European Journal of Vascular and Endovascular Surgery 44 (2012) 203–209

Contents lists available at SciVerse ScienceDirect

European Journal of Vascular and Endovascular Surgery

journal homepage: www.ejves.com

Epidemiology and Outcome of Vascular Trauma at a British Major Trauma Centre☆

Z.B. Perkins [a,*], H.D. De'Ath [a], C. Aylwin [a], K. Brohi [a], M. Walsh [a], N.R.M. Tai [a,b]

[a] Trauma Clinical and Academic Unit, The Royal London Hospital, Whitechapel Road, London E1 1BB, UK
[b] Academic Department of Military Surgery and Trauma, Royal Centre for Defence Medicine, Birmingham, UK

WHAT THIS PAPER ADDS

- Historically the United Kingdom has not had an organised system for trauma care. As a result little is known about the epidemiology, management and outcomes of vascular trauma. Small case series suggest that these injuries are uncommon with a low mortality. This 6-year review from the first British Major Trauma Centre is the largest description of civilian vascular trauma in Britain. The results show that vascular trauma is not uncommon, is associated with high mortality and morbidity, and places a significant burden on hospital resources. These results will improve understanding of vascular trauma and aid resource planning of future trauma and vascular systems.

A R T I C L E I N F O

Article history:
Received 10 February 2012
Accepted 14 May 2012
Available online 2 June 2012

Keywords:
Vascular injury
Trauma
Epidemiology
Outcome

A B S T R A C T

Objectives: In the United Kingdom, the epidemiology, management strategies and outcomes from vascular trauma are unknown. The aim of this study was to describe the vascular trauma experience of a British Trauma Centre.
Methods: A retrospective observational study of all patients admitted to hospital with traumatic vascular injury between 2005 and 2010.
Results: Vascular injuries were present in 256 patients (4.4%) of the 5823 total trauma admissions. Penetrating trauma caused 135 (53%) vascular injuries whilst the remainder resulted from blunt trauma. Compared to penetrating vascular trauma, patients with blunt trauma were more severely injured (median ISS 29 [18–38] vs. ISS 11 [9–17], $p < 0.0001$), had greater mortality (26% vs. 10%; OR 3.0, 95% CI 1.5–5.9; $p < 0.01$) and higher limb amputation rates (12% vs. 0%; $p < 0.0001$). Blunt vascular trauma patients were also twice as likely to require a massive blood transfusion (48% vs. 25%; $p = 0.0002$) and had a five-fold longer hospital length of stay (median 35 days (15–58) vs. 7 (4–13), p<0.0001) and critical care stay (median 5 days (0–11) vs. 0 (0–2), $p < 0.0001$) compared to patients with penetrating trauma. Multivariate regression analysis showed that age, ISS, shock and zone of injury were independent predictors of death following vascular trauma.
Conclusion: Traumatic vascular injury accounts for 4% of admissions to a British Trauma Centre. These patients are severely injured with high mortality and morbidity, and place a significant demand on hospital resources. Integration of vascular services with regional trauma systems will be an essential part of current efforts to improve trauma care in the UK.

Introduction

Vascular injury resulting from trauma is a leading cause of mortality and morbidity worldwide. Exsanguination is perhaps the most significant cause of potentially preventable death after injury,[1,2] whilst ischaemic tissue damage leads to high rates of amputation in a characteristically young and active population.[3]

Although uncommon following civilian trauma, vascular injuries may be responsible for up to 20% of trauma deaths[4] and these patients have the highest utilisation of hospital resources amongst the trauma population.[5]

The impact of vascular injuries is well described in countries with mature trauma systems. Approximately one and a half percent of civilian trauma patients in the United States[6] and one to 2% of

☆ Presented to a meeting of the Association of Surgeons of Great Britain and Ireland, Bournemouth, UK, 2011, and published in abstract form as *Br J Surg* 2011; 98(S3): 53.

* Corresponding author. Tel.: +44 0207 377 7695; fax: +44 0207 377 7044.
E-mail addresses: Zane.Perkins@bartsandthelondon.nhs.uk, zaneperkins@gmail.com (Z.B. Perkins).

1078-5884/$ – see front matter
doi:10.1016/j.ejvs.2012.05.013

such patients in Australia[4,7] have a vascular injury. In these countries, the overall mortality resulting from vascular trauma is between twenty and 26%.[4,6–8]

In the United Kingdom (UK), however, the epidemiology, management and outcome of vascular trauma are poorly described.[9] The low incidence, combined with a lack of organised trauma systems, has limited individual hospital exposure to these injuries. As a result, existing studies on civilian vascular injury in the UK are few, with low case numbers and limited descriptions.[10–13] A notable exception is the important contribution made during the height of the IRA terrorist campaign in Northern Ireland.[14] As UK trauma and vascular services evolve, an understanding of the impact of these injuries on services becomes increasingly important to enable appropriate allocation and planning of resources.

The aim of this study was to describe the vascular trauma experience of a Major Trauma Centre in the UK in terms of epidemiology, outcomes and impact on hospital resources. A second aim was to compare the outcomes of vascular trauma caused by blunt and penetrating injuries.

Methods

Study design and setting

This was a single centre retrospective observational study of patients with traumatic vascular injuries that presented to a Major Trauma Centre in the United Kingdom, between January 2005 and December 2010.

Patient selection

All trauma patients (≥14 years) who were admitted following injury to a named blood vessel were included. Injuries to the heart, solid organs and facial and intra-cranial vessels were excluded. We also excluded all iatrogenic vascular injuries.

Data collection

Data on patient demographics, mechanism of injury, Abbreviated Injury Score (AIS) and Injury Severity Score (ISS), admission physiology, patient management and outcome were abstracted from an existing, prospectively maintained trauma registry held by the hospital Trauma Clinical Academic Unit. Clinical records, mortality reports and radiographic imaging were used to supplement data collection.

Definitions

Vascular injuries were classified into three anatomical zones based on the injury location. 1) Junctional, which included injuries to the Subclavian and Axillary vessels of the axilla; injuries to the external iliac, common femoral and Profunda Femoris vessels of the groin; injuries to the Carotid, Vertebral and Jugular vessels of the neck and branches of the aortic arch and associated major veins (Brachiocephalic and Jugular) of the Thoracic inlet. 2) Central, which included injuries to any vessels proximal to the junctional zone. 3) Extremity, which included injuries to any vessels distal to the junctional zone.

Polytrauma was defined as an AIS of ≥3 in two or more body regions. Hypovolaemic shock was defined as a systolic blood pressure (SBP) <90 mmHg or base deficit[15] >6 or a blood transfusion requirement >4 units in the first 24 h. Massive transfusion was defined as a transfusion requirement of ≥10 units Packed Red Blood Cells (PRBCs) in 24 h. Primary repair included patch angioplasty, direct suture repair or end-to-end anastomosis.

Outcome measures

Our two primary outcomes were mortality and amputation.

Mortality: Trauma registry patients were followed up until either hospital discharge or death. For the purposes of analysis, patients surviving to hospital discharge were assumed to have survived.

Amputation: Only amputations that were performed during the initial admission were included. However, we were not aware of any late amputations occurring in this cohort.

Secondary outcome measures, and hospital resource use were measured in terms of hospital length of stay (LOS, days), ITU length of stay (LOS, days) and blood transfusion requirements in the first 24 h.

Statistical analysis

Statistical analyses were performed using SPSS version 20 (SPSS, Chicago, IL, USA). Normal-quartile plots were used to test for normality. Non-parametric data are reported as median with interquartile range (IQR) and categorical data as frequency (n) and percent (%). Mann–Whitney U test was used to compare numerical data and Fisher's exact test or chi-squared test for trend was used to compare categorical data.

A univariate analysis was used to compare admission variables and ISS with mortality. Variables significantly associated with death were included in a multivariate model.

Multivariate analysis was performed using binary logistic regression. Statistical significance was set as a two tailed p-value of <0.05.

Results

During the six-year study period there were a total of 5823 consecutive trauma admissions. Two hundred and fifty six (4.4%) of these patients met our eligibility criteria, and were recruited to this study. The majority of vascular trauma occurred in severely injured young males. Significant baseline demographic differences exist between patients suffering penetrating or blunt vascular trauma. Patient characteristics are shown in Table 1.

There was an annual increase in the number of admissions for both general and vascular trauma at our hospital. The incidence of vascular trauma remained relatively static, however, with no significant difference noted from one year to the next (Fig. 1).

Table 1
Baseline characteristics of vascular trauma patients by mechanism of injury.

	Vascular trauma		p value
	Penetrating	Blunt	
Demographics			
Number of patients	135	121	
Age	25 (14–83)	37 (16–89)	< 0.0001
Male	125 (93%)	91 (75%)	0.0001
Injury characteristics			
ISS	11 (9–17)	29 (18–38)	< 0.0001
ISS > 15	60 (44%)	101 (84%)	< 0.0001
Polytrauma	17 (13%)	81 (67%)	< 0.0001
Hypovolaemic Shock	80 (59%)	92 (76%)	0.005

Data are presented as Median (IQR) or frequency (%).

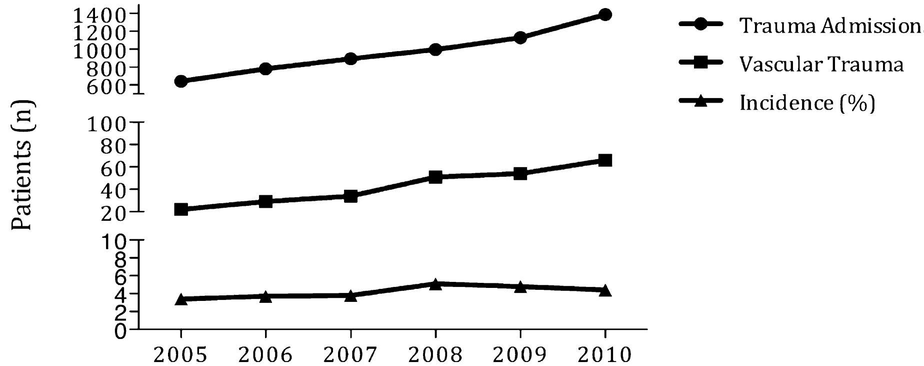

Figure 1. Total trauma admissions, vascular trauma admissions and incidence of vascular trauma by year. Both total and vascular trauma admissions increased each year. The annual incidence of vascular trauma remained static, however, with no statistical difference from one year unto the next ($p = 0.07$).

Mechanism of injury

Penetrating trauma accounted for a significantly higher proportion of vascular trauma admissions than general trauma admissions (53% vs. 24%, $p < 0.0001$). Stab wounds were the most frequent cause of vascular injuries and were five times more common than gunshot wounds (GSW). Road traffic collisions (RTC) and falls from height were the predominant cause of blunt vascular injuries (Fig. 2). When compared to penetrating vascular injuries, patients with a blunt mechanism were more severely injured and more frequently shocked (Table 1).

Type and anatomical distribution of injuries

Amongst the recruited patients, a total of 314 vascular injuries were identified (241 arterial, 73 venous). Two hundred and twenty three patients (87%) had arterial injuries, 37 of whom had concurrent venous injuries. Thirty-three patients (13%) had isolated venous injuries. In terms of anatomical distribution, central vascular injuries were most frequent (48%) followed by extremity (34%) and finally junctional (20%) injuries (Fig. 3A). In patients with extremity vascular injuries, the distribution of upper and lower limb injuries was similar (47% vs. 53%).

The proportion of injuries in each anatomical zone was influenced by the mechanism of injury. Penetrating trauma resulted in more junctional and extremity vascular injuries whilst central vascular injuries were more common following blunt trauma (Fig. 3B and C).

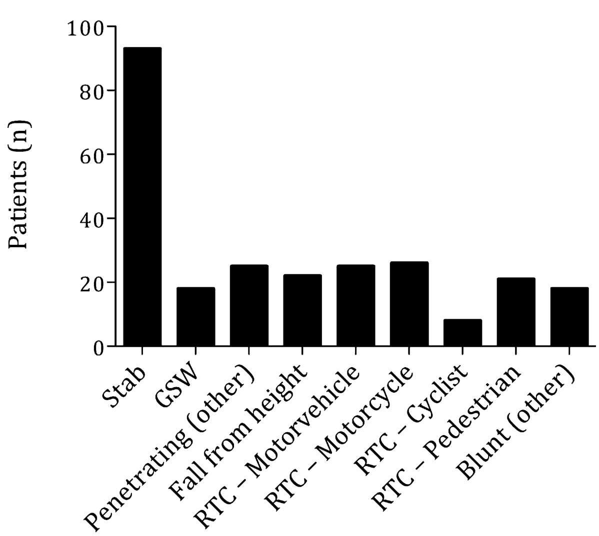

Figure 2. Mechanisms of vascular injury amongst our study cohort.

Management strategies

The predominant investigation for vascular injuries within this cohort was a contrast Computerised Tomography (CT) scan. The proportion of patients having a contrast CT increased annually, peaking at 96% of blunt vascular and 40% of penetrating vascular trauma in 2010. Diagnostic angiograms were utilised in 6% of patients and the majority were on-table procedures.

The frequency of therapeutic procedures carried out for vascular injuries is shown in Fig. 4. Penetrating vascular injuries were treated with open surgical procedures in 93% of cases with the remainder managed by interventional radiology. Stents were used to repair four penetrating injuries, all in junctional zones (Fig. 5).

Blunt vascular injuries were subject to more varied management strategies. Open surgery was required in 56% of cases and interventional radiology in 37%. A combination of the two was employed in 9% of the cases. Overall, two thirds of embolisations were used to control bleeding from injuries to the internal iliac arteries and three quarters of stents were used to treat blunt aortic injuries.

In this series 22 patients had blunt thoracic aortic injuries. Eighteen (82%) were treated with endovascular stents of which seventeen survived. One patient with a laceration of the aortic root underwent successful operative repair with an interposition graft while one patient in hypovolaemic shock died during attempted operative repair. The remaining two patients died prior to any opportunity for intervention.

Patient outcome

Forty five (18%) patients died following vascular injury. However, mortality approached 50% in certain subgroups, particularly patients with blunt injuries to junctional zones. The majority of deaths occurred in patients with central or junctional vascular injuries and the odds of death from a blunt vascular injury were three times higher than for a penetrating injury (Fig. 5A). Univariate analysis showed that age, ISS, blunt mechanism of injury, polytrauma, shock and a junctional or central zone of injury were significantly associated with death. However, in a multivariate logistic regression analysis model, only age, ISS, shock and the zone of injury remained as significant independent risk factors of death (Table 2).

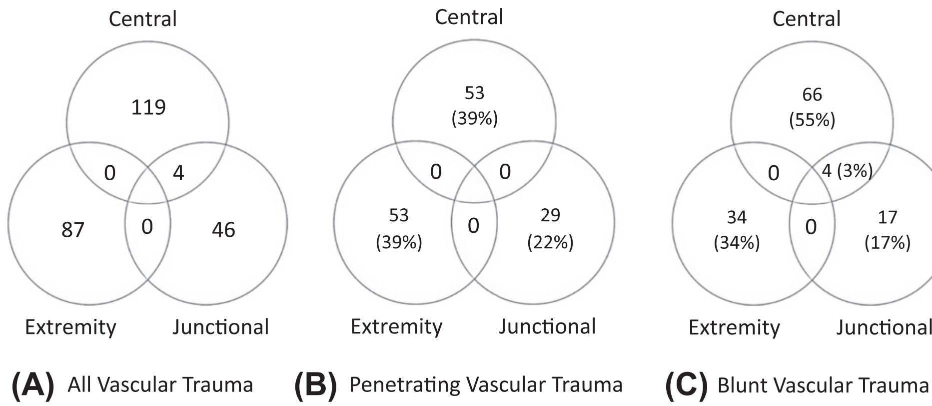

Figure 3. Venn diagrams demonstrating numbers of vascular injury per anatomical zone. A) 256 patients with vascular trauma, B) 135 patients with penetrating vascular trauma and C) 121 patients with blunt vascular trauma.

Forty percent of patients who died had suffered a cardiac arrest either pre-hospital or on arrival to the Emergency Department, and prior to any opportunity for intervention. However, a third (5/14) of patients with penetrating vascular injuries and 10% (1/10) of individuals with blunt vascular injuries, who suffered a cardiac arrest prior to intervention, survived to discharge.

Fifteen patients underwent limb amputation and all amputations were the result of blunt vascular trauma (Fig. 5B). In nine cases revascularisation was not possible and primary amputation was performed. Limb revascularisation was performed in 34 patients and was successful in 29 (85%), the remaining five patients underwent a delayed amputation. One patient with a ligated femoral vein injury required a delayed amputation.

Utilisation of hospital resources

Overall, vascular trauma patients were more severely injured and had significantly greater use of hospital resources in terms of blood transfusion requirements, critical care requirements and hospital length of stay than general trauma admissions (Table 3). During the study period, patients with a vascular injury received one third of all blood transfusions and nearly 80% of all massive transfusions administered to trauma patients. In total, 256 vascular trauma patients required 2397 units of PRBC in the first 24 h of admission and occupied 1176 ITU bed days and 5539 hospital bed days.

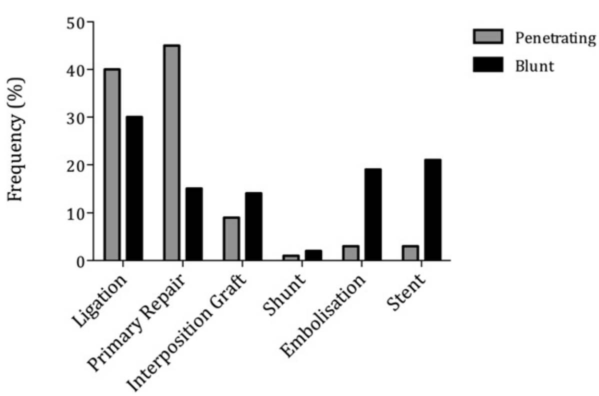

Figure 4. Frequency of therapeutic procedures used to treat penetrating and blunt vascular trauma.

In patients with a vascular injury, blood transfusion requirements were significantly higher in patients who suffered a blunt mechanism of injury compared to those with penetrating trauma (Table 4). Furthermore, survivors of blunt vascular trauma had a five-fold longer hospital length of stay and critical care length of stay compared to survivors of penetrating vascular trauma (Table 4). The greater use of hospital resources by blunt vascular trauma patients held true for comparisons in each anatomical zone of injury (Table 4).

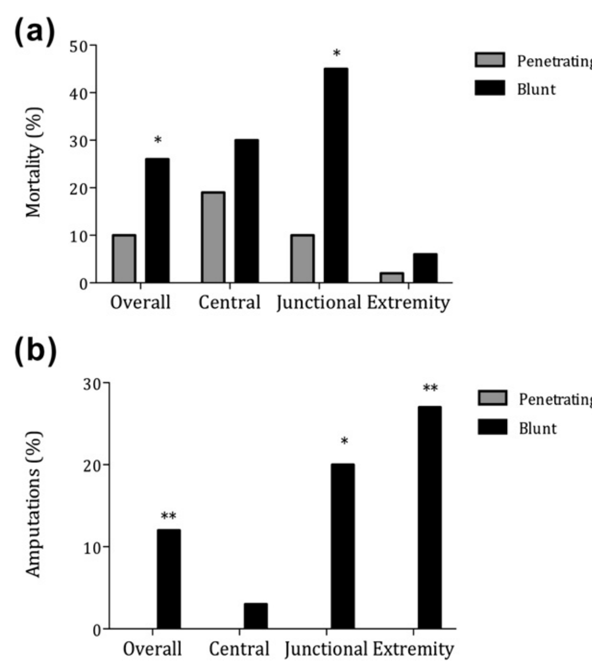

Figure 5. Outcomes following vascular injury A: Mortality following vascular trauma. Overall, and when analysed by each anatomical zone, blunt trauma was associated with a higher mortality (Overall: penetrating 10% vs. blunt 26%, or 3 (95% CI 1.5–5.9), $^{*}p < 0.01$; Central: penetrating 19% vs. blunt 30%, or 1.8 (95% CI 0.7–4.3), $p = 0.2$; Junctional: penetrating 10% vs. blunt 45%, or 7 (95%CI 1.6–31.3), $^{*}p < 0.01$; Extremity: penetrating 2% vs. blunt 6%, or 3.2 (95%CI 0.28–37.3), $p = 0.5$). B: Limb amputation rates following vascular trauma. There were no recorded incidences of amputation following penetrating vascular trauma, whilst blunt extremity vascular injury accounted for the highest amputation rates (Overall: penetrating 0% vs. blunt 15%, $^{**}p < 0.001$; Central: penetrating 0% vs. blunt 3%, $p = 0.5$; Junctional: penetrating 0% vs. blunt 20%, $^{*}p < 0.05$; Extremity: penetrating 0% vs. blunt 27%, $^{**}p = 0.0001$).

Table 2
Multivariate analysis of factors associated with overall mortality in 256 patients with vascular trauma.

Mortality	Adjusted OR (95% CI)	p value
Age (yrs)	1.03 (1.01–1.05)	0.008
ISS	1.05 (1.00–1.10)	0.050
Shock	4.98 (1.37–18.14)	0.015
Zone of injury		
Peripheral	1.0	
Junctional	6.23 (1.47–26.47)	0.013
Central	4.36 (1.13–16.87)	0.033

OR, Odds ratio; CI, confidence interval; MOI, Mechanism of injury; ZOI, Zone of injury.

Discussion

Key findings

This study is the first to characterise the epidemiology of vascular trauma within an organised British trauma system. Currently, vascular injury is present in 4.4% of general trauma admissions with a roughly equal proportion of blunt and penetrating mechanisms of injury. In this civilian population, two thirds of the distribution of vascular injuries involved the torso vessels (central and junctional zones) whilst one-third concerned the extremity vessels. Open surgery is the mainstay of treatment with interventional radiology useful in selected cases, most notably in the treatment of blunt aortic injuries and arterial haemorrhage associated with pelvic fractures. The results of this study demonstrate the high mortality and marked utilisation of hospital resources that this subgroup of trauma patients incur. Furthermore, we have shown that significant differences in outcome exist between patients with a blunt versus penetrating mechanism of vascular injury.

Comparison with previous studies

Epidemiology

Our results are in keeping with published data from countries with organised trauma systems. Reports from mature trauma centres in Australia and the United States (US) describe vascular trauma as responsible for between 1% and 2.5% of general trauma admissions with penetrating trauma a significant source of these injuries.[4,6–8] These reports also consistently report that torso vascular injuries account for approximately two thirds of vascular trauma[4,8,16] and overall mortality is high, between 23% and 26%.[4,6,8]

Table 3
Comparison of hospital resource utilisation between general trauma admissions and vascular trauma admissions.

	General trauma[a] ($n = 5823$)	Vascular trauma ($n = 256$)	p value
Age (years)	32 (23–45)	29 (22–43)	0.05
ISS	9 (4–19)	17 (9–29)	<0.0001
Hospital resources			
PRBC transfusion[b]	578 (16%)[d]	195 (76%)	<0.0001
Massive transfusion[c]	117 (3%)[d]	92 (36%)	<0.0001
ITU admission	1611 (28%)	126 (49%)	<0.0001
Hospital LOS (days)	2 (0–9)	12 (6–34)	<0.0001

Data are presented as median (IQR) or frequency (%).
[a] General trauma admissions include all patients with a vascular injury.
[b] Proportion of patients requiring a PRBC transfusion in first 24 h of admission.
[c] Massive transfusion: 10 or more units of PRBC transfused in first 24 h of admission.
[d] Proportions relate to 3601 general trauma admissions with complete transfusion data.

Table 4
Use of hospital resources according to mechanism of injury.

	Vascular trauma		p value
	Penetrating ($n = 135$)	Blunt ($n = 121$)	
Median PRBC/24 h (Units)			
Overall	4 (0–10)	9 (3–18)	0.0002
Central	8 (2–16)	11 (4–21)	0.009
Junctional	4 (0–10)	10 (5–15)	0.082
Extremity	2 (0–6)	4 (0–13)	0.061
Massive transfusion			
Overall	34 (25%)	58 (48%)	0.0002
Central	20 (38%)	36 (51%)	0.147
Junctional	8 (28%)	11 (65%)	0.028
Extremity	6 (11%)	11 (32%)	0.025
ITU LOS (days)[a]			
Overall	0 (0–2)	5 (0–11)	<0.0001
Central	1 (0–3)	10 (3–17)	<0.0001
Junctional	0 (0–4)	5 (0–11)	0.162
Extremity	0	0 (0–4)	0.016
Hospital LOS (days)[a]			
Overall	7 (4–13)	35 (15–58)	<0.0001
Central	7 (5–13)	38 (19–60)	<0.0001
Junctional	5 (3–22)	15 (3–46)	0.302
Extremity	8 (4–13)	35 (15–73)	<0.0001

Data are presented as median (IQR) or frequency (%).
[a] Length of stay calculated for survivors only.

The higher incidence of vascular trauma in our series is most likely a consequence of our pre-hospital system, which is both physician-led and exclusively dedicated to trauma. This may result in increased survival to hospital rates for otherwise lethal vascular injuries. Approximately one in ten patients in our system had suffered a cardiac arrest pre-hospital or on arrival to the Emergency Department. It may also be a consequence of the liberal use of contrast CT in our hospital leading to a higher diagnostic rate of vascular injury compared to other centres. It is also noteworthy that the incidence of vascular trauma may be higher in major cities compared to the national average.

Preliminary data from our centre has been published recently.[9] Although the reported epidemiology is similar, the absolute numbers are slightly different between the two articles because of differences in inclusion criteria. Otherwise, our results conflict with previous reports on the epidemiology and outcome of vascular trauma in the United Kingdom. These describe vascular trauma as being uncommon and usually the result of blunt trauma.[17] In the few small case series that exist, the majority (>75%) of vascular injuries involved extremity vessels and the overall mortality is low, between 0 and 4%.[10–13] This may represent a selection bias where the more serious torso vascular injuries did not survive to hospital or were not triaged to these centres.

Mechanism of injury

Penetrating trauma is known to result in a disproportionate amount of vascular injuries. This is unsurprising as the elastic content of arteries makes them one of the most robust tissues in the body, resistant to blunt injury but susceptible to incision. In our study, patients with penetrating injury were three and a half times more likely to have a vascular injury than those with a blunt mechanism of injury. Other UK cities have also experienced a high proportion of penetrating vascular trauma; a recent report from Leicester observed that 56% of traumatic vascular injuries had a penetrating Aetiology.[12] In the US, just over half of all vascular injuries on the National Trauma Data Bank (NTDB) resulted from penetrating trauma[6] despite only 10% of all injuries being of penetrating aetiology during the same time period.[18] Major cities may experience a higher than average proportion of penetrating vascular injuries.[16]

Although more common following penetrating trauma, our findings support the presence of a vascular injury following blunt trauma as a marker of significant transmission of force and therefore substantially more severe injury.

Mortality

This study highlights the high morbidity and mortality associated with vascular trauma. The overall mortality in this series was 18%, and compares favourably to that observed by other Major Trauma Centres with similar mechanisms and distributions of vascular injuries (24%–26%).[4,8] Our results iterate that age; ISS and the presence of shock are established independent predictors of trauma deaths. For vascular trauma, injury location was also an independent predictor of death. Although blunt mechanism of injury and polytrauma were significant markers of more severe injury and worse outcome, they were not independent predictors of death in our study.

Commonly used trauma-scoring systems underestimate the actual mortality associated with vascular trauma,[8] and these injuries account for disproportionately high death rates amongst trauma patients. For example, in a report from an Australian Major Trauma Centre, vascular trauma was responsible for 21.6% of trauma deaths despite only accounting for 1.8% of trauma admissions.[4]

Torso haemorrhage is non-compressible and recognised as a leading cause of death following civilian and military trauma.[19,20] Of the patients in our cohort that died, 93% had injuries to torso vessels. Furthermore, 40% of these patients died prior to, or soon after arrival in the Emergency Department, before any opportunity for intervention. Trauma systems have optimised access to standard interventions for haemorrhage control such as surgery and interventional radiology. For further substantial improvements in survival research into novel methods of earlier haemorrhage control is required.

Amputation

Vascular injuries also lead to significant disability. The most important causes of post-injury disability are injuries involving the central nervous system followed by amputation and severe limb injuries.[21] Vascular injuries contribute to both. Blunt extremity vascular injuries are associated with particularly high amputation rates[22] and our series affirms this. No penetrating vascular injuries resulted in limb amputation. For this reason, we feel that limb salvage rates after penetrating trauma are limited markers of quality of outcome, although this may not be the case in systems with a high incidence of GSW's. In a South African series of lower limb arterial injuries the limb salvage rate was 83.8%, however, approximately two thirds of amputations were the result of GSW's.[23] Most amputations in our series were performed on patients with mangled extremities where limb revascularisation was not possible. In those that underwent limb revascularisation the limb salvage rate was 85%.

Hospital resources

Vascular trauma patients are recognised as having the highest utilisation of hospital resources amongst the trauma population.[5] Although less than 5% of trauma admissions had a vascular injury at our hospital, these patients required a third of all blood transfusions and the majority of massive blood transfusions administered to trauma patients. Critical care and hospital length of stay were also significantly longer in vascular trauma patients. Blunt vascular trauma patients in particular had substantial hospital resource requirements with a median hospital length of stay of more than a month.

Limitations

There are several limitations to this study. Most notably, the project is retrospective in nature and therefore potentially subject to information bias. In spite of this, however, the primary source of information was a prospectively maintained database. Furthermore, records were corroborated through multiple objective sources.

In addition, these results are from a single major trauma centre in the most populated city in Europe. Consequently, our patient characteristics may not necessarily be reflective of other European or English cities therefore limiting the applicability of the findings. By virtue of trauma centre status and the transient population of the city, both our catchment area and population numbers are ill-defined. Consequently, we are only able to describe the epidemiology of vascular trauma as a factor of general trauma admissions, rather than that of the general population.

Conclusion

Vascular trauma in a British Major Trauma Centre has a similar epidemiology and outcome to that experienced by Major Trauma Centres in organised trauma systems worldwide. Even with expert care, these injuries are associated with high morbidity and mortality, and place a substantial burden on hospital resources. As UK trauma and vascular systems evolve, these injuries should be a focus of attention for injury prevention, novel therapy research and priority of care. An understanding of the impact of these injuries on services will be valuable in future resource planning.

Conflict of interest

No external funding received and no competing interests declared.

Acknowledgements

The authors would like to thank Mr R. Walker for his assistance in collating data and Mr T. Brockamp for his assistance with statistical analysis.

References

1 Kauvar DS, Wade CE. The epidemiology and modern management of traumatic hemorrhage: US and international perspectives. *Crit Care* 2005;**9**(Suppl. 5):S1–9.
2 Gruen RL, Jurkovich GJ, McIntyre LK, Foy HM, Maier RV. Patterns of errors contributing to trauma mortality: lessons learned from 2594 deaths. *Ann Surg* 2006 Sep;**244**(3):371–80.
3 Rozycki GS, Tremblay LN, Feliciano DV, McClelland WB. Blunt vascular trauma in the extremity: diagnosis, management, and outcome. *J Trauma* 2003 Nov;**55**(5):814–24.
4 Sugrue M, Caldwell EM, Damours SK, Crozier JA, Deane SA. Vascular injury in Australia. *Surg Clin North Am* 2002 Feb;**82**(1):211–9.
5 Caps MT. The epidemiology of vascular trauma. *Semin Vasc Surg* 1998 Dec;**11**(4):227–31.
6 Barmparas G, Inaba K, Talving P, David JS, Lam L, Plurad D, et al. Pediatric vs adult vascular trauma: a National Trauma Databank review. *J Pediatr Surg* 2010 Jul;**45**(7):1404–12.
7 Gupta R, Rao S, Sieunarine K. An epidemiological view of vascular trauma in Western Australia: a 5-year study. *ANZ J Surg* 2001 Aug;**71**(8):461–6.
8 Loh SA, Rockman CB, Chung C, Maldonado TS, Adelman MA, Cayne NS, et al. Existing trauma and critical care scoring systems underestimate mortality among vascular trauma patients. *J Vasc Surg* 2011 Feb;**53**(2):359–66.

9 Stannard A, Brohi K, Tai N. Vascular injury in the United Kingdom. *Perspect Vasc Surg Endovasc Ther* 2011 Mar;**23**(1):27–33.

10 Golledge J, Scriven MW, Fligelstone LJ, Lane IF. Vascular trauma in civilian practice. *Ann R Coll Surg Engl* 1995 Nov;**77**(6):417–20.

11 Magee TR, Collin J, Hands LJ, Gray DW, Roake J. A ten year audit of surgery for vascular trauma in a British teaching hospital. *Eur J Vasc Endovasc Surg* 1996 Nov;**12**(4):424–7.

12 Bains SK, Vlachou PA, Rayt HS, Dennis M, Markose G, Naylor AR. An observational cohort study of the management and outcomes of vascular trauma. *Surgeon* 2009 Dec;**7**(6):332–5.

13 De'Ath HD, Galland RB. Iatrogenic and non-iatrogenic vascular trauma in a district general hospital: a 21-year review. *World J Surg* 2010 Oct;**34**(10):2363–7.

14 Barros D'Sa AA. Twenty five years of vascular trauma in Northern Ireland. *BMJ* 1995 Jan 7;**310**(6971):1–2.

15 Sprung J, Abdelmalak B, Gottlieb A. Analysis of risk factors for myocardial infarction and cardiac mortality after major vascular surgery. *Anesthesiology* 2000 Jul;**93**(1):129–40 (6585995).

16 Mattox KL, Feliciano DV, Burch J, Beall Jr AC, Jordan Jr GL, De Bakey ME. Five thousand seven hundred sixty cardiovascular injuries in 4459 patients. Epidemiologic evolution 1958 to 1987. *Ann Surg* 1989 Jun;**209**(6):698–705. discussion 6–7.

17 Fingerhut A, Leppaniemi AK, Androulakis GA, Archodovassilis F, Bouillon B, Cavina E, et al. The European experience with vascular injuries. *Surg Clin North Am* 2002 Feb;**82**(1):175–88.

18 National Trauma Databank. *American College of Surgeons*. Available from: www.facs.org/trauma/ntdb; 2006.

19 Demetriades D, Murray J, Charalambides K, Alo K, Velmahos G, Rhee P, et al. Trauma fatalities: time and location of hospital deaths. *J Am Coll Surg* 2004 Jan;**198**(1):20–6.

20 Kelly JF, Ritenour AE, McLaughlin DF, Bagg KA, Apodaca AN, Mallak CT, et al. Injury severity and causes of death from Operation Iraqi Freedom and Operation Enduring Freedom: 2003–2004 versus 2006. *J Trauma* 2008 Feb;**64**(2 Suppl.):S21–6. discussion S6–S7.

21 Pape HC, Probst C, Lohse R, Zelle BA, Panzica M, Stalp M, et al. Predictors of late clinical outcome following orthopedic injuries after multiple trauma. *J Trauma* 2010 Nov;**69**(5):1243–51.

22 Feliciano DV, Moore FA, Moore EE, West MA, Davis JW, Cocanour CS, et al. Evaluation and management of peripheral vascular injury. Part 1. Western Trauma Association/critical decisions in trauma. *J Trauma* 2011 Jun;**70**(6):1551–6.

23 Hafez HM, Woolgar J, Robbs JV. Lower extremity arterial injury: results of 550 cases and review of risk factors associated with limb loss. *J Vasc Surg* 2001 Jun;**33**(6):1212–9.