Injury, Int. J. Care Injured 50 (2019) 137–141

Contents lists available at ScienceDirect

Injury

journal homepage: www.elsevier.com/locate/injury

Abdominal vascular injuries: Blunt vs. penetrating

Supparerk Prichayudh*, Pattanapong Rassamee, Suvit Sriussadaporn, Rattaplee Pak-art, Sukanya Sriussadaporn, Kritaya Kritayakirana, Pasurachate Samorn, Natawat Narueponjirakul, Apinan Uthaipaisanwong

Chulalongkorn University, Surgery, Rama4 rd, Bangkok, Thailand

ARTICLE INFO

Keywords:
Abdominal vascular injury
Blunt injury
Penetrating injury

ABSTRACT

Introduction: Abdominal vascular injuries (AVIs) remain a great challenge since they are associated with significant mortality. Penetrating injury is the most common cause of AVIs; however, some AVI series had more blunt injuries. There is little information regarding differences between penetrating and blunt AVIs. The objective of the present study was to identify the differences between these two mechanisms in civilian AVI patients in terms of patient's characteristics, injury details, and outcomes.

Method: From January 2007 to January 2016, we retrospectively collected the data of AVI patients at King Chulalongkorn Memorial hospital, including demographic data, details of injury, the operative managements, and outcomes in terms of morbidity and mortality. The comparison of the data between blunt and penetrating AVI patients was performed.

Results: There were 55 AVI patients (28 blunt and 27 penetrating). Majority (78%) of the patients in both groups were in shock on arrival. Blunt AVI patients had significantly higher injury severity score (mean(SD) ISS, 36(20) vs. 25(9), $p = 0.019$) and more internal iliac artery injuries (8 vs. 1, $p = 0.028$). On the other hand, penetrating AVI patients had more aortic injuries (5 vs. 0, $p = 0.046$), and inferior vena cava injuries (7 vs. 0, $p = 0.009$). Damage control surgery (DCS) was performed in 45 patients (82%), 25 in blunt and 20 in penetrating. The overall mortality rate was 40% (50% in blunt vs. 30% in penetrating, $p = 0.205$).

Conclusions: Blunt AVI patients had higher ISS and more internal iliac artery injuries, while penetrating AVI patients had more aortic injuries and vena cava injuries. Majority of AVI patients in both groups presented with shock and required DCS.

Introduction

Abdominal vascular injuries (AVIs) remain a great challenge even for experienced surgeons since they are associated with significant mortality (17–54%), mainly from exsanguination [1–13]. Most of AVIs in civilian settings were caused by penetrating trauma [1–4,6,8–12]. However, some AVI series had more blunt trauma as the main mechanism of injuries, especially road traffic accident [5,7,13]. Differences between penetrating and blunt AVIs have been described in terms of pathophysiology [14]. Nevertheless, there is little information regarding the other characteristic differences between penetrating and blunt AVIs [8]. Due to high volume of road traffic accidents in Thailand; our earlier report demonstrated a higher proportion of blunt AVIs and comparable number of blunt and penetrating AVI patients [5], which remains unchanged over the years. Hence, the objective of the present study was to identify the differences between these two mechanisms in civilian AVI patients in terms of patient's characteristics, injury details, and outcomes.

Patients and methods

A retrospective study was done on AVI patients at King Chulalongkorn Memorial Hospital, a 1300-bed university hospital and a level 1 trauma center in Bangkok, Thailand, from January 2007 to January 2016. The study was approved by the institutional review board. The diagnosis of AVIs was made either by a preoperative computed tomography and/or intraoperative findings. The patients who were in shock (systolic blood pressure < 90 mmHg not responding to the initial fluid resuscitation) with an evidence of intraabdominal bleeding would be taken immediately to the operating room for exploratory laparotomy. Resuscitative thoracotomy would be performed in the patients who were in extremis (i.e., cardiac arrest or severe persistent hypotension). Damage control surgery (DCS) was defined as an abbreviated laparotomy performed in unstable AVI patients including

* Corresponding author.
E-mail address: Supparerk.P@Chula.ac.th (S. Prichayudh).

https://doi.org/10.1016/j.injury.2018.11.045
0020-1383/

intraabdominal packing, temporary intravascular shunting, and temporary abdominal closure. The decision to use DCS was made in the patients with massive bleeding and deranged physiology (i.e., when hypothermia, acidosis, and coagulopathy occurred).

Data collection included demographic data, emergency department (ED) parameters (vital signs, trauma scores, hematocrit, and base deficit), details of AVIs, details of operative management, and outcomes in terms of blood component transfusions, complications, intensive care unit (ICU) days, ventilator days, length of stay, and mortality. Zones of retroperitoneal hematoma were described as Zone I (midline retroperitoneum), Zone II (upper lateral retroperitoneum), Zone III (pelvic retroperitoneum), porta hepatis, and retrohepatic hematoma [15]. Statistical analysis was performed using the Window SPSS program version 17.0 with the statistical significance set at $p < 0.05$. Comparison of categorical variables was performed with the chi-squared test (with p values reported by using twice one-tailed exact probability) and comparison of continuous variables was performed with the Student's *t*-test The non-parametric (Mann-Whitney U) test was used for comparison of variables that were not normally distributed (blood transfusion, ICU days, ventilator days, and length of stay).

Results

There were 55 AVI patients during January 2007 to January 2016 (28 blunt and 27 penetrating). Forty-five patients were male and 10 were female, with the mean age of 35 years. Forty-three patients (78%) presented with shock from intraabdominal bleeding (22 blunt and 21 penetrating). Road traffic accidents and abdominal stab wounds were the most common mechanisms responsible for AVIs in blunt and penetrating groups, respectively. AVIs were diagnosed intraoperatively in 46 patients (84%), while computed tomography (CT) was used preoperatively to identify AVIs in 9 stable patients (16%). Resuscitative thoracotomy was performed in 4 patients (2 in each group), all died from exsanguination. The demographic data and ED parameters were summarized in Table 1. Blunt AVI patients were significantly older (mean(SD) age 38(19) years vs. 31(13) years, $p = 0.016$), had higher injury severity score (mean(SD) ISS, 36(20) vs. 25(9), $p = 0.019$), and higher new injury severity score (mean(SD) NISS, 40(18) vs. 30(9), $p = 0.0158$) than penetrating AVI patients.

Retrohepatic hematoma was the most common hematoma encountered during laparotomy (15 patients, 27%), followed by Zone I hematoma (13 patients, 24%), as shown in Table 2. There were 70 AVIs identified in these 55 patients. The most common injured vessel was inferior vena cava (IVC, 23 injuries, 33%). The most commonly injured vessel in blunt AVIs was retrohepatic IVC (11, 35%), while infrahepatic IVC was the most commonly injured vessel in penetrating AVIs (7, 18%). The distribution of AVIs was summarized in Table 3. Penetrating AVI patients had more aortic injuries (5 vs. 0, $p = 0.046$) and infrahepatic IVC injuries (7 vs. 0, $p = 0.009$), while blunt AVI patients had more internal iliac artery

Table 2
The Zones of retroperitoneal hematoma encountered during laparotomy.

Hematoma zones	Total (N = 55)	Blunt (N = 28)	Penetrating (N = 27)	*p*-value
- I	13 (24%)	3 (11%)	10 (37%)	0.102*
- II	7 (13%)	4 (14%)	3 (11%)	
- III	9 (16%)	5 (18%)	4 (15%)	
- Retrohepatic	15 (27%)	11 (39%)	4 (15%)	
- Porta hepatis	1 (2%)	1 (4%)	0 (0%)	
- Multiple zones	10 (18%)	4 (14%)	6 (22%)	

The italic value in the table is meant to highlight the significant values ($p < 0.05$).
* The analysis of hematoma zones is based on a single Fisher's exact test.

Table 1
Demographic data and emergency department (ED) parameters.

	Total (N = 55)	Blunt (N = 28)	Penetrating (N = 27)	*p*-value
Sex				
M	45 (81%)	22 (79%)	23 (85%)	0.776
F	10 (19%)	6 (21%)	4 (15%)	
Age (Mean (SD))	35 (16)	38 (19)	31 (13)	*0.016*
Presentations				
- Shock	43 (78%)	22 (78%)	21 (78%)	1*
- Cardiac arrest	6 (11%)	3 (11%)	3 (11%)	
- Peritonitis	5 (9%)	3 (11%)	2 (7%)	
- Intraoperative detection	1 (2%)	0 (0%)	1 (4%)	
Detailed mechanisms		MCA 9 (32%)	SW 13 (48%)	
		MVA 5 (18%)	GSW 9 (33%)	
		Fall 8 (29%)	Blast 2 (7%)	
		Other 6 (21%)	Iatrogenic 3 (11%)	
ED parameters (Mean (SD))				
-SBP	80 (42)	82 (44)	79 (40)	0.815
-PR	101 (43)	107 (41)	95 (45)	0.310
-GCS	10 (5)	9 (5)	11 (5)	0.138
-ISS	31 (16)	36 (20)	25 (9)	*0.019*
-NISS	35 (15)	40 (18)	30 (9)	*0.011*
-Abdominal AIS	4.5 (0.8)	4.4 (0.9)	4.7 (0.6)	0.158
-RTS	5.6 (2.3)	5.6 (1.9)	5.7 (2.7)	0.896
-TRISS	66.0 (37.7)	61.6 (38.0)	70.6 (37.7)	0.379
-BD	14.0 (7.0)	15.5 (7.2)	12.4 (6.6)	0.106
-Hematocrit	28.8 (9.5)	29.3 (8.8)	28.2 (10.2)	0.686
CT	9 (16%)	6 (21%)	3 (11%)	0.504
Resuscitative thoracotomy	4 (7%)	2 (7%)	2 (7%)	1

SBP: systolic blood pressure, PR: pulse rate, GCS: Glasgow Coma Scale, ISS: Injury Severity Score, NISS: New Injury Severity Score, AIS: Abbreviated Injury Scale, RTS: Revised Trauma Score, TRISS: Trauma and Injury Severity Score, BD: base deficit, SD: standard deviation, CT: computed tomography, MCA: motor cycle accident, MVA: motor vehicle accident, SW: stab wound, GSW: gunshot wound. The italic value in the table is meant to highlight the significant values ($p < 0.05$).
* The analysis of presentations is based on a single Fisher's exact test.

Table 3
Distribution of 70 abdominal vascular injuries.

Injured vessels	Total (N = 70)	Blunt (N = 31)	Penetrating (N = 39)	*p*-value
Aorta	5 (7%)	0 (0%)	5 (13%)	*0.046*
Celiac axis	1 (1%)	1 (3%)	0 (0%)	1
Hepatic artery	3 (4%)	2 (6%)	1 (3%)	1
SMA	8 (11%)	2 (6%)	6 (15%)	0.228
SMV/PV	4 (6%)	2 (6%)	2 (5%)	1
Renal artery/vein	11 (16%)	5 (16%)	6 (15%)	0.945
IMA	1 (1%)	0 (0%)	1 (3%)	0.980
Common iliac artery	2 (3%)	0 (0%)	2 (5%)	0.472
Common iliac vein	2 (3%)	0 (0%)	2 (5%)	0.472
Internal iliac artery	9 (13%)	8 (26%)	1 (3%)	*0.028*
Internal iliac vein	1 (1%)	0 (0%)	1 (3%)	0.980
Retrohepatic IVC	16 (23%)	11 (35%)	5 (13%)	0.160
Infrahepatic IVC	7 (10%)	0 (0%)	7 (18%)	*0.009*

SMA: superior mesenteric artery, SMV: superior mesenteric vein, PV: portal vein, IMA: inferior mesenteric artery, IVC: inferior vena cava. The italic value in the table is meant to highlight the significant values ($p < 0.05$).

injuries (8 vs. 1, $p = 0.028$). Liver (51%) and small bowel injuries (22%) were the two most common associated intraabdominal organ injuries. Blunt AVI patients had more concomitant head injuries (15 vs. 3, $p = 0.002$), and pelvic fractures (8 vs. 0, $p = 0.005$); while penetrating AVI patients had more associated small bowel injuries (11 vs. 1, $p = 0.002$).

Surgical management of AVIs was shown in Table 4. Forty-five AVIs patients (82%) required DCS (25 blunt vs. 20 penetrating, $p = 0.264$). Simple (lateral) repair was the most commonly used method (39 vessels, 56%) in the present study. Interposition graft was used in 2 cases in penetrating group, 1 infrarenal aortic injury (Dacron graft) and 1 left common iliac artery injury (polytetrafluorothylene-PTFE graft); both cases survived without graft complications. Ligation was done in 2 hepatic artery injuries, 1 inferior mesenteric artery injury, and 2 internal iliac artery injuries; three of these ligations (1 hepatic artery and 2 internal iliac arteries) were part of DCS. Angiographic embolization was performed in 4 internal iliac injuries from pelvic fractures, and 2 renal artery injuries. Preperitoneal pelvic packing was performed in conjunction with bilateral internal iliac artery ligation in a 30-year-old male with pelvic fracture from a road traffic accident who was too unstable to be transferred to the angiography suite, the patient survived with erectile dysfunction. Atriocaval shunt was used in a 15-year-old male with retrohepatic IVC injury from a motorcycle accident who had failed perihepatic packing, the patient survived to discharge with no functional impairment.

Table 5
Outcomes.

	Total (55)	Blunt (28)	Penetrating (27)	*p*-value
Blood transfusion (Median (IQR))				
-PRC	10 (4–15)	10 (5–24)	8 (4–14)	0.224
-FFP	9 (3–14)	12 (3–17)	7 (3–10)	0.112
-Platelets	4 (0–10)	5 (0–14)	1 (0–10)	0.303
Complications				
-ACS	4 (7%)	4 (14%)	0 (0%)	0.113
-Intraabdominal infection	6 (11%)	5 (18%)	1 (4%)	0.209
-Bleeding	2 (4%)	2 (7%)	0 (0%)	0.509
-Liver failure	1 (2%)	1 (4%)	0 (0%)	1
-Gut obstruction	1 (2%)	1 (4%)	0 (0%)	1
-CNS	2 (4%)	1 (4%)	1 (4%)	1
-Respiratory	2 (4%)	2 (7%)	0 (0%)	0.509
-Cardiovascular	2 (4%)	2 (7%)	0 (0%)	0.509
-Renal	6 (11%)	6 (21%)	0 (0%)	*0.025*
-DVT	1 (7%)	1 (4%)	0 (0%)	1
Ventilator days (Median (IQR))	1 (0–3)	1(0–6)	1 (0–3)	0.686
ICU days (Median (IQR))	1 (0–7)	2(0–9)	1 (0–4)	0.327
Length of stay (Median (IQR))	12 (1–43)	11 (1–56)	14 (1–30)	0.832
Mortality	22 (40%)	14 (50%)	8 (30%)	0.205
-Exsanguination	16 (73%)	8 (57%)	8 (100%)	
-Multiple organ failure	5 (23%)	5 (36%)	0 (0%)	
-Severe head injury	1 (4%)	1 (7%)	0 (0%)	

PRC: Packed Red blood Cells, FFP: Fresh Frozen Plasma, ICU: Intensive Care Unit, ACS: abdominal compartment syndrome, CNS: central nervous system, DVT: deep vein thrombosis, IQR: inter-quartile range, SD: standard deviation. The italic value in the table is meant to highlight the significant values ($p < 0.05$).

Outcomes of AVI patients were summarized in Table 5. There were no differences in blood transfusion, ICU days, ventilator days, and length of stay between blunt and penetrating groups. Nevertheless, blunt AVI patients had more renal complications (5 acute renal failures and 1 iatrogenic ureteric injury) than penetrating group (6 vs. 1, $p = 0.025$). The overall mortality in the present study was 40% (blunt 50% vs. penetrating 30%, $p = 0.205$). The most common cause of death was exsanguination (73%), followed by multiple organ failure (23%), and severe head injury (4%).

Grading according to the American Association for the Surgery of Trauma-Organ Injury Scale (AAST-OIS) for AVI was shown in Table 6. The mortality did not correlate well with the injury grades in the blunt group, in which the highest mortality occurred in grade III AVI patients (58%).

Table 4
Surgical management of 70 abdominal vascular injuries.

	Simple repair	Interposition graft	Ligation	Others
Aorta	4	1	0	0
Celiac axis	1	0	0	0
Hepatic artery	1	0	2	0
SMA	8	0	0	0
SMV/PV	4	0	0	0
Renal artery/vein	3	0	0	Nephrectomy 6 AE 2
IMA	0	0	1	0
Common iliac artery	1	1	0	0
Common iliac vein	2	0	0	0
Internal iliac artery	3	0	2	AE 4
Internal iliac vein	1	0	0	0
Retrohepatic IVC	4	0	0	Packing 11 Atriocaval shunt 1
Infrahepatic IVC	7	0	0	0

SMA: superior mesenteric artery, SMV: superior mesenteric vein, PV: portal vein, IMA: Inferior mesenteric artery, IVC: inferior vena cava. AE: angiographic embolization.

Table 6
Grading according to the American Association for the Surgery of Trauma-Organ Injury Scale (AAST-OIS) for abdominal vascular injury with mortality stratified by injury grade.

	Total (N = 55)	Blunt (N = 28)	Penetrating (N = 27)
Grade II	6	1	5
Mortality (%)	0 (0%)	0 (0%)	0 (0%)
Grade III	18	12	6
Mortality (%)	9 (50%)	7 (58%)	2 (33%)
Grade IV	11	2	9
Mortality (%)	4 (36%)	1 (50%)	3 (33%)
Grade V	20	13	7
Mortality (%)	9 (45%)	6 (46%)	3 (43%)

Discussion

Differences between blunt and penetrating AVIs have been described in terms of pathophysiology; i.e., blunt trauma from rapid deceleration can cause avulsion or thrombosis of abdominal vessels, while penetrating trauma usually causes lateral wall defect or transection of the vessels resulting in hemorrhage and/or hematoma [14]. Comparing to penetrating AVIs, blunt AVIs have been shown to have higher mortality rates in some studies (40–57% vs. 30–43%) [5,8]. However, some series with high numbers of blunt AVIs from road traffic accidents demonstrated low mortality rates (7–17%) [7,13]. Besides these particular points, there is not much information regarding the differences between these two mechanisms of AVIs. Since our study has comparable number of patients in each group, the authors compared the differences between blunt and penetrating AVIs in terms of patient's characteristics, injury details, and outcomes.

Regarding the demographic data and ED parameters, the present study showed that blunt AVI patients were older, had higher ISS, and higher NISS than penetrating AVI patients (Table 1). The higher ISS and NISS in the blunt group could be explained by higher numbers of associated injuries seen in blunt trauma, particularly head injuries and pelvic fractures. Majority (78%) of the patients in the present study were in shock, which was also commonly noticed in other AVI studies (44–76%) [1,4–6,8,10,12].

The most commonly injured vessel in the present study was IVC (33%, Table 3), which corresponds with several previous studies (IVC injury rates 25–41%) [1,4,6,8,10]. The most commonly injured vessels in the blunt group were retrohepatic IVC (35%) and internal iliac artery (26%) since we experienced high proportion of associated liver injuries (64%) and pelvic fractures (29%) in our blunt AVI patients, mainly from motorcycle accidents. These findings are in contrast to a blunt AVI series from motor vehicle crashes with high incidence of associated small bowel injuries that had mesenteric vessels as the most commonly injured vessels [7]. The present study revealed that penetrating AVI patients had more aortic injuries and infrahepatic IVC injuries than blunt AVI patients, which also explained higher number of zone I retroperitoneal hematomas encountered during laparotomy in the penetrating group (Tables 2 and 3).

Despite the advance in endovascular management in trauma; the data supporting its use in AVIs, especially in unstable patients, is sparse and open surgery remains the mainstay treatment in most series [1–13,15,16]. Lateral repair, whenever the pathology allows (i.e., lateral tear), was the most commonly used method to treat AVIs in the present study (56%) and also in several other studies (28–56%) [3–7,11]. Complex AVIs requiring resection of the injured segment are usually repaired with either an end to end anastomosis or an interposition graft (4–17%) [3,5,6,11,15]. The use of prosthetic graft in the presence of fecal contamination has been reported to be safe with no graft infections [3,11]. Ligation could be performed safely in some vessels (e.g. inferior mesenteric vessels and internal iliac vessels), or as a part of DCS to rapidly achieve bleeding control in unstable AVI patients [15]. Ligation of common or external iliac veins in AVI patients has been reported to be well tolerated, carrying low venous complication (7–12%) [3,11]. On the other hand, ligation of superior mesenteric vessels and IVC is associated with poorer outcomes and should be reserved only for AVI patients who are in extremis (mortality 34% for superior mesenteric artery, 40% for superior mesenteric vein, and 40% for IVC ligations) [17–19].

Since significant proportion of AVI patients are usually in shock with physiologic derangements (hypothermia, acidosis, and coagulopathy), DCS has been commonly used in these particular patients as seen in 82% of our patients and 16–53% in other series [1,5,6,11,12]. Besides vessel ligation and packing, the use of temporary intravascular shunt has been reported as a damage control option to treat AVIs that should not be ligated, e.g., common/external iliac artery [5,11], superior mesenteric artery [17,20], and retrohepatic IVC [21,22]. In the present study, we used an atriocaval shunt to facilitate the repair of a retrohepatic IVC injury in one patient with a successful outcome.

In the present study, the mortality rates in blunt and penetrating AVI patients were not significantly different (50% vs. 30%, p = 0.205) with an overall mortality rate of 40%, reflecting a high mortality associated with AVIs (mainly from exsanguination) as reported in other studies (17–54%) [1–13]. Number of factors predicting mortality in AVIs have been described, i.e., the presence of shock, hypothermia, acidosis, dysrhythmias, transfusion requirement, and number of injured vessels [2,4,8,10,17]. The correlation between mortality and AAST-OIS for AVI has also been demonstrated in previous studies [6,13]. However, this correlation was not shown in our blunt AVI patients, in which highest mortality occurred in grade III AVIs (58%). This finding may be explained by high number of associated injuries found in our 12 grade III blunt AVI patients (4 had liver injuries and 5 had pelvic fractures), which may have also contributed to exsanguination.

There are some limitations in the present study. Our center is a low volume center for AVIs (55 cases in 9 years) with a high incidence of blunt trauma (mainly from motorcycle accidents), this rendered more number of liver injuries (51%) and retrohepatic IVC injuries (23%) in our series and makes the comparison of our outcomes to the studies with high incidence of penetrating trauma difficult. Furthermore, due to the retrospective nature of the present study, data collection was not complete as we do not have some important physiologic parameters, e.g., body temperature and coagulation profiles.

In conclusion, the present study demonstrated that blunt AVI patients had higher ISS and more internal iliac artery injuries, while penetrating AVI patients had more aortic injuries and IVC injuries. Majority of AVI patients in both groups presented with shock and required DCS. Both blunt and penetrating AVI patients carried high mortality rates, mainly from exsanguination, emphasizing the need for prompt operative intervention to control hemorrhage in AVI patients.

Conflict of interest

The authors declare that there are no conflicts of interest.

References

[1] Kashuk JL, Moore EE, Millikan JS, Moore JB. Major abdominal vascular trauma—a unified approach. J Trauma 1982;22:672–9.
[2] Collins PS, Golocovsky M, Salander JM, Champion H, Rich NM. Intra-abdominal vascular injury secondary to penetrating trauma. J Trauma 1988;28:S165–70.
[3] Burch JM, Richardson RJ, Martin RR, Mattox KL. Penetrating iliac vascular injuries: recent experience with 233 consecutive patients. J Trauma 1990;30:1450–9.

[4] Jackson MR, Olson DW, Beckett [111_TD$DIFF]Jr WC, Olsen SB, Robertson FM. Abdominal vascular trauma: a review of 106 injuries. Am Surg 1992;58:622–6.
[5] Sriussadaporn S. Abdominopelvic vascular injuries. J Med Assoc Thai 2000;83:13–20.
[6] Asensio JA, Chahwan S, Hanpeter D, Demetriades D, Forno W, Gambaro E, et al. Operative management and outcome of 302 abdominal vascular injuries. Am J Surg 2000;180:528–33 discussion 533-4.
[7] Yasuhara H, Naka S, Kuroda T, Wada N. Blunt thoracic and abdominal vascular trauma and organ injury caused by road traffic accident. Eur J Vasc Endovasc Surg 2000;20:517–22.
[8] Tyburski JG, Wilson RF, Dente C, Steffes C, Carlin AM. Factors affecting mortality rates in patients with abdominal vascular injuries. J Trauma 2001;50:1020–6.
[9] Davis TP, Feliciano DV, Rozycki GS, Bush JB, Ingram WL, Salomone JP, et al. Results with abdominal vascular trauma in the modern era. Am Surg 2001;67:565–70 discussion 570-1.
[10] Eachempati SR, Robb T, Ivatury RR, Hydo LJ, Barie PS. Factors associated with mortality in patients with penetrating abdominal vascular trauma. J Surg Res 2002;108:222–6.
[11] Oliver JC, Bekker W, Edu S, Nicol AJ, Navsaria PH. A ten year review of civilian iliac vessel injuries from a single trauma centre. Eur J Vasc Endovasc Surg 2012;44:199–202.
[12] Sorrentino TA, Moore EE, Wohlauer MV, Biffl WL, Pieracci FM, Johnson JL, et al. Effect of damage control surgery on major abdominal vascular trauma. J Surg Res 2012;177:320–5.
[13] Heuer M, Hussmann B, Kaiser GM, Lefering R, Paul A, Lendemans S, et al. Abdominal vascular trauma in 760 severely injured patients. Eur J Trauma Emerg Surg 2013;39:47–55.
[14] Dante JD, Feliciano DV. Abdominal vascular injuries. In: Mattox KL, Moore EE, Feliciano DV, editors. Trauma 7th ed.. New York: McGraw-Hill; 2013. p. 632–54.
[15] Feliciano DV, Moore EE, Biffl WL. Western Trauma Association critical decisions in trauma: management of abdominal vascular trauma. J Trauma Acute Care Surg 2015;79:1079–88.
[16] Karaolanis G, Moris D, McCoy CC, Tsilimigras DI, Georgopoulos S, Bakoyiannis C. Contemporary strategies in the management of civilian abdominal vascular trauma. Front Surg 2018;5:7.
[17] Asensio JA, Britt LD, Borzotta A, Peitzman A, Miller FB, Mackersie RC, et al. Multiinstitutional experience with the management of superior mesenteric artery injuries. J Am Coll Surg 2001;193:354–65 discussion 365-6.
[18] Asensio JA, Petrone P, Garcia-Nuñez L, Healy M, Martin M, Kuncir E. Superior mesenteric venous injuries: to ligate or to repair remains the question. J Trauma 2007;62(668) discussion 675.
[19] Sullivan PS, Dente CJ, Patel S, Carmichael M, Srinivasan JK, Wyrzykowski AD, et al. Outcome of ligation of the inferior vena cava in the modern era. Am J Surg 2010;199:500–6.
[20] Reilly PM, Rotondo MF, Carpenter JP, Sherr SA, Schwab CW. Temporary vascular continuity during damage control: intraluminal shunting for proximal superior mesenteric artery injury. J Trauma 1995;39:757–60.
[21] Schrock T, Blaisdell FW, Mathewson [111_TD$DIFF][66_TD$DIFF]Jr C. Management of blunt trauma to the liver and hepatic veins. Arch Surg 1968;96:698–704.
[22] Liu PP, Chen CL, Cheng YF, Hsieh PM, Tan BL, Jawan B, et al. Use of a refined operative strategy in combination with multidisciplinary approach to manage blunt juxtahepatic venous injuries. J Trauma 2005;59:940–5.