

## Liver trauma. Diagnosis and treatment

M. BARBUSCIA<sup>1</sup>, A. QUERCI, A. TONANTE, F. TARANTO, M. SANÒ,  
E. CINGARI, A. ILACQUA, G. STURNIOLO

SUMMARY: Liver trauma. Diagnosis and treatment.

M. BARBUSCIA, A. QUERCI, A. TONANTE, F. TARANTO, M. SANÒ,  
E. CINGARI, A. ILACQUA, G. STURNIOLO

*The authors summarize the essential steps in liver surgery. Modern imaging techniques are of great help in establishing a circumstantiated diagnosis of post-traumatic lesions of the intra-abdominal parenchymatous organs, and especially the liver. Such diagnosis must always be based on the AAST (American Association for the Surgery of Trauma) classification, essential for a correct approach.*

*Each therapeutic choice must be based on a careful clinical evaluation to establish whether emergency exploration of the abdomen or simple patient monitoring is indicated. Organ injuries and consequent hemoperitoneum must be found and quantified.*

*In any case, diagnosis and treatment must only begin once all measures have been taken to ensure the maintenance of vital functions and the normalization of the main blood chemistry parameters.*

RIASSUNTO: I traumi del fegato. Note sulla diagnosi e sul trattamento.

M. BARBUSCIA, A. QUERCI, A. TONANTE, F. TARANTO, M. SANÒ,  
E. CINGARI, A. ILACQUA, G. STURNIOLO

*Gli Autori sintetizzano le tappe fondamentali della chirurgia del fegato. Si soffermano quindi sulle possibilità che le moderne tecniche di imaging offrono nel definire una diagnosi circostanziata delle lesioni post-traumatiche degli organi parenchimatosi intraaddominali e soprattutto del fegato e puntualizzano come tale diagnosi sia alla base dell'inquadramento di ogni singolo caso nella classificazione formulata dall'AAST, condizione indispensabile per un corretto approccio al paziente.*

*Nel riportare la loro esperienza relativa all'ultimo decennio, precisano come ogni scelta terapeutica debba essere conseguente ad una corretta valutazione clinica che consenta di porre l'indicazione all'esplorazione dell'addome in urgenza o, invece, di avviare un protocollo di monitoraggio del paziente. Si soffermano in particolare sulla validità della ricerca e della quantizzazione delle lesioni d'organo e del conseguente emoperitoneo.*

*Una corretta valutazione diagnostica e la conseguente terapia debbono essere attuate solo dopo l'avvio di tutte le misure atte a garantire il mantenimento delle funzioni vitali ed il ristabilimento dei principali parametri emato-chimici.*

KEY WORDS: Liver trauma - Liver resection - Hepatectomy - Hemoperitoneum  
Trauma del fegato - Resezione epatica - Epatectomia - Emoperitoneo.

### Introduction

The principles underlying surgery for liver trauma are those unanimously recognized as the essential steps marking the progress of liver surgery in the 20<sup>th</sup> century (1), which can be summarized as follows:

- the benefits of and techniques for clamping of the

hepatic peduncle, established by Pringle as far back as 1908 (2);

- the topographic anatomy of the liver and the intrahepatic duct system, described by Hjortsjo in 1951 (3);
- the anatomical and surgical structure of the liver and hepatic portal/arteriobiliary system, published by Couinaud in 1954 (4);
- the principles established by Fékété and Guillet in 1969: use of temporary hemostasis, adequacy of facilities and competence of the surgical team (5).

There has been a further change in the approach to the emergency surgery of all parenchymatous organs, including the liver, with the development of imaging techniques enabling a more accurate diagnosis of the location, type and extent of the injury.

University of Messina, Italy  
Chair of General Surgery  
(Head: G. Sturniolo)  
<sup>1</sup> Chair of Digestive Surgery  
(Head: M. Barbuscia)

© Copyright 2012, CIC Edizioni Internazionali, Roma

Blunt abdominal trauma is a relatively common event and a significant cause of death in all industrialized countries (6, 7). It is often caused by traffic accidents (75% of all liver injuries, of which 69% are associated with other injuries) (8, 9). Other causes include industrial accidents, sports activities, housework, violence and iatrogenic causes consequent to diagnostic procedures and/or surgery.

Liver segments V, VI, VII and VIII are most commonly affected, due to rib or vertebral fractures or crushing of the parenchyma at the back of the abdomen (10).

There are various types of parenchymal injury, depending on the intensity and characteristics of the trauma (11). The most common is hematoma, which may be intraparenchymal or subcapsular, followed by laceration – a deep or superficial interruption of the hepatic parenchyma – and fracture, consisting of a full thickness laceration of an entire segment or even an entire lobe. Another important injury is rupture, involving the destruction of one or more segments.

In 1987 the American Association for the Surgery of Trauma (AAST) published a six-grade classification of liver trauma, from superficial injuries to those incompatible with life. It is now universally applied. The variability of liver injuries means that resection is not always necessary, with some cases being treatable by coagulation, use of hemostatic agents, suturing, binding with absorbent meshes or even conservatively, with close monitoring alone.

## Patients and methods

In the last 10 years we have treated 57 patients with liver trauma, 39 (68.4%) male and 18 (31.6%) female, aged between 12 and 73 years, of whom 35 (61.4%) had abdominal or chest and abdominal trauma and 22 (38.6%) multiple trauma. After initial clinical evaluation, monitoring was begun and vital parameters were corrected as necessary in all patients and, where possible, CT was performed (Table 1).

In 5 (8.8%) young patients in a stable circulatory condition CT revealed *grade I injuries*, with two cases of circumscribed subcapsular lesions and three of minor capsular lacerations with minimal blood pooling around the wound. These injuries were mainly in segments VI and VII, with one case in segment III. All patients underwent a standard observation protocol with clinical, laboratory and radiological assessments, and were discharged after 6-8 days, returning for regular follow-up for at least six months.

CT revealed *grade II injuries* affecting the II, IV, V, VI and VII segments in 26 patients (45.6%) aged between 19 and 72. Their circulatory condition was good or in any case easily stabilized with crystalloid infusion or transfusion of fresh blood (1-3 units). Five of them had multiple traumas (3 ruptured spleen, 1 ruptured right kidney, 1 intestinal perforation). Specifically:

- in 9 cases, including the five with multiple traumas, there were roughly triangular hepatic lacerations extending down from the liver margin to between 3.8 and 5.6 cm. In all cases, there was also a capsular laceration and pooling of perihepatic blood, which in six cases extended along the paracolic grooves and into the pouch of Douglas. The presence of the hemoperitoneum required the ex-

ploration and lavage of the peritoneal cavity, revision of the parenchymal lesions and hemostasis with warm gauze, hemostatic agents or argon coagulation in the seven cases of oozing, and the use of hemostatic clips in the other two, which presented blood vessel injuries. The associated injuries required splenectomy in two cases, use of hemostatic agents on the capsular laceration of the spleen in one case, right nephrectomy in another and suture of two small lacerations of the ileal loops in the last case;

- there were subcapsular hematomas of between 7.2 and 9 cm in 12 patients, while the remaining five presented intraparenchymal hematomas of between 3.4 and 7.9 cm. Revision with removal of blood clots, ligation of the injured vessels and use of hemostatic agents was required in only three of these (one subcapsular and two intraparenchymal hematomas), where CT had revealed an increase in the size of the hematoma. All these patients were discharged after 8-10 days and underwent regular follow-up.

*Grade III injuries*, almost all of the right lobe, were found in 18 patients (31.5%), of whom nine had suffered multiple traumas (three pelvic fractures, two spleen ruptures, two vertebral and rib fractures, one right kidney rupture, one laceration of the diaphragm). Specifically:

- 5 patients presented stellate parenchymal lacerations. In four of these, hemoperitoneum and the proximity of lesions to the surface of the organ required revision of the cavity, removal of the blood clots and devitalized tissue fragments, and hemostasis, including the use of hemostatic clips. In the last case, the depth of the injury and stabilization of the circulation indicated careful monitoring;

- in 6 patients with large subcapsular hematomas (12-14.6 cm) we cleaned the hepatic parenchyma and optimized hemostasis, where possible using hemostatic agents or argon coagulation;

- in 2 cases of intra-parenchymal hematoma of 10 and 10.8 cm, after cleaning and hemostasis we closed the residual chamber and sutured the hepatic parenchyma with large stitches;

- in the last 5 patients, the presence and continuous shedding into the hemoperitoneum by ruptured subcapsular hematomas and the oozing of blood and bile induced us to carry out atypical resections. The section was treated with argon and then left open in all cases, with one or more drains positioned to spot any recurrence of bleeding or bile leakage. In this group there were four deaths of patients with multiple trauma, not due to their liver injuries: three were due to cranial trauma and one to cardiovascular complications. In the others, the timescale and procedures for discharge and subsequent follow-up were similar to those for patients with grade 2 injuries.

In 5 patients with multiple trauma and circulatory instability (Hb <8 mg despite transfusion of >500 mL blood) ultrasound and/or CT examination revealed *grade IV injuries*, involving destruction of the left lobe in one case, severe segment V and VI injury in two cases and segment II and VII injury in the other two. One patient had a little more than punctate lesion of the right suprahepatic vein. These patients were also treated with resection, with vein suture in the last case. Only three of these patients survived, and were discharged on day 14, while the other two died, one from a sudden recurrence of hemorrhage from the liver section and the other due to cranial trauma.

Finally, 3 patients with multiple trauma and severe circulatory instability underwent immediate laparotomy due to the extensive destruction of the right lobe (*grade V injury*) and severe peritoneal effusion. The severe injury to the right lobe was confirmed intraoperatively in all cases, with a laceration of segment I and an injury to the right suprahepatic vein also being found in one patient. The patients underwent right hepatectomy and, in the last case, ligation of the suprahepatic vein. Only one of these patients survived, and was discharged on day 14. The other two died on day 3 and day 7 from multiple organ failure (Table 1).

TABLE 1 - LIVER TRAUMA - PERSONAL CASELOAD

AAST grade	No. Cases	%	Diagnosis	Treatment	Hospitalization (days)	Outcome
I	5	8,8	2 circumscribed subcapsular lesions 3 small capsular lesions	Observation	6-8	Survived
II	26	45,6	9 parenchymal lacerations, Ø 3,8-5,6 cm 12 subcapsular hematomas Ø 7,2-9 cm 5 intraparenchymal hematomas Ø 3,4-7,9 cm	Hemostatic agents Vessel ligation + Hemostatic agents Vessel ligation + Hemostatic agents	8-10	Survived
III	18	31,5	5 stellate parenchymal lacerations 6 subcapsular hematomas Ø 12-14,6 cm 2 intraparenchymal ematoma Ø 10-10,8 cm 5 ruptured subcapsular hematomas	Cleaning of cavity and hemostatic agents (4 cases); Observation (1 case) Parenchmal clearing and coagulation with con argon Cleaning of cavity and suture Atypical resection	10-12	14 Survived 4 Died (cranial trauma complications 3 cases and cardiovascular complications 1 case)
IV	5	8,8	1 disruption of left lobe 2 severe bi-segment injuries right lobe (V e VI) 2 severe bi-segment injuries (II and VII) (with right suprahepatic vein lesion 1 case)	Resection and suture of suprahepatic vein (1 case)	14	3 Survived 2 Died (1 recurrence of bleeding; 1 cranial trauma complications)
V	3	5,3	2 severe tri-segment injuries right lobe (V, VIII and part of VI) 1 severe right lobe with laceration of segment I and right suprahepatic vein lesion	Right hepatectomy and ligation of right suprahepatic vein (1 case)	14	1 Survived 2 Died (multiple organ failure)

## Discussion

In liver trauma, hemoperitoneum is the most common clinical event, although in the initial stages it is often misidentified, due to signs and symptoms related to multiple trauma. Once monitoring of vital signs has begun it is vital to start the diagnostic procedure, to estab-

lish if there are any injuries that might indicate the need for emergency laparotomy. Abdominal ultrasound is increasingly important for this purpose and is now the first level examination, although it is hindered by meteorism, the presence of free air and pain.

CT is the gold standard in the overall evaluation of patients with chest and abdominal trauma. Literature re-

ports reveal that a routine CT scan in trauma patients has considerably reduced the number of unnecessary laparotomies (today accounting for less than 5%) as well as the percentage of false negatives (12,13). It is the findings from this procedure that provide the premises for any decision to opt for close monitoring rather than surgery, at least for the first 48 hours, given that most cases of liver trauma involve grade 1 or 2 lesions and the consequent bleeding is self-limiting (14-16).

An attentive conservative approach has had an important role in reducing mortality following blunt abdominal trauma, eliminating possible complications related not to the trauma itself but to surgery (effusions and abscesses, biliary fistulas, bilomas, choleperitoneum, hemobilia, compartmental syndrome), which can occur in between 3% and 40% of cases (17,18). It should be reiterated that although the conservative approach can be successful, there are a number of conditions (19-21):

- circulatory stability, achieved if necessary with the transfusion of no more than 3-4 units of blood;
- accurate and meticulous diagnostic procedure;
- no signs of peritonism or multiple peritoneal lesions;
- no brain or spinal cord lesions requiring neurosurgery;
- no other extra-abdominal lesions that might cause circulatory instability;
- adequate clinical and instrumental monitoring (22).

In any case, where there is shock, uncontrollable bleeding requiring the transfusion of more than four units of blood, a penetrating abdominal wound, signs of peritonism or a worsening of the clinical picture, surgery is required to control bleeding, remove any necrotic or infected tissue and repair any lesions, including of the duct system.

There are numerous surgical options not involving resection for grade II to IV injuries, which can be summarized as follows:

- simple hemostasis with clips or biological materials (absorbable gelatin, regenerated cellulose, fibrin glue) or warm gauze packs;
- coagulation (ultrasound or argon, radiofrequency);
- direct suturing of the wound flaps after debridement of devitalized tissue and careful ligation or suturing of any vessels or bile ducts;
- for serious bleeding, full thickness suture following Pringle's maneuver, which is sometimes affected by serious complications (recurrent hemorrhage and large intraparenchymal hematoma, arteriovenous fistula, pseudo-aneurysm, bile duct stenosis, hemobilia);
- for unstopable bleeding, use of compressive gau-

ze packing or wrapping with prosthetic material may be useful as an initial measure.

Clearly, which of these options to take is a decision made at the operating table following evaluation of the anatomopathological picture (23).

With minor injuries (lower AAST grades), diagnostic and therapeutic laparoscopy can be useful (24,25) and is in any case indicated for the onset of abdominal compartmental syndrome (26,27), sudden signs of peritoneal irritation with no apparent cause, recurrence of bleeding or when an ongoing complication is suspected (28-30). With more serious injuries (grades IV and V), after a generous laparotomy and clamping of the peduncle and/or large vessels and mobilization of the liver from its ligaments, treatment generally consists of anatomical or atypical liver resection.

In the rare cases of associated vessel lesions (suprahepatic vein, vena cava), whether diagnosed preoperatively or suspected when Pringle's maneuver does not stop bleeding, direct suturing, T-T anastomosis or positioning of a vascular prosthesis is carried out after resection of the damaged part.

Finally, when the injury cannot be repaired (grade VI) the only option is hepatectomy and the possibility of survival is thus related to the availability of a liver transplant.

## **Conclusions**

In the case of a patient with abdominal, chest and abdominal trauma or multiple trauma, once all necessary measures have been taken to ensure the maintenance of vital functions and the normalization of the main blood chemistry parameters, a careful diagnostic procedure and close monitoring of the patient are necessary. This enables surgery to be avoided in patients with minor liver injuries, even in the presence of moderate bleeding, where there are no signs of peritoneal irritation or other abdominal organ injuries, with successful restoration of vital parameters and circulatory stability.

If the clinical picture worsens after initial stabilization, probably due to recurrent bleeding involving between 20% and 40% of the total blood volume, surgery is required, but even in the case of grade IV lesions application of hemostatic agents, coagulation or suturing or binding with absorbent gauze may be all that is needed, depending on the anatomopathological situation.

In patients with more serious lesions resection must be carried out as needed; this must be immediate in patients whose clinical condition is progressively worsening and who do not respond to infusion or require continuous transfusions to maintain their circulatory stability.

## References

1. David Richardson J, Franklin GA, Lukan JK, Carrillo EH, Spain DA, Miller FB, Wilson MA, Polk HC Jr, Flint LM. Evolution in the management of hepatic trauma: a 25-year perspective. *Ann Surg* 2000;232(3):324-30.
2. Pringle JH. V. Notes on the arrest of hepatic hemorrhage due to trauma. *Ann Surg* 1908;48(4):541-9.
3. Hjortsjo CH. The topography of the intrahepatic duct system. *Acta Anat (Basel)* 1951;11(4):599-6.
4. Couinaud C. Lobes de segments hépatiques: notes sur architecture anatomique et chirurgicale du foie. *Press Med* 1954;62(33):709-12.
5. Fékété F, Guillet R. Les traumatismes du foie. *J Chir* 1969;98(1):55-74.
6. Scollay JM, Beard D, Smith R, McKeown D, Garden OJ, Parks R. Eleven years of liver trauma: the Scottish experience. *World J Surg* 2005;29(6):744-9.
7. Coughlin PA, Stringer MD, Lodge JP, Pollard SG, Prasad KR, Toogood GJ. Management of blunt liver trauma in a tertiary referral centre. *Br J Surg* 2004;91(3):317-21.
8. Nawaz Khan A, Vadeyar H, Macdonald S, Chandramohan M. Liver trauma. From: *eMedicine.com* 2009.
9. Brammer RD, Bramhall SR, Mirza DF, Mayer AD, McMaster P, Buckels JA. A 10-year experience of complex liver trauma. *Br J Surg* 2002;89(12):1532-7.
10. Rulli F, Galatà G, Maura A, Cadeddu F, Olivi G, Farinon AM. Dynamics of liver trauma: tearing of segments III and IV at the level of the hepatic ligament. *Chir Ital* 2008; 60(5):659-67.
11. Malhotra AK, Latifi R, Fabian TC, Ivatury RR, Dhage S, Bee TK, Miller PR, Croce MA, Yelon JA. Multiplicity of solid organ injuries: influence on management and outcome after blunt abdominal trauma. *J Trauma* 2003;54(5):925-9.
12. Livingston DH, Lavery RF, Passannante MR, Skurnick JH, Baker S, Fabian TC, Fry DE, Malangoni MA. Free fluid on abdominal computed tomography without solid organ injury after blunt abdominal injuries does not mandate celiotomy. *Am J Surg* 2001;182(1):6-9.
13. Jacobs DG, Sarafin JL, Marx JA. Abdominal CT scanning for trauma: how low can we go? *Injury* 2000;31(5):337-43.
14. Basile G, Chiarenza S, Di Mari P, Primus A, Boscarelli G, Buffone A, Cirino E. Il trattamento dei traumi addominali chiusi. Nostra esperienza. *Ann Ital Chir* 2006;77(2):149-54.
15. Stassen NA, Lukan JK, Carrillo EH, Spain DA, Norfleet LA, Miller FB, Polk HC Jr. Examination of the role of abdominal computed tomography in the evaluation of victims of trauma with increased aspartate aminotransferase in the era of focused abdominal sonography for trauma. *Surgery* 2002;132(4):642-6.
16. Fang JF, Chen RJ, Wong YC, Lin BC, Hsu YB, Kao JL, Chen MF. Classification and treatment of pooling of contrast material on computed tomographic scan of blunt hepatic trauma. *J Trauma* 2000;49(6):1083-8.
17. Marmorale C, Guercioni G, Siquini W, Asselhab S, Stortoni P, Fianchini M, Fianchini A, Landi E. Il trattamento non operativo dei traumi addominali chiusi. *Chir Ital* 2007;59(1):1-15.
18. Rousseau A, Regimbeau JM, Vibert E, Vullierme MP, Sauvanet A, Belghiti J. Hémobilie après traumatisme hépatique ferme: une complication par fois tardive. *Ann Chir* 2004;129(1):41-5.
19. Schwab CW. Selection of nonoperative management candidates. *World J Surg* 2001;25(11):1389-92.
20. Velmahos GC, Toutouzas KG, Radin R, Chan L, Demetriades D. Nonoperative treatment of blunt injury to solid abdominal organs: a prospective study. *Arch Surg* 2003;138(8):844-51.
21. Miller PR, Croce MA, Bee TK, Malhotra AK, Fabian TC. Associated injuries in blunt solid organ trauma: implications for missed injury in nonoperative management. *J Trauma* 2002;53(2):238-42.
22. Ochsner MG. Factors of failure of nonoperative management of blunt liver and splenic injuries. *World J Surg* 2001; 25(11):1393-6.
23. Richardson JD. Changes in the management of injuries to the liver and spleen. *J Am Coll Surg* 2005;200(5):648-69.
24. Chelly MR, Major K, Spivak J, Hui T, Hiatt JR, Margulies DR. The value of laparoscopy in management of abdominal trauma. *Am Surg* 2003;69(11):957-60.
25. Simon RJ, Rabin J, Kuhls D. Impact of increased use of laparoscopy on negative laparotomy rates after penetrating trauma. *J Trauma* 2002;53(2):297-302.
26. De Sena G. Trattamento dei traumi epatici. *Atti 106° Congresso SIC Roma* 2004;22:1-290.
27. Christmas AB, Wilson AK, Manning B, Franklin GA, Miller FB, Richardson JD, Rodriguez JL. Selective management of blunt hepatic injuries including non operative management is a safe and effective strategy. *Surgery* 2005;138(4):606-10.
28. Hashemzadeh SH, Hashemzadeh H, Dehdilani M, Rezaei S. Non-operative management of blunt trauma in abdominal solid organ injuries: a prospective study to evaluate the success rate and predictive factors of failure. *Min Chir* 2010;65(3):267-74.
29. Lee JY, Chiang HH, Chang PC, Lin JY, Chang YT. Early laparoscopic approach for complicated blunt hepatic injury in an adolescent. *J Trauma* 2009;67(6):E190-33.
30. Leenen LP. Abdominal trauma: from operative to nonoperative management. *Injury* 2009;40 Suppl 4:S62-8.