Original Research Article Journal of College of Medical Sciences-Nepal, Vol-13, No 3, July-Sept 017

ISSN: 2091-0657 (Print); 2091-0673 (Online)
Open Access

Analysis of Consecutive Cases of Vascular Injury in Tertiary Level Hospital in Central Nepal

Bijay Sah, Krishna Gopal Shrestha, Kaushal Kishore Tiwari, Jayapal Reddy

Department of Cardiothoracic and Vascular Surgery, College of Medical Sciences, Bharatpur, Chitwan, Nepal

Correspondence
Dr.Bijay Sah
Department of CTVS, CMS-TH, Bharatpur, Nepal

Email:
bijaysah@hotmail.com

DOI: http://dx.doi.org/10.3126/jcmsn.v13i3.17857

Orcid ID: orcid.org/0000-0003-3848-7742

Article received: July 27th 2017
Article accepted: Sept 10th 2017

ABSTRACT

Background & Objectives: Vascular injury diagnosis and management can be challenging and need expert clinical judgments. The current study aims to present diagnostic methods and management outcome in vascular injury patients attending our centre. **Materials & Methods:** The study is a prospective study conducted during the study period of one and half years (From January 2015 to June 2016). Diagnosis of vascular injury was done by clinical examination, hand Doppler or in conjugation with duplex scan/CT Angiography. Primary vascular repair with end to end anastomosis was carried out whenever technically feasible; however, if it was not possible interposition reversed saphenous graft (SVG) was used to complete the repair. **Results:** Out of hundred cases of vascular injury, 77% were male and 23% female with a mean age of 35.18± 16.93 years. The majority of the cases 53% were diagnosed by duplex study followed by additional imaging by CT angiography in 30% cases and 17% cases were diagnosed only on clinical judgment. The main type of vascular injury was a complete transaction in 62% of cases followed by complex wall defect in 22%. The most common type of vascular reconstruction was end-end anastomosis in 76% of cases followed by ligation and haemostasis in 13% and reverse SVG graft repair in six percent of cases. **Conclusion:** The study concluded with the observation that early presentation, diagnosis and management including initial resuscitation and definitive multi-specialist surgical approach are paramount for excellent outcome after vascular injury.

Key words: Color Doppler Study; CT Angiography; Vascular Injury; Vascular Reconstruction

Citation: Sah B, Shrestha KG, Tiwari KK, Reddy A. Analysis of Consecutive Cases of Vascular Injury in Tertiary Level Hospital in Central Nepal. JCMS Nepal. 2017;13(3):357-62.

INTRODUCTION

Trauma including vascular injury is a national health matter in many parts of the world including ours. Relative numbers of the injuries are due to road traffic accidents and penetrating traumas with associated orthopedic injuries and complex soft tissue injuries.[1-3] Injury to the major arteries, veins and nerves if not diagnosed and managed promptly may have serious predictable, resulting in sacrifice of life or the limb.

In most part of the earth, peripheral vascular trauma are most commonly caused by penetrating trauma (70 to 80%) and half of the penetrating injuries are caused by missiles from handguns with bullet and low dynamic energy.[4, 5] Peripheral vascular trauma from blunt trauma to the limbs such as fractures, dislodgement, crunch injuries, and tractions, account for about 5 to 25% of the cases.[5, 6]

In many series of vascular injuries, the extremities are the most common location. Among the arteries of the extremities, 50 to 60% of the wounds occur in the femoral or popliteal arteries and 30% in the brachial artery. Chest and abdominal vessel injury carry a high mortality and morbidity and its early diagnosis and treatment is challenging.[6]

Vascular injuries to the lower extremity are more common than upper extremity injuries and the majority of the cases are due to penetrating trauma followed by blunt trauma, however, the injury pattern might change from place to place and geographical location. The peripheral vascular injuries mostly results in bleeding, swelling,

hematoma formation, deformity that is usually visible during examination and bleeding can be controlled by compression, tourniquet or surgical intervention.[1, 4, 6] The current study demonstrates the mechanism, time of presentation, associated injuries, diagnostic approach, surgical intervention outcome and complications in vascular injury cases presented in our centre in last one and half years time period.

MATERIALS AND METHODS

A prospective study of all the vascular trauma cases from January 2015 to June 2016 was collected for analysis after clearance from the institutional review committee. All the vascular trauma cases with clinical features of vascular injury like hard and soft sign or/and diagnosed by clinical examination, hand Doppler or in combination with Duplex study/CT Angiography was included in the study. Initial resuscitation including management of shock, securing hemostasis by application of short period of a tourniquet or by vascular bulldog clamps and management of other life-threatening injuries was performed simultaneously.

During surgery, associated fractures were first stabilized by the orthopedic team and the vascular surgeon used the hand Doppler to reassess the injured vessels and all the findings were recorded. Primary repair (end to end) was the preferred approach and when technically not feasible, reverse saphenous vein graft was used to repair the vessels. Postoperative limb viability and complications related were recorded. Data were analyzed in descriptive and inferential way. P-value <0.05 was considered statistically significant.

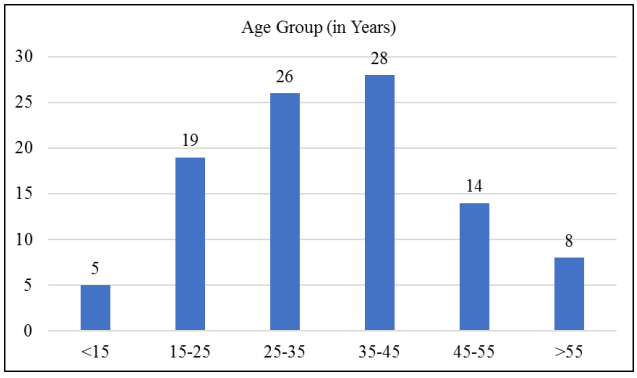

Figure 1: Distribution of Age

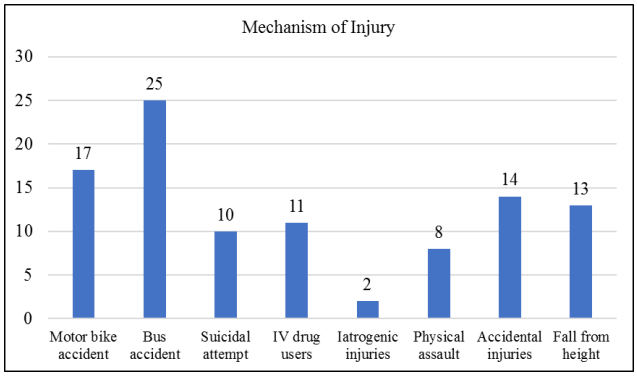

Figure 2: Mechanism of Vascular Injury

RESULTS

Out Out of the hundred cases of vascular injury, most of the cases were in the age group of 35 to 45 years with mean age of 35.18±16.93 years (Figure 1). The pediatric age group below 15 years was present in five percent of cases while above 55 years was present in eight percent of cases. Vascular injury was present in 77% male and 23% female cases and blunt trauma was present in 68% while penetrating trauma was present in 32% of cases.

Road traffic accident like bus accident caused 25% of vascular injury while motorbike accident accounts for 17% of vascular injury in the present study (Figure 2). The time of presentation of all the vascular injury patients was divided into two categories. The maximum number of cases (52%) presented after six hours of trauma while 48% presented within six hours. The most common associated injury was fractures accounting for 48% of all the cases. Majority of cases had upper extremity orthopedic fractures (27%) followed by lower extremities fractures in 21% of cases. The diagnosis was made by clinical examination in 17% cases followed by Duplex study in 53% cases and combined with CTA in 30% of cases (Table 1). The most common vascular injury was complete transection present in 62% of cases, followed by

Table 1: Diagnostic Methods

Diagnosis Method	No. of cases	Percent
Clinical	17	17
Duplex study	53	53
Duplex + CT Angiography	30	30
Total	100	100

Table 2: Management Methods

Management Methods	No. of cases	Percent
Conservative	05	5
End to End Anastomosis	76	76
SVG Interposition Graft Repair	06	6
Ligation and Hemostasis	13	13

Table 3; Comparison of complications with time of presentation

Time of presentation	Complication			P-value
	Yes	No	Total	
>6 Hours	6	46	52	0.114
≤6 Hours	1	47	48	
Total	7	93	100	

complete wall defect in 22% of cases and intimal injury, spasm in 6% and 5% cases respectively.

The surgical technique used in the vascular injury management was end-end repair of the vessel in 76% of cases followed by ligation and hemostasis in 13% of cases (Table 2). Vascular repair with fasciotomy was needed in 43% of cases. The most common complication of vascular repair was wound infection in six percent of cases, reperfusion injury in four percent of cases, bleeding in three percent of cases, sepsis in two percent cases and amputation in two percent of cases (Table 3). The overall limb salvage outcome in our study was 98% after vascular repair and management.

DISCUSSION

in Trauma has become a public health problem in many parts of the world including ours, and vascular trauma contributes to fatal results when diagnosis and management are delayed. The majority of the injuries are due to penetrating traumas and road traffic accidents with associated fracture and complex soft tissue injuries. The vascular injury needs prompt intervention because of the risk of ongoing limb ischemia or hemorrhage threatening limb and/or life.

Vascular trauma occurs infrequently in civilian adult trauma and pediatric vascular trauma is even less frequent comprising of 0.6% of all pediatric trauma admissions.[1, 2] Murad et al.[3] and DuBoss et al.[1] showed the increased incidence of vascular injury between 17 to 40 years (Mean 28.5 years). The present study showed 28% of cases between 35 to 45 years of age, followed by 26% between 25 to 35 years, 19% between 15 to 25 years, eight percent above 55 years and five percent below 15 years of age. Cunningham et al.[4] review of vascular injury summarize that most of the road traffic accident cases were young between 25 to 44 years and probably about 20% were between 15 to 44 years.

Trauma cases are more common in males than in female and Murad et al.[3] study showed that 95.83% of their cases were male and 4.16% were female. The present study showed 77% of male cases and 23% female cases. The study shows that most common vascular injury in male and female was blunt trauma (Bus accident) followed by motor bike accident in male and accidental injury in a female.

Mechanism of injury plays an important factor for diagnosis, management, surgical decision making and risk stratification. Perkins et al.[5] systemic review and meta-analysis identified male gender, mechanism of injury (blast 19%, blunt 16%, penetrating 5%) anatomical site of injury (iliac 18%) as a significant prognostic factor for amputation after surgical repair of lower extremity vascular trauma. Penetrating injuries have been the main cause of vascular trauma in both urban and rural communities whereas blunt trauma accounts for approximately 50% of vascular injuries, mostly due to road traffic accident.[6]

Blunt vascular injury is associated with worse outcomes when compared to penetrating vascular injury since high impact force causes extensive damage to soft tissue, bones and nerves. Tan et al.[7] evaluation of mechanism of injury revealed that blunt injury was more common in patients with lower extremity vascular trauma and penetrating injury was present in upper extremity trauma and complication was more common in blunt trauma than penetrating trauma.

Our study showed 68% of vascular injury due to blunt trauma and 32% penetrating trauma. Blunt trauma such as bus accident (25%), motor bike accident (17%), fall from height (13%) along with associated fracture and complex soft tissue injury was the mechanism of vascular injury in most of our cases. The penetrating injuries such as intravenous drug users (11%), suicidal attempt (10%), and accidental injury by sharp objects 14% were most cases of penetrating trauma.

Most of the vascular trauma patients are rapidly transported to the casualty after initial resuscitation and vascular arrest by clamp or tourniquet. Regardless of the presenting complain of vascular injury, the main principles of management are emergency resuscitation, triage and rapid specialized surgery with a multi-discipline

approach.[8] Most of our cases presented to the casualty after six hours of the vascular injury (52%) and only 48% of the cases presented within the golden period of six hours after trauma. Surgical steps in vascular surgery are planned to decrease the duration time of tissue ischemia, limit its consequences or condition tissues to adjust ischemia longer.

The importance of early presentation after vascular injury is well recognized and six hours of the golden period of restoring perfusion is recommended in many studies.[9] Many contemporary studies focus on the need to reestablish perfusion more rapidly to enhance neuromuscular revival of the dysfunctional limb.[10]

Although peripheral nerve cells respond quickly to ischemia, skeletal muscles are possibly the most principal tissue to respect in the context of vascular trauma and ischemia, as it make up the mass of the limb and acute injury leads to myonecrosis, edema and compartment syndrome.[11]

The earliest change of limb ischemia is observed in the endothelium of arterioles and capillaries of skeletal muscles. There is non-uniform progressive swelling of endothelial cells with endothelium dysfunction even when there is ischemia for a few minutes within the muscles.10 This process is followed by swelling of RBC in the capillaries and arterioles causing arrest of blood flow to the injured site.

Within few hours of ischemia time after vascular injury, due to increasing endothelium dysfunction, there is thrombosis of the arterioles and capillaries leading to infiltration of leucocytes. With constant circulation and oxygen starvation, the metabolic demand of muscle exceeds anaerobic metabolism, and the cells experience necrosis and release of inflammatory mediators.[10]

When the blood flow to the ischemic limb is reperfused, there is a no-flow phenomenon which is vascular edema in the arterioles and capillaries due to haemo-concentration, thrombosis and congestion of the endothelium. Therefore the standard use of anticoagulant such as heparin at the time of vascular repair as practiced globally and in our center is a crucial adjunct to limit the no-reflow phenomenon.[10-12] In our study, four cases developed reperfusion injury when evaluated postoperatively which was managed by rapid infusion of hypertonic saline, statins and diuresis when needed along with routine fasciotomy.

Out of hundred cases of vascular injury in our study, 48% were associated with fractures and soft tissue injury. Lower limb fracture was more common than upper limb fractures. Most common cause of fracture was bus accident (25%) and motor bike accident (17%) along with fall from height accounting for 13%.[13] Rozycki et al.[9] study on blunt vascular trauma to the extremity demonstrated that associated fracture and/or dislocation were present in 95% of their cases. The study showed that blunt vascular injuries in the lower extremities occurred most commonly in the anterioposterior tibial arteries.

Mavrogenis et al.[14] reviewed vascular injury with orthopedic trauma and highlighted the importance of rapid and accurate diagnosis along with through understanding of the management priorities for successful salvage of the limb. The review demonstrates that around 33% of vascular injuries in the wartime were associated with orthopedic injuries and lower extremities vascular injury occur more than upper extremity injuries in the military setup.

Elbow trauma in children is common and mostly caused by sports activities. The most common mechanism of trauma to the elbow is a declivity with outstretching hand with hyperextension. Due to the close proximity of vascular structures to the elbow joint, elbow trauma run the risk of vascular injury especially anterior elbow dislocations or penetrating injuries.[15] Our study showed five cases of vascular injury below 15 years mostly associated with elbow trauma and all recovered well mostly by conservative management.

Major vessel injury is a serious complication of military and civilian trauma especially road traffic accident. Blunt injuries account for about 8% of upper extremity vascular trauma and are mostly conjoined with musculoskeletal injuries. Shalabi et al.[16] study of upper limb vascular injury showed that 51% of the injury was associated with concomitant orthopedic injuries. The most commonly injured vessels were brachial, femoral and popliteal arteries while some places have variability according to the mechanism of injury.

In the military setting, the superficial femoral artery is mostly injured accounting for 33 to 37%, followed by the popliteal and tibial arteries in 25% of cases each.[14] The present study showed that the brachial artery tributaries were the major vessel involved in the vascular trauma accounting for 41% followed by a brachial artery (26%) and femoral artery in 12%. Upper limb injury was more

common than lower limb vascular injury.

Around 53% of cases were diagnosed by duplex study followed by 30% conformed by CT Angiography and 27% clinically using hard and soft sign, ABPI/BBPI and explored in the operating theater. DuBoss et al.[1] analyzed 542 injuries from 14 centers and found that 28.2% of cases were diagnosed by exploration, 38.9% by CT Angiography, 3.1% by duplex study and 10.7% by angiography.

Clinical examination findings in vascular injury patients are the hard sign and soft signs. The incidence of vascular injuries in patients with any hard sign is significant and greater than 90%. When hard signs of injury are present, there is limited need for imaging diagnostic tests which may take more time and can lead to serious consequences. In these cases, immediate operation on the injured extremity is necessary with the wide exploration of the injury site to enable vascular repair.[17]

Those stable cases with diminished peripheral pulsation or ABPI <0.9 should be investigated with a duplex study, CT angiography or arteriography. Chapagain et al.[18] studied arterial injury management using duplex study and found that duplex scanning had 100% sensitivity and 95.23% specificity compared with operative exploration.

The recent literature search classified vascular injury into five types: an intimal damage which consists of intimal flaps, interruption, or subintimal/ inner hematomas, absolute wall defects with pseudoaneurysms or injury, absolute transections with bleeding, AVF and vessels spasm. Clinical presentations of vascular injuries are not always straight forward.[14, 19, 20]

The most common injury in the present study was complete wall transection in 62% followed by complete wall defect in 22% of cases, intimal injury in six percent cases, spasm five percent and AVF in five percent cases. Intimal defects and subintimal hematomas with secondary occlusion were most commonly caused by blunt trauma while complete wall defect and transection occurred with penetrating trauma. Spasm occurred in blunt or penetrating trauma to the extremities mostly in young cases.

Most of the vascular repairs (76%) were end-end anastomosis followed by ligation and hemostasis in 13% of cases, reverse SVG interposition graft repair in 6% of cases, conservative treatment with anticoagulant in 5% of cases. DuBose et al.[1] identified arterial transection in 24.3% of cases, occlusion in 17.3% of cases, partial transaction/ flow limiting defect in 24.5% of cases, intimal defect in 22.7% of cases. Damage control maneuvers were used in 10.5% of cases including ligation and shunting. The definitive repair was done in 7.4% of cases.

In a study by Wahlgren et al.[21] about vascular repair management, it consisted of interposition graft repair 25%, patch repair 20%, bypass 10%, lateral suture 9%, direct end-end anastomosis 2.5%, ligation and hemostasis 1.2% as the operation technique. White et al.[19] epidemiology of vascular injury in the wars in Iraq and Afghanistan had five times more vascular injury than previously reported and interposition graft along with ligation of minor distal vessels was the operative method.

Vascular injury can have serious complications when presented late and when associated with complex tissue and orthopedics injury coexists. Peck et al.[22] reported vascular trauma management in local population and described that wound infection occurred in 3.7% of 192 major vascular and complex tissue injuries, along with acute anastomosis disruption in three percent, graft thrombosis in 4.5% with early amputation and mortality rate of three percent.

The present study showed that the incidence of wound infection was 6% which needed debridement and secondary closure and four percent of the cases had reperfusion injury which was managed medically. Bleeding occurred in three percent of cases while one case developed sepsis and there was one percent mortality due to multiorgan dysfunction syndrome (MODS). There were two cases that required immediate amputation due to complex soft tissue injury and fractures along with severe infection which was a threat to life.

College of medical science and teaching hospital is backed up by the multi-specialist team like orthopedics, neurosurgery, gastrointestinal surgery, cardiothoracic vascular surgery department and at the time of presentation of complex injuries, each team come along and work in a team. The diagnosis and management of vascular injury have been prompt once the patient arrives in the casualty. The overall outcome of 98% in our study has been accomplished as a team work in the management and with experienced hands. Wong et al. studied the impact of experienced multi-specialist trauma service on complex vascular injury and demonstrated that specialist trauma service

decreased the mortality of cases and overall hospital stay. [23]

CONCLUSION

Trauma is rising worldwide and is the leading cause of death between the age of 35 to 45 years in the United States and many parts of the world, and probably ours too. The majority of the cases are due to road traffic accident and penetrating trauma. In our study, most of the vascular injury cases were diagnosed by duplex study in 53% of cases followed by additional imaging with CTA in 30% of cases and clinically in 17% of cases. Complete transaction of the vessels were seen in 62% of cases and complete wall defect was observed in 22% of cases. The majority of the vessels were repaired by end-end anastomosis (76%) followed by ligation and hemostasis in 13% of cases. Thought vascular trauma can have devastating consequences, its early diagnosis and management with expert multi-specialties team can demonstrate good results.

REFERENCES

1. DuBose JJ, Savage SA, Fabian TC, Menaker J, Scalea T, Holcomb JB, et al. The American Association for the Surgery of Trauma PROspective Observational Vascular Injury Treatment (PROOVIT) registry: multicenter data on modern vascular injury diagnosis, management, and outcomes. J Trauma Acute Care Surg. 2015;78(2):215-22; discussion 22-3. https://doi.org/10.1097/TA.0000000000000520. PMID: 25757104.
2. Jaipuria J, Sagar S, Singhal M, Bagdia A, Gupta A, Kumar S, et al. Paediatric extremity vascular injuries - experience from a large urban trauma centre in India. Injury. 2014;45(1):176-82. https://doi.org/10.1016/j.injury.2013.08.002. PMID: 23993647.
3. Murad M, Eweda A, Abdel-Moamen H, Hussien M, Elsaghir M. Vascular trauma and its management: one and a half years after the 25th January revolution. Journal of the Arab Society for Medical Research. 2013;8:43-7.
4. Cunningham PR, Cushman M. Management of vascular trauma. Journal of the national medical association. 1987;79(7):721. PMID: 3625794.
5. Perkins ZB, Yet B, Glasgow S, Marsh W, Brohi K, Rasmussen TE, et al. Prognostic Factors for Amputation Following Surgical Repair of Lower Extremity Vascular Trauma: A Systematic Review and Meta-Analysis of Observational Studies. Journal of Vascular Surgery. 2014;59(6):75S. https://doi.org/10.1016/j.jvs.2014.03.167
6. Galindo RM, Workman CR. Vascular trauma at a military level II trauma center. Current surgery. 2000;57(6):615-8. https://doi.org/10.1016/S0149-7944(00)00393-7.
7. Tan TW, Joglar FL, Hamburg NM, Eberhardt RT, Shaw PM, Rybin D, et al. Limb outcome and mortality in lower and upper extremity arterial injury: a comparison using the National Trauma Data Bank. Vasc Endovascular Surg. 2011;45(7):592-7. https://doi.org/10.1177/1538574411415125. PM: 21984027.
8. Frykberg ER. Advances in the diagnosis and treatment of extremity vascular trauma. Surgical Clinics of North America. 1995;75(2):207-23. https://doi.org/10.1016/S0039-6109(16)46584-9.
9. Rozycki GS, Tremblay LN, Feliciano DV, McClelland WB. Blunt vascular trauma in the extremity: diagnosis, management, and outcome. Journal of Trauma and Acute Care Surgery. 2003;55(5):814-24. https://doi.org/10.1097/01.TA.0000087807.44105.AE. PMID: 14608150.
10. Blaisdell FW. The pathophysiology of skeletal muscle ischemia and the reperfusion syndrome: a review. Cardiovascular surgery. 2002;10(6):620-30. https://doi.org/10.1016/S0967-2109(02)00070-4.
11. Percival TJ, Rasmussen TE. Reperfusion strategies in the management of extremity vascular injury with ischaemia. Br J Surg. 2012;99 Suppl 1:66-74. https://doi.org/10.1002/bjs.7790. PMID: 22441858.
12. Klocker J, Falkensammer J, Pellegrini L, Biebl M, Tauscher T, Fraedrich G. Repair of arterial injury after blunt trauma in the upper extremity - immediate and long-term outcome. Eur J Vasc Endovasc Surg. 2010;39(2):160-4. https://doi.org/10.1016/j.ejvs.2009.11.019. PMID: 19969475.
13. Paryavi E, Pensy RA, Higgins TF, Chia B, Eglseder WA. Salvage of upper extremities with humeral fracture and associated brachial artery injury. Injury. 2014;45(12):1870-5. https://doi.org/10.1016/j.injury.2014.08.038. PMID: 25249243.
14. Mavrogenis AF, Panagopoulos GN, Kokkalis ZT, Koulouvaris P, Megaloikonomos PD, Igoumenou V, et al. Vascular Injury in Orthopedic Trauma. Orthopedics. 2016;39(4):249-59. https://doi.org/10.3928/01477447-20160610-06. PMID: 27322172.
15. Guler F, Baz A, Kose O, Cicek E, Akalin S. Delayed diagnosis of rupture of brachial artery due to closed posterior elbow dislocation. Hong Kong Journal of Emergency Medicine. 2011;18(2):112.
16. Shalabi R, Al Amri Y. Vascular injuries of the upper extremity. Jornal Vascular Brasileiro. 2006;5(4):271-6. https://doi.org/10.1590/S1677-54492006000400006.
17. Elfiki IM, Hassan TA. Utility of Multidetector Computed Tomography Angiography in evaluation of post traumatic neglected vascular injuries of the upper extremity. The Egyptian Journal of Radiology and Nuclear Medicine. 2016;47(3):867-73. https://doi.org/10.1016/j.ejrnm.2016.04.009.
18. Chapagain D, Reddy D, Chadha S, Agarwal S, Shrestha K, Shah S. Management of acute peripheral arterial injury by using doppler ultrasonography. Journal of College of Medical Sciences-Nepal. 2013;8(3):36-42. https://doi.org/10.3126/jcmsn.v8i3.8684.
19. White JM, Stannard A, Burkhardt GE, Eastridge BJ, Blackbourne LH, Rasmussen TE. The epidemiology of vascular injury in the wars in Iraq and Afghanistan. Ann Surg. 2011;253(6):1184-9. https://doi.org/10.1097/SLA.0b013e31820752e3. PMID: 21217514.
20. Dunn JC, Kusnezov N, Schoenfeld AJ, Orr JD, Cook PJ, Belmont PJ, Jr. Vascular Injuries in Combat-Specific Soldiers during Operation Iraqi Freedom and Operation Enduring Freedom. Ann Vasc Surg. 2016;35:30-7. https://doi.org/10.1016/j.avsg.2016.01.040. PMID: 27238996.
21. Wahlgren C, Kragsterman B. Management and Outcome of Pediatric Vascular Injuries. Journal of Vascular Surgery. 2014;59(6):75S. https://doi.org/10.1016/j.jvs.2014.03.168.
22. Peck MA, Clouse WD, Cox MW, Bowser AN, Eliason JL, Jenkins DH, et al. The complete management of extremity vascular injury in a local population: a wartime report from the 332nd Expeditionary Medical Group/Air Force Theater Hospital, Balad Air Base, Iraq. Journal of Vascular Surgery. 2007;45(6):1197-205. https://doi.org/10.1016/j.jvs.2007.02.003. PMID: 17543685.
23. Wong TH, Lumsdaine W, Hardy BM, Lee K, Balogh ZJ. The impact of specialist trauma service on major trauma mortality. J Trauma Acute Care Surg. 2013;74(3):780-4. https://doi.org/10.1097/TA.0b013e3182826d5f. PMID: 23425735.