The Management of Liver Injuries

The Management of Liver Injuries

J. M. Little
M.S., F.R.A.C.S.
Senior Lecturer in Surgery
University of Sydney

E & S LIVINGSTONE
EDINBURGH AND LONDON
1971

ISBN 0 443 00728 4

Printed in Great Britain

Preface

This monograph is meant to be a practical guide to the management of liver injuries, not a comprehensive review of all the literature on the topic. The references have been selected from my own reading and I have deliberately omitted some which I admire and respect because their application to the problem of human liver injury is not certain. This work began because I was made aware of the appallingly high mortality from liver injury in the community served by the Royal Prince Alfred Hospital in Sydney, Australia, and grew out of an attempt to design a programme to cope with this problem. There is, for this reason, a bias toward the management of blunt injury to the liver because it is the commonest form encountered in the civilian practice of this hospital. The fact that there has been some success in reducing the mortality of liver injury provides the sole justification for this report.

Although this monograph is small, there are many people to thank for help in its preparation. Mr. Frank Mills first roused my interest in the problem. Professor John Loewenthal generously allowed me to use the experimental facilities in the Department of Surgery at the University of Sydney and he has always encouraged me to continue this work. The surgeons at the Royal Prince Alfred Hospital have cooperated in this study, and the results reported in Chapter 17 represent our joint experience. Dr. Denis Halmagyi and Dr Tony Goodman helped with the study of peritoneal hypothermia. Mrs Penelope Zylstra and Miss Robyn Rasdall typed the manuscript, and Mrs Zylstra also checked the references and drew many of the illustrations.

I am particularly grateful to Mr W. A. Hanna of Belfast for his help; his criticism of this work has been most constructive and I have learnt from him a great deal about the management of hepatic vascular injuries.

Messrs E. & S. Livingstone have been most cooperative and helpful, and I must thank them for their patience.

Finally, I thank my wife for her help and her tolerance. She has not only endured the whole business with great patience, but has actively encouraged me and has helped with the tedious process of indexing.

J. M. LITTLE

1971

Contents

I

History of Liver Surgery

SURGERY almost certainly began with the treatment of wounds. Meade (1968) states 'To be a man is to be highly susceptible to wounding, and there is evidence that at a very early stage in man's development, some attempt was made to repair the damage that the bodies of our ancestors sustained with harrowing frequency.' No doubt some simple attempts were made to treat abdominal or thoracic wounds involving the liver from the earliest times, but the rational surgery of any organ or system depends on the understanding of its anatomy, structure and functions. This knowledge of the liver was slow to develop. An accurate account of the intrahepatic anatomy of the vessels and bile ducts is only 50 years old, while the enormous complexities of liver function are still being unravelled.

A knowledge of the gross anatomy of the liver in animals and birds was essential to the Babylonian priests, who examined the liver of sacrificial animals, and made auguries based on variations in the form of the organ (Fig. 1). This practice probably dates to at least 2500 B.C., and was still seriously discussed as late as the sixth century A.D. The Ancient Greeks, of the Homeric era, seem to have had a reasonable knowledge of anatomy, but the results of their war surgery were poor.

The later Greek doctors and philosophers added much to the science and practice of medicine. It is hard to see how they could have had any knowledge of the remarkable regenerative powers of the liver, but at least two of the Greek myths of eternal punishment stressed how quickly the damaged liver could grow again. Both Prometheus and Tityus were compelled to suffer their livers to be eaten eternally by vultures. While this aspect of liver pathology seems to have anticipated the truth, Greek ideas of physiology were dominated by the concept of the four humours, so that there was little real understanding of liver function.

The Alexandrian medical school flourished for about 500 years from 300 B.C. onwards. It seems certain that Herophilus of Chalcedon and Erasistratus of Cos, the first teachers of anatomy and medicine at Alexandria, both dissected the human body. This practice was forbidden in Rome, however, so that most of the writings of Galen were based on the anatomy and physiology of animals. Galen postulated a physiological system which was accepted until the last few hundred years. The life-spirit was breathed in through

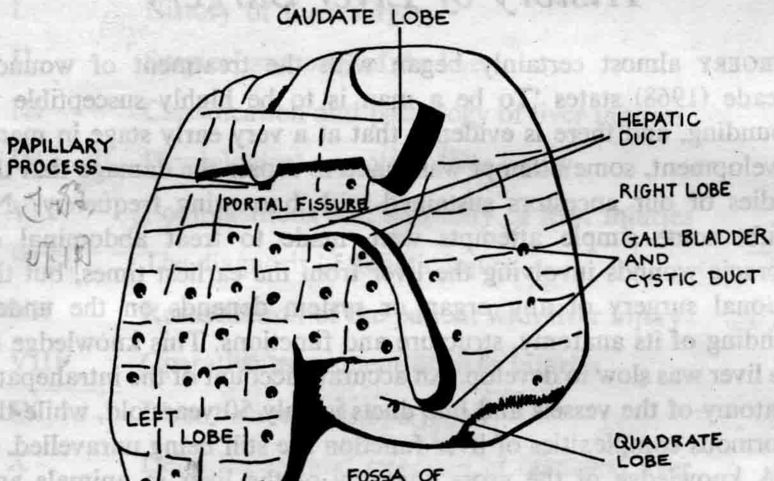

Fig. 1. Babylonian clay model of a sheep's liver, c.a. 2000 B.C. (Redrawn after Singer, C. and Underwood, E.A. (1962). *A Short History of Medicine*, p. 13. Oxford: Clarendon Press.)

the lungs, whence it passed to the left ventricle and encountered the blood. Chyle from the intestines passed in the portal vein to the liver, which imbued it with natural spirit. The liver controlled ebb and flow in the veins. Some venous blood entered the right ventricle, where most was purified by the lungs. A small proportion of the right ventricular blood passed through minute pores in the interventricular septum to enter the left ventricle (Fig. 2).

The theory of the four humours and the Galenic concepts of anatomy were accepted without question in Europe until the Renaissance. Mediaeval representations of the liver were not notably accurate, and it was usually represented as having a number of discrete lobes (Fig. 3), an arrangement common to a number of lower animals. Not until the time of Andreus Vesalius (1515–1564) was the authority of Galen successfully challenged. Vesalius, in his *De humanis corporis fabrica libri septum* of 1543, corrected many of

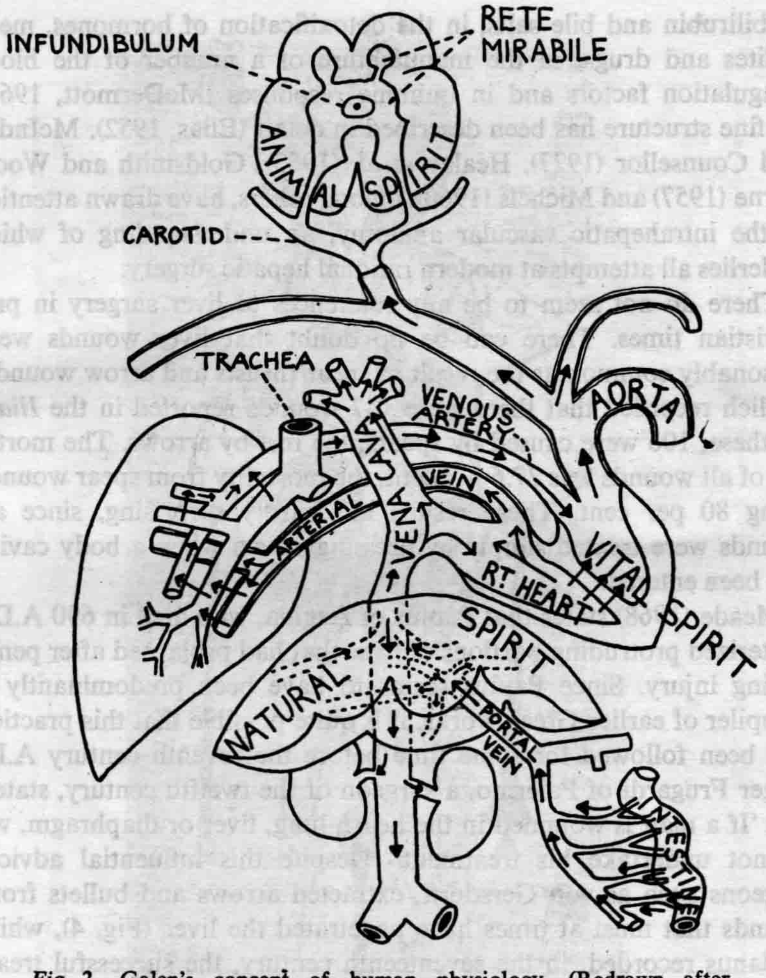

Fig. 2. Galen's concept of human physiology. (Redrawn after Singer, C. and Rabin, C. (1946). *A Prelude to Modern Science,* Cambridge: Cambridge University Press).

Galen's errors, and gave a far more accurate description of the anatomy of the liver and bile ducts. In 1628, Harvey published *Exercitatio anatomica de motu cordis et sanguinis in animalibus,* and this concept of blood circulation made possible rational techniques of haemostasis, and a new understanding of the distribution of blood vessels.

From the time of these pioneers, progress has been steady. It is now known that the liver occupies a central place in the metabolism of fat, carbohydrate and protein, in the manufacture and excretion of bilirubin and bile salts, in the detoxification of hormones, metabolites and drugs, in the manufacture of a number of the blood coagulation factors and in immune responses (McDermott, 1965). Its fine structure has been described in detail (Elias, 1952). McIndoe and Counsellor (1927), Healey *et al.* (1953), Goldsmith and Woodburne (1957) and Michels (1960), among others, have drawn attention to the intrahepatic vascular anatomy, an understanding of which underlies all attempts at modern rational hepatic surgery.

There do not seem to be any references to liver surgery in pre-Christian times. There can be no doubt that liver wounds were reasonably common as the result of spear thrusts and arrow wounds. Frölich recorded that there were 147 wounds reported in the *Iliad.* Of these, 106 were caused by spears, the rest by arrows. The mortality of all wounds was 77.6 per cent, the mortality from spear wounds being 80 per cent. These results are hardly surprising, since all wounds were treated simply by dressings, even when a body cavity had been entered.

Meade (1968) states that Paulus of Aegina, who died in 690 A.D., cauterized protruding portions of liver that had prolapsed after penetrating injury. Since Paulus seems to have been predominantly a compiler of earlier Greek works, it is quite possible that this practice had been followed for some time before the seventh century A.D. Roger Frugardi of Palermo, a surgeon of the twelfth century, stated that 'If a man is wounded in the heart, lung, liver or diaphragm, we do not undertake his treatment.' Despite this influential advice, surgeons such as von Gersdorff, extracted arrows and bullets from wounds that must at times have penetrated the liver (Fig. 4), while Hildanus recorded, in the seventeenth century, the successful treatment of a young man whose liver was injured by a penetrating wound of the abdomen. A liver sequestrum was removed, and the man recovered.

These extempore and unplanned surgical manoeuvres were sometimes successful. The first planned resection of the liver for injury was performed by von Bruns in 1870, when he carried out a partial hepatectomy for a gun-shot wound of the liver. Langenbeck, in 1872, resected the whole of the left lobe of the liver for tumour. A number of reports of successful liver resections for tumour, gumma and injury began to appear. By 1899, Keen was able to find 75 cases of resection for tumour in the literature, and to add a further case of his own.

Much of the early writing on the subject of liver resection was concerned with the technical problems of haemostasis. The pioneering work of Kousnetzoff and Pensky (1896) influenced surgeons for many years. They designed flexible blunt needles for liver suture (Fig. 5), and advised that a line of mattress sutures should be inserted to demarcate the lines of resection (Fig. 6). The raw area resulting from the partial hepatectomy was then packed with gauze, which was brought out through the main incision. In cases where, for some reason, this technique could not be used, they advised the excision of a wedge of liver tissue, the resulting defect being packed with iodoform gauze and closed on its capsular margin with a running suture (Fig. 7). Once again the gauze was to be brought out through the main wound and removed in 10 to 15 days.

Many variations of these techniques were reported. Auvray (1897) modified the method of suture, so that more liver could be controlled with each length of suture material (Fig. 8). Frank (1905) advised the wedge excision of the lips of a hepatic wound if closure of the gap was difficult. Difficulties with the friability of tissue led Payr and Martina (1903) to recommend the use of magnesium plates along the edge of the cut liver to hold the haemostatic sutures, and prevent them from cutting through the liver capsule. Stamm (1905) suggested that plates of cartilage, taken from calf scapula, could be used for the same purpose (Fig. 9).

These complicated methods for achieving definitive haemostasis were criticized by Garré (1907), who advocated careful identification of the intrahepatic vessels by blunt dissection, and their ligation with 4-0 silk. Additional protection was provided by a row of sutures of No. 2 catgut, passed through the liver (Fig. 10). Garré reported six liver resections without a death. His technique is still commonly used.

Even with accurate methods of this type, oozing from the liver edge may be troublesome. In attempts to control this, Masters *et al.* (1954) have used skin grafts to the liver surface, Beck (1902) used a pedicled graft of muscle and peritoneum, Lanzillo (1954) used the intact diaphragm and Madding and Brauer (1965) have reported the experimental use of Eastman Monomer 9–10.

Madding and Peniston (1957) have summarised various other methods that have been used. They included thermic methods, topical haemostatic agents and various tourniquets and clamps. Most of these were mentioned only to be condemned, because their effects were too uncertain, too traumatic or too elaborate for widespread use. In particular, they attacked the use of packing for definitive haemostasis, pointing out that its use is followed by numerous serious complications, and that the mortality of liver injury can be reduced by excluding packing from the definitive treatment.

Before definitive haemostasis can be attained, it may be necessary to achieve temporary control of haemorrhage. Packs, soft clamps and the hands of the assistant may all be useful. In 1908, Pringle pointed out that control could easily be achieved if the structures of the portal triad were compressed between finger and thumb. Rafucci (1953) has shown that occlusion of the hepatic inflow in dogs for more than 20 minutes is hazardous at normal body temperature, but Pringle's manoeuvre has shown itself to be useful in emergencies.

The most important advances in liver surgery in the last twenty years have followed from the new understanding of the intrahepatic anatomy of the vessels and bile ducts. The concept of segmental anatomy has made possible rational, controlled resection of the liver, with maximal control of bleeding. Lortat-Jacob and Robert (1952) described the operation of right hepatic lobectomy, using an anatomical approach that began with the ligation of the vessels and ducts to the right lobe, and employing blunt dissection through the liver substance along the line of junction between the vascular right and left lobes. This technique has been further elaborated by Quattlebaum and Quattlebaum (1959), Stone and Saypol (1952), Fry and Child (1962), Dagradi and Brearley (1962) and Guynn *et al.* (1963).

II

Surgical Anatomy of the Liver

THE anatomy of the liver has been reviewed many times in recent years. Good accounts of the vascular anatomy are to be found in McIndoe and Counsellor (1927), Healey *et al.* (1953) and Goldsmith and Woodburne (1957). It must be stressed that the conventional account of the division into right and left lobes by the ligamentum teres is misleading and inaccurate from the surgical viewpoint.

The surface markings of the liver are shown in Figure 11. The dome of the right lobe reaches the level of the fifth rib or fourth interspace anteriorly. In the midline, the upper surface of the left lobe lies beneath the junction of the body of the sternum and the xiphoid process. The tip of the left lobe lies at the level of the junction of the fifth rib and its costal cartilage. In the mid-axillary line, the tip of the right lobe reaches to the costal margin.

The liver itself is suspended from the diaphragm by the two layers of the coronary ligament on the right side, and by the triangular ligament on the left. The falciform ligament branches superiorly to join the anterior leaves of the coronary and triangular ligaments. The line of the falciform ligament anteriorly, and the fissure for the ligamentum venosum posteriorly demarcate the junction of the medial and lateral segments of the left lobe. They do not separate the right and left lobes.

In the free edge of the lesser omentum run the portal vein, the common bile duct and the hepatic artery. The portal vein is formed by the junction of the splenic and superior mesenteric veins behind the neck of the pancreas. It measures 7 to 8 cm in length, and lies behind the hepatic artery and bile ducts in the free edge of the lesser omentum. It commonly receives pyloric and coronary gastric veins in this part of its course. In the hilum of the liver it divides into right and left main branches. The left main branch runs transversely for 2 to 3.5 cm, and then turns anterolaterally at the level of the attachment of the ligamentum venosum. Medial and lateral branches come from this umbilical part, and supply superior and inferior subsegments of the medial and lateral segments of the left lobe. The right

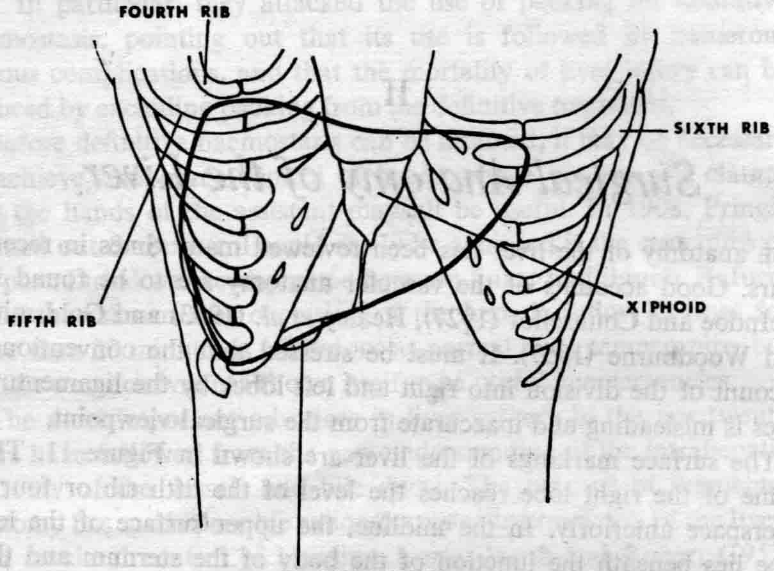

Fig. 11. Surface markings of the liver. (Redrawn after Madding, G. F. and Kennedy, P. A. (1965), *Trauma to the Liver*, p. 4, Philadelphia: Saunders).

main branch runs for 2 to 3 cm before dividing into anterior and posterior segmental veins. These divide into superior and inferior subsegmental veins. There is some variation from individual to individual, but this general pattern can usually be distinguished (Fig. 12).

Michels (1960) has described the many variations of the extra-hepatic course of the hepatic artery. The common hepatic artery usually begins as a branch of the coeliac axis, runs above the pancreas to the free border of the lesser omentum, where it lies in front of the portal vein and to the left of the bile duct. In the hilum of the liver, it divides into right and left branches, the right branch running behind the common hepatic duct, and giving off the cystic artery within Calot's triangle. The right hepatic artery divides into anterior and posterior segmental branches, which in turn divide into superior and inferior subsegmental branches. The left hepatic artery runs a short intrahepatic course, and divides into medial and lateral segmental branches, which then divide into superior and inferior subsegmental branches.

The bile ducts follow a similar segmental course. The right and left hepatic ducts are formed by the union of the intrahepatic segmental bile ducts, emerge from the liver at its hilum and unite to

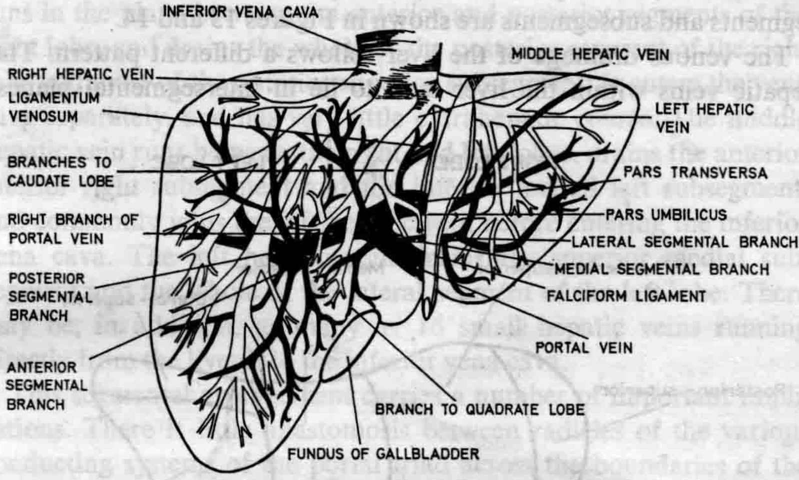

Fig. 12. **Intrahepatic course of the portal vein, and its relation to the hepatic veins. (Redrawn after Goldsmith, N. A. and Woodburne, R. T. (1957). *Surgery Gynec. Obstet.*, 105; 310).**

form the common hepatic duct in the upper part of the free edge of the lesser omentum. The cystic duct joins the common hepatic duct to form the common bile duct. Although the anatomy of the extrahepatic duct system is reasonably consistent, the intrahepatic arrangement is variable. Once again, a segmental pattern is always discernible, with minimal anastomosis between segments and subsegments.

The ramifications of the structures of the portal triad divide the liver into fairly constant segments. On this 'vascular' basis, the junction of the right and left lobes lies along a line drawn between the gallbladder fossa and the inferior vena cava. The right lobe is then divided into anterior and posterior segments, the line of division lying approximately beneath the ninth rib. The anterior and posterior segments are further subdivided into superior and inferior subsegments. The left lobe is divided into medial and lateral segments along the line of attachment of the ligamentum venosum. The left medial and lateral segments are subdivided into superior and inferior subsegments. On this basis, the classical quadrate lobe becomes simply part of the medial segment of the left hepatic lobe, while the caudate lobe is divided between right and left lobes. The blood supply and biliary drainage of the caudate lobe reflect this junctional position, and may be shared equally between the right and left branches, or may be dominated by one or other moiety. The segments and subsegments are shown in Figures 13 and 14.

The venous drainage of the liver follows a different pattern. The hepatic veins within the liver tend to lie in intersegmental planes.

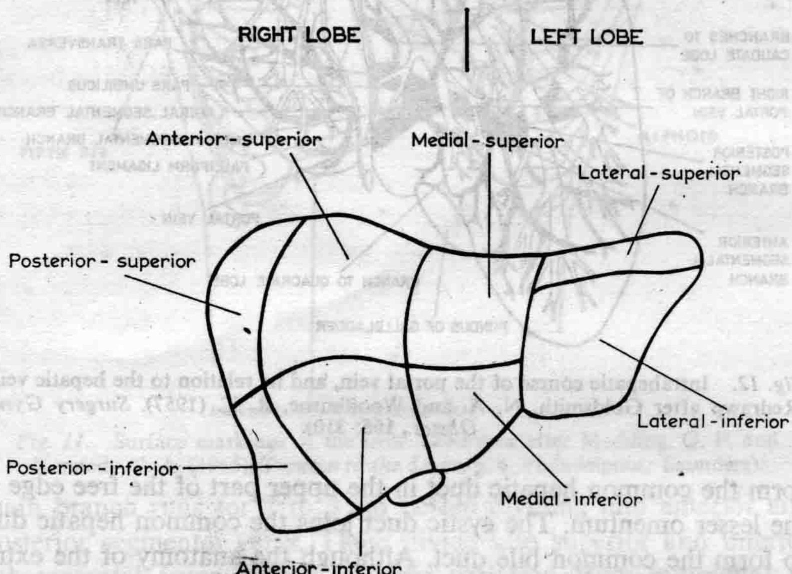

Fig. 13. **Segments of the liver, viewed from the front.**

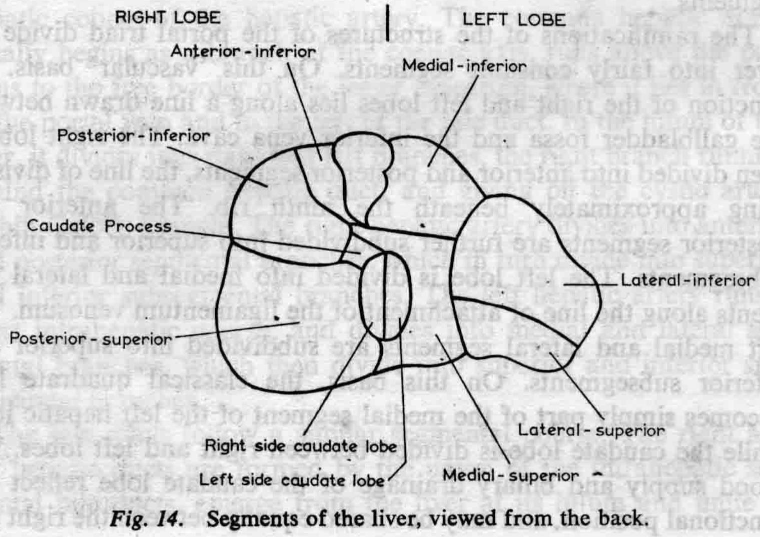

Fig. 14. **Segments of the liver, viewed from the back.**

There are three main hepatic veins (Fig. 12). The right hepatic vein runs in the plane between the anterior and posterior segments of the right lobe, and drains the whole of the posterior segment of the right lobe and most of the anterior superior subsegment. It enters the vena cava separately, and has very little extrahepatic course. The middle hepatic vein runs between the right and left lobes, drains the anterior inferior right subsegment and the inferior medial left subsegment, and commonly joins the left hepatic vein before entering the inferior vena cava. The left hepatic vein drains the superior medial subsegment and the whole of the lateral segment of the left lobe. There may be, in addition, as many as 16 small hepatic veins running directly from the liver into the inferior vena cava.

This segmental arrangement carries a number of important implications. There is little anastomosis between radicles of the various conducting systems of the portal triad across the boundaries of the lobes, segments and subsegments. For this reason, damage to a major segmental vessel will devitalize the whole segment, and will require debridement of the whole segment. At the same time, if liver resection is necessary, a knowledge of this anatomy will allow the purposeful use of the least vascular planes of dissection within the liver substance. Liver injuries must always be assessed with a clear knowledge of the intrahepatic anatomy in mind. A simple knife wound may devitalize a whole liver segment.

III

Classification and Pathology of Liver Injuries

CLASSIFICATION OF LIVER INJURIES

The liver may be wounded by penetrating or non-penetrating injuries. Penetrating injuries may be caused by sharp instruments, such as knives, or by missiles, such as bullets or shot-gun pellets. Penetrating injuries predominate in most modern North American series (Mikesky *et al.*, 1956; Madding and Kennedy, 1965; Williams and Byrne, 1966), whereas blunt injuries have been more common in series reported from Britain (Mills, 1961; Hanna *et al.*, 1965), Sweden (Hellstrom, 1961) and Australia (Little, 1965; Thomas and Wright, 1968).

Knife injuries produce clean incised wounds, the depth of which depends on the weapon and the strength of the assailant. Generally, knife wounds carry the lowest mortality, since they are rapidly diagnosed and readily treated by simple suture and drainage. Crosthwait *et al.* (1962) reported a mortality of 3.4 per cent among stab injuries in Dallas. While it is true that stab wounds are generally easy to manage, careful anatomical assessment of each injury is mandatory, since a narrow incised wound can sever a major segmental branch of the portal vein or hepatic artery. The usual knife wound produces little damage beyond the track of the weapon.

Gun-shot wounds produce more damage. The kinetic energy of the missile can be calculated from the formula $E = \frac{1}{2}mV^2$, where E = kinetic energy, m = mass and V = velocity. It is easy to see that the destructive energy of the missile depends more on its velocity than on its mass. A bullet will destroy the tissue through which it passes, and will, in addition, damage a varying amount of the surrounding tissue. Love and Evans (1963) have pointed out that arterial damage from a bullet wound may extend several millimetres beyond the obvious trauma. High velocity bullets can produce damage well beyond their actual track (Martin, 1947).