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# TOTAL MESH WRAPPING OF PARENCHYMATOUS LIVER INJURY: AN EXPERIMENTAL STUDY

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***Uncontrollable bleeding remains a life-threatening problem in severe liver injury. The majority of liver injuries can be managed by simple techniques, however a substantial proportion of hepatic injuries require more complex procedures.***

***To investigate the value of an absorbable mesh wrap under standardized conditions, an experimental study was performed in fifteen dogs. A standard liver laceration imitating liver injury grade IV (liver injury scale of the American association for the surgery of trauma) was made in all animals, and they were classified into 3 groups (five animals in each group). The first group animals served as controls, the second group animals were treated by laparotomy packs, and the third group animals were treated with total mesh wrap. Four of five animals in the first group died, all animals in the second group died, and all animals in the third group survived. Intrahepatic pressure in the third group varied from 3 to 55 mm Hg. Liver function tests were temporary elevated. Necropsy at 2 weeks revealed adhesions to the wrapped lobe, but no hematomas or abscess formation. Histologic examination revealed foreign-body reaction to the mesh.***

***It can be stated that the application of this type of mesh wrap is a relatively simple and easy procedure. It can effectively control bleeding from severely injured liver and improve survival significantly in animal model.***

***Abbreviations:Hepatic injury, Liver packing, Mesh wrap.***

## INTRODUCTION

The liver being the largest abdominal organ is particularly vulnerable to injury and, indeed, is the second most commonly injured organ after the spleen, following blunt abdominal trauma [1]. Most deaths after complex liver injuries resulted from massive hemorrhage [2]. The resultant hemorrhage and biliary leakage, difficulty in assessing the extent of damage, operative difficulties, and the complex postoperative problems present a formidable challenge [3]. The surgical treatment of liver trauma has been the subject of controversy for many years. A variety of techniques have been described, none of which is uniformly successful, or ideal, for control of these exanguinating liver injuries [4,5]. Depending on the type of injury and the experience and preference of the surgeon, it varies from simple hepatorrhaphy to partial liver resection; even liver transplantation has been performed as a treatment for liver injury [6].

The majority of liver injuries can be managed by simple techniques including electrocautery, hemostatic agent application, temporary packing, and Perihepatic drainage. However, a substantial proportion of hepatic injuries require more complex procedures. The definitive treatment of major hemorrhage from deep parenchymal fractures, severe lobar disruption, or retrohepatic vena caval injuries remains a formidable challenge[7]. The surgical techniques applied to manage these advanced injuries has evolved from deep parenchymal suturing or formal hepatic lobectomy in favor of nonresectional techniques relying on hepatotomy with direct vessel ligation [8], limited debridment [9], and prehepatic packing[10]. With the use of an absorbable mesh, which is

common practice in treatment of splenic injury for several years now the need of reoperation is avoided. To investigate its value under standardized conditions, an experimental study was performed to compare the value of total mesh wrapping versus other treatment modalities in securing hemostasis and management of severe parenchymatous liver injuries.

## MATERIAL AND METHODS

Fifteen dogs weighing 5 to 10Kg obtained from animal house at Faculty of Medicine, Mansoura University, were used in this study. The animals were kept in cages (one in each cage) at room temperature and were observed for 2 weeks prior to the start of the study to exclude the presence of any disease. The animals were fed bread in milk, reminance of meat, and had free access to water. The animals were divided into 3 groups, each was 5 in number. Guidelines for the care of laboratory animals were followed.

***Surgical procedures:***

Animals were anaesthetized with intramuscular injection of Ketamine hydrochloride (Ketalar) 10-mg/ kg as induction and maintained with intravenous infusion of Ketamine 300 mg/hr. After insertion of an intravenous line a median laparotomy was made. A standard cholecystectomy was performed. A standard liver laceration was mad, imitating a grade IV injury (according to the liver injury scale of the American Association for the Surgery of Trauma)[11] (Fig..1). This laceration was produced with the blunt side of the hand of the scalpel. It was parenchymal disruption involving 25-50% of hepatic lobe. Immediately after the inflicting injury, the animals were divided at random into 3 groups.

***First group:*** (Control group). Five in number, the abdominal wall was closed after the injury was made.

***Second group:*** Five in number, after injuring the lobe of the liver, laparotomy packs were placed above and below the liver to produce compression to the injured lobe. After 48 hours reexploration was done for removal of the packs.

***Third group:*** Five in number, The injured lobe was wrapped with a polyglycolic acid mesh (Vicryl mesh), the technique was applied as made by Fred et al., 1995 [12]. It had to be fixated with parallel purse-string sutures (Fig..2). Tension applied to these sutures caused compression of the treated lobe. Compression was applied until hemorrhage ceased. The intrahepatic pressures were measured at 3 standardized locations in the wrapped lobe, with a needle that was attached to a pressure transducer and recorder.

All other variables, including intravenous fluids and medications, were held constant for all groups. Blood pressure and heart rate were monitored throughout the operative period, and also before, and immediately after the operative procedure. Liver function tests were performed on all animals, before operation, and 24 hours, 7 days, and 14 days postoperative in all surviving animals.

The livers of the treated animals were harvested for gross and microscopic examination at the 14TH postoperative day. Upon necropsy, special attention was given to possible hematomas, abscesses, or signs of bile leakage. Microscopic examination was done for liver tissue near the mesh wrap and for more centrally located tissue.

***Statistical analysis:***

The data were collected, and the analysis was done by using SPSS (statistical package for social science) program version 8, 1998. F test was used to compare between more than 2 groups. Student T test was used to compare between quantitative data of 2 groups.

## RESULTS

***Experimental prognosis of the studied groups:***

***Group I:*** Only one animal survived. The other animals died within 50 to 120 minutes with an average 80 minutes after surgery from hemorrhagic shock. At 2 weeks, necropsy of the survived animal showed a small amount of blood in the abdomen and a complete anatomic adherence of the laceration, despite a cephalic-kaoline time exceeding 120 seconds.

***Group II:*** All the animals in group II died in the second or third postoperative day due to septicemic shock in which the animal lost its appetite, fever 38-39˚C, sunken eyes and loss its brightness. Necropsy demonstrated presence of infected peritoneal fluid in the abdomen, pyogenic membrane on the liver and intestine, greenish discoloration of the liver and gall bladder due to bile leakage in some animals and the pack was soaked with infected offensive fluid. Pathological examination of the liver revealed massive necrosis (Fig. 3).

***Group III***: All the animals in group III survived without any problem. The operative procedure was performed in 40-60 minutes, with an average of 45 minutes. One animal was complicated with wound dehiscence and disruption of the suture line due to rubbing of the abdomen by its legs. A secondary suture was done with smooth postoperative course. Intrahepatic pressures varied from 3 to 50 mm Hg. All the liver function tests of the animals in group III, were elevated at 24 hours and 1 week postoperative, and were back to normal after 14 days (Table 1). Necropsy revealed extensive adhesions to the wrapped hepatic lobe, but no hematomas, free bile, or abscesses, but there were excessive adhesions between the wrapped lobe of the liver and intestine and anterior

abdominal wall in 3 animals. Pathological examination of the wrapped lobe showed marked areas of esteatosis (Fig. 4). Near the mesh a foreign-body reaction was present and signs of acute on top of chronic inflammation, with necrosis.

***Complications:***

Intra-abdominal sepsis occurred in all animals of group II. Wound infection occurred in one animal in group III. Wound dehiscence occurred in one animal in group III. Fever occurred in the second postoperative day in 5 animals in group II that persisted until death occurred

**Table (1):** ***Mean liver function tests in animals with a mesh wrap***

| | *Preoperative* | *1 day postop.* | *7 day postop.* | *14 day postop* |
|---|---|---|---|---|
| Total S.Bilirubin µmol/l | 2.6 | 5.0 | 2.8 | 2.2 |
| Alk. Phosph Units/l | 91 | 149 | 163 | 82 |
| AST units/l | 18 | 184 | 22 | 19 |
| ALT units/l | 20 | 136 | 22 | 18 |

***Fig. (1): Iatrogenic liver injury***

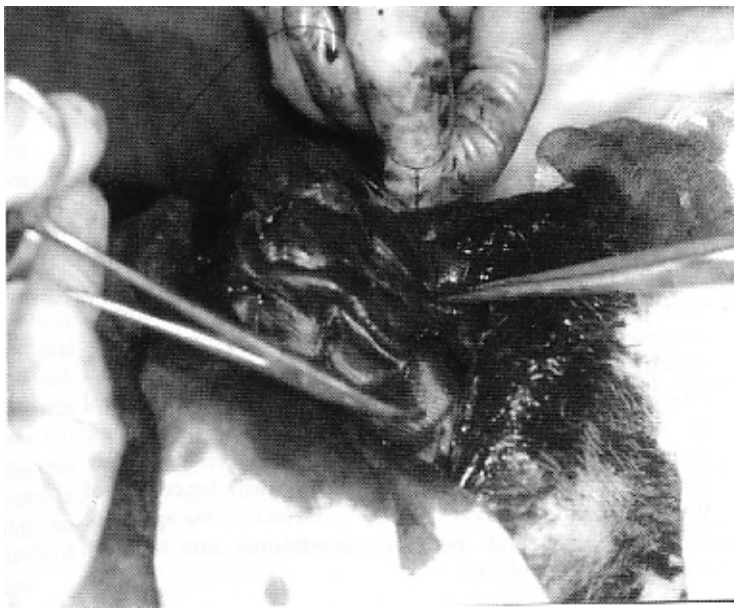

***Fig. (2): Mesh wrap***

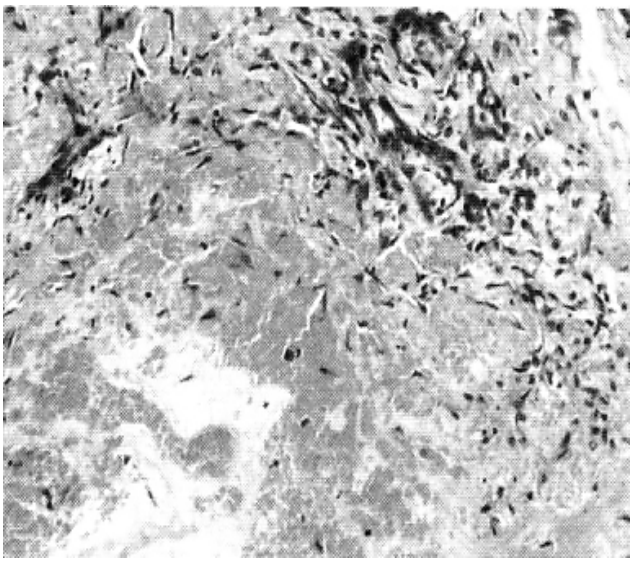

*Fig. (3) : Pathology of the liver after prehepatic packing shows massive necrosis.*

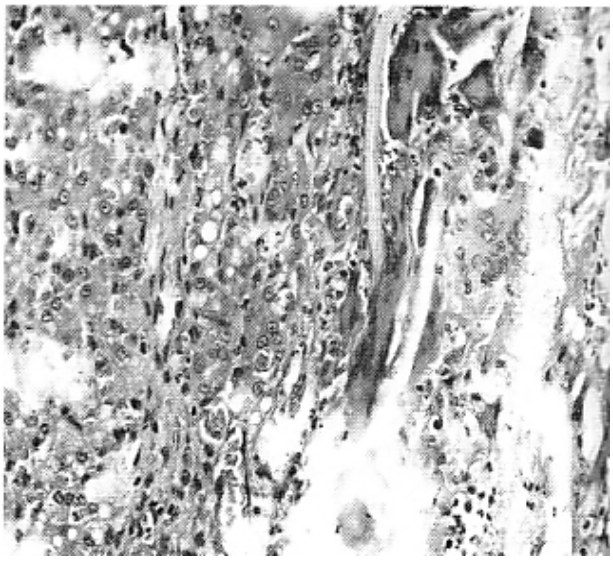

*Fig. (4) : Pathology of the liver after mesh wrapping shows marked esteatosis, foreign body reaction, and signs of acute on top of chronic inflammation.*

## DISCUSSION

Major liver injuries, either from blunt trauma, or penetrating trauma, are a predominant cause of death in abdominal trauma. Mortality Fig.ures of 36 to 76% have been reported [13]. Despite technological advance, uncontrollable bleeding remains a crucial problem in these cases. Patients who have sustained severe liver damage, massive blood loss often leads to hypotension, hypothermia, acidosis, coagulopathy, and persistent diffuse parenchymal bleeding, which propel the patient further down the spiral of coagulopathy, hemorrhage and deeper physiologic trespass[14]. A variety of techniques have been described, none of which is uniformly successful, or ideal, for control of these exanguinating liver injuries [15]. It has become apparent that prolonged and extensive procedures are not the solution of this problem.

Prehepatic packing, left in the abdomen for 24 to 96 hours, has recently enjoyed renewed popularity as a method of controlling hemorrhage [16]. This technique has obvious disadvantages, as reoperation is required when the patient usually just been stabilized, there is a definite incidence of rebleeding when the packing is removed, septic complications can be expected, and the packing may give a rise in intra-abdominal pressure, and by that causing respiratory and renal failure [17], and also compression on the IVC may partially or completely obstruct venous return which will have consequences on hemodynamic parameters.

An absorbable mesh, wrapped with tension around the injured liver, does not increase intraabdominal pressure and avoids the need of reoperation. Following the successful use of absorbable mesh in splenic injury for several years now, its application in hepatic trauma is so far described. Menegaux et al [18] described the application of mesh wrap in five patients with traumatic rupture of the liver. Four patients survived without complications, and one patient died of hemorrhage 2 days postoperatively. Another study made on 14 patients with blunt liver injury, all of them were treated with an absorbable mesh wrap, and they all survived [19]. Stevens et al [20] reported their experience with six patients. The hepatic wrap method successfully controlled hemorrhage in four patients with severe parenchymal injury, and two patients died intraoperatively. Postmortem examination revealed juxtacaval lacerations and hepatic vein avulsion injuries, which are not treatable by this technique. Another study made by Stevens et al [20] investigated the technical feasibility and effectiveness of the mesh wrap technique in eight miniature swine. Uniform stellate injuries were produced in the right and left hepatic lobes of all animals. The animals were randomly divided into two groups. All four animals in the control group (without mesh or wrap other measures of hemostasis) died. The animals treated with a mesh wrap all survived. We anticipated the utility of this technique for the tamponade of large intrahepatic or subcapsular hematomas, which might be at risk for delayed rupture. Clearly mesh wrapping

would not be expected to control juxtahepatic venous injuries.

In a study made by Lewis 1992, he had used this technique in 5 patients; one of them was taken back because of sepsis and found to have a necrotic gall bladder, which was included in the mesh [21]. The explanation was unclear, but this process might have resulted from transient hypotensive episodes before and after operation.

Based on the experience with mesh wrap splenorrhaphy, it appears that the mesh can be used in the presence of gastrointestinal contamination, without unwanted effects [22].

A study made by Krige 1997, on 446 patients, with liver injuries, proposed classification based on segmental anatomy, and demonstrated the mortality in isolated liver injuries, increased from 1% in patients with liver injuries limited to a single hepatic segment to 46% if 2 or more segments were involved, in addition they revealed that the mortality was influenced also by the extent of operative intervention required [23].

From our study we noticed that the use of mesh was able to reduce the amount of operative injury necessary to control bleeding, hence a reduction in mortality. It appears that the versatility of an absorbable mesh to wrap the liver in major injuries provides distinct advantage over other techniques of repair. Its exact role in the surgery, or armamentarium of methods for control of major hepatic injuries and hemorrhage will require further study.

It appears, however, that the absorbable mesh wrap eliminates most of the disadvantages of peripheral packing, while retaining the primary goal of tamponade, no sepsis or increase in the intra abdominal pressure. It can be stated that the application of this type of mesh wrap is relatively simple, and quick procedure. It can effectively control bleeding from a severely injured liver, and improve survival significantly in animal model. Based on the results of this experimental study, and based on the clinical experience reported in the literature, they are convinced that an absorbable mesh wrap can be recommended as a standard treatment for severe hepatic injury.

We recommend its use early in any major hepatic injury with significant bleeding, before complications of massive hemorrhage such as hypothermia, coagulopathy, or acidosis develop.

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