WOUNDS OF THE LIVER*

REVIEW OF 100 CASES

ROBERT S. SPARKMAN, M.D. AND MORRIS J. FOGELMAN, M.D.

DALLAS, TEXAS

FROM THE DEPARTMENT OF SURGERY OF THE SOUTHWESTERN MEDICAL SCHOOL OF THE UNIVERSITY OF TEXAS, DALLAS, TEXAS

IN THE FIRST 40 years of the twentieth century the mortality rate of wounds of the liver underwent little significant change. During World War II a striking improvement in results was achieved. Although the technical procedures for management of the liver wound underwent some modification, the principal factors in reduction of mortality were the general refinements in care of the severely wounded, which typified the era.

The following study was undertaken in an effort to evaluate the treatment of liver wounds in the period following World War II. Material for study consists of 100 consecutive cases of liver injury admitted to one city-county general hospital subsequent to January 1, 1946.

The treatment of liver wounds does not lend itself well to standardization. Opinions vary concerning the precise management of a wound of a given type. Moreover, while a particular procedure such as suture may be adaptable to one wound, it may be inappropriate to another.

In the present series, while uniform policies were followed with respect to blood and fluid replacement, early operation, antibiotic therapy and other general principles, the wound of the liver itself was subjected to diverse methods of treatment, depending upon the individual preferences of members of the attending staff. The variety of technics employed in this series is representative of the methods generally employed in this country at the present time.

HISTORICAL SURVEY

In a review of surgery of the liver published in 1902, Beck[2] credits Bruns with having successfully resected the lacerated portion of a gunshot wound of the liver in 1870. The first operation for hemorrhage from a liver wound is attributed by Deaver and Ashhurst[18] to Burckhardt,[10] who, in 1887, packed a stab wound of the liver; the patient recovered. In 1887 Edler[21] compiled data concerning 543 cases of liver injury, all treated without initial operation, with a collective mortality rate of 66.8 per cent. Nine years later, in 1896, Kousnetzoff and Penski[38] described several methods for suture of liver wounds and proposed the employment of a blunt flexible needle for this purpose. The authors of the late nineteenth and early twentieth centuries were concerned chiefly with measures for the control of hemorrhage, which constituted the immediate threat to life. Many ingenious methods were devised for suture of the liver and for coagulation or compression of the bleeding surface.

Statistics of this period are of limited value for present comparison, since they were compiled largely from selected cases. Operative treatment rapidly gained popu-

* Presented before the Southern Surgical Association, Hot Springs, Virginia, December 9, 1953.

larity, however, and by 1912 Thöle[67] was able to collect from the literature 680 case reports of patients who had undergone operations for liver injury. The relationship between surgical delay and mortality rate was apparent in his series. In the meantime, notable contributions to the literature were made by Terrier and Auvray (1896),[66] Fraenkel (1901),[27] Moynihan (1905),[47] Tilton (1905),[68] Pringle (1908),[51] and Boljarski (1910).[6] Early operation was advocated, and the relationship of associated injuries to mortality rates was recognized. Pringle (1908) described digital compression of the portal vein and hepatic artery for temporary control of hemorrhage. The danger of delayed secondary hemorrhage was stressed by Fraenkel. Statistical data indicated that non-penetrating crush injuries of the liver were the most lethal and stab wounds the least so, while gunshot wounds occupied an intermediate position with respect to mortality and morbidity. In time, as measures were developed for the control of hemorrhage, greater attention was paid to the delayed complications of liver injury. Infections and accumulations of bile were recognized to be related to inadequate drainage.

An over-all mortality rate of 66.2 per cent was reported for all wounds of the liver incurred in World War I.[3] In the interval between the two wars many series of liver wounds were reported, the largest being those of Krieg,[39] Lamb,[40] Boyce,[7] and O'Neill.[48] Mortality rates of these and other series were generally in excess of 60 per cent[1, 46, 73] (see Table I). This figure is deceptively high, since many of the reports were limited to a consideration of the more severe non-penetrating crush injuries. Many informative reports published during this period dealt with varied aspects of the treatment and complications of liver wounds.[8, 14, 29, 35, 50, 52, 62]

The interval between the wars was a time of notable advance in appreciation of the derangements of hepatic physiology in relation to liver injury. The hepatorenal syndrome was first described in 1924 by Heyd,[32] who attributed postoperative deaths following biliary tract surgery to hepatic and renal failure. The concept of the hepatorenal syndrome was subsequently extended to account for deaths associated with a variety of conditions,[13, 30, 34, 69, 71] one of which was hepatic trauma. In his classic monograph published in 1941, Boyce[7] reviewed all previous work concerning this phenomenon, and presented experimental and clinical data relative to the mechanism of the syndrome. He also advocated the debridement of damaged liver tissue as a practical and desirable objective. In recent years better understanding of the mechanisms of renal failure has necessitated re-appraisal of many of the deaths previously attributed to the hepatorenal syndrome. Nevertheless, while the present status concerning the reality of the hepatorenal syndrome as a definite entity is controversial, the importance of early recognition of hepatic and renal failure in a patient who has suffered liver injury cannot be denied.

During World War II a striking improvement in results of treatment of liver injuries was achieved. The notable report of Madding, Lawrence, and Kennedy[41] described the experiences of the Second Auxiliary Surgical Group with wounds of the liver in the European Theatre during 1944 and 1945. These authors presented data concerning a series of 829 wounds of the liver, in which an over-all mortality rate of 27.0 per cent was achieved. They emphasized the importance of drainage and called attention to the hazards of gauze packs. In their experience the control of hemorrhage was not as great a problem as the management of infection and complications related to biliary drainage and hepatic necrosis.

While technical advances in management of the liver wound itself were of un-

TABLE I. *Mortality Rates in Wounds of the Liver.*

Author	Year Published	Period of Report	Source of Material	Type of Injury	No. of Cases	Mortality Rate
World War I	1918	World War I	U. S. Army	All types	?	66.2%
Allen	1931	1900–1931	Mass. Gen. Hosp.	Non-penetrating & without other significant injury.	24	66.6%
Krieg	1936	1927–1934	City of Detroit Receiving Hosp.	All types.	60	61.6%
Lamb	1939	1915–1937	Boston City Hosp.	Non-penetrating except one.	60	68.0%
Boyce	1941	Ten year period antedating 1941	New Orleans Charity Hosp.	All types.	98	61.2%
O'Neill	1941	Ten year period antedating 1941	Los Angeles Co. Gen. Hosp.	Non-penetrating	100	81.0%
Wright, Prigot & Hill	1946	1935–1945	Harlem Hosp., New York	Non-penetrating	32	81.3%
Mikal & Papen	1950	1935–1945	Boston City Hosp.	Non-penetrating	40	62.5%
Madding, Lawrence & Kennedy	1946	1944–1945	U. S. Army	All types.	829	27.0%
Cohn	1947	Prior to 1947	San Francisco Hosp.	All types.	26	30.8%
Sparkman & Fogelman	1953	1946–1953	Parkland City-Co. Hosp. Dallas	All types.	100	10.0%

questioned importance in the improvement of results during World War II, the greatest measure of credit must be attributed to general refinements in the management of the severely wounded. Significant factors include the following: early surgery of the wounded; the liberal use of whole blood and other agents for the treatment of traumatic shock; the advent of antibiotic therapy; and improvements in management of associated injuries of all types, but especially of thoraco-abdominal wounds.

The war years were described by Churchill[15] as a time when the focus of attention was changed from the pleural space to the lung. Early in the war all literature pertinent to the treatment of wounds of the chest was reviewed by DeBakey.[19] Extensive experiences with the initial management of thoraco-abdominal wounds were described by Betts,[4, 5] Sanger,[55] Snyder,[63] Shefts,[61] Wylie,[74] Fox,[26] and others. The adaptability of the thoracic trans-diaphragmatic approach to wounds of the liver and other abdominal organs was demonstrated, and the importance of closure of the diaphragm in combined wounds of the chest and abdomen was emphasized. The necessity of establishment of respiratory equilibrium preliminary to celiotomy was recognized. Results of treatment of thoracic and thoraco-abdominal wounds were reviewed by Carter and DeBakey,[12] Foresee,[25] and others. Refinements in anesthesia went hand in hand with the more widespread employment of open thoracotomy.

During this time additional understanding of hepatic physiology was gained from the studies of Markowitz,[42] Fine,[23] and other, regarding the relationship of intrahepatic bacterial growth to blood flow in the liver. It is now known that the liver harbors anaerobic bacteria which may be stimulated to propagate in response to anoxia induced either by hypotension or by local vascular insufficiency.[72] This information has extensive applications to the treatment of liver wounds, both with respect to the importance of early antibiotic therapy and the desirability of maintenance of adequate blood flow to the injured part.

During and following the war various substances were developed for use as top-

ical hemostatic agents. Fibrin foam, the earliest of these, was a product of the fractionation of plasma, and was never available in quantity. The experimental and clinical employment of oxidized cellulose was described by Frantz, *et al.*,[28] while Jenkins[37] was engaged in comparable studies with gelatin sponge. Each of these agents was subjected to trial in wounds of the liver. The extent to which they may be employed safely in liver wounds has not yet been fully determined.

The relationship of hepatic insufficiency to derangements in the clotting of blood has been established by numerous investigators in the fields of physiology and hematology. The concentrations of prothrombin, fibrinogen, or factor V in the blood may be altered in response to functional or traumatic injury to the liver. Defective coagulation secondary to extensive hepatic damage may result in bleeding from multiple sources or from the liver alone. The possibility of this type of bleeding in wounds of the liver has been mentioned by Martin[44] and others.

No strict analogy can be drawn between the wounds of warfare and those of civilian life. The wounds of warfare are generally more severe, and the time interval prior to the institution of definitive treatment is greater.

MATERIAL FOR STUDY

The present study consists of an analysis of 100 consecutive cases of liver injury admitted to Parkland Hospital, Dallas, Texas, between January 1, 1946, and September 15, 1953. Admissions to the hospital during this period exceeded 70,000, yielding an incidence of liver wounds of 1.43 per 1000, or one in 700 admissions.

Mode of Injury. Only eight non-penetrating wounds were observed, of which only three were severe. Of the 92 penetrating wounds, 54 were due to pistol or rifle fire, while four were inflicted with shotguns. The remainder consisted of 34 lacerations inflicted by a knife or similar agent.

Sex, Age and Race. The series consisted of 85 males and 15 females. The extremes of age were three years and 64 years, with an average age of 31 years. There were 60 negroes and 40 white patients; the latter group included 13 of Latin-American extraction.

Location of Wound. In 60 patients the wound involved the abdomen only, while 30 patients sustained thoraco-abdominal injuries. In the remaining ten there were separate wounds of the abdomen and thorax. With respect to the liver injury, the right lobe only was involved in 71 cases, the left lobe only in 24 cases, and both lobes in five.

Relation of Associated Injuries to Mortality. The total mortality for the group was 10 per cent. The mortality for wounds involving only the liver was 3.1 per cent. The significance of associated injuries as a determinant in mortality has been apparent in all previous reports. In the series of Madding, *et al.*, the mortality was 9.7 per cent in the group suffering injury to the liver alone. When the liver was injured in combination with one other organ, their mortality rose to 26.5 per cent. The most lethal combination observed by Madding was that of liver and colon, where the mortality was 33.4 per cent.

In the series under consideration, there were 117 associated injuries which were considered to be significant. The combination of injury to the liver and chest was observed more frequently than any other (36 cases), while the next most frequent combination was that of liver and stomach (21 cases). Detailed anatomical distribution of associated injuries is shown in Table II. Although there was no fatality in the group with injury to the liver and one other organ, the mortality rose sharply with each additional injury (liver plus two organs: 14.6 per cent; liver plus three organs: 30.8

per cent), and no patient survived when there was injury to the liver in conjunction with four or more additional significant injuries. The relationship of associated injuries to mortality is shown in Table III.

TABLE II. *Anatomical Distribution of Associated Injuries.*

Structure	Number of Injuries	Structure	Number of Injuries
Chest	36	Spleen	6
Stomach	21	Pancreas	6
Kidney	12	Major artery	5
Small intestine	9	Spinal cord	4
Duodenum	7	Femur	2
Colon	7	Gall bladder	2

TABLE III. *Relationship of Associated Injuries to Mortality Rate.*

Number of Associated Injuries	Number of Cases	Deaths	Mortality Rate (%)
One injury only (liver alone)	32	1	3.1
Liver plus one injury	38	0	0.0
Liver plus two injuries	14	2	14.6
Liver plus three injuries	13	4	30.8
Liver plus four injuries	1	1	100.0
Liver plus five injuries	2	2	100.0

TREATMENT

Throughout the series under consideration, operation was performed on all cases of known or suspected liver injury as soon as adequate resuscitation could be accomplished. While expectant treatment of selected wounds is still recommended by an occasional author, the fact remains that copious hemorrhage or drainage of bile may occur from wounds of small size. In the series of 100 cases under consideration, 98 underwent operation upon admission or shortly thereafter, while two patients not suspected of having abdominal injury were treated expectantly. Both of these required eventual operation for complications of the unrecognized abdominal injury.

General Pre-operative Measures. In the initial phase attention was directed to the following: correction of shock and replacement of blood, fluid, and electrolyte; relief of hypoxia and improvement of respiratory function; control of pain; and gastric decompression.

Whole blood was employed extensively as the fluid of choice in the management of shock associated with liver injuries. Approximately half of the patients were in shock on admission. Blood was given before or during operation in 76 patients; of this group, the average patient received two and one-half pints of blood during the initial phase. Autotransfusion, as described by Griswold and Ortner,[31] was not attempted. In the later years of the series, recognition of the characteristic loss of significant amounts of salt water in association with chemical peritonitis led to the general employment of lactate-Ringer's solution in conjunction with whole blood as the optimum type of fluid and electrolyte replacement therapy.

Impaired respiratory function was encountered frequently in conjunction with associated thoracic injuries. Fifteen patients underwent closed thoracotomy in addition to laparotomy. Several additional patients underwent aspiration of hemothorax. In the latter portion of the period of study, closed intercostal drainage was employed more commonly, with a corresponding diminution in frequency of needle aspiration.

The usual drugs were employed for the relief of pain. It should be borne in mind that the capacity of the damaged liver to utilize opiates may be diminished, and that the release of such drugs from subcutaneous depots may be delayed in the hypotensive state. Analgesics should therefore be employed in small amounts, preferably by the intravenous route.

In view of the frequent distention of the stomach, either with food or with air, the institution of gastric decompression by nasal tube is an essential preoperative measure. This measure was employed routinely.

An antibiotic drug or combination of drugs was given to 99 of 100 patients. Penicillin was the most frequent choice, and was often employed alone. In view of the probability of development of mixed infections in necrotic liver tissue, the employment of aggressive antibiotic therapy is desirable at the outset in all cases of liver injury.

Suture of Liver Wound	27 Cases
Suture only, without drainage	6
Suture and hemostatic pack without drainage	4
Suture with drainage	9
Suture with absorbable hemostatic pack and drain	8
	27
Drainage of Abdominal Cavity	61 Cases
By rubber tissue drains alone	55
By gauze pack	3
By sump drain	3
	61
Closure of the Abdominal Cavity without Drainage	37 Cases
Exploration only	17
Suture only	6
Absorbable hemostatic pack only	10
Suture and absorbable hemostatic	4
	37
Employment of Packs	40 Cases
Oxidized cellulose	20
Gelatin sponge	17
Gauze pack	3
Muscle	1
Round ligament	1
	42*

Operative Approach. An abdominal incision alone was employed in 91 cases. Thoracotomy alone was employed as an initial procedure in five instances, and as a delayed procedure twice. On one occasion separate incisions in the abdomen and chest were made. A combined thoracoabdominal incision was used once.

Treatment of the Liver Wound. No uniform method of therapy is applicable to all varieties of liver wounds. The following classification, as outlined by Krieg,[39] is regarded as the most practical from the therapeutic standpoint:

(1) Clean incision produced by a stab.
(2) Clean puncture by a bullet.
(3) Macerating puncture by a bullet.
(4) Rough fracture or contusion.

This classification should be elaborated to include shotgun wounds, which constitute a special category.

Specific measures which were employed for repair of the damaged liver are outlined in Table IV and include the following: suture, drainage, packing, debridement, and combinations of the foregoing. In our series of 98 cases subjected to early operation these measures were employed with the following frequency:

Suture. Closure of a liver wound by suture is an effective measure for the control of hemorrhage and biliary drainage. It is best adapted to the treatment of sharp incised wounds of the liver, where it appears to be the procedure of choice. It can be employed effectively, however, in deep linear tears of the liver. The surfaces of such tears, if not fragmented, show a pronounced tendency to heal. The interposition of any quantity of absorbable sponge between such surfaces is subject to the criticism that the period of absorption of the gauze exceeds the usual time required for union of the wound surfaces. Attempts at suture are least successful in wounds associated with extensive loss of tissue or stellate fragmentation of the liver. Even here, however, considerable patching together of irregular wounds can sometimes be accomplished. Prior to the suture of large bleeding surfaces, it is often possible to identify and tie the major vascular or biliary radicals which are visible on the surface. From the technical standpoint the most difficult situations for the utilization of suture methods are those in which the wound is inaccessibly located, or so fragmented that the tissues will not hold the stitches.

* In two cases oxidized cellulose and gelatin sponge were used in combination.

Suture methods may be employed either to bring two torn surfaces together or to effect hemostasis in a bare surface. The extent to which suture of liver surfaces can be employed effectively has been demonstrated in many elective resections of liver tumors. Tight closure of an hepatic defect by suture possesses two potential disadvantages. A closed cavity may be created wherein bile, blood, or pus may accumulate. Hepatic abscesses or collections of bile and blood developing in such circumstances have been described, and an instance of massive hemobilia secondary to closure was encountered in our series. Complications of this type are relatively uncommon. Krieg[39] has suggested that an intra-hepatic drain be introduced to the depth of a deep hepatic tear when the surface is closed by suture. The second source of difficulty arises from the probability that the introduction of deep mass ligatures for the control of hemorrhage may lead to segmental necrosis, with resultant autolysis and infection. However, the same objection can be offered to the introduction of a pack tight enough to control hemorrhage, and the fact remains that it is preferable to accomplish hemostasis at the expense of some necrosis than to fail to control hemorrhage. Some necrosis of liver tissue should be regarded as the inevitable cost of measures undertaken for the control of severe hemorrhage; in such situations the eventual development of infection and biliary drainage should be anticipated, and especial attention paid to the provision of avenues of drainage.

In this series closure of a liver wound by suture was performed in 27 cases, in 12 of which an absorbable hemostatic sponge was also employed, either within the defect or over the line of closure. Cotton and catgut were used with approximately the same frequency; no advantage of one over the other could be demonstrated. A preference was shown for sutures of the larger sizes which were less likely to cut through the tissue. A variety of needles was employed. It is our impression that the blunt needles traditionally employed in liver suture cause considerably more bleeding than very slender curved needles with tapered points.

Drainage. Abdominal closure without drainage has been practiced successfully in many selected cases of liver injury reported heretofore, as well as in numerous instances in this series. Whether this practice is ever justifiable is open to serious question.

The rationale of omission of drainage is based upon the assumption that the wound will not drain bile in significant quantities thereafter, and that abscess formation will not occur. Such a conclusion can be reached only by appraisal of the liver wound at the time of exploration. While many small wounds of the liver will not drain significant quantities of bile, copious flow may occur in small wounds if a large biliary radicle should be incised. The appearance of the wound at the time of operation is not a reliable guide to the probability of subsequent drainage of either bile or blood. Hemorrhage or drainage of bile may recur upon detachment of a clot or correction of hypotension. Omission of drainage of a liver wound may be compared to the performance of cholecystectomy without drainage, except that the probability of drainage of bile is much greater following injury to the liver than as a sequel to cholecystectomy, and the added hazard of necrotic liver tissue is usually present in some degree.

In discussing 829 wounds of the liver treated by his group during the war, Madding[41] expressed the opinion that the establishment of adequate external drainage of both bile and products of tissue injury was the most important feature in the surgical care of liver wounds. A similar view was held by Jarvis, *et al.*,[36] DeBakey,[20] and Sawyer.[56] However, in a report published

in 1950, Mikal and Papen[46] advocated packing the liver wound with absorbable sponges and closing the abdomen without drainage as a means of lowering the morbidity rate in ruptures of the liver. This recommendation was based on their experience with four consecutive cases treated without fatality. Cohn[16] described a series of 17 perforating or lacerating wounds of the liver, of which ten were closed without drainage, with no untoward results. He felt, however, that the risk involved was unwarranted.

In the series of cases under consideration, 37 were closed without abdominal drainage. The type of associated therapy employed in these cases is indicated in the foregoing outline and in Table IV. In general, the cases subjected to closure without drainage were those in which the least severe degrees of hepatic damage were encountered. No specific ill effect could be attributed to omission of drainage in any case in this series.

Our experiences relative to drainage could be embodied in the statement that in those instances in which it was needed, it was usually inadequate. The conventional forms of drainage too often consist of one or two narrow rubber strips brought out of a wound of exploration, which is then closed tightly around them. This offers little protection against the accumulation of subphrenic or subhepatic collections or the sequestration of fragments of tissue. The subphrenic abscesses in our series all developed in spite of the employment of drains. The simplest measures for the provision of more liberal drainage are as follows: greater numbers of drains, fanned out over the area of injury and brought as directly through the abdominal wall as possible; adequate apertures in the abdominal wall for their exit; supplementary postero-lateral drainage through the flank, utilizing incisions near the tip of the 12th rib. In the more severe liver wounds avenues of drainage should be adequate to allow egress of fragments of necrotic tissue. In liver wounds associated with perforations of the diaphragm the establishment of subcostal drainage is especially important. The sump drain has usually been reserved for instances of pancreatic injury.

An occasional author has suggested that drainage of the injured liver should be avoided for fear of introducing infection from external sources. We hold this view to be invalid. It is our feeling that the omission of drainage offers little advantage and involves great risk; drainage is therefore recommended as a routine measure in all cases, excepting only those incised wounds of the magnitude of a liver biopsy which have been securely sutured.

Packing. The introduction of a gauze pack for the control of hemorrhage is a traditional mode of therapy for wounds of the liver. During the second World War Madding reported a significant decline in mortality and morbidity of liver wounds coincident with decline in the employment of packs. To attain hemostasis it is necessary that a pack be introduced tightly. Boyce has indicated that the high incidence of infection associated with the use of gauze packs may be attributed in part to liver damage resulting from sustained pressure. The additional disadvantage of secondary hemorrhage upon removal of gauze packs has also contributed to the decline of this method of treatment.

In an effort to avoid the disadvantages of gauze packs, various autografts have been employed, including muscle, peritoneum, fascia, omentum and round ligament. However, any free autograft possesses the considerable disadvantage that it constitutes an additional mass of potentially devitalized tissue. Moreover, these materials are not tenacious, and are often difficult to obtain in adequate quantity except as free grafts.

Subsequent to the war, oxidized cellulose and gelatin sponge have been em-

TABLE IV. *Methods Employed in Treating Liver Wound.*

Procedure	Stab 34	Crush 8	Shot-gun 4	GSW 54	Total
Exploration only; closure without drainage	8	2	0	7	17
Drainage only	7	1	2	18	28
Suture only—no drain	3	0	0	3	6
Suture and drain	4	2	1	2	9
Hemostatic agent and suture	3	0	0	1	4
Hemostatic agent and suture and drain	4	2	0	2	8
Hemostatic agent alone without drainage	1	0	0	9	10
Hemostatic agent and drain	3	1	1	10	15
Gauze pack	1	1	0	1	3

ployed extensively in liver wounds, either alone or in conjunction with sutures. The absorption of these materials is slow and variable, and ordinarily exceeds the period in which primary union would occur. Such authorities as Frantz[28] and Jenkins[37] caution that they should be regarded as foreign bodies and accordingly used in as small amounts as possible. Of the two, oxidized cellulose is the more tenacious, and can be maintained in position with greater ease. While Vanderhoof and Merendino[70] reported unfavorable results in three of four cases in which oxidized cellulose was placed in the gallbladder bed, there has been no evidence of untoward reaction following its use in wounds of the liver.

In our series, gauze packs were used on three occasions only, while round ligament and muscle were each used once. Oxidized cellulose was used on 20 occasions, and gelatin sponge on 17. These materials were employed most frequently in simple perforating gunshot wounds of the liver, where they were introduced as plugs for tamponade of entrance and exit wounds. They were occasionally used in conjunction with suture of hepatic defects, either by introduction in the defect or as a support for the suture line. No complications were encountered which could be attributed specifically to the employment of these materials. Pending their ultimate evaluation, they should be used sparingly. The temptation should be avoided to interpose packs between two liver surfaces which, given the opportunity, would probably heal. They may be employed as a lining for large defects which cannot be closed by suture.

There are instances in which the character of the wound, the extent of the hemorrhage, and the condition of the patient dictate the use of a gauze pack as a life-saving procedure. Infectious complications may be anticipated as a likely sequel. It is, therefore, desirable that packing be reserved for the occasional wound which cannot be dealt with satisfactorily by other means. Burnett[11] and others have interposed absorbable hemostatic agents between a gauze pack and the liver surface to minimize the likelihood of secondary hemorrhage at the time of removal of the pack.

Debridement. In 1870 Bruns[9] treated a gunshot wound of the liver by resection of the lacerated portion, and the patient recovered. Beck,[2] in describing a gunshot wound of the liver in 1902, stated, "I was inclined to resect the ugly torn substance, being afraid of infection from it, but I refrained from doing so for fear that new hemorrhage would be started by a fresh cut, and perhaps be fatal to this already very anemic boy." It remained for Boyce,[7] in 1941, to become the first real proponent of debridement of damaged tissue resulting from liver trauma. The causal relationship of necrotic liver tissue to infection and sequestration is established, and the ablation of devitalized tissue is an important objective. The practical accomplishment of this objective may be difficult, and the surgeon of today, like Beck, is still obliged to overcome a natural hesitancy to perform debridement, arising from his fear of creating new bleeding surfaces or adding to the extent of the surgical procedure in a patient already in critical condition.

There are many instances in which debridement is feasible. In fragmentation injuries, if doubt exists concerning the viability of a segment, it is safer to remove it. In deep fissures which traverse most of the substance of the liver, it would be preferable on occasion to complete the amputation rather than to attempt to re-attach the segment. Removal of the entire left lobe can be accomplished in extensive injuries of this structure. In view of the extensive functional reserve of the liver, there need be no fear of hepatic insufficiency as a consequence of such resections.

In our series limited debridement was performed in several instances, usually consisting of removal of fragments which were already partly detached. Experiences with debridement of liver tissue have been described by Sanders, Macguire and Moore,[54] and others.

Thoraco-Abdominal Wounds. Because of their frequency and the unique problems which they present, thoraco-abdominal wounds deserve special consideration. During World War I the mortality for wounds of this type exceeded 60 per cent. In World War II the mortality showed a progressive decline from 36.7 per cent in the initial years to approximately 20 per cent in the final ones. The progressive reduction in mortality has coincided with the development of thoracic surgery as a specialty.

The mortality rate of thoraco-abdominal wounds may be correlated closely with the number of abdominal organs which are injured. Thus, wounds of the right hemidiaphragm are less often fatal than those of the left, since the interposition of the liver affords some protection to the other abdominal viscera.

Beebe and DeBakey,[3] in a review of thoraco-abdominal wounds of World War II, state that it is the abdominal rather than the thoracic component which determines mortality. Betts,[5] on the other hand, presented figures to show that more deaths occurred from pulmonary than from abdominal complications. However, approximately half the deaths in his series were attributed to shock and were not classified as being abdominal or thoracic deaths.

In the reports of Betts,[4, 5] Snyder,[63] Sanger,[55] Shefts,[61] Wylie,[73] and Fox,[26] a preference is shown for the thoracic trans-diaphragmatic approach in thoraco-abdominal wounds. During the war this choice was apparent wherever experienced thoracic surgeons were available, while general surgeons more frequently employed the abdominal route. The advantages and disadvantages of each are well known. The thoracic approach permits considerable work to be done in the abdomen, while the abdominal route permits none to be done in the chest. The thoracic route affords better access to wounds of the diaphragm and dome of the liver, while the abdominal approach allows a more complete exploration of abdominal organs.

It is generally agreed that practically all thoraco-abdominal wounds require surgical exploration. The only possible exception is that group suffering penetration of chest and diaphragm by minute metallic fragments which can be shown roentgenographically to lie in the region of the liver. Betts states that approximately 1 per cent of all thoraco-abdominal wounds fall in this category, and recommends exploration when any fragment is thought to exceed 3 mm. in diameter. In penetrating wounds of the chest with questionable abdominal involvement, needle aspiration of the abdominal cavity may be a valuable diagnostic aid.

Injuries of the chest were more frequent than any other associated injury in our series. Thoraco-abdominal injury, with perforation of the diaphragm, occurred in 30 instances, while in six additional cases the chest and abdomen were penetrated by separate missiles. A pronounced preference was shown for the abdominal route

of exploration. This is due in part to the fact that the general surgical service received the first call when there was any suspicion of abdominal injury. However, consultation was available from the Thoracic Surgery Section of the hospital staff, and was employed frequently. An additional factor which must be recognized in this series is the pronounced difference between the thoraco-abdominal wounds of warfare, and those of civilian life. In the former group the missile was often large, and caused such extensive damage to chest and diaphragm that thoracotomy was mandatory. Wounds of this severity are uncommon in civilian life. In many instances in our series a thoracic approach would have been equally desirable if not preferable. However, no patient appeared to have been penalized by failure to perform thoracotomy.

Initial thoracotomy was performed six times in the series (five times as the sole procedure and once following laparotomy). The combined thoraco-abdominal approach was used only once. Two patients underwent delayed thoracotomy for biliary pleural fistulae arising as complications of small stab wounds of the chest; each of these was treated initially without operation, and thoracotomy was the sole operative procedure. The remaining 91 patients underwent exploration through abdominal incisions. In 15 of this group, closed intercostal drainage of the pleural cavity was established prior to abdominal operation.

While every attempt was made to close the diaphragm, this frequently could not be accomplished by the abdominal route. The diaphragm was closed by suture in 17 of 30 thoraco-abdominal wounds. In the remaining 13 the defect in the diaphragm was left open. All such defects were small. In no instance was an additional thoracotomy performed for the sole purpose of closure of the diaphragm. No biliary pleural fistula developed in this group. There were four deaths among the 30 patients suffering thoraco-abdominal wounds, yielding a mortality rate of 13.3 per cent for the group.

If the defect in the diaphragm is not closed, it is urged that adequate subcostal drainage be established. Shaw[59] and Mason[45] state that careful closure of the diaphragm does not afford complete protection against the development of biliary pleural fistulae, since accumulations of bile may break through the line of repair. Each of these authors urges that subcostal drainage be established in every instance of liver injury with perforation of the diaphragm. Spontaneous sealing of the diaphragm is much more likely to occur if pleural complications such as hemopneumothorax are adequately treated. Careful attention to the progress of the thoracic lesion should be maintained whenever closure of the diaphragm is not accomplished.

Results of Treatment. There were ten deaths in the series of 100 cases. No patient who reached the hospital succumbed before operation could be performed.

From the standpoint of effectiveness of therapy, the patients fall into two broad groups. Those with small, sharp lacerations and simple gunshot wounds without fragmentation usually recovered satisfactorily regardless of the method of management of the liver wound. On the other hand, those who suffered extensive hepatic damage and fragmentation exhibited a very high incidence of complications. Of 100 cases studied, 56 were considered to have undergone uncomplicated recovery with respect to the liver injury. In the remaining group of 44 cases, significant complications clearly or probably due to the liver injury were encountered. These are considered in a subsequent section. The average hospital stay was 18 days per patient.

COMPLICATIONS

The incidence of complications in patients who have suffered wounds of the

liver is closely related to the extent of the hepatic wound and the number and type of associated injuries. While hemorrhage constitutes the principal immediate threat to life, the most frequent complications are those related to infection, liver necrosis and inadequate drainage. These latter complications are closely interrelated, for accumulations of blood or bile favor the development of infection; tight sutures or packs employed for the arrest of hemorrhage may cause necrosis of liver tissue, leading to subsequent sequestration or infection which in turn may be followed by recurrent hemorrhage, abscess formation or the drainage of bile. In any classification of the complications of liver wounds the interdependence of these factors is implied. The complications of liver injury may be classified as follows:

I. *Hemorrhage*
   - A. Uncontrolled bleeding from liver wound
     1. Continuous
     2. Delayed
     3. Intra-hepatic
   - B. Hemobilia
   - C. Bleeding tendency with defective coagulation

II. *Avascular Necrosis or Disruption of Liver Tissue*
   - A. Retained fragments
   - B. Sequestration
   - C. Pulmonary embolism of liver tissue

III. *Infection*
   - A. Without abscess formation
   - B. With abscess formation
     1. Subphrenic
     2. Intra-hepatic
     3. Other abdominal abscesses
   - C. Wound infection

IV. *Biliary Drainage*
   - A. Bile peritonitis
   - B. Bile pleuritis
   - C. External biliary fistula
   - D. Intra-hepatic bile cyst

V. *Miscellaneous Complications*
   - A. Shock
   - B. Cerebral vascular accident
   - C. Pulmonary failure
   - D. Cardiac failure
   - E. Hepatic failure
   - F. Lower nephron nephrosis
   - G. Hepatorenal syndrome
   - H. Wound disruption

In the present series 56 cases underwent uncomplicated recovery. The distribution of complications in the remaining 44 cases was as follows: infection, 26; hemorrhage, nine; biliary drainage, seven; lower nephron nephrosis, one; and evisceration, one.

I. *Hemorrhage.* The control of hemorrhage from the injured liver has been considered at length in many of the publications previously cited. The more unusual manifestations of bleeding, including subcapsular hemorrhages or blood cysts, have been described by Hitzrot,[35] Robertson and Graham,[52] and others.

In the series under consideration hemorrhage was the principal cause of death. Bleeding of hepatic origin occurred in nine cases as a postoperative complication. Two of these were the result of unsuccessful control of initial bleeding. Both cases terminated fatally. One instance of secondary hemorrhage was observed in association with hepatic necrosis and abscess. This patient succumbed. In three cases of bleeding, abnormalities of coagulation were demonstrated. Two of the three exhibited bleeding from multiple sources; one of them died of lower nephron nephrosis. The remaining cases exhibiting secondary hemorrhage recovered.

In addition to the above, there were seven instances of significant bleeding from injuries to abdominal organs or structures other than the liver. Two patients in this group died of perforations of the aorta.

With one exception, all cases who developed postoperative hemorrhage had exhibited hemorrhagic shock at the time of admission. It may be said that hemorrhage itself tends to beget bleeding, through the induction of shock, hypotension, anoxia and alterations in blood coagulation. It is axiomatic that hepatic bleeding which is not controlled at operation will not be controlled thereafter.

Recurrent Hemorrhage Secondary to Hepatic Necrosis. Severe recurrent hemorrhage from the liver may occur as a sequel of necrosis, infection and sequestration of liver tissue. Such a complication is described in the report of Sanders, Macguire and Moore.[54] The characteristic sequence of events is illustrated by the following case from our series, which terminated fatally. This outcome is attributed in part to our failure to provide adequate initial drainage.

CASE REPORTS

Case 1. A Negro man, age 24, sustained a gunshot wound of the abdomen at close range. Severe shock was treated initially. Operation disclosed a perforating cruciate wound of the liver, and perforations of stomach, small intestine, and colon. The peritoneal cavity was contaminated with free feces. No active bleeding was observed from the wound of the liver. Intestinal perforations were repaired and the abdomen was closed around a single Penrose drain. The postoperative course was stormy. A wound abscess developed and dehiscence occurred. On the 8th day a large subphrenic abscess was drained. On the 14th day massive bleeding was observed around the drains. At re-operation a large intra-hepatic abscess was found; the necrotic lining was bleeding actively. The bleeding liver was packed with gelatin sponge and the area was drained. Continued bleeding occurred, and death ensued within 24 hours.

Hemorrhagic Tendency (Abnormal Coagulation). While most instances of hemorrhage from a liver wound are adequately explained by the character of the wound itself, in an occasional case the bleeding may be the result of a generalized hemorrhagic tendency incident to the injury. The factors responsible for such abnormalities of coagulation are poorly understood. However, it is known that the liver plays a role in the synthesis of some of the factors essential to coagulation. Blood clotting is not appreciably altered by the administration of large amounts of compatible blood.[24] Incompatible blood, on the other hand, induces severe hemorrhagic phenomena characterized by hypotension and bleeding from multiple sites. Additional mechanisms which may be responsible for a hemorrhagic state include deficiencies of Factor V (Ac. Globulin) or the production of heparinoid substances. The latter condition is associated with generalized bleeding and may respond to treatment with protamine sulfate. The mechanism of development of acute Factor V deficiency following liver injury is not known; it is apparently distinct from the reduction in classical prothrombin activity which occurs in acute hemorrhage. This deficiency is best treated by the administration of fresh whole blood and fresh plasma. While postoperative hemorrhage from liver wounds is usually due to inadequate control of bleeding at operation, it may be initiated or aggravated by abnormalities of blood coagulation. Unexplained or continued bleeding should arouse the suspicion of a hemorrhagic tendency; hematologic consultation is desirable in such instances, since specific diagnostic and therapeutic measures may be undertaken.

In the present series postoperative hemorrhage was shown to be associated with abnormalities in blood clotting in three cases (Table V). In one instance (Case 70) the features of the hemorrhagic tendency were suggestive of a hemolytic transfusion reaction. This patient died of lower nephron nephrosis. The other two survived.

Hemobilia. Bleeding into the bile ducts may occur in association with deep wounds or closed cavities in the liver, with resultant massive gastro-intestinal hemorrhage. This phenomenon was first described by Owen[49]

in 1848. One hundred years later Sandblom[53] proposed the term "traumatic hemobilia" to designate the condition. The syndrome is characterized by the following triad:

(1) Antecedent injury of the lower abdomen or chest.

(2) Pain simulating biliary colic.

(3) Gastro-intestinal bleeding accompanying or following the pain.

The initial appearance of gastro-intestinal bleeding may occur a few days or several weeks after injury. Symptoms of intermittent common duct obstruction are common, although the retention of clots in the gallbladder may mimic acute cholecystitis. In 14 cases of traumatic hemobilia reported to date the collective mortality is 50 per cent. The treatment of choice is evacuation and drainage of the hepatic cavity. One case of hemobilia was encountered in our series, as a sequel of closure of a deep rent in the liver by suture. This complication might have been prevented by the insertion of an intra-hepatic drain as a supplement to suture. This case has previously been reported in detail by one of us.[64]

Case 2. A male child, age 3, sustained nonpenetrating injury of the right lower chest when he was kicked by a horse. At operation a huge linear tear of the right lobe of the liver was closed by primary suture. Flank drainage was established. Initial convalescence was uncomplicated, and he was dismissed 10 days after injury. He was readmitted 3 days later because of massive gastro-intestinal hemorrhage. During the ensuing month he suffered 3 prolonged episodes of exsanguinating gastro-intestinal hemorrhage. Re-exploration was performed 6 weeks after initial injury. The wound of the liver appeared to be healed, and no abnormality could be detected on palpation. No other source of bleeding could be identified. Consequently, an incision was made in the healed scar in the liver, disclosing a deep central cavity containing old bile, clotted blood, and autolyzed liver tissue. The cavity was evacuated and packed with narrow gauze tape. No subsequent bleeding occurred. Bile drained copiously for 2 weeks and then ceased. The packing was withdrawn gradually between the 9th and 12th days. He remains well 2 years after operation.

Hemocholecyst. Combined injury of the liver and gallbladder is uncommon. Hemorrhage into the gallbladder (hemocholecyst) may occur in liver injuries either as a result of hemorrhage into the intra-hepatic bile ducts, as described heretofore, or by direct liver bleeding into the gallbladder along the path of a missile which penetrates both structures. A singular instance of this complication is included in our series. This is our sole experience with a wound of the liver which was inflicted while the patient was confined to the hospital.

Case 3. A white male, age 57, was hospitalized because of severe anemia and recent massive gastro-intestinal hemorrhage. Diagnosis of duodenal ulcer had been established previously. He responded to medical management, but refused gastrectomy. Needle biopsy of the liver was undertaken by the Medical Service. On one afternoon the Silverman needle was introduced twice, but no liver specimen was obtained. On the following morning the procedure was repeated. Although the needle was inserted to its hilt, attempts to obtain liver tissue were still unsuccessful. Within 30 minutes he developed severe right upper abdominal pain, followed shortly thereafter by generalized abdominal pain and rigidity. At operation 3 small lacerations were demonstrated on the lateral surface of the liver. These were not bleeding, and there was no evidence of free blood in the abdominal cavity. The gallbladder was tensely distended and discolored. The external surface was intact. Upon entering the gallbladder at the fundus a large quantity of clotted blood was found to occupy the lumen. Active bleeding had apparently ceased. A hemorrhagic area in the liver indicated the region through which the needle had passed from the liver substance into the gallbladder. Cholecystostomy was performed, with recovery.

II. *Avascular Necrosis or Disruption of Liver Tissue.* Fragments of liver tissue may be detached at the time of the initial injury or may undergo delayed separation secondary to autolytic changes. Retained fragments commonly give rise to foreign body reactions, often associated with suppuration. The phenomenon of liver seques-

TABLE V. *Blood Clotting Factors and Hepatic Wounds.*

Case No.	Wound	Clotting Time	Bleeding Time	Heparinoids	Factor V Deficiency	Prothrombin Time	Platelets	Remarks
70	stab	>4 hrs.	3½ min.	+	−	40%	200,000	Treated with Protamine Sulfate 150 mgm q6h. Bleeding ceased in 72 hrs.
82	stab	infinity	7 min.	+	+	38%	120,000	Treated with Toluidine Blue, 100 mgm., and fresh whole blood. Bleeding ceased in 48 hrs.
93	GSW	—	—	—	+	45%	—	Treated with fresh whole blood. Bleeding ceased in 64 hrs.

tration following injury was described in the early part of the seventeenth century by Fabricius Hildanus, according to Shedden and Johnson.[60] Subsequent to a stab injury a large piece of liver appeared in the wound and was withdrawn by forceps, with ultimate recovery of the patient. The subject of liver sequestration following accidental and surgical trauma is reviewed by Shann and Fradkin,[58] who cite several instances of sequestration which have been reported in recent years.

In the initial evaluation of fragmentation injuries of the liver, it is extremely difficult to decide which fragments are still viable and which are likely to undergo avascular necrosis. The ideal procedure would be a wide excision of damaged liver back to healthy tissue, following the concept of Boyce that debridement should be performed. However, the technical difficulties incident to such debridement would be formidable in some instances.

Retention of a sequestrum commonly results in suppuration, which continues until the sequestrum is extruded or removed surgically. The frequent association of suppuration is presumably related both to foreign body reaction and to bacterial growth in autolyzed liver tissue.[22] Sequestration of the entire left lobe and other fragments of comparable size has been described. Boyce believes that tight packs may contribute to necrosis of the liver. Deep mattress sutures may have a similar effect. The following example of sequestration was observed in our series:

Case 4. A 42-year-old white woman suffered a shotgun wound of the right chest at close range. After treatment for shock she was explored through a right thoracotomy incision (8th interspace). At operation she was found to have a thoraco-abdominal wound with right hemo-pneumothorax and destructive laceration of the right lobe of the liver. The liver was studded extensively with multiple pellets radiating laterally from the destroyed area. The liver was not bleeding. The operative procedure consisted of abdominal subcostal drainage, with rubber tissue drains and water sealed catheter drainage of the chest. Perforations of the right diaphragm were closed. Following operation septic fever persisted despite therapy with penicillin, aureomycin and chloromycetin. Twenty-six days after injury a large anterior subphrenic abscess was drained. Several large fragments of necrotic liver tissue were removed, along with 13 lead shot. The area was drained. Further convalescence was uncomplicated, and she was discharged 48 days after injury.

Pulmonary Embolism of Liver Tissue. This rare and remarkable complication of liver injury was first described by Marshall[43] in 1874. A man of 20 died shortly after sustaining a crushing injury when he was pinned between two wagons. All ribs and the right clavicle were fractured. At autopsy a long rupture of the liver was demonstrated near the junction of the two lobes. A fragment of liver tissue weighing 4 Gm. was recovered from the pulmonary artery.

Additional instances of this complication have been reported infrequently.

Usually it has occurred in association with crush injuries, although the case reported by Zenker[75] followed a gunshot wound. In a more recent case described by Straus (1942),[65] multiple particles of liver were discovered at autopsy in several intrinsic pulmonary arteries.

This complication has not been observed in our series.

III. *Infection.* The most frequent complication of wounds of the liver are those related to infection. The bacterial contaminant responsible for infection in a wound of the liver may be introduced in a variety of ways. It may be brought in by the inflicting agent; it may result from the growth of bacteria harbored by the liver; or it may arise from associated visceral injuries, notably wounds of the bowel. Circumstances favorable to bacterial growth are established by necrosis and sequestration of liver tissues and drainage of bile.

An additional factor now known to be significant in the pathogenesis of infection of the liver is the state of hemorrhagic shock. The growth of anaerobic bacteria in the liver may be initiated by shock,[23] or by ligation of the hepatic artery.[72] In addition, the permeability of the bowel may increase appreciably during hemorrhagic shock with subsequent dissemination of virulent gram negative organisms throughout the body. Approximately half the cases in our series exhibited shock on admission to the hospital. The significance of shock as a contributory factor in the development of infection in this or in any series of liver wounds can only be surmised; nevertheless, these considerations suggest the importance of the early restoration of blood volume and the universal employment of antibiotics in patients who have been hypotensive for any appreciable period of time.

The incidence of infectious complications in our series are indicated in Table VI.

In most cases temperatures as high as 102° were recorded during the initial days following injury. Without exception every case showed an elevation as high as 100°. Only one case of 100 failed to receive at least one antibiotic. It is clear that antibiotics do not prevent abscess formation and cannot replace hemostasis, debridement and adequate drainage.

TABLE VI

	Stab (34)	Crush (8)	Shot-gun (4)	G S W (54)	Total
Subphrenic Abscess	0	2	1	3	6
Other Abdominal Abscess	0	0	0	1	1
Wound Infection	2	1	0	4	7
Hepatic Abscess	0	1	1	1	3
Infection Without Localization	3	0	0	4	7
Wound Sinus	0	0	1	1	2
					26

In the series of cases reported by Madding, the highest mortality in associated injuries occurred in combined wounds of the colon and liver. There were seven cases of associated colon injury in our series, three of whom died. Five of the seven patients with associated colon injury developed intra-abdominal abscesses. The importance of drainage, as emphasized by Madding, is apparent from these considerations.

The following case from our series is an example of severe wound infection complicating liver injury.

Case 5. A 27-year-old Negro man suffered multiple stab wounds of the abdomen with evisceration of small bowel. After restoration from severe shock he underwent operation. A laceration of the left lobe of the liver was bleeding profusely. In addition there were multiple lacerations of the stomach, terminal ileum and duodenum. A small free portion of the lacerated liver was amputated, and the liver repaired with one No. 0 chromic mattress suture over a gelatin sponge pack. Bleeding was controlled. The lacerations of the stomach and intestine were repaired. Two Penrose drains were brought out the incision. Penicillin and streptomycin were administered after operation.

On the third postoperative day he developed fever and severe tenderness about the wound. The

wound was explored under general anesthesia. A large amount of foul smelling purulent material exuded. Further examination revealed necrosis of the deep fascia, the anterior rectus sheath and a portion of the rectus muscle. The wound was undermined from the xiphoid to the pubic tubercle, with the typical appearance of necrotizing fasciitis. Dead tissue was excised, the area of undermining exposed, and a counter drainage incision made in the right flank. The peritoneum was opened, but no intra-abdominal abscess was encountered; the wound was closed with through and through silver wire sutures. Culture of the wound yielded *Aerobacter aerogenes* and *B. Subtilis.*

The remainder of his hospital stay was complicated by progressive necrosis of tissue requiring additional debridement, and by prolonged episodes of chills and fever. The process finally subsided, and skin grafts were applied to the abdominal wall. He was discharged on the 58th hospital day.

The chronicity of infection which may attend an extensive wound of the liver is illustrated by the following case history.

Case 6. A white man, age 48, suffered extensive contusion of the right chest and abdomen when he was hit by a train. After treatment of severe shock he was taken to the operating room, where extensive lacerations and fragmentation of the right lobe of the liver were found. The lacerations were repaired with deep mattress catgut sutures over a gelfoam pack and the abdomen was drained with 5 Penrose drains through a lateral subcostal incision. After the operation he received penicillin. Subsequently he developed chills and fever. On the 14th hospital day he underwent drainage of a right posterior subphrenic abscess through the 12th rib approach. On the 23rd hospital day a right anterior subphrenic abscess was drained. A portion of the abscess extended into liver substance. Eight Penrose drains and one soft rubber catheter were introduced. Following this procedure the patient improved and was discharged 6 weeks after injury.

He was admitted 13 months following injury with a history of chills, fever and right upper abdominal pain. Anterior subphrenic and intra-hepatic abscesses were drained (his fourth operation). The course thereafter was uneventful until one year later, when he was readmitted to the hospital because of chills, fever and right upper abdominal pain of one week's duration. An anterior superior subphrenic abscess was drained, constituting his fifth surgical procedure. Healing occurred after a prolonged period of drainage; he has remained free from recurrence for more than 2 years.

IV. *Biliary Drainage.* The simple drainage of bile is not a very potent source of danger as long as there is a free pathway for its escape from the serous cavities. However, grave difficulties arise when bile drainage is confined within the peritoneal or pleural cavities, or when it is associated with infection. The probability of serious consequences is greatly increased when drainage of bile occurs in association with wounds of the pancreas, penetrations of the colon, or perforations of the diaphragm.

Although the magnitude of the drainage is roughly proportional to the size of the wound, small liver wounds may drain profusely if a large bile duct is divided. Closure of an incised wound by suture offers some protection against the subsequent drainage of bile. This cannot be depended upon, however, and the routine establishment of supplementary drainage is urged.

Complications related to biliary drainage in our series consisted of three transient external biliary fistulae, two instances of bile peritonitis, and two of bile pleuritis. Each of the pleurobiliary fistulae occurred in patients in whom penetrating abdominal injury was not suspected upon admission to the hospital. Neither case underwent operation on admission; both required eventual thoracotomy. One was the result of a stab, and the other of a bullet. These cases illustrate the dangers incident to the escape of bile from small wounds of the liver when there is no external avenue for the escape of bile.

Case 7. A boy, age 6, was shot in the right chest with a .22 calibre rifle. On admission to the hospital he was in shock (blood pressure 78/50 mm. Hg). Wounds of entry and exit were situated in the 4th right anterior interspace and the 7th right posterior interspace respectively. Admission roentgenogram of the chest demonstrated evidence of intrapulmonary hemorrhage and a

small right hemothorax. Since no abdominal penetration was suspected, he was treated expectantly. On the day after injury chest aspiration yielded 300 ml. of dark blood. Repeated aspirations of comparable amounts were performed until the 10th day, when bile colored fluid with yellow foam was obtained. On that day a right thoracotomy was performed through the 8th rib bed. Extensive fibrinous adhesions had formed between the lower and middle lobes and the parietal pleura. Two perforations were demonstrated in the diaphragm. A modified decortication was performed and the diaphragm was incised to permit the establishment of subcostal abdominal drainage. The diaphragm and chest wall were closed with an intercostal catheter in place. Following operation there were recurrent episodes of profuse subcostal drainage of bile. Drains were expelled spontaneously 13 days after operation. The patient was discharged on the 23rd postoperative day. Drainage of small amounts of bile continued for two additional weeks. He remains well two years after injury.

External Biliary Fistula. Although copious external drainage of bile occurred in several cases in this series, no persistent biliary fistula was observed. Continued drainage of bile may occur in association with injuries of the gallbladder or major biliary ducts (intra- or extra-hepatic), or in response to infection and foreign body reaction caused by a retained projectile or a fragment of liver tissue. In a case described by Jarvis *et al.*,[36] drainage of bile persisted for 73 days after operation; the initial lesion was a fracture of the liver of moderate size. However, many biliary fistulae will close spontaneously. An initial period of observation is therefore desirable. The following case from our series represents the spontaneous closure of an external biliary fistula.

Case 8. A man, age 22, suffered a stab wound in the left hypochondrium. Initial therapy for shock was required. Operation disclosed a 2 cm. laceration of the left lobe of the liver; bleeding from the liver wound had ceased. The laceration was sutured with No. 0 chromic catgut, and the abdomen was drained. Five days after operation the wound became tender and copious drainage of bile ensued. This persisted for 5 days, after which it ceased spontaneously. He was discharged on the 10th day following injury, and has experienced no further difficulty.

V. *Miscellaneous Complications.* It is often difficult to say whether the development of a certain complication is a specific sequel of the liver injury or whether it is related to associated injuries or to pre-existing states of disease. Miscellaneous complications in our series include the following: lower nephron nephrosis, one case; evisceration, one case; cardiac failure, one case; pulmonary failure, one case; pancreatitis, one case. All deaths in the series are summarized in Table VII.

Hepatorenal Syndrome. In 1931 Heyd[33] applied a descriptive term, hepatorenal syndrome, to the fatal course of events characterized by fever, jaundice, coma and anuria, which occurred in patients who died following biliary tract surgery. He advanced the hypothesis that the causal agent responsible for this syndrome was a "toxin" liberated from the liver which had been traumatized during surgery.

Helwig and Orr (1932)[34] extended the observations of Heyd and described the hepatorenal syndrome in association with hepatic trauma. They attempted to produce the syndrome in dogs by traumatizing the liver. The similarity of the lesions in the dog and those described in man led them to believe that the hepatorenal syndrome existed as an entity and that "toxins" liberated from the liver probably played a causative, though not a singular, role in the development of the lesions.

Wilensky (1939)[71] reviewed the occurrence and pathogenesis of the hepatorenal syndrome. He stressed the fact that there were many factors in a variety of disease states which were capable of producing concomitant renal and hepatic disease. It was his impression that bacterial infection and glandular disorders might sometimes play a role in development of the lesion. He separated hyperpyrexia and liver death

TABLE VII. *Deaths Following Liver Injury—Summary of Cases.*

Case No.	Age	Mode of Injury	Nature of Liver Wound	Treatment of Liver Wound	Time of Death	Associated Injuries	Remarks
82	43	stab	6 cm. laceration right lobe.	drainage only.	21st day	0	Severe post-operative bleeding from liver → Hemorrhagic tendency → lower nephron nephrosis → death.
76*	25	shot-gun	large grapefruit size defect in liver.	oxycel and drainage.	4th day	chest & kidney	Post-operative distention; secondary hemorrhage suspected → re-operation → shock and death during operation.
77	48	GSW	perforation right lobe	none	9 hours	stomach duodenum spleen	Irreversible hemorrhagic shock → death.
78	40	GSW	perforation right lobe	drainage only	34 hours	duodenum pancreas retro-peritoneal hematoma	Post-operative atelectasis, pancreatitis and fat necrosis, peritonitis → shock → death.
79	64	GSW	deep laceration right lobe	oxycel pack	5th day	stomach duodenum kidney	Post-operative cerebral vascular accident → auricular fibrillation → heart failure → death.
80*	40	GSW	perforation left lobe	none	40th day	chest stomach colon pancreas	Retroperitoneal abscess → fecal fistula → gastro-colic-cutaneous fistula → death.
81	24	GSW	perforation right lobe	drainage only	15th day	stomach small bowel colon	Wound abscess → wound dehiscence → sub-hepatic and intra-hepatic abscess → hemorrhage from liver → death.
83	36	GSW	mult.lacerations l. lobe with free fragments	drainage only	22 hours	stomach spleen pancreas kidney, aorta	Hemorrhagic shock → death due to perforation of aorta.
84*	17	GSW	perforation left lobe	drainage only	21st day	spleen, aorta chest, stomach spinal cord	Massive sudden hemorrhage → death due to ruptured aorta.
85*	27	GSW	perforation right lobe	drainage only	4th day	chest colon kidney	Sudden shock → death due to hemorrhage.

*Thoracoabdominal injury.

from the hepatorenal syndrome, and presented evidence indicating that the former was usually due to bacterial infection while the latter was of diverse etiology.

Boyce (1941)[7] extended the observations of his predecessors and collected clinical and experimental data correlating renal and hepatic lesions. He concluded that a toxin of hepatic origin was intimately related to the pathogenesis of the hepatorenal syndrome.

Following Boyce's work, many reports attributed deaths from a variety of causes to the hepatorenal syndrome. In recent years advances in knowledge concerning the functions of the liver and the kidney, and the responses of these organs to trauma, have been accompanied by a decline in the frequency of reports attributing death to the hepatorenal syndrome. Castrén[13] reviewed the literature on liver trauma and the occurrence of the hepatorenal syndrome. He indicated that shock, transfusion reactions and fluid and electrolyte disturbances were often important factors affecting the postoperative course.

It is now known that concomitant hepatic and renal disease may accompany or follow ligation of the hepatic artery, infection,[17] prolonged salt water deficit, shock, hemolytic transfusion reactions, cardiac failure, renal failure and anaphylaxis.[57]

No instance of the hepatorenal syndrome has been recognized in the present series.

Pancreatic Injury. Associated injuries of the pancreas and liver merit special consideration because of the high rate of morbidity attending this combination of wounds. The escape of bile from the liver increases the digestive activity of the pancreatic enzymes. The control of hemorrhage and the provision of liberal drainage are the essentials of treatment. Nonabsorbable suture material should be employed for hemostasis. Drainage should be as direct as possible, either postero-laterally or anteriorly through the lesser sac. The employment of a sump drain is especially desirable in injuries of the pancreas.

Due attention should be paid to correction of physiologic disturbances which may attend pancreatic injuries; these include disturbances in calcium and carbohydrate metabolism (Sandmyer's diabetes), and alterations in fluid and electrolyte balance. Blocking agents may be employed to reduce pancreatic secretion.

There were three deaths in six cases of associated pancreatic injury in our series.

SUMMARY

A study of 100 consecutive wounds of the liver has disclosed a case fatality rate of 10 per cent and a morbidity rate of 44 per cent. Civilian wounds are more favorable than war wounds, both with respect to the severity of injury and the time of institution of treatment. The favorable mortality rate of liver wounds reported in this series is attributed more to the general medical advances of the era than to any special technics in management of the liver wound itself. It is probable that the results are representative of those generally being obtained in other hospitals of the same type throughout the country.

In known or suspected injuries of the liver, early operation is recommended, to be preceded by adequate resuscitative measures. Assuming that a policy of early operation is carried out, the principal factors relating to the outcome are the amount of blood loss, the number and type of associated injuries, and the extent of the hepatic damage.

Approximately half the patients in the series exhibited shock on admission. An average of two and one-half pints of blood was given to each of 76 patients. Salt water was also employed liberally, based on the premise that considerable losses of this fluid may be expected in chemical peritonitis. In half the cases active bleeding had ceased at the time of abdominal exploration.

Complications relative to the liver wound occur in rough proportion to the extent of the hepatic damage. Thus, the highest incidence of fatality is usually seen in non-penetrating crush injuries or shotgun wounds, where fragmentation of the liver is most extensive. In our series the group of severe non-penetrating wounds was too small to be significant. Stab wounds, representing the least severe grades of tissue damage, are commonly associated with the lowest mortality and morbidity rates, while wounds due to pistol or rifle fire are intermediate in severity. Hemorrhage is the most common cause of death. Infection, necrosis and biliary drainage account for the greatest number of non-fatal complications.

It is apparent that small incised, penetrating, or perforating wounds of the liver possess a pronounced capacity to heal, regardless of the method of therapy employed. Simple perforating bullet wounds tend to seal themselves and to undergo spontaneous cessation of hemorrhage. However, an occasional small wound will bleed profusely or drain bile in large amounts; this seems equally likely in incised wounds and those due to bullets. In sharp incised wounds of the liver, closure by suture is recommended as the treatment of choice. Simple bullet holes without fragmentation and without evidence of active bleeding may be treated by the establishment of

drainage alone. When such wounds are bleeding actively, plugs of oxidized cellulose or gelatin sponge may be introduced at the small risk of creating a closed cavity favoring the eventual development of abscess, bile cyst, or hemobilia. Suture of entrance and exit wounds may be accomplished with the same type of risk. Either of these measures is preferable to withdrawal in the face of continuing hemorrhage.

Injuries associated with extensive fragmentation of the liver yield a high incidence of complications regardless of the method of therapy employed. Further improvement of results should be sought in this group. The factors usually responsible for the development of complications are necrosis, infection, and accumulations of bile and blood. The best hope for reduction of complications of this type lies in the more extensive application of debridement and the establishment of better facilities for drainage. The conventional forms of drainage have too often proved to be inadequate. Patients who developed subphrenic abscesses in this series did so in spite of the establishment of drainage. We share the views of many authors who have urged the establishment of more liberal drainage. This may be accomplished by the provision of supplementary dependent posterolateral subcostal drainage and the employment of greater numbers of rubber tissue drains both anteriorly and through the flank. In this series, 37 cases were closed without drainage, with no serious mishap. Nevertheless, the incidence of complications related to inadequate drainage is so high that the authors feel that the omission of this step subjects the patient to needless risk. If closure without drainage is ever to be practiced, it should be limited to those instances of small lacerations comparable to the wound of a liver biopsy.

Satisfactory repair by suture may be accomplished in large rents of the liver. Suture methods are also adaptable to bare surfaces which remain following debridement. However, some necrosis of liver tissue may ensue from the introduction of sutures tight enough to control hemorrhage. The complete surface closure of a large hepatic defect may create a closed cavity with ensuing complications related to infection or to the accumulation of bile or blood; the introduction of an intrahepatic drain is recommended as a supplement to closure.

The decline in use of gauze packing of liver wounds may be attributed to the frequent association of infectious complications and the hazard of secondary hemorrhage upon removal of the pack. Occasional situations will arise wherein it is necessary to resort to packing as a life saving measure. When packs are employed, extensive supplementary drainage should be maintained in anticipation of infectious complications. The "absorbable" hemostatics as agents for packing warrant fur ther trial, since their limitations remain to be defined. When gauze packing is used, the interposition of oxidized cellulose or gelatin sponge between the gauze and the liver tissue may facilitate the eventual removal of the pack.

Injury of the chest, either separately or by the same missile, occurs frequently in association with liver wounds. Adequate attention to altered respiratory function is imperative as a preliminary to celiotomy. With regard to the choice of the thoracic or abdominal route for exploration in combined injuries, each possesses its advantages and its disadvantages, and the selection is frequently a matter of individual choice. This choice may be exercised more freely in the wounds of civilian life than in the more devastating wounds of warfare, where more serious pulmonary and thoracic damage is the rule. The abdominal route was used predominantly in this series, and usually proved to be adequate.

Thoracotomy is essential when the injury to the chest so dictates, or when persistent hemorrhage from a wound of the dome of the liver cannot be controlled by the abdominal route. Every attempt should be made to close wounds of the diaphragm. However, when laparotomy discloses a small defect in the diaphragm which cannot be closed by the abdominal route, it does not appear necessary to perform thoracotomy as an additional procedure for the sole purpose of closing the defect in the diaphragm. The establishment of subdiaphragmatic drainage in such instances provides a by-pass for the escape of bile and reduces the probability of development of biliary pleural fistula and subphrenic abscess. Patients so treated should be followed with careful attention to any resultant intrapleural complication. Only two pleural biliary fistulae were observed in this series; both of these occurred in patients who suffered small stab wounds of the chest and who were not subjected to operation upon admission.

A high incidence of complications may be anticipated in combined injuries of liver and colon or liver and pancreas. The provision of wide direct drainage is especially important in these groups.

Abnormalities in blood coagulation should be suspected when bleeding from unexplained sources occurs in association with liver injuries, or when bleeding from the liver is not controlled by measures which ordinarily would be effective. The assistance of the hematologist should be sought in such instances.

All of the ten deaths in this series could be accounted for adequately on the basis of hemorrhage, shock, peritonitis, sepsis, or lower nephron nephrosis. We are unable to cite any case in the series which is representative of the hepatorenal syndrome.

Antibiotic therapy was administered in 99 of 100 patients. The agent most commonly employed was penicillin. Early intensive antibiotic therapy is desirable in all liver injuries in view of the probability of development of mixed infections. The impression was gained that some potential subphrenic abscesses were aborted, probably as a result of antibiotic therapy. Fever was noted in every case in the series, and appears to be a regular sequel of hepatic damage.

BIBLIOGRAPHY

1 Allen, A. W.: Internal Injuries Without Penetrating Wounds. New Eng. J. Med., **205:** 34, 1931.

2 Beck, Carl: Surgery of the Liver. J. A. M. A., **38:** 1063, 1902.

3 Beebe, G. W., and M. E. DeBakey: Battle Casualties. Charles C Thomas, Springfield, Ill., 1952.

4 Betts, R. H.: Thoraco-Abdominal Injuries. Ann. Surg., **122:** 793, 1945.

5 ———: Initial Surgery of Thoraco-Abdominal War Injuries. J. Thoracic Surg., **15:** 349, 1946.

6 Boljarski, N.: Concerning Rupture of the Liver. Langenbeck's Arch. f. Klin. Chir., **93:** 507, 1910.

7 Boyce, F. F.: The Role of the Liver in Surgery. Charles C Thomas, Springfield, Ill., 1941.

8 Branch, C. D.: Injury of the Liver. Ann. Surg., **107:** 475, 1938.

9 Bruns: Referred to by Carl Beck: Surgery of the Liver. J. A. M. A., **38:** 1063, 1902.

10 Burckhardt: Zentr. f. chir., **14:** 88, 1887.

11 Burnett, W. E., G. P. Rosemond, H. T. Caswell and J. H. Hall: Unusual Case of Gastro-intestinal Hemorrhage. Surgery, **26:** 1044, 1949.

12 Carter, B. N., and M. E. DeBakey: Current Observations on War Wounds of the Chest. J. Thoracic Surg., **13:** 271, 1944.

13 Castrén, Paavo: On Subcutaneous Liver Rupture and the Hepatorenal Snydrome. Acta Chir. Scand., **93:** Supp. 105, 1946.

14 Christopher, F.: Rupture of Liver. Ann. Surg., **103:** 461, 1936.

15 Churchill, E. D.: Trends and Practices in Thoracic Surgery in Mediterranean Theatre. J. Thoracic Surg., **13:** 307, 1944.

16 Cohn, Roy: Treatment of Traumatic Injuries of the Liver, Stanford Med. Bull., **5:** 120, 1947.

17 Connell, F. G.: Liver Death (So-Called); Rapid High Temperature Deaths. Ann. Surg., **100:** 319, 1934.

[18] Deaver, J. B., and A. P. C. Ashhurst: Surgery of the Upper Abdomen, **2**: 236. P. Blakiston's Son and Co., Philadelphia, Pa., 1914.

[19] DeBakey, M.: Management of Chest Wounds. Int. Abst. Surg., **74**: 203, 1942.

[20] DeBakey, M. E.: In discussion of J. D. Martin, Jr.: Wounds of the Liver. Ann. Surg., **125**: 756, 1947.

[21] Edler, L.: Die traumatischen Verletzungen der parenchymatosen Unterleibsorgane. Arch. f. klin. Chir., **34**: 343, 1887.

[22] Ellis, J. C., and L. R. Dragstedt: Liver Autolysis in Vivo. Arch. Surg., **20**: 8, 1930.

[23] Fine, J.: Infectious Element in Shock. Trans. 1st. Macy Conf. on Shock, p. 140. Josiah Macy, Jr. Foundation, New York, 1951.

[24] Fogelman, M. J., K. I. Robins, R. Hennington, and W. F. Stapp: Effects of Hemolytic Transfusion Reactions on Blood Clotting Factors. Surg. Forum, Amer. Coll. Surg., p. 467, W. B. Saunders, Philadelphia, 1952.

[25] Foresee, J. H.: Surgical Management of Pulmonary and Thoracic Trauma. Symposium on Treatment of Trauma in Armed Forces, Sec. 3, part 17. Army Med. Serv. Grad. Sch., Washington, D. C., 1952.

[26] Fox, D. B.: Thoracoabdominal Wounds. Surg., Gynec. & Obst., **82**: 64, 1946.

[27] Fraenkel, F.: Subcutaneous Rupture of the Liver—Management by Primary Laparotomy. Beitr. z. klin. Chir., **30**: 418, 1901.

[28] Frantz, V. K., H. T. Clarke, and R. Lattes: Hemostasis with Absorbable Gauze. Ann. Surg., **120**: 181, 1944.

[29] Graham, A. J.: Subcutaneous Rupture of the Liver. Ann. Surg., **86**: 51, 1927.

[30] Graham, R. R., and D. Cannell: Accidental Ligation of Hepatic Artery. Brit. J. Surg., **20**: 566, 1933.

[31] Griswold, R. A., and A. B. Ortner: Use of Autotransfusion in Surgery of Serous Cavities. Surg., Gynec. & Obst., **77**: 167, 1943.

[32] Heyd, C. G.: Hepatitis: a Condition Associated with Gallbladder Disease. Surg., Gynec. & Obst., **39**: 66, 1924.

[33] ————: "Liver Deaths" in Surgery of Gallbladder. J. A. M. A., **97**: 1847, 1931.

[34] Helwig, F. C., and T. G. Orr: Traumatic Necrosis of Liver. Arch. Surg., **24**: 136, 1932.

[35] Hitzrot, J. M.: Subcutaneous Injuries of the Liver. Ann. Surg., **66**: 50, 1917.

[36] Jarvis, F. J., W. L. Byers, and E. V. Platt: Experience in Management of Abdominal Wounds of Warfare. Surg., Gynec. & Obst., **82**: 174, 1946.

[37] Jenkins, H. P., and R. Janda: Studies on Gelatin Sponge or Foam as a Hemostatic Agent. Ann. Surg., **124**: 952, 1946.

[38] Kousnetzoff, L., and J. Penski: Sur la Résection partielle du foie. Rev. de Chir., **16**: 501, 954, 1896.

[39] Krieg, E. G.: Hepatic Trauma. Arch. Surg., **32**: 907, 1936.

[40] Lamb, Charles A.: Rupture of the Liver. New Eng. J. Med., **221**: 855, 1939.

[41] Madding, G. F., K. B. Lawrence, and P. A. Kennedy: War Wounds of the Liver. Texas State J. Med., **42**: 267, 1946.

[42] Markowitz, J., A. Rappaport and A. C. Scott: The Function of the Hepatic Artery in the Dog. Am. J. Dig. Dis., **16**: 344, 1949.

[43] Marshall, L. W.: Rupture of Liver; Plugging of Pulmonary Artery with Hepatic Substance. Lancet, **1**: 197, 1874.

[44] Martin, J. D., Jr.: Wounds of the Liver. Ann. Surg., **125**: 756, 1947.

[45] Mason, J. M.: The Early Treatment of Thoracico-Abdominal Wounds. Southern Med. J., **45**: 30, 1952.

[46] Mikal, S., and G. W. Papen: Morbidity and Mortality in Ruptured Liver. Surgery, **27**: 520, 1950.

[47] Moynihan, B.: Abdominal Operations. W. B. Saunders Co., Philadelphia and London. 2nd Ed., 1906.

[48] O'Neill, J. N.: Traumatic Rupture of the Liver. Calif. and West. Med., **54**: 68, 1941.

[49] Owen, H. K.: Case of Lacerated Liver. London Med. Gaz., **7**: 1048, 1848.

[50] Pilcher, L. S.: Massive Rupture of the Liver. Ann. Surg., **116**: 827, 1942.

[51] Pringle, J. H.: Notes on the Arrest of Hepatic Hemorrhage Due to Trauma. Ann. Surg., **48**: 541, 1908.

[52] Robertson, D. E., and R. R. Graham: Rupture of the Liver without Tear of the Capsule. Ann. Surg., **98**: 899, 1933.

[53] Sandblom, Philip: Hemorrhage into the Biliary Tract Following Trauma—"Traumatic Hemobilia." Surgery, **24**: 571, 1948.

[54] Sanders, G. B., C. H. Macguire, and R. H. Moore, Jr.: Massive Rupture of the Liver. Am. J. Surg., **78**: 699, 1949.

[55] Sanger, P. W.: Evacuation Hospital Experiences with War Wounds and Injuries of Chest. Ann. Surg., **122**: 147, 1945.

[56] Sawyer, K. C., W. R. Coppinger, and R. G. Witham: Traumatic Rupture of the Liver. Amer. Surg., **17**: 289, 1951.

[57] Sborov, V. M., and P. E. Teschan: The Hepatorenal Syndrome. Military Notes, Army Med. Serv. Grad. Sch., Vol. 2, Washington, D. C., 1951.

58 Shann, H., and W. Z. Fradkin: Liver Sequestration after Cholecystectomy. J. A. M. A., **101**: 829, 1933.

59 Shaw, R. R.: in discussion of R. H. Betts: Initial Surgery of Thoracoabdominal War Injuries. J. Thoracic Surg., **15**: 349, 1946.

60 Shedden, W. M., and F. Johnston: Traumatic Rupture of the Liver. New Eng. J. Med., **213**: 960, 1935.

61 Shefts, L. M., and E. A. Doud: Management of Thoracic and Thoracoabdominal Wounds in Forward Areas. J. Thoracic Surg., **15**: 205, 1946.

62 Smith, H. C.: Traumatic Injury to the Liver. Bull. of Ayer Clin. Lab. of Penn. Hosp., **3**: 215, 1938.

63 Snyder, H. E.: Management of Intrathoracic and Thoraco-Abdominal Wounds in Combat Zone. Ann. Surg., **122**: 333, 1945.

64 Sparkman, R. S.: Massive Hemobilia Following Traumatic Rupture of Liver. Ann. Surg., **138**: 899, 1953.

65 Straus, R.: Pulmonary Embolism Caused by Liver Tissue. Arch. Path., **33**: 69, 1942.

66 Terrier, F., and M. Auvray: Trauma of Liver and Biliary System. Rev. de Chir., **16**: 717, 1896.

67 Thöle, F.: Die Verletzungen der Leber und Gallenwege. Neue Deutsche Chir., **4**: 204, 1912.

68 Tilton, B. T.: Some Considerations Regarding Wounds of the Liver. Ann. Surg., **61**: 20, 1905.

69 Touroff, A. S. W.: Unrecognized Postoperative Infection: Cause of Syndrome of So-Called "Liver Shock." Surg., Gynec. & Obst., **62**: 941, 1936.

70 Vanderhoof, E. S., and K. A. Merendino: Unfavorable Reactions to Oxidized Cellulose in Bed of Gallbladder. Arch. Surg., **58**: 182, 1949.

71 Wilensky, A. O.: Occurrence, Distribution and Pathogenesis of So-Called Liver Death and/or Hepatorenal Syndrome. Arch. Surg., **38**: 625, 1939.

72 Woolling, K. R., A. H. Baggenstoss, and J. F. Weir: Infection of the Liver. Proc. Staff Meetings Mayo Clinic, **28**: 239, 1953.

73 Wright, L. T., A. Prigot, and L. M. Hill, Jr.: Traumatic Rupture of Liver without Penetrating Wounds. Arch. Surg., **54**: 613, 1947.

74 Wylie, R. H., H. L. Hoffman, D. B. Williams and W. F. Rose: The Thoraco-Abdominal Casualty. Ann. Surg., **124**: 463, 1946.

75 Zenker, F. A.: Deutsches Arch. f. Klin. Med., **42**: 505, 1888.

DISCUSSION.—DR. FREDERICK A. COLLER, Ann Arbor, Mich.: I want to express my appreciation of these papers; I have learned a great deal from them all. I would like to speak more definitely on the paper of Dr. Morton. We have all had the difficulties he has told us about, with patients who have had the gallbladder removed and have had symptoms afterward, and I think his exposition will aid us in recognizing the cause of some of the difficulties that these patients have. However, there is a corollary in this that I might mention, and a very tragic one. Dr. Morton has had more than 20 patients who have had these recurrences of symptoms, but I can report in the same period of time 130 patients who have had injuries, very serious ones, to the common or hepatic ducts, for which I had little to offer. No one knows how many common or hepatic ducts are injured during the operation of cholecystectomy in this country. There are a few reports on this, but a great many of us have not published, and the point I wish to emphasize is that I believe that for every patient whose crippled duct gets to another hospital for repair, there are undoubtedly four or five or more who die in the primary hospital of that injury, before they can be taken to a skilled surgeon for repair.

This has bothered me very much because it is a blot on the escutcheon of American Surgery. For years I did my best to repair these injuries, using the methods suggested by my colleagues, and I assumed that all injuries were caused by ignorance or carelessness. However, this is not so. I have had the opportunity to interview surgeons who have operated upon these patients, and I have seen, and have been shocked to find that they were doing their best in many cases to follow the teachings of the eminent surgeons and teachers in this country. What are these points? It won't take long to give them.

In the first place there are those, like Dr. Morton, who insist upon removal of every bit of the