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Classification of gunshot wounds of the liver

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Objective The purpose of this study was to evaluate our management policy for gunshot wounds of the liver in the light of our original classification.

Methods One hundred and seven patients with gunshot wounds of the liver (GSWL) were evaluated. Based on the gunshot wound's treatment principles and criteria, which include the amount of devitalised liver tissues and caliber of injured intrahepatic vascular and ductal structures (VDS) , the 4 severity grade of the GSWL were evaluated. The patients with Grade I injures had nonbleeding, small than 2 cm wounds. Such patients did not require surgery. In patients with Grade II injures the amount of devitalised liver tissues was smaller than that of one segment, and slower but continued bleeding was noted. In these patients the debridment was performed and bleeding was controlled by simple methods (temporary compression, electrocauther, spongiose). In patients with Grade III injures, the amount of devitalisation was up to one segment and severe bleeding occurred. In these patients a portal clumping, hepatotomy, ligation of bleeding vessels and debridment were performed. In Grade IV injures the amount of the primary or secondary (after ligation of bleeding vessels) devitalised liver tissues was more than that of one segment, and an anatomic resection was required.

Results The liver was one of the most frequently injured organ in patients with gunshot wounds to the thorax and abdomen (31.6%). Also in most of these cases the liver injuries were associated with other organ injuries (59.8%). Grade I injuries occurred in 16 patients, Grade II injuries in 48 patients, Grade III injuries in 29 patients and Grade IV injuries in 14 patients. Morbidity and mortality rates were 18.7% and 13.1% in total; 0% and 0% in Grade I injuries; 6.2% and 4.2% in Grade II injuries, 34.5% and 20.6% in Grade III injuries and 50% and 42.8% in Grade IV injuries, respectively.

Conclusion The preferred classification, which is based on the amount of devitalized parenchyma and caliber of the damaged intrahepatic vessels and bile ducts, may be helpful for treatment choice and for assessment of the treatment results in the patients with gunshot wounds of the liver.

Key words Liver, gunshot wounds, classification, surgical treatment

Introduction

Many classifications of liver trauma are present. These classifications have some disadvantages concerning the gunshot wounds of the liver (GSWL). First, in these classifications the liver injuries are characterized in general and the properties of gunshot wounds are not described (1,2,3,4). However, it is known that gunshot wounds have some morphologic and physiologic properties, which determine their own management. The wounds, which were caused by high velocity missiles morphologically appeared to have three zones: centrally localized necrose zone, contusion zone and zone of reactive inflammation. These physiologic and morphologic processes in gunshot wounds determine their treatment principles, which include: hemostasis, debridment, repair, drainage and no suture on the first days after trauma (3,5,6,7). When these principles are overlooked, an inappropriate management are employed, especially suture on gunshot wounds are made in early period after trauma (2,8). Second disadvantage of the known classifications is that, the size of the wounds are taken as main factor for determination of the severity of the liver injury (1,2,3). But it is known that, the wounds with same sizes in the center of the liver or near porta hepatis and hepatic veins can cause different consequences and severity and can require different approaches.

Another disadvantage of these classifications is that, there are no descriptions about the volume of necrosis, which were developed after hemostasis procedure and aggravate severity of the trauma.

Thus, not only the size of the wounds, but the volume of devitalised parenchimal tissues and the caliber of injured intrahepatic vascular and ductile structures (VDS) are also very important factors for determination of the severity of the liver gunshot injuries.

We present new classification for the determination of the severity and treatment approach of the gunshot wounds of the liver (GSWL), which are based on physiologic and morphologic properties and management principles of gunshot wounds and also the devitalised tissue volume and the caliber of the damaged intrahepatic VDS.

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Material and Method

From 1988 to 1994 we managed 107 patients with GSWL at Surgical Department of Azerbaijan Medical University and Military Hospitals. There were 96 (89.7%) men and 11 (10.3%) women. Thoracoabdominal gunshot wounds were occurred in 31 (28.9%) patients and abdominal injury were noted in 76 (71.1%) victims. Incidence of liver injury was 31.6 % (338/107) among the patients with penetrating abdominal gunshot wounds. Most of the patients (64/107: 59.8%) with the liver gunshot wounds were associated with other organ injuries (Table 1).

Table 1. Incidences of mono and associated liver gunshot injuries

Injured organ	No	%
Only liver	43	40.2
Associated liver injuries	64	59.8
Small intestine	61	57
Colon	41	38.2
Diaphragm	31	28.9
Stomach	23	21.4
Spleen	22	20.5
Kidney	21	19.6
Lung	14	13.1
Pancreas	8	7.4
Duodenum	7	6.5
Vena cava	3	2.8
Ekstrahepatic portal structures	3	2.8
Others	3	2.8
Total	**344**	

Liver trauma were most frequently associated with small bowel (57%), colon (38.3%) and diaphragm (28.9%) injuries. The victims were hospitalized within 6 hours after trauma. In admission, of the 40.2% patients had shock, 18.7% had pneumothorax and 13.1% had hemothorax (Table 2).

Table 2. Syndromes in patients with GSWL at admission.

SYNDROME	No	%
Shock	43	40.2
Pneumothoracs	20	18.7
Hemotoracs	14	13.1

Classification of the GSWL.

In this treatment oriented classification of the GSWL the caliber of an injured intrahepatic vascular and ductal structures (VDS) and amount of devitalized tissues were taken as major criteria for determination of injury severity. Depending on the caliber of damaged intrahepaic VDS the severity of hemorrhage, circulation disorders and bile drainage in the liver are changed. Besides, the amount of devitalized tissue, which arise from direct damaged effect of missiles or is a consequence of the vascular injury, determines extent of debridment. In addition, the classification were accorded with general management principles of gunshot wounds, which include debridment, hemostasis, repair and drainage.

Based on these criteria and management foundation of gunshot injuries the GSWL were divided into 4 severity grades (Table 3).

Small (<2cm), nonbleeding wounds, which appear to have not devitalized tissues, were evaluated as Grade I gunshot injuries. There were considered damage of capillaries and parenchimal microdestruction in such wounds. Because of nonbleeding and very small devitalization, Grade I injuries didn't require any management.

Table 3. Characteristics, severity grades and treatment choice of the GSWL

	Characteristics of wounds				Management	
Grade	Size and depth	Caliber of injured VDS	Bleeding	Appearance and amount of the devitalized parenchyma	Control of bleeding	Debridement
Grade 1	< 2 cm	Capillary	No	No appear	Spontaneously	Don't require
Grade 2	> 2 cm	Lobular branches	Slow, continuing	Appeared, subsegment	Compression, electrocauthery, sponges	Subsegmentar y necrectomi
Grade 3	> 2 cm	Segmentar or their branches	Severe	Appeared, subsegment	Portal clumping, hepatotomy and vascular ligasion. Hemostais don't led to secondary necrosis	Subsegmentar y necrectomi
Grade 4	> 2 cm	Segmentar, lobar or magisterial	Severe	Appeared, segment, lobe	Portal clumping, hepatotomy and vascular ligasion. Hemostais led to secondary necrosis	Resection

Grade II injuries included the wounds with the size more than 2cm, active bleeding and with the visible devitalized tissues. In such injuries, a damage of subsegmentar VDS are suspected and the amount of devitalized tissues were smaller than that of one segment. For the treatment of these wounds the debridment and hemostasis were needed. In most of Grade II injuries, bleeding were controled by simple procedures, such as electrocauthery, temporary compression and spongiose.

In Grade III injuries very active bleeding occurred and the amount of devitalized tissues reached up to the volume of one segment. Grade III injuries were differed from Grade II injuries by that, the relatively large vessels (segmentar vessels and their branches) were damaged and simple methods were not sufficient for control of bleeding. Because, for control of bleeding a portal clumping (Pringler's maneuver), hepatotomy and selective ligation of bleeding vessels and ducts were needed. In addition, ligation of bleeding vessels didn't produce secondary necrosis in the liver parenchyma and only primary devitalized tissues were debrided. Thus, a necessity of portal clumping, hepatotomy and selective ligation of VDS, which are not followed by secondary necrosis are characteristics of Grade III injuries.

Grade IV injuries included wounds with massive devitalization and very severe active bleeding, which required liver resection. The bleeding arise from the main damaged vessels and their branches such as liver artery, portal vein, hepatic veins and caval vein. Due to damage and ligation of the main vessels the circulation disorders and secondary necrosis in the liver parenchyma were developed. The amount of devitalized tissues appears to extent up to one lobe or more. The development of secondary necrosis after hemostasis and necessity of liver resection are clinical characteristics of Grade IV GSWL.

Treatment

GSWL were treated according to their severity grade and to the general management principles of gunshot wounds. Gunshot wounds have very important characteristics such as necrosis and edema, which were caused by the direct damaged and cavitation effects of missiles. For these reasons, debridment and drainage are required in these wounds besides hemostasis and repair.

In patients, who had shock and thorax syndromes (hemothorax, pneumothorax) in admission, the thorax drains were applied and antishock therapies were begun immediately. Then a median laparatomy, revision and temporary hemostasis were performed to found the organ injuries. In patients with the multiple organ injuries, the solid organ wounds were managed initially. Severity of the GSWL were evaluated by accurate revision and during debridment. Primarily, the size and depth of the wounds, severity of bleeding and amount of devitalized tissues were assessed.

Small (<2cm), nonbleeding wounds without visible devitalization didn't require any management and were assessed as Grade I injuries.

In bleeding wounds with large size and with appearance of parenchimal destruction the accurate evaluation of injury severity and treatment choice were provided during operation. So, after temporary hemostasis, the devitalized tissues were debrided and control of bleeding were attempted. A continuing slow bleeding are usually controlled by simple procedure such as compression, electrocauthery and spongiose. Such wounds were evaluated as Grade II injuries. When simples procedures were insufficient and an intensive severe bleeding continued a selective ligation of the bleeding vessels was required. To find bleeding vessels, the portal thriad was temporary compressed (Pringler's maneuver) and the wound was extended by hepatotomy with digitoclasia technique. Then the bleeding vessels were ligated. We did not use and did not refer sutures for bleeding control. After bleeding control the liver was evaluated carefully if the ligated vessels led to circulatory disorders in liver parenchyma. If no disorders were encountered the control of bile leakage were attempted. These injuries were evaluated as Grade III injuries. When a circulatory disorder occurred, an anatomic resection of the ischemized parenchyma was performed. These situations usually occurre when the main branches of portal vein and hepatic artery or hepatic veins were damaged. Anatomic resections were also performed for treatment of the patients, who had primary destruction more than an anatomic unite of the liver (segment, sector, lobe). Thus indications for liver resection in our patients with GSWL included:

1. Destruction of the segment, sector or lobe at revision

2. Secondary necrosis after ligation of the damaged main branches of the portal vein, liver artery or hepatic veins.

Resections were performed by the finger fracture technique. The cases, in which resection

was treatment of choice, were evaluated as Grade IV injuries.

In all of patients the perihepatic space were drained at the end of operation.

Results

Of 107 patients with GSWL, 16 (14.9%) patients had Grade I injuries, 48 (44.8%) had Grade II injuries, 23 (27.1%) had Grade III injuries and 14 (13.1%) patients had Grade IV injuries. Mortality and morbidity rates are seen in Diag 1. No complication and mortality were recorded in patients with Grade I injuries. Of patients with Grade II injuries, 3 (6.2%) developed complication and 2 (4.2%) died. There was bleeding in one case and abscess in the two cases. Complication and mortality rates in patients with Grade III injuries were 34.5% (10/29) and 20.6% (6/29) respectively. Of the patients with complication 4 (13.7%) had bleeding, 3 (10.3%) had abscess, 3 (10.3%) had bile leak and one had cholangitis.

Of 14 patients with Grade IV injuries, complication occured in 7 (50%) and death in 6 (42.8%) patients. There was postoperative bleeding in 4 (28.5%) cases, abscess in 3 (21.4%) cases, bile leak in 2 (14.2 %) cases.

Overall complication and mortality rates in 107 patients were 18.7% (20/107) and 13.1% (14/107) respectively. The causes of death were postoperative bleeding and shock in 9 (64.3%) patients, sepsis in 3 (21.4%) and respiratory failure in 2 (14.2%) patients. Those, who died, had shock, and two or more organ injuries in admission. Median arterial pressure and pulse rate of these patients were 55.6 (42 mm Hg and 112 (11 respectively.

Discussion

There are many classifications of traumatic injuries of the liver, including gunshot liver wounds. These classifications have two general disadvantages in concerning gunshot wounds. First, in these classifications the liver injuries are characterized in general and the properties of gunshot wounds are not described (1,2,3,8). However, it is known that gunshot wounds have some morphologic and physiologic properties, which determine their own management. The wounds, which were caused by high velocity missiles morphologically were appeared to have three zones: centrally localized necrose zone, contusion zone and zone of reactive inflammation. If the necrose zone seemed immediately after trauma, but the contusion zone clinically appeared to have edema, which developed in 3-6 hours after injury and continued up to 3-5 days. Depending on treatment modalities and infection the contusion zone can result in necrosis or healing. These physiologic and morphologic processes in gunshot wounds determine their treatment principles, which include: hemostasis, debridment, repair, drenage and no suture on the first days after trauma (5,6,7,9). When these principles are overlooked, an inappropriate management are employed, especially suture on gunshot wounds are made in early period after trauma (2,8).

Second disadvantage of the known classifications is that, the size of the wounds are taken as main factor for determination of the severity of the liver injury (1,2,3,4,8-13). But it is known that, the wounds with same sizes in the center of the liver or near porta hepatis and hepatic veins can cause different consequences and severity and may require different approaches.

Another disadvantage of these classifications is that, there are no descriptions about the volume of necrosis, which develop after hemostasis procedure and aggravate severity of the trauma.

Thus, not only the size of the wounds, but the volume of devitalised parenchimal tissue and the caliber of injured intrahepatic vascular and ductile structures (VDS) are also very important factors for determination of the severity of the liver gunshot injuries. Depending on the volume of devitalised tissues, the debridment extensions may vary from subsegmentary necrectomies to segmentary, sectoral or lobar resections. Consequently, the devitalisation volume and the extension of debridment determine the severity of trauma, operation and postoperative course.

In trauma patients, depending on the caliber of the injured intrahepatic VDS, the severity of hemorrhage, methods of hemostasis and the possibility of secondary necrosis after hemostasis differ.

Thus, determination of the severity of the injury, treatment choice and prediction of postoperative course in patients with the liver gunshot wounds can be possible by accurate evolution of the volume of devitalization in the liver parenchyma and of the caliber of injured intrahepatic VDS.

We present new classification for the determination of the severity and treatment approach of the gunshot wounds of the liver (GSWL), which were based on physiologic and morphologic properties and management

principles of gunshot wounds and also the devitalised tissue volume and the caliber of the damaged intrahepatic VDS. In this classification GSWL are divided into four severity grade.

Grade I gunshot wounds were usually caused by low-velocity missiles. In these wounds the parenchymal destruction was in microscopic level and very small VDS damaged. Grade I gunshot wounds did not require any management.

Grade II gunshot wounds included continuously bleeding injuries with evident parenchimal destruction, in which the amount of devitalisation was smaller than the volume of one segment. For treatment of such wounds the debridment was required and hemostasis was completed by simple procedures such as temporary compression, electrocauthery or spongies. The successful hemostasis by simple methods and the little bleeding considered that the small than segmentary VDS are damaged in Grade II injuries.

Grade III GSWL had active continuous bleeding and parenchimal destruction, the amount of which sometimes were reached up to one segment. To control of bleeding in such injuries the temporary portal thriad clamping (Pringler's maneuver), hepatotomy and the ligation of the bleeding vessels were required. The ligation of these vessels didn't lead to the circulatory disorders and secondary necrosis in the liver tissues, and because, only the primary devitalised tissues were underwent to the debridment. It is considered that the segmentary or subsegmentary branches of VDS were damaged in Grade III injuries.

Grade IV GSWL were evaluated as very severe liver trauma and for which the resection was treatment of choice. In these injuries more than of one segment of the liver were underwent to devitalisation and very severe bleeding were occurred. Devitalisation were resulted from the direct damaged effect of missiles or developed after ligation of the large bleeding vessels.

Over the past decade the authors reported from 3% to 11% resection rates in patients with the liver trauma (1,2,14). In our series the resection were performed in 13,1% of patients. So, it was high than reported in the literature. This is due to extent indication for the liver resection in our patients. Probably, devitalisation of the liver tissue with the amount more than the one segment, damage of hepatic veins and injury to the lobar or segmental branches of portal structures were accepted as indications for liver resection in our patients.

This classification of the GSWL, which was based on the amount of devitalized tissues and caliber of damaged VDS, promised to determine a treatment choice and to accurately evaluate results of the treatment. Depending on severity of the trauma the treatment modalities may be changed from mini debridment and the simple hemostasis methods to the extensive liver resections. The evaluation of the results of treatment showed that, with increasing in severity of injury the incidence of the morbidity and mortality cases increased. So the overall morbidity and mortality rates were 18.7% and 13.1% respectively. Whereas these values were 0% and 0% in Grade I injuries, 6.2% and 4.2% in Grade II injuries, 34.5% and 20.6% in Grade III injuries, 50% and 42.8% in Grade IV injuries respectively. The differences between these values were statistically significant. All of these results consider that, in generally, the presented classification of the GSWL is safe.

In conclusion, the liver is one of most frequently injured organ in patients with gunshot wounds to the thorax and abdomen. Also, in most of such cases the liver injuries are associated with other organ injuries. We consider that, the present classification, which is based on the amount of devitalized tissues and caliber of the damaged intrahepatic VDS, may be helpful for treatment choice and for assessment of the treatment results in the patients with gunshot wounds of the liver.

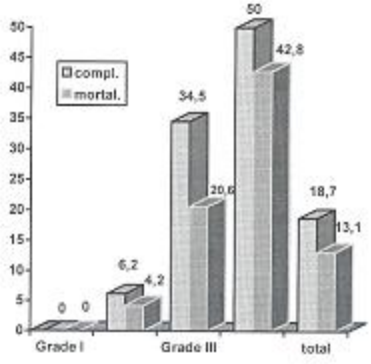

Figure 1. Complication and mortality rates (%) in patients with GSWL

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