Significant Trends in the Treatment of Hepatic Trauma

Experience With 411 Injuries

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Several significant advances in the treatment of hepatic injuries have evolved over the past decade. These trends have been incorporated into the overall treatment strategy of hepatic injuries and are reflected in experiences with 411 consecutive patients. Two hundred fifty-eight patients (63%) with minor injuries (grades I to II) were treated by simple suture or hemostatic agents with a mortality rate of 6%. One hundred twenty-eight patients (31%) sustained complex hepatic injuries (grades III to V). One hundred seven patients (83.5%) with grades III or IV injury underwent portal triad occlusion and finger fracture of hepatic parenchyma alone. Seventy-three surviving patients (73%) required portal triad occlusion, with ischemia times varying from 10 to 75 minutes (mean, 30 minutes). The mortality rate in this group was 6.5% (seven patients) and was accompanied by a morbidity rate of 15%. Fourteen patients (11%) with grade V injury (retrohepatic cava or hepatic veins) were managed by prolonged portal triad occlusion (mean cross-clamp time, 46 minutes) and extensive finger fracture to the site of injury. In four of these patients an atrial caval shunt was additionally used. Two of these patients survived, whereas six of the 10 patients managed without a shunt survived, for an overall mortality rate of 43%. Over the past 4 years, six patients (4.7%) with ongoing coagulopathies were managed by packing and planned re-exploration, with four patients (67%) surviving and one (25%) developing an intra-abdominal abscess. One additional patient (0.8%) was managed by resectional debridement alone and survived. During the past 5 years, 25 hemodynamically stable and alert adult patients (6%) sustaining blunt trauma were evaluated by computed tomography scan and found to have grade I to III injuries. All were managed nonoperatively with uniform success. The combination of portal triad occlusion (up to 75 minutes), finger fracture technique, and the use of a viable omental pack is a safe, reliable, and effective method of managing complex hepatic injuries (grade III to IV). Juxtahepatic venous injuries continue to carry a prohibitive mortality rate, but nonshunting approaches seem to result in the lowest cumulative mortality rate. Packing and planned reexploration has a definitive life-saving role when used adjunctively in the presence of a coagulopathy. Nonoperative management of select hemodynamically stable adult patients, identified by serial computed tomography scans after sustaining blunt trauma is highly successful (95–97%).

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FOR ALMOST A quarter of a century, the overall mortality rate from civilian hepatic injuries has remained at a relatively low constant of 10%. One reason for this is that most hepatic injuries are minor (grades I to II), and require minimal or no operative intervention. Significant mortality rates, however, are associated with more complex injuries (grades III to V), often exceeding 50%.[1-6]

In 1983, the authors reported their experience with portal triad occlusion (Pringle maneuver)[7] and the finger fracture technique for achieving intrahepatic hemostasis in patients with complex injuries. We recorded a morbidity rate of 8.3% and a mortality rate of 5.3%.[4] Subsequent data accumulated over the past 8 years have corroborated this treatment modality as safe, reliable, and highly effective.

Over the past decade, however, several significant advances have evolved that radically change the way trauma surgeons approach the injured liver. These advances have been incorporated into our overall treatment plan. Foremost among them are perihepatic packing and planned re-exploration and nonoperative management of select hemodynamically stable patients identified by computed tomography (CT) scan.

The purpose of this report is (1) to present data substantiating portal triad occlusion coupled with finger fracture of hepatic parenchyma as the preferred method of managing most grade III to IV injuries; (2) to delineate

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newer trends, establish guidelines for them, and present the results of their use; and (3) to support the contention that juxtahepatic venous injuries can be managed adequately without the use of vena caval shunts.

Materials And Methods

From January 1977 to January 1991, we managed 411 consecutive adult patients with hepatic injuries at Bellevue Hospital, an Urban Level I Trauma Center. Classification of severity of injury was based on the American Association for the Surgery of Trauma hepatic injury scale[8] (Table 1).

Management of Four Hundred Eleven Hepatic Injuries

Two hundred fifty-eight patients (63%) (Fig. 1) sustained minor injuries (grades I to II), and were treated by simple suture, electrocautery, or adjunctive hemostatic agents. Fifteen of these 258 patients all died of nonrelated hepatic injuries.

One hundred twenty-eight patients (31%) sustained complex hepatic injuries (grades III to V). The specific characteristics pertaining to these patients are depicted in Table 2.

Three different treatment modalities were employed alone or in combination for the management of these 128 patients (Table 3).

Portal Triad Occlusion and Finger Fracture of Hepatic Parenchyma (121 Patients)

Group I: Grade III to IV Injuries (107 Patients). One hundred seven patients, representing 83.5% of all complex

TABLE 1. *Liver Injury Scale*

Grade*		Injury Description†
I	Hematoma	Subcapsular, nonexpanding, < 10% surface area
	Laceration	Capsular tear, nonbleeding with < 1-cm-deep parenchymal disruption
II	Hematoma	Subcapsular, nonexpanding, < 10–50%; intraparenchymal, nonexpanding < 2-cm-diameter
	Laceration	< 3-cm parenchymal depth, < 10-cm length
III	Hematoma	Subcapsular, > 50% of surface area or expanding; ruptured subcapsular hematoma with active bleeding; intraparenchymal hematoma > 2 cm
	Laceration	> 3-cm parenchymal depth
IV	Hematoma	Ruptured central hematoma
	Laceration	Parenchymal destruction involving 25–75% of hepatic lobe
V	Laceration	Parenchymal destruction > 75% of hepatic lobe
	Vascular	Juxtahepatic venous injuries (retrohepatic cava/major hepatic veins)
VI	Vascular	Hepatic avulsion

* Advance one grade for multiple injuries to the same organ.
† Based on most accurate assessment at autopsy, laparotomy, or radiologic study.

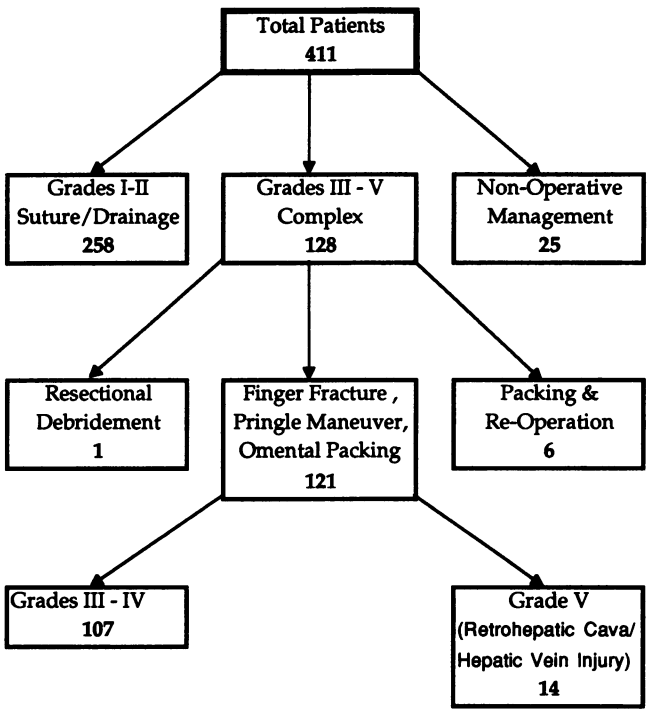

FIG. 1. Management of 411 hepatic injuries (1977–1991).

hepatic injuries, were managed by seven key maneuvers previously described[4]: (1) manual compression of the injury and intraoperative resuscitation before starting definitive operative therapy; (2) hepatocyte protection by bolus infusion of 30 to 40 mg/kg of Solu-medrol (Upjohn, Kalamazoo, MI), and the maintenance of a hepatic temperature of 30 C through topical hypothermia; (3) portal triad occlusion; (4) finger fracture of normal hepatic parenchyma in the direction of injury for ligation of lacerated blood vessels and bile ducts under direct vision; (5) resectional debridement either for severe parenchymal destruction or for removal of nonviable ischemic hepatic tissue; (6) the insertion of a viable omental pack into the liver to aid in hemostasis as well as to reduce dead space; and (7) closed suction drainage.

Eighty-six of the 107 patients (80%) were classified as grade III injuries and 21 (20%) as grade IV. In this group of 107 patients, penetrating trauma was responsible for 83% of the injuries—52 stab wounds (48.5%) and 37 gun-

TABLE 2. *Characteristics of 128 Complex Hepatic Injuries*

75% hypotensive (systolic blood pressure <90)
60% associated injuries (25% hollow viscus)
Mean ISS score = 39 (range 16–75)
Mean transfusion = 14.5 units (range 4–60 units)
Etiology
Penetrating 99 (77%)
Stab wound 56
Gunshot wound 43
Blunt 29 (23%)

TABLE 3. *Management Techniques and Results in 128 Complex Operative Cases*

Treatment	No. of Patients	Mean ISS	Mortality	Postoperative Bleeding	Abscess	Bile Fistula
Portal triad occlusion and finger fracture						
Grade III–IV	107 (83.5%)	35	7 (6.5%)	2 (1.9%)	8 (7.5%)	6 (5.6%)
Grade V	14 (11.0%)	50	6 (43%)	—	2 (25%)	2 (25%)
Packing and reoperation	6 (4.7%)	33	2 (33%)	—	1 (25%)	1 (25%)
Resectional debridement	1 (0.8%)	16	—	—	—	—
Total	128	33.5	15 (12%)	2 (1.6%)	11 (8.6%)	9 (7.0%)

ISS, injury severity score.

shot wounds (34%)—whereas 18 sustained blunt injuries (17%). The abbreviated injury severity score ranged from 16 to 66, with a median of 35.

Seventy-three surviving patients (73%) required portal triad occlusion to achieve intrahepatic hemostasis, with a range of ischemia time of 10 to 75 minutes and a mean cross-clamp time of 30 minutes. In 47 of these 73 (64%), the portal triad was occluded for more than 20 minutes. Moreover, occlusion time exceeded 30 minutes in 28 patients (38%) and 1 hour in 5 (7%). Liver function tests were transiently elevated in all patients during the postoperative period, but returned to normal by the time of discharge. Neither hepatic failure nor hepatic necrosis was recognized in any of these patients.

There were seven deaths, for a mortality rate of 6.5%. Two patients (1.9%), both with blunt grade IV injuries, required reoperation for bleeding in the early postoperative period. Eight (7.5%) patients went on to form perihepatic abscesses, of which two required operative drainage, and the remaining six were drained percutaneously. Six patients (5.6%) developed biliary fistulae; all, however, resolved spontaneously.

Group II: Grade V Injury (14 Patients). Fourteen patients (11%) sustained injuries to the retrohepatic cava or the hepatic veins. The abbreviated injury severity score ranged from 16 to 75, with a median of 50. Nine of these 14 (64%) resulted from penetrating trauma—five stab wounds (36%) and four gunshot wounds (28%)—and five sustained blunt injuries (36%). An atrial caval shunt was used in the initial four patients, with two surviving. One patient died before any form of operative intervention. Nine patients were managed without a vena caval shunt. Instead, prolonged portal triad occlusion (mean cross-clamp time, 46 minutes) and extensive finger fracture to the site of injury were employed. Of these nine patients, six survived. The overall mortality rate for the entire group was 43%. Of the five patients sustaining blunt injuries, however, there was only one survivor, whereas seven of the nine with penetrating injuries survived.

Two of the surviving patients went on to form postoperative subphrenic abscesses, which necessitated operative drainage in one and percutaneous drainage in the other. Two additional patients went on to form bile fistulas, both of which resolved spontaneously before discharge.

Perihepatic Packing and Re-exploration (Six Patients)

Over the past 4 years, six patients (4.7%) with complex injuries required packing and planned re-exploration to arrest hemorrhage. The abbreviated injury severity score for this group varied from 16 to 57, with a median of 35. Perihepatic packing was employed only where conventional methods failed to control bleeding, usually as a result of an ongoing coagulopathy. The method of pack insertion conformed to the technique described by Feliciano et al.[3,9] Pack removal varied from 36 hours to 4 days after operation. Four of the six patients (67%) survived, one of them going on to form an intrahepatic abscess and a biliary fistula. Both were successfully drained percutaneously.

Resectional Debridement (One Patient)

One patient (0.8%) sustaining a blunt hepatic injury was managed by resectional debridement as the primary mode of treatment.

Nonoperative Management Of Blunt Hepatic Injuries (25 Patients)

Over the past 5 years, hemodynamically stable and alert patients with blunt abdominal or lower thoracic cage injuries were evaluated by CT scanning employing a GE-9800 scanner (General Electric Medical Systems, Milwaukee, WI). All scans then were reviewed by a trauma attending physician, who made the decision for nonoperative therapy. This was based primarily on continued hemodynamic stability in an alert patient, capable of responding to serial physical examinations, coupled with the degree of injury ascertained by the CT scan.

Twenty-five patients were identified by CT scan as having either an isolated hepatic injury (23 cases), or a com-

TABLE 4. *Nonoperative Management of Blunt Hepatic Trauma in 25 Patients**

Injury Grade	No. of Patients (%)
I	7 (28%)
II	13 (52%)
III	5 (20%)

* Mean transfusion 2.2 units; mean hospitalization 14 days; success rate 100%.

bined hepatic and splenic injury (2 cases). Specific data relating to these patients are detailed in Table 4. All patients were managed initially in an intensive care unit setting. A repeat CT scan was performed at 1 week after injury. If significant resolution was achieved, patients were transferred to the ward. All patients then were rescanned before discharge and at 1-, 2-, or 3-month intervals, depending on the degree of injury resolution (Figs. 2 to 5). At the end of 3 months, virtually all lesions had resolved, and patients were then permitted to resume normal activities with the exclusion of contact sports. This mode of management was uniformly successful, and no patient required operative intervention either for failure of treatment or for the development of an abscess.

Discussion

Since 1979, the authors have advocated portal triad occlusion, the finger fracture technique, individual ligation of lacerated blood vessels and bile ducts under direct vision, coupled with extensive debridement and omental packing, for treatment of complex hepatic injuries.[10] The use of this method resulted in a mortality rate of only 5.3% in 75 patients presenting with complex hepatic injuries.[4] Of the 128 complex injuries reported in this series, 117 (91%) were managed solely by portal triad occlusion, finger fracture technique, debridement, and an omental pack. An additional 10 patients required adjunctive maneuvers (intracaval shunt in four, and packing in six) to achieve hemostasis. Thus, 127 of the 128 patients (99%) with complex hepatic injuries were managed with the techniques mentioned above. The cumulative mortality rate for these 128 patients, including those with juxtahepatic venous injuries (grade V) and those requiring packing, was 12% (15 patients). In the 107 patients with grade III to IV injuries, however, the mortality rate was only 6.5% (7 patients) with an accompanying morbidity rate of 15% (postoperative bleeding occurred twice [1.9%], eight patients [7.5%] developed perihepatic sepsis, and six [5.6%] formed biliary fistulae [Table 3]).

These successful results serve to reinforce our belief that portal triad occlusion coupled with the finger fracture

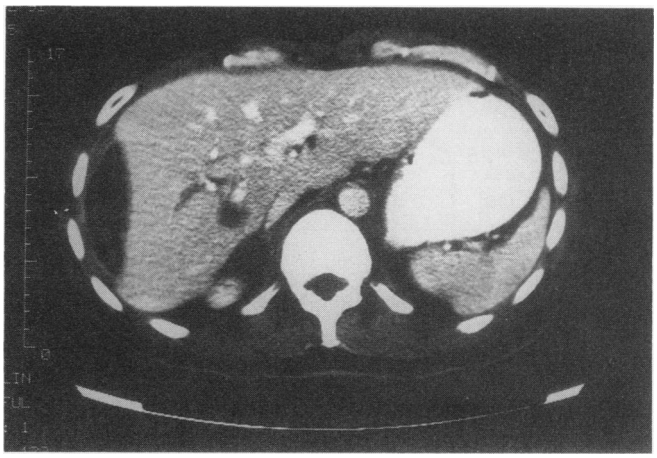

FIG. 3. CT scan 1 mo later showed significant improvement of the hepatic laceration and the parenchymal hematoma.

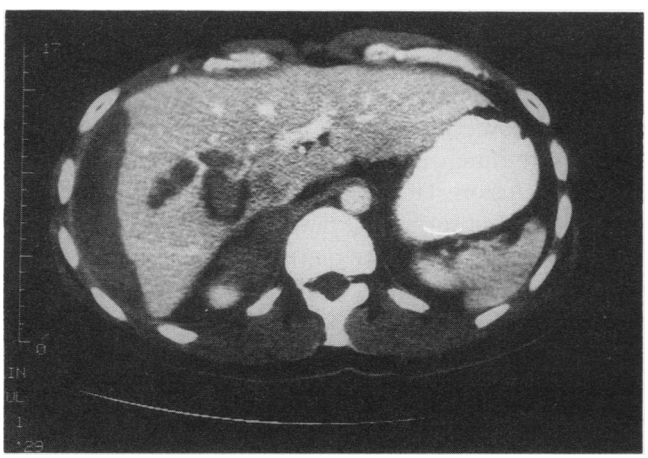

FIG. 2. A 46-year-old black man was thrown over the top of his bicycle and was brought to the emergency room. He reported right upper quadrant and right flank pain. An admitting CT scan showed a large hepatic laceration with a significant parenchymal hematoma. Because the patient was alert and hemodynamically stable, he was managed nonoperatively.

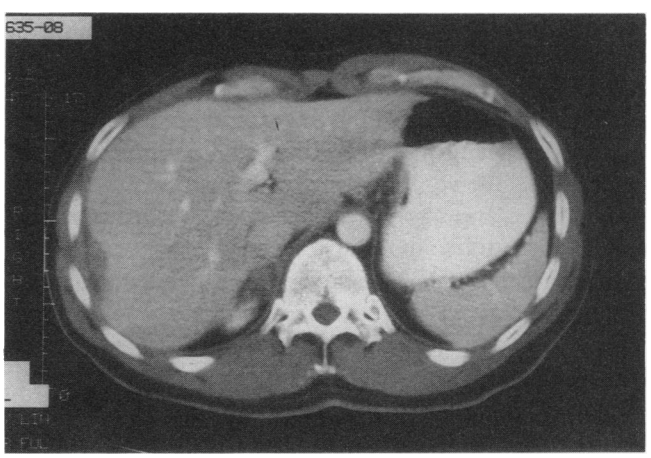

FIG. 4. Repeat CT scan 3.5 mo after injury shows complete resolution of the laceration and minimal residua of the hepatic hematoma.

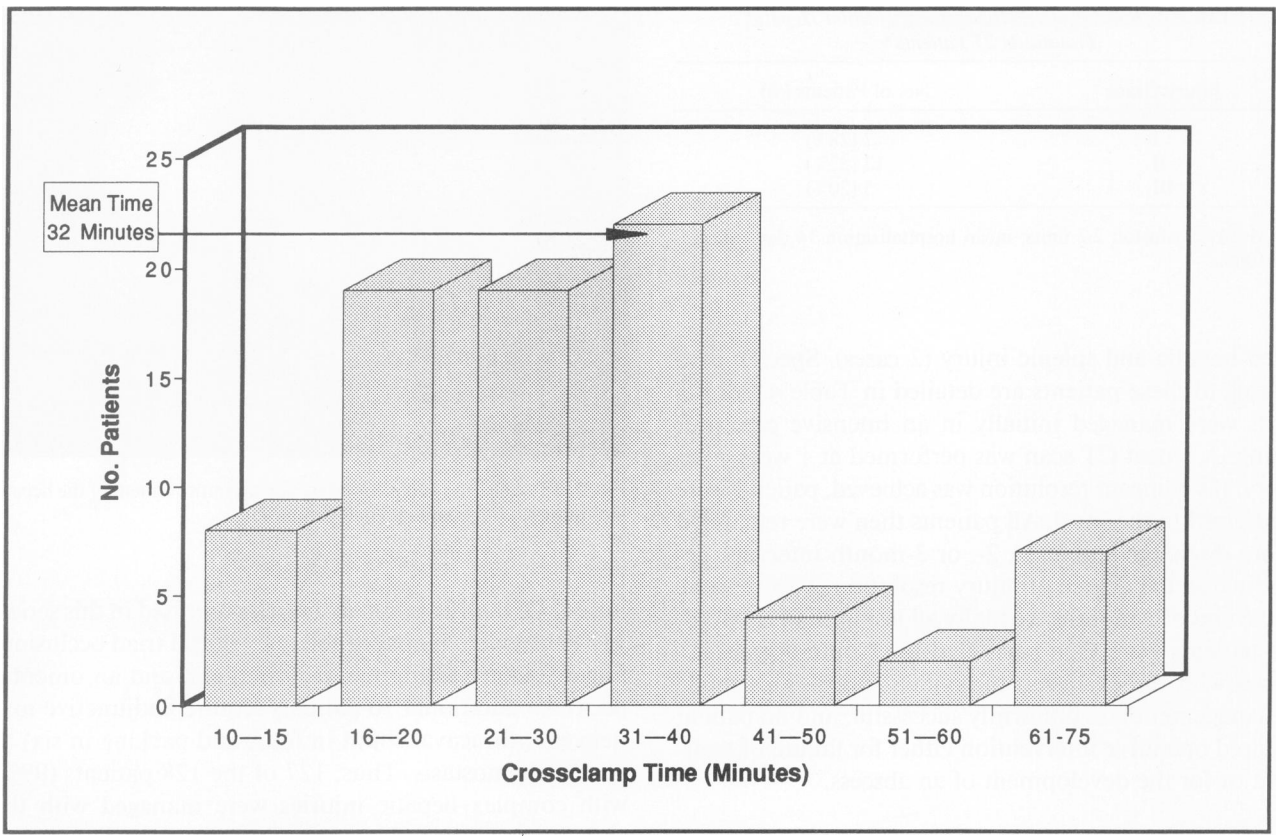

FIG. 5. Cross-clamp time: 81 patients.

technique and omental packing[6,11,12] is the optimal treatment strategy for grade III to IV hepatic injuries. Among the objections to this operative approach is the fear of excessive bleeding caused by finger fracture of normal hepatic parenchyma along nonanatomic planes[13–15] and the mistaken premise that hepatic ischemia can be safely tolerated for only 15 to 20 minutes. We have found these concerns to be entirely unwarranted. Of 128 patients in this series, 127 (99%) were managed by finger fracture of the hepatic parenchyma to the site of injury, almost always along nonanatomic planes. The fact that no major morbidity rate was incurred should dispel any fears about this approach. Acceptance of the finger fracture technique as a safe and efficient treatment modality is evidenced by its use in 45% of the complex hepatic injuries treated by Feliciano et al.,[1] and 41% of the grade III injuries reported in Cogbill's multicenter study.[2] Most recently, Beal[5] reported using this technique in 44% of 121 complex hepatic injuries, with a success rate of 87%.

As to prolonged portal triad occlusion, it would appear that despite the continued documentation of its safety during both elective and traumatic hepatic surgery,[4,10,15–19] the myth of the 15- to 20-minute time limit persists. That the human liver can safely tolerate ischemia times beyond 20 minutes is irrefutable.[4,10,15–19] The maximal limit of safe portal triad occlusion is yet to be determined. Recent data provided by Delva et al.[17] and Bismuth et al.,[18] stemming from their work with elective hepatic surgery, document warm ischemia times of up to 90 minutes, with mean cross-clamp times of 32.3 minutes and 46.5 minutes, respectively. Prolonged warm ischemia times did not adversely affect postoperative stay, incidence of hepatic failure, or mortality rate. Whether an injured liver that has sustained further damage through periods of hypotension can then undergo prolonged portal triad occlusion under normothermic conditions is unknown. For this reason we routinely use hepatocyte protection before portal triad occlusion. This concept is based on experimental and clinical data suggesting that normothermic ischemia can be extended by either regional hypothermia[20–22] or by the use of single-bolus large dose steroids (30 to 40 mg/kg Solu-Medrol).[23,24] Despite the suggestion that steroids may render patients more susceptible to postoperative sepsis,[25] this complication has failed to materialize in this series; as our abscess rate was only 8.6%.

Without randomized trials, of course, there is no hard evidence substantiating the use of either topical hypothermia or steroids as being beneficial in extending normothermic hepatic ischemia time. The authors' uniform success, however, along with the minimal complications

encountered with these methods, make us decidedly reluctant to change our approach. In the current series, 81 of the 113 surviving patients (72%) with complex hepatic injuries (grades III to V) required portal triad occlusion, with a range of ischemia time varying from 10 to 75 minutes, along with the finger fracture technique to achieve intrahepatic hemostasis. The mean ischemia time for the group was 32 minutes (Fig. 5). There were no instances of hepatic necrosis or permanent hepatic dysfunction. Although the efficacy of portal triad occlusion in arresting hepatic hemorrhage has been firmly established,[4,10,19,26] there is little documentation for its use apart from the current authors. The value of this maneuver in the management of complex hepatic trauma cannot be overemphasized. Wider documentation of its use by level I trauma centers will be necessary to generate a broader database to provide the impetus necessary for acceptance of prolonged portal triad occlusion without the fear of subsequent hepatic necrosis or hepatic failure.

Retrohepatic Caval And Hepatic Venous Injuries

Injuries to the retrohepatic cava and main hepatic veins continue to result in a prohibitive mortality rate irrespective of operative management. Surviving patients have, for the most part, been salvaged by means of a vena caval shunt, usually inserted through the right atrium (atrial caval) with an ensuing mortality rate of 77%.[26] Undue delays in both prompt recognition of the injury and shunt insertion seem to predominantly be responsible for the poor results attained with atrial caval shunting.[26–28] Despite strict attention to these pitfalls, mortality rates ranging from 50% to 90% continue to be reported by major trauma centers.[14,26,31] These discouraging results with atrial caval shunts have led several investigators to attempt rapid direct exposure of the injured retrohepatic cava or hepatic veins for primary vascular repair without the concomitant use of a shunt.[26,31,32]

Among the 14 patients in this series who sustained juxtahepatic venous injuries, the initial four were managed with an atrial caval shunt, with two surviving. The next nine patients were managed without a shunt. An additional patient died before any form of therapy could be instituted. The nonshunting approach consisted of four essential features: (1) manual compression and vigorous resuscitation; (2) prolonged portal triad occlusion (mean occlusion time, 46 minutes); (3) rapid and extensive finger fracture for vascular control, almost always through normal hepatic parenchyma to the site of injury; and (4) wide mobilization of the hepatic attachments with medial rotation of the liver to provide access to both the retrohepatic cava and the hepatic vein. Six of the nine nonshunted patients (67%) survived. This experience parallels that of Buechter et al.,[31] who reported five survivors (25%) in 20 patients with juxtahepatic venous injuries. Ten of them were managed with a vena caval shunt and only one survived, whereas in the remaining 10 total hepatic vascular occlusion was employed, with four patients (40%) surviving. Similarly, Burch et al.[27] reported a 67% mortality rate in 31 patients when an atrial caval shunt was used, but only a 47% mortality rate in 15 patients (seven survivors) when the shunt was omitted. Of 142 adult patients with juxtahepatic venous injuries recorded over the past 5 years, 35 (24.6%) were managed without a shunt. The survival rate achieved in these patients was a remarkable 49%, compared with a survival rate of 19% in patients treated with shunts.[2,27,28,30,31,33]

The devastating nature of blunt juxtahepatic venous injuries is evidenced by the fact that, with rare exception, no institution can present more than one or two surviving patients.[33] Of the five blunt injuries reported in this series, only one patient survived.

Based on our own experience and that of others, several conclusions can be drawn concerning juxtahepatic venous injuries: (1) blunt injuries to these structures are almost always fatal[2,29]; (2) the cumulative mortality rate of 74% in 142 patients sustaining juxtahepatic venous injuries over the past 5 years differs little from the 77% previously reported[26]; (3) as the authors observed in 1986,[26] a direct approach to juxtahepatic venous injuries rather than using a vena caval shunt might result in better survival statistics, and this seems to be borne out in a small cadre of subsequently reported cases; and (4) advances in transplantation technology, logistical problems notwithstanding, may provide additional options in the management of these severe injuries; there has been a recent report of successful hepatectomy and second-stage transplantation.[34]

Perihepatic Packing And Planned Re-exploration

Serious complications associated with gauze packing of hepatic injuries during the early part of World War II led to the abandonment of this treatment for complex liver trauma.[35–37] When faced with threatened exsanguination from massive hemorrhage or a coagulopathy, however, packing has become an essential and lifesaving maneuver. Initial reports[19,38,39] of successful results achieved served as the basis for further investigation of this technique. Over the past decade, at least 250 documented adult patients with severe hepatic injuries were managed by packing and planned re-exploration, with 163 survivors (65%).[2,9,40–45]

In our series, six patients (4.7% of all complex injuries) were treated with perihepatic packing and planned re-exploration because of an ongoing coagulopathy. The decision for packing was made after a mean of 15 units of blood had been given and conventional attempts at repair

of major lacerated blood vessels had been accomplished yet nonmechanical bleeding was evident. Four of the six patients (75%) survived who would otherwise have died. The appropriate timing for pack removal has been debated, but should logically be determined by correction of the patient's acidosis, hypothermia, and coagulopathy. For the most part these goals can be achieved within 18 to 36 hours. Packing is associated with a 20% to 30% incidence of perihepatic sepsis,[2,9,40–45] but early pack removal, along with the evacuation of intraperitoneal clots and the debridement of necrotic hepatic tissue, would appear to lessen the incidence of this problem.

Packing is most likely to be useful when a coagulopathy complicates conventional repair, or where bleeding can be specifically localized before a coagulopathy has set in.[40] When employed in this framework as an adjunctive method, a 67% survival rate has been reported in 106 patients. When it was used as a last desperate maneuver, however, only one of 47 patients (2%) survived.[2,9,45]

It should be emphasized, however, that perihepatic packing and planned re-exploration is applicable to only 3% to 5% of all hepatic injuries, because conventional techniques for controlling hemorrhage will usually suffice.

Nonoperative Management of Blunt Adult Hepatic Injuries

Nonoperative management of blunt hepatic injuries in children has been extensively documented.[46,47] The extrapolation of this approach to the adult patient, however, was initially met with scant enthusiasm, predominantly because concomitant intra-abdominal injuries could not be detected with sufficient certainty.[48,49]

Recent technological advances in the field of computerized scanning[50–53] have to some degree negated this concern. The initial success achieved by both Meyer[52] and Andersson and Bengmark[54] has subsequently been corroborated by others. At institutions nonoperatively managing 16 or more blunt hepatic injuries, at least 160 patients have been treated since 1988, with a success rate of 97%.[53,55–58]

For nonoperative management of blunt hepatic injuries to be successful, strict criteria for patient selection should be established. Patients must demonstrate (1) hemodynamic stability, either initially or through modest fluid infusions; (2) absence of peritoneal signs; (3) neurologic integrity so that frequent serial examinations by the same surgical team are possible; (4) CT scan findings consistent with a grade I to III injury; (5) absence of an associated intra-abdominal injury; (6) need for no more than two hepatic-related transfusions; and (7) CT-scan–documented stabilization or improvement of the injury.[56–58] The number of patients with blunt hepatic injuries who can be treated nonoperatively is unknown. It would seem, however, based on available published data, that at least 20% to 45% can be.[53,55–58]

Our own experience with 25 consecutive adult blunt hepatic injuries (grades I to III) managed nonoperatively (Table 4) reflects the national trend toward this newer treatment modality. Patients considered for this form of treatment should be classified as having a grade I to III type of injury. Of the 52 patients managed nonoperatively by Knudson et al.,[58] 77% were classified as grade I to III injuries. Knudson and colleagues also successfully managed 12 more hemodynamically stable patients nonoperatively, seven (13%) grade IV and five (10%) grade V injuries (60). Although their success rate speaks for itself, the routine nonoperative treatment of grade IV and V injuries may be fraught with risks even in the hemodynamically stable patient. Further data will be required to ascertain if indeed nonoperative management of highly complex injuries (grades IV to V) can be safely undertaken.

The detection of intra-abdominal injuries by CT scan has been reported to be highly accurate. This assurance notwithstanding, one must take into consideration the recent disturbing study by Croce et al.,[59] which was undertaken to correlate CT scan grading of blunt hepatic injuries and operative findings. In that study, CT scan grading correlated with operative findings in only 16%. Moreover, in 15 instances (41%) there was an underestimation of the hepatic injury. These findings seem alarming, but conversely, one wonders if the clinical course of any patient would have changed if all the criteria for nonoperative management were met and the patients were not operated on. Although the CT scan grade of injury is essential in the selection of patients for nonoperative management, the ultimate decision for operative intervention must be based on the hemodynamic stability of the patient irrespective of the grade of injury.[58] Additionally, inherent basic surgical objectives must remain of primary importance. Unnecessary blood loss increases the risk of contracting hepatitis or the human immunodeficiency virus and must be avoided. Nor must associated intra-abdominal injuries be allowed to escape detection by sole reliance on CT scanning. Serial physical examinations, preferably by the same examiner, remain essential. The commitment to treat patients nonoperatively should at no time result in the slightest hesitation to choose operative intervention if valid concerns arise.

Conclusions

Several conclusions can be drawn from our study. First, the combination of prolonged portal triad occlusion (up to 75 minutes), the finger fracture technique, and the use of a viable omental pack is, in our opinion, the optimal treatment for patients with grade III to IV injuries. This

is shown by a recorded mortality rate of only 6.5% in 107 treated patients. Second, juxtahepatic venous injuries continue to carry a prohibitive mortality rate. Nonshunting approaches, however, seem at present to yield the greatest success. Third, the technique of packing and planned re-exploration has a definitive and lifesaving role when a coagulopathy is present. Fourth, nonoperative management of adult blunt hepatic injuries is highly successful (95% to 97%) in patients meeting strict criteria.

Adherence to these guidelines in the management of hepatic injuries should continue to keep mortality rates below 10% and morbidity rates to a minimum.

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Discussion

Dr. David V. Feliciano (Atlanta, Georgia): Dr. Bland, Dr. Jones, Members and Guests, I would like to congratulate Dr. Spencer on a very clear presentation, and also congratulate both him and Dr. Pachter on choosing me as their discussant rather than Basil Pruitt. Since his landmark presentation before this Association in 1982, Dr. Pachter has continued to educate all of us in the fine points of management of grade III, IV, and V hepatic injuries. These fine points include prolonged periods of clamping of the porta, vigorous mobilization of the injured lobe, and aggressive approach to finger fracture, which most of us now call hepatotomy, insertion of omental packing into hepatotomy sites, and a selective approach to perihepatic packing. Using this approach he has obtained enviable results, including a 93.5% survival for patients with grade III and IV injuries. In my travels around the country, I find many surgeons in the community most reluctant to adopt prolonged periods of clamping of the porta and to pursue finger fracture in a patient who already has bleeding. In essence, Dr. Pachter has emphasized an aggressive technical approach, and this is the basis for the following three questions.

First, in which patients, Leon, should the finger fracture technique not be used? For example, what do you do with a grade III hepatic injury, a through-and-through bullet wound, in a hemodynamically stable patient with only 500 mL of blood in the abdomen at operation and no active bleeding from either bullet hole? Frankly, I would do nothing with that.

Second, how often do you use the viable omental pack to truly tamponade venous oozing rather than just use it as a space filler?

And, thirdly, what drains do you use after insertion of an omental pack in a grade IV injury? This is a most comprehensive description of the state of the art in hepatic trauma, and I recommend it to the membership. Thank you for the privilege of the floor.

Dr. Timothy C. Fabian (Memphis, Tennessee): Thank you. I, too, would like to congratulate Drs. Spencer, Pachter, and colleagues for an excellent review of a very large series of liver injuries. Their results in terms of perihepatic sepsis in liver-related deaths are actually very similar to what we reported here last year, although our populations are somewhat different, with theirs being 70% penetrating *versus* ours being 49%. And I think it leads us to different approaches to some degree in the management of liver wounds, because I think the mechanism of injury is very important for consideration. Your basic methods for complex injuries as described include portal occlusion, finger fracture, and omental packing. I would like to ask you to address two questions relative to that.

One, I think it is very helpful to have the Pringle maneuver applied for penetrating wounds when you have hepatic venous injuries, as well as artery and portal vein. Our experience has been not quite so good with blunt injuries, where primarily the oozing tends to be hepatic venous injuries. Could you address that?

Secondly, I think this is a grand opportunity to do a prospective evaluation to measure the effectiveness of your use of steroids and hypothermia. Clearly, steroids potentially could be harmful in this situation with multiple-injured patients with relative immunoincompetence, and they are an additional cost. We have heard a lot about hypothermia being bad for patients already this afternoon. How exactly do you pack the liver with ice, and do you think that contributes in any way to any hypothermia?

I would like to mention atrial-caval shunting for a second because it will come up year after year. Your recommendations certainly satisfy our bias relative to this. In fact, I used to believe that there were more papers on the subject than there were survivors of the procedure. But I do believe that there is, I guess, a small number of patients in whom this can be effective today. I think Jon Burch demonstrated about a 50% survival rate earlier in his paper, and other people have. Also, we have not been too anxious to use it, but I would like to hear what your current recommendations are. Should it ever be used?

And I would like to conclude the comments with addressing the nonoperative management issue. I think you should be congratulated for excellent results in 25 patients. You had no failures. I would, first of all, like to know, is that the true denominator? Is there a potential in series like this that are retrospective to a degree that some patients actually failed but went over into the operative group of management? We have had a couple of failures in our nonoperative management group that had to go to the operating room. I think that, looking at what is in the literature today, we can deceive ourselves because these are all retrospective studies. For one thing, in smaller experiences, people tend not to report bad results. I am not saying that results are other than what has been reported, but there are other people who may not have as good results and are not reporting them. And, two, they may not be recognizing that some of their surgically managed patients were indeed observed at first. I think that clearly this could only be addressed by a prospective study looking at nonoperative management very specifically and controlling your data very closely. Dr. Croce from our institution found in a report a year ago that, looking at computed-tomography (CT)–described anatomy with liver injuries, 40% of those underestimated the degree of injury, and there were some that were overestimated. It did not correlate very well at all. Consequently, what we have found now is that the volume of blood in the perihepatic tissues, gutters, and pelvis are at least as important, or maybe more important, than the anatomic description by CT scanning. If you have a grade IV injury on CT scan but no perihepatic blood, those patients generally do well. If you have some blood in the gutter, it's not quite as good. And then if you have blood in the gutter, pelvis, and perihepatic area, then there is probably a clear indication for operation regardless of grade of injury. Clearly, again, this does need more prospective evaluation. I think we'd better be a little reserved before we recommend it widely based on hepatic injury grading scale. Thank you very much.

Dr. J. David Richardson (Louisville, Kentucky): It certainly is a pleasure to discuss this paper by Drs. Pachter, Spencer, and their colleagues. I have read the manuscript, and like the other discussants, cer-