ORIGINAL RESEARCH

Laparotomy Due to War-Related Penetrating Abdominal Trauma in Civilians: Experience From Syria 2011-2017

Bayan Alsaid, MD, PhD; Maryam Alhimyar, MD; Ahmad Alnweilaty, BS; Ehab Alhasan, BS; Zein Al Abidin Shalhoum, BS; Mustafa Bathich, BS; Ahmad Mustafa Ahmad, BS; Tareq Ahmad, MD; Khaled Turkmani, MD; Samer Sara, MD

ABSTRACT

Objectives: Penetrating abdominal trauma is one of the injuries that could affect civilians in wartime. This retrospective study investigates the commonly injured abdominal organs, and the impact of multiple injured organs on mortality.

Methods: We reviewed the operating room (OR) logs of patients who presented to the surgical emergency department (SED) at Al-Mouwasat University Hospital with war-related abdominal penetrating trauma requiring exploratory laparotomy between April 1, 2011 and December 31, 2017.

Results: Of 7826 patients with traumatic injuries, 898 patients (11.5%) required exploratory laparotomy. Of all patients who had an exploratory laparotomy (n = 898), 58 patients (6.5%) died in the perioperative period. Regarding complete laparotomies (n = 873 patients), small intestines, large intestines, and liver were the most commonly affected organs (36.4%, 33%, 22.9%, respectively). A total of 92 patients (10.2%) had negative laparotomy in which all the abdominal organs were not injured. The perioperative mortality rate (POMR) increased when more organs/organ systems were injured per patient reaching a peak at 3 organs/organ systems injuries with a POMR of 8.3%. POMR was highest in patients with musculoskeletal injuries (18.2%), followed by vascular injuries (11.8%), and liver injuries (7%).

Conclusions: The management of civilians' abdominal injuries remains a challenge for general and trauma surgeons, especially the civilian trauma team. The number and type of injured organs and their correlation with mortality should be considered during surgical management of penetrating abdominal injuries.

Keys Words: abdominal trauma, damage control surgery (DCS), perioperative mortality rate (POMR), Syrian armed conflict (SAC), Syrian war

Middle East and North African (MENA) regions have engaged in many wars in the past few decades.[1] For instance, the Middle East has suffered from Arab-Israeli wars, the Lebanese civil war, the Iraqi War, and recently the Syrian armed conflict (SAC). Unstable political situations in MENA states, violence, and terrorist attacks were on the rise. There is a surge of preventable civilian mortality and morbidity in conflict and war, especially in MENA regions, and since 2011, the SAC has put many Syrian civilians' lives in danger.

Bombings and terrorist attacks cause large numbers of causalities, which require urgent assessment and management. The continuous influx of injured people limits the tests that are possible to use and proves to be a challenge for medical teams.[2]

In the past century, plain radiography of the abdomen and diagnostic peritoneal lavage (DPL) were used to assess penetrating abdominal trauma. Those methods resulted in many false positive results, making DPL a controversial method of assessing penetrating trauma patients.[3] The Second World War gave way to laparotomy to increase the survival of such cases, which were previously managed by observation.[4]

Damage control surgery (DCS) is a 3-phased technique of surgery used to save the lives of severely injured trauma patients. Phase I is based on "abbreviated laparotomy" that is done for hemorrhage and contamination control, followed by temporary abdominal closure. Phase II targets correcting hypothermia, coagulopathy, and acidosis in the intensive care unit (ICU), after which phase III of re-exploration is undertaken for definitive management of injuries and abdominal closure.[5]

Damage control resuscitation (DCR) is a strategy for resuscitating patients from hemorrhagic shock to restore homeostasis. Efforts are focused on blood product transfusion in which the use of crystalloid are limited to avoid dilutional coagulopathy, hypotensive resuscitation until bleeding control is achieved, empiric use of tranexamic acid, correction of acidosis and hypothermia, and rapid surgical control of hemorrhage.[6]

https://doi.org/10.1017/dmp.2020.77 Published online by Cambridge University Press

Mandatory laparotomy is the main management for patients with penetrating abdominal trauma having a positive FAST (focused assessment with sonography in trauma), while immediate laparotomy must be conducted when hemodynamic instability is present.[3,7] Otherwise, a computed tomography (CT) scan should be done to assess and find the injury.[3] Constant factors are thought to play a great role in defining the types of injuries such as the mechanism of injury; whether caused by high-velocity gunshots, mortars, shrapnel, or improvised explosive devices (IEDs).[1]

The types of organ injuries relate to the mortality rate,[8] and the number of injured organ systems affects the final health status.[9]

The experience gained during wars and terrorist attacks—regardless of differing battle environments—helps to get a clear vision of trauma injuries and their management.[10,11] While reviewing the literature, a single study regarding SAC was done in Syrian medical facilities,[12] while all other studies were conducted in non-Syrian institutions.[13-29] In this study, we present 898 wartime abdominal injuries, considering that the management of abdominal injuries remains a challenge despite the evolving medical technologies in diagnosis and therapy.[3,10,30]

METHODS

Study Design and Data Sources

After obtaining the required permission and the ethics committee approval, we reviewed the operating room (OR) logs of patients who presented to the surgical emergency department (SED) at Al-Mouwasat University Hospital suffering from traumatic injuries and underwent surgical intervention, then we extracted data about patients who were subject to exploratory laparotomy due to war-related penetrating abdominal trauma. Some patients' data were missing in the OR logs. So, we retrieved the missing data from the hospital's archive. Patients who died in the SED before reaching the OR were not included in our study design because their data were not registered in OR logs.

Al-Mouwasat University Hospital is a teaching hospital linked to the faculty of medicine in Damascus University. The hospital has 850 beds, 60 in the SED.

Our population was the patients who came to the SED at Al-Mouwasat University Hospital requiring exploratory laparotomy due to high-velocity gunshot and explosive device injuries between April 1, 2011 and December 31, 2017. However, data on laparotomies during the period from August 23, 2011 to June 2, 2012 were missing because of the war damage to record storage, so we excluded them.

Data Analysis

We collected data from patients' records, sorted it into tables created with Microsoft Excel 2016, and arranged it in 7 categories: injury type, age, gender, admission date, affected organs, treatment, and death (mortality).

We analyzed data using Microsoft Excel 2016 and Google sheets; calculations were compared using means and percentages (Table 1; Figure 1).

RESULTS

Description of the Sample

From April 1, 2011 to December 31, 2017, 7826 patients arrived at SED at Al-Mouwasat University Hospital because of traumatic injuries. A total of 898 (11.5%) had a war-related penetrating abdominal injury requiring exploratory laparotomy. Distribution of patients during years (2011-2017) is demonstrated in Figure 1.

Exploratory laparotomy was performed on patients having a penetrating abdominal injury with hemodynamic instability, positive FAST showing free fluid, or positive findings on abdominal CT scan. A total of 898 patients underwent exploratory laparotomies, 873 (97.2%) patients underwent complete laparotomies with well-known intra- and extra-abdominal injuries, while 25 patients (2.8%) had fulminant hemorrhage and death that impeded full exploration of the abdomen.

Among all patients who had an exploratory laparotomy (n = 898), 680 (75.7%) patients were males. The age distribution peaks in the second decade of life (Figure 2). Women (aged between 18 and 60 years old), elderly (> 60 years), and children (< 18 years) constitute 51.2% of patients, while 48.8% were men (18-60 years old).

The major cause of injury was shrapnel from explosive devices (47% of patients who underwent an exploratory laparotomy n = 898), while gunshots were responsible for 36.1%. However, the type of projectile was undetermined in 16.9% of patients.

Abdominal Injuries in Detail

Of patients who had complete laparotomies (n = 873), the 3 most common organs affected by abdominal penetrating injuries were the small intestines (including duodenum, jejunum, and ileum) in 36.4% of patients, the large intestines (ascending, transverse, descending, sigmoid colons and the upper third of rectum) in 33% of patients, and the liver in 22.9%. The rates of spleen, stomach, and pancreas injuries are shown in Figure 3.

A percentage of 42.8% of patients had other concomitant injuries, including, from the most common to the least, vascular, genitourinary, thoracic, musculoskeletal, gynecological, neurological, and other extra-abdominal injuries (Figure 3).

A total of 56.4% of patients had multiple injuries, while 34.6% had isolated injuries. Considering the injury of each of the

https://doi.org/10.1017/dmp.2020.77 Published online by Cambridge University Press

TABLE 1

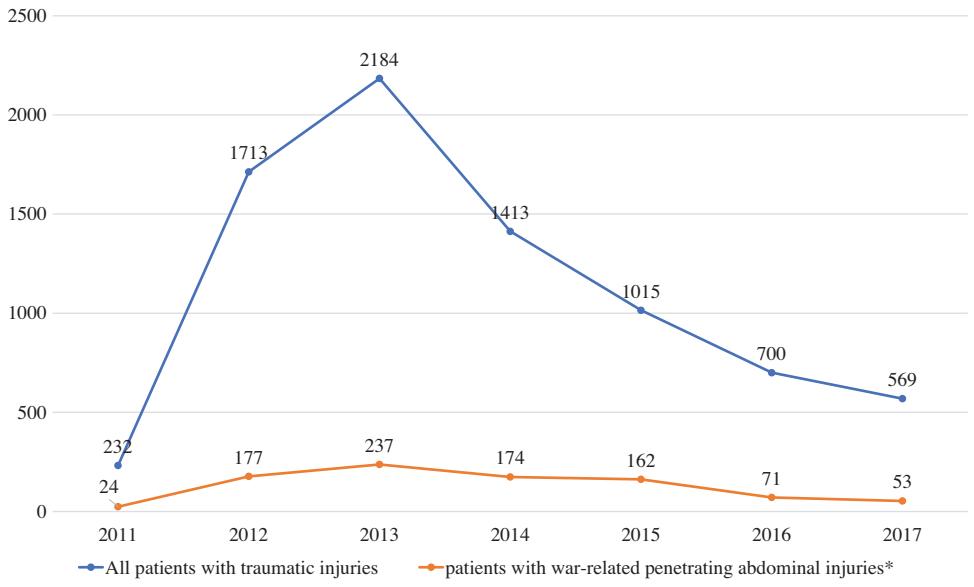
Rates of Numbers of Organs/Organ Systems Injured per Patient in 873 Patients Who Had a Complete Laparotomy, in Addition to the Rates of the Mechanism of Injury in Each Group of Patients

No. of Organs/Organ Systems Injured per Patient	No. of Patients	Deaths (POMR)	Shrapnel Injured (From Explosive Devices)	Gunshots Injured	Undetermined Cause of Injury
0	79 (9.0%)	0 (0.0%)	38 (48.1%)	25 (31.6%)	16 (20.3%)
1	302 (34.6%)	7 (2.3%)	153 (50.7%)	79 (26.2%)	70 (23.2%)
2	273 (31.3%)	9 (3.3%)	127 (46.5%)	108 (39.6%)	38 (13.9%)
3	145 (16.6%)	12 (8.3%)	61 (42.1%)	67 (46.2%)	17 (11.7%)
4	50 (5.7%)	4 (8.0%)	21 (42.0%)	24 (48.0%)	5 (10.0%)
5	18 (2.1%)	1 (5.6%)	13 (72.2%)	5 (27.8%)	0 (0.0%)
6	4 (0.5%)	0 (0.0%)	2 (50.0%)	2 (50.0%)	0 (0.0%)
7	1 (0.1%)	0 (0.0%)	0 (0.0%)	1 (100.0%)	0 (0.0%)
8	1 (0.1%)	0 (0.0%)	1 (100.0%)	0 (0.0%)	0 (0.0%)
Multiple: ≥ 2	492 (56.4%)	26 (5.3%)	225 (45.7%)	207 (42.1%)	60 (12.2%)

Abbreviation: POMR, perioperative mortality rate.

FIGURE 1

Number of All Patients Who Presented to the Surgical Emergency Department at Al-Mouwasat Hospital, and the Number of Penetrating Abdominal Injuries Requiring Exploratory Laparotomy from April 1, 2011 to December 31, 2017. *The data from August 23, 2011 to June 2, 2012 were missing.



following organs: small intestines, large intestines, liver, spleen, stomach, pancreas, or other intra-abdominal injuries (ie, mesenteric, omental injuries) as 1 organ injury, and each vascular, genitourinary, thoracic, musculoskeletal, gynecological, neurological, or other extra-abdominal injuries (ie, wounds) as 1 organ system injury (Table 1). The rest 9% of patients (n = 79) had neither intra- nor extra-abdominal injuries.

For instance, of the patients who had exploratory laparotomies (n = 898), 92 patients (10.2%) had negative laparotomies (there was no intra-abdominal organ injury, despite the penetrating injury of the abdomen). However, 13 patients (14.1%) had concomitant extra-abdominal injuries (Table 2).

Perioperative Mortality Rate

Of patients who had exploratory laparotomies (n = 898), 58 patients (6.5%) died in the operating or recovery room. Twenty-five patients (2.8%) died because of fulminant hemorrhage before getting their abdomen fully explored, so their injuries remained unknown, while 33 patients (3.7%) died with diagnosed injuries (Table 2).

https://doi.org/10.1017/dmp.2020.77 Published online by Cambridge University Press

FIGURE 2

Distribution of 898 Patients Who Had Laparotomies by Age and Sex.

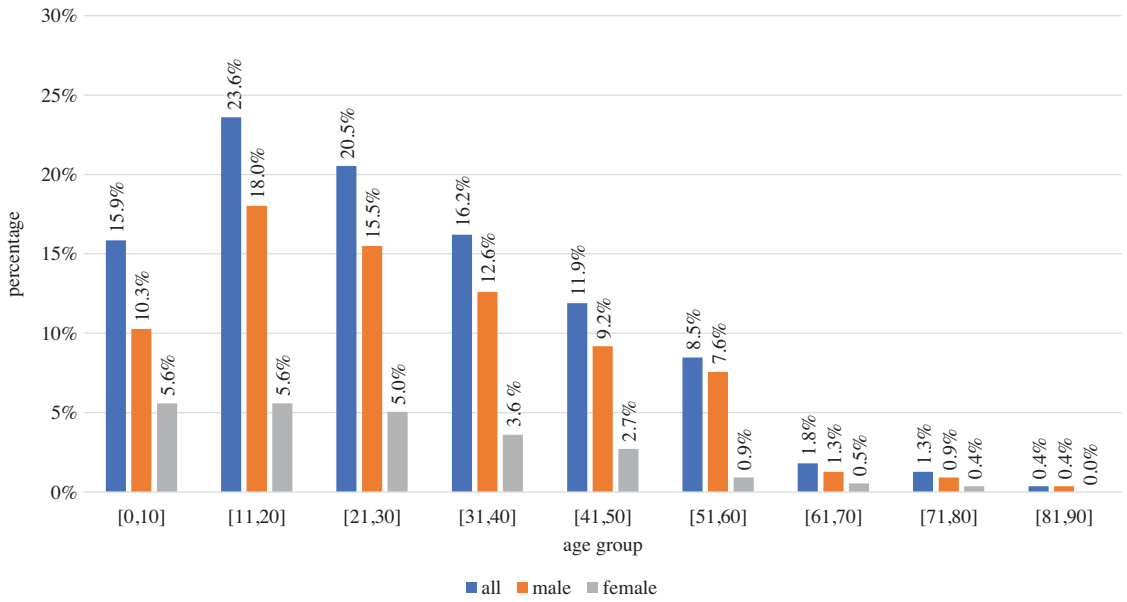
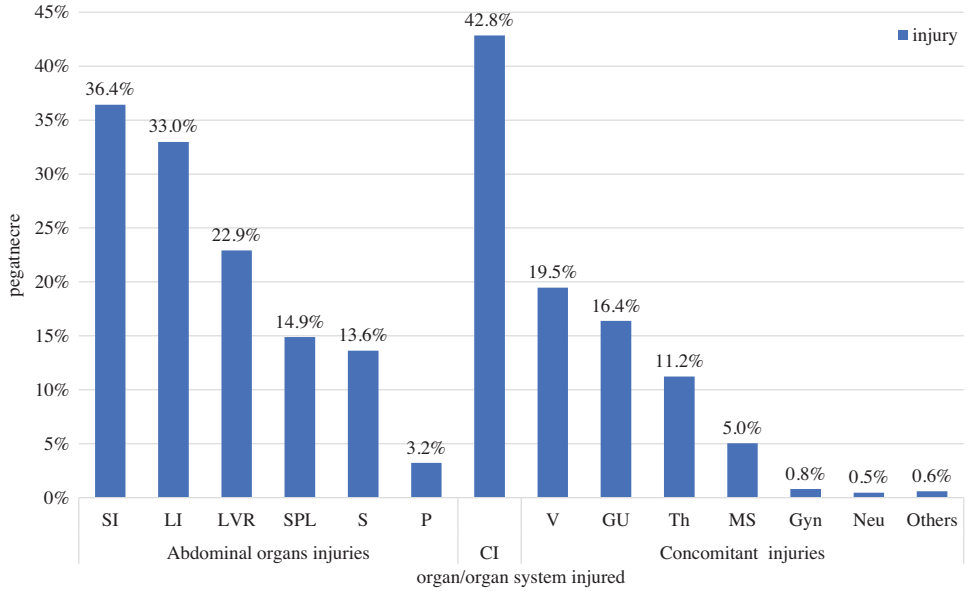


FIGURE 3

Rate of Intra-abdominal Organ Injuries, and Concomitant Organ System Injuries in 873 Patients Who Had a Complete Laparotomy. SI: small intestines; LI, large intestines; LVR, liver; SPL, spleen; S, stomach; P, pancreas; CI, concomitant injuries; V, vascular; GU, genitourinary; Th, thoracic; MS, musculoskeletal; Gyn, gynecologic; Neu, neurologic; Others, other extra-abdominal Injuries.



https://doi.org/10.1017/dmp.2020.77 Published online by Cambridge University Press

TABLE 2

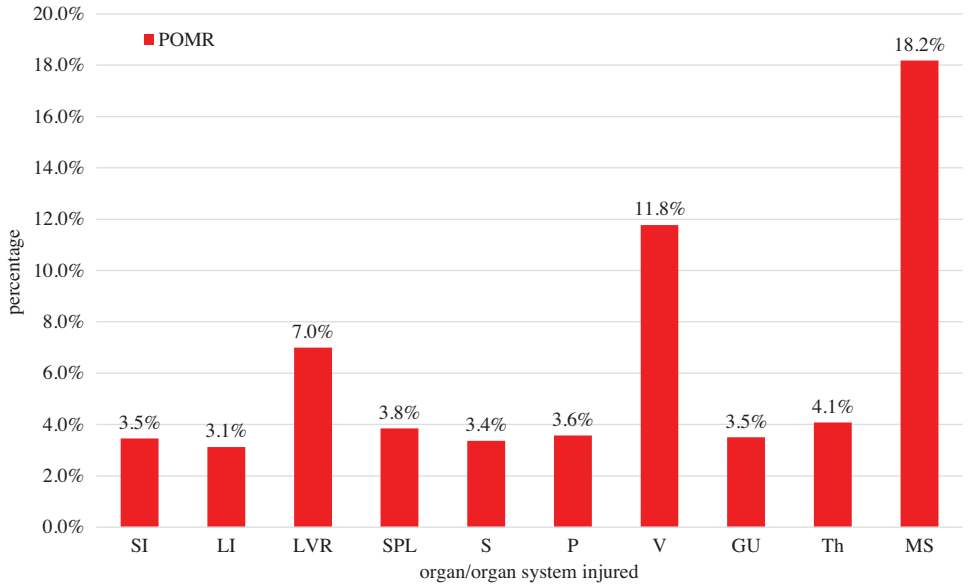
Rates of Deaths Due to Fulminant Hemorrhage, Deaths With Diagnosed Injuries, and Negative Laparotomies in All Patients Who Had Laparotomies (898 Patients) in Addition to the Rates of the Mechanism of Injury in Each Group of Patients

	No. of Patients	Deaths (POMR)	Shrapnel Injured (From Explosive Devices)	Gunshots Injured	Undetermined Cause of Injury
Deaths due to fulminant hemorrhage	25 (2.8%)	-	6 (24.0%)	13 (52.0%)	6 (24.0%)
Deaths with diagnosed injuries	33 (3.7%)	-	13 (39.4%)	12 (36.4%)	8 (24.2%)
Negative laparotomies	92 (10.2%)	2 (2.2%)	45 (48.9%)	30 (32.6%)	17 (18.5%)

Abbreviation: POMR, perioperative mortality rate.

FIGURE 4

Perioperative Mortality Rate of Abdominal Organ Injuries, and Concomitant Organ System Injuries* in 873 Patients Who Had a Complete Laparotomy. SI, small intestines; LI, large intestines; LVR, liver; SPL, spleen; S, stomach; P, pancreas; V, vascular; GU, genitourinary; Th, thoracic; MS, musculoskeletal; POMR, perioperative mortality rate. *The POMRs of gynecological, neurological, and other extra-abdominal concomitant injuries were not shown because of the lack of sufficient sample size.



Seven percent (14 deaths/200 patients) of patients who had a liver injury died in the perioperative period. Thus, liver injuries were associated with the highest perioperative mortality rate (POMR) of intra-abdominal organ injury, while the remaining intra-abdominal organ injuries POMRs ranged from 3.1% to 3.8%. The highest POMR of other concomitant injuries was due to musculoskeletal injuries (POMR: 18.2%; 8 deaths/44 patients), followed by vascular injuries (POMR: 11.8%; 20 deaths/170 patients) (Figure 4).

The POMR increased when more organs/organ systems were injured reaching a peak at 3 organs/organ systems injuries with a POMR of 8.3% (12 deaths/145 patients). Afterward, POMR slightly decreased at 4 organs/organ systems injuries (POMR 8%; 4 deaths/50 patients), and decreased clearly afterward (Table 1).

The type and the number of organs/organ systems injured affected mortality rates. For instance, among the patients who died because of isolated injuries (n = 7), 3 patients had vascular injuries (presenting as retroperitoneal hematoma), two patients sustained liver injuries, and 2 patients died because of severe musculoskeletal injuries. While among patients who sustained multiple injuries (n = 26), the main cause of death was liver and vascular injuries with or without concomitant intra or extra-abdominal injuries (n = 8).

https://doi.org/10.1017/dmp.2020.77 Published online by Cambridge University Press

The remainder of deaths (n = 18) were caused by various combinations of injuries (ie, intestinal, vascular, musculoskeletal, splenic, genitourinary, hepatic, thoracic, gastric, and neurological injuries, arranged by their incidence rates).

Negative laparotomies had a POMR of 2.2% (2 deaths/ 92 patients), in which deaths were attributed to severe musculoskeletal injuries (Table 2).

Specific Details About Organs/Organ Systems Injuries

Small Intestines (Duodenum, Jejunum, and Ileum)

Three hundred eighteen patients had small bowel injuries; the POMR was 3.5% (11 deaths/318 patients). A total of 58.7% of the patients had multiple small intestine (SI) injuries, and 14.8% of these patients had an accompanying mesenteric injury. Repair procedures included primary repair, resection of the involved segment and anastomosis, a combination of these 2, and sometimes ileostomy was performed.

Large Intestines (Ascending, Transverse, Descending, Sigmoid Colons, and the Upper Third of Rectum)

A total of 288 patients had large intestine (LI) injuries (POMR: 3.1%, 9 deaths/288 patients). Most of the LI injuries were single. Operative approaches were primary repair, resection and anastomosis, and ileostomy or colostomy.

Liver

Two hundred patients had liver injuries (POMR: 7.0%; 14 deaths/200 patients). Twelve patients had accompanying gallbladder injuries. A total of 66.4% of injuries were in the right lobe, 26.5% in the left lobe, and in 7.1% of patients both lobes were injured. Most of the liver injuries were managed by debridement and hemostatic maneuvers such as sutures and hemostatic agents (ie, dressings and Gelfoam).

Spleen

One hundred thirty patients had splenic injuries, ranging from a minor laceration to complete rupture (POMR: 3.8%; 5 deaths/130 patients). Surgical management included 2 main procedures, splenectomy, and hemostatic maneuvers.

Stomach

A total of 119 patients had gastric injuries (POMR: 3.4%; 4 deaths/119 patients). Isolated gastric injuries exceeded multiple ones. Almost all gastric perforations were treated with 1 or 2-layer continuous sutures, rarely resection of the injured part and anastomosis were needed.

Pancreas

Twenty-eight patients had pancreatic injuries (POMR: 3.2%; 1 deaths/28 patients). The injury site varied between the head, neck, body, and tail of the pancreas. Treatment included mainly 2 options depending on the severity of the injury, primary repair, and debridement and resection of the injured part.

Vascular Injuries

A total of 170 patients had vascular injuries (POMR: 11.8%; 20 deaths/170 patients). The most common presentation of vascular injuries was a retroperitoneal hematoma, which was seen in 106 patients, 13 of them died. Primary repair and ligation of the bleeding vessel were the main management options.

Genitourinary

A total of 143 patients had genitourinary (GU) tract injuries (ie, kidneys, ureters, bladder, urethra, vas deferens, testes, and penis). POMR: 3.5%, 5 deaths/143 patients. Two patients had an injury to the adrenal gland. Primary repair, hemostatic agents, partial and total nephrectomy, nephrostomy, orchiectomy, and suprapubic catheter were performed to manage different types of GU injuries.

Thoracic

Ninety-eight patients had thoracic injuries (POMR: 4.1%; 4 deaths/98 patients). The major type of injury was diaphragmatic perforation; other types included rib fractures and lung injuries. Almost all patients were managed by primary repair and chest tube placement.

Musculoskeletal

Forty-four patients had limb injuries (ie, muscle lacerations and bone fractures)(POMR: 18.2%, 8 deaths/44 patients). The management included sutures, external fixation, or amputation of the injured limb.

Other Injuries

Four patients had neurological injuries (1 died), 7 female patients had uterine and ovarian injuries (no deaths), and 5 patients had other extra-abdominal injuries (ie, wounds), no deaths were reported either.

DISCUSSION

The medical staff usually deals with penetrating abdominal injuries sustained by civilians. These injuries are mostly stab wounds, traffic accidents, and low-velocity gunshot wounds. However, during wars and armed conflicts, injuries and trauma are different, and they comprise high-velocity gunshot wounds and explosive device injuries. In those exceptional situations, the civilian trauma teams providing damage control resuscitation and damage control surgery to civilians suffer from some extra difficulties, most importantly the large influx of critically traumatized patients and the relative lack of adequately experienced staff to deal with such cases. This is compounded or exacerbated by high-velocity weapon systems, high order explosives, and other lethal weapon systems designed for

https://doi.org/10.1017/dmp.2020.77 Published online by Cambridge University Press

killing of populations and deployed by state level militaries and armed groups. War injuries convey a higher mortality rate mainly due to the major energy transmitted to tissues.[31]

During the SAC, our hospital was one of the major medical centers to handle emergencies in Damascus. The medical staff in our hospital had to manage new cases of penetrating injuries to large numbers of civilians. This constitutes a challenge for the medical establishment. To our knowledge, 18 studies about Syrian war victims' injuries were published from 2011 to 2015.[12-29] However, all these studies were relatively in a short period of time, the shortest study was 1 mo long and the longest was 27 mo long. Two studies were concerned with abdominal penetrating injuries; Arafat et al. conducted a study in Damascus-Syria and reviewed abdominal trauma victims for 9 months,[12] and Iflazoglu et al. studied mortality in penetrating abdominal firearm injuries.[29] Other studies were about the orthopedic trauma,[15] pediatric trauma,[16] vascular trauma,[19,28] hospital costs,[21] trauma care,[23] intensive care units,[24] post-traumatic growth,[26] head and neck injuries and patterns of trauma.[13,14,17,18,20,22,25,27] We reviewed the characteristics of penetrating abdominal injuries endured by civilian victims at the emergency department of our hospital from April 2011 to December 2017 (76 months). These victims arrived at the emergency department within several minutes to an hour after injury from different regions of Damascus and the nearby suburbs. The waiting time from arrival at the hospital to entry into OR depended on the patients' influx and the nature of massive attacks, but typically it did not exceed 30 min to perform the operation in unstable critical patients.

During the SAC, some attacks were perpetrated in residential neighborhoods, schools, and markets, especially in Damascus city. Consequently, women, children, and the elderly accounted for almost half the victims (51.2%) in our sample, which shows that a higher percentage of men were injured in comparison with the general population gender/age distribution in Syria (2018) according to Syrian Central Bureau of Statistics[32]: Men (20-60 years) 22%; women (20-60 years), elderly(>60 years), and children (<20 years) 78%, simply because men are more likely to be outdoors due to local traditional customs and war condition, therefore, they were more prone to injury. In contrast with other studies, the elderly, children, and women casualties do not usually exceed 15% of total victims.[20,21] This difference is related to the differences in the sample of civilian patients. Al-Mouwasat University Hospital is located in urban Damascus and serves a mainly civilian population; injured soldiers were typically transported to military or field hospitals.

There are 2 main types of attacks: gunshots and explosions. The explosive injuries are those caused by mortars, shrapnel, and IEDs. Explosive attacks often result in more civilian casualties than gunshots.[33]

In our study, explosive devices accounted for 47% of injuries and gunshots accounted for 36.1%, while 16.9% of injuries had unknown causes due to the lack of patient records. These results are in accordance with a previous study conducted in Damascus Hospital, where explosive devices resulted in 56.5% of total injuries and gunshots resulted in 43.5%.[12] However, the findings of the current study differ from those published by Iflazoglu et al., where shrapnel resulted in 40% and bullets resulted in 60% of injuries. This difference is due to the fact that the majority of their sample were males 95.8%,[29] probably male combatants are more likely to be injured in battle by gunshots.

According to studies conducted on war injuries in Afghanistan and Iraq, abdominal injuries constitute only 2% and 6.9% of the total war injuries, respectively.[34,35] Whereas, abdominal injuries sustained by Syrian refugees in Turkey and Jordan account for 8% of the injuries.[20,21] In our study, abdominal injuries constitute 11.5% of total reported injuries and this percentage is higher than the ones reported in similar studies.[20,21,34,35] A possible explanation for this result might be that only civilians were included in our study and they were not wearing any means of protection at the time of injury, unlike soldiers who often wear body armor.

The initial diagnosis was based mainly on the scenario of the attack, physical examination, and rapid investigations, such as FAST. CT was performed when possible and was especially ordered for stable conditions. The final diagnosis was determined in the OR.

In our study, negative laparotomy presented in 92 patients (10.2%) of the total performed laparotomies (n = 898), and 85.9% of them (n = 79) had neither intra-abdominal nor extra-abdominal injuries at the time of the procedure, while the remaining 14.1% (n = 13) had extra-abdominal injuries. Negative laparotomy percentages resemble the reported values during the Lebanese war, in the study conducted in Damascus Hospital and in the study conducted in Turkey (9.7%, 8.3%, and 7%, respectively).[12,29,36]

Physical examination is the cornerstone in making an early diagnosis.[37] Factors influencing the diagnosis and the severity of the damage include firearm type, firearm-to-target distance, number of heard gunshots, the mass of missiles, and distance from the explosion's epicenter.[33,38]

However, important information may frequently be forgotten or missed. In such situations, X-ray and FAST are useful diagnostic procedures for detecting any abnormal fluid or air in the pleural and abdominal cavities and may help in choosing the most suitable procedure for each case.[3] CT has a limited role in the diagnosis of penetrating abdominal injuries, because of its low sensitivity for hollow visceral and diaphragmatic injuries. However, it is useful for evaluating patients with a high clinical suspicion of solid organ and retroperitoneal injuries.[4]

By following the previous protocol, of 873 patients who had complete laparotomies, 34.6% had 1 injured organ,

https://doi.org/10.1017/dmp.2020.77 Published online by Cambridge University Press

56.4% had 2 or more injured organs, and 9% had neither intra- nor extra-abdominal injuries. Although explosions may affect multiple body parts, gunshots cause more severe abdominal injuries, and the pattern of intra-abdominal injury after explosions resembles the pattern of injury caused by gunshots.[33] Explosive device injuries can be classified into 4 categories: primary, secondary, tertiary, and quaternary. Primary injuries are due to high-order explosives and affects mainly gas-filled structures such as lungs, gastrointestinal tract, and middle ear. Secondary injuries are caused by flying debris, weapon casings, and content fragments and mainly cause penetrating trauma. Tertiary injuries are caused by blast wave and sudden forceful push against fixed objects leading to fractures, amputation of limbs, solid organ injuries, and traumatic brain injuries. Quaternary injuries include other injuries that are not classified above, such as burns, inhalational injury, and radiation illness.[39]

Previous authors showed that explosive assaults could have multiple entry sites to the abdomen.[40] They have also revealed previously, that the penetrating projectiles result in the majority of intra-abdominal injuries after explosive attacks.[37]

Penetrating abdominal trauma resulting from gunshots and explosions causes characteristically high-grade damage to abdominal organs with large surface areas, such as the small and large intestines and the liver. Hollow viscera are the most commonly injured organs in penetrating injuries.[4,29,37]

Our findings are consistent with these results; because the most damaged intra-abdominal organs reported in our study are small and large intestines (36.4% and 33%, respectively), followed by the liver (22.9%).

One of the limitations on our study was the inability to collect data of patients who arrived dead or died in the SED and never made it to the OR, due to the collection of our data from the OR logs, this may be a potential confounder for our results, as their injury types were not identified. For instance, the injury types of those victims may have been significantly different from those who survived long enough to undergo surgery. However, our accessible data showed that 6.4% (n = 58) of the patients (n = 898) died in the operating or recovery room, 43% of them suffered from severe major uncontrolled hemorrhage. The most common risk factors of death were musculoskeletal, vascular, and hepatic injuries. Deaths were high in patients with multiple intra- and extra-abdominal injuries having a POMR of 5.3% (26 deaths/492 patients having multiple injuries) compared with patients who had isolated injuries (POMR: 2.3%; 7 deaths/302 patients having isolated injuries) especially patients with 3 injured organs (8.3% POMR; 12 deaths/145 patients). This correlation was previously mentioned by Morris and Sugrue in Afghanistan,[9] they noted that the mortality rate was highest when the injuries affected 3 abdominal organs.

The most prevalent cause of preventable death in trauma patients is hemorrhage.[41] Abdominal structure injuries are a significant source of bleeding, and they have important practical difficulties for suitable diagnosis and treatment, particularly when there are concomitant lesions.[41,42] In our sample, the highest POMR of other concomitant injuries was due to musculoskeletal injuries, probably because of the duration of surgical management in which the patients enter the trauma triad of death (hypothermia, acidosis, and coagulopathy). This triad must be aggressively addressed by all damage control resuscitation and surgical interventions from point of injury to surgical intervention. This will require a rethink and new approach from surgeons and anesthetists, especially when prehospital and theater duration is prolonged, and when multiple surgical teams are collaborating to repair concomitant injuries.

CONCLUSIONS

Civilians are the weakest part of any armed conflict, and penetrating abdominal injuries are common among them. Our study is one of the few in the literature concerned with civilians sustaining war-related injuries. The most commonly affected organs due to abdominal penetrating trauma are small and large intestines, followed by the liver. The most common risk factor of death is musculoskeletal, vascular, and hepatic injuries.

The number and type of injured organs and their relation to mortality should be considered during the surgical management of penetrating abdominal injuries, especially when the patient has 3 injured organs.

About the Authors

Department of General Surgery, Faculty of Medicine, University of Damascus, Syria (Drs Alsaid, Sara); and Faculty of Medicine, University of Damascus, Syria (Dr Alhimyar, Mr Alnweilaty, Mr Alhasan, Mr Shalhoum, Mr Bathich, Mr Ahmad, Dr Ahmad, Dr Turkmani).

Correspondence and reprint requests to Bayan Alsaid, Faculty of Medicine, Almazzeh Street, Damascus – Syria (e-mail: drbayan@gmail.com).

Acknowledgments

We express our sincere gratitude to the medical staff at Al-Mouwasat University Hospital for working under pressure and lack of sufficient resources for many years, and their dedication to save patients' lives under all circumstances. We thank Dr. Subhi Albahri and Dr. Ammar Raiy in the administration of Al-Mouwasat University Hospital for their kind cooperation and support, and we thank Lamia Kouba and Younis Hajeer for the linguistic revision.

Funding

No funding was received in support of this work.

Ethical Approval and Consent to Participate

Ethical Approval upon data access and Consent to participate was given from the general board of Al-Mouwasat University Hospital "number 5920".

Competing Interests

The authors declare that they have no competing interests.

https://doi.org/10.1017/dmp.2020.77 Published online by Cambridge University Press

Authors' Contributions

The study was designed and supervised by B. Alsaid and S. Sara. The literature search was done by M. Alhimyar. M. Alhimyar, A. Alnweilaty, E. Alhasan, M. Bathich, K. Turkmani, Z. Salhoum, A. Ahmad, and T. Ahmad collected the data. A. Alnweilaty, E. Alhasan, and M. Alhimyar analyzed the data. Figures were done by A. Alnweilaty. T. Ahmad, E. Alhasan, Z. Salhoum, A. Alnweilaty, M. Bathich, M. Alhimyar, K. Turkmani, and B. Alsaid wrote the manuscript. T. Ahmad, M. Alhimyar, A. Alnweilaty, E. Alhasan, and K. Turkmani revised the manuscript. S. Sara coordinated with the hospital staff. All authors have read and approved the final version submitted.

REFERENCES

1. Willy C, Hauer T, Huschitt N, et al. "Einsatzchirurgie"–experiences of German military surgeons in Afghanistan. *Langenbecks Arch Surg*. 2011; 396(4):507-522.
2. Frykberg ER. Principles of mass casualty management following terrorist disasters. *Ann Surg*. 2004;239(3):319-321.
3. Biffl WL, Leppaniemi A. Management guidelines for penetrating abdominal trauma. *World J Surg*. 2015;39(6):1373-1380.
4. Ferrada R, Birolini D. New concepts in the management of patients with penetrating abdominal wounds. *Surg Clin North Am*. 1999;79(6):1331-1356.
5. Chaudhry R, Tiwari GL, Singh Y. Damage control surgery for abdominal trauma. *Med J Armed Forces India*. 2006;62(3):259-262.
6. Cap AP, Pidcoke HF, Spinella P, et al. Damage control resuscitation. *Mil Med*. 2018;183(Suppl 2):36-43.
7. Kortbeek JB, Al Turki SA, Ali J, et al. Advanced trauma life support, 8th edition, the evidence for change. *J Trauma*. 2008;64(6):1638-1650.
8. Payravi H, Mortaz SS, Fazel I. Surgical treatment results of Iranian abdominal trauma casualties in the Iran and Iraq war. *Mil Med*. 2001;166(11):952-954.
9. Morris DS, Sugrue WJ. Abdominal injuries in the war wounded of Afghanistan: a report from the International Committee of the Red Cross Hospital in Kabul. *Br J Surg*. 1991;78(11):1301-1304.
10. Frykberg ER, Tepas JJ III. Terrorist bombings. Lessons learned from Belfast to Beirut. *Ann Surg*. 1988;208(5):569-576.
11. Hadden WA, Rutherford WH, Merrett JD. The injuries of terrorist bombing: a study of 1532 consecutive patients. *Br J Surg*. 1978;65(8):525-531.
12. Arafat S, Alsabek MB, Ahmad M, et al. Penetrating abdominal injuries during the Syrian war: patterns and factors affecting mortality rates. *Injury*. 2017;48(5):1054-1057.
13. Aras M, Altas M, Yilmaz A, et al. Being a neighbor to Syria: a retrospective analysis of patients brought to our clinic for cranial gunshot wounds in the Syrian civil war. *Clin Neurol Neurosurg*. 2014;125:222-228.
14. Biswas S, Waksman I, Baron S, et al. Analysis of the first 100 patients from the Syrian Civil War treated in an Israeli district hospital. *Ann Surg*. 2016;263(1):205-209.
15. Duramaz A, Bilgili MG, Bayram B, et al. Orthopedic trauma surgery and hospital cost analysis in refugees; the effect of the Syrian civil war. *Int Orthop*. 2017;41(5):877-884.
16. Er E, Corbacioglu SK, Guler S, et al. Analyses of demographical and injury characteristics of adult and pediatric patients injured in Syrian civil war. *Am J Emerg Med*. 2017;35(1):82-86.
17. Gurler B, Coskun E, Oner V, et al. Syrian Civil-War-related intraocular foreign body injuries: a four-year retrospective analysis. *Semin Ophthalmol*. 2017;32(5):625-630.
18. Hasanin A, Mukhtar A, Mokhtar A, et al. Syrian revolution: a field hospital under attack. *Am J Disaster Med*. 2013;8(4):259-265.
19. Hornez E, Boddaert G, Baudoin Y, et al. Concomitant vascular war trauma saturating a French forward surgical team deployed to support the victims of the Syrian War (2013). Interest of the vascular damage control. *Ann Vasc Surg*. 2015;29(8):1656.e1657-1612.
20. Hornez E, Ramiara P, Mocellin N, et al. Surgical management of Syria's war casualties: experience from a French surgical team deployed in the Zaatari refugee camp (Jordan). *Eur J Trauma Emerg Surg*. 2015;41(2):143-147.
21. Karakuş A, Yengil E, Akkucuk S, et al. The reflection of the Syrian civil war on the emergency department and assessment of hospital costs. *Ulus Travma Acil Cerrahi Derg*. 2013;19(5):429-433.
22. Kocamer Şimşek B, Dokur M, Uysal E, et al. Characteristics of the injuries of Syrian refugees sustained during the civil war. *Ulus Travma Acil Cerrahi Derg*. 2017;23(3):199-206.
23. Mowafi H, Hariri M, Alnahhas H, et al. Results of a nationwide capacity survey of hospitals providing trauma care in war-affected Syria. *JAMA Surg*. 2016;151(9):815-822.
24. Ozdogan HK, Karateke F, Ozdogan M, et al. The Syrian civil war: the experience of the surgical intensive care units. *Pak J Med Sci*. 2016; 32(3):529-533.
25. Qasaimeh GR, Shotar AM, Alkhail SJA, et al. The pattern of the Syrian refugee's injuries managed in King Abdullah University Hospital (Jordan). *Eur J Trauma Emerg Surg*. 2017;43(5):587-594.
26. Rizkalla N, Segal SP. Well-being and posttraumatic growth among Syrian refugees in Jordan. *J Traumatic Stress*. 2018;31(2):213-222.
27. Ronen O, Assadi N, Sela E. High velocity penetrating head and neck injuries of Syrian civil war casualties treated in the Galilee Medical Center. *Harefuah*. 2017;156(5):315-317.
28. Salamon T, Lerner A, Rothem D, et al. Retrospective analysis of case series of patients with vascular war injury treated in a district hospital. *Injury*. 2016;47(4):811-817.
29. Iflazoglu N, Ureyen O, Oner OZ, et al. Complications and risk factors for mortality in penetrating abdominal firearm injuries: analysis of 120 cases. *Int J Clin Exp Med*. 2015;8(4):6154-6162.
30. Vertrees A, Greer L, Pickett C, et al. Modern management of complex open abdominal wounds of war: a 5-year experience. *J Am Coll Surg*. 2008;207(6):801-809.
31. Lamb CM, Garner JP. Selective non-operative management of civilian gunshot wounds to the abdomen: a systematic review of the evidence. *Injury*. 2014;45(4):659-666.
32. Syrian Central Bureau of Statistics, Statistics SCBo. http://cbssyr.sy/Demographic/Demographic_2017_2018.pdf. Accessed January 29, 2020.
33. Bala M, Rivkind AI, Zamir G, et al. Abdominal trauma after terrorist bombing attacks exhibits a unique pattern of injury. *Ann Surg*. 2008; 248(2):303-309.
34. Belmont PJ Jr, Goodman GP, Zacchilli M, et al. Incidence and epidemiology of combat injuries sustained during "the surge" portion of operation Iraqi Freedom by a U.S. Army brigade combat team. *J Trauma*. 2010; 68(1):204-210.
35. Peoples GE, Gerlinger T, Craig R, et al. Combat casualties in Afghanistan cared for by a single forward surgical team during the initial phases of Operation Enduring Freedom. *Mil Med*. 2005;170(6):462-468.
36. Nassoura Z, Hajj H, Dajani O, et al. Trauma management in a war zone: the Lebanese war experience. *J Trauma*. 1991;31(12):1596-1599.
37. Almogy G, Mintz Y, Zamir G, et al. Suicide bombing attacks: can external signs predict internal injuries? *Ann Surg*. 2006;243(4):541-546.
38. Sampalis JS, Denis R, Frechette P, et al. Direct transport to tertiary trauma centers versus transfer from lower level facilities: impact on mortality and morbidity among patients with major trauma. *J Trauma*. 1997;43(2): 288-295; discussion 295-286.
39. Cubano MA, Butler FK, Borden Institute (U.S.). *Emergency War Surgery*. Fifth United States revision. Fort Sam Houston, Texas: Borden Institute, US Army Medical Department Center and School, Health Readiness Center of Excellence, Fort Sam Houston, Texas, Office of The Surgeon General, United States Army; 2018.
40. Almogy G, Belzberg H, Mintz Y, et al. Suicide bombing attacks: update and modifications to the protocol. *Ann Surg*. 2004;239(3):295-303.
41. Teixeira PG, Inaba K, Hadjizacharia P, et al. Preventable or potentially preventable mortality at a mature trauma center. *J Trauma*. 2007;63(6): 1338-1346; discussion 1346-1337.
42. Parreira JG, Oliari CB, Malpaga JM, et al. Severity and treatment of "occult" intra-abdominal injuries in blunt trauma victims. *Injury*. 2016; 47(1):89-93.

https://doi.org/10.1017/dmp.2020.77 Published online by Cambridge University Press