Extreme Hepatic Surgery and Other Strategies

Increasing Resectability in Colorectal Liver Metastases

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To my mentors,
Enrique Marcelo Beveraggi,
Thomas E. Starzl,
Víctor Pérez,
and Henri Bismuth,
with great gratitude.

And to all my trainees,
for sharing their passion with me.

Eduardo de Santibañes

Foreword

Liver surgery is always improving, and I wonder when it will stop. Probably never.

At the beginning, the liver was considered a bloody pouch that was too risky to operate on or even to get in. The first real changes occurred in the 1950s, and included the anatomy of Couinaud bringing a real road-map of the liver and the first true anatomical liver resection by Lortat Jacob. Then, until the early 1980s almost nothing happened. The real revolution was the first imaging technique of the liver, ultrasound, which for the first time made it possible to see inside the liver in vivo; at last, smaller tumors amenable to surgical treatment could be discovered. Now, the surgeon was able to use the segmental anatomy of Couinaud. This was soon followed by intraoperative ultrasound, now allowing the surgeon to use the anatomical map of the liver segments during surgery. All these advances permitted the description of a wide variety of anatomical liver resections from subsegmentectomies to extended hepatectomies. At the same time, different ways of clamping the liver vessels were developed for the best control of intraoperative bleeding, the first fear of the surgeon. During these two decades, liver surgery achieved its full development. According to the nature of the tumor, the size and number of nodules, and the quality of the parenchyma, the surgeon was now able to choose in the vast armamentarium of techniques the most suitable for the operable patient.

But there were limitations: too large or too numerous tumors to remove, or too small liver remnants could not be overcome. We entered a new area, with the objectives of changing the tumor and/or to changing the liver. Changing the tumor included chemoembolization for hepatocellular carcinoma, and more importantly in the Western world, the use of chemotherapy for colorectal metastases. Unresectable tumors were downsized to become operable, and in 1996, we introduced the concept of "resection of unresectable liver metastases": at the ASCO meeting in the same year, there were no communications on liver metastasis. On the other hand, changing the liver occurred with the use of portal vein embolization, which was able to increase volume of the future liver remnant to allow large or staged liver resections. The field of neoadjuvant therapies prior to liver resection was born, and opened a large avenue of research. These new concepts added to pure technical strategies that dealt with the tumoral load and the liver volume. This is the theme of this book: how to go to the extreme of our capabilities to treat the patient with this multiform spectrum of colorectal liver metastasis.

I have known Eduardo de Santibañes for more than 20 years. At the beginning, it was through Miguel Ciardullo, who trained with me at Paul Brousse in the mid-eighties before joining Eduardo. Then Eduardo and I became personal friends, and I admire his skills and leadership. Eduardo is surely one of the best expert liver surgeons in the world. He has brought together several other experts to produce this outstanding book that I think any liver surgeon will want to read in order to know what we may achieve today in the most difficult and extreme liver surgery.

Paris, France Henri Bismuth

Preface

Colorectal carcinoma is the third most commonly diagnosed cancer in the world. Over 1.2 million patients are diagnosed each year, and more than half of these patients develop liver metastases during the course of their disease. Despite the several advances in the systemic treatments for these patients, radical surgery still plays the major role, as complete tumor removal offers the possibility of cure or transforms patients with an acute illness into patients with a chronic disease and a reasonable quality of life. Nonetheless, the emergence of highly effective modern chemotherapy has made it possible to rescue patients who once could not undergo surgical treatment, and has contributed to the modification of the paradigms regarding safe resection margins. Nowadays, surgical resection with curative intent is being offered to a greater amount of patients thanks to multimodal therapies that brief decades ago we would not have dreamed possible.

The field of liver surgery has experienced an exponential growth over the past 15 years, mainly owing to the introduction of more effective cancer drugs, improvements of imaging modalities, novel techniques of liver function evaluation, and improvements in anesthesia and intensive care, as well as several advances of the surgical technique itself. Over time, liver surgeons have been constantly pushing the frontiers of resectability by the introduction of several surgical innovations, but also by using diverse strategies to either increase the amount of liver to remain after resection and/or reduce the tumor size. The combination of systemic treatments, endovascular procedures, and local ablation therapies with surgery has led to the successful treatment of patients having high tumor loads and otherwise poor prognosis. From an oncological perspective, the increased knowledge concerning tumor biology and the evolution of the concept of resectability have also played key roles in maximizing the survival benefit of patients with colorectal liver metastases. The concept of resectability has changed over time, and is highly dependent on the physician's expertise. Nowadays, there is consensus that resectability should be judged by a multidisciplinary board in a case-by-case fashion, in specialized centers, and taking into account a risk/benefit perspective, the technical feasibility of achieving complete tumor resection, and the oncological rationality behind the approach.

In the present book, we aim to portray the multimodal management of patients with colorectal liver metastases, and to describe in full range the state-of-the-art surgical techniques and adjunct therapies that form the armamentarium for increasing resectability of patients with advanced disease. The various strategies available are presented and illustrated, emphasizing the current trends and main advancements in each particular field.

This book would not have been produced without the invaluable contribution of worldwide leading experts from Argentina, Belgium, France, Germany, Italy, Japan, Netherlands, Norway, Pakistan, Spain, Switzerland, and the United States. Each of the authors of the different chapters have outstanding knowledge in the field, and have been pioneers in the development of the different strategies addressed in this book. I want to express my gratitude to these authors for their time and effort in writing informative, insightful, and up-to-date chapters. Finally, I would also like to thank the other editors, Victoria Ardiles, Fernando Alvarez, Virginia Cano Busnelli, and Martin de Santibañes, for their enthusiasm and remarkable dedication in the edition of this book.

I am convinced that the present book will be useful not only for junior and senior specialists in liver surgery who are frequently faced with clinical dilemmas of how best to care for a patient with advanced forms of colorectal liver metastases, but also for general surgeons who might be asked for an opinion, and even for general practitioners patientwho need to be aware of recent advances in order to implement a timely and accurate referral of the patient.

Buenos Aires, Argentina Eduardo de Santibañes, MD, PhD

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Part I

Global Patient Evaluation and Oncological Assessment

1 Liver Surgical Anatomy

Henri Bismuth, Ruben Balzarotti,
and Pietro Majno

Introduction

Modern hepatic surgery, and in particular the surgery of liver metastases, on patients with advanced and recurrent disease, as well as chemotherapy-induced liver injury, demands the pursuit of the apparently conflicting goals of radicality and tissue-sparing. Successful procedures require a perfect knowledge of the vascular anatomy of the liver, commonly based on Couinaud's *ideal* representation that will be illustrated in detail. Alternative anatomical representations will be briefly presented, as they allow a better understanding of some surgical procedures such as central hepatectomies. We will argue that the best results will be obtained by deep understanding of the individual *real* anatomy of the patient, based on radiological reconstructions that are now more widely available on the surgeon's laptop, and on intraoperative ultrasound. In addition, we will detail the anatomical characteristics of some structures of the liver, such as features particular to individual segments, the glissonean pedicles, the hepatic veins, the vestigial structures such as the umbilical and Arantius' ligaments, and the surgical approaches and maneuvers that knowledge of these structures allows. The customized procedures that result go beyond the conventional segmental representation, are best described as *tailored territorial liver resections*, fit the concept of precision liver surgery to which the authors fully subscribe [1], and illustrate the evolution from surgical anatomy to anatomical surgery that was anticipated in earlier work [2].

Classical Surgical Anatomy of the Liver

The morphological or gross anatomy of the liver reveals, from the superior (diaphragmatic) aspect, two lobes, the right and the left, separated by the round ligament and the falciform ligament, joining the round ligament to the vena cava (Fig. 1.1).

On the inferior aspect, the hepatic pedicle widens into the hepatic hilum, drawing grooves similar to an incomplete "H" (missing the left inferior limb). The upper limbs of the H, made of the gallbladder on the right and the round ligament on the left, create the borders of the

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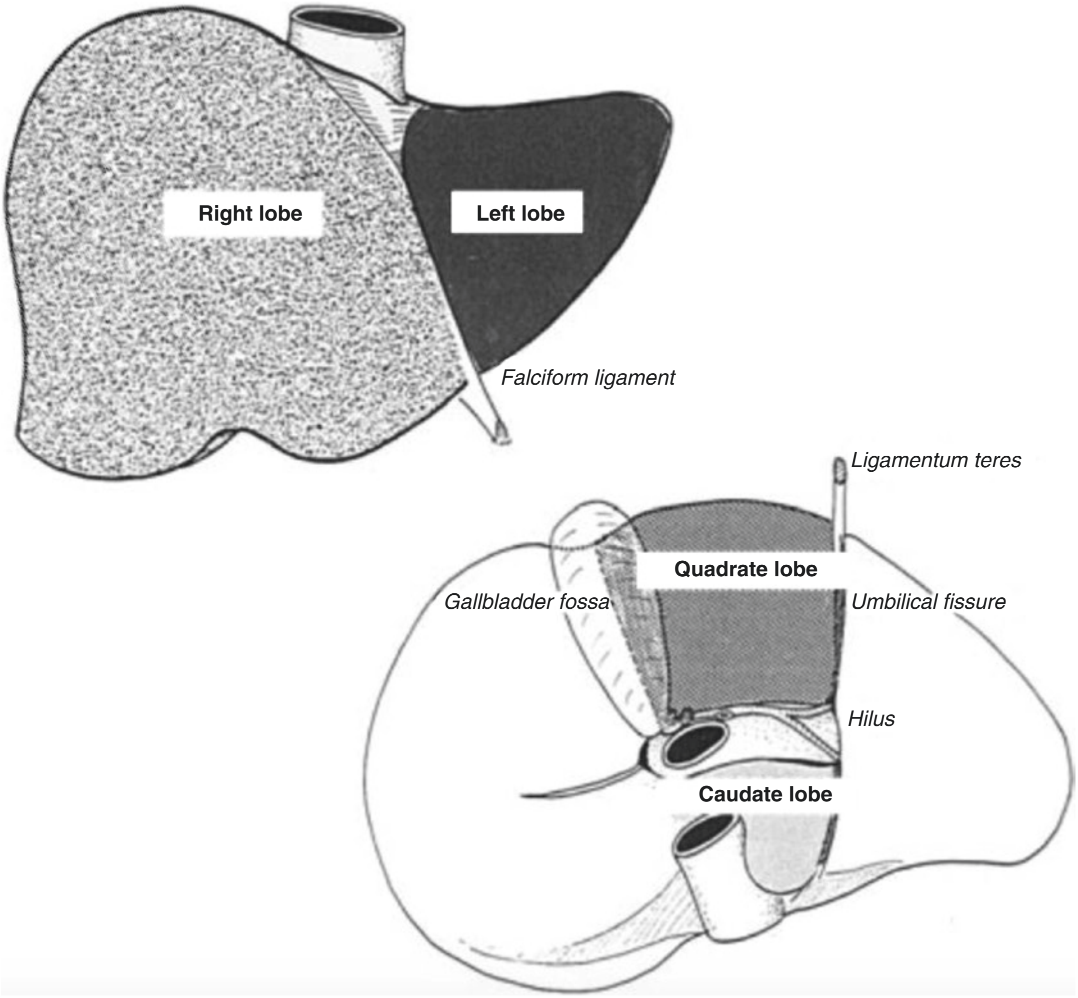

Fig. 1.1 Schematic representation of the gross appearance of the liver, with the macroscopical lobes. The external anatomical structures have little relation to the vascular anatomy (one exception is the round ligament)

quadrate lobe; the horizontal bar of the H, made of the left portal pedicle and the lower right limb, made of Arantius' ligament (joining the left portal vein to the confluent of the left and middle hepatic vein), create the boundaries of the caudate lobe, that encircles the vena cava.

Functional (Vascular) Anatomy

The morphological anatomy described above has little relation to the vascular anatomy of the liver, a point revealed from early anatomical drawings, but in particular from the work of Cantlie [3], Hjörtsjö [4], and Goldsmith and Woodburne [5], who identified separate vascular and biliary areas according to the branches of the portal pedicles.

It is the merit of the French anatomist Claude Couinaud [6] to have analyzed and systematized the vascular distribution of the main liver vessels into a scheme that is relatively constant and consensual. The scheme, popularized by an historical paper [2], is depicted in Fig. 1.2.

In Couinaud's representation, the three hepatic veins interdigitate with the portal pedicles as the fingers of two opposite hands. The vascular territories defined this way, the right and left LIVERS, on the first division of the portal vein,

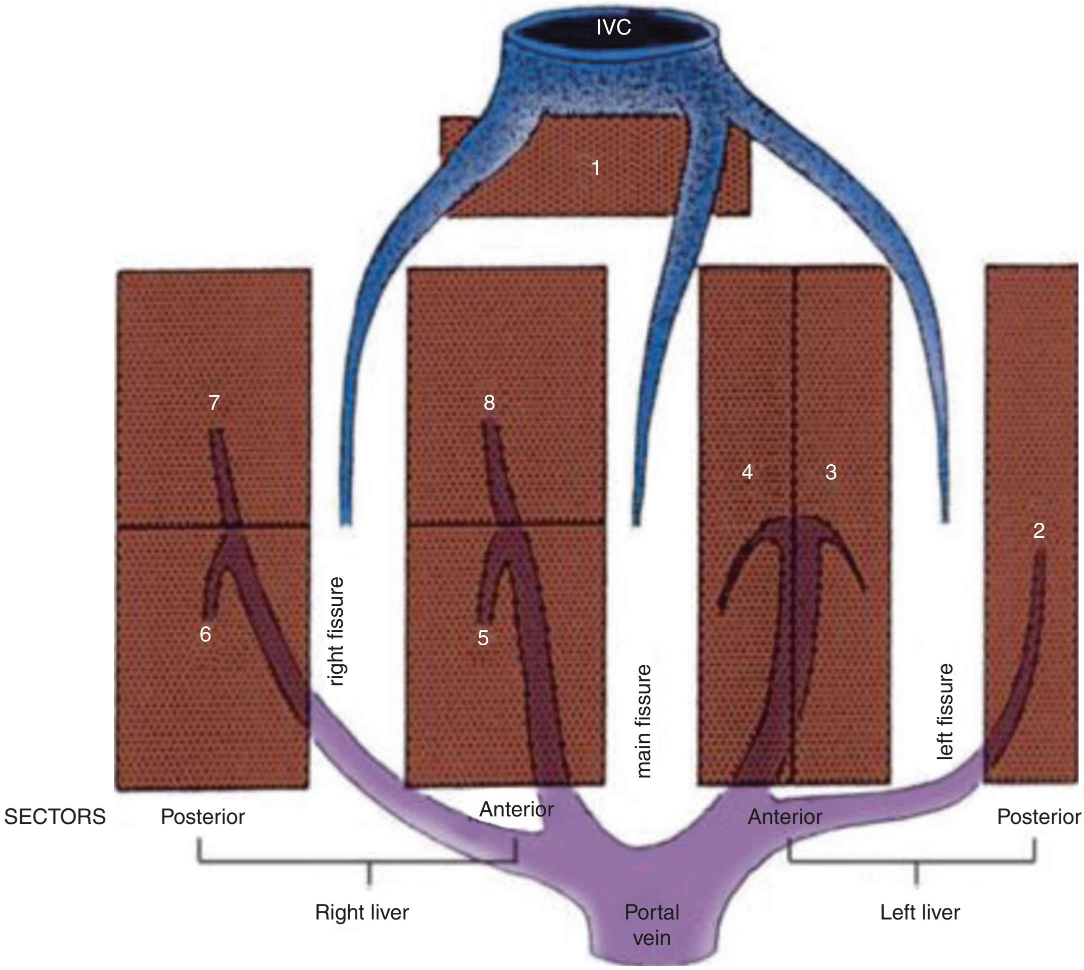

Fig. 1.2 Schematic representation of the vascular structure of the liver. The three hepatic veins and the four sectorial portal branches interdigitate like fingers of two opposing hands. The reader will notice the symmetry of the *right* and *left* liver, taking into account an anticlockwise rotation in the disposition of segment 4 and segment 3 (maybe because the round ligament retains the segments of the left liver from taking a position symmetrical to the right?). While segment 2 is embryologically a left posterior sector, it is practical to call it a segment because two segmental branches are generally not seen within it, and because this territory is small

and the SECTORS, on the second-order division, were further divided into SEGMENTS according to the distribution of third-order portal branches.

In extrapolating the above representation to obtain a closer fit to the morphological anatomy, Couinaud first postulated that there was only one segment (segment 2) in the lateral sector, and that there was a vertical plane rather than a horizontal plane dividing the medial sector into segment 3 and segment 4. Then, the sectors of the left liver fell into oblivion, leaving the simplified schemes with three segments in the left liver, illustrated in Fig. 1.3.

In this representation, the right and the left liver are defined by the bifurcation of the main portal vein. The middle hepatic vein runs in this plane, which can be *approximated* as the plane joining the gallbladder fossa to the vena cava, and corresponds to the main portal scissura or Cantlie's line. On the right, the right hepatic vein separates two sectors: the anterior sector, where the right anterior sectorial pedicle (second-order division) divides into two (third-order) segmental branches, and the same for a posterior sector. On the left, the portal vein runs first in a horizontal

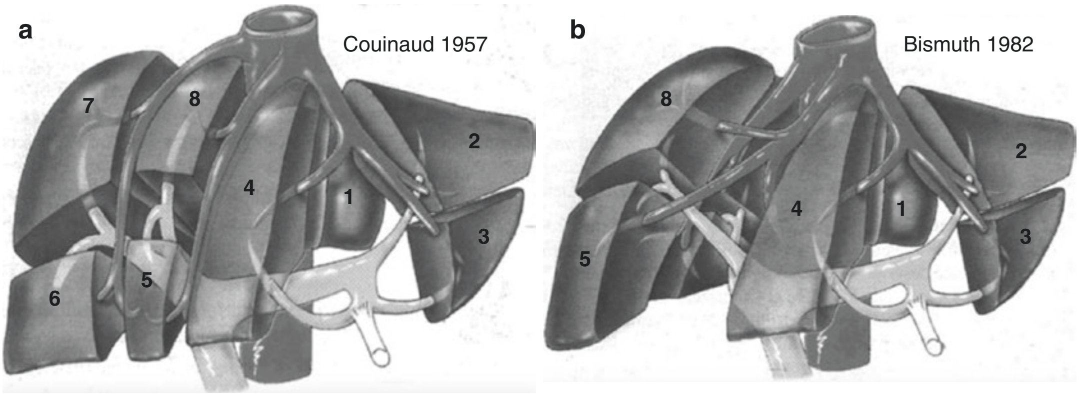

Fig. 1.3 (**a**) Schematic representation of Couinaud's segments. As an anatomist, Couinaud drew the liver "flattened out" on a dissecting table. In fact, segments 6 and 7 are posterior to segments 5 and 8, as illustrated by (**b**), a much more faithful reproduction of the radiological and surgical reality

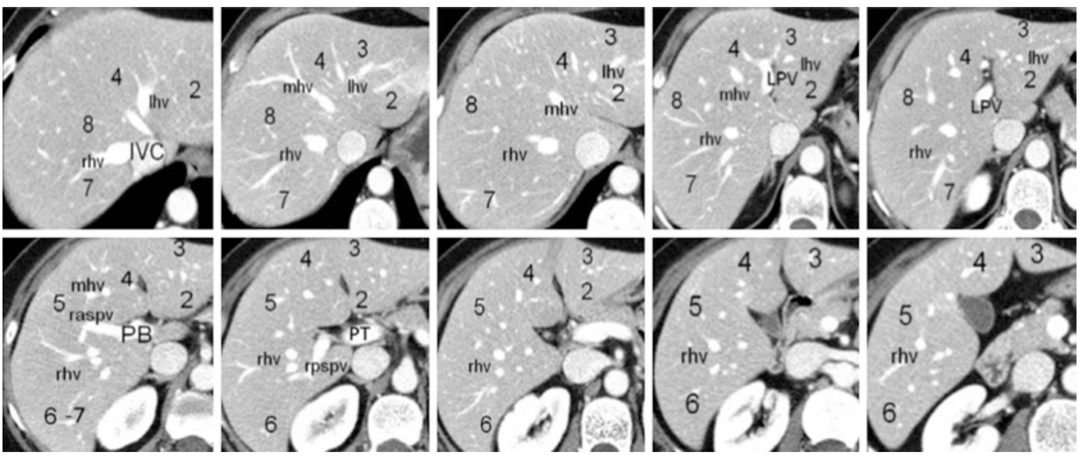

Fig. 1.4 Transposition of Couinaud's segmental representation in a modern axial radiological study (computerized axial tomography, venous phase). The vascular landmarks are easily recognized, and so are the segments (courtesy of Dr Pierre Loubeyre, Department of Radiology, University Hospitals of Geneva). *IVC* inferior vena cava, *lhv* left hepatic vein, *rhv* right hepatic vein, *mhv* middle hepatic vein, *LPV* left portal vein, *raspv* right anterior sector portal vein, *rpspv* right posterior dector portal vein

direction, then in the direction of the umbilical ligament, with a concave side encasing one segment, and on the convex side where two segments are separated by the left hepatic vein. The caudate lobe remains on the posterior side of the portal vein and surrounds the vena cava. Indeed, this anatomy is not exactly the one described by Couinaud. Couinaud described the two sectors of the right liver as paramedian and lateral (Fig. 1.3a). This corresponds to a liver that has been flattened out on the anatomist's table. The true three-dimensional liver was reestablished by naming the two sectors on the right as anterior and posterior, according to their position when the organ lies in the body and under the hands of the surgeon (Fig. 1.3b) [2].

Couinaud's classification has many advantages. The classification of the main territories according to the hepatic veins, that are easily recognized in particular in modern axial imaging, is convenient; with the second and third-order portal branching that can be assumed to occur at the level of the portal bifurcation, it establishes an unambiguous system of coordinates that defines the segments (Fig. 1.4), and therefore the position of focal lesions.

Also, in particular for some segments, there is a relatively good correspondence between the main anatomical planes of the common liver resections (right hepatectomy, left hepatectomy, left lobectomy) and Couinaud's anatomical description (Fig. 1.5).

On closer study, however, there are several inconsistencies of the (simplified) Couinaud scheme that need to be resolved.

From a theoretical point of view, the conceptual and embryological symmetry of the liver is not respected: if the analogy of the interdigitating hands and the order of the portal branches defining sectors and segments were to be respected, Couinaud would have insisted on a large left medial sector composed by segments 3 and 4, separated by a vertical division, and a small left lateral sector to the left of the left hepatic vein, where two segments cannot be individualized. This discrepancy was recognized in the 1982 paper popularizing Couinaud's classification [2] and underlined in our last paper [7].

What happens in this part of the liver is that the umbilical vein—coming from the left branch of the portal vein—is pulling out the portal branch and creates an additional division of this part of the liver, which is, in fact, if we put inside the portal branch, a single segment. The left medial sector becomes one segment, and segments 3 and 4 are indeed half-segments. The left

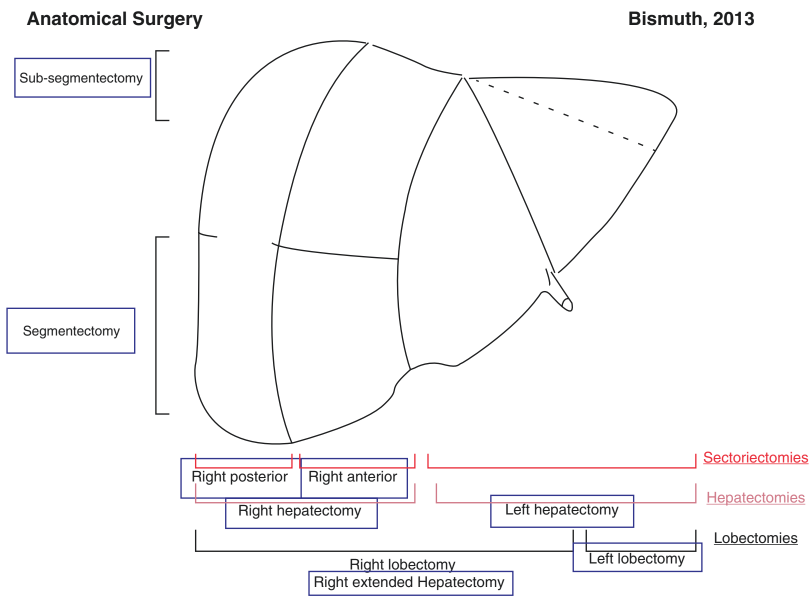

Fig. 1.5 The terminology of the hepatectomies consistent with Couinaud's classification. In *red* are indicated the most precise denominations of liver resections; left lobectomy is the preferred term of the bisegmentectomy 2-3, and right and left extended hepatectomies for the five or six segmentectomies on the right and the left. Alternatively, hepatectomies may be defined by the number and identification of the resected segments. For one segment removed: segmentectomy + number, 1–8. Resection of two segments: bisegmentectomy + numbers. For three segments: trisegmentectomy + numbers (for instance: trisegmentectomy 8-5-1). Central hepatectomy (it is better to avoid using the term middle hepatectomy) has to be defined by the segments removed: usually segments 5-8-4, but it may also include segment 1. Resection only of segment 4 is segmentectomy 4. As segment 4 is divided into two subsegments—4a, the upper one, and 4b, the lower one—each may be removed independently: subsegmentectomy 4a or 4b. Right or left hepatectomies are well defined. For the lobectomies, left lobectomy may also be called bisegmentectomy 2-3. Right lobectomy includes five segments (segments 4-5-6-7-8). Because this extension of the right hepatectomy may remove segment 1 instead of segment 4, it is better to say right extended hepatectomy to segment …*n*, which makes it possible to specify to which segment the right hepatectomy is extended: segment 4 or 1. Extension may involve two segments: 4 and 1, which is the 6-segmentectomy on the right, also called right hepatectomy extended to segments 1 and 4. The left extended hepatectomy to segments 1, 5, and 8 is the mirror resection on the left: left hepatectomy extended to segments 1, 5, and 8, or 6-segmentectomy on the left

lateral sector, only with segment 2, has to be united to the left medial sector that becomes one segment, and together they constitute one sector: one sector with two segments (Fig. 1.3b); this is in accordance with the usual description of Couinaud. In order not to change the numbers put by Couinaud, it is better to keep the numbers 3 and 4, knowing that these segments are in fact half-segments.

We arrive at the following description of the liver anatomy (Fig. 1.5):

- two hemilivers (right and left)
- three sectors (the right posterior, the right anterior, and the left)
- seven segments
  - six segments (each sector divided in two segments)
    - right posterior sector: segments 6 and 7
    - right anterior sector: segments 5 and 8
    - left sector: half segments 3–4 (as one segment) and segment 2
  - plus segment 1

It is in fact fortunate for the diffusion of Couinaud's segmental system that his obscure book was never translated, that neither he nor I (HB) insisted on this point in further papers, leading to the simplified but useful system diffusing in the world.

Alternative Representations

It is worthwhile for the experienced liver surgeon to whom this book is dedicated, to understand some points where the scheme of Couinaud does not fit the anatomical reality, better represented by alternative schemes or by a deeper understanding of Couinaud's work. This not for a sterile anatomical discussion, but because we believe that conceptualizing these alternatives allows to perform the radical yet conservative liver resection required in modern liver surgery [8].

From an embryological point of view, a scheme recognizing the symmetry of the right and the left liver does make sense. As an embryological recall, there are at the beginning two umbilical veins entering the right and the left liver, as illustrated in Fig. 1.6 [9]. This embryological point is not only evident in the anatomical variations where the gallbladder is located on the left side, but also in all the cases where a distribution of the whole right anterior sectorial branches or of the branches of segment 5 recall the pattern of the left portal vein (Fig. 1.7 [10], in

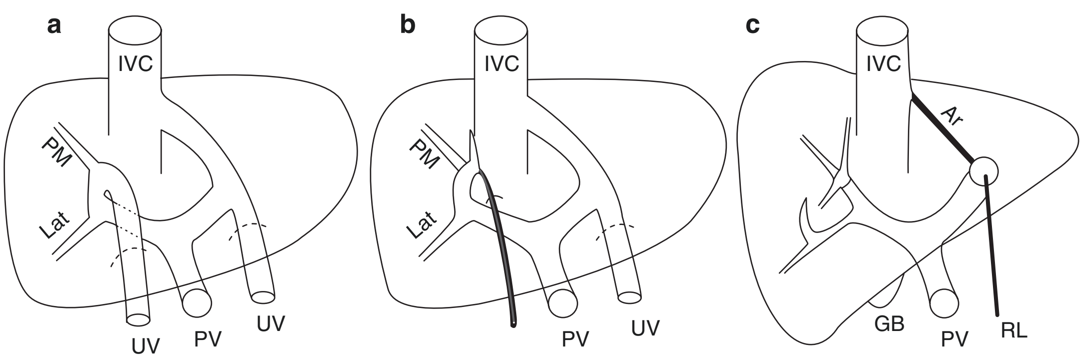

Fig. 1.6 Schematic representation of the development of the liver. (**a**) Two umbilical veins (UV) enter the right and the left portal vein (PV). (**b**) The right umbilical vein obliterates and the left umbilical vein remains. (**c**) The left umbilical vein obliterates and becomes the round ligament (RL), Arantius' canal obliterates into a ligament (AR). *PM* paramedian sector, *Lat* postero-lateral sector (modified with permission from Makuuchi Ann Surg 2013)

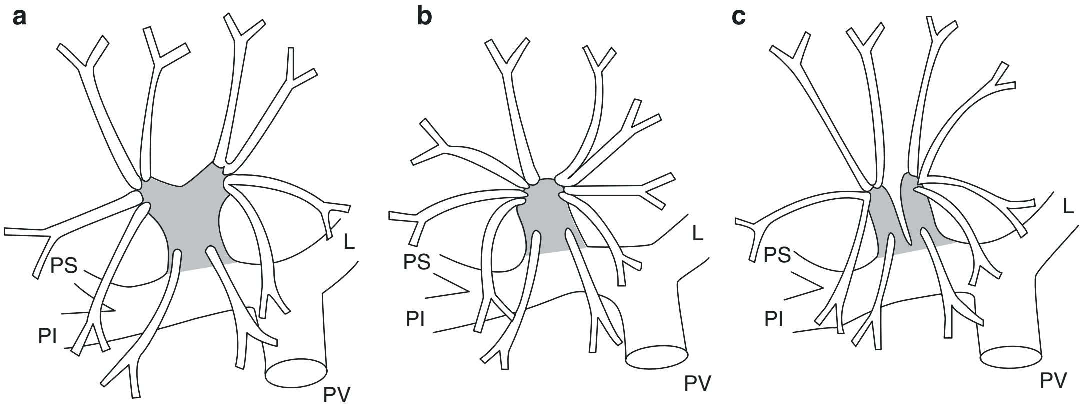

Fig. 1.7 Schematic representations of different patterns of the anterior sectorial branch (**a**, **b** and **c**), in cases where the remains of the right umbilical vein are more easily visible. The analogy with the branching of the left portal vein is obvious (reproduced with permission from Kogure Arch Surg 2002)

particular configurations (a) and (b), Fig. 1.8). In these cases, the surgeon can perform limited yet radical resections of territories in the anterior sector that keep the lateral branches of the traditional segments 5 and 8 well vascularized and drained by the right hepatic vein. The authors have performed, simply following the glissonean plane from the roof of the plate of the hilar bifurcation and ligating all the medial branches going to the left, some very satisfactory central hepatectomies, or resection of the posterior sector extended to part of the anterior sector and the right hepatic vein.

This situation, at least on the right, is well conceptualized by the representation of Hjörtsjö [4], where the right anterior sector is divided in a ventral and dorsal portion (Fig. 1.9). Hjörtsjö's representation also accounts for the apparently weird distribution of the segments of the left liver, in a symmetry and respect of the embryological development that can be developed further by the interested reader.

Similarly, central and lateral hepatectomies in the glissonean planes can be well conceptualized in the representation of Takasaki [11], where only three segments (+segment 1) are described (Fig. 1.10). In this representation, the left, middle, and lateral segment constitute approximately 30% of the liver each. We find Takasaki's representation more suitable for conceptualizing the larger hepatectomies needed for HCC in well-compensated cirrhotics than the finer resections that are needed in the surgery of liver metastases, in particular when multiple resections are needed.

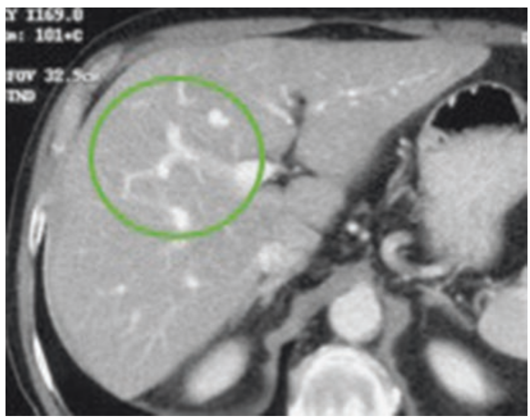

Fig. 1.8 CT scan of a patient in whom the similarity of the branching of the portal vein of Segment 5 (*green circle*) with the branching of the left portal vein can be recognized and exploited, for a resection of just the medial part of S5, leaving the lateral part intact. This case illustrates well the relevance of Hjörtsjö's representation.

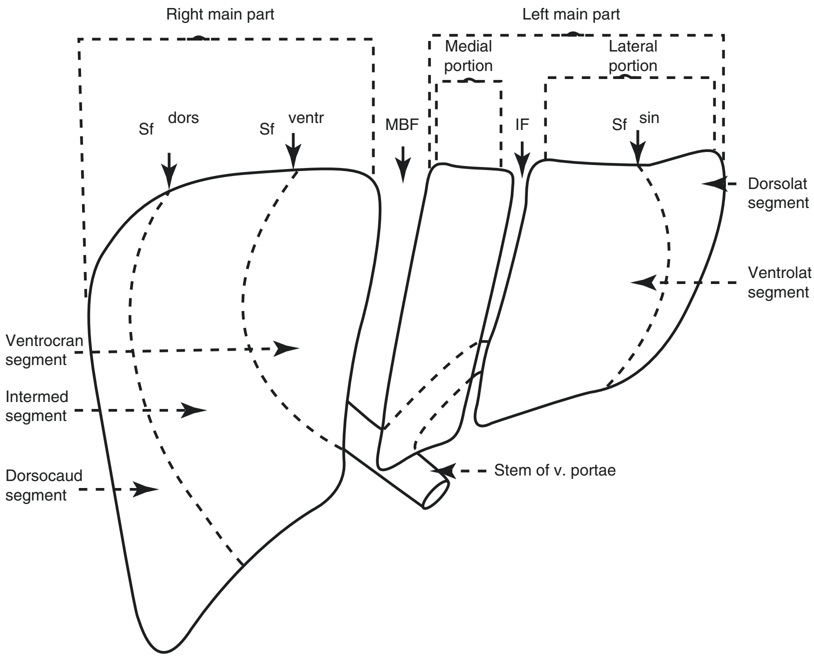

Fig. 1.9 Hjörtsjö's division of the liver into four portions (corresponding to Couinaud's sectors), each of which is divided into segments. This representation is interesting for conceptualizing the surgical anatomy of the anterior sector

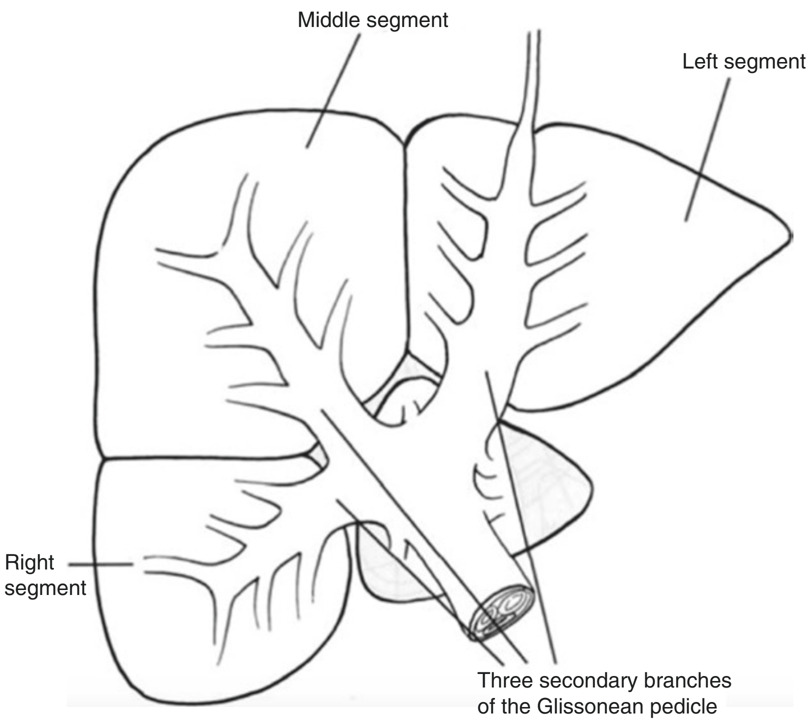

Fig. 1.10 Takasaki's representation, dividing the liver in three segments (+segment 1), separated by the three hepatic veins. This representation is particularly useful to guide resection in the intra-hepatic, extra-glissonean plane, or to perform central hepatectomies "pruning" the (secondary, in this case) branches medial or lateral to the main divisions of the portal vein

A More Independent Look at the Anatomies of the Liver

It appears from the above consideration that there is no unique representation of liver anatomy that satisfies all needs, and it is in fact the needs of the situation that have to guide the type of anatomical representation that is best used [8]. *For the localization of liver lesions*, the common language of the simplified Couinaud's scheme is unambiguous and consensual, and there is no necessity to change it. Besides, Couinaud's representation is useful to plot preoperatively all liver lesions that have to be found during the operation, a practice instituted by the authors in their units, on a chart such as the one in Fig. 1.11.

For the description of liver resections, we are probably in a period of transition, where the simple application of Couinaud's terms, based on a right liver and a left liver, and factually recognizing a morphological left lobe, is challenged by the Brisbane classification [12] that in our view has no appreciable added value (the new term, *section*, to define the left lobe is not useful nor does it have an embryological substrate). For the time being, we would simply describe the resection in terms of the Couinaud's segments that have been removed, cutting short any ambiguity.

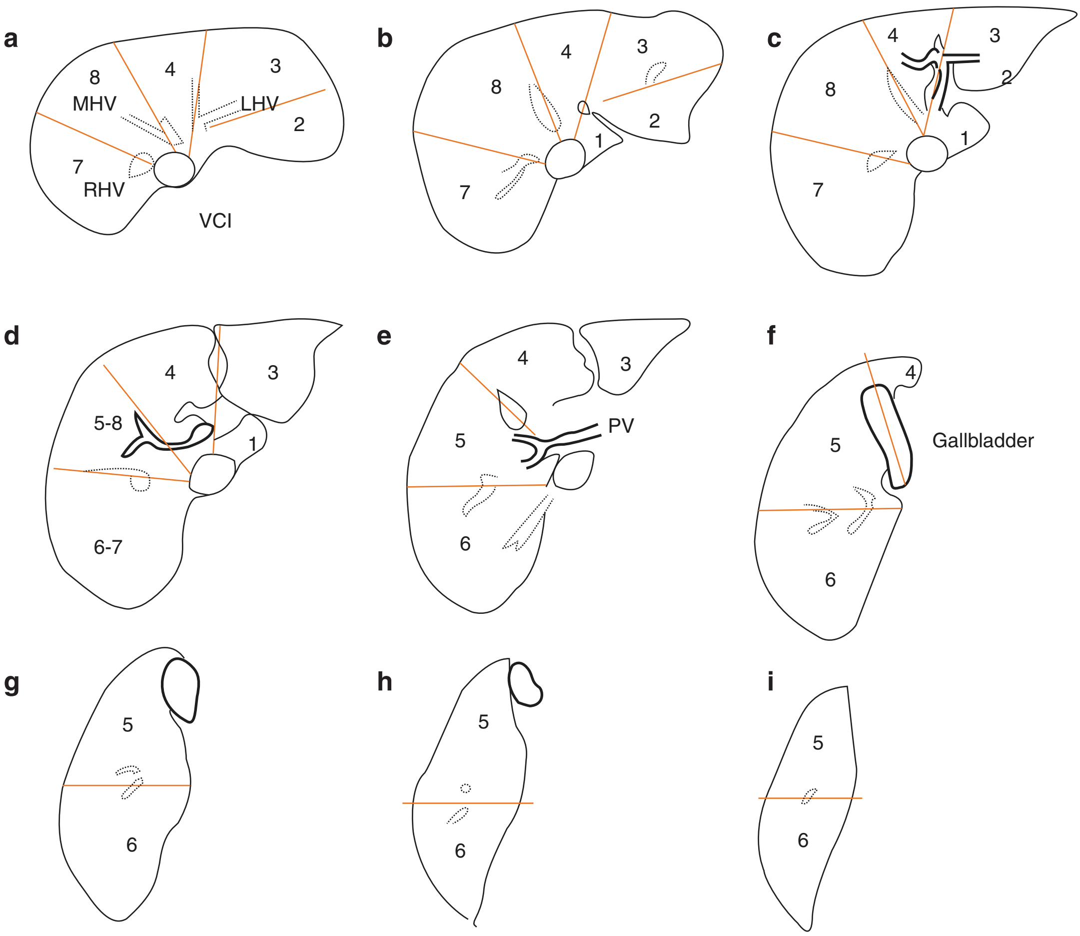

Fig. 1.11 Schematic chart with the main landmarks used for Couinaud's segmentation on different axial planes of the liver (**a** to **i**). Such a chart can be used to plot all the lesions that have to be identified during a liver resection. This particular model is freely available for download on the internet (www.compagnons-hb.org)

For the needs of advanced liver surgery, we anticipate that a freer approach based on the study of individual cases will turn out to be the most appropriate. This can be linked to the different representations of liver anatomy as illustrated above, but more importantly, to the real revolution that the transfer of radiological images from the radiology reporting room to the surgeons' laptop has started [13]. These new approaches have contributed to challenging the simplifications of Couinaud's scheme, and are indeed useful for the accurate planning of tailored territorial liver resections [8].

New radiological software, taking advantage of mathematical algorithms such as the nearest neighbor calculations, can depict the vascular territories with more precision and less prejudice than human-made segmentations, and are now commonly used in experienced units.

From the point of view of the anatomist, an unbiased view based on these models, on comparative anatomy and on mathematical analogies to other natural patterns such as fractals and crystals, can open new insights on the complexity of the liver. Representations that do not systematize the liver segments beyond the second order branches and leave the number of segments variable such as the 1-2-20 systems may offer the closest approximation to anatomical reality [14]. It is unlikely, however, that advances in this field will have short-term repercussions in surgical practice, where the preponderant need is a simple, reliable, and automatic segmentation starting from a standard axial imaging.

Surgical Anatomy and Anatomical Surgery of the Structures and Planes in the Liver

The above considerations on the surgical anatomy of the liver's vascular tree can be complemented by some comments on particular segments and structures of the liver, useful both for tailored territorial liver resections and for approaching lesions in awkward locations.

The Hilar Plate

The hilar plate is a layer of connective tissue that surrounds and accompanies the main liver vessels and bile ducts, separating them from the liver parenchyma. The denomination of this structure as a *plate* does not simplify its understanding. The plate is in fact a *tube* that surgical dissection can *transform* into a plate, when the surgeon opens the anterior peritoneum that in well-identified locations (listed below) constitutes the non-parenchymal side of this tube. This surgical transformation can take place only close to the central structures (Fig. 1.12), as follows:

– at the hilum (where it is possible to separate the portal vein, the hepatic arteries, and the bile ducts as far as the connective tissue joining them remains loose);
– on the right side once the gallbladder has been removed (exposing the vesicular, or gallbladder plate);
– on the left, when the peritoneum on the left pedicle is opened, exposing a transverse plate proximally and an umbilical plate more distally.

At the level of the biliary confluent, the bile duct can sometimes be separated from the hilar plate, but beyond this point the right and left hepatic bile ducts are contained in the tissue of the plate, and cannot be dissected from it. Also, it is generally not possible to dissect the portal vein and hepatic arteries beyond the bifurcation of the right portal branches, and beyond the umbilical portion of the left hepatic pedicle, as these vessels are completely encircled in the tube of connective tissue (here called the glissonean sheath), with no recognizable surgical plane (Fig. 1.12).

At the level of the umbilical portion of the portal vein, however, it is useful to distinguish three concentric planes, as illustrated in Fig. 1.13. These planes can be entered in the fat that surrounds the ventral side of the umbilical portion of the portal vein, and the left hilar plate can be unraveled to expose this structure from the inside,

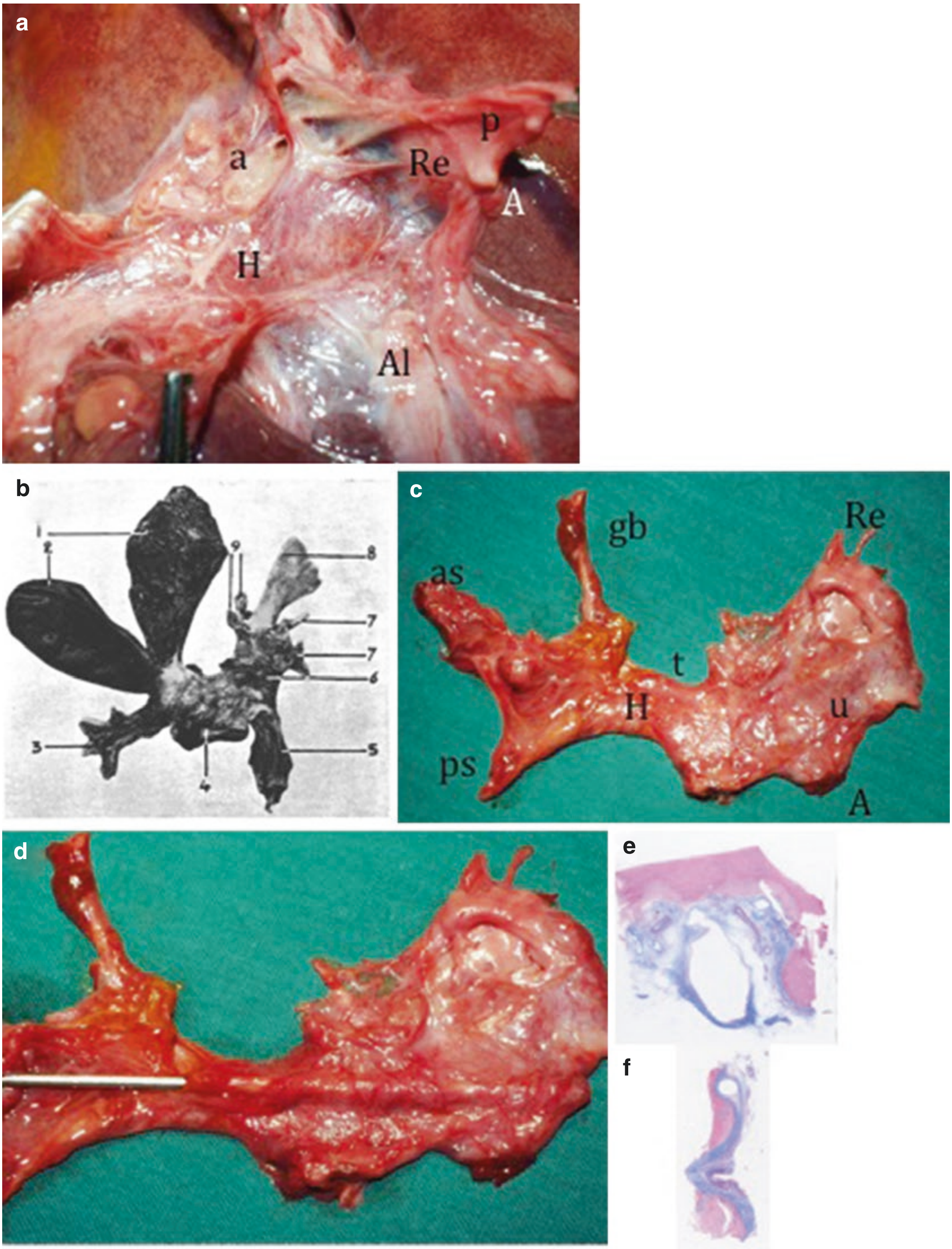

Fig. 1.12 (**a**) The hilar plate, in an anatomical dissections by the authors, after the portal vein, the hepatic artery and the common bile duct have been lifted and pulled to the left; (**b**) in the original illustration by Couinaud; (**c**) after removal of the portal vein, the hepatic artery and the parenchyma; (**d**) a probe enters the left bile duct, soon embedded into the plate in such a way that it cannot be dissected from it; (**e**, **f**) histological preparation of a transverse section at the hilum. The fibrous tissue is colored in *blue* and the liver parenchyma in *red*. It is obvious that the structure is a tube that can be prepared into a plate by dissection of the anterior peritoneal layer. The sheath is not symmetric, however, and the artery and the vein can be dissected from it as they are surrounded by loose connective tissue (courtesy of Prof. Laura Rubbia-Brandt, University of Geneva, Switzerland)

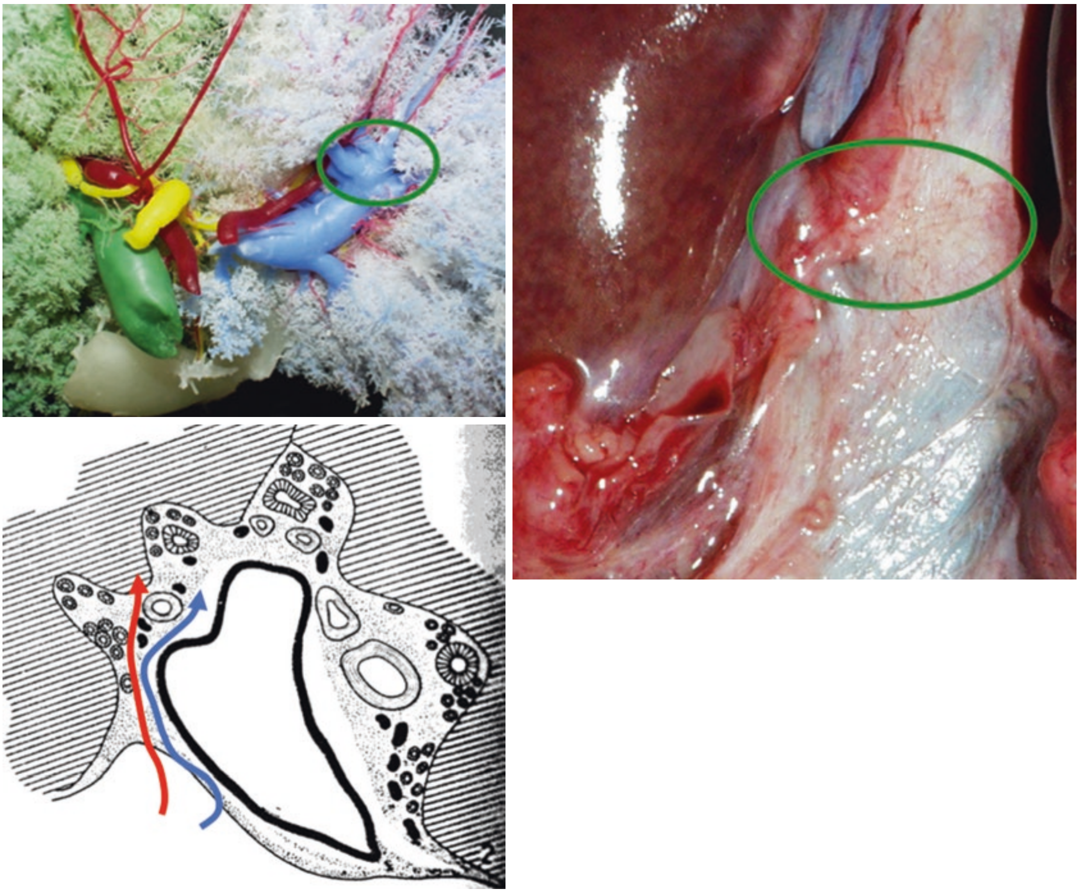

Fig. 1.13 The outermost layer is the one of the peritoneum anteriorly (*green oval*) and of the hilar plate posteriorly; the second layer is the one of the hepatic arteries (*red line*), and the third one of the portal vein (*blue line*)

to prepare it for the resection of Klatskin's tumors, or for the separation of metastases adhering to the hilar structures (Fig. 1.13).

Approaches to the Portal Pedicles

Clearly defined planes around the hilar plate (centrally) or the glissonean sheaths (beyond the second-order branches) can be found *within the liver parenchyma* (we say this to underline that when accessing these planes the surgeon has to enter frankly the liver tissue, rather than dissecting within a glissonean structure) at any level in the liver; the closer to the pedicle (once this has been identified from *within* the liver), the lower the chances of entering one of the hepatic veins, that in some locations run very close to the glissonean structures. The plane on the hilar plate can be entered, (generally with blunt dissection, such as the suction aspirator rather than with the tip of the ultrasonic dissector that can produce thermal injuries to the bile ducts) at the level of the portal bifurcation, to control the right or the left hepatic pedicles, or once the arterial and portal vessels have been dissected free and protected, for the transection of the bile ducts in the preparation of right or left liver grafts or when a the tumor close to the second order branches argues for a intra-hilar dissection rather than for a intrahepatic extra-glissonean approach for the control of the hepatic pedicles.

Also, the glissonean plane can be followed to expose and "prune" from the level of the portal