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BASIC AND CLINICAL HEPATOLOGY

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BASIC AND CLINICAL HEPATOLOGY

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FOREWORD

The liver has been an organ of mystery for centuries. Slowly but surely its secrets have been disclosed by both basic research and clinically oriented investigators whose current concepts have been brought together in this book by authors from five different countries.

Three major groups with many subgroups have made inroads into our better understanding of the liver. The first of these comprises the basic scientists whose study of single hepatocytes may provide the key to comprehension of mechanisms that will lead eventually to improvement in the morbidity and mortality associated with a variety of hepatic disorders.

The second group has been concerned with studies in depth of the liver's response to a variety of hormones, drugs, viruses, and infections. Both early and late results are their concern in the diagnosis and treatment of the individual patient.

A third group comprises the surgeons who have become increasingly aggressive in the removal of one or more segments of the liver. They have increased the scope of hepatic resection as a result of a better understanding gained from studies of various segments of the liver. They have accepted the term, segmentectomy, and have extended feasible procedures to include trisegmentectomy. Indeed, transplantation of the liver has been successfully accomplished.

The clinician has become increasingly reliant on the roentgenologist for assistance in localizing tumors of the liver and providing information with regard to its blood supply by angiogram. Fewer hepatic common ducts require surgical reexploration since calculi can be removed technically by the roentgenologist, absorbed by the new solvents, or removed via an incised ampulla of Vater with use of a special flexible scope passed orally.

Those interested in basic research should be aware of the problems encountered by the clinician. It is just as important for the clinician to be knowledgeable regarding basic science studies on the individual liver cell. Such studies are often the cornerstone of subsequent developments in the successful diagnosis and treatment of patients.

Such a multifaceted organ as the liver doubtless has many more unsolved mysteries that continue to challenge the basic scientist, but the combined efforts of all these groups have begun to bring long-time liver problems under control.

The authors have succeeded together in building a storehouse of current knowledge about the liver. The basic scientist as well as the clinician should find this book invaluable.

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PREFACE

Recent technological and scientific advances from the subcellular to the macroscopic levels of organization discussed during the Symposium of the Pan American Congress of Anatomy, held in São Paulo, Brazil, in 1977, were the primum movens that prompted the editors to present in this monograph the major basic achievements and clinical applications of new knowledge on hepatology. Although limited by the relatively concise text, this comprehensive approach corresponds to what may be called modern hepatology, as the subject matter in each chapter concentrates on innovations and recent contributions as well as on pure and applied data based on theoretical, practical, and even speculative aspects of recent knowledge of the liver. Experimental details, case reports, and controversial interpretations have been avoided to give place to new findings that have gained acceptance by the majority of investigators and practitioners dealing with hepatology.

Basic and Clinical Hepatology is intended to serve general practitioners, surgeons, specialists, investigators, and students. This publication compiles data from scientific articles, review papers, and textbooks. We have attempted to summarize basic, clinical, and surgical information and, at the same time, point out gaps in present knowledge as well as the need for further research. This approach favors the presentation of new trends in the study of the liver and has consequently led to the exclusion of traditional well-established information. Contributions obtained by means of new techniques utilized in transmission and scanning electron microscopy, with or without freeze-fracture, as well as those made with the remarkable tools that have been developed for use in radiology have been included. These techniques have enabled pathologists and clinicians to better understand the anatomy and physiology of the liver, both normal and diseased; to help with interpretation of clinical and experimental findings; and to offer a sound basis for surgical treatment of ailments of the human liver.

Although the use of the Nomina Anatomica, Nomina Embriologica, and Nomina Histologica was recommended, there are some departures from the official nomenclature, and in these instances the terminological change is justified.

We are grateful to Mr. John Flukas for his skillful editorial cooperation, and to Dr. Silvia Correr who offered many constructive suggestions while checking and carefully reading most of the text. Special thanks are due to Mr. Jeffrey K. Smith for his effort and encouragement during all the stages of the preparation of this volume.

We regret to add a sad note relating to the deaths of Prof. Renato Locchi and Prof. Dr. J.-C. Wanson, in whose memories this book is dedicated.

Finally, we would like to mention the pioneering interest of Prof. Z. Fumagalli in the modern correlation between basic and applied study on the liver, as evidenced by his sponsorship of special reports on the subject during the Italian Congress of Anatomy in Messina (1958).

In a publication of this magnitude and diversity, some errors and omissions may be found. The editors ask the reader's indulgence and, additionally, hope that corrections and comments will be forwarded to them.

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CONTENTS

1. SEGMENTS OF THE LIVER: THE ANATOMICAL BASIS FOR PARTIAL HEPATECTOMY

L.J.A. DIDIO

1. THE CONCEPT OF ANATOMICOSURGICAL SEGMENTS OF THE LIVER

The etymology of the word *segment* gives an indication of the cause for the confusion that has surrounded subdivision of the liver, and may help in the understanding of the concept of anatomical and surgical territories of viscera.

The term *segment* originates from the Latin *segmentum* (a section, a piece cut off, a fragment, a cutting) and it is related to *secare* (to cut).

In biology, segment designates any of the portions, divisions, sections, or territories into which a body, an organ, or a viscus is separable by imaginary, natural, artificial, or arbitrarily established boundaries. In geometry, it is a part of a figure; for example, a circle or sphere, marked off by a line or plane, as a part of an area limited by an arc and its chord. It is also defined as a piece cut along the radii of a circular area. In embryology, segments may mean metameres or serially homologous structures, such as the repetition of similar parts of annelids, somites, or myotomes. In spite of there being good reasons to use the word zone instead of segment [1] worldwide adoption of the latter overrides any possible change.

In anatomy and in surgery, a segment is defined as a territory of an organ or viscus having an independent function, supply, or drainage, and as susceptible to anatomical identification and surgical separation or removal.

The best-known examples are the bronchopulmonary, the renal [2–5], the splenic [6–12] segments and, more recently, the gastric [13] and the cardiac segments [14].

Anatomicosurgical visceral segments are independent territories of parenchymatous organs, now extended to hollow organs, that provide the natural and essential background for systematic surgical removal of portions of anatomical structures. Recognized, classified, and described in the lungs, kidneys, spleen, liver, stomach, and heart, among other viscera, the anatomicosurgical segments have a common denominator and organ differences.

The common denominator is the complete, or almost complete, independence in certain divisions or subdivisions of each organ of their blood supply and drainage as well as their ducts or canals (or bronchi, for example), where present. The vascular and ductal elements constitute the segmental pedicle analogous to that of each lobe (lobar pedicle) and that of the entire viscus. At least in some organs, the lymph drainage and nerve supply also follow the other components of the segmental pedicle. The independence between segments can be complete or incomplete, the latter being related to the presence of anastomoses between vessels of adjacent segments. These anastomoses are, however, small in size and/or in number, and are located at the limits between segments. These intersegmental limits are recognizable as avascular or paucivascular zones, i.e., areas or lines, at which level surgical incisions are made for removal of the segment. Segmental independence can be permanent or temporary. Temporary independence, which is observed for example as lines or zones of ischemia when the blood supply is cut, need be sufficiently long for the performance of the segmentectomy. The normal, dynamic anatomy of the segment is modified and eventually altered by the surgical reduction or obliteration of the blood supply, drainage, or the flow of the contents of bronchi, renal calyces, or bile ducts, as the case may be, and thus facilitates the removal of a portion of the organ.

The differences among the organs stem from the

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morphological and functional features of each viscus. Accordingly, the 'segmenta hepatis' differ morphologically from the segments of other viscera but, similar to these, they constitute the anatomical basis for partial resection of the organ.

2. PORTO-BILIO-ARTERIAL (PORTAL) SEGMENTS AND HEPATIC (DRAINAGE) VENOUS SEGMENTS

The segments of the liver are defined as subdivisions of its parenchyma, based on the arterial and portal supply as well as on the biliary and venous drainage. The segments, however, are not separated by septa of connective tissue.

The historical background of the segments of the liver is relatively short. In fact, the anatomy of the segments has been known for many years but application of this knowledge for surgical purpose is recent, especially in comparison to the chronology of the identification and classification of segments in other organs. Although known for a long time, it is obvious that the practical importance of the anatomy of the segments depended upon advances in the technology related to surgery and pathology.

Traditional division and nomenclature of the liver were based on its surface morphology and anatomical relationships, and were directed by descriptive guidelines: right, left, quadrate, and caudate lobes, the latter comprising in turn the caudate and papillary processes.

The new or segmental division of the liver takes into account primarily the tridimensional arrangement of vascular (blood supply and drainage, lymph drainage) and ductal (biliary drainage) components as well as the nerve supply of the surgically removable independent territories of the liver. The hepatic angio-architecture shows very well that these segments are separate, supplied by isolated pedicles, and their independence allows for the performance of partial hepatectomy [15].

The characteristics of the segmental division of the liver are (a) the individual supply and drainage of each territory, (b) the constant pattern in the arrangement of vascular, ductal, and nerve elements, (c) the presence of eight porto-bilio-arterial segments intertwined with four hepatic segments, (d) the hepatic veins bridging the limits between porto-bilio-arterial segments, and (e) the permanent or temporary independence of the segments and, when temporary, at least of sufficient duration for the performance of the surgical procedure, such as partial hepatectomy, single or multiple segmentectomy.

The most demonstrable background for recognition of liver segments was found in the intraparenchymatous distribution of the portal vein, of the hepatic artery, of lymph vessels and nerves, and of the arrangement of the biliary ducts, which happen to run together (ordinarily an element representative of each component). On the other hand, the rootlets and roots of the hepatic veins, as expected, follow a course separate from the mentioned elements. The major trunks of the hepatic veins occupy intersegmental positions and each drains adjacent porto-bilio-arterial segments.

3. HEPATON, LOBULE, SEGMENT, LOBE

For practical and mnemonic purposes, the segmental arrangement of the liver can be considered as the magnification of the oversimplified classic liver lobule. This lobule is, according to Elias, an ephemeral expression of a field of pressure gradient [16]. In addition, one can extrapolate the topography of the vascular, ductal, and nerve elements of the hepaton (the supracellular morphological and functional unit of the liver) to the entire organ in order to better understand the framework in which the segments and their pedicles are arranged. (Analogous to nephron, neuron, and osteon, a hepaton represents the minimum amount of parenchyma able to function as the entire liver.) In fact, a section through a hepatic lobule or acinus as well as a stereoscopic diagram of hepatic structure show that (a) branches of the portal vein, (b) radicles of the biliary tree, (c) branches of the hepatic artery, (d) lymphatic vessels, and (e) nerve elements run together in angles of each polyhedral lobule; whereas the small central vein, a rootlet or a tributary of the hepatic (formerly called suprahepatic) vein, occupies the center (as implied in the name), the core, or the axis of the lobule (Fig. 1).

Considering the elements (artery and bile duct) that are located in the angles of the hepatic lobule as

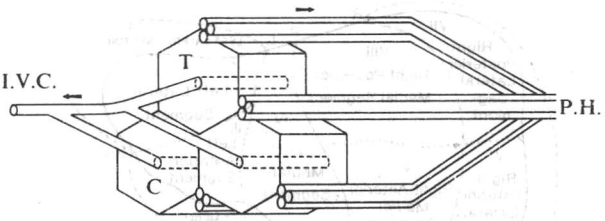


Figure 1. Simplified diagram of three liver lobules that illustrate portal triads (T), the elements of which unite and lead ultimately to the porta hepatis (P.H.), while the central veins (C) join and lead ultimately to the inferior vena cava (I.V.C.). The location of the triads and of the central veins reminds one of the different arrangement of porto-bilio-arterial (portal) segments and of hepatic venous segments as well as their interdigitation.

satellites or 'comitantes' of the portal branches, the name portal triad (or tetrad or pentad, if one also counts the lymphatic and/or nervous elements) can be applied. Disregarding for purposes of simplification the lymphatic and nervous components, the *portial triad* is made up of a branch of the portal vein (representative of *vasa publica*), a branch of the hepatic artery (representative of *vasa privata*), and a rootlet of the bile ducts (the interlobular bile ductule). A comprehensive name for all these structures could, therefore, be 'porto-bilio-arterial' elements (the so-called Glissonian system) or, simply, 'portal' elements, as they seem to follow, or to be followed by, the portal ramification or distribution in the parenchyma of the liver.

It is apparent that the arrangement of the porto-bilio-arterial elements does not coincide with that of the hepatic venous elements. In fact, these two sets of elements interdigitate, an arrangement that explains why the hepatic veins are intersegmental, that is, located on the boundaries of the porto-bilio-arterial segments, draining adjacent segments.

By comparing the liver (portal and hepatic) segments and other known visceral segments, one notices that to a certain extent the position of the central veins (or their corresponding larger vessels) is equivalent to that of the intersegmental veins of the lungs and of the kidney while the segmental pedicles of the spleen stand alone by not resembling the other parenchymatous organs in this respect. Another exclusive feature of liver segmentation resides in the different location of the segmental pedicles; the porto-bilio-arterial segments have pedicles at the level of the hilum or porta hepatis, whereas the hepatic venous segments are drained by veins directed toward the inferior vena cava. Finally, one or more segments are contained in the traditional lobes of the liver.

Carrying the microscopic image to the entire liver and primarily utilizing plastic injection and corrosion specimens, it is easy to visualize and understand the different topography of the porto-bilio-arterial elements and of the hepatic venous elements. As pointed out, this difference leads to the identification of 'portal' (porto-bilio-arterial) segments and 'hepatic venous' segments, and to the recognition that the segmental pedicles do not contain all the elements relating to each segment: the porto-bilio-arterial elements of a segment have to be reached from the hepatic hilum, while the hepatic vein(s) draining the segment will be found at the limit between segments, which can be better identified when one (or more) vascular element(s) of the segmental pedicle is temporarily or permanently ligated.

4. HISTORICAL BACKGROUND OF SEGMENTATION OF THE LIVER

A brief survey of the literature shows that several descriptions, implicit or explicit, of the segments of the liver have been published with a number of classifications and variable nomenclature, and with the use of a wide variety of techniques that have given rather consistent results. The most commonly known are contained in papers, theses, books, or monographs [1, 15, 17–19, 20–45].

Comparison between the descriptions of liver segmentation presented by the authors mentioned above indicated that the variations, oscillating around a medium, which is the most frequent type, can be explained by observation of different samples of the population. The average pattern, however, was found and can be utilized as a basis for study and practical application [1], especially in surgery and pathology.

5. NOMENCLATURE AND NUMBERING OF THE SEGMENTS OF THE LIVER

The variable terminology used by the investigators is explained by the fact that the segments were studied in situ, in the isolated liver, in the ana-

tomical position for description, or in another position, considering the middle of the organ or the sagittal plane of the human body as the major reference.

The International Anatomical Nomenclature Committee [46] recognized that there is not yet complete agreement among authorities on segmentation. It is hoped that a recommendation will be prepared by the committee for adoption of a terminology that will satisfy the majority. Toward this goal, the following nomenclature, numbering of segments, and naming of fissural planes and elements of segmental pedicles will serve as a subsidy to the Committee.

Previous excellent contributions on the subject by several authors, already quoted, were compared and correlated, and were again compared and correlated with the traditional morphological division. It was found that the correlations were conducive to an average or prevailing pattern in the intrahepatic distribution of the elements of the hepatic pedicle and of the venous drainage of the liver toward the inferior vena cava. In fact, it became evident that Couinaud's system of liver segmentation was the natural culmination of the pioneering work done or developed by the investigators mentioned above, as is demonstrated in his comprehensive monograph [33]. This conclusion was drawn on the basis of the confirmation of Couinaud's system of division and subdivision of the liver by several authors [1, 30, 35, 36, 39, 44, 45, 47, 48].

In our former department of anatomy (Faculty of Medicine, University of Minas Gerais, Belo Horizonte, Brazil), Nogueira [35, 36] was able to duplicate Couinaud's findings in 52 specimens and we reproduced his results in eight preparations in the department of anatomy of the Medical College of Ohio [45]. Based on our own experience and on the data of other investigators, we recommend the adoption of Couinaud's classification with slight modification and a few additions to the terminology and numbering of the hepatic venous segments (Fig. 2).

The portal (porto-bilio-arterial) segments are numbered clockwise with Roman numerals from I to VIII. The hepatic venous segments (venous drainage segments) interdigitate with the portal segments and are numbered clockwise in Arabic

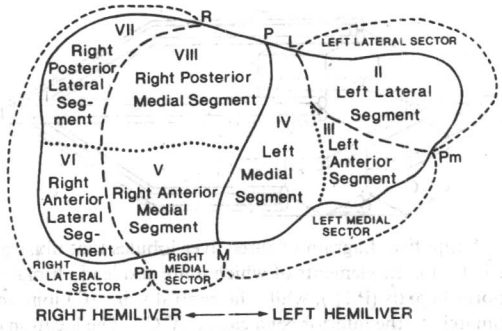


Figure 2. Diagram of the diaphragmatic aspect of the human liver showing the division into halves, sectors, and segments, based on the porto-bilio-arterial or, simply, portal distribution, according to Couinaud [33]. M-cystic fossa and P-fossa of the inferior vena cava, united by a line – MP – indicating the *median* fissural plane, on the surface of the liver; R and Pm, posterior and anterior extremities of the right paramedian fissural plane (broken line, long dashes – RPm); L and Pm, posterior and anterior ends of the left paramedian fissural plane (broken line, long dashes – LPm); dotted lines indicate intersegmental fissural planes. The limits of the sectors are indicated by broken lines (small dashes), external to the periphery of the liver. RPmMP, right medial sector; LPmMP, left medial sector. The dorsal segment (1 or I) is not visible.

numerals from 1 to 4, looking at the diaphragmatic aspect of the liver in situ from an anterosuperior view (the numbering is counterclockwise when looking at the visceral aspect of the liver).

The *portal segmentation* ordinarily presents the following pattern. The liver is divided into halves, that is, *right hemiliver* and *left hemiliver*, by a middle plane that runs from the middle of the cystic fossa to the left side of the fossa of the interior vena cava, except for the caudate lobe or dorsal sector, which remains undivided to constitute a segment (Fig. 3). Each hemiliver is subdivided into *sectors* by paramedian planes. (The adjective paramedian is used in

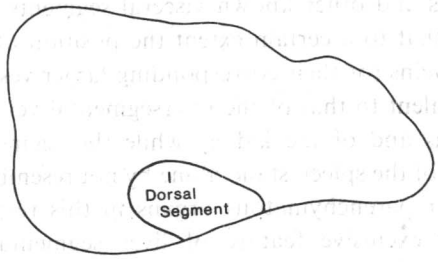


Figure 3. Diagram of the visceral aspect of the liver, reflected superiorly, to show the location of the dorsal segment I of the porto-bilio-arterial segmentation or dorsal segment 1 of the hepatic venous drainage segmentation (the territory is the same in either subdivision) and corresponds to the former caudate lobe.

relation to the isolated liver and not in relation to the median sagittal, or simply sagittal, plane of the body.) Each sector is further subdivided into eight portal *segments* by certain planes of separation, as illustrated (Figs. 2 and 3).

The *hepatic venous segments* correspond to the four independent territories drained by the hepatic veins into the inferior vena cava and are separated by fissural planes (Fig. 4).

The segment that is represented by the traditional caudate lobe is the only one where there is coincidence and not interdigitation of the two systems (Figs. 3 and 4). It is called the dorsal segment and is the only territory that corresponds at the same time to a portal segment (I) and to a hepatic venous segment (1).

The segments of the liver (Figs. 2–5) may be classified, named, and numbered as shown in Table 1.

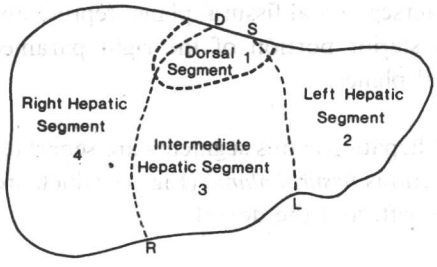


Figure 4. Diagram of the diaphragmatic aspect of the liver, showing the boundaries between the four hepatic venous segments (of blood drainage). The dorsal segment 1 is seen by transparency. The broken lines indicate the fissural planes: dorsal, to separate the homonymous sector and segment (caudate lobe); left (SL), and right (DR) fissural plane.

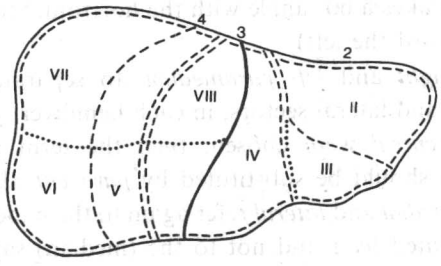


Figure 5. Diagram of the diaphragmatic aspect of the liver showing all the segments except dorsal segment 1 or I. The portal segments (II–VIII) are superimposed on the hepatic venous segments (2, 3, 4) or vice versa, to show their interdigitation and other relationships.

6. FISSURAL PLANES

The planes of separation, incision, or cleavage are called fissural planes because they are seen after vascular injection of a plastic substance, followed by corrosion, or after permanent or temporary surgical obliteration of a vessel. While a fissure, therefore, is a cleft (anatomically visible), a fissural plane is a cleavage or a potential plane of separation that may correspond to a limit or boundary of pathological lesions and may be artificially made.

The *fissural planes* of portal segmentation are (Figs. 2–4):

1) Median, main, or principal fissural plane between the hemilivers. The term *median* could be replaced by *central* if one wishes to avoid possible confusion with the median plane of the body. This

Table 1.

A. Portal (porto-bilio-arterial) segmentation

	Dorsal sector[a] ...	dorsal segment (I): invisible on the diaphragmatic aspect
Left hemiliver	Left lateral sector[a] ...	left lateral segment (II)
	Left medial sector ...	left anterior segment (III) left medial segment (IV)
Right hemiliver	Right medial sector ...	right anterior medial segment (V)
	Right lateral sector ...	right posterior medial segment (VIII): invisible on the visceral aspect right anterior lateral segment (VI) right posterior lateral segment (VII)

B. *Hepatic venous segments (segments for blood drainage)*

Dorsal hepatic venous segment (1)
Left hepatic venous segment (2)
Intermediate hepatic venous segment (3)
Right hepatic venous segment (4)

[a] Unisegmental sectors; the other sectors are bisegmental.

plane makes a 60° angle with the horizontal (opening toward the left).

2) *Right* and *left paramedian*, to separate the medial and lateral sectors, in each hemiliver. If the word *central* were chosen, then the term paramedian should be substituted by *paracentral*. The terms *medial* and *lateral* refer again to the middle of the isolated liver and not to the (median) sagittal plane of the body. The *right paramedian plane* has the anterior extremity at a point in the inferior margin of the liver situated between the median fissural plane and the right hepatic 'angle' (one-third from the latter). From this point, the plane runs 6 cm from and parallel to the right liver margin, then curves toward the left and ends at its posterior extremity (behind the termination of the right hepatic vein, on the right side of the inferior vena cava). This plane makes a 50° angle with the horizontal (opening toward the right). The *left paramedian plane* has the anterior extremity at a point in the inferior margin of the liver located midway between the round ligament and the left hepatic 'angle'. Its posterior extremity is situated to the left of the termination of the left hepatic vein. This plane almost transversely cuts the left lobe of the liver since it is curved, having the concavity toward the left and posteriorly; it has a transverse anterior portion and a sagittal posterior portion.

3) *Dorsal*, to separate the dorsal sector, which constitutes the segment (I) that corresponds to the traditional caudate lobe.

4) *Intersegmental*, between the following segments:

a) Left lateral segment (II) and left anterior segment (III) separated by the intersegmental plane, represented by the transverse portion of the left paramedian fissural plane (which is curved and not straight as the right paramedian fissural plane).
b) Left lateral segment (II) and left medial segment (IV), separated by the sagittal portion of left paramedian fissural plane.
c) Left anterior segment (III) and left medial segment (IV), separated by the left intersegmental fissural plane, which is the anterior continuation of the sagittal portion of the left paramedian fissural plane.
d) Left medial segment (IV) and right anterior medial segment (V), separated by the anterior portion of the median fissural plane.
e) Left medial segment (IV) and right posterior medial segment (VIII), separated by the intersegmental plane, represented by the posterior portion of the median fissural plane.
f) Right anterior medial segment (V) and right anterior lateral segment (VI), separated by the anterior portion of the right paramedian fissural plane.
g) Right anterior medial segment (V) and right posterior medial segment (VIII), separated by the medial portion of the transversal intersegmental fissural plane.
h) Right anterior lateral segment (VI) and right posterior lateral segment (VII), separated by the lateral portion of the transversal intersegmental fissural plane.
i) Right posterior lateral segment (VII) and right posterior medial segment (VIII), separated by the intersegmental fissural plane, represented by the posterior portion of the right paramedian fissural planes.

The four hepatic venous segments are separated by hepatic venous *fissural planes* (Fig. 4), which are the right, the left, and the dorsal:

a) The *dorsal*, to separate from the remaining liver the dorsal segment (1) that coincides with the portal segment (I).
b) The *left*, between the left hepatic venous segment (2) and the intermediate hepatic venous segment (3).
c) The *right*, between the intermediate hepatic venous segment (3) and the right hepatic venous segment (4).

The *dorsal fissural plane* can be divided into a right and a left portion as it separates the dorsal segment from the right and the left hemiliver.

The left hepatic fissural plane corresponds to the insertion of the falciform ligament on the diaphragmatic aspect and to the left longitudinal sulcus of the visceral aspect of the liver. Its anterior and posterior extremities correspond, respectively, to the insertion of the round ligament and to the dorsal termination of the sulcus of the ductus venosus. It is perpendicular to the visceral aspect of the liver, separates the left hepatic venous segment

(traditional left lobe) from the intermediate hepatic venous segment, and is located midway between the left and the intermediate hepatic veins.

The *right hepatic fissural plane*, situated midway between the intermediate and the right hepatic veins, separates the intermediate from the right hepatic venous segment. It is slightly curved with the concavity toward the left. Its posterior extremity is found between the terminations, in the inferior vena cava, of the right and intermediate hepatic veins. Its anterior extremity corresponds most frequently to a point midway between the cystic fossa and the right anterior angle of the liver or, in other words, it is located between the anterior extremities of the median and the right paramedian fissural plane.

7. DESCRIPTION OF THE SEGMENTS AND SEGMENTAL PEDICLES

7.1. Portal segmentation (Fig. 6)

I) The *dorsal segment* is seen only on the visceral aspect of the liver. It corresponds to the caudate lobe and includes the deep hepatic parenchyma, behind the hilum; that is, between the portal vein and the inferior vena cava. It has boundaries with the left medial (IV), right posterior medial (VIII), and right posterior lateral (VII) segments. The old caudate lobe constitutes at the same time a portal segment (I) and a hepatic venous segment (1) from the standpoint of vascularization. The elements of its segmental *pedicle* are (a) three veins from the left branch of the portal vein; (b) one or two arteries from the left branch of the hepatic artery; (c) biliary ducts leading to the right and left roots of the hepatic duct; and (d) dorsal hepatic veins draining into the inferior vena cava, in the intermediate or in the left hepatic vein.

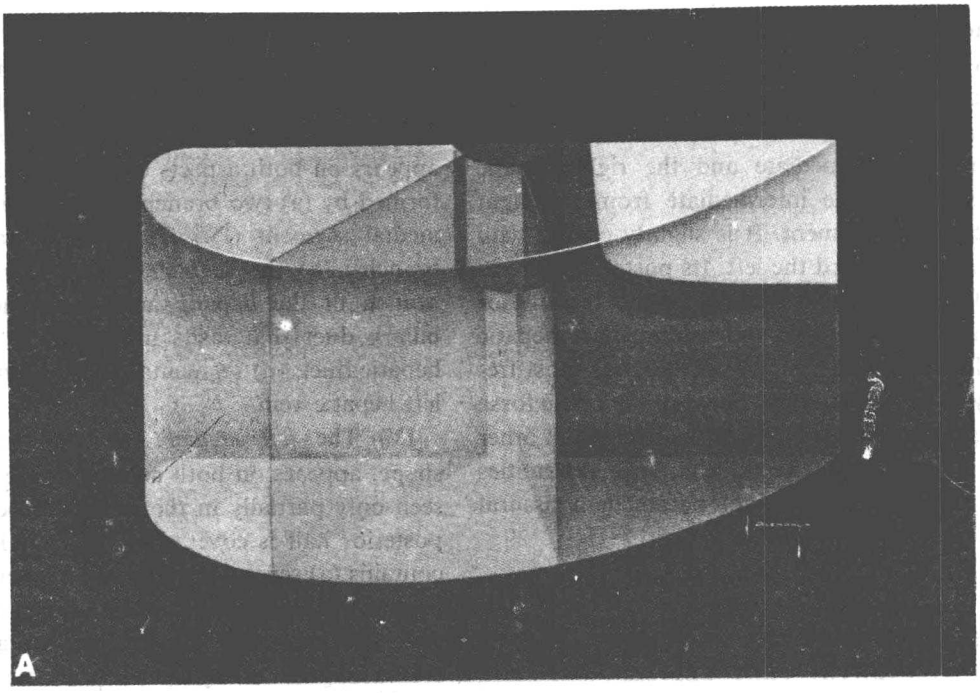
II) The *left lateral segment* is seen as an oval territory on visceral and diaphragmatic aspects of the liver in the extreme left of the organ. The *pedicle* of the left lateral segment is made up of (a) the homonymous vein (or angular vein) of the portal vein; (b) the homonymous artery, originating with the artery of segment III from a common trunk given off by the left branch of the hepatic artery; (c) the segmental biliary duct, which joins that of segment III to form a large duct that in turn becomes the left root of the hepatic duct; (d) segmental veins that drain into the left hepatic vein.

III) The *left anterior segment*, triangular in shape, appears on both aspects of the liver. Its *pedicle* is formed by (a) two branches of the vein of the left medial segment (IV) from the portal vein (left branch); (b) the segmental artery, from the left branch of the hepatic artery; (c) the segmental biliary duct that leads into the left root of the hepatic duct; (d) segmental veins draining into the left hepatic vein.

IV) The *left medial segment*, rectangular in shape, appears on both aspects of the liver, but is seen only partially in the visceral aspect since the posterior half is covered by segment I. Its *pedicle* contains (a) several branches of the vein of the left medial segment (IV), in turn a branch of the portal vein (left branch); (b) the segmental artery, a collateral given off by the left branch of the hepatic artery; (c) the segmental biliary duct empties in the trunk formed by the confluence of the ducts of segments I and II; (d) the left root of the intermediate hepatic vein and its affluents.

V) The *right anterior medial segment* is seen in both aspects of the liver as a quadrangular territory. Its *pedicle* comprises (a) a group of veins, which are the anterior branches of the vein of the right medial sector, in turn a branch of the portal vein (right branch); (b) the segmental arteries originated from the artery of the right medial sector; (c) the biliary ducts that lead to the biliary duct of the right medial sector; (d) segmental veins that drain into the right root of the intermediate hepatic vein and a few that are tributaries of the right hepatic vein.

VI) The *right anterior lateral segment* is visible on both aspects of the right anterior 'angle' of the liver. Its *pedicle* consists of (a) one or more branches of the vein of the right lateral sector, a branch of the portal vein (right branch); (b) segmental arteries originated from the artery of the right lateral sector; (c) segmental biliary ducts which join those of segment VII to form the biliary duct of the right lateral sector; (d) the roots and affluents of the right hepatic vein. In 20% of the cases, Nogueira [35] observed that the right root of the intermediate hepatic vein contributes to the drainage of this segment.



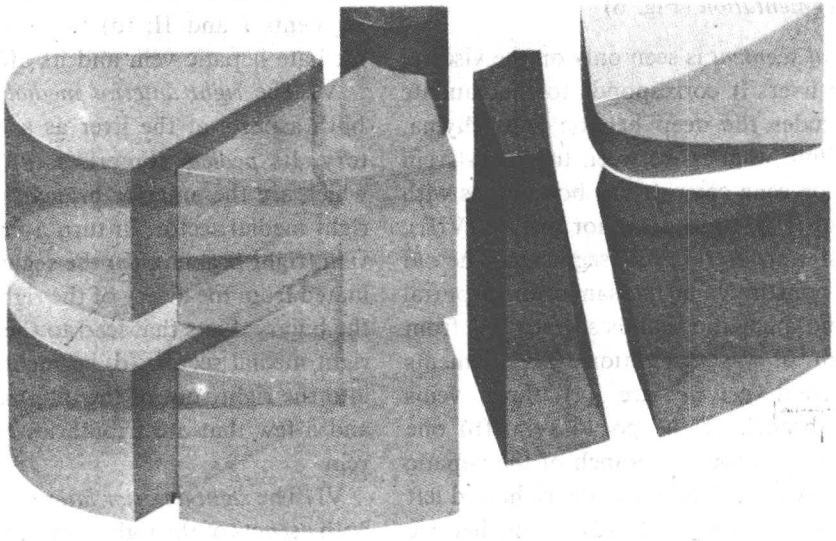


Figure 6. Ideal diagrams of the sectors and segments of the liver in transparent colors to give their approximate arrangement. In diagrams *A–C*, colors indicate the following: *blue*, dorsal sector, segment I or I or caudate lobe; *yellow*, left lateral sector or segment II; *brown*, left medial sector, made up of segments III and IV (left anterior and left medial, respectively); *red*, right medial sector, made up of segments V and VIII (right anterior medial and right posterior medial, respectively); *green*, right lateral sector, made up of segments VI and VII (right anterior lateral and right posterior lateral, respectively). The sectors are made up of one or more segments.