Background: Trauma to the common or external iliac arteries has a mortality rate of 24% to 60%. “Damage control” options for these severely injured vessels are either ligation or temporary intravascular shunts (TIVSs). Complications of ligation include a 50% amputation rate and up to 90% mortality. The primary goal of this study was to identify the consequences of using ligation versus TIVS for common or external iliac artery injuries in damage control scenarios.

Methods: All patients with injuries to an iliac artery (1995–2008) at a Level I trauma center were reviewed. Demographics and outcomes were analyzed using standard statistical methodology.

Results: Iliac artery injuries were present in 88 patients (71 external and 17 common; 72% penetrating; median Injury Severity Score, 25; mean hospital stay, 28 days). Most nonsurvivors (73%) died of refractory shock within the first 24 hours after presenting with hemodynamic instability (66%). Ligation was required in one (6%) common and 14 (20%) external iliac arteries. TIVS was used in two (12%) common and five (7%) external iliac arteries. Patients requiring ligation (1995–2005) or TIVS (2005–2008) for their common or external iliac arteries had similar demographics and injuries (p > 0.05). Compared with patients who underwent ligation, patients receiving TIVS required fewer amputations (47% vs. 0%) and fasciotomies (93% vs. 43%; p < 0.05). Mortality in the ligation group was 73%, versus 43% in the TIVS cohort.

Conclusions: TIVSs have replaced ligation as the primary damage control procedure for injuries to common and external iliac arteries. As a result, the high incidence of subsequent amputation has been virtually eliminated. With increased TIVS experience, an improvement in survival is likely.

Key Words: Iliac artery, Intravascular shunt, Trauma.
with those receiving a TIVS. Patient demographics, injury characteristics, and outcomes were each obtained via the trauma registry and selected patient charts. Exclusion criteria included any patient without an iliac artery injury and those who arrived without signs of life. This retrospective analysis was intended to be primarily descriptive.

Analysis was performed using Stata version 8.0 (Stata Corp, College Station, TX). Normally or near-normally distributed variables were reported as means and non-normally distributed variables as medians. Means were compared using the Student’s t test and medians using the Mann-Whitney U test. Differences in proportions among categorical data were assessed using Fisher’s exact test. A p value less than 0.05 was considered to represent statistical significance for all comparisons.

RESULTS

Records for 88 patients with common or external iliac artery injuries (vital signs present) were available for the 13.5-year study period. Injuries included 17 common and 71 external iliac arteries. Ligation was required in one (6%) common and 14 (20%) external iliac arteries. TIVS was used in two (12%) common and five (7%) external iliac arteries. In addition, 16 internal iliac arteries were injured, with 14 (88%) ligations and 0 TIVS.

Of the patients with common or external iliac artery injuries 88% (77 of 88) were men, with a mean age of 33.5 years. They were injured via a penetrating mechanism in 72% of cases (57 gunshot wounds and 6 stab wounds). Blunt mechanisms caused all remaining injuries (18 motor vehicle collisions, 6 pedestrian, and 1 fall). The median Injury Severity Score was 25, with an associated mean length of hospital stay of 28 days. Most patients (66%) presented to the hospital with hemodynamic instability.

The overall mortality rate was 45% (40 of 88), with 73% (37 of 51) of patients dying from refractory shock within the first 24 hours. The mean base deficit of survivors was −9.8 compared with −15.9 in nonsurvivors (p < 0.05). More patients requiring damage control (ligation or TIVS; 64%) died when compared with those who did not (39%; p < 0.05). Patients requiring ligation or TIVS for damage control purposes were found to have similar demographics and injury characteristics (Table 1). Seventeen percent (15 of 88) of all patients with common and external iliac artery injuries underwent ligation. Patients receiving TIVS required fewer amputations and underwent fasciotomies less often (p < 0.05; Table 1). The lone patient who died after 24 hours in the TIVS cohort succumbed to overwhelming sepsis. The first TIVS used for common or external iliac artery injuries occurred in 2005. After its introduction, only one common or external iliac artery was ligated.

Of the seven TIVS used, four were 14 Fr. Argyle shunts (Kendall Healthcare Products, Mansfield, MA) (4 external iliac arteries) and three were small caliber chest tubes (2 common and 1 external iliac arteries). Chest tubes were used when 14 Fr. Argyle shunts were too small. Although Pruitt-Inahara shunts (LeMaitre Vascular, Burlington, MA) are also commonly used at our institution, none were placed for iliac artery injuries. Before the insertion of these “in-line” shunts (not heparin bonded), proximal and distal vascular control was obtained. Balloon catheter thrombectomy and occasionally regional heparinization was also used. The TIVS was then rapidly inserted into the proximal artery, flushed with blood, and delivered into the distal end of the vessel. The shunt was typically “locked” into place with heavy silk ties on each end. Soft rubber vessel loops were also occasionally used. No shunt was dislodged. Patency was monitored by a combination of distal pulse palpation and Doppler flow detection over distal arteries. Systemic anticoagulation (heparin, aspirin, or dextrose) was not used for any TIVS. No TIVS thrombosed, and the mean indwelling time was 22.3 hours. Of the five patients with TIVS who survived beyond 24 hours (1 common and 4 external iliac artery injuries), definitive vascular repairs were completed with polytetrafluoroethylene (4) and reversed saphenous vein (1) grafts. The lone patient with a saphenous vein reconstruction (external iliac artery) possessed a concurrent colonic injury with significant intestinal spillage. One patient with a polytetrafluoroethylene repair also had a bladder injury.

DISCUSSION

The epidemiology, diagnosis, treatment, and rehabilitation of patients with iliac artery injuries has been thoroughly described during the past 30 years.1–14,33–37 The overall cohort of patients described in this study displays the classic incidence (0.6% of all injured patients), age (mean, 33.5 years), sex (87% men), Injury Severity Score (median, 25), length of hospital stay (mean, 26 days), and mortality (49%) for patients with iliac artery trauma.1–14,33–36 As expected, the majority of nonsurvivors died of early hemorrhage and refractory shock after presenting with hemodynamic instability. Associated injuries were also present in nearly 90% of patients. The survival of patients

**TABLE 1. Comparison of Damage Control Techniques for Common and External Iliac Artery Injuries**

<table>
<thead>
<tr>
<th></th>
<th>Ligation</th>
<th>TIVS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total patients (n)</td>
<td>15</td>
<td>7</td>
</tr>
<tr>
<td>Common iliac artery (n)</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>External iliac artery (n)</td>
<td>14</td>
<td>5</td>
</tr>
<tr>
<td>Penetrating mechanism (%)</td>
<td>81</td>
<td>77</td>
</tr>
<tr>
<td>Mean age (yrs)</td>
<td>32</td>
<td>35</td>
</tr>
<tr>
<td>Mean ISS</td>
<td>29</td>
<td>27</td>
</tr>
<tr>
<td>Hemodynamic instability at presentation (%)</td>
<td>80</td>
<td>76</td>
</tr>
<tr>
<td>Mean base deficit at presentation</td>
<td>−12.6</td>
<td>−13.2</td>
</tr>
<tr>
<td>Associated injuries (%)</td>
<td>87</td>
<td>86</td>
</tr>
<tr>
<td>Mortality (%)</td>
<td>73</td>
<td>43</td>
</tr>
<tr>
<td>Early (&lt;24 h) mortality (%)</td>
<td>36</td>
<td>67</td>
</tr>
<tr>
<td>Amputation (%)</td>
<td>47</td>
<td>0*</td>
</tr>
<tr>
<td>Amputation among late deaths (%)</td>
<td>64</td>
<td>0*</td>
</tr>
<tr>
<td>Extra-anatomic bypass</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>Fasciotomies (%)</td>
<td>93</td>
<td>43*</td>
</tr>
<tr>
<td>Mean length of stay (d)</td>
<td>18</td>
<td>21</td>
</tr>
</tbody>
</table>

* Statistically significant difference with a p < 0.05

ISS, Injury Severity Score.
with iliac artery injuries is known to vary depending on the number of associated injuries (vascular and nonvascular), preoperative base deficit, pH, temperature, and coagulopathy, as well as the presence of a contained hematoma. The overall mortality rate of 49% among study patients fits well within these parameters, as does the observed nonsurvivor preoperative base deficit of −15.9 (compared with −9.8 in survivors). The unique observation among our study cohort is the high number (30%) of iliac artery injuries caused via a blunt mechanism. Of these 31 patients, most were injured by a motor vehicle collision (71%) or as a pedestrian (26%). Blunt iliac artery injuries are generally considered less common, with the largest experience (36%) described by Haan et al.14

The observed distribution of iliac artery injuries was also consistent with the current literature. The majority of patients injured their external (68%), followed by common (16%) and internal (15%) iliac arteries. As expected, patients requiring a damage control procedure (ligation or TIVS) were also statistically more likely to die than those who did not. This is a reflection of massive preoperative blood loss and, therefore, poor presenting physiologic status.

The options for damage control treatment of a common or external iliac artery injury in patients who are considered to be in physiologic extremis (coagulopathic, acidotic, or hypothermic) are limited to vascular ligation and the insertion of a TIVS. Ligations were performed in 6% of common, 20% of external, and 88% of internal iliac artery injuries in this study. Although the consequences of internal iliac artery ligation are minimal, limb loss or late sepsis are frequent when common or external iliac arteries are ligated.1–14,33–37 Limb loss is classically cited to approach 50%, with an associated mortality rate of 90%.17,18 As a result of this high morbidity and mortality, as well as the recent success of TIVS in peripheral vascular trauma, TIVS is now being considered for truncal vascular damage control. Since 2005, TIVS has been used for two (12%) common and five (7%) external iliac artery injuries in damage control scenarios. To prevent vascular thrombosis (caused by using an undersized shunt, tube kinking, or venous outflow obstruction), the largest shunts possible (14 Fr. Argyle or small caliber chest tubes) were inserted into the injured iliac arteries. Regardless of the indwelling time, systemic anticoagulation is rarely necessary, given the inherently coagulopathic nature of patients requiring damage control maneuvers. Although we describe only one TIVS patient with concurrent gastrointestinal injuries who survived beyond 24 hours, colonic spillage remains a relative contraindication for insertion of polytetrafluoroethylene during a subsequent vascular reconstruction. We also recommend that vascular repairs be completed before any gastrointestinal reconstruction, as well as encircled with viable soft tissue if possible. It should be noted that since TIVS was successfully used for a common iliac artery in early 2005, only one ligation of either a common or external iliac artery has occurred.

When the consequences of ligation and TIVS use were compared, it became evident that TIVS had eliminated the requirement for subsequent extremity amputations. Among all common and external iliac artery ligations, 47% of patients in the study underwent an amputation. When those patients who died of refractory shock within the first 24 hours were removed, 64% (7 of 11) required an amputation. Six of the patients who underwent ligation were able to undergo a delayed extra-anatomic bypass once they had been resuscitated in the intensive care unit. By using a TIVS, limb salvage reached 100% in seven cases and no patient surviving longer than 24 hours required an extra-anatomic bypass procedure. The high rate (93%) of ipsilateral extremity fasciotomies performed in patients undergoing ligation was also reduced (43%) when a TIVS was inserted. This was a result of the surgeon’s willingness to closely monitor limb compartment pressures once distal blood flow has been expediently returned to the extremity by a TIVS.

Although small patient numbers limited the statistical conclusions of this study, the observed mortality rate in patients who received a TIVS for damage control (43%) trended toward a reduction when compared with those who underwent a ligation (73%). This may be the result of a reduction in late mortality from sepsis.

When compared with a previous audit of our institution’s iliac vessel injuries from 1989 to 1998,3 it became apparent that TIVS has begun to replace ligation as the most common damage control technique. Cushman et al.3 ligated 27% of all common and external iliac artery injuries compared with 17% in this study. This has occurred concurrent to a consistently high rate of ligation for internal iliac artery trauma (80% vs. 88%).3 Although the original audit used no TIVS, the 20% and 29% rates of common and external iliac artery ligation have been reduced to 6% and 20%, respectively, because of the introduction of TIVS. This is confirmed by the relatively stable rate of overall damage control procedures for common (18% and 20%) and external (27% and 29%) iliac artery trauma in both the previous study3 and this study, respectively.

This study has several limitations. It is retrospective and, therefore, the possibility of bias cannot be eliminated. Although this study represents one of the largest published experiences with iliac artery injuries, the relatively small number of patients undergoing a TIVS also limited our ability to derive significant statistical conclusions.

In summary, TIVSs seem to have replaced the need for ligation as the primary damage control procedure for injuries to common and external iliac arteries. These devices can be inserted rapidly, remain indwelling for prolonged periods, and rarely require systemic anticoagulation. As a result, the high incidence of subsequent amputation in these severely injured patients has been virtually eliminated. With an expected increase in the TIVS experience for iliac artery injuries, an observed improvement in survival is likely.

REFERENCES
6. Carrillo EH, Spain DA, Wilson MA, Miller FB, Richardson JD. Alternatives 
    in the management of penetrating injuries to the iliac vessels. J Trauma. 
8. Asensio JA, McDuffie L, Petrone P, et al. Reliable variables in the 
    exsanguinated patient which indicate damage control and predict outcome. 
11. Milikan JS, Moore EE, Van Way III CW, Kelly GL. Vascular trauma in 
15. Feliciano DV, Mattox KL, Graham JM, Bitondo CG. Five-year experience with 
16. Landreneau RJ, Lewis DM, Snyder WH. Complex iliac arterial trauma: 
17. Burch JM, Richardson RJ, Martin RR, Mattox KL. Penetrating iliac vascular 
18. DeBakey ME, Simeone FA. Battle injuries of the arteries in World War II: an analysis of 
20. Eggink WF, Schreve RH, Oberport H, Terpstra OT, Van Urk H. Acute 
    superior mesenteric artery occlusion: revascularization by means of a 
    shunts: resolution of a management dilemma in complex vascular 
22. Reilly PM, Rotondo MF, Carpenter JP, Sherr SA, Schwab CW. Temporal 
    vascular continuity during damage control: intraluminal shunting for 
    Successful damage control of complex vascular and urological gunshot 
    Feliciano DV. A decade’s experience with temporary intravascular 
25. Weinstein MH, Golding AL. Temporary external shunt bypass in the 
26. Szuchmacher PH, Freed JS. Immediate revascularization of the popliteal 
27. Majeski JA, Gauto A. Management of peripheral arterial vascular 
28. Nunley JA, Koman IA, Urbaniak JR. Arterial shunting as an adjunct to 
29. Khalil IM, Livingston DH. Intravascular shunts in complex lower 
30. Nichols JG, Svoboda JA, Parks SN. Use of temporary intraluminal 
31. Rozyczki GS, Tremblay LN, Feliciano DV, McClelland WB. Blunt 
    vascular trauma in the extremity: diagnosis, management, and outcome. 
32. Chambers LW, Green DJ, Sample K, et al. Tactical surgical intervention 
    with temporary shunting of peripheral vascular trauma sustained during 
    Operation Iraqi Freedom: one unit’s experience. J Trauma. 2006;61: 
    824–830.
34. Mullins RJ, Huckfeldt R, Trunkey DD. Abdominal vascular injuries. 
37. Halsted WS. The effect of ligation of the common iliac artery on the 
    circulation and function of the lower extremity. Bull Johns Hopkins 
    shunts: when are we really using them according to the NTDB? Am Surg. 