Clinical Radiology of the Biliary Tract

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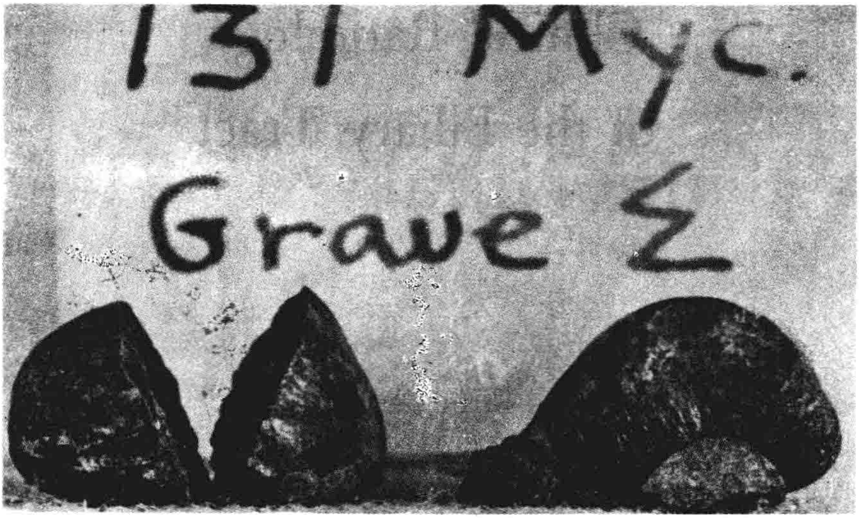

Gallstones found in Grave Sigma, excavated from the circle outside the walls of Mycenae in Southern Greece. These were between the right lower costal margin and the right iliac crest of the skeleton of a man about 50 years of age (45 to 60) who lived about 1600 to 1500 B.C. The gallstones measure 11 x 10.5 x 6.5 mm. Undoubtedly there were others that must have been lost. One of the stones disintegrated and pulverized as Professor Angel held it between his fingers. A study of the skeleton revealed arthritis of the spine, right shoulder, and the left cuboid-metatarsal V joint. (*The author is indebted for this information and the photograph to Professor J. Lawrence Angel, The Daniel Baugh Institute of Anatomy, The Jefferson Medical College of Philadelphia.*)

DEDICATED TO MY MOTHER,

My First and Most Devoted Teacher

Preface

In the diagnosis and treatment of disease of the biliary tract, the medical profession as a whole is immeasurably indebted to the specialty of radiology. Radiologic examinations of the biliary tract before, during, and after surgery are now routine and indispensable procedures.

Blind areas in the liver, gallbladder, and bile ducts have come to light through the judicious use of oral and intravenous cholangiography, operative and postoperative cholangiography, splenoportography, and, more recently, through the use of radioactive isotopes. Further advances, particularly in the field of preoperative studies of the liver, are still to come. The use of radioactive material in the study of the normal and abnormal anatomy as well as the physiology of the liver bears promise of fruitful results.

This work stems from a long-standing interest in the digestive tract in general and the biliary tract in particular. My interest, however, was more keenly aroused as I became actively engaged in the investigation of opaque contrast media, especially those used in opacification of the biliary tract.

No effort should be spared to bring the best medical care to the patient. The radiologist is grateful for the opportunity to cooperate with his colleagues in the various medical specialties and to make his contribution towards the accomplishment of this goal. It is hoped that this volume will help in attaining this goal.

Disease of the biliary tract is as old as the recorded history of man, and we may correctly assume that it is as old as man himself.

Recent excavations in Greece[1] have unearthed an adult human skeleton, about 50 years of age, lying on the right side in a crouched position, with two faceted cholesterol calculi between the lower costal margin and the iliac crest (see the Frontispiece). This patient, who was afflicted with cholelithiasis, lived about 1600 to 1500 B.C.

The significant role played by the biliary tract in health and disease was recognized by the fathers of ancient medicine. The early Egyptians

[1] George Mylonas, Ancient Mycenae, Princeton, N.J., Princeton University Press, 1957.

considered bile one of the significant body "excretions" related to health and disease.

Hippocrates recognized four humours of the body: blood, phlegm, yellow bile, and black bile—"a right proportion or mixing of which constitutes health, while improper proportions or irregular distribution constitutes disease." He discovered that jaundice and liver involvement were complications of disease of other organs. The "case record" of a patient afflicted with pneumonia indicates that the patient became irrational after the tenth day, but improved under treatment. The sputum became clear, and he appeared to be recovering, but he subsequently became somnolent, his eyes jaundiced, and he died after 20 days.

Hippocrates seems also to have recognized that liver bile is derived from the destruction of blood.

Galen made specific reference to "bitter bile" and "black bile," though he did not consider them to be humours in the Hippocratic sense. He described tumors of the liver, hardening of the liver, and ascites due to liver disease.

A new era in medicine was to be introduced through methodical dissection of the body and the performing of autopsies. Antonius Benivenius learned that great knowledge was to be acquired by attempting to explain clinical symptoms by the postmortem findings. He described stones of the gallbladder, ulcers of the intestines, and carcinoma of the stomach.[2]

With the advent of dissection, the anatomy of the liver and gallbladder became known. The drawings of Vesalius and Leonardo da Vinci were quite revealing. However, an understanding of the function of the two organs has been gained only in the very recent history of modern medicine. Thus the role of the liver as a balance wheel of life became more definitely recognized, if not clearly understood.

The first case of lithotomy of the gallbladder (cholecystotomy for removal of stones) was performed in the United States by Bobbs in 1868. The first successful cholecystectomy was performed by Langenbuch in Germany in 1882.

Roentgen's discovery in 1895 opened a totally new era in medicine and science which made possible the study of the human body in health and disease in a manner never before considered possible.

Space limitations do not permit full recognition to all those who have helped in the realization of this work—patients, colleagues, and members of my staff, most of whom will not be mentioned by name.

I wish to record my thanks to Dr. John E. Hammett, Emeritus Professor and Director of the Department of Surgery, The New York Polyclinic Medical School and Hospital, who through the years gave unfailing en-

[2] Book of Some Hidden and Remarkable Diseases and Their Cure, published in 1507, 5 years after his death.

couragement and support. His assistance in correlating the surgical findings, often with heartwarming confirmation of radiologic findings, is most valued. I am indebted to Dr. Hammett's successor, Dr. William H. Cassebaum, for his critical review of the section on operative cholangiography.

I wish also to express my thanks to Drs. Dominick DiMaio and Raymond Carnes, former Director, and Assistant Director, respectively, of the Department of Pathology at The New York Polyclinic Medical School and Hospital, for their evaluation and comments on the gross and histologic sections of surgically removed specimens; to Dr. Joseph MacDonald, Dean of the Faculty of Medical Sciences, American University of Beirut, for permission to use some of the material on hydatid disease and amebiasis of the liver; and to Dr. George Melcher, of the College of Physicians and Surgeons and The Presbyterian Hospital in New York, for his critical review of the material on the values of liver function tests.

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I wish to express sincere thanks to Mr. Leon Schlossberg, of The Johns Hopkins Hospital, for the excellent diagrams and sketches; to Mr. Don Allen, of New York City, for preparation of the glossy prints used for the illustrations; and to Mrs. Mary Morrison, of the Library of The New York Academy of Medicine, for her constant cooperation and ever willingness to give valuable assistance.

To none could I owe more than to the members of my staff and loyal coworkers, for their kind and understanding handling of patients and for the excellence of their technical work.

Miss Vilma Genchy, my former secretary, will always be remembered with deep gratitude for her help in preparing and typing the manuscript. I am also grateful to Miss Helen Dvoraninovitch, of the Westchester County Medical Society, for additional help in typing the manuscript.

Last, but not least, my profound gratitude goes to my wife, Ruth, for her constant stimulation and encouragement, her graciousness and patient understanding, without which this work would not have been possible.

William H. Shehadi, M.D.

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General Considerations

ANATOMY

The liver, the largest gland in the body, is a vital organ located in the upper portion of the abdomen immediately under the diaphragm. It weighs approximately 1,500 Gm and is about $\frac{1}{50}$th of the total body weight. Practically all the liver substance is protected by the lower portion of the thoracic cage. Most of the organ is to right of the midline. It occupies the right hypochondrium and epigastrium and, in varying degrees, extends to the left hypochondrium.

The inferior border coincides with the right lower costal margin, crosses the midline in the upper epigastrium, at about the level of the xiphoid process of the sternum, and is well above the lower costal margin on the left side. The upper border is at the level of the fifth to the sixth ribs, anteriorly, as indicated by the position of the diaphragm, the right diaphragm being a little higher than the left. Variations occur in the position of the liver conforming with the habitus of the patient. The liver may be relatively high in a broad chest (sthenic individual), while in a narrow chest (asthenic individual) the lower border may extend below the lower costal border.

The liver consists essentially of two main lobes, the right and the left, with the right about six times as large as the left lobe. There are two additional small lobes, the caudate and quadrate lobes, located on the inferior surface.

Anatomically the right and left lobes of the liver are quite independent as to bile duct distribution and ramification. On the other hand, the vascular system shows a great deal of cross anastomosis between the two lobes.

Based on the vascular supply and biliary drainage the liver is divided, functionally, into a right and left lobe which differ somewhat from the anatomic right and left lobes. The line of functional division is slightly to the right of the falciform ligament, which represents the line of anatomic division. The functional right and left lobes are supplied by the right and left hepatic bile ducts, and by the corresponding branches of the portal vein and hepatic artery. Blood from the alimentary tract, where products of digestion are absorbed, goes to the right side of the liver. Blood from the spleen, stomach and a large portion of the colon, goes chiefly to the left lobe.

The liver is composed essentially of innumerable small lobules, which are the basic anatomic-functional units. These lobules consist of cords or columns of hepatic cells and the ramifications of the portal vein, the hepatic artery and vein, and the bile ducts. The columns of hepatic cells constitute the walls of the intervening blood sinusoids and bile capillaries.

As the blood flows through the sinusoids, various substances enter the hepatic cells, later to be returned to the blood stream or excreted in the bile. From a radiologic point of view, the transmission from the blood stream into the biliary tract of those elements which go into the formation of bile constitutes the most important single liver function. The importance of this function can best be appreciated through the realization of the fact that the contrast media used for the examination of the biliary tract, whether by oral or intravenous methods, must travel the same route, or follow the same path, as the bile. It is thus obvious that the *prerequisites* of a *good contrast medium* for use in the biliary tract examinations are that it be *bile soluble* and *bile transportable.*

LIVER FUNCTION TESTS

The liver is the most important glandular organ in the body and without it man and the higher animals cannot live. Teachings of modern physiology thus justify the belief of the ancient peoples that the liver is the seat of Life.

For an organ as complex as the liver, with its multiple and diverse functions, no single test can be expected to give adequate and accurate information about its functional capacity and activity. Furthermore, because of the tremendous reserves of the liver, considerable functional impairment, or insufficiency, may be present without being clinically evident.

A large number of tests are in current use to determine or evaluate one or more of the many liver functions. In a clinical study of the liver, or in attempts at differential diagnosis of disease of the liver and biliary tract, there may be a tendency to resort to the "gunshot" method of ordering many tests. A careful history and clinical study of the patient, however, should result in the selection of tests of maximum usefulness for the evaluation of the liver function. Periodic repetition of these tests will give an indication of the course and progress of the liver derangement and will serve as an adequate check on the value of the therapy and the progress and evolution of the disease.

The degree of liver cell damage is reflected by an increase in cephalin-cholesterol flocculation, thymol turbidity, zinc sulfate turbidity, and the serum bilirubin levels. Increased alkaline phosphatase and serum bilirubin are associated with biliary obstruction.

The results of liver function tests should be carefully interpreted in the light of the clinical findings.

Flocculation Tests. All flocculation tests are related to protein metabolism and will indicate any disturbance in the ratio of the large and small protein particles. These include the cephalin-cholesterol flocculation test (Hanger's test), the thymol turbidity test, and the zinc sulfate turbidity test. They show positive reactions with an increase in globulin. The albumin component of serum protein is manufactured mostly by the liver cells, while the globulin is produced by the reticuloendothelial cells. Therefore, in hepatic disorders, e.g. hepatitis, cirrhosis, disintegration of the liver parenchyma, there is a decrease in the albumin component, with an elevation of the gamma-globulin. Flocculation tests are particularly useful in the differential diagnosis between hepatic (medical) and posthepatic (surgical) jaundice. In hepatic jaundice, the gamma-globulin is usually increased, or elevated, while in posthepatic jaundice it remains normal or at most is only slightly elevated.

It is important to keep in mind that the results of flocculation tests for liver damage are not specific. An elevation of the gamma-globulin level may also occur in chronic infections, tuberculosis, sarcoidosis, myeloma, and in collagen disease.

Serum Alkaline Phosphatase Tests. Elevation of the alkaline phosphatase level in the serum may indicate disease either of the skeleton or of the liver. The serum alkaline phosphatase level is markedly elevated in diseases with increased osteoblastic activity, such as rickets, osteomalacia, and Paget's disease and moderately elevated in osteoblastic metastatic carcinoma of the bone. Since alkaline phosphatase is normally excreted in the bile, any interference with the free flow of bile will cause a rise in alkaline phosphatase levels in the serum because of backflow of bile into the blood stream. The level is markedly increased in obstructive jaundice, either extrahepatic or intrahepatic, with only a slight to moderate increase, if any, in hepatocellular jaundice. There is no disturbance of bile excretion in hemolytic jaundice and, consequently, the serum alkaline phosphatase level is normal.

In space-occupying lesions within the liver, such as an abscess and a carcinoma, the serum alkaline phosphatase level may be elevated even in the absence of jaundice.

Bromsulphalein Retention Test. Intravenously injected Bromsulphalein is excreted by the liver, and the test is based on the determination of the percentage of the retained dye 45 minutes after the injection. Such retention is less than 5 per cent in normal persons. Bile pigment excretion into the intestines is dependent on normal or adequate function of the liver cell as well as patency of the bile ducts. The same holds true for the excretion of Bromsulphalein. In obstructive jaundice, bile stasis prevents the uptake of the dye, resulting in increased retention. Damaged liver cells take up much less of the dye, hence increased retention of the dye in liver cell disease.

Serum Bilirubin Test. The extent of increase of serum bilirubin level depends on the type and intensity of jaundice. In hemolytic jaundice, a slight increase may occur. In obstructive jaundice, there is marked increase, while in hepatocellular jaundice, the increase is directly proportional to the severity or intensity of the damage to the liver cells.

For the radiologist, this is the most significant test to be used in determining the feasibility of contrast studies of the biliary tract (oral or intravenous cholangiography). As serum bilirubin returns to normal, adequate radiologic visualization of the biliary tract may be obtained.

Icteric Index. The icteric index indicates the degree of "yellowness" of the serum, which is usually an indication of the degree of jaundice. It is not specific inasmuch as carotene and other substances may influence the degree of yellowness, in which case it is not true jaundice.

Table 1 serves as a guide in evaluating liver function and establishing a possible correlation between the clinical and radiologic findings.

LIVER BIOPSY

At times, despite all available clinical and laboratory data, a definite diagnosis of liver disease cannot be established. Under these circumstances a liver biopsy will help determine the presence and nature of the disease and the extent of the liver cell damage. In conjunction with liver function tests, a liver biopsy should provide valuable information and a clearer picture of the severity and progress of the disease. Thus a more accurate prognosis can be made. Liver biopsy may be performed by removal of a piece of liver tissue during laparotomy or by needle aspiration. In competent hands the latter is a relatively simple and safe procedure.

Liver biopsy may be indicated in the diagnosis and differential diagnosis of jaundice, cirrhosis, malignant disease of the liver, miliary granulomatous disease involving the liver, disease of the reticuloendothelial system, liver infections, and abscess formation as well as for the evaluation of the results of therapy and the progress attained.

TABLE 1 EVALUATION OF LIVER FUNCTION

	Normal values	Hemolytic jaundice (prehepatic)	Hepatocellular jaundice (hepatic medical)	Obstructive jaundice (posthepatic surgical)
Significant pathological process	. . .	Red blood cell destruction	Liver cell impairment	Bile flow interference
Cephalin-cholesterol flocculation	0–1	Normal	Elevated	Normal or slightly elevated
Thymol turbidity	0–4	Normal	Elevated	Normal or slightly elevated
Zinc sulfate turbidity	0–4	Normal	Elevated	Normal or slightly elevated
Serum alkaline phosphatase	1–4 Bodansky units 5–13 King-Armstrong units	Normal	Normal or elevated	Markedly elevated
Bromsulphalein retention	5% or less at 45 min	Normal	Increased retention	Increased retention
Serum bilirubin	Up to 1.0 mg %	Slight increase	Increase in proportion to degree of liver damage	Elevated
Icteric index	8–10	Elevated	Elevated	Elevated
Visualization of the gallbladder and bile ducts by means of cholecystography, oral and intravenous		Adequate Density may be slightly decreased	Possible but not satisfactory until BSP retention is 5% or below, preferably not above 10% Icteric index 10 or below, possible but faint up to 15 Bilirubin below 2 mg, preferably 1 mg; poor or unlikely above 3 mg, not possible above 4 mg	None Sometimes possible in intermittent type, as jaundice is clearing, or between phases of obstruction