Chapter 3

OPERATIVE MANAGEMENT OF LIVER INJURIES

Packing for control of hemorrhage in major liver trauma

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ABSTRACT

Background: Packing for complex liver injuries has been associated with an increased risk of abdominal sepsis and bile leaks. The aim of the present study was to determine the optimum timing of pack removal and to assess whether the total duration of packing increases the incidence of these complications.

Methods: The study was based on a retrospective review of all patients requiring liver packing over an 8-year period in a level 1 trauma center.

Results: Ninety-three (17%) of 534 liver injuries identified at laparotomy required perihepatic packing. Penetrating and blunt trauma occurred in 72 (77%) and 21 (23%), respectively. The mean total duration of packing was 2.4 days (range: 0.5–6.0 days). There was no association between the total duration of packing and the development of liver-related complications (P = 0.284) or septic complications (P = 0.155). Early removal of packs at 24 h was associated with a higher rate of re-bleeding than removal of packs at 48 h (P = 0.006).

Conclusions: The total duration of liver packing does not result in an increase in septic complications or bile leaks. The first re-look laparotomy should only be performed after 48 h. An early re-look at 24 h is associated with re-bleeding and does not lead to early removal of liver packs.

INTRODUCTION

The use of liver packing for complex liver injuries with a subsequent re-look laparotomy and removal of the packs has resulted in the control of bleeding from coagulopathy in up to 80% of patients presenting with these injuries.[1–11] The leading cause of death in severe liver injuries remains uncontrollable bleeding, whereas sepsis and multiple organ dysfunction are the primary causes of morbidity and late death.[12] Mortality also appears to be higher in older patients, those with higher grade injuries, and those with hemodynamic instability on presentation and with blunt trauma.[13] Over half of patients surviving grade 3–5 liver injuries will be at risk for the development of complications including hemorrhage, intra-abdominal abscess formation, and bile leaks.[14] Sepsis is a major source of morbidity following packing, and this has led to the recommendation that liver packs be removed as soon as possible. Others have stated that the timing of pack removal is not as critical as ensuring that hemodynamic stability has been achieved. These opposing viewpoints have resulted in concern about the timing of the planned re-look laparotomy with removal of the liver packs, which can vary from as early as 12 h to as late as 7 days after the original liver injury.[4,10,15] There appears to be little consensus on the optimum timing for re-look and removal of liver packs. The aim of the present study was to determine when liver packs should be removed following packing for complex liver trauma and whether the total length of time that liver packs are in situ is related to the development of subsequent complications.

PATIENTS AND METHODS

Patients presenting between January 1996 and May 2004 to Groote Schuur Hospital Trauma Unit with liver injuries that required laparotomy were identified. An emergency laparotomy was performed on patients with persistent hemodynamic instability, an acute abdomen, ongoing blood transfusion requirements, a denervated abdomen with penetrating abdominal injuries, and the finding of free fluid on computed tomographic (CT) scan without any solid organ injury in the unconscious patient. Laparoscopy was used to exclude tangential gunshot wounds, but the finding of peritoneal penetration was used as an indication for laparotomy. Since January 2000 isolated low-velocity gunshot wounds of the liver have been treated conservatively provided the patient was hemodynamically stable, fully conscious to allow for serial clinical examinations, and if there was no active liver bleeding apparent on the CT scan.[16] All patients were resuscitated according to Advanced Trauma Life Support[17] (ATLS) recommendations. At laparotomy the liver injury was graded according to the liver injury scale of the American Association of Surgery in Trauma.[18] On-going bleeding from the liver led to liver packing

in conjunction with the Pringle maneuver and selective ligation of any visible bleeders and large bile leaks. In such circumstances, the Pringle maneuver was employed for a period of 20 min, after which the clamp was released and the liver was re-examined for any further bleeding. Selective ligation of any arterial bleeders was then undertaken. Failure to control bleeding led to packing the liver with approximately 6 abdominal swabs so as to restore liver continuity and to provide compression. This technique was employed as part of the strategy of damage-control surgery. Abdominal swabs were never placed into a laceration, and the liver was never merely sutured over a bleeding vessel. After liver packing, the abdomen was left open if there was any concern about the intra-abdominal pressure. All patients were then transferred to the intensive care unit for correction of acidosis, coagulopathy, and hypothermia. A re-look laparotomy was performed when the patient's temperature

had normalized, shock had been corrected, and the International Normalized Ratio (INR) was less than 1.5. A re-bleed was defined as bleeding from the liver after pack removal and requiring re-packing. A liver-related complication was defined as a biloma or a biliary fistula and an infected intra-abdominal collection was a collection (serosanguinous or purulent) identified at laparotomy with positive pus swabs or requiring percutaneous drainage after CT scan associated with positive swabs. Blood collections on and around the prosthetic plastic bag were not considered significant. The total duration of packing was the total amount of time that the liver packs were left in the patient's abdomen. Statistical analysis was performed using the Fisher's exact test for noncontinuous variables and the nonparametric analysis of variance (ANOVA) and Wilcoxon ranksum test for continuous variables. SAS System Package version 8.2 software (SAS Systems International, Cary, North Carolina, USA) was used for this analysis. A P value < 0.05 was considered statistically significant.

RESULTS

During the 8 years of the retrospective study, 534 patients presented to Groote Schuur Hospital with liver injuries identified at laparotomy. In 369 (69%) patients the liver was not bleeding at the time of operation; in 306 (57%) the liver was drained, and the remaining 63 patients were managed without drainage (Table 1). Fortysix patients required suturing of their liver injury to obtain hemostasis. A liver resection was performed in 22 patients. This consisted of non-anatomic resection and debridement in 21 patients and a right lobectomy and a Roux-en-Y hepaticojejunostomy in a single patient for a gunshot wound through the porta hepatis with an injury to the intrahepatic portion of the right hepatic duct. Four patients required temporary packing of the injury in conjunction with the Pringle maneuver, which controlled the bleeding, allowing removal of

Table 1.
Surgical management of 534 liver injuries at laparotomy

Surgical management	Number of patients
Drainage	306
No drainage	63
Suturing of liver	46
Liver resection	22
Temporary packing	4
Liver packing	93

the liver packs before the abdomen was closed. Definitive liver packing with subsequent re-laparotomy and removal of packs was used in 93 of the 534 patients (17%). The mean age of the 93 patients that required liver packing was 30 years (range: 14–68 years). The mean revised trauma score was 6.4 (range: 0.6–7.8). Seventytwo patients sustained penetrating trauma, most commonly from gunshot wounds (Table 2). Liver packing was required predominantly for the higher-grade 3, 4, and 5 injuries (Table 3). Twenty-one of the 93 patients who underwent liver packing died in the first 24 h. Eleven of these deaths were on the operating table and 10 patients died later in the surgical intensive care unit. At autopsy the predominant causes of death appeared to hypovolemia and irreversible shock in 10, and multiple injuries in 8 patients. Two patients died from head injuries and 1 from an associated cardiac injury. The early operative mortality (< 24 h) was 23%. All twenty-one patients who died within the first 24 h after arrival at the hospital were excluded from further analysis. The remaining 72 patients, who survived more than 24h, were divided into three groups, depending on whether the first re-look laparotomy and removal of packs was performed at 24 h, 48 h, or 72 h (Table 4). Twenty-five patients underwent first re-look laparotomy at 24 h. Eleven of these patients were taken to the operating room for decompression of the abdomen after they developed signs of abdominal compartment syndrome. Another 2 patients had associated cardiac injuries that required sternotomy and repair; of these 13 patients, 9 required re-packing of the liver. The remaining 12 of the 25 patients were hemodynamically stable. They

Table 2.
Mechanism of injury in 93 patients with liver packing

Mechanism of Injury	Number of patients
Gunshot wound	66
Stab	6
Motor vehicle accident	15
Train accident	3
Blunt assault	3

Table 3.
Grade of liver injuries and numbers packed and not packed

Grade	Packed	Not packed
1	0	40
2	1	123
3	20	151
4	58	123
5	14	4
Total	93	441

Table 4.
Timing of the first re-look laparotomy and re-bleeding rate requiring packing in hemodynamically stable patients with an INR < 1.5

Re-look (h)	No. of patients	Exclusions[a]	No. of patients INR < 1.5	Re-bleeding
24	25	11 ACS 2 Cardiac	12	8
48	44	1 ACS	43	5
72	3		3	0

[a] Patients excluded as the reason for their re-look laparotomy was either ACS (abdominal compartment syndrome) or in two cases a re-look was performed as the patient was being taken to the operating room for a cardiac injury.
INR: International Normalized Ratio.

had been re-warmed, and their coagulopathy was corrected (INR of less than 1.5), and they were taken to the operating room for removal of their liver packs at 24 h. Eight of these patients required re-packing of their liver injuries due to bleeding that occurred during removal of the packs. Forty-four patients had their first re-look laparotomy at 48 h. One patient developed abdominal compartment syndrome, but the remaining 43 patients were all hemodynamically stable with an INR corrected to less than 1.5. Of these patients only 5 had bleeding on removal of the liver packs that required re-packing. In the remaining 38 patients, of this group, the liver packs were successfully removed. Three patients were taken for their first re-look laparotomy at 72 h, and in all 3 cases the packs were removed without any further bleeding. Early removal of packs at 24 h was associated with a higher rate of re-bleeding than removal of packs at 48 h ($P = 0.006$). The mean total duration of packing was 2.4 days (range: 0.5–6.0 days). To summarize, In 8 patients the liver packs were left in for a total of 24 h (Table 5), and 44 patients had their liver packs left in for a total of 48 h. In the latter group there were 17 intra-abdominal collections and 6 liver-related complications. Another 20 patients were packed for a total duration of 3 days or longer. In that group, there were 9 intra-abdominal collections and 3 liver-related complications. The total duration of packing, whether 2 or 3 days, did not appear to be related to the development of either intra-abdominal collections ($P = 0.284$) or liver-related complications ($P = 0.155$). The presence of a small bowel or colon injury was an important factor with regard to the development of an intra-abdominal collection ($P = 0.001$). There were only 15 intra-abdominal collections in the 52 patients without bowel injuries, whereas 16 intra-abdominal collections were recorded in 20

Table 5.
Total duration of liver packing and the development of complications

Duration (days)	No. of patients	Intra-abdominal collections	Liver-related complications
1	8	6	5
2	44	17	6
3 or longer	20	9	3
		$P = 0.284$	$P = 0.155$

patients with associated small bowel or colon injury. The other factor that was important in the development of an intra-abdominal collection was an open abdomen. Eighteen of the 72 patients who survived more than 24 h had an open abdomen. There were 13 intra-abdominal collections in these 18 patients. Only 18 of the 54 patients in whom primary closure of the abdomen was possible developed an intra-abdominal collection. Thus the presence of an open abdomen appeared highly significant (P = 0.004) with respect to the development of an intraabdominal collection. Twenty-one of the surviving 72 patients required repacking. There was no increase in liver-related (P = 0.120) or septic complications (P = 0.246) in the patients who were re-packed compared to the 51 patients who did not require re-packing. Re-packing did not appear to result in an increased incidence of liver-related or septic complications.There were 27 intra-abdominal collections detected in the 54 patients with penetrating abdominal injuries compared to 5 in the 18 patients with blunt abdominal trauma (P = 0.210). Fourteen liver-related complications occurred in the penetrating trauma group, compared to nil in the blunt trauma group (P = 0.002). Prolonged packing in the presence of blunt liver trauma was not associated with an increased complication rate with respect to liver-related (there were none) and septic complications (P = 0.963). There were a further 7 deaths from multiple organ dysfunction in the intensive care unit. Including the deaths in the first 24 h, 28 patients died from their injuries to give an overall mortality rate of 30% in the cohort of patients with complex liver injuries that required packing.

DISCUSSION

Ninety-three (17%) of 534 patients with liver injuries identified at laparotomy required liver packing. The vast majority of injuries could be handled by drainage or suturing. The incidence of liver injuries requiring liver packing varies from 5%[19] to 36%[20] in the literature. This figure is expected to be higher in level 1 trauma centers because of more complex injuries and referrals with packs in situ. Our incidence of 17% appears

high when compared to Feliciano et al.,[10] who reported in 1986 on 1,348 liver injuries of whom only 66 (5%) required liver packing. This higher incidence is most likely due to an increased awareness of the need to institute damage control procedures in the unstable patient. It has been stated that liver packs should be removed as soon as the patient is stable and coagulopathy, hypothermia, and acidosis have been corrected.[10,12,21] This usually takes 12–36 h to achieve, yet liver packs have been removed as long as 7 days after the initial packing.[15] Leaving packs around the liver is also known to cause significant cardiopulmonary compromise,[22,23] and abdominal compartment syndrome appears to be an independent predictor for the development of multiple organ failure.[24,25] There is obviously a desire to remove the liver packs as soon as possible, but the cardiopulmonary benefits of pack removal have to be weighed against the risk of a re-bleed requiring repeat liver packing.

Caruso et al.[25] demonstrated that re-bleeding from the liver was greater when liver packs were removed within 36 h than after 36 h. In the present series the optimum time for the removal of packs was at least 48 h after the initial surgery. If liver packs are removed at 24 h in the stable patient the risk of bleeding from the liver requiring re-packing is significantly higher ($p = 0.006$) than if the packs are left in to the 48-h point. In this series 8 of 12 hemodynamically stable patients who had been rewarmed and their coagulopathy corrected, required re-packing of the liver injury when the first re-look was performed at 24 h. In contrast, only 5 of 43 patients who had the packs removed at 48 h required re-packing. This would seem to indicate that in the majority of patients packing of the liver for a period of at least 48 h is required to achieve hemostasis. It would appear that it takes time for the liver tamponade to take effect and for any clot to become stable and not to become dislodged on the removal of the packs. It is important to recognize that liver packing will not control arterial bleeding and that any bleeding artery should be suture ligated prior to liver packing. The abdomen should be closed if possible, provided closure is not performed under tension. The presence of an open abdomen was associated with a higher chance of developing an intra-abdominal collection ($P = 0.004$). At the same time, patients require close observation in the intensive care unit because a significant number will develop abdominal compartment syndrome and require decompression. In the present series early decompression (< 24 h) was required in 11 patients. The mean total duration of liver packing was 2.4 days (0.5–6.0 days). There was no association between the total duration of packing and the development of liver-related complications ($P = 0.284$) or intra-abdominal collections ($P = 0.155$). The concern that the longer that liver packs are left in situ the higher the rate of complications such as intra-abdominal collections and bilomas will be, does not appear to be warranted. A multidisciplinary approach is required in the management of complex liver injuries. Angiography and embolization was performed in our series only in those patients in whom the second attempt to remove the liver packs was unsuccessful because of liver bleed-

ing. Hepatic angioembolization has been recommended immediately post-packing, and certainly this may prove to be a useful adjunct in controlling hepatic hemorrhage. [26]

Our data show that the total duration of liver packing does not appear to result in an increase in septic complications or bile leaks. The first re-look laparotomy following packing for a liver injury should only be performed after 48 h and when hypotension, hypothermia, coagulopathy, and acidosis have been corrected. An early re-look at 24 h is associated with re-bleeding and does not lead to the successful removal of the liver packs.

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