Review of Surgical Treatment of Popliteal Artery Injury: Outcomes of Open vs Endovascular Repair

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ABSTRACT: Background: Popliteal artery injury (PAI) is the second most common infrainguinal arterial injury and is being increasingly treated with an endovascular approach. Objective: We examined the outcomes of surgical repair of popliteal artery injury. Methods: Patients who underwent surgery for PAI were identified from National Trauma Database (NTDB) using ICD-9 and CPT codes. Patients with severe head injury (GCS <8), age ≤16 and >65 were excluded. Demographics, injury characteristics, and outcomes of endovascular repair (ER) of PAI were compared with open repair (OR). The trend of ER of PAI over time was also evaluated. Results: Between 2002 and 2010, 1,388 patients underwent surgery for PAI. The majority of PAI was treated with OR (95%) and 5% (67/1,388) was treated with ER. Endovascular repair of PAI was more commonly performed in whites (60% vs 38%, P<.001) whereas OR was performed more commonly in blacks (37% vs 10%, P<.001). Patients who underwent ER were more likely to have associated fracture (18% vs 8%, P<.001) but had a lower number of venous injury (4% vs 8%, P<.001). Overall mortality (ER: 3% vs OR: 2%), amputation rate (13% vs 19%), wound infection rate (2% vs 3%), and hospital length of stay (15 days vs 18 days) were similar between both groups. Patients who underwent ER had significantly lower rates of fasciotomy (33% vs 61%, P<.001) when compared to OR. Also, ER had been increasingly used for repair of PAI (2008: 4%, 2009: 6%, 2010: 8%, P<.001). Conclusions: Endovascular approach has been increasingly used for repair of popliteal artery injury. Patients who underwent endovascular treatment for popliteal artery injury had comparable short-term outcomes and similar hospital length of stay to OR. Endovascular approach appears to be a safe alternative to traditional OR in selected patients.

Popliteal artery injury (PAI) is considered to be rare, with a reported incidence of <.2%.1

It is the second most common vessel injury in the lower extremity and is associated with significant amputation rates when compared to other lower-extremity artery injuries.1,2 The majority of PAIs are due to blunt trauma, which is also associated with a worse outcome when compared to PAI due to penetrating injury.1,3,4 Management of patients with PAI requires
expeditious recognition and diagnosis of arterial trauma, open surgical repair, repair of associated venous injury, and early fasciotomy. Endovascular repair is a relatively new alternative treatment for traumatic PAI. When compared to open repair, the potential advantages of the use of an endovascular approach is less invasive, associated with decreased blood loss, shorter operative time, faster recovery, and shorter inpatient stay. Additionally, use of endovascular treatment involves accessing the injury from a remote site, which eliminates the risk of iatrogenic trauma to nearby structures while avoiding major dissection of an already traumatized region.

The purpose of this study was to determine the incidence, treatment approach, and outcomes of patients with PAI with the goal of comparing outcomes of open vs endovascular repair of PAI, as well as investigating trends and outcomes of patients treated with endovascular repair.

METHODS

The National Trauma Data Bank (NTDB) was queried to identify the study subjects. The NTDB is a prospective multicenter trauma registry established and maintained by the American College of Surgeons (ACS), and is the largest aggregation of voluntarily reported trauma registry data in the United States (www.facs.org/trauma/ntdb). The Institutional Review Board of Louisiana State University Health Shreveport approved the use of this de-identified database for this study.

All adult patients (age ≥18 years) with PAI who underwent surgery from 2002 to 2010 were identified from the database (NTDB version 7.2) using International Classification of Diseases, Ninth Revision code 904.1 (popliteal artery injury) and 904.40 (popliteal artery injury, nonspecific). Pediatric patients (<18 years), burn patients, and patients with severe brain injury (Glasgow coma scale [GCS] <8) were excluded. Patients were stratified into 2 treatment groups based on treatment approach on the basis of procedure codes (Figure 1). Those who underwent open surgery (OS) were compared to those treated with endovascular surgery (ES). Demographics and injury characteristics included age, gender, race, injury severity score (ISS), GCS, mean heart rate, mean systolic blood pressure, and associated injuries. Outcomes included perioperative mortality, amputation,
fasciotomy, pulmonary complication, wound infection, wound complication, stroke, thromboembolism, and overall hospital and intensive care unit (ICU) length of stay (LOS).

Analyses were performed using the SAS statistical package. Univariate analyses were performed by
Fischer exact test for categorical variables and two-sample t tests for continuous variables. A P value of <.05 was considered to be statistically significant.

**RESULTS**

One thousand three hundred and thirty-eight patients with PAI were identified; the majority of patients (1,321, 95%) underwent OR and 67 (5%) underwent ER. Patients who underwent ER were significantly older and more likely to be white (Table 1) when compared to OR. The majority of patients with PAI were treated in an American College of Surgeon (ACS) designated level I and II trauma centers. Those who were treated at a level I center were more likely to have open surgical repair. Although ISS and GCS on presentation were similar, patients who underwent OR had a significantly higher mean heart rate and lower systolic blood pressure. Those who underwent ER had a higher incidence of associated fracture but lower incidence of popliteal vein injury.

Overall mortality was 2% and amputation rate was close to 19%. Perioperative mortality, pulmonary complication, stroke and thromboembolism were noted to be similar in both groups (Table 2). Amputation rate, wound infection or complication were also similar in patients who underwent OR and ER. Although total hospital and ICU LOS were also similar, patients who underwent OR had a significantly higher rate of fasciotomy (61% vs 33%, P<.0001) compared to ER.

There was an increasing trend in the use of endo-

<table>
<thead>
<tr>
<th>Outcomes</th>
<th>Total (n=1388)</th>
<th>Endovascular repair (n=67)</th>
<th>Open repair (n=1321)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mortality, n (%)</td>
<td>28 (2.0%)</td>
<td>2 (2.9%)</td>
<td>26 (2.0%)</td>
<td>.6</td>
</tr>
<tr>
<td>Pulmonary complication, n (%)</td>
<td>54 (3.9%)</td>
<td>4 (6.0%)</td>
<td>50 (3.8%)</td>
<td>.37</td>
</tr>
<tr>
<td>Wound infection, n (%)</td>
<td>41 (3.0%)</td>
<td>1 (1.5%)</td>
<td>40 (3.0%)</td>
<td>.47</td>
</tr>
<tr>
<td>Wound complication, n (%)</td>
<td>19 (1.4%)</td>
<td>1 (1.5%)</td>
<td>18 (1.4%)</td>
<td>.93</td>
</tr>
<tr>
<td>Stroke/cerebrovascular accident, n (%)</td>
<td>3 (0.2%)</td>
<td>0 (0%)</td>
<td>3 (0.2%)</td>
<td>.69</td>
</tr>
<tr>
<td>Thromboembolism, n (%)</td>
<td>50 (3.6%)</td>
<td>3 (4.5%)</td>
<td>47 (3.6%)</td>
<td>.69</td>
</tr>
</tbody>
</table>

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<tr>
<th>Secondary surgical intervention</th>
<th></th>
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</thead>
<tbody>
<tr>
<td>Major amputation, n (%)</td>
<td>261 (18.8%)</td>
<td>9 (13.4%)</td>
<td>252 (19.1%)</td>
<td>.25</td>
</tr>
<tr>
<td>Fasciotomy, n (%)</td>
<td>826 (59.5%)</td>
<td>22 (32.8%)</td>
<td>804 (60.9%)</td>
<td>&lt;.001</td>
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<tr>
<td>Length of stay (LOS), days</td>
<td></td>
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<tr>
<td>Hospital LOS</td>
<td>17.6</td>
<td>15.4</td>
<td>17.7</td>
<td>.27</td>
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<tr>
<td>Intensive LOS</td>
<td>5.3</td>
<td>6.7</td>
<td>5.2</td>
<td>.29</td>
</tr>
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</table>

**DISCUSSION**

In our review of patients who underwent surgery for PAI, more than 95% were treated with open surgical repair. There was, however, an increasing trend in the use of endovascular intervention especially toward the latter part of the study period. The overall perioperative mortality, amputation rate, and LOS were similar between the two surgical approaches. Patients who underwent OR had a significantly higher rate of fasciotomy compared to ER. Although PAI is an uncommon peripheral arterial injury, it is associated with significant risk of major limb amputation.\(^1,11\) Up to 15% of cases PAI are associated with limb loss, especially in patients with combined popliteal arterial and venous injuries, blunt injury, fractures and dislocations, or associated nerve injuries.\(^1,11\) In one series evaluating outcomes of high-risk blunt PAI, the risk of limb loss was even higher, reported to be more than 37%.\(^5\) It has traditionally been managed with open revascularization, which includes vein graft interposition, primary anastomosis, lateral arterial repair, and repair using a synthetic patch.\(^5,12\)

With the advances in technique, endovascular re-
pair is emerging as a viable option in treatment of traumatic arterial injuries.\(^7,13\) In some areas, endovascular treatment has progressively replaced open surgery and has become the main approach used for treatment.\(^7,13\) There has also been an increase in the use of endovascular therapy in other acute arterial injuries, such as for iliac artery, carotid artery, brachial artery, and superficial femoral artery.\(^7\) In general, endovascular repair was most commonly used in less severe injury and in those who were hemodynamically stable.\(^7\) Popliteal artery is more commonly treated with open surgery due to a concern of short and long-term patency after repair.\(^7\) More recently, there have been a number of successful reports of endovascular repair of popliteal artery trauma.\(^14-18\) The types of lesions that were treated with the endovascular approach in popliteal artery injury includes thrombosis, pseudoaneurysm, dissection, hematoma, and arteriovenous fistula.\(^16-18\) In this series, a majority of patients with PAI were treated with open surgery in ACS trauma level I and II. There is, however, an increasing trend in the use of an endovascular approach, especially toward the later part of the study period. Interestingly, patients who were treated with an endovascular approach were slightly older and more likely to be white. Patients who were treated in level I trauma centers were more likely to undergo open surgical repair, while endovascular repair was increasingly used in PAI in level II trauma centers. There were significantly more patients who underwent fasciotomy during OR compared to those who underwent ER. The likely explanation for this finding is the larger number of prophylactic fasciotomies performed in patients who underwent open surgical repair. Patients who underwent ER were more likely to have therapeutic fasciotomy after development of compartment syndrome.

There are important limitations in our study. It is limited by a retrospective review of a prospectively maintained database and not a randomized control trial designed to compare different treatment approaches for treatment of PAI. In addition, since the NTDB has a disproportionate number of larger hospitals, it may not represent all trauma hospitals in the nation. The NTDB samples are also submitted voluntarily by hospitals that participate in the database, making the data subject to selection bias. We were not able to determine the anatomy and severity of the vascular injury in this study, which likely is important to properly examine the outcomes in surgical repair of PAI. One other major limitation is lack of data for patency after surgical repair, as well as mid- and long-term outcomes for these patients with PAI. The information regarding the operator’s endovascular skill set and devices used were not available due to limitation of the dataset. We were also not able to determine the functionality of the injured limb.

While there are limitations to our study, it encompasses a large number of patients with PAI using a nationally validated trauma database. As one of the largest series to date, we found that perioperative outcomes and LOS were similar for endovascular and open approaches in adult patients with PAI. There was an increased use of the endovascular approach, which appeared to be a safe alternative to open surgery in selected patients.
CONCLUSION

Popliteal artery injury is a relatively uncommon peripheral arterial injury and is associated with significant risk of major limb amputation. Patients who underwent endovascular treatment for PAI had comparable short-term outcomes, similar hospital LOS, and lower rates of fasciotomy compared to patients who underwent open repair. An endovascular approach appears to be a safe alternative to traditional open repair in selected patients, especially in those who are hemodynamically stable and have less severe injury.

Editor’s note: Disclosure: The authors have completed and returned the ICMJE Form for Disclosure of Potential Conflicts of Interest. The authors report no potential conflicts of interest related to the content herein.

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REFERENCES