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Recent Concepts in the Treatment of Hepatic Trauma

Facts and Fallacies

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Experience with 85 consecutive patients treated at Bellevue Hospital for hepatic trauma over the past two years has established the importance of several principles of management. Simple liver injuries can be treated by superficial suture and drainage. Using this approach in 57 patients there were no deaths and no postoperative abscesses. Among 28 other patients with complex liver injuries, the first six patients (Group 1) were treated by lobectomy alone (1 patient), lobectomy and intracaval shunt (3 patients), hepatic artery ligation (1 patient), and left lateral segmentectomy (1 patient). Only one of the six survived. In the next 22 consecutive patients managed by the Pringle maneuver combined with finger fracture technique of the hepatic parenchyma and a viable omental pack there was only one death (4.5%). An intracaval shunt was used successfully once in this group, in a patient with a lacerated middle hepatic vein. Only one patient developed a postoperative subphrenic abscess (4.5%), and no patients required reoperation for bleeding. Eighty-two per cent of these 22 patients safely tolerated inflow occlusion of greater than 20 minutes with steroid protection. Hepatic artery ligation is superfluous in the majority of liver injuries. In complex injuries involving lobar branches of the portal vein, the retrohepatic cava or hepatic veins hepatic artery ligation is probably ineffective. Hepatic resection is rarely required and carries a prohibitive mortality. The finger fracture technique provides a direct approach to the source of hemorrhage and is probably the procedure of choice.

COMPLEX LIVER INJURIES with laceration of lobar branches of the portal vein, the retrohepatic cava or hepatic veins continue to challenge surgeons as the mortality from these injuries remains in excess of 50%.

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Several operative approaches to complex liver injuries have been tried, including anatomic hepatic lobectomy, hepatic artery ligation and the insertion of temporary vena caval shunts. Neither anatomic hepatic lobectomy nor hepatic artery ligation have significantly lowered the high mortality rate. Injuries to the retrohepatic cava and hepatic veins have stimulated an abundance of literature concerning temporary vena caval shunts. However, in a collective review of 46 vena caval shunt insertions the reported mortality was 76%.[39]

This report presents experiences at Bellevue Hospital with 85 consecutive hepatic injuries treated over a two year period. One of the authors (H.L.P.) participated directly in the care of all but one of these patients.

Twenty-eight of the 85 patients had massive injuries with major intrahepatic vascular lacerations or juxtahepatic venous injuries. In the first six of these 28 patients, four underwent hepatic lobectomy (including insertion of an intracaval shunt in three) and the other two left lateral segmentectomy and hepatic artery ligation respectively. Only one of these six patients survived, the patient undergoing segmentectomy.

Because of this unacceptable mortality, a different approach was tried in the next 22 patients. Experience with these patients forms the basis for this report.

The essential features of the new approach included temporary control of hemorrhage by the Pringle Maneuver,[32] extending the abdominal incision into the chest

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TABLE 1. *Mechanisms of Hepatic Trauma and Associated Injuries in 85 Patients*

Cases	Associated Injuries
85	46/85–54%
Blunt 8/85–9.4%	3/8–37.5%
SW 55/85–64.7%	25/55–45.4%
GSW 22/85–25.8%	18/22–81.8%

SW: stab wound. GSW: gunshot wound.

only if hemorrhage was not controlled; subsequent finger fracture[21,22] of normal hepatic parenchyma to expose the site of hemorrhage; debridement of devitalized tissue; and the insertion of a viable pedicle of omentum within the liver.[35]

Material

From 1976–1978, 85 consecutive patients underwent operative treatment for hepatic injuries. The mean age of the entire group was 32 years, with a male to female ratio of 9:1. 64.7% of all injuries were due to stab wounds, 25.8% resulted from gunshot wounds, and 9.4% were secondary to blunt trauma. 54% of all patients had associated injuries (Table 1).

Fifty-seven of the 85 patients sustained simple liver injuries and 28 sustained complex liver injuries. Of the latter, 24 were not associated with either injuries of the retrohepatic cava or hepatic veins. Of the 22 patients that form the basis for this report, 68.2% had associated injuries. Approximately one-half, (54.5%) of the injuries involved the right lobe of the liver alone, and 18% involved both the right lobe and the medial segment of the left lobe (Table 2). Four patients sustained injuries to the juxtahepatic venous vasculature.

Operative Management

Methods of operative management are summarized in Table 3. Control of hemorrhage and prompt resuscitation were the initial maneuvers in all patients who were actively bleeding at the time of laparotomy.

TABLE 2. *Associated Injuries Among 22 Patients with Complex Hepatic Trauma*

Site of Injury	Mode of Injury	Associated Injuries
1. MSLL	GSW	Duodenum, cecum, middle colic vein
2. RL	Blunt	None
3. MSLL	SW	Diaphragm, stomach, kidney, pancreas
4. RL, MSLL	GSW	Lung, esophagus, stomach
5. RL	GSW	Small bowel, gallbladder
6. RL	Blunt	None
7. RL	GSW	Lung
8. RL	SW	Right ventricle, gallbladder, stomach
9. RL, MSLL	Blunt	None
10. MSLL	SW	Pancreas
11. RL	SW	Gallbladder, kidney, renal artery
12. MSLL	SW	None
13. RL	GSW*	Kidney, spine, paraspinal muscles
14. RL	Blunt	Gallbladder, colon
15. RL	GSW	None
16. MSLL	SW	None
17. RL, MSLL	SW	Stomach
18. RL	SW	Small bowel, colon
19. MSLL	SW	None
20. RL	GSW	Lung, diaphragm, kidney
21. RL, MSLL	SW	Pulmonary artery, spleen, stomach
22. RL	SW	Diaphragm, stomach

Associated Injuries—68.2%
Injuries for specific anatomic location

RL	*MSLL*	*RL & MSLL*
12 (54.5%)	6 (27.2%)	4 (18%)

RL: right lobe. MSLL: medial segment left lobe. SW: stab wound. GSW: gunshot wound.
* Patient shot with a 30.06 rifle—death due to associated injuries.

The Pringle Maneuver was successful in controlling hemorrhage in 21 of 22 patients (Fig. 1). Glisson's capsule was then incised with the electrocautery and normal hepatic parenchyma was opened in the direction of the injury by the finger fracture technique to allow ligation of bleeding vessels and lacerated bile

TABLE 3. *Management and Results in 85 Patients with Hepatic Trauma*

Management	No. Patients Treated	Mortality	Postop Abscess
Simple injuries			
drainage or superficial suture and drainage	57	0%	0%
Complex injuries			
Group I	6 (21.4%)	5 (83.3%)	1 (17%)
hepatic lobectomy			
hepatic lobectomy and intracaval shunt			
left lateral segmentectomy			
hepatic artery ligation			
Group II			
finger fracture technique, ligation of bleeding vessels, debridement and omental pack*	22 (78.5%)	1 (4.5%)	1 (4.5%)

* Intracaval shunt used once successfully in conjunction with this technique.

ducts under direct vision (Fig. 2). Nonviable segments of the liver were debrided and a pedicle of omentum based on the gastroepiploic vessels was placed within the liver. The two open edges of the liver were then loosely approximated around the omental pedicle with 0-chromic or 0-dexon blunt nose liver sutures. Closed suction drainage anteriorly and posteriorly to the injury was regularly employed (Fig. 3). One of the 22 patients treated in this fashion had an injury of the middle hepatic vein as well as lobar branches of the portal vein. This injury necessitated the use of an intracaval shunt.

Inflow Occlusion Time

The mean inflow occlusion time for the 22 patients treated in the above described fashion was 31 minutes. All patients were given 30–40 mg/kg of solumedrol intravenously as a bolus prior to inflow occlusion. 82 per cent had inflow occlusion times of greater than 20 minutes and 45% had inflow occlusion times greater than 30 minutes (Table 4).

Results

Mortality (Table 3)

There were no deaths in 57 patients with simple hepatic injuries. In the first six of the 28 patients (Group 1) with complex liver injuries treated with lobectomy alone or in conjunction with an intracaval shunt, hepatic artery ligation or segmentectomy, only one patient survived, a mortality of 83%. However, in the next 22 consecutive patients (Group 2) treated by temporary inflow occlusion; finger fracture of the hepatic parenchyma; suture ligation of bleeding vessels and lacerated bile ducts; debridement; and the omental pedicle, there was only one death (4.5%).

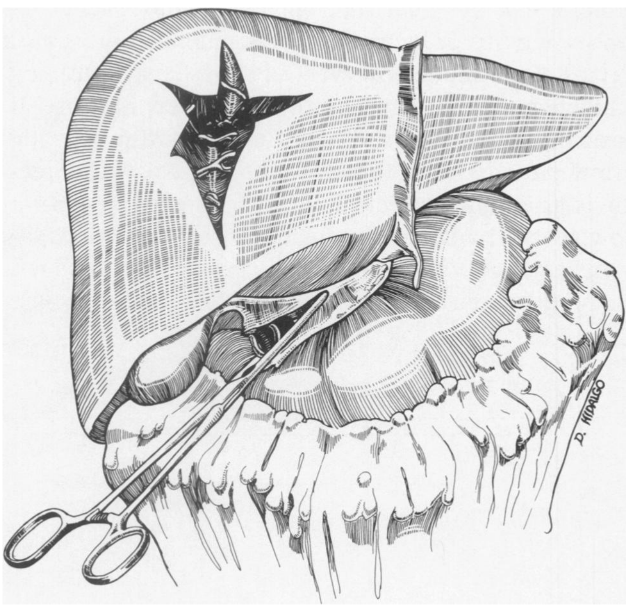

FIG. 1. An injury to the right lobe and medial segment of the left lobe is shown. The Pringle maneuver has been accomplished with an atraumatic vascular clamp. Finger fracture of the hepatic parenchyma has begun in the direction of the injury exposing blood vessels and bile ducts.

FIG. 2. Lacerated blood vessels and bile ducts have been ligated and devitalized tissue has been debrided. The omentum has been mobilized off the stomach and transverse colon on a pedicle of gastroepiploic vessels.

Postoperataive Abscess

One patient in the subgroup of 22 patients with complex liver injuries developed a right subphrenic abscess which was treated on the tenth postoperative day by extraperitoneal drainage through the bed of the twelfth rib. Recovery was then uneventful.

Discussion

Based on this encouraging experience with 22 patients who sustained complex liver injuries, the following plan of operative management is recommended.

Bimanual compression of the liver usually arrests bleeding temporarily and allows for replacement of blood volume and correction of lethal acidosis. Inflow occlusion is then accomplished by the Pringle maneuver.[32] The limit of warm ischemia time to the liver is usually regarded as 20 minutes,[28,33] but longer periods of warm ischemia have been reported with elective

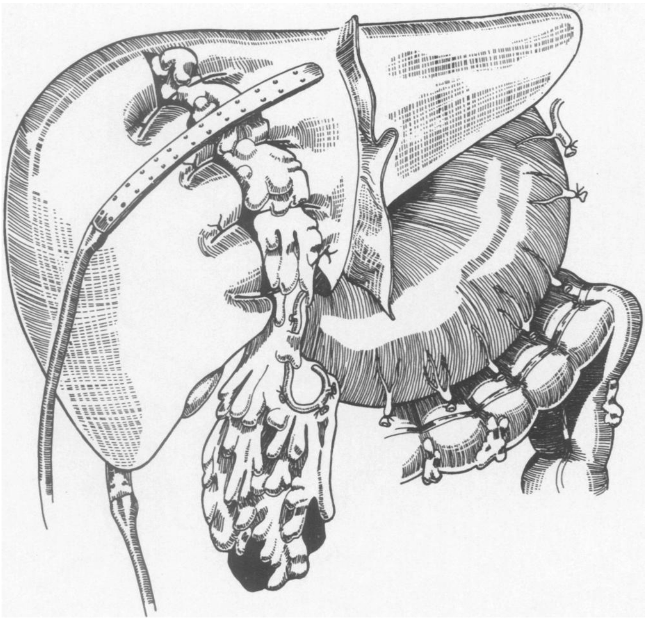

FIG. 3. The omentum has been inserted into the area of liver injury and is held in place by several interrupted liver sutures. Closed suction drainage anteriorly and posteriorly is accomplished by a pair of Jackson-Pratt drains.

hepatic surgery.[17,18] Uncertainty, still exists, however, as to whether unprotected warm ischemia to the liver for greater than 20 minutes is safe in emergency situations.

Methods of extending warm ischemia time include the use of steroids[11,12] and hypothermia.[5,6,15] Solumedrol (30–40 mg/kg) was given intravenously as a bolus in all 22 patients reported in this series prior to inflow occlusion. The use of steroids may have been responsible for inflow occlusion tolerance beyond 20 minutes in 82%, and beyond 30 minutes in 45% of these patients. In addition, two liters of iced Ringers lactate was used topically on the liver to induce some degree of hypothermia. This method of local hypothermia cannot be evaluated adequately, however, as an intrahepatic temperature probe was not used.

Bleeding Arrested with Inflow Occlusion

The Pringle Maneuver will usually control hemorrhage that originates from the intrahepatic branches of the portal vein and hepatic artery. The key step in the operative approach is then to incise normal hepatic parenchyma in the direction of the injury by the finger fracture technique,[21,22] until the source of bleeding can be identified and controlled under direct vision. This approach was strikingly effective in disclosing the site of lacerated blood vessels and bile ducts which could then be ligated directly. Debridement of hepatic parenchyma is then limited to obviously devitalized tissue. Failure to debride adequately is likely to result in an intrahepatic or an intra-abdominal abscess. An omental pack is then fashioned as described by Stone[35] and placed within the liver. The two edges of the liver are loosely approximated around the omental pedicle. The "viable pack of omentum" has a two-fold function, in that it serves to eliminate dead space and at the same time to tamponade minor venous oozing from the hepatic parenchyma. Development of only one subphrenic abscess and the absence of postoperative bleeding in the patients reported here supports its effectiveness.

Bleeding Not Arrested by Inflow Occlusion

Failure of inflow occlusion to control massive hemorrhage from within the liver suggests injury to the retrohepatic cava or hepatic veins. This occured only once in the 22 patients treated. Once the injury is recognized prompt extension of the abdominal incision through the sternum offers optimal exposure for vascular isolation,[30] by any one of a variety of techniques.[2,7,8,16,31,34,37,40] The continued high mortality in these cases probably derives from the fact that shunt insertion was delayed until 10–15 units of blood has been lost with development of associated coagulation defects. If the decision for vascular isolation can be made quickly and the shunt is placed expeditiously, patients may be saved who would otherwise succumb.

Hepatic Artery Ligation

Hepatic artery ligation has frequently been advocated for the control of bleeding from hepatic trauma.[1,13,25–27] In the majority of liver injuries, hepatic artery ligation may be superfluous however, as superficial suture and drainage is all that is required. Moreover, in those injuries involving lobar branches of the portal vein, the retrohepatic cava or hepatic veins, hepatic artery ligation is probably ineffective. Flint[14] reported a 14% failure rate with hepatic artery ligation and a 54% mortality in those patients in whom hepatic artery ligation failed. His report confirms the inability of hepatic artery liga-

TABLE 4. *Inflow Occlusion in 22 Patients with Complex Liver Injuries**

Time	Patients
15–20 min	4 (18%)
21–30 min	8 (36%)
31–40 min	7 (32%)
41–50 min	2 (9%)
>60 min	1 (4.5%)

Inflow occlusion time: >20 minutes—18 (82%). >30 minutes—10 (45%).

Mean inflow occlusion time: 31 minutes.

* All patients were given 30–40 mg/kg Solumedrol IV as a bolus prior to inflow occlusion.

tion to control bleeding from lobar branches of the portal vein. Bleeding from injuries to the retrohepatic cava and hepatic veins is retrograde bleeding. It is difficult to understand how such bleeding could be helped by hepatic artery ligation. Furthermore, the safety of hepatic artery ligation in patients with massive injuries remains in question. Hepatic necrosis, rebleeding and abscess formation all have been reported recently.[3,4,14,24]

Hepatic Resection

The frequency of hepatic resection for trauma has progressively declined, and currently seems to be employed in only 2.5–13%.[9,10,19,20,23,29,38] Although the techniques of hepatic resection have been well defined in the past decade, the mortality of hepatic resection for trauma remains above 50%. These two facts suggest that anatomic lobectomy is required only rarely for liver trauma and that the mortality from this procedure is prohibitively high. The finger fracture technique to incise the liver, provides a much simpler and more direct approach for the isolation of bleeding intrahepatic vessels.[21,22] Combined with inflow occlusion, the finger fracture technique renders anatomic hepatic lobectomy unnecessary in the vast majority of cases. Hepatic lobectomy may still have a limited role, however, in those patients with either total destruction of normal hepatic anatomy or those in whom resection is absolutely essential to gain control of juxtahepatic venous injuries.[27] In such patients the use of the Storm-Longmire clamp would appear to facilitate resection.[36]

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Discussion

Dr. F. William Blaisdell (Sacramento, California): Many of the principles that Drs. Pachter and Spencer outlined in the management of liver trauma are appropriate and will lead to lower morbidity and mortality. I particularly agree with the appropriateness of definitive direct ligature of the bleeding point.

I would like to take issue with a couple of their facts and say that they are, perhaps, fallacies. The first of these relates to the fact that hepatic venous injury is a common result of liver laceration and is a frequent source of hemorrhage. In my opinion it is a relatively rare cause of persistent hemorrhage.

Hepatic venous injury occurs most often in association with high velocity, blunt trauma. Bleeding from hepatic veins is usually from the undersurface of the liver, and under these circumstances the use of an internal shunt has provided a means of temporary control of bleeding. When the hepatic venous injury is in the depths of a laceration, bleeding usually stops spontaneously. This is because along with portal injuries this is low pressure bleeding and generally is tamponaded by the liver. Major, open lacerations can be a serious problem. Attempts to control stab wounds or gunshot wounds by further opening the laceration results in the potential of devascularization of major segments of the liver and for more ultimate morbidity.

Another issue I take with the authors' "facts" relates to hepatic artery ligation. I have little question that hepatic artery ligation has been a major advance in the management of certain types of liver injury, particularly penetrating types of trauma in which disruption of the substance of the liver is minimal. Under these circumstances portal venous injury and hepatic venous injury are readily tamponaded and are not clinical problems. The primary bleeding problem relates to hepatic artery injury, and this is the reason that hepatic artery ligation works. We have reported a series that confirms the observation of Dr. Truman Mays that it is a safe procedure. We have had no mortality with the selective use of hepatic artery ligation, and it is a much simpler procedure than hepatic resection.

Certainly if the bleeding persists after the portal triad clamp has been applied usually it is due to hepatic venous bleeding. In some instances, however, abnormal supply of the left lobe of the liver by anomalous branches of the hepatic artery are the source of hemorrhage, and one should look for these should hemorrhage not be controlled by the application of the clamp. If the bleeding persists, and the hepatic arteries are controlled, then a procedure to isolate the hepatic vein is indicated. However, coming down on the hepatic vein through the laceration is like looking directly into the vena cava; this can be difficult and associated with massive loss of blood.

The principles outlined of good drainage, the application of the omental pack are something that all of us can apply and improve upon our results in the management of liver trauma.

Dr. Ben Eiseman (Denver, Colorado): Drs. Pachter and Spencer have identified important principles in the management of liver injuries and have shown that by a straightforward method of gaining exposure of deep injuries in the parenchyma they can achieve an excellent chance of survival by simple suture of the major vascular bleeding points.

At the Denver General Hospital, Dr. Aragon and I reviewed 300 consecutive liver injuries and more recently Dr. Eugene Moore reviewed 273 more. We recognize three main types of injuries. The first category, making up 85% of the cases, are simple superficial lacerations in which there is almost no mortality from the liver injury itself.

The second category, making up about 10% of the injuries, is deep lacerations into the parenchyma, and it is with these that Dr. Pachter is largely dealing in his paper. He states that bleeding was controlled in 21 of 22 of his injuries by cross clamping the porta hepatis. This is how to differentiate a serious deep Class II injury from the far more dangerous Class III injuries that are into the vena cava and into the hepatic veins as they converge into the cava. The Pringle maneuver does not usually even slow down bleeding from these rare (±5%) but grave injuries. We agree with Drs. Pachter and Spencer that you have to get to them quickly through the chest.

The message of this carefully detailed experience is to expose the bottom of deep liver injuries and accurately ligate the bleeding point. The authors have shown us that, if the site of bleeding cannot be seen, the overlying liver wound should be extended by finger fracture to expose the vessel deep in the liver substance. The technique is simple, direct, sound and well documented, as is typical of the work of authors of this paper.

Dr. Alexander J. Walt (Detroit): I believe that the liver has been given excessive attention in recent years but at least our perspectives on liver injury are much improved and clearer. By and large, injury to the liver tends to be relatively innocuous, as 50% of patients will have stopped bleeding by the time we operate on them and almost another 40% require little more than some sutures or hemoclips. It is the remaining 10% of patients that we are bothered about.

I would point out as a matter of historical interest that Mr. Pringle, when he reported his maneuver in 1908, presented eight cases. He had gone to the surgical laboratories in Vienna and worked on a lot of rabbits—presumably, they did not have rabbits in Scotland at that time—came back and operated on eight patients; they all died. So the mortality was 100% for those on whom he tried his maneuver. Even today, however, the Pringle maneuver is not effective in a fair number of instances of massive liver injuries. Dr. Blaisdell has given some reasons for this, not the least of which is the occasional anomalous blood supply to the liver such as a branch of the left gastric supplying the left lobe.

What we really need in liver injuries is an injury severity score if we are to assess our results accurately. Indeed, I believe that we need a reliable injury severity score for all trauma as we currently tend to match apples and oranges. If we were to have such an index for liver injuries, four main things would need to be looked at. The first is the patient—and our patients in Detroit often tend to be drugged, drunk or debilitated, which works against their recovery. Second, we must look at the nature of liver lesions carefully as they obviously vary a great deal in different environments. Third,