Hollow viscus injury due to blunt trauma.
Epidemiology and outcome in a large urban area

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INTRODUCTION: *Hollows viscus injury (HVI) is a rare occurrence and represents a clinical challenge because of its subtle and nonspecific clinical findings. The specific aims of this study were to determine the overall frequency of HVI in blunt trauma patients occurring in large urban area, the relative frequency of various hollow organ injuries, and the outcomes of such injuries.*
MATERIALS AND METHODS: *A retrospective trauma registry review was performed by analysing data from the University Hospital Sant' Andrea in Rome and data from the Emergency Surgery and Trauma Care Unit of S. Filippo Neri Hospital in Rome The clinical records of all blunt abdominal trauma observed between January 2006 and December 2014 were blind analysed. Variables considered for analysis were: sex, age, time/type of trauma, associated injuries, timing/characteristics of operative treatment, ISS, AIS, length of hospital stay, morbidity and mortality.*
RESULTS: *Seventy-one, 7.5% of all abdominal trauma recorded, were coded having 89 HVI. The overall morbidity and mortality rates were 29.6% (n=21/71) and 19.7% (n=14/71) respectively. Multivariate analysis indicated that only WBC (p=0.007) was significant independent predictor of morbidity whereas preoperative transfusion (p=0.010) and ISS (p<0.001) were significant risk factors for mortality.*
DISCUSSION: *HVI is rarely found in patients with blunt abdominal trauma and it can be fatal and life-threatening, particularly in patients for whom a pertinent diagnosis is delayed.*
CONCLUSION: *It appears clearly that during an ER evaluation of a blunt abdominal trauma an HIV has nowadays always to be considered to reach a quick diagnosis and prompt surgical intervention.*

KEY WORDS: Emergency, Hollow Viscus Injury, Surgery, Trauma

Introduction

Hollow Viscus Injury (HVI) in blunt abdominal trauma is a rare occurrence and represents a clinical challenge because of its subtle and non-specific clinical findings [1-4]. The high morbidity and mortality associated with the traumatic lesions of the HV have been attributed to the delay in establishing the diagnosis. The management of bowel injuries has significantly changed in the last 5 decades. In the beginning, diversion and stoma was almost the rule, while at present we have witnessed a shift toward primary repair or damage control surgery and delayed restoration of intestinal continuity [5-8]. The aims of this study were to determine the overall frequency of HVI in blunt trauma patients occurring in large urban area, the relative frequency of various hollow organ injuries, and the outcomes of such injuries.

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Materials and Methods

A retrospective trauma registry review was performed by analysing data from the University Hospital Sant' Andrea in Rome and data from the Emergency Surgery and Trauma Care Unit of S. Filippo Neri Hospital in Rome. These two hospitals are both tertiary and teaching hospitals located in the same large urban area accounting for about 600.000 people. The Trauma Registry Study Project provided for the enrolment of patients older than 16 years of age victims of trauma and burn injury has been extensively previously described [9]. The clinical records of all blunt abdominal trauma observed between January 2006 and December 2014 were blind analysed. Patients with HVI were identified as follows: from Sant'Andrea Hospital Trauma Registry based on Abbreviated Injury Scale (AIS) codes (5406xx, 5408xx, 5410xx, 5414xx, 5420xx, 5422xx, 5436xx, and 5444xx), and from San Filippo Neri Hospital Informatic System (Sistema Informatico Ospedaliero-SIO) based on International Classification of Disease, 9th Revision codes (863.0 to 863.99; 867.0; and 868.xx). The abdominal gastrointestinal tract eligible for the study was defined as the tubular gut and its mesentery between the cardio-esophageal junction and the rectum at the level of the peritoneal reflection. Bladder injury was included only if not due to pelvic fracture. Variables considered for analysis were: age, gender, cause and mechanism of injury, Systolic Blood Pressure (SBP), Glasgow Coma Scale (GCS), White Blood Cell Count (WBC) upon admission, preoperative transfusion, presence and type of associated lesions, Abbreviated Injury Scale (AIS) for head, chest, extremities, and for each hollow viscous injured. The higher AIS of hollow viscous in each patient was also recorded as the Maximum HV-AIS and considered for the statistical analysis. Injury Severity Score (ISS) was calculated to evaluate the entire body trauma severity. CT scan findings on admission, time from Emergency Room (ER) arrival to Operative Room (OR), operative findings and procedures, length of hospital stay (LOS), morbidity and mortality were also retrieved from the database. CT overall diagnostic accuracy was estimated by reviewing CT finings of all blunt trauma patients underwent any abdominal surgical procedure for trauma. Morbidity was evaluated according to Clavien–Dindo (C-D) Classification [10]. Mortality was identified as any death occurring within the first 30 days from trauma or during the entire hospital stay if it could be linked to the event. Since the two main senior authors (GC and LL) could have been involved in the management of a number of clinical cases included in the study, they were blinded for patient's name, identity number and his or her clinical course. The investigators were also blinded with regards to the name of the surgeons and physicians involved in the diagnosis and treatment. The research was undertaken according with the Italian Privacy Laws concerning collection, storage and analysis of private data for scientific purpose. Approval from both the University Hospital Sant' Andrea and the "S. Filippo Neri "Hospital Institutional Research Ethics Boards was not required because of the retrospective and anonymous study design. Statistical analysis was carried out using the 17.0 version of the PASW Statistics Programme (SPSS Italy, Bologna) for MacOsX. Data were encoded either as continuous descriptive data or as categorical dichotomous covariate (yes/no). Descriptive data are summarized as mean ± SD, median [range/interquartile], or percentage (%).The separate effect of each variable upon outcome was examined individually in a univariate analysis considering morbidity and mortality as dependent variable. The one-way analysis of variance (ANOVA) test, the chi-square test, the Spearman's test and the t Student's test or Mann-Whitney statistical test were used when appropriate. All variables with p value ≤ 0.20 in the univariate analysis were included in a multivariate logistic binary regression analysis by forward stepwise and backward stepwise method. CT overall diagnostic accuracy was calculated with on-line calculators.(www.medcalc.org/calc/diagnostic_test.php and-www.hsls.pitt.edu/medcalc/OverallAccSS.htm). P<0.05 (two-tailed) was considered statistically significant. The 95% confidence interval (CI) and the odds ratio (OR) were reported when appropriate.

Results

Demographic Findings

Nine hundred and forty-five patients were admitted at the two institution following blunt abdominal trauma during the study period. Seventy-one, 7.5% of all abdominal trauma recorded, were coded having 89 HVI. Demographic data and CT scan overall diagnostic accuracy are summarized in Table I. There were 56 males (78.9%) and 15 females (21.1%). The average age was 36.69 ±16.55 years (range 16 – 82yrs, median 32). Sixty-two hemodynamically stable patients had abdominal CT scan as part of their secondary survey at admission while nine patients with a positive FAST and hemodynamic instability were immediately transferred to the operating theatre.The anatomical site of the 89 injuries and the average value of the AIS grade with respect to the organ involved are shown in Table II. The distribution of findings with respect to the HVI-AIS grading showed 45 injuries (63.3%) with AIS = 3, 40 injuries (56.3%) with an AIS = 2; a AIS = 4 has been observed in two patients (1.4%). The mean value of Maximum HV-AIS was 2.54±0.55.The mean ISS was 22.00±16.28 with a median of 13 [range 4-66]. The correlation between ISS and Maximum HV-AIS value was not statistically significant (Max HV-AIS/ISS r= 0.131, p=NS). All but two patients (97.2%) were operated on and 62 (69.6%) surgical procedures for treating a HVI have been performed. The

TABLE I - *Demographic Data*

Demographic and clinical findings	Pts n. 71	95% CI
Mean age, yr	36.69 ± 16.55	
Gender, n (%)		
Male	56 (78.9%)	
Female	15 (21.1%)	
Mechanism, n (%)		
Motor vehicle accident	62 (87.3%)	
Accidental falling	3 (4.3%)	
Sports accident	2 (2.8%)	
Trauma by crushing	2 (2.8%)	
Assault	2 (2.8%)	
HVI CT scan findings		
Extraluminal gas	6 (9.6%)	
Active extravasation of ev contrast	7 (11.3%)	
Mesenteric streding	9 (14.5%)	
Enhancement of bowel wall	16 (25.8%)	
Mesenteric Hematoma	23 (37.1%)	
Bowel Wall thickening	25 (40.3%)	
Isolated free fluid	35 (56.4%)	
Any positive HVI CT scan findings (sensitivity)	52 (83.8%)	
CT specificity	91.8%	72.3 - 91.9%
CT overall accuracy	90.4%	87.9 - 94.8%
CT Positive Predictive Value (PPV)	70.3%	58.5 - 80.3%
CT Negative Predictive Value (NPV)	96.1%	92.9 - 98.1%
Mean ISS	21.92±16.73	
ER access to OR time (min)	524.13±1782.88	
Overall Morbidity	27 (29.6%)	
Overall Mortality	14 (19.7%)	
Average hospital stay (days)	19.94±20.57	

(ER= emergency room; OR: operating room)

TABLE II - *Anatomical site of Injuries and Average AIS*

Organ	n.(%)	Average AIS
Stomach	3 / 71 (4.2)	2.67±0.57
Duodenum	2 / 71 (2.8)	3
Jejunum/ileum	30 / 71 (42.2)	2.77±0.43
Large intestine	17 / 71 (24)	2.18±0.39
Mesentery	32 / 71 (45.0)	2.47±0.62
Omentum	2 / 71 (2.8)	2
Bladder	3 / 71 (4.2)	3

TABLE III - *Associated body region injuries*

	n. (%)
Intra-abdominal	38/71 (53.5)
Orthopaedics	36/71 (50.7)
Thoracic	33/71 (46.5)
Neurological	17/71 (23.9)
Maxillo-facial	9/71 (12.6)

remaining 27 (30.4%) lesions were treated conservatively. The median time from access in the ER to the operation room was 180 minutes [range 45-14400 min]. The 2 duodenal perforations were treated with, wound edge debridement and primary closure performing intestinal derotation in one case. The 3 stomach injuries underwent primary gastric suture associated in one case with repair of the mesentery and diaphragm for associated injuries. Small bowel injuries were managed with primary repair of serosal tear or defects in 14 cases and resections with anastomosis in 10 cases. One patient underwent delayed explorative laparoscopy with only abscess drainage because no gut injury was found. Colonic lesions required 9 primary sutures, 2 multiple sutures associated with diverting stoma, and 2 Hartmann's procedure. Isolated mesenteric lesions without HVI in 9 cases required hemostatic control suture, in 2 cases laparoscopic exploration and hemostasis and in 2 cases laparotomy with drainage of infected hematoma. In 5 patients (7.0%) with an ISS higher than 35 a simple stapling segmental resection of the ileum or of the right colon was performed as a part of damage control surgery including splenectomy, liver packing, and temporary abdominal closure. Forty-nine patients (69%) had one or more associated body injuries (Table III). The average hospital stay was 19.94±20.57 days (range 1-119; median 14).

Univariate and Multivariate Analysis of Morbidity and Mortality

The overall morbidity and mortality rates were 29.6% (n=21/71) and 19.7% (n=14/71) respectively. In the 21 patients with eventful course there were 12 cases of respiratory failure (C-D grade III), one of which was further compounded by ARDS (Acute Respiratory Distress Syndrome C-D grade IV), 8 patients of severe sepsis with MOF evolved favorably (C-D grade IV), and 10 surgical site infections (C-D grade I). No HVI treatment-related complication was observed. The median hospital stay in the non-survivor patients was 4.50 days [range 1-23].

By univariate analysis, colon injury, additional intra-abdominal organ injuries, head/brain trauma, and orthopedic trauma were the categorical covariates having the greater odds for the occurrence of complication (Table IV). Among continuous variables, the mean ISS observed in patients who experienced complications and those with regular course was 27.00±16.96 and 19.90±15.69respectively. However, the difference did not reach statistical significance (p=0.094). The mean elapsed time from ER to OR was 1161.67±3163.23 min. in the 21 patients who experienced complications and 245.21±282.88 in patients with uneventful post-operative course. The difference was statistically significant (p=0.049). However when the analysis has been performed not taking into account the only one patient operated on 10 days after trauma, the difference was not statistically significant (mean value 499.75±920.65 min. vs 245.21±282.88 min.; p=0.086; median 240 min. vs 160 min.). The WBC count on admission was higher in patients who experienced complications (mean value of 16.37±4.61 $x10^3$ vs 12.69±3.94 $x10^3$; p=0.002). Unlike expectations,the mean value of Maximum HV-AIS was higher in the group of patients with uneventful postoperative course (2.62±0.56 vs2.33±0.48; p=0.047).

Preoperative transfusion, colon injury, stomach injury, accompanying body injuries, additional intra-abdominal organ injuries, thoracic trauma, head/brain trauma (Table V), ISS (mean value of 41.14±12.34 in non-survivors vs 17.30±13.49 in survivors; p<0.001), and MaximumHV-AIS(mean value of2.86±0.66 in non-survivors vs 2.46±0.50 in survivors; p=0.015) were found to be associated with increased risk of mortality.

Multivariate analysis indicated that only WBC(p=0.007) was significant independent predictor of morbidity whereas preoperative transfusion (p=0.010) and ISS (p<0.001) were significant risk factors for mortality.

Discussion

Blunt abdominal trauma is found in 7%-10% of trauma patients with the spleen and the liver most frequently involved. Hollow viscous injuries in blunt trauma are rare representing less than 1% of all patients with blunt trauma but the incidence is worldwide increasing. Moreover only 0.3% of all blunt trauma patients will have a perforated HVI [1-4, 15-17].

Two primary mechanisms of intra-abdominal structure damage can be considered: compression forces and deceleration forces [18,19]. Compression or concussive forces may result from direct blows or external compression against a fixed object (e.g. lap belt, spinal column). As concerning hollow viscus the forces may deform the gut and transiently increase intraluminal pressure, resulting in rupture. Deceleration forces cause stretching and linear shearing between relatively fixed and free objects resulting in bowel mesenteric attachments injuries and splanchnic vessels ruptures or thrombosis. To recognize an isolated traumatic injury to the bowel can be a clinical challenge because of subtle and non-specific clinical signs, thus eventually leading to a delay in diagnosis and treatment [20-22]. It is thought that an overlooked bowel injury is very dangerous because of its tremendous septic potential [17,23]. Whereas the type and distribution of injuries to the gastro-intestinal tract were similar to other series, the overall HVI frequency observed was high-

Table IV - *Univariate analysis of risk for morbidity*

Risk factor	Score	Morbidity rate	$\chi 2$	P	Odds ratio	95% CI
Colon injury	yes no	38.1% (8 of 21) 18.0% (9 of 50)	3.279	0.070	2.803	0.898-8.753
Orthopedic trauma	yes no	71.4% (15 of 21) 42.0% (21 of 50)	5.124	0.024	3.425	1.148-10.380
Additional intra-abdominal injury	yes no	71.4% (15 of 21) 46.0% (23 of 50)	3.844	0.050	2.935	0.979-8.799
Head/brain trauma	yes no	42.9% (9 of 21) 16.0% (8 of 50)	5.858	0.016	3.983	1.249-12.414

TABLE V - *Univariate analysis of risk for mortality*

Risk factor	Score	Morbidity rate	$\chi 2$	P	Odds ratio	95% CI
Stomach injury	yes	14.3% (2 of 14)	4.361	0.037	9.333	0.782-111.463
	no	1.8% (1 of 57)				
Preoperative blood transfusion	yes	78.6% (11 of 14)	12.163	0.000	9.396	2.314-38.150
	no	28.1% (16 of 57)				
Accompanying Body Injury	yes	100% (14 of 14)	7.830	0.005	Not calc	
	no	61.4% (35 of 57)				
Thoracic trauma	yes	100% (14 of 14)	20.081	0.000	Not calc	
	no	33.3% (19 of 57)				
Additional intra-abdominal injury	yes	100% (14 of 14)	15.144	0.000	Not calc	
	no	42.1% (24 of 57)				
Head/brain trauma	yes	50.0% (7 of 14)	6.501	0.011	4.700	1.346-16.411
	no	17.5% (10 of 57)				
Orthopedic trauma	yes	71.4% (10 of 14)	2.997	0.083	2.981	0.836-10.628
	no	45.6% (26 of 57)				
Maxillo-facial trauma	yes	28.6% (4 of 14)	3.980	0.046	4.160	0.948-18.252
	no	8.8% (5 of 57)				

er than those reported in literature. However as other study, our research shows that HVI mostly occurs generally in patients with a very high ISS [2,4,17]. These epidemiologic findings could be explained with the high rate of motor-vehicle crushes. The small intestine is the most commonly gastrointestinal tract injured, the colon and the stomach the less. Mesenteric and omentum injuries per se are rare [11,21] maybe because of unreported or underestimated. According to the literature our study shows that Multi-slice CT for bowel and mesenteric injuries should be considered the investigation of choice in hemodynamically stable patients suffering of blunt abdominal injury. Several investigations have reported a sensitivity and a specificity ranging between 69-95% and 94-100% respectively while other clinical studies failed to agree with these findings [24-31]. Present data are in the range of high overall diagnostic accuracy of CT examination, even when a retrospective pictures review was undertaken.

Although in our series the high mean elapsed time between the access to the ER and surgery seems to confirm the clinical challenge represented by traumatic HVI, it should be underlined that in the multivariate analysis the elapsed time does not play a significant role even when grouping patients for ISS value. However, early explorative laparotomy has to be considered crucial [2,6,32-34]. Simple primary repair is adequate for partial thickness laceration or for simple single perforation either of the small bowel or colon. More extensive injuries, multiple organ perforations and ischemia due to mesenteric injuries usually require resection and anastomosis with or without diverting stoma. Damage control surgery should be considered in high-risk patient. The high mortality rate reported in the present study reflects the severity of the trauma since our series shows a strong correlation only between mortality rate and ISS value. This finding means that mortality rate is closely dependent on the associated lesions and not strictly with HVI [3, 35] as well as recognized in the literature even in the face of penetrating injury.

The morbidity rate associated with HVI is remarkable high, however the HVI-related morbidity rate is often difficult to assess. Previous reports have shown that a long time to surgery correlates positively with the risk of developing complications [22,32,36]. Although the exact mechanism has not been clarified yet, the development of sepsis and MOF in trauma patients seems multifactorial. The prognostic impact of abdominal cavity contamination by intestinal microbiota has been unclear as demonstrated in studies evaluating the surgical outcomes of fecal peritonitis. Recently results reported by Han and coll. [37] showed that fecal contamination not significantly influenced morbidity or mortality in cases of colonic perforation. It is well known that trauma/hemorrhagic shock leads to gut barrier failure that initiates a systemic inflammatory response resulting in acute lung injury and multiple-organ dysfunction syndrome. The gut releases pro inflammatory mediators into the mesenteric lymph that activate inflammatory and endothelial cells. As a matter, the gut is considered to be central in the pathogenesis of multiple-organ dysfunction syndrome following trauma/hemorrhagic shock. Therefore the increased intra-abdominal pressure, the gut permeability alteration, the impairment of intestinal microcirculation, and the release of gut cytokines become even more paramount in in the pathogenesis of sepsis and MOF when the gut

itself is injured [38-42]. The most convincing and consistent finding of our study is that in the multivariate analysis the morbidity correlates only to systemic inflammatory response (elevated WBC count), even when the elapsed time between the traumatic event and the diagnosis and treatment has been taking into account.

Conclusion

In conclusion traumatic HIV, although rare, are complex and severe lesions associated with high mortality due to the high incidence and severity of associated lesions. Moreover morbidity could be related to the delay in diagnosis and treatment. Though our study had some limitations mainly because of its retrospective design, it appears clearly that during an ER evaluation of a blunt abdominal trauma an HIV has nowadays always to be considered to reach a quick diagnosis and prompt surgical intervention. The optimal management of these patients is still a matter of debate. The majority of injuries can now be safely managed by simple suture or resection and anastomosis. On the other hand the decision to perform a damage control surgery leaving defunctioned bowel should be based not only on the nature of the injury but rather on the ISS and the hemodynamic status of injured patient.

Riassunto

INTRODUZIONE: L'incidenza dei traumi addominali si attesta fino al 10% rappresentando frequentemente la principale causa di decesso nei pazienti politraumatizzati. Le lesioni degli organi cavi addominali, anche se rare, rappresentano una importante sfida diagnostica terapeutica, in quanto non presentano specifici quadri clinici e sono spesso misconosciute e associate ad un elevato tasso di mortalità e morbilità. Scopo di questo studio è stato quello di analizzare l'incidenza delle lesioni degli organi cavi addominali valutando le difficoltà diagnostiche e terapeutiche ed il loro significato prognostico
MATERIALI E METODO: Sono stati presi in considerazione i dati del Registro Traumi dell'Azienda Ospedaliera Sant'Andrea ed i dati provenienti dall' U.O.C. Chirurgia d'Urgenza A.C.O. San Filippo Neri di Roma nel periodo compreso tra Gennaio 2006 e Dicembre 2014. Settantuno pazienti, ovvero il 7.5% di tutti i pazienti con trauma addominale registrati, presentavano 89 HVI.
RISULTATI: La mortalità è stata del 19.7% (n=14/71) con una morbilità del 29.6% (n=21/71). Tutti i pazienti sono stati sottoposti a laparotomia d'urgenza. L'intervento chirurgico più frequentemente eseguito per le lesioni digiuno-ileali è stato la resezione con anastomosi seguita dalla rafia ileale. Per quanto riguarda le lesioni coliche, l'intervento effettuato nella maggior parte dei casi è stato la sutura della lesione. Dalla analisi multivariata solo il valore dei WBC è risultato essere un fattore predittivo statisticamente significativo per la morbidità, invece numero di trasfusioni pre-operatoria, valore dell'ISS sono risultati essere fattori di rischio significativi legati alla mortalità.
DISCUSSIONE: La nostra esperienza ha evidenziato come nel paziente politraumatizzato sia di fondamentale importanza un precoce inquadramento diagnostico delle lesioni intestinali ed un immediato ed appropriato trattamento chirurgico al fine di migliorare gli outcomes a breve e lungo termine.

References

1. McStay C, Ringwelski A, Levy P, Legome E: *Hollow viscus injury.* J Emerg Med, 2009; 37(3):293-99. Epub 2009 May 5.

2. Watts DD, Fakhry SM: *Incidence of Hollow Viscus Injury in Blunt Trauma: An Analysis from 275, 557 Trauma Admissions from the EAST Multi-Institutional Trial.* J Trauma, 2003; 54(2):289-94. Erratum in: J Trauma. 2003 54(4):749.

3. Swaid F, Peleg K, Alfici R, Matter I, Olsha O, Ashkenazi I, Givon A: Israel Trauma Group, Kessel B: *Concomitant hollow viscus injuries in patients with blunt hepatic and splenic injuries: An analysis of a National Trauma Registry database.* 2014; 45(9):1409-12. Injury.2014.02.027. Epub 2014 Feb 28.

4. Watts DD, Fakhry SM: *Colon injury after blunt abdominal trauma: Results of the EAST multi-institutional hollow viscus injury study.* J Trauma, 2003; 55(5):906-12.

5. McNutt MK, Chinapuvvula NR, Beckmann NM, Camp EA, Pommerening MJ, Laney RW, West OC, Gill BS, Kozar RA, Cotton BA, Wade CE, Adams PR, Holcomb JBJ: *Early surgical intervention for blunt bowel injury: The Bowel Injury Prediction Score (BIPS).* Trauma Acute Care Surg, 2015; J8(1):105-11.

6. Lin HF, Chen YD, Lin KL, Wu MC, Wu CY, Chen SC: *Laparoscopy decreases the laparotomy rate for hemodynamically stable patients with blunt hollow viscus and mesenteric injuries.* Am J Surg, 2015; 210(2):326-33. Epub 2015 Apr 14.

7. Roberts DJ, Bobrovitz N, Zygun DA, Ball CG, Kirkpatrick AW, Faris PD, Stelfox HT: *Indications for use of damage control surgery and damage control interventions in civilian trauma patients: A scoping review.* J Trauma Acute Care Surg, 2015; 78(6):1187-96.

8. Gonser-Hafertepen LN, Davis JW, Bilello JF ,et al.: *Isolated free fluid on abdominal computed tomography in blunt trauma: Watch and wait or operate?* J Am Coll Surg, 2014; 219(4):599-605.

9. Costa G, Stella F, Venturini L, Tierno SM, Tomassini F, Fransvea P, Frezza B, Bocchetti T, Di Somma S, Balducci G: *The usefulness of a Trauma Registry and the role of the general surgeon in the multidisciplinary approach to trauma patients: 3 years experience at Sant'Andrea University Hospital in Rome.* Ann Ital Chir, 2013; 84(1):1-8.

10. Dindo D, Demartines N, Clavien PA: *Classification of surgical complications a new proposal with evaluation in a cohort of 6336 patients and results of a survey.* Ann Surg, 2004; 240(2):205-13.

11. Pekkari P, Bylund PO, Lindgren H, et al.: *Abdominal injuries in a low trauma volume hospital-a descriptive study from northern Sweden.* Scand J Trauma Resusc Emerg Med, 2014; A15;15;22:48.

12. Campbell BT, Saleheen H, Borrup K, McQuay J, Luk S, Hiscoe J: *Lapidus G. Epidemiology of trauma at a level 1 trauma center*. Conn Med, 2009; 73(7):389-94.

13. Kraus JF, Peek-Asa C, Cryer HG: *Incidence, severity and patterns of intrathoracic and intra-abdominal injuries in motorcycle crashes*. J Trauma, 2002; 52(3):548-53.

14. Jansen JO, Yule SR, Loudon MA: *Investigation of blunt abdominal trauma.* BMJ, 2008; 336:938-42.

15. Lu Q, Xu DZ, Sharpe S, Doucet D, Pisarenko V, Lee M, Deitch EA: *The anatomic sites of disruption of the mucus layer directly correlate with areas of trauma/hemorrhagic shock-induced gut injury.* J Trauma, 2011; 70(3):630-35.

16. Wisner DH, Chun Y, Blaisdell FW: *Blunt intestinal injury: keys to diagnosis and management*. Arch Surg, 1990; 125:1319-323.

17. Hughes TMD, Elton C, Hitos K, Perez JW, McDougall P.: *An Intra-abdominal gastrointestinal tract injuries following blunt trauma: The experience of an Australian trauma center.*Injury, 2002; 33(7):617-26.

18. Hughes TMD, Elton C: *The pathophysiology and management of bowel and mesenteric injuries due to blunt trauma.* Injury, 2002; 33(4):295-302.

19. Hunt JP, Weintraub SL, Marr AB: *Kinematics of trauma.* In: Feliciano DV, Moore EE, Mattox KL (eds):. *Trauma.* 6rd ed. New York: McGraw-Hill, 2008; 106-17.

20. Matsushima K, Mangel PS, Schaefer, et al.: *Blunt hollow viscus and mesenteric injury: still under recognized*. World J Surg, 2013; 37(4):414-18.

21. Watts DD, Fakhry SM, Fred AL.: *Diagnostic approaches lack sensitivity in the diagnosis of perforated blunt small bowel injury: Analysis from 275,557 trauma admissions from the EAST Multi-Institutional HVI Trial.* J Trauma, 2003; 54(2):295-306.

22. Malinoski DJ, Madhukar PS, Didem OY, Green D, Qureshi F, Inaba, K, Brown CVR, Salim Ali: *A diagnostic delay of 5 hours increases the risk of death after blunt hollow viscous injury*. J Trauma, 2010; 69(1):84-7.

23. Pfeifer R, Ivan ST, Rocos B, Pape HC: *Patterns of mortality and causes of death in polytrauma patients-has anything changed?* Injury, 2009; 40(9):907-11.

24. Kokabi N, Harmouche E, Xing M, Shuaib W, Mittal PK, Wilson K, Johnson JO, Nicolaou S, Khosa F: *Specific radiological findings of traumatic gastrointestinal tract injuries in patients with blunt chest and abdominal trauma.* Can Assoc Radiol J, 2015; 66(2):158-63. Epub 2015 Feb 20.

25. Petrosoniak A, Engels PT, Hamilton P, Tien HCJ: *Detection of significant bowel and mesenteric injuries in blunt abdominal trauma with 64-slice computed tomography*. Trauma Acute Care Surg, 2013; 74(4):1081-86.

26. Ekeh AP, Saxe J, Walusimbi M, et al.: *Diagnosis of blunt intestinal and mesenteric injury in the era of multidetector CT technology. Are results better?* J Trauma, 2008; 65(2):354-59.

27. Bhagvan S, Turai M, Holden A, Ng A, Civil I: *Predicting hollow viscus injury in blunt abdominal trauma with computed tomography.* World J Surg, 2013; 37(1):123-26.

28. Khan I, Bew D, Elias DA, Lewis D, Meacock LM: *Mechanisms of injury and CT findings in bowel and mesenteric trauma.* Clin Radiol, 2014; 69(6):639-47. Epub 2014 Mar 4.

29. Allen TL, Mueller MT, Bonk RT, et al.: *Computed tomographic scanning without oral contrast solution for blunt bowel and mesenteric injuries in abdominal trauma*. J Trauma, 2004; 56(2):314-22.

30. LeBedis CA, Anderson SW, Soto JA: *CT imaging of blunt traumatic bowel and mesenteric injuries.* Radiol Clin North Am, 2012; 50(1):123-36.

31. Tan KK, Liu JZ, Go TS, Vijayan A, Chiu MT: *Computed tomography has an important role in hollow viscus and mesenteric injuries after blunt abdominal trauma.* Injury, 2010; 41(5):475-78.

32. Fakhry AM, Browstein M, Watts DD, Baker CC, Oller D: *Relatively short diagnostic delay (<8 hours) produce morbidity and mortality in blunt small bowel injury: An analysis of time to operative intervention in 198 patients from a multicenter experience.* J Trauma, 2000; 48(3):408-14; discussion 414-15.

33. Demetriades D, Murray JA, Chan LS, et al.: *Handsewn versus stapled anastomosis in penetrating colon injuries requiring resection: Amulticenter study.* J Trauma, 2002; 52(1):117-21.

34. Demetriades D, Murray JA, Chan LS, et al.: *Penetrating colon injuries requiring resection: Diversion or primary anastomosis? An AAST prospective multicenter study.* J Trauma, 2001; 50(5):765-75.

35. Arikanoglu Z, Turkoglu A, Taskesen F, Ulger BV, Uslukaya O, Basol O, Aldemir M: *Factors affecting morbidity and mortality in hollow visceral injuries following blunt abdominal trauma.* Clin Ter, 2014; 165(1):23-6.

36. Hazlitt M, Hill JB, Gunter OL, Guillamondegui OD: *Disparities in trauma: the impact of socioeconomic factors on outcomes following traumatic hollow viscus injury.* J Surg Res, 2014; 191(1):6-11. Epub 2013 Jun 5.

37. Han EC, Ryoo SB, Park BK, Park JW, Lee SY, Oh HK, Ha HK, Choe EK, Moon SH, Jeong SY, Park KJ: *Surgical outcomes and prognostic factors of emergency surgery for colonic perforation: Would fecal contamination increase morbidity and mortality?* Int J Colorectal Dis, 2015.

38. Shimizu K, Ogura H, Hamasaki T, Goto M, Tasaki O, Asahara T, Nomoto K, Morotomi M, Matsushima A, Kuwagata Y, Sugimoto H: *Altered gut flora are associated with septic complications and death in critically ill patientswith systemic inflammatory response syndrome*. Dig Dis Sci, 2011; 56(4):1171-177.

39. Senthil M, Brown M, Xu DZ, Lu Q, Feketeova E, Deitch EA: *Gut-lymph hypothesis of systemic inflammatory response syndrome/multiple-organ dysfunction syndrome: validating studies in a porcine model.* J Trauma, 2006; 60(5):958-65.

40. Suliburk J, Helmer K, Moore F, Mercer D: *The gut in systemic inflammatory response syndrome and sepsis. Enzyme systems fighting multiple organ failure.* Eur Surg Res, 2008; 40(2):184-89.

41. Sodhi CP, Jia H, Yamaguchi Y, Lu P, Good M, Egan C, Ozolek J, Zhu X, Billiar TR, Hackam DJ: *Intestinal epithelial TLR-4 activation is required for the development of acute lung injury after trauma/hemorrhagic shock via the release of hmgb1 from the gut*. J Immunol, 2015; 194(10):4931-939.

42. Morishita K, Costantini TW, Ueno A, Bansal V, Eliceiri B, Coimbra R: A *pharmacologic approach to vagal nerve stimulation prevents mesenteric lymph toxicity after hemorrhagic shock*. J Trauma Acute Care Surg, 2015; 78(1):52-8.