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ORIGINAL ARTICLE

# Conservative approach in the management of isolated penetrating liver trauma

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KEYWORDS

Isolated penetrating liver injuries;
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**Abstract** *Background:* Damage to the liver is the most common cause of death after abdominal injury. The most common cause of liver injury is blunt abdominal trauma. In the case of penetrating injury, non-intervention management has not been adequately addressed. Selective non-operative management of stab wounds especially to the liver has been reported.

*Methods:* This study was carried out from May 2006 to April 2011 at the Main Alexandria University Hospital, Faculty of Medicine, Alexandria, Egypt. This study consisted of 62 liver trauma patients and the following data were collected: demographics, mechanism of injury, pre-hospital care, hemodynamic status, grade of hepatic injury, associated injuries, failure of non-operative (NOP) management, hospital stay in intensive care unit (ICU) or in the ward and death. Patients were eligible for the study if they sustained isolated penetrating right hypochondrial injury. Assessment of hemodynamic stability was based on routine vital signs. Injury severity was determined from CT and classified by means of the Liver Injury Scale.

*Results:* This study was carried out for 62 consecutive patients with hepatic trauma in a five year period. Mean age was 33.6 years with a range of 16–54 years. The isolated penetrating liver injuries included knives, guns (gunshot & shotgun injuries) and other sharp objects.

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All patients were treated successfully via NOP management except five patients (8%) who failed NOP management. These five patients were hemodynamically unstable and were unresponsive to crystalloid and blood transfusion. The five patients underwent surgery (suturing, packing, and resectional debridement). Two patients (3.2%) died because of high grade liver injury. The overall actuarial one-year survival in NOP management was 96.8%.

*Conclusions:* Low grade penetrating hepatic injuries (G I-III) can be managed non-operatively with excellent results; even G IV penetrating liver injuries with hemodynamically stable patients can be managed safely non-operatively.



## 1. Introduction

The liver is the largest solid abdominal organ with a relatively fixed position, which makes it prone to injury. It is the most common abdominal organ injured by penetrating trauma. Damage to the liver is the most common cause of death after abdominal injury. The most common cause of liver injury is blunt abdominal trauma, which is secondary to motor vehicle crashes (MVC) in most instances. Mandatory surgical exploration for penetrating wounds to the abdomen has been surgical dictum for the greater part of the last century. Selective non-operative (NOP) management of stab wounds to the liver has been reported.[1–4]

Unlike blunt liver trauma, penetrating liver trauma especially that secondary to projectiles has not seen a shift in emphasis from operative to NOP management. Surgical intervention is still the management of choice.[1] The reasons are: (i) a high likelihood of associated injuries and an inability to accurately predict hollow viscus injury with noninvasive investigations; and (ii) an inability to accurately predict the extent of parenchymal liver damage around the projectile track.[5]

The two major consequences of liver trauma, hemorrhage and infection have dictated a primarily surgical approach to the management. Over the past three decades there has been a distinct move toward NOP approach in the management of blunt liver trauma. This has largely been the result of a growing awareness that most liver injuries have stopped bleeding by the time an operation is undertaken.[3] The mortality rate after surgical attempts at dealing with major (grade IV,V) hepatic trauma ranges from 17% to 45% with a similar incidence of postoperative morbidity.[1, 4–6] The success of NOP management with acceptable morbidity and mortality for isolated liver injuries due to blunt trauma has now been well documented. The initial fears about later complications such as delayed hemorrhage, infection and bile collections have been shown to have been over rated. The wide availability of high quality radiological imaging as provided by multislice CT scanning has been an important aid to the NOP management. Noninvasive imaging has helped by not only objectively and noninvasively defining the severity of injury but also by allowing the natural progression of the injury to be monitored.[6–8]

In the case of penetrating injury non-intervention management has not been adequately addressed.[3] There are no generally accepted recommendations for conservative management of projectile injuries to the liver. However, individual authors have reported on the success of NOP management.[6] The two major issues involved are: (i) assessment of damage to the liver parenchyma particularly in relation to the major vascular and biliary channels; and (ii) exclusion of injuries to other organs especially the hollow viscera, which may require surgical intervention in their own right.

It is important to differentiate penetrating trauma from hand-held sharp weapons and low velocity projectiles from that resulting from high velocity and shot-gun projectiles. In injuries due to low velocity projectiles there is an absence of a cavitation effect. In dealing with penetrating liver injuries, the innate hemostatic ability of an injured normal liver, so well demonstrated in cases of blunt trauma, should not be ignored.[6,9]

Mandatory surgical exploration of the abdominal cavity and a low threshold for thoracotomy have been advocated as the safest approach.[10–16] However, the high overall rate of non-therapeutic thoracotomies and laparotomies has challenged the dogma of mandatory surgical management.[9–11,14,17,18] Renz and Feliciano demonstrated that NOP management of selected patients who had sustained penetrating right side thoracoabdominal (RST) trauma is safe with only minor complications.[9] Furthermore, recent reports of successful NOP management of selected patients with penetrating liver injuries has raised additional support for NOP management of RST penetrating injuries. Selective NOP management of stab wounds especially to the liver has been reported. If hemodynamically stable, a patient with a stab wound that is either directly over the liver or apparently tangentially (without likely entrance into the peritoneal cavity) may be evaluated by CT. If the CT suggests an isolated liver injury and a knife tract unlikely to have caused other visceral injury, NOP management may be pursued. Close serial abdominal examination is essential, and any evidence of generalized peritonitis mandates laparotomy.[2,19,20]

Until recently, there has been a broad consensus that a gunshot wound to the abdomen is an indication for laparotomy.[21] However, this strategy has been challenged in selected patients with isolated gunshot wounds of the liver.[20]

The aim of this work is to study the role of non-operative management of isolated penetrating liver trauma as regards its indications, feasibility and safety.

## 2. Methods

This prospective and observational study was carried out from May 2006 to April 2011 at the Main Alexandria University Hospital, Faculty of Medicine, Alexandria, Egypt. The study was approved by the Research Ethics Committee of the hospital and informed consent was obtained from all patients.

This study consisted of 62 consecutive liver trauma patients referred to the Main Alexandria University Hospital. The following data were collected: demographics, mechanism of

injury, pre-hospital care, hemodynamic status, grade of hepatic injury, associated injuries, failure of NOP management, hospital stay in intensive care unit (ICU) or in the ward and death.

Patients were eligible for the study if they sustained isolated penetrating right hypochondrial injury. Assessment of hemodynamic stability was based on routine vital signs and was defined as a systolic blood pressure $>90$ mmHg throughout the study, respiratory rate between 10 and 29 breaths/min, arterial oxygen saturation (O2 sat) $>95\%$ and a Glasgow coma scale (CCS) score of 15. NOP management has been applied to all hemodynamic stable patients with penetrating hepatic injury. Patients with more than one visceral injury, hemodynamic instability or signs of peritonitis were considered ineligible for the study.

Patients with significant penetrating liver injuries (G III-V) selected for NOP management should be admitted to the ICU for close monitoring and observation. The patients with G I-II liver injuries are also admitted to the surgical ward for observation Any patient subsequently requiring surgery was considered a failure of NOP management. NOP management was discontinued in patients with hemodynamic instability unresponsive to moderate amounts of crystalloid and blood infusion, or if any intra-abdominal hollow viscus injury was suspected. There were no other specifically defined criteria for abandonment of NOP management.

Patients with liver injuries selected for NOP management underwent a sonography and multislice computed tomography (CT). Diagnostic peritoneal lavage (DPL) was used only for unstable patients to assess free blood in the abdominal cavity. All these patients had at least one contrast-enhanced multislice high-speed helical–CT scan examination during their hospital stay. The first CT scan was performed on admission to characterize the injuries to the liver, and to ascertain that the patient had no indication for surgery. Other CT scan examinations were performed as follow up needed and based on other specific indications Fig. 1 (a–f).

Injury severity was determined from CT and operative observations, and classified by means of the Liver Injury Scale (LIS) (Table 1).[22] Hepatic injury was graded according to the LIS established by the American Association for the Surgery of Trauma (AAST).

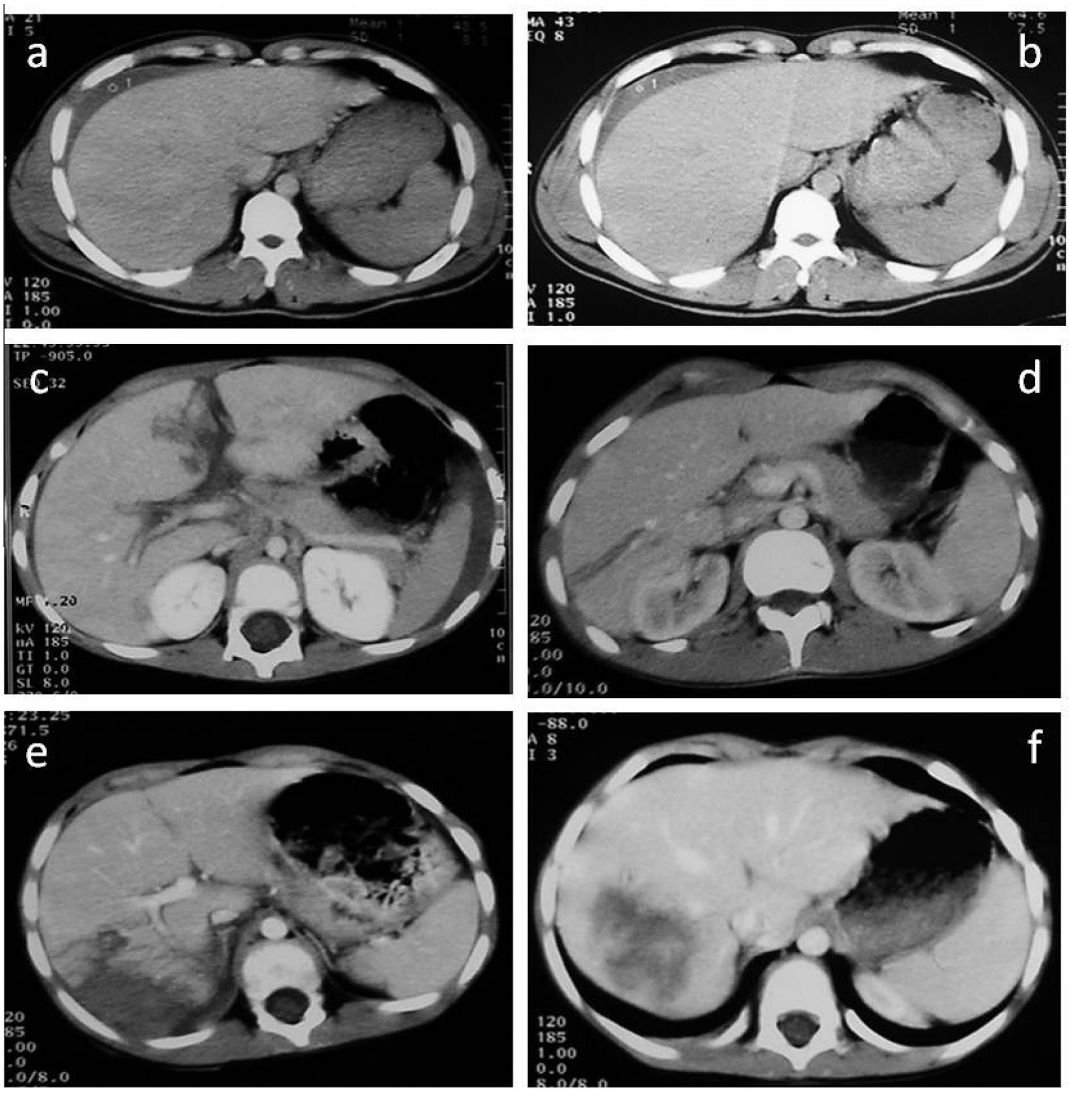


**Figure 1** (a–f) Multislice CT showing penetrating liver trauma [G I in (a, b), G II in (c), G III in (d) and G IV in (e,f)].

### 2.1. Statistical analysis

Statistical analysis was performed with SPSS version 18, using the chi-square test for discrete variables and the unpaired *t* test for continuous variables. Values for qualitative variables were given as percentages and those for quantitative variables were given as medians and ranges. Survival curves were calculated using the Kaplan–Meier method. Level of significance was set at $P < 0.05$.

## 3. Results

Sixty-two patients with hepatic trauma in a five year period, 50 patients (80.6%) were males and 12 (19.4%) were females. Mean age was 33.6 years with a range of 16–54 years. Twenty-nine patients (46.8%) received pre-hospital care.

The isolated penetrating liver injuries included: knives, guns (gunshot & shotgun injuries) and other sharp objects. Associated injuries were thoracic injuries in 5 patients (8%) with a right chest tube inserted in a hospital near the accident, and lower extremity injuries in 3 cases (4.8%) and head injury in 2 cases (3.2%) (Table 2).

Tenderness and guarding were confined mainly to the right upper quadrant of the abdomen for all patients with isolated penetrating stab wound or gunshot wounds directly over the liver without likely entrance to the peritoneal cavity (site of entry or site of exit). All patients were managed non-operatively and remained hemodynamically stable and hemoglobin was kept above or around 10 g/dl, units of packed cells and fresh frozen plasma were transfused in addition to crystalloids. Nine patients (14.5%) had pre-hospital co-morbid disease, hypertension ($n = 5$), diabetes mellitus ($n = 3$), and ischemic heart disease ($n = 1$).

All patients were treated via NOP management except five patients (8%) who failed NOP management. NOP management was discontinued in these five patients with hemodynamic instability unresponsive to crystalloid and blood transfusion with a fall in hemoglobin and hematocrit. Patients with failure of NOP management had significantly worse admission hemodynamic parameters and higher grade of liver

**Table 2** Demographic data of 62 patients with penetrating liver injury.

| Liver injury | Patients ($N = 62$) | Percent |
|---|---|---|
| *Sex:* | | |
| Male | 50 | 80.6 |
| Female | 12 | 19.4 |
| *Age in years:* | | |
| Mean (range) | 33.6 (16–54) years | |
| *Penetrating liver trauma:* | | |
| Isolated liver trauma | 57 | (92) |
| Thoracoabdominal trauma | 5 | (8) |
| *Associated injuries:* | | |
| Lower extremities | 3 | (4.8) |
| Head trauma | 2 | (3.2) |
| *Types of penetrating liver trauma:* | | |
| Knives | 34 | 54.8 |
| Gunshot (bullet) | 9 | 14.5 |
| Shotgun | 15 | 24.2 |
| Other sharp objects | 4 | 6.5 |

**Table 3** Grading of 62 patients with hepatic trauma.

| Grade: | Patients ($N = 62$) | NOP management ($N = 57$) | Operative management ($N = 5$) | Death ($N = 2$) |
|---|---|---|---|---|
| I | 25 (40.4%) | 25 (40.4%) | 0 | 0 |
| II | 23 (37%) | 23 (37%) | 0 | 0 |
| III | 7 (11.3%) | 6 (9.7%) | 1 | 0 |
| IV | 6 (9.7%) | 3 (4.8%) | 3 | 1 |
| V | 1 (1.6%) | 0 | 1 | 1 |

**Table 1** Classification of severity of hepatic injuries: LIS based on AAST.

| Grade | Description of injury |
|---|---|
| I | |
| Hematoma | Subcapsular, non-expanding, less than 1% of surface area |
| Laceration | Capsular tear, non-bleeding, parenchymal depth less than 1 cm |
| II | |
| Hematoma | Subcapsular, non-expanding, 10–50% of surface area; or intraparenchymal, non-expanding, less than 2 cm in diameter |
| Laceration | Capsular tear, active bleeding, parenchymal depth 1–3 cm, less than 10 cm in length |
| III | |
| Hematoma | Subcapsular, more than 50% of surface area or expanding; ruptured subcapsular hematoma with active bleeding; intraparenchymal hematoma larger than 2 cm |
| Laceration | Parenchymal depth more than 3 cm |
| IV | |
| Hematoma | Ruptured intraparenchymal hematoma with active bleeding |
| Laceration | Parenchymal disruption of more than 25–50% of hepatic lobe or one to three segments within a single lobe |
| V | |
| Laceration | Parenchymal disruption of more than 50% of hepatic lobe or more than three segments within a single lobe. |
| Vascular | Juxtahepatic venous injuries: retrohepatic caval / central major hepatic veins |
| VI | |
| Vascular | Hepatic avulsion |

**Table 4** Surgery in 5 patients.

| Operation | Operative management and grading of liver injury($N = 5$) | Percent |
|---|---|---|
| Suturing | 3 (III-IV) | 4.8 |
| Resectional debridement | 1 (IV) | 1.6 |
| Packing | 1 (V) | 1.6 |

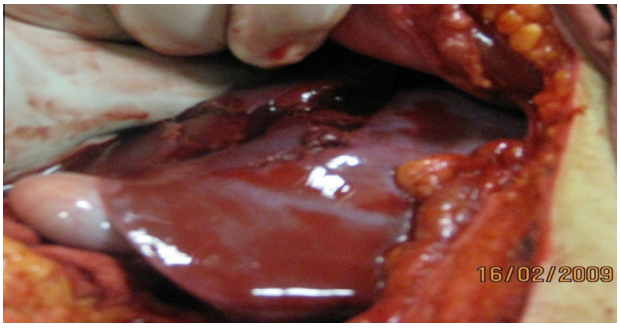


**Figure 2** Penetrating liver trauma (G III).

trauma (G III-V) (Table 3). These five patients underwent surgery in the form of: suturing, packing, and resectional debridement (Table 4 and Figs. 2–5).

The median time of hospital stay was 35 days (mean 15.2, range 8–46). There was no significant difference in hospital stay between patients managed non-operatively and patients operated upon.

Two patients (3.2%) died with a higher grade of liver injury. Both patients were hemodynamically unstable after few days of NOP management with increasing amount of hemoperitoneum by CT. One patient with grade IV liver injury underwent immediate surgery after five days of NOP management and died postoperatively due to severity of hepatic injury and hemorrhage, the other patient with grade V liver injury underwent surgery after three days of NOP management and had associated injuries including head (subarachnoid hemorrhage) and thoracic injury.

Follow-up of stable patients with penetrating injuries were evaluated by clinical, laboratory and multislice CT examinations during the first year of the NOP management. Complications of the NOP management of isolated penetrating liver trauma were listed in Table 5.

The overall actuarial one-year survival in patients with isolated penetrating liver injuries was 97% (Fig. 6).

## 4. Discussion

The liver is the largest intra-abdominal solid organ and is enclosed anteriorly and laterally by the rib cage. The large size of the liver, its friable parenchyma, its thin capsule, and its

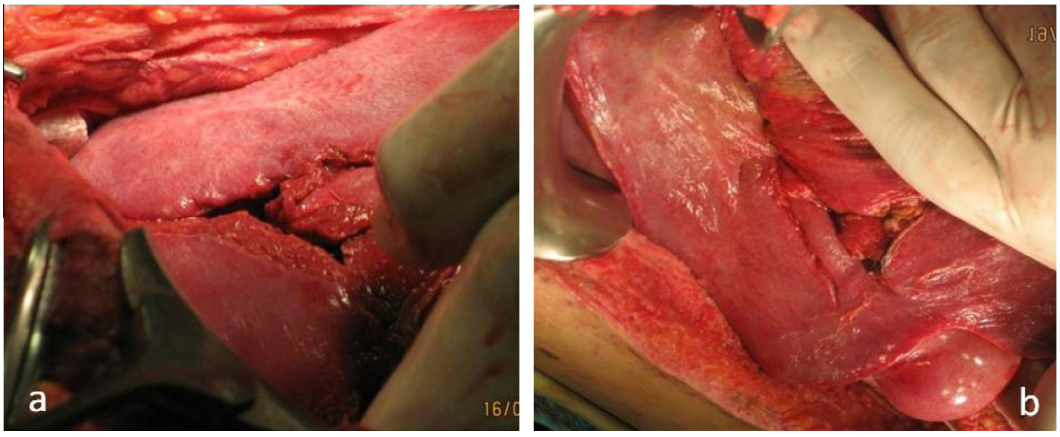


**Figure 3** (a–b) Penetrating liver injury (G III) after control of bleeding (suturing).

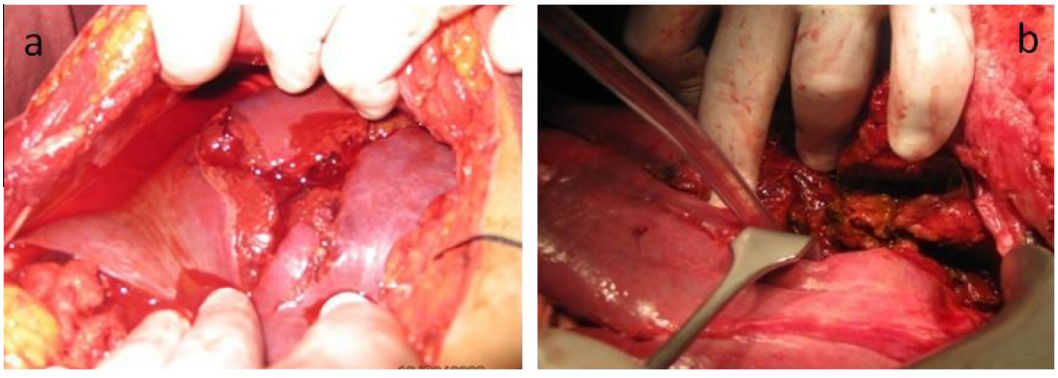


**Figure 4** (a–b) Penetrating hepatic injuries (G IV), bullet bisecting the liver, resectional debridement was done.

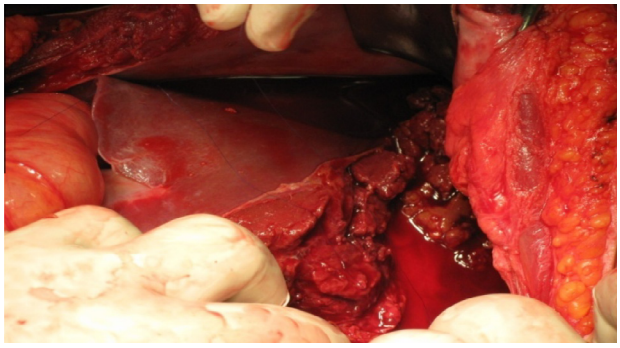

**Figure 5** penetrating liver injury (G V), packing was done to control bleeding.

**Table 5** Complications of the NOP management of penetrating liver trauma.

| Liver – related complications | Patients | Percent |
|---|---|---|
| Biloma | 2 | 3.2 |
| False aneurysm | 2 | 3.2 |
| Arteriovenous fistula | 1 | 1.6 |
| Hemobilia | 1 | 1.6 |
| Rebleeding from the liver | 2 | 3.2 |

relatively fixed position in relation to the spine make the liver particularly prone to blunt injury. As a result of its larger size and proximity to the ribs, the right lobe is injured more commonly than the left. The common cause of liver injury is blunt abdominal trauma commonly secondary to MVC.[23]The liver is the most common abdominal organ injured by penetrating trauma. Penetrating trauma of the liver may be caused by bullets, shrapnel, knives, and other sharp objects. In most centers, surgery for stab wounds is performed only in patients in whom internal injury is strongly suspected. Complications from liver trauma occur in approximately 20% of patients and include delayed rupture (very rare), hemobilia, arteriovenous fistula, pseudoaneurysm, biloma and abscess formation. Interventional radiology procedures, as percutaneous biopsy, transjugular intrahepatic portosystemic shunt procedures (TIPS), biliary drainage, and percutaneous injection of alcohol, can cause capsular tears, hematoma, bile leaks, and hemoperitoneum.[24–26]

In our study, the isolated penetrating liver injuries included: knives, gunshot, shotgun injuries and other sharp objects. Associated injuries were found in 10 patients (16.2%). Out of 62 patients with penetrating liver trauma, isolated liver trauma was found in 92% and thoracoabdominal injuries were found in 8%. In our study, the most common penetrating injury to the liver was caused by knives (stab wound) in 34 patients (54.8%) followed by shotgun in 15 patients.

Non-operative management of penetrating abdominal trauma has also recently been shown to be safe and reliable in selected patients, it has not experienced the same broad acceptance as in blunt trauma.[24–30] Non-operative management of penetrating thoracoabdominal injuries creates additional challenges when compared to the same approach for penetrating trauma to the abdomen only.[10,12,13,31–37]

Most blunt liver trauma (80% in adults, 97% in children) is currently treated conservatively. Surgical literature confirms that more than 86% of hepatic injuries have stopped bleeding at the time of surgical exploration. Conservative treatment requires the ability to clinically monitor the physiologic signs adequately and to intervene surgically if conservative treatment fails.[23,38]

Mild hepatic injuries that involve less than 25% of one lobe resolve within 3 months. Most moderate injuries involving

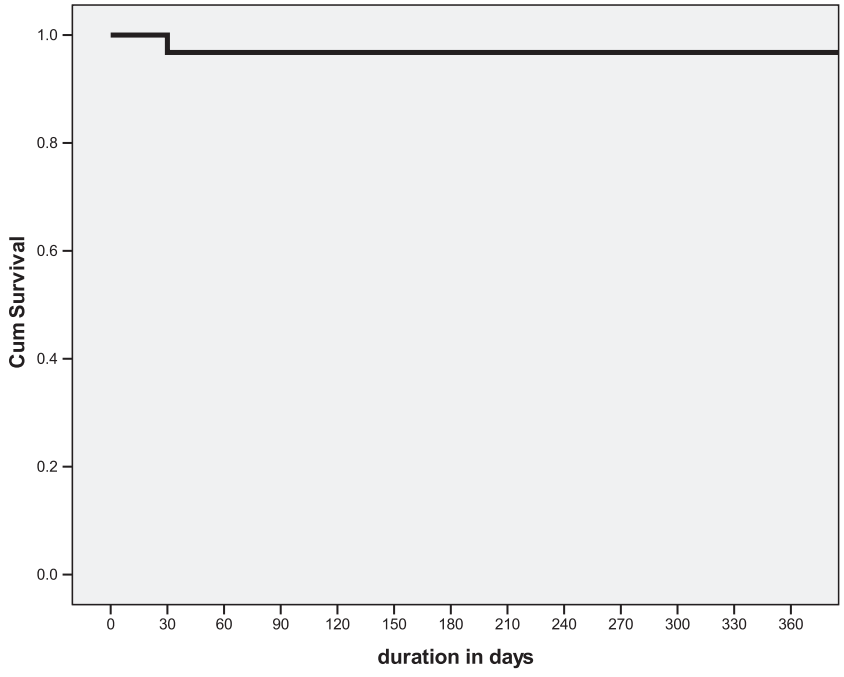


**Figure 6** the overall cumulative survival is 97% (1-year Kaplan–Meier survival curve).

25–50% of one lobe heal within 6 months, whereas severe injuries require 9–15 months to heal. In the case of penetrating injury non-intervention management has not been adequately addressed.[6] There are no generally accepted recommendations for the non-operative management of projectile injuries to the liver. However, individual authors have reported on the success of non-operative management.[6,9]

A more recent retrospective observational study[39] of patients admitted to the Mediterranean Institute for Transplantation and Advanced Specialized Therapies, Palermo, Italy, from 1999 to 2010, a total of 53 adult patients were admitted with liver injury and 29 underwent surgical treatment; Mechanism was blunt in 52 patients. The operative management is mainly centered on packing, damage control, and early utilization of interventional radiology for angiography and embolization. The overall morbidity was 30%, morbidity related to liver resection was 15.3%. Mortality was 2% in the series of patients undergoing liver resection for complex hepatic injury, whereas in the non-operative group, morbidity was 17% and mortality 2%.

In our study, all patients were treated via NOP management except five patients who failed NOP management and were operated upon, NOP management was discontinued in these patients with hemodynamic instability unresponsive to crystalloid and blood infusion. Patients with failure of NOP management had a higher grade of liver trauma (G III-V). The five patients were operated via techniques of suturing, packing, and resectional debridement.

Imaging techniques, particularly CT scanning, have made a great impact on the treatment of patients with liver trauma, and the use of these techniques has resulted in marked reduction in the number of patients requiring surgery and non-therapeutic operations. Almost 80% of adults and 97% of children are treated conservatively by using careful follow-up imaging studies. The death rate of patients with liver injury was around 15.5% in these reports.[40,41]The patients with significant liver injury leading to death usually have early indications for surgery.

A more recent retrospective study[42] of totally 468 consecutive patients with liver trauma treated between 1986 and 2010 at a single level 1 trauma center were reviewed as regards, mechanisms of injury, diagnostic imaging, hepatic and associated injuries, operative vs. non-operative management. A significantly increased use of CT scans as the initial diagnostic modality (which completely replaced DPL and ultrasound) for the NOM in hemodynamically stable patients resulted in improved survival and should be the gold standard management for liver trauma.

In our study, two patients (3.2%) died. Both patients were hemodynamically unstable after five and three days of NOP management respectively with increasing amount of hemoperitoneum by CT. The dead patients had a higher grade of injury G IV, V. The overall one-year survival in NOP management of our patients was 96.8%.

Demetriades and colleagues[20] reported 52 patients with isolated liver injuries due to abdominal gunshot wounds, of whom 16 were initially managed non-operatively. Five patients subsequently required laparotomy for peritonitis or an abdominal compartmental syndrome. Eleven patients were therefore successfully managed without laparotomy. Given that this represented just 7% of all liver gunshot injuries and 21% of isolated liver injuries in the series, the non-operative approach applies in only very selected cases. A prospective series from South Africa[4] attempted NOP management in 33 of 124 (27%) patients with liver gunshot injuries, avoiding laparotomy in 31 patients (94%).

## 5. Conclusion

We concluded that, low grade penetrating hepatic injuries (G I-III) can be managed non-operatively with excellent results; even G IV penetrating liver injuries with hemodynamically stable patients can be managed safely non-operatively. Urgent surgery continues to be the standard for hemodynamically unstable patients with hepatic trauma. The NOP management does not lead to longer hospital stay than the operative management.

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