ORIGINAL ARTICLE

Complications and treatment to liver wound by gunshot. A retrospective approach

Complicaciones y tratamiento de herida hepática por proyectil de arma de fuego. Un enfoque retrospectivo

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Abstract

Introduction: *A penetrating trauma can damage a variety of organs. Since the liver is an inelastic solid organ, it does not have the necessary stretch tolerance to cope with a gunshot wound (GSW).* **Methods:** *This was a retrospective, observational, and descriptive study of 53 clinical records of patients admitted to the Department of Surgery for liver trauma (LT) by a GSW.* **Results:** *Of the total clinical records analyzed, 89% of the patients presented a lesion associated with LT. The most common associated organic lesion was thoracic, specifically lung injury, in 58%. The most important predictor of mortality was a stay in the intensive care unit (ICU), which increased the risk about 21 times.* **Conclusion:** *A stay in the ICU, followed by the presence of fractures, was the most important predictor of mortality. New prognostic measures are needed to counteract the variables that the increase in GSWs has created, in addition to decreasing the waiting time from the traumatic event to relevant treatment.*

Key words: *Mortality. Injuries. Abdominal. Liver. Violence. Wound.*

Resumen

Introducción: *Un trauma penetrante puede dañar una variedad de órganos. Dado que el hígado es un órgano sólido inelástico, no tiene la tolerancia al estiramiento necesaria para hacer frente a una herida por proyectil de arma de fuego (GSW).* **Métodos:** *Este fue un estudio retrospectivo, observacional y descriptivo de 53 registros clínicos de pacientes ingresados en el Departamento de Cirugía por trauma hepático (LT) por un GSW.* **Resultados:** *Del total de historias clínicas analizadas, el 89% de los pacientes presentaron una lesión asociada con LT. La lesión orgánica asociada más frecuente fue la torácica, específicamente la lesión pulmonar, en el 58%. El predictor más importante de mortalidad fue una estancia en la unidad de cuidados intensivos (UCI), que aumentó el riesgo unas 21 veces.* **Conclusión:** *Una estadía en la UCI, seguida de la presencia de fracturas, fue el predictor más importante de mortalidad. Se necesitan nuevas medidas de pronóstico para contrarrestar las variables que ha creado el aumento de GSW, además de disminuir el tiempo de espera desde el evento traumático hasta el tratamiento relevante.*

Palabras clave: *Mortalidad. Lesiones. Abdomen. Hígado. Violencia. Herida.*

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Introduction

A penetrating trauma, such as that caused by a firearm, can damage a wide variety of organs. Speaking specifically of the abdomen, this includes the diaphragm, lung, colon, and liver which are the most affected organs in the right upper quadrant[1]. The liver, unlike the lung or intestinal wall which are flexible, is an inelastic solid organ that does not have the stretch tolerance necessary to cope with a gunshot wound (GSW). At the same time, diaphragmatic and lung injuries are reported as accompanying injuries of the liver; therefore, these thoracic structures should be included as important factors to consider when there is liver trauma (LT) due to a GSW. Complications directly associated with LT or associated organ or non-organ lesions should also be considered. These range from 20% to 70%[2-4].

Treatments for LT and their respective associated lesions have presented modifications in the last two decades, placing non-surgical treatment as the first choice in hemodynamically stable patients[5-7]. However, in terms of mortality and morbidity associated with this type of trauma, although a considerable increase has not been demonstrated, it could still be considered serious, due to its unquestionable relationship with hemorrhage, which is the main cause of death due to LT and which define the prognosis of the patient in the first 24-48 h after and before performing surgical procedures, confirming the importance of the response time[8-11].

A relevant assessment of the prognosis and associated injuries regarding mortality due to LT has not been performed in recent years. This is probably due to the close relationship of LT with traffic accidents and falls, which are considered the most common causes, even more than from GSW, although the liver is generally considered one of the most affected organs in the case of GSW with increasing figures from 1990 to date[2,5,12-16]. The objective of this study is to provide statistical information regarding LT and its correlated variables, increase the objectivity of LT treatment, as well as the factors that decrease its morbidity. In addition, optimize the use of therapeutic procedures and the prognosis of TH; all this in a metropolitan area where violent crimes with firearms are increasing, considering the significant number of hospital admissions received in the hospital of this research[17].

Materials and methods

File selection

This was an observational, descriptive, and retrospective study that was conducted from 2011 to 2015. Fifty-three clinical records of patients admitted to the Department of Surgery with LT caused by a GSW were reviewed.

Medical records of adult patients admitted with LT caused by a firearm projectile and which clearly and completely contained the study variables, were analyzed. In addition to suffering LT due to a GSW, other injured organs were analyzed such as lesions in the chest, diaphragm, duodenum, pancreas, small intestine, large intestine, liver, kidney, and associated fractures. Liver lesions were classified according to the organ injury scale of the American Association for the Surgery of Trauma (Table 1)[18]. A GSW was defined as any wound caused by any firearm that injured the liver. Patients with an incomplete or not clear medical record were excluded from the study.

Variables

The data were collected in a database for later statistical analysis. The private information of the patients was reviewed only by the authors and co-authors.

Data were collected on the number of injured organs, sex, age, number of days in hospital, number of days in intensive care, existence of associated fractures, chest, diaphragm, duodenum (these were considered apart from the rest of the intestinal structures), pancreas, small intestine, large intestine, liver, and kidney injury, and their respective therapeutic management, associated lesions, liver lesion grades (liver injury 1st grade, liver injury 2nd grade, liver injury 3rd grade, and liver injury 4th grade) number of red blood cell units transfused, hospitalization in the intensive care unit (ICU), prolonged stay, follow-up, and complications as empyema, wound dehiscence, and anastomosis leak.

Statistical analysis

The data were analyzed using a spreadsheet from the Numbers® v3.6.1 program (Apple Inc., Cupertino, CA). Statistical analysis was performed using the IBM SPSS Statistics v20.0 program (IBM, Inc., Armonk, NY)

Table 1. Liver injury scale—2018 revision

AAST Grade	AIS Severity	Imaging criteria (CT Findings)
I	2	– Subcapsular hematoma
II	2	– Subcapsular hematoma 10–50% surface area; intraparenchymal hematoma
III	3	– Subcapsular hematoma > 50% surface area; ruptured subcapsular or parenchymal hematoma – Intraparenchymal hematoma > 10 cm – Laceration > 3 cm depth – Any injury in the presence of a liver vascular injury or active bleeding contained within liver parenchyma
IV	4	– Parenchymal disruption involving 25-75% of a hepatic lobe – Active bleeding extending beyond the liver parenchyma into the peritoneum
V	5	– Parenchymal disruption > 75% of hepatic lobe – Juxtahepatic venous injury to include retrohepatic vena cava and central major hepatic veins

Vascular injury is defined as a pseudoaneurysm or arteriovenous fistula and appears as a focal collection of vascular contrast that decreases in attenuation with delayed imaging, active bleeding from a vascular injury presents as vascular contrast, focal or diffuse, that increases in size or attenuation in delayed phase. Vascular thrombosis can lead to organ infarction. Grade based on highest grade assessment made on imaging, at operation or on pathologic specimen. More than one grade of liver injury may be present and should be classified by the higher grade of injury. Advance one grade for multiple injuries up to a grade III. Adapted from Kozar *et al.*[18]

Results

2nd and 3rd liver lesion grades obtained the highest prevalence in our study. The presence of complications was correlated with the degree of liver injury, found that 100% of 4th lesion grade presented complications, in contrast to 1st, 2nd, and 3rd lesion grades, which revealed 50%, 37%, and 20% of presence of complications, respectively. The lesion grade does not seem to affect the number of patients admitted in UCI. Liver hemostasis was performed as the first therapeutic intervention for LT in 100%. The rest of the surgical procedures performed were specific to treat associated organ and non-organ lesions. Of the evaluated patients, 38% were admitted to the ICU because of LT, and 45% had a hospital stay ≥ 14 days without entering the ICU. Finally, 36% presented various complications, such as wound dehiscence, empyema, and anastomosis leak, which were presented in 15%, 11%, and 6% with respect to the total sample, and in 42%, 32%, and 16%, respectively, with respect to the total number of complicated patients within the sample (36%). Of all the complicated patients, 8 (42% respect to the total of complicated patients) needed an UCI stay, most of them by empyema. Only 10% died (Table 3).

Table 2. Baseline of clinical and demographic characteristics of patients with LT (n=53).

Associated Liver Trauma variable	n (%)
Personal data	
Female	5 (9%)
Male	48 (91%)
≥ 40 years old	15 (28%)
40 years old	38 (72%)
On Admission injury data	
Liver injury 1st Grade	6 (11%)
Liver injury 2nd Grade	24 (45%)
Liver injury 3rd Grade	20 (38%)
Liver injury 4th Grade	3 (6%)
LT associated lesions	47 (89%)
Large intestine	14 (26%)
Small intestine	11 (20%)
Diaphragm	13 (25%)
Lung	31 (58%)
Kidney	9 (17%)
Stomach	18 (34%)
Spleen	9 (17%)
Duodenum	8 (15%)
Pancreas	7 (13%)
Fractures	8 (15%)
Applied surgeries	22 (42%)
Applied second surgeries	22 (42%)
>1 wound	28 (53%)
Hemothorax	32 (60%)
Chest tube application	32 (60%)
Diaphragmatic repair	15 (28%)
Stomach management	17 (32%)
Gastrojejunoanastomosis	8 (15%)
Termino-terminal enteroenteroanastomosis (TT EEA)	11 (21%)
Large intestine resection plus colostomy	13 (25%)
Gastrointestinal resection plus ileocolontransverseanastomosis	2 (4%)
Resection of large intestine plus ileostomy	4 (8%)
Spleen hemostasis	3 (6%)
Splenectomy	7 (13%)
Pancreatic drainage	2 (4%)

(Continues)

Table 2. Baseline of clinical and demographic characteristics of patients with LT (n = 53) (*Continued*)

Associated Liver Trauma variable	n (%)
Pancreatic repair	5 (9%)
Nephrectomy	5 (9%)
Renal hemostasis	4 (88%)
Outcomes	
Hospital stay≥14 days	24 (45%)
Survival	44 (83%)
Use of red blood cell units	39 (74%)
Stay in intensive care unit (ICU)	20 (38%)
ICU stay≤13 days	12 (23%)
ICU>13 days	8 (15%)
Presence of complications	19 (36%)
Wound dehiscence	8 (15%)
Empyema	6 (11%)
Anastomosis leak	6 (6%)
Pancreatic fistula	2 (4%)

Data related to liver trauma (LT), variables that respond to therapies, comorbidities and negative/positive factors, modifiable and non-modifiable. Liver lesions were classified according to the organ injury scale of the American Association for the Surgery of Trauma. *Adapted from: Kozar RA, et al.*[18]

The odds ratio obtained regarding mortality yielded significant results. The greatest predictor of mortality was a stay in the ICU, increasing the risk about 21 times, followed by the presence of fractures (Table 4).

Regarding the prediction of complications related to LT, significant results were obtained with the variables age ≥ 40 years, management with a chest tube, and repair due to duodenal trauma. The rest of the variables were not related to an increase or decrease in post-LT complications.

Table 5 summarizes the variables that obtained statistical significance to predict an increased chance of entering the ICU. Surgical treatments include lesions associated with LT and with organ and non-organ structures. Of these, the variable with the highest risk of admission to the ICU was nephrectomy associated with renal trauma.

Discussion

According to the literature, male is the gender most affected by GSW[19] as occurred in our study. LT by GSW has increased in the last decade; however, it is not the first cause of death in young population, as in the United States, where most LTs are due to automobile accidents[20].

The demographic variables in this study revealed hemostasis as the initial treatment for LT. This mainly includes non-operative management. If this is not possible, laparotomy could be considered as the initial therapeutic measure[21]. In this case, management was hemorrhage and infection control by perihepatic packing, temporary abdominal closure, and ventilatory support in the ICU also called damage control[22]. The latter, with the intention of preventing the lethal triad of acidosis, hypothermia, and coagulopathy, which are variable and whose interaction considerably increases patient mortality[23].

Our research indicates that the first cause of death from LT is hemorrhagic, which justifies one of the essential procedures which is hemostatic control of the patient. Velasco et al. report that the mortality of this entity related to LT is between 4% and 15% varying with angiographic treatment and embolization and depending on whether or not there is an associated organ lesion; in addition to providing evidence that hemorrhage is the main cause of death due to LT, occurring in the first 72 h after non-surgical treatment[24]. Invasive surgical techniques have declined because conservative treatment is successful in percentages close or equal to 100%, considering current data regarding the increasing incidence of GSW[25]. However, invasive methods should not be considered in disuse because of the associated lesions that the patient may present. In addition to complications secondary to hemorrhage in our study, the most significant complications of surgical intervention were empyema, wound dehiscence, and septic shock, similar to other studies[26].

Empyema is defined as the presence of pus in the pleural space. This occurs after surgery as a complication of diverse traumatic events[27], most of the time due to the presence of *Streptococcus pneumoniae*[28]. In addition to this complication, our patients presented, together with LT, thoracic involvement, which required surgical intervention. It is known that an important determinant for an optimal post-operative course is the pre-operative state of our patients; this includes multiorgan lesions and the patient's hemodynamic status as previously analyzed[29]. These factors were the most serious and with an indication for admission to the ICU and are also reflected in the mortality in our study.

Table 3. Percentage comparison above complications

	Number of complications	% Respect to the total sample (n = 53)	% Respect to the total of complicated patients (n = 19)	Number of deaths related to complications (n = 9)	Number of complicated patients related to ICU stay (n = 20)
Wound dehiscence	8	15	42	0	0
Empyema	6	11	32	1	6
Anastomosis leak	3	6	16	1	1
Pancreatic fistula	2	4	10	0	1
Total	19	36	100	2	8

Percentage analysis on the presence of different complications related to liver trauma by gunshot wound. Percentage related to the total number of patients in addition to the number of complications itself, all is included to identify the prevalence of each complication separately. In addition, the number of deaths related to each of these complications separately and who required an UCI stay.

Table 4. Level of fatal risk due to liver trauma caused by a gunshot wound

Risk variable	Sig.	OR (95%CI)
Fractures	0.008	15.796
ICU stay	0.006	21.333
ICU stay > 13 days	0.015	8.000
ICU stay ≤ 13 days	0.099	3.600

CI: confidence Interval; ICU: intensive care unit; OR: odds ratio; Sig: significance. Statistically significant predictive mortality factors related to gunshot wound. A p-value ≤0.05 was considered statistically significant.

Table 5. Level of risk of stay in ICU due to LT due to gunshot wound

Risk variable	Sig.	OR (95%CI)
≥ 40 years	0.085	3.915
Gastric repair	0.016	6.410
Renal trauma nephrectomy	0.016	21.698
Stomach	0.022	5.157
Duodenum	0.022	9.188
Fractures	0.034	6.972

CI: confidence Interval; ICU: intensive care unit; OR: odds ratio; Sig: significance. Variables that reached statistical significance to predict an increased chance of entering the ICU. A p-value ≤0.05 was considered statistically significant.

Infections and surgical procedures cause patients to spend more time in the ICU, according to other studies[30]. The lung was the organ that was most frequently injured together with LT in 57% of living patients and 67% of dead patients in our study, in addition to an obvious hemothorax and therapeutic use of a chest tube (Table 2). The description of these lesions is reflected in the literature as a percentage of the relationship between thoracic and abdominal lesions due to GSW, which is 18% of the sample, demonstrating a high prevalence of this type of associated lesions with respect to LT.

It was also found that most patients with LT did not require hospitalization in the ICU or the hospital ward for more than 14 days since they mostly had a 1st-grade lesion. Current evidence has shown a predominance of traumatic grade 1st organ lesions, even > 2nd-, 3rd-grade lesions, or more together, unlike our study, in which 2nd- and 3rd-grade lesion prevailed[31]. Therefore, it is necessary to carry out studies that indicate the prevalence of lesions according to the AAST for LT[32], as well as figures that predict the association of organ lesions, since treatment varies depending on the degree of injury, from simple hemostasis to partial or total organic removal.

One of our main objectives was to analyze the possibility that a patient has, according to the demonstrated variables, of entering the ICU, using the criteria described by Irone et al.[33], which are respiratory, neurological, or cardiovascular failure, in addition to severe metabolic and a high-risk post-operative state. According to these criteria, in general, patients do not require hospitalization in the ICU for more than 14 days, given the effectiveness of the primary intervention and the absence of complications in most cases, both pre-operative and post-operative. In addition, in those who continued with their stay in the ICU, it was found that the vast majority have criteria that encompass respiratory disorders[34].

Our patients were admitted to the ICU, first due to hypovolemic shock and respiratory alterations due to associated thoracic trauma, severe hemorrhage that led to this state, and a high-risk post-operative evolution. In addition to this, respiratory alterations were present in 58% (percentage of lung injury) of patients, because of

the proximity of anatomical structures. Of the patients mentioned above, 60% of the sample developed hemothorax, which was managed with a chest tube.

The need for a chest tube is highly predictive of an increased risk for complications[35] as in our study. Due to the presence of infection directly attributable to the use of a chest tube and the fact that the chest tube was used in practically 100% of patients with associated chest lesions, we consider that it is imperative to review the use of the chest tube for treatment of a penetrating GSW in the chest, always taking into account that in the same way that the chest tube can become infected, it can also prevent empyema by reducing bleeding. The use of a chest tube for this reason is justified as long as bleeding is > 300 mL[36]. The use of prophylactic antibiotics with the chest tube is reserved for penetrating wounds[37]; however, there is no consensus on the length of time they should be used; therefore, it is suggested to stop them on the removal of the chest tube[38]. The use of antibiotics for only 24 h is also suggested, which is currently accepted to significantly reduce the length of hospital stay (2 ± 2 days vs. placebo), in addition to reducing the number of cases of empyema and in-hospital pneumonia. Ayoub et al.[39]. conclude in their study that the administration of prophylactic antibiotics for patients with penetrating and blunt thoracic trauma after insertion of a chest tube is associated with a reduced risk of developing empyema and pneumonia. Future studies should evaluate the optimal type, dose, and duration of the antibiotic administered to patients with thoracic trauma. In addition, these studies need to be replicated in our population to determine if the use of clindamycin, doxycycline, or cephalexin is effective for this purpose.

The limitations in this research prevented delving deeper into different therapeutic techniques that may or may not be considered at some point in the therapeutic process and the criteria used to decide to use them; for example, the use of retrograde endoscopic cholangiography (for complications in bile ducts), and invasive surgical procedures, if necessary.

In our study, the degree of injury and multiorgan involvement provided prominent variables to define the prognosis of the patient; therefore, it is necessary to measure these variables separately and evaluate mortality in each of the groups, in addition to correlating the severity of this type of wounds with the different therapeutic options available according to the comorbid situation of each patient, individualizing the procedure from hospital admission to post-operative management of complications or medical follow-up.

Most of our patients had 2nd- and 3rd-grade lesions; thus, we did not obtain a significant number of cases with complications, considering this an inconvenience for the study since it is of vital importance to provide figures to establish guidelines.

Our study represents current statistics in response to the increase in violent crimes associated with the use of firearms. In addition, it acquires applicable statistics regarding the increase in the number of this type of lesions for the correct optimization of resources to reduce the reaction time between the moment when the injury occurs and the required medical attention.

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Conflicts of interest

The authors declare no conflicts of interest.

Ethical disclosures

Protection of human and animal subjects. The authors declare that no experiments were performed on humans or animals for this study.

Confidentiality of data. The authors declare that they have followed the protocols of their work center on the publication of patient data.

Right to privacy and informed consent. The authors declare that no patient data appear in this article.

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