OPERATIVE MANAGEMENT OF MAJOR LIVER INJURIES

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SUMMARY

Background: For many years, management of liver injuries has involved many operative strategies ranging from simple suture to hepatic resection. Although mortality rates from liver injury have reduced recently, operative management of major liver injuries still remains a significant challenge. Aim of this study is to evaluate our 12 year experience of major liver injuries and to document the factors influencing treatment and outcome.

Methods: One hundred and fifty-five consecutive patients with major hepatic injuries (grades III to V) were managed during the 12 year period (1990-2002). Demographic, clinical and operative data were recorded evaluating the patients in two separate time periods (1990 to1996; 1996 to 2002). Associated organ injuries, types of the operative treatment, postoperative complications, and mortality rates were also analyzed for each group.

Results: All 155 patients sustaining either blunt trauma or penetrating trauma were managed operatively. There were 73 patients (47%) in the first group (1990-1996) and 82 patients (53%) in the second group (1996-2002). When non-operative treatment was not used to treat any patient with liver injury, 71 patients (46 %) were managed by simple suture alone. Non-anatomical resection (resectional debridement) was the type of treatment in 39 patients (25 %). Eighteen (12 %) patients had perihepatic packs placed to stop bleeding during the initial laparotomy. There were 27 (17 %) patients who were definitively treated by anatomical resection. 132 (85%) patients had one or more associated organ injuries, with skeletal and chest injury being the most common. Among the postoperative complications occurred, re-bleeding, biliary fistula ,cholangitis, and coagulopathy were the most important. The mean operative time, blood loss and transfusion requirement resulted in a significant decrease in the second group ($P < 0.05$). Whereas length of hospital stay was similar in two groups, length of ICU stay was significantly prolonged in the second group ($P < 0.01$). There were a total of 18 deaths (overall mortality, 11.6%), half of which ascribed to the liver itself. Other half of deaths were related to associated organ injuries and systemic organ failures. The mortality rates for the first period and the second period were 15% and 8.5%, respectively.

Conclusions: Management of the major liver injuries remains a formidable challenge for the surgeon. Multimodal surgical strategies are available for control of bleeding from the liver and mortality can be reduced by multidisciplinary approaches.

KEY WORDS : Major liver injury, operative management, complications, mortality

INTRODUCTION

After the spleen, the liver is the most commonly injured intra-abdominal organ in abdominal blunt trauma[1]. The primary goal in the treatment of severe liver injuries is to preserve life, and management is divided into four sequential phases; resuscitation, evaluation, initial management, and definitive treatment. Associated organ injuries, uncontrollable bleeding from the liver and subsequently developed septic attacks are the basic factors contributing to morbidity and mortality[2]. The overall mortality from liver trauma has fallen to 10-15 % over the past few decades. However, major liver injuries which account for 10 % to 30 % of injuries remain formidable challenges for the surgeons[3,6]. Bleeding from the injured liver still remains the most significant problem in the management of major liver injuries. Surgical treatment strategies vary from simple suturing to aggressive approaches[2,4,6,7]. Recently, the improvements in the use of rapid transport systems of traumatized patients, good intensive care, and resuscitation, better knowledge of liver anatomy and physiology have contributed to better survival in patients with liver injury. In addition to improvements technical and anatomical knowledge, increased experience also is important for management of major liver injuries. In this study, authors divided own institutional experience as a first and second six years for approach in patients with major liver injuries.

Patients and methods

During a period of 12 years from January 1990 to January 2002, a total of 322 patients who sustained hepatic trauma were treated operatively at our center. Of these, 167 patients with minor hepatic injuries were not considered in this study. The remaining 155 patients who sustained major hepatic injuries (grades III to V) form the basis of this report. In all, 155 patients with major injuries were

evaluated in two groups over two separate time periods. Group 1 included 73 patients treated between 1990 and 1996, Group 2 included 82 patients treated between 1996 and 2002. The clinical data from patients included demographics, mechanism of injury, hemodynamics on admission, hepatic injury grade, injury severity score (ISS), associated injuries, operative time, blood loss, transfusion requirements, surgical procedures, postoperative complications, length of stay in the intensive care unit (ICU) and the hospital mortality. The severity of the liver injury was graded according to guidelines established by the Organ Injury Scaling Committee of the American Association for the Surgery of Trauma (AAST)[8]. The ISS was determined by the methods described by Baker et al[9]. The assessment of hemodynamic stability was based on routine vital signs. Patients with admission systolic blood pressure lower than 90 mmHg, a requirement for >2 liters electrolyte solution and >2 units blood over the next 2 hours were regarded as hemodynamically instable. Patients who underwent laparotomy for hemodynamic instability or any other indications such as evidence of free intraperitoneal air on plain abdominal film, signs of peritoneal irritability clinical deterioration during the observation, and presence of gunshot and stab wounds. Some of the patients exhibiting equivocal abdominal signs owing to additional head injury underwent diagnostic peritoneal lavage (DPL) and if DPL proved to be positive, immediate laparotomy was undertaken. Statistical analyses were performed using one-way factor analysis of variance (ANOVA) with Scheffe's test as a post hoc test. Probability values less than 0.05 were considered significant.

RESULTS

Group 1 comprised 44 male and 29 female patients with a mean age of 33 (range, 18-58) year and Group 2

Table 1. Characteristics of 155 major hepatic injuries

		Group I (n=73)	Group II (n=82)	P
Age (years)		33 (18-58)	36 (18-62)	N.S.
Male/Female		44/29	45/37	N.S.
Mechanism of injury				N.S.
Blunt		59	64	
Motor vehicle accident		53	59	
Beat		3	3	
Fall from a height		3	2	
Penetrating		14	18	
Stab wound		8	11	
Gunshot wound		6	7	
Hemodynamic instability on admission	Yes	14	22	N.S.
	No	59	60	
Grade of liver injury				N.S.
	3	34	43	
	4	30	30	
	5	9	9	
	ISS	29 (13-75)	31 (13-59)	N.S.

ISS; Injury Severity Score, N.S; Not significant.

Table 2. Associated organ injuries

Injury	Group 1	Group 2	P
Skeletal	19	25	N.S.
Chest	15	21	N.S.
Head	20	18	N.S.
Splenic rupture	12	9	N.S.
Intestinal rupture	11	8	N.S.
Retroperitoneal hematoma	4	6	N.S.
Fascial	3	5	N.S.
Spinal	2	4	N.S.
Pancreas	2	1	N.S.
Kidney	-	1	N.S.
Others	4	7	N.S.

N.S; Not significant.

Table 3. Initial operative procedures

Grade	Operation	Group I	Group I	Total
III	Primary suture	31	40	71
	Non-anatomical resection	3	3	6
IV	Non-anatomic resection	15	17	32
	Anatomical resection	7	9*	16
	Perihepatic packing	8	4	12
V	Non-anatomic resection	1	-	1
	Anatomical resection	4*	7	11
	Perihepatic packing	4	2	6

*Atrial caval shunt was employed in two patients during the surgery.

Table 4. Operative outcomes in patients with major hepatic injury

	Group I (n = 73)	Group II (n = 82)	P
Operative time (min)	280 (170-415)	255 (155-390)	0.04
Blood loss (ml)	1480 (660-5380)	970 (390-4140)	0.001
Blood transfusions (units)	4.8 (2-13)	3.9 (1-9)	0.02
Length of ICU stay (days)	3.2 (1-11)	4.1 (1-15)	0.005
Length of hospital stay (days)	8.6 (1-19)	9.4 (1-22)	N.S.

ICU; Intensive Care Unit, , N.S; Not significant.

Table 5. Postoperative complications of all patients

Complications	Group 1	Group 2	P
Wound infection	10	7	N.S.
Pleural effusion	9	7	N.S.
Re-bleeding	3	2	N.S.
Biliary fistula	3	1	N.S.
Coagulopathy	2	2	N.S.
Cholangitis	1	3	N.S.
Renal failure	2	1	N.S.
Subphrenic abcess	1	2	N.S.
Intraabdominal sepsis	1	1	N.S.
ARDS	2	0	N.S.
Pulmonary embolism	1	1	N.S.
Hepatic failure	1	-	N.S.

N.S; Not significant.

Table 6. Causes of deaths

	Group I (n)	Group 2 (n)	P
Liver related			N.S.
Grade 4		2	1
Grade 5		3	3
Liver unrelated			
Head injury	2	2	
ARDS	1	1	
Intraabdominal sepsis	1	-	
MODS	1	1	
Overall mortality	10	8	N.S.

MODS: Multiple organ dysfunction syndrome

comprised 45 male and 37 female patients with a mean age of 36 (range, 18-62) years. The comparison results of evaluation of two distinct groups are presented in Table 1. There were no remarkable differences in the demographics, mechanism of injuries, hemodynamic parameters, associated injuries, ISSs, and grades injury. The mean injury severity score (ISS) were 29 (range, 13-39) in Group1 and 31 (range, 13-59) in Group2, respectively, demonstrating no difference between two groups. The associated organ injuries both intra-abdominal and extra-abdominal are shown in Table2. While twenty three (15%) patients had no associated injuries, one hundred and thirty two (85%) patients had one or more injuries with skeletal and chest injuries being the most common. The distribution of the patients by injury grade and the details of operative procedures employed on the liver are given in Table 3. A total of 71 patients (31 in Group1, 40 in Group2) with grade III liver injuries were managed by primary suturing and required no further surgery for hemostasis. Non-anatomical resection, namely resectional debridement which involves the removal of all devitalized liver tissue was performed in 39 patients with grade 4 to 5 injury (19 in Group 1, 20 patients in Group 2). Three patients (two in Group 1, one in Group 2) re-bled postoperatively and required anatomical resections to stop bleeding. Based on the severity of liver injury, anatomical resections varying in extent were employed in 27 patients (11 in Group 1 and 16 in Group 2) as the initial surgical treatment. Atriocaval shunt was also performed in two of these patients. Perihepatic packing and planned re-operation was attempted in 18 patients with hypothermia resulting from excessive blood loss. Of these, twelve patients had perihepatic packing placed during the initial period and the subsequent six during the second period. However, two patients who re-bled after the planned re-operation underwent anatomical hepatic resections and 6 required resectional debridement to remove the discrete area of devitalized parenchyma.

Operative outcomes are listed in Table 4. When compared with Group 1, operative time was found significantly shorter in Group 2 ($P < 0.05$). Mean intraoperative blood loss was 1480 ml (range, 660-5380 ml) in Group 1 and 970 ml (range, 390-4140 ml) in Group 2, respectively. The difference between two groups was statistically significant ($P < 0.01$). The average blood transfusion requirement for Group 1 was 4.8 (range, 2-13) units and for Group 2 was 3.9 (range, 1-9). The mean intraoperative transfusion requirement was also significantly higher in the first group than in the later group ($P < 0.05$). The lengths of ICU and hospital stay were 3.2 days and 8.6 days in Group 1, respectively; 4.1 days and 9.4 days in Group 2, respectively. Length of ICU stay was found to be significantly longer in the later group ($p<0.05$). The most important complications encountered in both groups were pleural effusion, rebleeding, biliary fistula and coagulopathy (Table5). There were 18 deaths, giving an overall mortality rate of 11,6 % (Table 6). Nine deaths were directly attributable to the liver injury. Of these, five patients died of continued hemorrhage (hemorrhagic shock) as a result of severe liver injury itself not appreciated during the initial surgery. Three patients who had packs placed receiving massive transfusions developed coagulopathy, and died within 72 hours of surgical intervention. One patient died of hepatic failure which developed ten days after surgery. Among the non-liver causes head injury in four patients, adult respiratory distress syndrome in two, intraabdominal sepsis developed after removal of packing in one, multiple organ dysfunction in two were responsible for deaths. Although in the second period was observed a slightly decline in both liver related mortality and liver unrelated mortality, this decline was not significant.

DISCUSSION

Although it is protected by the costal cage, the liver is the most frequently injured intraabdominal organ in blunt abdominal trauma after the spleen[1]. Associated organ injuries, uncontrollable bleeding and subsequent septic

complications continue to pose life-threatening challenges for the surgeons[2,6]. The magnitude of the injury, the management requirements and complexity of the surgical repair are determined by the extent, anatomical location, and mechanism of injury. Blunt liver injury differs from penetrating trauma in that there is frequently more extensive parenchymal disruption, subsequent devitalization, and a high incidence of accompanying hepatic venous injuries [10,11]. The majority of the injuries to the liver in both groups in our series were due to blunt trauma.

Most liver injuries are simple and can be treated non-operatively. In view of recent experiences, it is possible to say that there has been an evolution towards non-operative management of liver injuries in selected patients [12,15]. Pachter and Hofstetter outlined the criteria for selection,the most important of which was hemodynamic stability on admission to hospital or the achievement of such with a modest volume of intravenous fluid[12]. Additional criteria included presence of neurological integrity, absence of peritoneal signs, and absence of the need for excessive liver related transfusions. On the other hand, non-operative treatment necessitates close observation of vital signs, repeated examination of abdomen, serial estimation of hemoglobin, and follow up imaging with computed tomography (CT) scanning to determine resolution of injury[16]. If intraabdominal bleeding does not stop or there is evidence of associated organ injury, operative intervention becomes mandatory. Complex lesions need early diagnosing and require major surgery. The priorities of surgery are rapid control of bleeding and removal of dead or devitalized liver tissue, and ligate or repair damaged blood vessels and bile ducts. Since the beginning of the former century, a variety of surgical methods including hepatorraphy (primary suture), hepatotomy, resectional debridement (non-anatomic resection), anatomical resection, perihepatic packing, hepatic arterial ligation, atrial caval shunt have been described in the management of severe liver injuries [1,4,6,7,17]. Hepatorraphy is one of the earliest methods to be performed to arrest bleeding from the liver. Although this type of repair has fallen out of favors in the last few years, many surgeons still believe its usefulness in liver injuries[15]. In the present series, seventy-one patients with grade III liver injuries were treated with primary suture alone. After the treatment of primary suture no complication related to liver occurred. Resectional debridement, namely non-anatomical resection involving the removal of all devitalized liver tissue that borders the injury site as the boundaries of resection. This procedure rather than anatomical resection allows rapid surgery, an important consideration in critically ill patients, and reduces the risk of postoperative complications such as liver failure[18,20]. Non-anatomical resection was the choice of treatment method in 39 patients (19 in Group 1 and 20 in Group 2). Of patients who had nonanatomical resection, 3 re-bled postoperatively and converted to anatomical resection. Disruption of blood supply to the remaining hepatic lobe may cause subsequent bleeding which requires extensive hepatic resection [21,22,23].

Hepatic resection is a salvage procedure in patients with diffuse parenchymal damage. The principal indications for anatomical resection are deep lacerations involving major vascular structures and bile ducts in the liver, extensive devitalization and hepatic venous bleeding. Anatomical resection was initially performed in a total of 27 patients, eleven of whom were in Group 1 and sixteen of whom were in Group 2. Anatomical resection or formal hepatectomy is performed along formal anatomic planes that are unrelated to the lines of fracture. It may be required at the original operation as the only method of salvaging a patient from exsanguinations or in a patient whose bleeding has been controlled by other methods but where the liver is so badly damaged that it is unlikely to function normally and where subsequent necrosis and sepsis will jeopardize survival. As our experiences accumulated, more patients with major liver injury were managed by formal resection for initial attempt.

When conventional procedures fail to control bleeding in a patient with complex hepatic injury, perihepatic packing with manual compression is a temporary, life-saving maneuver. As pointed out by Calne et al and others, packing is also a useful adjunct facilitating transfer of patients to a tertiary care center for definitive management[24,27]. During the transportation of patients with severe liver injury, excessive blood loss may occur, which necessitates massive transfusion of banked blood. This situation, together with hypothermia and acidosis, results in clinical coagulopathy. In this regard, use of perihepatic packing for bleeding control was carried out in 18 patients (12 in the first,6 in the second) with grades4 to 5 injuries, declining in the second period. However, this surgical technique was successful in 10 patients (55%) as definitive treatment. Despite this outcome, we believe that perihepatic packing remains not only a definitive treatment with complex liver injuries beyond the surgeon's ability to manage but a surgical adjunct if hypothermia and coagulopathy develop, causing diffuse bleeding from the injured liver which is not possible to alleviate by other means. On the other hand, controversy exists concerning timing of packing, and many authors believe that it should be performed when suspected of coagulopathy. As in our experience of packing, some have considered transfusion requirements exceeding 10 units, hypothermia (body temperature below 320C), acidosis (pH below 7.2) and clinical signs of diffuse coagulopathy indications for packing[27,28].

Recently, improvements in approaching traumatized patients have led to a fall at the mortality rates[1,4,7,29]. Better knowledge of liver anatomy and physiology, aggressive resuscitative methods, intensive care are those contributing to this improvement. In many reports, early mortality has been linked to uncontrolled hemorrhage and associated injuries, whereas late mortality has been resulted from sepsis and multiple organ failure[5,28,30,32]. Present study was carried out comparing the clinical characteristics and treatment outcomes in two separate time periods. Interestingly, when length of hospital stay was similar in

two intervals of patients, length of ICU stay was significantly prolonged in the later group (P<0.01). Not significantly, a comparison of the mortality rates between two intervals of patients demonstrated that the second interval of patients had a relatively lower mortality rate than in the first interval. On the other hand, the mean operative time, estimated blood loss and the number of units transfused were significantly lower in the second interval. Our more disciplined approaches to correction of general status of patients with major hepatic injury may have led to more successful treatment in the second interval. In addition to advanced technical expertise in handling of damaged liver, improvements in postoperative care such as use of positive pressure ventilation for good pulmonary function, systemic hemodialysis programs for renal failure, nutritional support and infection prophylaxis may be considered important aspects in management of patients with major liver injury. Based on these expectations, length of ICU stay during the second period might have been prolonged.

In conclusion, major liver injury is still associated with a significant mortality rate. Associated organ injuries and severity of the liver injury seem to be responsible for the majority of deaths in patients with major liver injuries. Also, we provide remarkable advances in ICU and in critical care surgery as well as the experience at hepatobiliary surgery. We believe that the main points in the management of severe liver injuries should include the rapid control of bleeding from the liver together with aggressive resuscitation, definitive surgical procedures, dealing with associated organ injuries and supportive postoperative care.

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