnosis (months)</th>
<th>Colon site involved</th>
<th>Treatment</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ferris</td>
<td>50</td>
<td>M</td>
<td>1/3</td>
<td>Unknown</td>
<td>Left iliofemoral bypass graft</td>
<td>Peripheral arterial disease</td>
<td>Left groin abscess/25</td>
<td>Sigmoid</td>
<td>Graft ligation; above-the-knee amputation; colostomy</td>
<td>Unknown</td>
</tr>
<tr>
<td>Beach</td>
<td>69</td>
<td>M</td>
<td>1/1</td>
<td>0</td>
<td>Aortoiliac Dacron graft</td>
<td>Presumed symptomatic abdominal aortic aneurysm</td>
<td>Hematochezia, tender abdominal mass/2</td>
<td>Sigmoid</td>
<td>Graft removal; aortoiliac oversewing; proximal and distal colon stomas</td>
<td>Death four days postoperatively</td>
</tr>
<tr>
<td>Mannick</td>
<td>62</td>
<td>M</td>
<td>1/1</td>
<td>15</td>
<td>Aortoiliac Dacron graft</td>
<td>Ruptured abdominal aortic aneurysm</td>
<td>GI bleeding/36</td>
<td>Sigmoid</td>
<td>Partial colectomy; omental vascular interposition; axillofemoral bypass + graft excision</td>
<td>Initial recovery; infected pseudoaneurysm 6 months postoperatively; bilateral limb thrombosis</td>
</tr>
<tr>
<td>Shucksmith</td>
<td>64</td>
<td>M</td>
<td>1/2</td>
<td>0</td>
<td>Aortoiliac Dacron graft</td>
<td>Abdominal aortic aneurysm and aortocaval fistula</td>
<td>Right iliac fossa pain and blood in bowel movements/16</td>
<td>Sigmoid</td>
<td>Primary repair of colon and Dacron graft ligation</td>
<td>Death six days postoperatively</td>
</tr>
<tr>
<td>Dalinka</td>
<td>47</td>
<td>F</td>
<td>1/1</td>
<td>Unknown</td>
<td>Aortofemoral bypass graft</td>
<td>Peripheral arterial disease</td>
<td>GI bleeding/1</td>
<td>Sigmoid</td>
<td>Graft revision</td>
<td>Did well</td>
</tr>
<tr>
<td>Thompson</td>
<td>59</td>
<td>F</td>
<td>1/10</td>
<td>Unknown</td>
<td>Aortobifemoral graft</td>
<td>Abdominal aortic aneurysm</td>
<td>Pain, left groin mass, sepsis/7</td>
<td>Sigmoid</td>
<td>Unknown</td>
<td>Unknown</td>
</tr>
<tr>
<td>Thompson</td>
<td>Unknown</td>
<td>Unknown</td>
<td>1/2</td>
<td>Unknown</td>
<td>Aortichificuration graft</td>
<td>Abdominal aortic aneurysm</td>
<td>Hematochezia, pulsatile abdominal mass/23</td>
<td>Sigmoid</td>
<td>Graft removal and axillofemoral bypass</td>
<td>Unknown</td>
</tr>
<tr>
<td>Kron</td>
<td>83</td>
<td>M</td>
<td>1/1</td>
<td>16</td>
<td>Aortoiliac Dacron graft</td>
<td>Abdominal aortic aneurysm</td>
<td>Unknown</td>
<td>Sigmoid</td>
<td>Limb excision, sigmoid loop colostomy, femorofemoral crossover bypass graft</td>
<td>Did well</td>
</tr>
<tr>
<td>Bergkvist</td>
<td>56</td>
<td>M</td>
<td>1/1</td>
<td>0</td>
<td>Aortoiliac Dacron graft</td>
<td>Peripheral arterial disease</td>
<td>Melena/60</td>
<td>Sigmoid</td>
<td>Sigmoid resection; transverse colon stoma; re-suturing of graft-iliac anastomosis</td>
<td>Death 18 days postoperatively (pulmonary embolism)</td>
</tr>
<tr>
<td>Cranston</td>
<td>69</td>
<td>M</td>
<td>1/1</td>
<td>Unknown</td>
<td>Tube Dacron graft</td>
<td>Ruptured aortic aneurysm</td>
<td>Bleeding per rectum/60</td>
<td>Unknown</td>
<td>Primary repair of colon and proximal anastomosis</td>
<td>Did well</td>
</tr>
<tr>
<td>Criado</td>
<td>53</td>
<td>M</td>
<td>1/4</td>
<td>0.3</td>
<td>Left aortoiliac Dacron bypass graft</td>
<td>Peripheral arterial disease</td>
<td>Left leg rash, swelling and pain, left lower quadrant pain, sweating/108</td>
<td>Sigmoid</td>
<td>Axillofemoral bypass + ligation of proximal left common femoral artery; later needed near-total graft excision; infrarenal aorta, right common iliac and left external iliac arteries ligation; sigmoid resection + primary anastomosis</td>
<td>Did well</td>
</tr>
<tr>
<td>Dobbs</td>
<td>66</td>
<td>M</td>
<td>1/1</td>
<td>0</td>
<td>Aortobifemoral graft</td>
<td>Peripheral arterial disease</td>
<td>Fever, hematochezia/10</td>
<td>Sigmoid</td>
<td>Sigmoid resection, graft limb excision</td>
<td>Unknown</td>
</tr>
<tr>
<td>Year</td>
<td>Author</td>
<td>Age</td>
<td>Day</td>
<td>Cause of Death</td>
<td>Procedure Description</td>
<td>Status</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>------</td>
<td>--------</td>
<td>-----</td>
<td>-----</td>
<td>----------------</td>
<td>-----------------------</td>
<td>--------</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1983</td>
<td>Flye</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown/unknown</td>
<td>Sigmoid × 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1984</td>
<td>Robbins</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown/unknown</td>
<td>Sigmoid</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1985</td>
<td>Paaske</td>
<td>56 M</td>
<td>1/9</td>
<td>Peripheral arterial disease</td>
<td>Resection of right prosthetic limb and external iliac artery</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1985</td>
<td>Yeager</td>
<td>73 M</td>
<td>1/8</td>
<td>End-to-end, aortoiliac</td>
<td>Ax-ileofemoral with total graft removal and colectomy</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1985</td>
<td>Bergkvist</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1985</td>
<td>Bergkvist</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Uknown</td>
<td>Unknown</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1985</td>
<td>D’Souza</td>
<td>57 M</td>
<td>1/5</td>
<td>Thoracoabdominal Dacron aortoiliac graft</td>
<td>Excision infrarenal portion of graft and insertion of axillofemoral graft; colostomy</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1987</td>
<td>Harris</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1987</td>
<td>Travis</td>
<td>68 M</td>
<td>1/10</td>
<td>Aortoiliac Dacron graft</td>
<td>Intraoperative death</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1987</td>
<td>Vollmar</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Sigmoid</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1988</td>
<td>DeMaerel</td>
<td>68 M</td>
<td>1/1</td>
<td>Aortofemoral Dacron graft</td>
<td>Left axillofemoral bypass; graft removal; sigmoid resection Discharged 2 weeks after procedure (presumably well) Death</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1989</td>
<td>Aarnio</td>
<td>73 M</td>
<td>1/3</td>
<td>Thoracoabdominal Dacron aortoiliac graft</td>
<td>Excision infrarenal portion of graft and insertion of axillofemoral graft; colostomy</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1990</td>
<td>Higgins</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1990</td>
<td>Wilcox</td>
<td>66 F</td>
<td>1/1</td>
<td>Right aortoiliac Dacron graft</td>
<td>Primary repair of colon; graft removal; right ileofemoral bypass with vein</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1990</td>
<td>Wilcox</td>
<td>58 F</td>
<td>1/1</td>
<td>Aortoiliac Dacron graft</td>
<td>Primary repair of colon; graft removal; left axillo-iliac bypass + iliac-iliac crossover graft</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1991</td>
<td>Peters</td>
<td>74 M</td>
<td>1/1</td>
<td>Aortoiliac Sauvage-velour graft</td>
<td>Axillary bifemoral bypass; presumably did well</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1992</td>
<td>Barman</td>
<td>62 M</td>
<td>1/1</td>
<td>Dacron graft</td>
<td>Axillary bifemoral bypass; left sided abdominal pain + hematoma/12</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paper</td>
<td>Age</td>
<td>Sex</td>
<td>Number/total PEF number</td>
<td>Follow-up (months)</td>
<td>Prior surgery</td>
<td>Indication</td>
<td>Presentation/time between 1st surgery and PEF diagnosis (months)</td>
<td>Colon site involved</td>
<td>Treatment</td>
<td>Outcome</td>
</tr>
<tr>
<td>---------</td>
<td>-----</td>
<td>-----</td>
<td>-------------------------</td>
<td>-------------------</td>
<td>---------------</td>
<td>----------------------------</td>
<td>---------------------------------------------------------------</td>
<td>----------------------</td>
<td>----------------------------------------------------------------------------</td>
<td>----------------------------------</td>
</tr>
<tr>
<td>Peck</td>
<td></td>
<td></td>
<td>1/25</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Left iliofemoral bypass</td>
<td>Unknown/unknown</td>
<td>Unknown</td>
<td>Sigmoid resection + omentum coverage of prosthesis; had recurrent infection needing graft removal + left axillofemoral bypass</td>
<td>Died from sepsis</td>
</tr>
<tr>
<td>Fernandez</td>
<td></td>
<td></td>
<td>1/2</td>
<td>18</td>
<td>Unknown</td>
<td>Peripheral arterial disease</td>
<td>Hematochezia/unknown</td>
<td>Unknown</td>
<td>Left above-the-knee amputation</td>
<td></td>
</tr>
<tr>
<td>Li</td>
<td>65</td>
<td>M</td>
<td>1/1</td>
<td>12</td>
<td>Right</td>
<td>Peripheral arterial disease</td>
<td>Fever, chills, hematochezia/5</td>
<td>Sigmoid</td>
<td>Left axillofemoral bypass; graft removal; sigmoid resection</td>
<td>Did well</td>
</tr>
<tr>
<td>Shindo</td>
<td>69</td>
<td>M</td>
<td>1/1</td>
<td>6</td>
<td>Right</td>
<td>Peripheral arterial disease</td>
<td>Melena/324</td>
<td>Ascending</td>
<td>Did well</td>
<td></td>
</tr>
<tr>
<td>Chan</td>
<td>72</td>
<td>M</td>
<td>1/1</td>
<td>0</td>
<td>Aortobiliary</td>
<td>Abdominal aortic aneurysm</td>
<td>Abdominal pain/108</td>
<td>Sigmoid</td>
<td>Exploratory laparotomy</td>
<td>Died in operating room</td>
</tr>
<tr>
<td>Floriani</td>
<td>65</td>
<td>M</td>
<td>1/1</td>
<td>9</td>
<td>Aortobifemoral graft</td>
<td>Periperal arterial disease</td>
<td>Fever/156</td>
<td>Sigmoid</td>
<td>Exploratory laparotomy</td>
<td>Did well</td>
</tr>
<tr>
<td>Hamdani</td>
<td>67</td>
<td>M</td>
<td>1/1</td>
<td>2</td>
<td>Aortobifemoral graft</td>
<td>Abdominal aortic aneurysm</td>
<td>Fever, chills, left leg swelling/120</td>
<td>Sigmoid</td>
<td>Hartmann’s procedure, graft removal, axillofemoral bypass</td>
<td>Did well</td>
</tr>
<tr>
<td>Kuestner</td>
<td></td>
<td>F</td>
<td>1/33</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown/unknown</td>
<td>Sigmoid</td>
<td>Redo in-line aortic reconstruction</td>
<td>Death due to SAEF after redo in-line aortic reconstruction because of infection involving prosthetic axillofemoral graft</td>
</tr>
<tr>
<td>Novali</td>
<td>65</td>
<td>F</td>
<td>1/2</td>
<td>2</td>
<td>Aortobifemoral graft</td>
<td>Periperal arterial disease</td>
<td>Cutaneous fistula/28</td>
<td>Sigmoid</td>
<td>Graft excision; sigmoid resection; aortobifemoral homograft. Later needed colostomy + replacement of iliac homograft with saphenous vein</td>
<td>Did well</td>
</tr>
<tr>
<td>Van Baalen</td>
<td></td>
<td></td>
<td>1/31</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Aortobiliary bypass</td>
<td>Unknown/unknown</td>
<td>Sigmoid</td>
<td>Graft removal, colostomy, ascending aorta to femoral artery bypass graft</td>
<td>Unknown</td>
</tr>
<tr>
<td>Davidovic</td>
<td>64</td>
<td>M</td>
<td>1/5</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Fever, hematochezia, elevated sedimentation rate and white cell count/24</td>
<td>Sigmoid</td>
<td>Unknown</td>
<td></td>
</tr>
</tbody>
</table>
In 17 cases, the type of surgery was not cited (an additional 4 cases had an imprecise description of the procedure). Precise proximal and distal anastomotic sites were not generally stated. We were able to infer that the procedure most commonly performed was an aortoiliac graft in 17 cases (unilateral aortoiliac in 12, aortobiiliac in 5), followed by aortofemoral grafts in 11 cases (aortobifemoral in 7; unilateral aortofemoral in 4). Other operations reported included left iliofemoral (2), thoracoabdominal-iliac (1) and aorto-popliteal (1) bypass grafts. An association between the specific types of aortic reconstruction and the subsequent development of a SAEF has not been previously reported. In the series collected by Armstrong et al.43 an aortobifemoral bypass configuration was most commonly noted (n = 19), with aortobiiliac (n = 7) and aortic tube grafts (n = 3) less frequently reported.

Several reports have related their experience with alternative surgical reconstructive techniques. A 10-year experience with 831 patients (761 elective, 70 urgent) undergoing the retroperitoneal exclusion technique to treat infrarenal AAA was reviewed.61 During follow-up (5–103 months), no cases of graft infection or SAEF were identified in patients reconstructed by this approach. Connolly et al.62 suggested that the use of paramedian retroperitoneal incisions for aortic reconstructions provides an intact peritoneum and retroperitoneal fat tissue layer to protect the graft from the viscera. They also preferred an end-to-end over end-to-side anastomosis in aortobifemoral bypasses, in order to allow placement of prosthetic cuff slid over the proximal anastomosis to cover the suture line. The latter technique is controversial.

Graft material for the initial operation

In the report of Armstrong et al.43 most repairs had been performed using Dacron grafts (n = 27) except two cases with polytetrafluoroethylene (PTFE) conduits. Our review identified Dacron as the most frequent material used, with only one report involving PTFE.32 This reflects the preference for the use of Dacron for inflow arterial reconstructions. Dacron is thought to promote a foreign body reaction to adjacent bowel and eventually erode into it.63 Suture material has also been related to SAEFs. Silk sutures, historically used for arterial-graft anastomosis, degenerate over time, resulting in primary suture failure with pseudoaneurysm formation and eventual rupture. Our gratitude to Dr. Rifat Latifi for translating the articles in foreign languages.
SAEF. Permanent synthetic sutures have reduced the incidence of suture line failure.

**Time interval for diagnosis**

SAEF tends to present late. This information was available for 33 cases. The mean interval between the initial operation and symptom development was 59.5 months (range: 1–324). This is in agreement with prior reports, the average being approximately 72 months. Kuestner et al. reported a mean interval between placement of the original aortic graft and definitive treatment of SAEF of 73.2 ± 49.2 months. O’Mara and Imbembo reported an average of 22 months (range: 1–84). Vollmar and Kogel published similar results in their series of 11 SAEFs (1–73 months; mean 34).

**Clinical presentation**

The most frequent presenting sign of SAEF is massive upper GI bleeding. SAEF should always be suspected in a patient after aortic prosthetic reconstruction who presents with GI hemorrhage. In colonic PEF cases, massive bleeding is not seen as often given that there is no true communication between the prosthesis lumen and the bowel. Therefore, absence of GI bleeding does not rule out the presence of PEF. Other reported presentations include sepsis, malaise, weight loss and other non-specific symptoms. Our review indicates that GI bleeding is the most prevalent presentation (in 24 instances: melena [3], hematochezia [15] and non-specified GI bleed [6]), but it was not frequently massive. When seen, bleeding is often the result of exposed bowel mucosa surrounding the eroding prosthetic limb.

Sepsis has been previously reported as a relatively infrequent presentation. However, we noted that sepsis was the 2nd most commonly reported presentation in patients with SAEF (n = 14). O’Mara and Imbembo noted that 14/21 of patients with PEFs present with sepsis, regardless of the involved bowel segment. At the same time, overt GI bleeding as the presenting symptom occurred in 19% (4/21) and abdominal pain in 14%. Rosenthal et al. suggested that whenever patients present with a history of aortic reconstruction and fever, aerobic and anaerobic blood cultures are indicated. If these are positive for enteric organisms, the diagnosis of SAEF should be strongly suspected. Clostridial graft infection also has been rarely reported.

The most frequent symptoms and signs reported in our series include abdominal pain (6), leg pain or edema (4), chills (4), abdominal mass (3) and diarrhea (2). A high index of suspicion is essential for diagnosis, since there is a substantial subset of patients with nonspecific clinical findings in whom routine studies are not diagnostic. This is especially true for colonic as opposed to duodenal PEF.

**Diagnosis**

Following development of signs and symptoms, SAEF diagnosis is typically delayed, by as long as 1 month in 50% of patients in one report, with the diagnosis being made within 10 days of hospitalization in only 15% of cases. Diagnostic studies include plain radiography, computed tomography scan (CT), barium GI series, endoscopy, 18-fluorodeoxyglucose positron emission tomography, gallium 67 scanning and angiography. However, it is not unusual for these studies to be negative or equivocal and for the diagnosis to be established only at surgical exploration.

CT findings are frequently of great diagnostic utility. Perigraft fluid, soft tissue or gas (“black dots”), contrast extravasation, peri-prosthetic inflammatory tissue in contact with adjacent bowel, bowel thickening, pseudoaneurysms, aneurysmal wrap disruption, or intraluminal gas within the graft >3 months after graft implantation are suggestive findings.

Tagged white cell scans have excellent sensitivity but low specificity for diagnosis. However, when applied by experienced personnel, they can be very useful in the early diagnosis of PEF, as shown by Causey et al. These techniques are not definitive, but provide useful supportive information when other findings are inconclusive.

Whereas upper endoscopy is very helpful in both visualizing a possible SAEF and excluding other causes of GI bleeding, the benefits of colonoscopy have been infrequently reported. Nevertheless, lower endoscopy was the definitive diagnostic study of SAEF in a patient we recently reported (Fig. 1). Malaki et al. visualized the limb of an aortobifemoral graft within the patient’s cecum following an inflammatory AAA repair. Hamdani and Summers diagnosed a PEF involving the limb of an aortobifemoral graft and the sigmoid in a patient 10 years after an open AAA repair.

Interestingly, even with surgical exploration, the relationship between the graft and the intestinal site involved in some cases cannot be established. Bergqvist et al. reported four such cases where the graft was lying in a pool of pus and the site of GI involvement could not be precisely identified. Interestingly, in
about 7% of cases, more than one fistula in the same patient was identified.\(^\text{18}\)

The mortality rate for surgical treatment of SAEFs ranges from 14% to 70%.\(^\text{77}\) The choice of surgical repair remains controversial. Multiple approaches have been described,\(^\text{51,78}\) including non-operative management,\(^\text{50,78}\) graft excision alone, local repair with the original prosthetic left in-situ or graft excision with in-situ replacement using a new prosthesis with or without antibiotic-bonding. Reported outcomes using these approaches are variable. More aggressive strategies, with enteric excision and GI tract restoration, prosthesis removal, infrarenal aortic stump closure and immediate extra-anatomic axillobifemoral bypass (EAB) have also been described.\(^\text{19}\) The latter approach has been the most traditional recommendation.

SAEF is associated with a high operative mortality (about 52%) and significant morbidity (e.g. recurrent infection; aortic stump blowout). Graft excision and EAB either as a single or staged procedure is still the most commonly used treatment for SAEF.\(^\text{79}\)

In situ reconstruction has recently been utilized with increasing frequency using deep\(^\text{80}\) or superficial\(^\text{81}\) veins, rifampin-bonded Dacron grafts\(^\text{82}\) or cryopreserved arterial\(^\text{83}\) or venous allografts.\(^\text{84}\) Endovascular techniques to repair SAEFs in high-risk patients\(^\text{85}\) have been used as a bridge to more definitive therapy after hemodynamic stabilization.\(^\text{86}\)

Other approaches have been individually considered. For instance, GI defect closure, partial excision and replacement of the inserted vascular prosthesis, an encircling omental sleeve covering the prosthesis and anastomoses has been used.\(^\text{22}\) A seromuscular jejunal patch for securing closure of the proximal aortic stump after removal of prosthetic grafts has also been suggested.\(^\text{87}\) D’Souza \textit{et al.}\(^\text{19}\) have recommended stapling the bowel loops involved in the SAEF with a GIA device in cases of massive bleeding. This is done to tamponade the bleeding, allowing time to dissect the graft and to clamp the infrarenal aorta. They also recommended this technique for cases of undiagnosed GI bleeding in a hospital with no vascular units, in order to stabilize the patient for transfer to a tertiary center.

The technique for GI tract reconstruction differs in cases of colonic compared to duodenal or jejunal involvement. For the latter, either a lateral bowel repair\(^\text{10}\) or resection and end-to-end anastomosis of grossly normal bowel usually suffices, given the lower virulence of the bacteria populating the upper GI tract compared with the lower. The bowel can be hand sewn, or anastomosed end-to-end with an EEA stapler or side-to-side with a GIA stapler.\(^\text{19}\) Duodenal exclusion is not generally needed, and is reserved for cases of extensive tissue loss.\(^\text{41}\) Proximal bowel decompression by a gastrostomy has also been recommended.\(^\text{13}\) A route for nutrition, such as a feeding jejunostomy is also important.\(^\text{13,41}\)

Colonic defects are managed differently. They can be repaired with either direct closure, or resection with either primary anastomosis or stoma creation. During surgical exploration, it is crucial to fully mobilize the bowel; despite a normal appearing anterior bowel wall, a posterior wall erosion could be missed.\(^\text{11,13}\) Resection should be performed back to grossly normal colon.\(^\text{13}\) In general, primary colonic anastomosis is not advised, although successful outcomes have been also reported with its use.\(^\text{28}\) If severe contamination is noted at exploration, or if the patient is malnourished or acutely ill, a temporary colostomy is preferred.\(^\text{41}\) Colostomies in the sigmoid (Hartmann’s procedure) or transverse colon are thought to allow immediate fistula control with minimal intra-peritoneal contamination. The colostomy site should be placed away from the axillofemoral graft and can be left closed, to be opened postoperatively to avoid further intraoperative contamination.\(^\text{9}\) Omental interposition is universally advocated.\(^\text{15,30,44}\) Finally, bowel

---

\(\text{Fig. 1. Colonoscopy finding in a 58 year-old male patient who presented to our institution with a history of aortobifemoral graft performed two years prior due to critical limb ischemia. Computed tomography and a white blood cell scan performed previously suggested the presence of an aortic paraprosthetic-colonic fistula. The Figure shows the left limb of the graft within the colonic lumen, which undoubtedly established the diagnosis.}\)
reparative studies prior to restarting oral intake.43

SAEFs tax the ingenuity of vascular surgeons. Our review showed a wide variety of therapies, including intestinal stomas or primary colonic repair; graft removal with extra-anatomic bypass for revascularization or graft revision (the latter by replacing the involved graft with homograft or with a new prosthetic graft, aided by omental interposition, re-suturing of a previously involved anastomosis, or endovascular placement of a stent-graft). The wide variety of approaches and the small number of patients treated are not sufficient to provide evidence-based recommendations.

Morbidity and mortality

Most reports failed to cite follow-up periods (28 papers). For those studies that did so, the time span was very wide (0–72 months; average 8.4). All but three investigators documented follow-up periods of <2 years. The short-term outcomes in patients with aorto-colonic fistulae were generally favorable (22). In 19 cases the outcome was unknown. Ten patients died of a cause directly related to the SAEF or to its therapy. One patient was reported dead from unrelated causes (not specified). Complications reported after treatment of a PEF include pulmonary embolism, infected pseudoaneurysm, bilateral graft limb thrombosis, above-the-knee amputations, recurrent infection, limb or colon ischemia and renal failure.

Conclusions

SAEF involving the colon is a rare but well-known complication of aortic reconstructive surgery. It is a dreaded one, associated with high morbidity and mortality. High clinical suspicion and prompt therapy are essential in the management of these patients to avoid catastrophic consequences due to a delayed recognition of a highly treatable condition.

References

Aortic Paraprosthesis-colonic Fistulae


Accepted 4 July 2007
Available online 22 August 2007