Applied Anatomy in Liver Resection and Liver Transplantation

Editor in Chief **W.Y.Lau**

人民卫生出版社
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Applied Anatomy in Liver Resection and Liver Transplantation

This book is dedicated to my three most-respected mentors who have the greatest influence on my professional career:

- To Dr. Shu Hong Wong who inspired me to take up surgery as my professional career;

- To Professor Arthur K.C. Li who brought me into the challenging field of academic surgery and the international scene of surgery;

- To the late Professor Qiu Fa Zu who set a role model for me to follow and showed me the virtues of a great surgeon:
  - * Self discipline and life-long pursuit of excellence and knowledge;
  - * Self-sacrifice for the betterment of others;
  - * Willingness and eagerness to teach

W.Y. Lau

PREFACE

This book is written based on my 30 years of experience in liver surgery, extensive research in medical literature on applied liver anatomy, and meticulous studies on liver specimens and liver casts.

I strongly believe that surgery should be based on a solid foundation of anatomy, for without anatomy, there is no surgery. A thorough understanding of the relevant anatomy is a prerequisite to good surgery as a surgeon needs to know with confidence what needs to be removed and what needs to be preserved. When a surgeon encounters unexpected difficulties in an operation, it is the knowledge of anatomy which guides him from rough sea back to safe land. A change in surgical strategy/approach, and the design of a new operation/instrument, can only be done scientifically and logically with adequate knowledge in anatomy.

This book has 12 chapters which cover a full range of knowledge for what one needs to know before one embarks on carrying out a liver operation on a patient. The knowledge ranges from external to internal anatomy of the liver, from pure anatomy to its application in liver operations, from vascular inflow/outflow of the liver to techniques used in reducing intraoperative blood loss, from Couinaud's liver segments to segment-based liver resection, and from the different approaches to liver resectional techniques to the different types of liver transplantation.

The particular feature of this book is the heavy use of diagrams which makes reading easier. It is a must for all those surgeons who wish to embark on, and is an important textbook for those who have some experience with, liver surgery. Even the most experienced liver surgeons will find the value of this book as a reference book.

W.Y. Lau

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Acknowledgements are always difficult to write as it is never possible to acknowledge all of those who have helped contribute to a book.

I am deeply indebted to the Advisors of this book Professor Wu Meng-chao and Professor Zhong Shi-zhen for their valuable advice. I am honoured and thankful to my deputy editors Professor David Yew, Professor Zhou Wei-ping, Dr. Eric C.H. Lai, Dr. Stephanie H.Y. Lau and Dr. S.S. Ho for their help in redrafting, proof-reading and in the production of the operative photographs and pictures of the specimens. I am grateful to Jia Xiaowei for his coordination, and Li Xiaojie for the time she spent on the production of the beautiful medical illustrations.

From the production side at the People's Medical Publishing House, I am grateful to Mr. Hu Guo-chen, President and Editor in Chief, and Dr. Du Xian, Vice-Editor in Chief, who believed that a book on applied anatomy in liver resection and transplantation was needed. I am especially grateful to them in agreeing to publish this book in an English version for the international market, and a Chinese version for the local market. The production team has been a joy to work with. I appreciate their dedication and professionalism to this project.

I am grateful to my secretary Ms. Helena Lee for her dedication in typing the manuscript and for her support in compiling this book.

W.Y. Lau

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Chapter 1
Applied Anatomy of the Liver

1.1 Surface Anatomy (Figure 1.1)

When viewed from the front, the normal liver surface markings are:

Upper margin: approximately level with the xiphisternal joint, arching slightly upwards on each side. On the left it reaches the fifth intercostal space 7-8 cm from the midline, and on the right to the fifth rib.

Right border: curving down to the right border from ribs 7 to 11 in the mid axillary line.

Inferior border: along a line which joins the right lower and upper left extremities. On the right side the inferior border lines approximately level with the right costal margin while centrally it crosses behind the right upper abdominal wall between the costal margins.

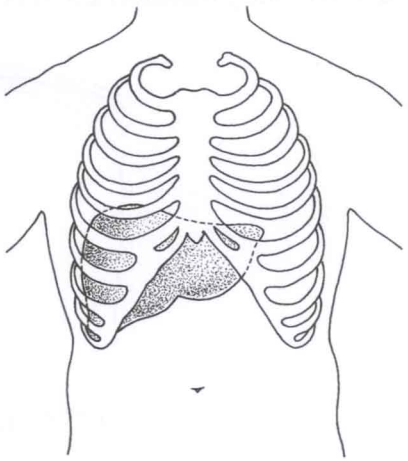

Figure 1.1 Surface Anatomy of the Liver

Clinical Applications

(1) As most of the liver is undercover of the right rib cage, a tumour in the liver is difficult to detect clinically unless the tumour is very large.

(2) Surgical access to the liver requires a bilateral subcostal incision with a mid-line upward extension with good retraction of the rib cages in a forward, outward and upward direction, or a right thoracoabdominal incision with division of the diaphragm.

(3) Trauma to the right lower chest can result in injury to the liver and vice versa.

(4) Ultrasound guided needle puncture for biopsy or interventional procedure is technically more difficult for liver lesions immediately underneath the diaphragm, as the needle has to go through the right pleural cavity. Approaches include the intercostal and the subcostal routes.

1.2 Gross Anatomy

The liver has three surfaces:- diaphragmatic, visceral and posterior surfaces.

Diaphragmatic Surface (Figure 1.2)

The diaphragmatic surface is covered for the most part in peritoneum, which forms a sheath around the liver, except in places where the ligaments reflect to join the adjacent diaphragm. In the midline of the abdomen and over the anterior convexity of the liver, the falciform ligament is attached, and divides the liver into the anatomical right lobe and left lobe. The ligametum teres, a remnant of the left umbilical vein, runs from the umbilicus in between the two leaves of the falcifom ligament to the visceral surface of the liver, where it disappears behind a bridge of either fibrous or liver tissue which connects the left lobe with the quadrate lobe to end in the left portal vein at the junction between the branches to the segments 3 and 4 (Figure 1.3). The fundus of the gallbladder peeps below the inferior border of the liver.

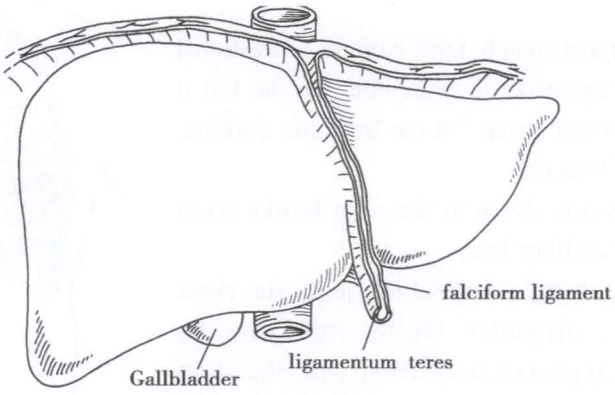

Figure 1.2 Diaphragmatic Surface of the Liver

Visceral Surface (Figure 1.3)

The sharp inferior border of the liver joins the diaphragmatic surface with the visceral surface of the liver. The main structures here are arranged in an H-shaped pattern. The cross-

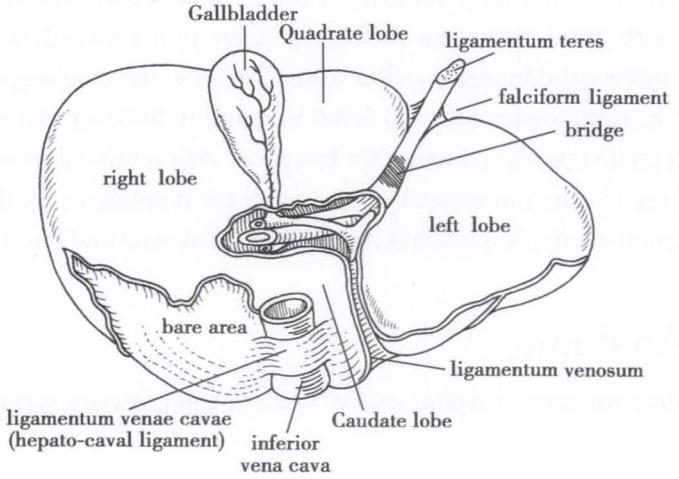

Figure 1.3 Visceral Surface of the Liver

piece of the H is made by the porta hepatis (the hilum of the liver). The right limb of the H is made incompletely by the inferior vena cava posteriorly, and the gallbladder anteriorly. The left limb of the H is made by the continuity of the fissures for the ligamentum teres anteriorly and the ligamentum venosum posteriorly. The vena cava lies in a deep groove and it is crossed over by the hepatocaval ligament. On its right side is the bare area and its left side the caudate lobe.

Posterior Surface (Figure 1.4)

The inferior vena cava (IVC) runs in the center of the posterior surface of the liver. A fibrous band called the ligamentum venae cavae (hepato-caval ligament) covers part of the inferior vena cava posteriorly. This fibrous band, sometimes replaced by a bridge of liver tissue, is attached to the bare area on the right side and the caudate lobe on the left side. The ligamentum venosum runs in a groove just to the left of the caudate lobe. The rest of the posterior surface of the liver is made up of by the ligaments (the left triangular ligament, the coronary ligament and the right triangular ligament) which attach the liver to the diaphragm.

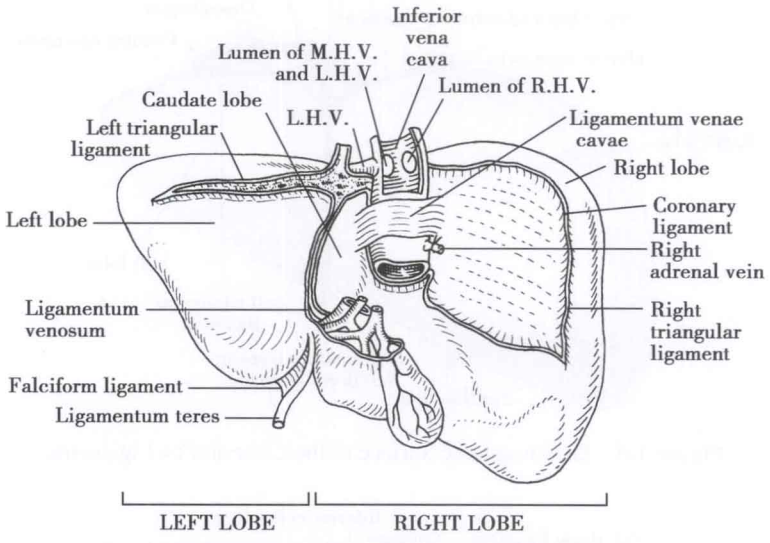

Figure 1.4 Posterior Surface of the Liver
(RHV=right hepatic vein, MHV=middle hepatic vein, LHV=left hepatic vein)

Clinical Applications

The gross external anatomy of the liver is important. It serves as an important anatomical landmark for a more in-depth study of the internal anatomy of the liver.

The internal anatomy of the liver can be seen in a living human body through modern imaging techniques with ultrasound (USG), computed tomography (CT) or magnetic resonance imaging (MRI). The hurdle that one has to overcome on looking at the two-dimensional (2D) image is to reconstruct a three-dimensional (3D) image in one's mind. This is now overcome by the use of 3D CT and MRI images.

1.3 Ligaments of the Liver

The falciform ligament is a sickle-shaped fold, consisting of two closely applied layers of peritoneum which connects the liver to the diaphragm and to the supra-umbilical part of the anterior abdominal wall. The ligamentum teres runs on its free edge, together with the small paraumbilical veins, at the upper end the two layers of the falciform ligament separate from each other (Figure 1.5).

On the right, it forms the upper layer of the coronary ligament, which continues inferiorly to form the right triangular ligament, then the lower layer of the coronary ligament. In between these ligaments is the bare area of the liver. At its left extremity, the lower layer of the coronary ligament passes in front of the lower end of the groove for the inferior vena cava and becomes continuous with the line of peritoneal reflexion from the right border of the caudate lobe (Figure 1.6).

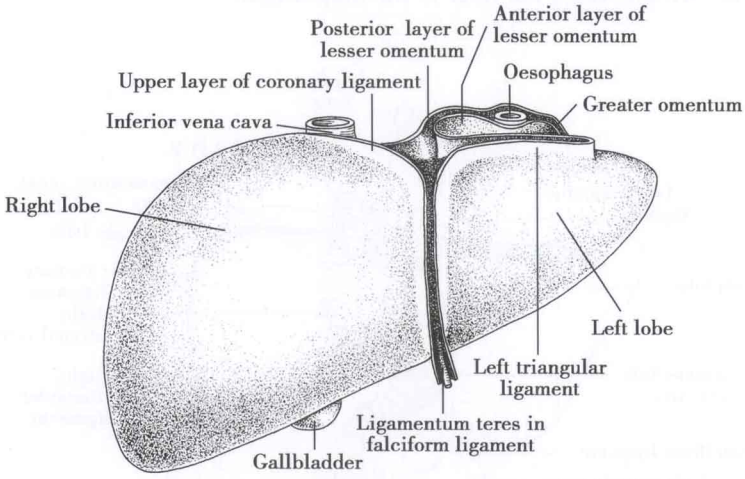

Figure 1.5 Diaphragmatic Surface of the Liver and Its Ligaments

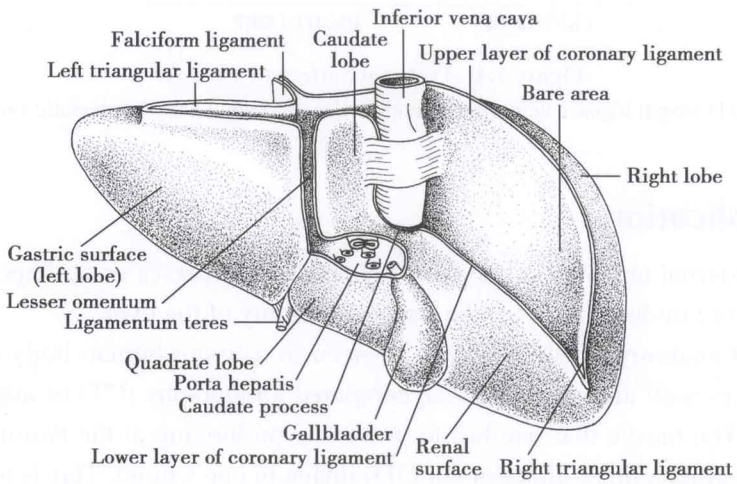

Figure 1.6 Posterior Surface of the Liver and Its Ligaments

On the left the falciform ligament forms the anterior layer of the left triangular ligament, which turns backward to form the posterior layer. At the upper end of the fissure for the ligamentum venosum, it becomes the anterior layer of the lesser omentum. The posterior layer of the lesser omentum is the line of reflexion of the peritoneum from the upper end of the right border of the caudate lobe. This layer then goes around the caudate lobe to join the lower layer of the coronary ligament (Figures 1.6, 1.7).

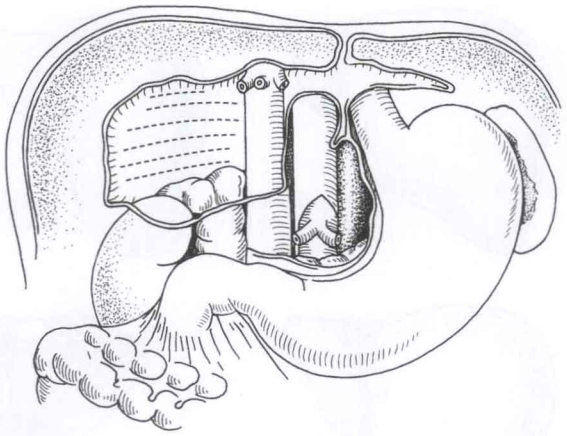

Figure 1.7 Ligaments and Bare Area left after Removal of the Liver

Clinical Applications

(1) Division of all the ligaments that connect the liver to the diaphragm and the anterior abdominal wall (i.e. division of the falciform ligament, ligamentum teres, coronary ligament, right triangular ligament and left triangular ligament) leaves the liver attached to the body by three structures:- the porta hepatis, the major hepatic veins (right, middle/left trunk) and the short hepatic veins which run directly from the inferior vena cava to the liver.

(2) In division of the lesser omentum, particular attention should be paid to avoid damaging the anterior and posterior vagus nerves and their gastric branches, and the biliary branch of the anterior vagus nerve. In patients with the left hepatic artery arising from the left gastric artery, the left hepatic artery may inadvertently be divided if the anomaly is not looked for.

1.4 Shapes of the Liver

The liver comes with many shapes (Figures 1.8, 1.9). The average weight is 1500 g and it receives 1500 ml of blood per minute.

The liver has a good regenerative power. Atrophy in one part of the liver can result in

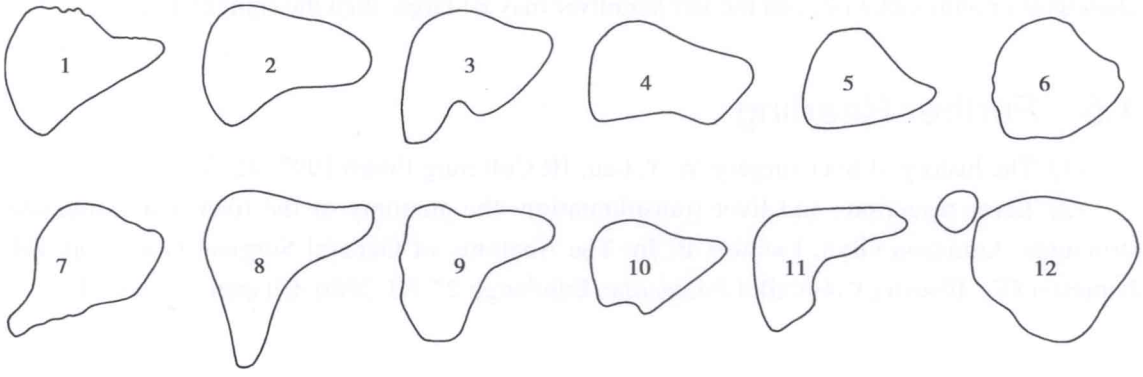

Figure 1.8 Normal variations in the Shapes of the Liver as shown on CT Scans