Venous trauma in the Lebanon War – 2006

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Abstract

Objectives: Reports on venous trauma are relatively sparse. Severe venous trauma is manifested by hemorrhage, not ischemia. Bleeding may be internal or external and rarely may lead to hypovolemic shock. Repair of major extremity veins has been a subject of controversy and the current teaching is to avoid venous repair in an unstable or multi-trauma patient. The aim of the current paper is to present our recent experience in major venous trauma during the Lebanon conflict, means of diagnosis and treatment in a level I trauma center.

Methods: All cases of major venous trauma, either isolated or combined with arterial injury, admitted to the emergency room during the 33-day conflict were reviewed. Results: Out of 511 wounded soldiers and civilians who were admitted to our service over this period, 12 (2.3%) sustained a penetrating venous injury either isolated (5) or combined with arterial injury (7). All injuries were secondary to high velocity penetrating missiles or from multiple pellets stored in long-range missiles. All injuries were accompanied by additional insult to soft tissue, bone and viscera. The mean injury severity score was 15. Severe external bleeding was the presenting symptom in three cases of isolated venous injury (jugular, popliteal and femoral). The diagnosis of a major venous injury was made by a CTA scan in five cases, angiography in one and during surgical exploration in six cases. All injured veins were repaired: three by venous interposition grafts, four by end to end anastomosis, three by lateral suture and two by endovascular techniques. None of the injuries was treated by ligation of a major named vein. Immediate postoperative course was uneventful in all patients and the 30-day follow-up (by clinical assessment and duplex scan) has demonstrated a patent repair with no evidence of thrombosis.

Conclusions: Without contradicting the wisdom of ligating major veins in the setup of multi-trauma or an unstable patient, our experience indicates that a routine repair of venous trauma can be safely and effectively performed in young patients. Postoperative course is not compromised and late sequelae of venous interruption may be prevented.

Keywords: Penetrating trauma; Combat injury; Venous trauma; Venous reconstruction; Venous ligation; CTA in trauma

1. Introduction

The aim of the present paper was to present our recent experience in major venous trauma during the Lebanon War in the summer of 2006 during which time twelve such patients were admitted to the emergency room.

Severe major venous trauma is manifested by hemorrhage and the surgeon’s primary objective is to prevent exsanguination. Repair of major extremity veins has been a subject of controversy. Ligation was the accepted treatment during World War II [1]. Thereafter, venous reconstruction was performed in selected Korean War casualties [2] and became almost a routine during and after the Vietnam War [3, 4].

Ballistic parameters are essential in the resulting tissue destruction and thus dictating reconstruction possibilities and their complexity [5, 6]. Internal and external ballistics are set by weapon (muzzle velocity) and bullet (projectile flight) types. Terminal ballistics (wound ballistics), however, is the one seen by medical teams and the most important factor in the resulting injury. Cavity and bullet fragmentation result in further tissue destruction and blood vessels stretching and bursting [5–7].

Proponents for repair claim better results in limb salvage rates in cases of combined arterial and venous injuries [8, 9] and prevention of early venous hypertension and their late sequelae [8–10]. Those in favor of ligation claim that there is a massive tissue destruction resulting in more complicating and time consuming reconstructions, there is no change in limb salvage rates and that late sequelae are rare [11–13].

2. Patients and methods

During the 33-day conflict in Lebanon, from 12th July to 15th August 2006, 511 wounded soldiers and civilians were admitted to our emergency room out of which 12 (2.3%) sustained a major venous injury. There were 11 males (92%) and only one female (8%) with a mean age of 28.5 years (range 21–48 years). All injuries were secondary to high velocity penetrating missiles from small arms used in direct
combat, shrapnels or multiple pellets from long-range missiles (Fig. 1).

All injuries were accompanied by additional insult to soft tissue, bones and viscera. The mean severity score was 15. There were five isolated venous injuries and seven combined with an arterial injury.

Upon arrival to the ER of our level I trauma center, patients were examined, primarily treated and underwent the obligatory scans (cervical spine and chest X-ray, FAST US scan). Next they were sent either directly to the operating room or for additional studies such as CTA, angiography or extremity X-rays, according to their condition assessment and diagnosis.

At surgery, antibiotic treatment was started (penicillin 5 million and gentamycin 80 mg) and carried on for three days as suggested by others [14]. Following operation, all extremities were elevated until edema resolved. Postoperative pain, fatigue and leg heaviness were assessed as well. If conditions allowed, intraoperative heparin (5000 U) was administered followed postoperatively by daily subcutaneous Clexane (40 mg) to prevent thromboembolic event in a non-mobile trauma patient. This was discontinued as the patients became ambulant and switched to aspirin (100 mg/d).

A duplex scan (Philips iU 22, Bothell, WA, USA) was performed on the fourth postoperative day and prior to discharge, in all the patients. Measurements of calibers, peak systolic velocities and velocity ratio were performed proximal to and at vascular repairs. Peak systolic velocities of lesser than 120 cm/s and a velocity ratio of <1.5 were considered as normal flow patterns. In some instances, when duplex scan was not possible due to local wound conditions (2 cases), a CT venography (Philips, Brilliance 64 slices) was performed or a formal venography (1 case) was obtained.

3. Results

Severe external bleeding was the presenting symptom in three patients with isolated venous injury (jugular, femoral and popliteal) for which they were taken to the operating room after primary assessment. In seven cases the injury was combined, arterial and venous. The signs and symptoms of an arterial injury surpassed and masqueraded the venous injury. In the upper extremity, subclavian and brachial vein injuries were encountered during surgery performed for a bleeding injury of accompanying arteries. In the lower extremity, treatment of a femoral artery injury was revealed the femoral vein injury; and ischemia due to injuries of popliteal (Fig. 2) or all three tibial arteries prompted surgery during which time the venous injuries were found. Preoperative diagnosis of a major venous injury was made by CTA scan (with a second, late, scan, Fig. 3) in five cases and by formal angiography in one. All other injuries were diagnosed during surgery. Anatomic locations of the injuries are presented in Table 1. Lower extremity vein injuries were encountered in nine out of twelve cases (75%).

All operations were done under general anesthesia during which time penicillin (5 million) and gentamycin (80 mg) were intravenously administered. Intravenous heparin (5000 U) was administered after control of active hemorrhage except in cases of excessive bleeding due to other injuries. No protamin was used.

Open fasciotomies were performed, in five patients, for a combined major arterial and venous injury (i.e. popliteal vessels) or for ischemia longer than 6 h.

All injured veins were repaired. The type of repair is presented in Table 2. Out of the twelve patients, ten had surgical repairs: three lateral sutures, four primary end to end and five venous grafts.
end anastomosis and three interposition vein grafts (Fig. 4). A contralateral saphenous vein was used for interposition grafts. Synthetic grafts were not used. Vascular repairs were not left exposed.

Endovascular technique (a Luminax, stent graft insertion) was employed for the treatment of the other two patients with traumatic arteriovenous fistula of the internal iliac vessels. None of the named injured veins was treated by ligation.

The immediate postoperative course was relatively uneventful in all patients. Two patients were reoperated for debridement of local necrotic tissues on the fifth and sixth postoperative days. Wound infection, treated by antibiotics alone, occurred in two patients.

Once the patients were ambulating, heaviness and fatigue occurred in four patients but had subsequently resolved.

Lower extremity edema was noted in five out of nine injured limbs (55%). The edema had completely resolved in three patients and only two were discharged with mild leg edema. In one patient, Duplex examination revealed the presence of deep vein thrombosis without clinical manifestations. There was no evidence for pulmonary emboli.

Duplex scans were performed on the fourth and 30th postoperative day if local conditions allowed the exam. A patent repair with no evidence of thrombosis was demonstrated in all cases. When leg swelling, local changes or a fasciotomy prevented an adequate and reliable duplex scan, a CT venography or contrast venography were obtained.

At last follow-up, nine months postoperatively, all patients were symptom free except one, with mild leg edema after a day-long standing. Duplex scan, at last follow-up, has revealed a mild stenosis in his popliteal interposition graft with a peak systolic velocity of 135 cm/min and velocity ratio of 1.6. All other patients had normal duplex scans.

4. Discussion

As opposed to arterial injuries, severe venous trauma manifests itself with bleeding and not ischemia. The bleeding may be external or internal and lead to hypovolemic shock. The surgeon’s primary objective is to prevent exsanguination. Repair of major extremity veins has been a subject of controversy. Ligation was the accepted treatment during World War II [1]. Thereafter, venous reconstruction was performed in selected Korean War casualties [2] and became almost a routine during and after the Vietnam War [3, 4]. Certainly, in the setup of a multi-trauma in an unstable patient, ligation is the treatment of choice. In a less extreme case the surgeon must consider whether to ligate or reconstruct the injured vein. In making this decision several factors must be considered: the general condition of the wounded patient, associated injuries and their needed mode of treatment and the complexity of the anticipated venous reconstruction. It appears that there is merit in extremity venous reconstruction. First, a return pathway is kept open as noted in reimplantation of extremities [8], reducing the outflow impedance and improving limb salvage rates especially in the presence of

Table 1
Venous injuries by anatomic location

<table>
<thead>
<tr>
<th>Vein</th>
<th>Number</th>
<th>%</th>
</tr>
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<tbody>
<tr>
<td>Internal jugular vein</td>
<td>1</td>
<td>8</td>
</tr>
<tr>
<td>Subclavian vein</td>
<td>1</td>
<td>8</td>
</tr>
<tr>
<td>Brachial vein</td>
<td>1</td>
<td>8</td>
</tr>
<tr>
<td>Internal iliac vein</td>
<td>2</td>
<td>17</td>
</tr>
<tr>
<td>Superficial femoral vein</td>
<td>2</td>
<td>17</td>
</tr>
<tr>
<td>Popliteal vein</td>
<td>3</td>
<td>25</td>
</tr>
<tr>
<td>Tibial vein</td>
<td>2</td>
<td>17</td>
</tr>
<tr>
<td>Total</td>
<td>12</td>
<td>100</td>
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</tbody>
</table>

Table 2
Methods of repair

<table>
<thead>
<tr>
<th></th>
<th>Number</th>
<th>%</th>
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<tbody>
<tr>
<td>Vein interposition graft</td>
<td>3</td>
<td>25</td>
</tr>
<tr>
<td>End to end anastomosis</td>
<td>4</td>
<td>33</td>
</tr>
<tr>
<td>Lateral suture</td>
<td>3</td>
<td>25</td>
</tr>
<tr>
<td>Endovascular technique</td>
<td>2</td>
<td>17</td>
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<tr>
<td>Total</td>
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</table>
combined arterial injury. It is, of course, more important for a single return conduit such as the popliteal vein [9]. Terminal (wound) ballistics in combat injuries as seen in our patients dictated massive tissue destruction due to pellets and bullet fragmentation that did not leave the body [5–7]. Cavitation and pressure waves resulted in stretching and disruption of blood vessels. As combat injuries have notoriously more extensive soft-tissue destruction with severe damage to collateral veins and lymphatic channels, it seems reasonable that repair of venous injury in this setup is justified. In addition, an open return conduit prevents acute venous hypertension initially and the sequelae of chronic venous hypertension subsequently [8, 10].

This approach, however, was challenged by others [11–13] who demonstrated in their retrospective analysis of civilian injuries that no extremity was lost after ligation of injured veins and that the permanent sequelae of venous hypertension in this set-up is quite rare. Proponents of ligation rather than reconstruction of venous injury claim that a substantial percentage of the reconstructions will thrombose in the early postoperative period. The rates of early postoperative thrombosis vary but can reach rates of 30–70% [15–17]. This high rate of thrombosis probably reflects the natural history of venous reconstruction and the high (approximately 60%) incidence of lower extremity deep vein thrombosis after major trauma [18] rather than surgical repair failure.

Meyer et al. [17] have found that 39% of the venous repairs had thrombosed within a week postoperatively. Furthermore, thrombosis rate increased for complex repairs such as interposition grafts. In the present study none of the reconstructions had thrombosed. Although the numbers are small, in 25% of our repairs a venous interposition graft was performed with the same results as for lateral repair. Our treatment protocol of intraoperative heparin administration, when not contraindicated, followed by Clexane until patients became ambulatory and then switched to aspirin, might have helped in the prevention of thrombosis. Similarly, Parry et al. have reported that the overall patency rate of venous repairs is approximately 75% irrespective of the type of repair [19]. It was suggested that a thrombosed venous repair will usually recanalize over time, similar to the natural process of thrombosis in the venous system. Should symptoms of chronic venous insufficiency later appear, a less prominent course is expected compared to that of complete obstruction of the venous outflow after ligation [20].

In conclusion, without contradicting the wisdom of ligating major veins in the set-up of a multi-trauma or an unstable patient our experience indicates that a routine repair of venous injury can be safely and effectively performed in young combat-injured patients. Postoperative course is not compromised and both early and late effects of venous interruption may be prevented.

References

ICVTS on-line discussion A
Title: Venous war injuries
Author: Narcis Hudorovic, University Hospital Sestre Milosrdnice, Zagreb 10000, Croatia
doi:10.1510/icvts.2007.158014A
eComment: It is well known that injuries and deaths due to penetrating projectiles have become an international epidemic in today’s society. The studies of penetrating trauma have been largely in the military domain where war-time specific applications were advanced with the use of high-velocity weapons. The principal goal of the studies of penetrating injuries in the civilian or/and soldier population is secondary prevention and optimized emergency care after occurrence. A thorough understanding of the dynamic biomechanics of penetrating injuries quantifies missile type, caliber, and velocity to hard and soft tissue damage [1, 2]. Such information leads to a comprehensive assessment of the acute and long-term treatment of patients with penetrating injuries.

Wound ballistics is a largely different problem in today’s surgical emergency centers and a thorough understanding of the dynamic biomechanics of penetrating injuries must include quantification and differentiation in the behaviors of the numerous available projectiles (for example: missile type, caliber, velocity, combinations in design, type of trauma center equipment, hard and soft tissue damage).

In the article by Nitecki et al. [3], the authors presented well the results after surgical treatment of venous wounds caused by high-velocity [2000 feet per second] long-range missiles (optimal duration of postoperative antibiotic treatment, intraoperatively/postoperatively administration of
Heparin, measures for prevention of thromboembolic complications) which could be comparable to previously published and further relevant military and civil research. Moreover, quantified data could assist young surgeons in the management of complications of penetrating venous wounds in highly contaminated areas.

Nitecki et al. overwhelmed the previously published results which referred to surgical repair of venous injury from World War II, Korean War, Vietnam War and War in Croatia. Combined with presented clinical results we must always bear in mind the formula for kinetic energy (it is one-half mass times the square of velocity $\times KE = 1/2$ $m^2$) while, there are a wide variety of weapons for inflicting injury upon victims. There is a predictable behavior of traveling projectiles from within the firearm to the time they strike the target; however, once they strike the target, there are several factors which make this a very complex process depending on the mass, velocity, and the type of ammunition used. The degree of injury is estimated by the amount of kinetic energy which is released by the projectile to the surrounding tissue. Representing data by Nitecki et al. combined with biomechanical rules may assist clinical personnel in the management of penetrating venous injuries.

References


ICVTS on-line discussion B

Title: Traumatic venous injury: ligation or repair?

Author: Senol Yavuz, Bursa Yüksek Ihtisas Education and Research Hospital, Bursa 16330, Turkey
doi:10.1510/icvts.2007.158014B

eComment: I read with great interest the paper by Nitecki et al. [1] regarding their experience in patients with major venous trauma during battle conditions. This report is on the treatment of a small series of venous injuries which continue to challenge surgeons in many areas of the world. The authors are to be congratulated on their success in venous repair. I would like to add some comments on this topic.

Traumatic venous injuries are seen in penetrating and blunt trauma. Venous injuries are often associated with concomitant injuries. They have been well documented during wartime, but there have been an increasing number of reports from the civilian arena.

Ligation vs. repair as management of traumatic major venous injury currently remains a controversial topic. Therefore, our inquiry is: do we have any evidence that venous repair is better than ligation? This is clearly the most important question to answer.

In the past, historically, ligation of injured veins was the most used modality of surgical approach. Later, various repair techniques including primary repair, interposition grafts, and sometimes endovascular techniques were put into practice.

Vein ligation should be considered as a clinical option of choice, especially in an unstable patient with life-threatening venous injuries. In civilian experience, permanent sequelae of venous injury ligation are rare and in patients with hemodynamic instability from blood loss, extensive local injury, associated organ injury, anesthesia requirements, or other concerns; venous ligation is an acceptable option. It does not increase in postoperative morbidity, the need for fasciotomy, or leg edema. In venous trauma, edema of the extremity may develop regardless of vein injury ligation or repair [2, 3].

Patients treated with venous ligation have a higher transfusion requirement, a greater incidence of shock, and a greater venous injury staging system, ranging from grade I (less than 50% laceration) to grade IV (complete interruption with soft-tissue injury).

Based on clinical and experimental research, there is an increasing interest in repairing venous injuries. However, overall treatment strategies remain largely unchanged since the Vietnam War. In spite of limitations, successful venous repair has been possible without complications of thrombophlebitis or pulmonary embolism. Venous repair is supposed to prevent or ameliorate the complications of pain, edema, and phlegmasia.

The type of venous repair was primarily affected by the mechanism of injury and hemodynamic instability. Extended repairs are more complex and time-consuming procedures [4]. Venous injuries are treated with primary repair (lateral venorrhaphy or end-to-end anastomosis), or complex repair (vein patch, spiral vein graft, reversed saphenous vein interposition graft or interposition ringed polytetrafluoroethylene graft).

Venous repair is a safe and durable surgical approach associated with minimal morbidity, good long-term patency, and preservation of venous competence. In patients with thrombosed venous repair, thrombus absorption with recanalization may occur [5].

Early detection of traumatic venous injury, prompting early operative exploration, vascular control, and repair increase the success in venous trauma.

Finally, the obvious limitations to the authors’ series are a small number of patients and the lack of long-term follow-up. As stated by Nitecki et al., we also recommend venous repairs in all hemodynamically stable patients, whereas ligation continues to be the primary indication for an unstable or multi-trauma patient.

References


