Endovascular Management of Popliteal Artery Aneurysms

Josie Ballast BA, Joel Harding BS, Mo Hooshmand BS, Frank Robert Arko, III, MD
History

The first successful surgical intervention of a popliteal artery aneurysm was in 1785 by Dr John Hunter.¹

In 1917, Dr Bernheim used the saphenous vein to bypass a popliteal aneurysm as the first interposed graft.²

In 1994, the first popliteal artery aneurysm stent graft repair was documented.³

Define Popliteal Artery

The popliteal artery is a continuation of the superficial femoral artery that claims its anatomical borders from the adductor hiatus to the bifurcation of the posterior and anterior tibial arteries.
Define Popliteal Aneurysms

- Peripheral artery aneurysms are difficult to define due to the naturally occurring variations in patients of different gender and ages.¹

- Most surgeons define popliteal aneurysms as a diameter greater than 2 cm, however some standards hold that a diameter greater than 1.5 cm or a diameter greater than 1.5 times an adjoining arterial segment to be aneurysmal.²

References:


Epidemiology and Risk Factors

- **Frequency**
  - Although rare in nature, popliteal artery aneurysms are the most frequently occurring *peripheral* aneurysm and contribute to 70% of all peripheral arterial aneurysms.\(^1\)
  - Occurrence of popliteal artery aneurysms is estimated to be less than 1% in men over 65 years old.\(^2\)
  - Incidence of femoral/popliteal artery aneurysms is estimated to be 7.4/100,000 males and 1.0/100,000 females.\(^1\)

- **Location**
  - The most common location for aneurysm formation is the proximal segment or midportion of the popliteal artery.

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Epidemiology and Risk Factors continued

- Conditions contributing to condition:
  - Abdominal Aortic Aneurysm 1.
  - Tibioperoneal Aneurysm 2.
  - Limb Trauma and Orthopedic Surgery (leading to Pseudoaneurysm) 3
  - Tobacco usage 4-7
  - Hypertension 4-7
  - Cerebrovascular disease 4-7
  - Diabetes mellitus* - associated with a slower progression of the disease 4-7

Diagnosis

- Clinical Findings
  - Symptomatic
    - Claudication-most common first sign occurring in 30-40% of pts
    - Petechial hemorrhage
    - Distal digit ischemia
  - Asymptomatic
    - Palpable mass in the popliteal fossa

- Imaging
  - Duplex ultrasonography- 1st line imaging modality in non-emergent cases
  - Digital subtraction angiography(DSA)-gold standard for preoperative planning
  - CTA and MRA- used in conjunction with DSA

Treatment Options

- Open Surgical Repair (OSR): GSV bypass
- Open Surgical Repair: Prosthetic bypass
- Endovascular Repair (EVR)
Treatment Options

Surgical bypass is considered the gold standard for popliteal artery aneurysm (PAA) repair, especially in young patients fit for conventional surgery. The great saphenous vein (GSV) is the ideal conduit and the prosthetic grafts a valid alternative to GSV for surgical bypass. Since the first endovascular treatment reported by Marin et al., a valuable increase in papers reporting on outcomes with this approach has emerged. This less invasive treatment allows the PAA exclusion also in patients considered unfit for conventional surgery. Mid and long-term results after PAA endovascular treatment are lacking. The aim of this study was to compare mid-term outcomes of endovascular treatment, GSV bypass and prosthetic bypass for PAA treatment in a single-center experience.

PAA repair has good early and long-term outcomes with different treatment options. Endovascular treatment was not inferior to surgical repair with a reduced InH-LoS and RBC transfusion. It can be successfully employed even in nonelective setting. A randomized controlled trial with long-term follow-up and appropriate patient inclusion criteria is necessary to compare these 3 treatment options.
Candidates for Endovascular Treatment

Inter-Society Consensus for the Management of Peripheral Arterial Disease (TASC II)

L. Norgren, a W.R. Hiatt, b J.A. Dormandy, M.R. Nehler, K.A. Harris, and F.G.R. Fowkes on behalf of the TASC II Working Group, Orebro, Sweden and Denver, Colorado

Recommendation 37
Treatment of femoral popliteal lesions

- **TASC A and D lesions:** Endovascular therapy is the treatment of choice for type A lesions and surgery is the treatment of choice for type D lesions [C].
- **TASC B and C lesions:** Endovascular treatment is the preferred treatment for type B lesions and surgery is the preferred treatment for good-risk patients with type C lesions. The patient’s co-morbidities, fully informed patient preference and the local operator’s long-term success rates must be considered when making treatment recommendations for type B and type C lesions [C].

Type A lesions:
- Single stenosis ≤10 cm in length
- Single occlusion ≤5 cm in length

Type B lesions:
- Multiple lesions (stenoses or occlusions), each ≤5 cm
- Single stenosis or occlusion ≤15 cm not involving the infrageniculate popliteal artery
- Single or multiple lesions in the absence of continuous tibial vessels to improve inflow for a distal bypass
- Heavily calcified occlusion ≤5 cm in length
- Single popliteal stenosis
Grafts

- Self-Expandable Polytetrafluoroethylene (PTFE) covered Nitinol Stents
- Viabahn and Hemobahn (GORE)

Other Options:
- Scaffolding with bare nitinol stent
- Multilayer flow modulator (MFM)
Penumbra Indigo System

**MECHANICAL CLOT ENGAGEMENT**
Proprietary Separator Technology

**MAXIMIZED ASPIRATION POWER**
Large Lumen Aspiration

**TIP DIRECTIONALITY**
For Circumferential Aspiration

**ADVANCED TRACKING TECHNOLOGY**
Multiple Materials Transitions
Indigo Catheters

CAT8

8F (0.37 mm) (1.12 mm)

6.7F (2.24 mm)

8F (0.37 mm) (1.12 mm)

CAT6

6F (0.35 mm) (1.06 mm)

5.4F (1.8 mm)

6F (0.35 mm) (1.06 mm)

CAT5

6F (0.35 mm) (1.06 mm)

4.9F (1.63 mm)

5F (1.37 mm) (0.06 mm)

CAT3

4.1F (1.64 mm) (0.06 mm)

3.1F (1.04 mm)

2.4F (0.41 mm) (0.04 mm)
Case 1:
Popliteal Aneurysm Occlusion
Pre Treatment Angio

No Distal Runoff
Treatment

- 10mg TPA via Cragg-McNamara
- Indigo CAT8 catheter
  - 2’ pass with no separator through SFA and Popliteal
  - (2) additional passes with CAT8 after aspirating the sheath and flushing the catheter each time
- Coaxial introduction of CAT3 catheter to treat Peroneal
- TPA drip post
Treatment

Clot extracted from first passes
Post CAT8 & CAT3 Treatment

Post CAT8

Post CAT3
Case 2:
Cold Leg Recanalization
Pre Treatment CT
Pre Treatment CT
Pre Treatment
Pre Treatment
Treatment

- 10mg TPA via Cragg-McNamara
- Indigo CAT8 catheter
  - 2’ pass with no separator through Popliteal
  - Immediate stoppage of flow due to clot engagement
- (2) additional passes with CAT8 after aspirating the sheath and flushing the catheter each time
- Coaxial introduction of CAT6 catheter to treat Popliteal aneurysm and TPT
- CAT3 catheter to treat Peroneal and Posterior Tibial arteries
- Placement of Gore Viabahn in Popliteal
Treatment

CAT3 used coaxially with CAT6

Initial Acute Clot passing through the CAT8 catheter
Post CAT8 Treatment

Extracted Clot
Post CAT6 & CAT3, Viabahn
Efficacy of Endovascular Repair

- Operative Outcomes
  - Operating time

- Peri-Operative Outcomes
  - Length of hospital stay
  - Peri-operative complications

- Post-Operative Outcomes
  - Primary patency
Complications¹

- Graft Thrombosis
- Graft Occlusion
- Endoleaks
- Distal limb ischemia
- Risk of new aneurysms²
- Stent-oversizing leading to in-folding³
- Graft migration
- Perforation of tibial artery
- Access site hematoma
- Access vessel dissection

From the Society for Clinical Vascular Surgery

Total Viabahn endoprosthesis collapse

Mark E. Ranson, MD, a Mark A. Adelman, MD, a Neal S. Cayne, MD, a Thomas S. Maldonado, MD, a and Bart E. Muhs, MD, PhD, b New York, NY; and New Haven, Conn

We present a case of Viabahn (W. L. Gore & Associates, Flagstaff, Ariz) collapse during popliteal artery aneurysm treatment. An elderly man with severe comorbidities presented with a 34-mm popliteal artery aneurysm. Proximal and distal landing sites of 11 and 9 mm, respectively, demonstrated by preoperative computed tomography angiography were confirmed by intraoperative angiography. After Viabahn deployment, angiography revealed a filling defect in the distal popliteal graft with poor flow. Balloon dilatation failed. A femoropopliteal bypass with aneurysm ligation was performed. Transection of the distal popliteal vessel demonstrated complete infolding. Our choice of grafts represented 15% to 18% proximal and distal oversizing. Focal areas of relative vessel narrowing may lead to incomplete graft unfolding and graft failure. (J Vasc Surg 2008;47:454-6.)
OUTCOMES: EVPAR

Table III. Early complications in 31 patients after attempts at endovascular repair of popliteal artery aneurysms (PAAs)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Limbs No. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(N = 31)</td>
</tr>
<tr>
<td>Technical success</td>
<td>30 (97)</td>
</tr>
<tr>
<td>30-day mortality</td>
<td>2 (6.4)</td>
</tr>
<tr>
<td>Elective</td>
<td>2/19 (10.5)</td>
</tr>
<tr>
<td>Emergent</td>
<td>2/12 (16.7)</td>
</tr>
<tr>
<td>Primary patency ≤30 days</td>
<td>29/31 (93.6)</td>
</tr>
<tr>
<td>Elective</td>
<td>19/19 (100)</td>
</tr>
<tr>
<td>Emergent</td>
<td>10/12 (83.3)</td>
</tr>
<tr>
<td>Secondary patency ≤30 days</td>
<td>30/31 (96.7)</td>
</tr>
<tr>
<td>Elective</td>
<td>19/19 (100)</td>
</tr>
<tr>
<td>Emergent</td>
<td>11/12 (91.6)</td>
</tr>
<tr>
<td>Groin hematoma</td>
<td>4 (13)</td>
</tr>
<tr>
<td>Myocardial infarction</td>
<td>1 (3.2)</td>
</tr>
<tr>
<td>Intracranial bleeding</td>
<td>1 (3.2)</td>
</tr>
</tbody>
</table>

*One patient died with a patent graft.

Table IV. Early and midterm complications

<table>
<thead>
<tr>
<th>Complications</th>
<th>No. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stent thrombosis†</td>
<td>6 (19.2)</td>
</tr>
<tr>
<td>Thrombolysis and PTA</td>
<td>3 (9.6)</td>
</tr>
<tr>
<td>Bypass</td>
<td>1 (3.2)</td>
</tr>
<tr>
<td>Endoleak</td>
<td>1 (3.2)</td>
</tr>
<tr>
<td>Type I</td>
<td>1 (3.2)</td>
</tr>
<tr>
<td>Type II</td>
<td>1 (3.2)</td>
</tr>
<tr>
<td>Stent infolding</td>
<td>1 (3.2)</td>
</tr>
<tr>
<td>Stent fracture</td>
<td>1 (3.2)</td>
</tr>
<tr>
<td>Stent separation</td>
<td>0 (0)</td>
</tr>
</tbody>
</table>

PTA: Percutaneous transluminal angioplasty.
†Includes two occlusions <30 days.

CONCLUSIONS

EVPAR is feasible in elective and emergency settings. Our results support elective EVPAR in anatomically suitable patients with increased risk for open repair; however, major adverse events after EVPAR, more so after emergency repairs, are frequent. Although there was a trend for increased mortality, limb loss, and decreased primary patency rate after emergency repair, the difference was statistically not significant. The low number of emergency procedures may explain that lack of statistical significance. In addition, most of the major adverse events, leading to death, occlusion, or reoperation, occurred in those who underwent emergency repair. To justify EVPAR in the emergency setting, larger number of patients and longer follow-up is needed. A prospective randomized multicenter study in this group of patients is clearly warranted.
Outcomes: EVR vs OSR

There were no statistically significant differences between open and endovascular treatment in the categories of patient survival, limb loss, and primary patency when calculated as the HR in a random model (Figs. S1–S3; see Supplementary material).

<table>
<thead>
<tr>
<th>Table 4. Operation details.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td><strong>EVR</strong></td>
</tr>
<tr>
<td>Operative time, min (mean ± SD)</td>
</tr>
<tr>
<td>Length of stay, d (mean ± SD)</td>
</tr>
<tr>
<td>30 d graft thrombosis, % (n)</td>
</tr>
<tr>
<td>30 d re-intervention, % (n)</td>
</tr>
</tbody>
</table>

Note: Significant values are given in bold. EVR = endovascular repair; OSR = open surgical repair; OR = odds ratio; MD = mean difference; CI = confidence interval.

\( a \) \( n = 150. \)

\( b \) \( n = 327. \)
### Outcomes: EVR vs OSR

#### Symptomatic PAA

<table>
<thead>
<tr>
<th></th>
<th>Open repair (90)</th>
<th>Stent graft (13)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>N/Total</td>
<td>N/Total</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primary patency, 30 days</td>
<td>83/89</td>
<td>10/13</td>
<td>.025</td>
</tr>
<tr>
<td>Secondary patency, 30 days</td>
<td>84/89</td>
<td>12/13</td>
<td>.767</td>
</tr>
<tr>
<td>Amputation within 30 days</td>
<td>3/90</td>
<td>0/13</td>
<td>.504</td>
</tr>
<tr>
<td>Death within 30 days</td>
<td>0/90</td>
<td>0/13</td>
<td></td>
</tr>
<tr>
<td>Amputation free survival, 30 days</td>
<td>87/90</td>
<td>13/10</td>
<td>.504</td>
</tr>
<tr>
<td>Primary patency, 1 year</td>
<td>60/74</td>
<td>4/7</td>
<td>.137</td>
</tr>
<tr>
<td>Secondary patency, 1 year</td>
<td>64/74</td>
<td>6/7</td>
<td>.995</td>
</tr>
<tr>
<td>Amputation within 1 year</td>
<td>7/81</td>
<td>0/9</td>
<td>.358</td>
</tr>
<tr>
<td>Death within 1 year</td>
<td>5/90</td>
<td>1/3</td>
<td>.758</td>
</tr>
<tr>
<td>Amputation free survival, 1 year</td>
<td>73/83</td>
<td>9/9</td>
<td>.207</td>
</tr>
</tbody>
</table>

#### PAA with Acute Ischemia

<table>
<thead>
<tr>
<th></th>
<th>Open repair (138)</th>
<th>Stent graft (27)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>N/Total</td>
<td>N/Total</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primary patency, 30 days</td>
<td>113/128</td>
<td>17/23</td>
<td>.001</td>
</tr>
<tr>
<td>Secondary patency, 30 days</td>
<td>122/131</td>
<td>19/27</td>
<td>1.001</td>
</tr>
<tr>
<td>Amputation within 30 days</td>
<td>5/134</td>
<td>4/27</td>
<td>.022</td>
</tr>
<tr>
<td>Death within 30 days</td>
<td>2/138</td>
<td>1/27</td>
<td>.423</td>
</tr>
<tr>
<td>Amputation free survival, 30 days</td>
<td>128/135</td>
<td>23/27</td>
<td>.009</td>
</tr>
<tr>
<td>Primary patency, 1 year</td>
<td>89/113</td>
<td>9/21</td>
<td>.001</td>
</tr>
<tr>
<td>Secondary patency, 1 year</td>
<td>99/114</td>
<td>10/21</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Amputation within 1 year</td>
<td>8/117</td>
<td>6/21</td>
<td>.098</td>
</tr>
<tr>
<td>Death within 1 year</td>
<td>6/138</td>
<td>4/27</td>
<td>.037</td>
</tr>
<tr>
<td>Amputation free survival, 1 year</td>
<td>109/122</td>
<td>19/25</td>
<td>.070</td>
</tr>
</tbody>
</table>

#### Asymptomatic PAA

<table>
<thead>
<tr>
<th></th>
<th>Open repair (245)</th>
<th>Stent graft (55)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>N/Total</td>
<td>N/Total</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primary patency, 30 days</td>
<td>232/244</td>
<td>50/53</td>
<td>.823</td>
</tr>
<tr>
<td>Secondary patency, 30 days</td>
<td>242/245</td>
<td>52/55</td>
<td>.944</td>
</tr>
<tr>
<td>Amputation within 30 days</td>
<td>0/245</td>
<td>1/55</td>
<td>.035</td>
</tr>
<tr>
<td>Death within 30 days</td>
<td>0/245</td>
<td>0/55</td>
<td></td>
</tr>
<tr>
<td>Amputation free survival, 30 days</td>
<td>245/245</td>
<td>54/55</td>
<td>.911</td>
</tr>
<tr>
<td>Primary patency, 1 year</td>
<td>186/209</td>
<td>31/46</td>
<td>.001</td>
</tr>
<tr>
<td>Secondary patency, 1 year</td>
<td>200/214</td>
<td>41/49</td>
<td>.837</td>
</tr>
<tr>
<td>Amputation within 1 year</td>
<td>2/220</td>
<td>1/60</td>
<td>.507</td>
</tr>
<tr>
<td>Death within 1 year</td>
<td>3/242</td>
<td>1/35</td>
<td>.045</td>
</tr>
<tr>
<td>Amputation free survival, 1 year</td>
<td>216/221</td>
<td>48/52</td>
<td>.968</td>
</tr>
</tbody>
</table>

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### Conclusions:
The number of operations for PA doubled while the indications remained similar. ER patency was inferior to OR, especially after treatment for acute ischaemia, and the amputation risk tended to be higher, despite similar pre-operative characteristics.
Outcomes: EVR vs OSR

The attractiveness of ER is clearly in the initial periprocedural outcomes as 30-day results consistently favor ER over OR. The decrease in early morbidity with ER is not surprising, and our series is consistent with recent reports of shorter length of stay\textsuperscript{9,20} and fewer 30-day complications\textsuperscript{9,10,20} with ER. Tsilimparis et al\textsuperscript{19} found similar complication rates for OR with an average rate of 16%.

**CONCLUSIONS**

ER is a safe and durable option for PAA, with lower complication rates and a shorter length of stay. OR has superior primary patency in patients treated electively but no difference in midterm secondary patency and amputations. Long-term outcomes are needed to evaluate the durability of ER.
Outcomes: EVR vs OSR

CONCLUSIONS

ER of PAAs demonstrates lower patency compared with open surgical bypass. However, given the general benefits of endovascular options, it remains a viable alternative particularly for high surgical risk patients without adequate autologous conduit.
Outcomes: EVR vs OSR

[ Intervention Review ]

Endovascular versus open repair of asymptomatic popliteal artery aneurysm

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ABSTRACT

Popliteal artery aneurysm (PAA) is a focal dilation and weakening of the popliteal artery. If left untreated, the aneurysm may thrombose, rupture or become a target for embolization, severe morbidity. PAA may be treated surgically by performing a bypass from the arterial segment proximal to the aneurysm to the arterial segment below the aneurysm, which excludes the aneurysm from the circulation. It may also be treated by a stent graft that is inserted percutaneously or through a small cut in the groin. The success of the procedure is gauged by the ability of the graft to stay patent over an extended duration. While surgical treatment is usually preferred in an emergency, the evidence on first line treatment is non-emergency setting is unclear.

Implications for practice

Due to the limitations of the current evidence from one small underpowered study, we are unable to determine the effectiveness of endovascular stent graft versus conventional open surgery for the treatment of asymptomatic popliteal artery aneurysms. A larger, ongoing multicentre RCT should provide more information in the future. However, it seems reasonable to suggest that endovascular repair should be considered as a viable alternative to open repair of PAA on a case by case basis.

Implications for research

There is a need for further randomised trials with adequate sample sizes to ascertain any advantage of endovascular repair over surgical repair of asymptomatic PAA. This will only be possible if the trial is a multicentre trial as it is not possible to recruit a large number of patients from a single centre. The ongoing multicentre RCT (NCT01817660) may be able to shed more light on this review question in the future. Additionally, it will be interesting to see if results in both the surgical and endovascular groups can be improved with the newer generation of grafts and stent grafts and the use of clopidogrel in the post-operative period.
Conclusion:

- Endovascular management of popliteal artery aneurysms is feasible
- Long-term outcomes suggest that endovascular management is equivalent to open surgery
- Thrombosed popliteal aneurysms may be better managed with endovascular repair
- Individual case reports
Endovascular Management of Popliteal Artery Aneurysms

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