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SEGMENTS OF THE LIVER

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After PECQUET (1651) it was GLISSON (1654) who gave a clear description of the liver hilum; the loose connective tissue entering the liver with the portal vessels and sheathing the larger vessels has been termed after him Glisson's capsule or Glisson's pedicle. Since these first descriptions no other works seem to have appeared until recent times which would deal with the part played by these sheaths of connective tissue in the structure and segmentation of the liver. Let us mention for the sake of comparison that a detailed description regarding the anatomy of the bronchi was published by AEBY as far back as 1880, while it was only in 1932 that KRAMER and GLASS divided the lung into much smaller anatomical and pathological parts than the lobes, namely into segments. The segmental structure of the lungs has become a household concept in medical science, and is of great significance in both clinical and pathological practice.

The development of the lung and that of the liver shows many common features. Both organs are entodermal in origin arising from the primitivegut. The chief features of their later structure appear as early as the third intrauterine month. Both organs are provided with a functional and a nutritive vascular system. We regard the pulmonary segments as bronchovascular units in which bronchi and arteries constitute the pedicle of the segment; subsequently, they run and divide together in the parenchyma, while the venous trunks are arranged alongside of the intersegmental septa. — In the division of the liver into segments the same principles have been observed. Thus, each hepatic segment constitutes a bilio-vascular unit, the pedicle of which consists of a branch of the portal vein, the hepatic artery and the hepatic duct. Arising in the porta hepatis from a common Glisson capsule, these structures divide together in the hepatic parenchyma. The branches of the hepatic vein run in the intersegmental scissures. These scissures of the liver appear between the Glisson capsules: they are comparatively poor in vessels, containing only one of the main rami of the hepatic vein. So far, no intersegmental septa could be demonstrated in them with any certainty.

The segmental structure of the liver has engaged the attention of a number of recent authors. The segmentation, as defined by them, is based either on the arrangement of the portal vessels or the ramification of the hepatic vein. Confining themselves to surgical considerations, they seem to neglect the fundamental principle that — in distinguishing separate hepatic areas — nothing but integral bilio-vascular units can be accepted as independent segments.

After a profound and detailed study of the anatomy of the intrahepatic vessels, biliary ducts and Glisson's-pedicles, COUINAUD (1954) divided the liver into eight segments (I to VIII) on account of the distribution of Glisson's capsules. The division suggested by ELIAS (1954), based principally on the ramification of the hepatic vein, rather arbitrary, while HEALEY (1954) and JUNES (1956) pay due regard to the topography of both the portal vessels and the branches of the hepatic vein, so that the primary significance of their segmentology lies in the field of surgery.

No segmentological works have been published in the Hungarian literature, while we encounter significant works concerning the intrahepatic anatomy of special formations, e. g. GELLÉRT, A. (1931), KÁDÁR, F. (1952), HITTNER, I., HÜTTL, T., ZSEBŐK, Z. (1952).

Relying on literary data and on their own preparations, the present authors propose to present in the following division into segments of the liver in which each segment forms a separate bilio-vascular unit and which may serve not only surgical purposes but also those of localization in pathology.

Anatomical descriptions distinguish two hepatic surfaces a convex anterior and a concave posterior surface. The first is divided into a right and a left part by the falciform ligament. An H-shaped groove appears on the second; the horizontal cross bar of this groove is occupied by the portal vessels, its left inferior leg by the round ligament of the liver, its left upper leg by the duct of Arantius, its right inferior leg by the gall bladder and its right upper leg by the v. cava inferior. The quadrate lobe lies between the inferior legs of the H-shaped figure, the caudate lobe between its superior legs. On the concave surface of the liver, near the upper border of the right lobe, we encounter a comparatively large area which is not covered by peritoneum, while all other parts of the liver — with the exception of the hilum — are protected by peritoneum. This peritoneal cover includes the gall bladder as well.

Between the bottom of the H-shaped groove on the concave surface and the parenchyma of the liver is a strong layer of connective tissue, the portal aponeurosis. The bed of the v. cava inferior is an exception in this respect: it lies in the parenchyma without intervening aponeurosis. While — as has been said above — the transversal bar of the H-shaped groove covers the portal vessels, no vessels are found in the upper left and lower right leg of the figure; these are the remains of the duct of Arantius and the supra-

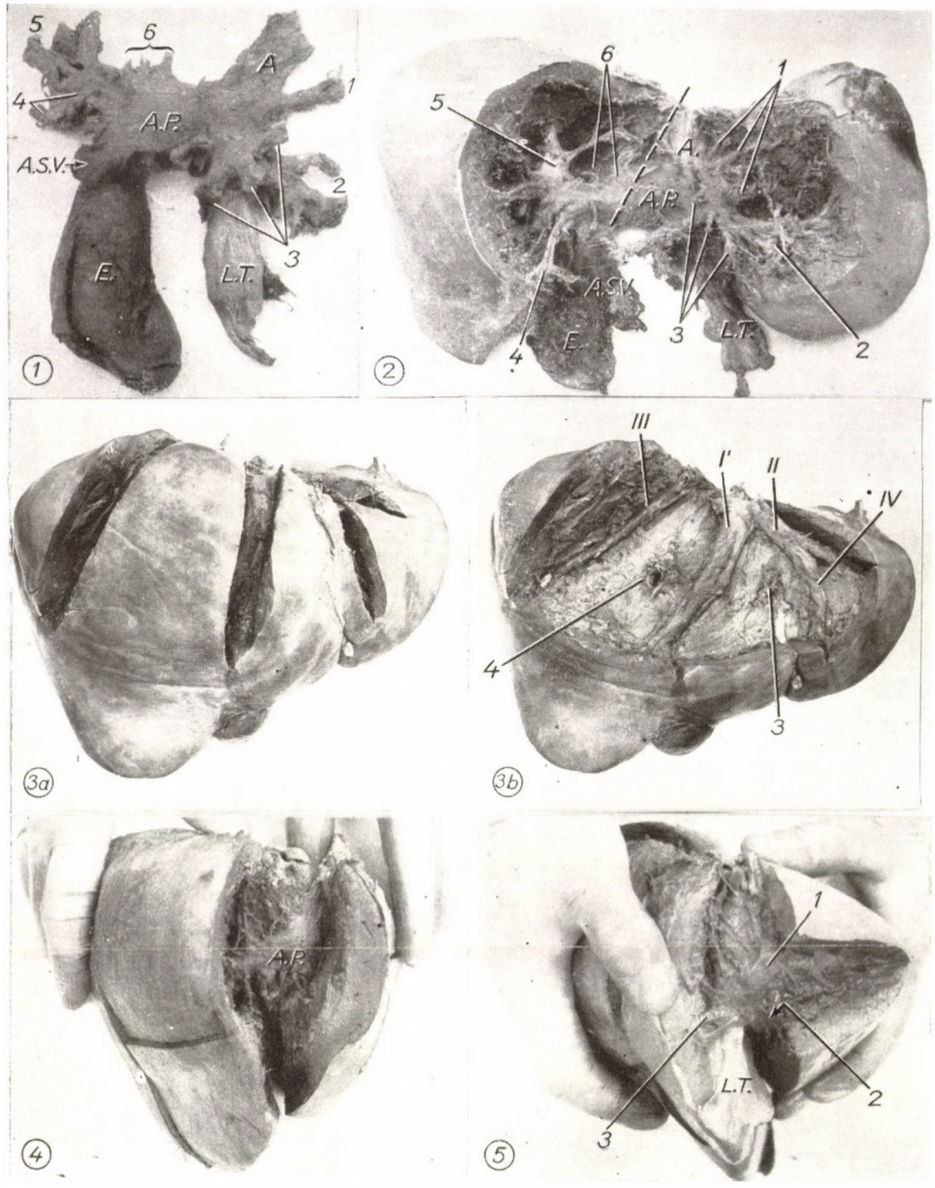

Fig. 1. Branches of the portal aponeurosis, and the origin of Glisson's capsules

E. Gallbladder
L. T. Lig. teres hepatis
A. Remains of Ductus venosus Arantii
A. P. Portal aponeurosis
A. S. V. Aponeurosis supravesicularis
1. Sinistro-posterior-superior capsule
2. Sinistro-posterior-inferior capsule
3. Sinistro-anterior capsule
4. Dextro-anterior capsule
5. Dextro-posterior capsule
6. Capsules of caudate lobe

Fig. 2. Glisson capsules in situ

E. Gallbladder
L. T. Lig. teres hepatis
A. Remains of Ductus venosus Arantii
A. P. Portal aponeurosis
A. S. V. Aponeurosis supravesicularis
1. Sinistro-posterior-superior capsule
2. Sinistro-posterior-inferior capsule
3. Sinistro-anterior capsule
4. Dextro-anterior capsule
5. Dextro-posterior capsule
6. Capsules of caudate lobe
Rex-Cantlie line indicated by dots

Fig. 3. Course of veins

a) Projection of veins on the surface of the liver
b) Veins in situ
3. Sinistro-anterior Glisson capsules
4. Dextro-anterior Glisson capsule
I. Vena hepatica r. med.
II. Vena hepatica r. sin.
III. Vena hepatica r. dext.
IV. Vena hepatica r. inf. sin.

Fig. 4. Main scissure, open

A. P. Portal aponeurosis

Fig. 5. Left lateral scissure, open

L. T. Lig. teres hepatis
1. Sinistro-posterior-superior capsules
2. Sinistro-posterior-inferior capsules
3. Origin of sinistro-anterior capsules

vesicular aponeurosis which lines the bed of the gallbladder. The proximal two thirds of the left lower leg of the H-shaped groove form an area penetrated by vessels, while its remaining distal third part forms the remains of the obliterated umbilical artery and vein. It is at the points where the portal aponeurosis is penetrated by the portal veins that Glisson's capsules take their origin (Fig. 1).

A little to the right of the juncture of the supra-vesicular and the portal aponeuroses, a thick Glisson capsule arises perpendicularly to the liver's convexity which, shortly after its origin, divides in the sagittal plane into an upper and a lower part. This is the dextro-anterior capsule. Laterally from this, in the frontal plane (or rather somewhat toward the liver's concavity and upper border), another capsule arises which divides in a pectinate form immediately after its origin, extending towards the right-side border of the liver. This is the dextro-posterior capsule. Again, two to three thick capsules, at right angles to the liver's convexity, arise from the left-side portion of the portal aponeurosis, immediately before its passing into the round ligament of the liver. These are the sinistro-anterior capsules. Next to the origin of the remains of the ductus venosus Arantii, one or two thicker capsules arise and extend in the frontal plane towards the liver's left-upper border. These are the sinistro-posterior-superior capsules. Between these and the point of origin of the sinistro-anterior capsules further two to three capsules are to be found, namely the sinistro-posterior-inferior capsules, which — arising possibly from a common trunk — extend frontally towards the left inferior border of the liver. — These are the Glisson capsules that must be regarded as the pedicles of the particular segments (Fig. 2).

Coming from the lower border of the liver, we encounter in the hilum, first, the hepatic duct ; second, the hepatic artery ; third, the portal vein. This vascular arrangement remains essentially unchanged in Glisson's capsules, the only difference being that the portal vein is invested with loose connective tissue in Glisson's capsule which facilitates its isolation. The artery and the hepatic duct, on the other hand, are embedded in the capsular tissue and, therefore, not easy to isolate. The intrahepatic neural and lymphatic plexuses, too, run in Glisson's capsules. Therefore, a radiographic inspection of any figure of a Glisson's capsule discloses to the observer the topography of all other vessels.

Viewed frontally, the boundaries of the segments are determined by the course of the branches of the hepatic vein. Most of the efferent hepatic vessels collect in three main trunks. The middle branch of the hepatic vein runs along the Rex-Cantlie line, i. e. the line which, passing near the liver's convexity, connects the central part of the bed of the gallbladder with the inferior vena cava. (Rex — in a fundamental work on the intrahepatic ramifications of the portal vein, published as far back as 1888 — indicated the said line as

the boundary between the two lobes of the liver.) The left branch of the hepatic vein follows the course of the falciform ligament. The right-side branch arises at the juncture of the liver's anterior and superior surface (approximately at the height of the right coronary ligament), and turns to the anterior surface at a distance of 1 to 2 inches medially from the right border of the liver. Before emptying into the inferior vena cava, the middle and the left branch usually unite in a short thick trunk, while the right branch empties independently into the said vein. Each of the venous rami drains two adjacent areas. Apart from these main trunks two more veins, draining the caudate lobe, empty directly into the inferior vena cava, and so does a varying number of veins from the area of the posterior segment. The venous pattern is rather variable, and it is only the position of the middle and left trunk which is comparatively stable. The veins and the Glisson capsules intersect; their relative positions are reminiscent of the spokes and the rim of a wheel (Fig. 3).

If we intersect the liver along the Rex-Cantlie line at an acute angle which is open towards the right, we arrive at the centre of the portal aponeurosis. Avoiding the middle trunk of the hepatic vein we encounter in this line of intersection no significant ramus of either the hepatic artery, the portal vein or the hepatic duct, which is to say that we arrive into a virtual scissure comparatively free of blood vessels. As, beneath the middle part of the portal aponeurosis (which constitutes the base of the line of section), the portal vessels divide into the branches that supply the right and left lobe, respectively, it is actually the main scissure, constituting the interlobar boundary, which, has been laid bare (Fig. 4). A section at an acute angle, open to the right, made under similar conditions along the line of the left hepatic vein, lays bare the left longitudinal intersegmental scissure. At the base of the line of section the origin of the left anterior, the left superior anterior and the inferior posterior capsules can be seen (Fig. 5). The left anterior capsules supply the hepatic area between the two scissures laid bare by the above-described two sections. Therefore, the area in question may be regarded as an independent biliovascular unit, whose efferent veins empty into the middle and left hepatic trunks. To this segment belongs the entire quadrate lobe. Considering its position we have termed it segmentum mediale anterius sinistrum. The area between the left scissure and the left border of the liver is supplied by Glisson's capsules that arise independently of, and form an acute angle with, one another. By making a horizontal cut between these capsules at right angles to the left scissure which reaches as far as the left border of the liver, we arrive at the left horizontal intersegmental scissure which divides the area between the left scissure and the left border of the liver into two segments, the segmentum laterale superius sinistrum and the segmentum laterale inferius sinistrum. The upper segment is drained by almost horizontally running venous branches which usually unite into a common trunk about the point where the ligamen-

tum coronarium sinistrum and the ligamentum falciforme meet; this trunk empties into the left hepatic vein. This segment, too, may be considered to constitute an independent bilio-vascular unit. Also the left inferior lateral segment forms a separate unit as it is usually drained by a ramus of the hepatic vein which runs at a steep acute angle. Sometimes, not frequently, this segment, devoid of a separate venous ramus, is supplied by the venous system of the upper segment: in these cases it must be regarded as a subsegment

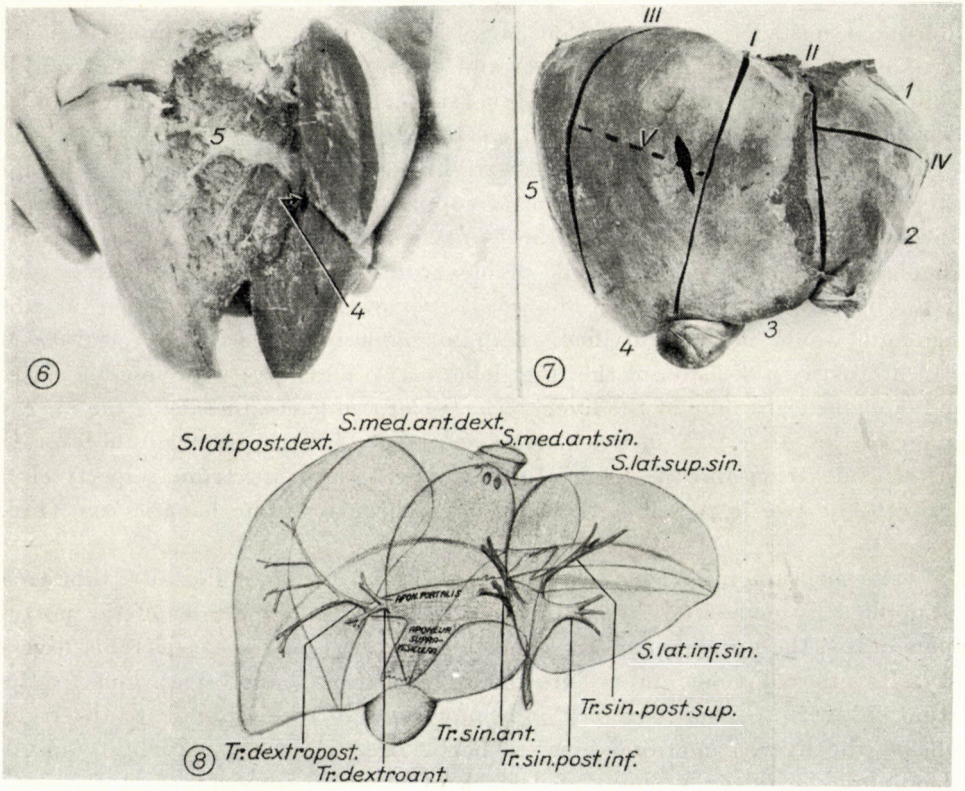

Fig. 6. Right lateral scissure, open

4. Origin of dextro-anterior capsules
5. Dextro-posterior capsule (comblike division well observable)

Fig. 7. Segments of the liver

I. Main scissure
II. Sinistro-lateral scissure
III. Dextro-lateral scissure
IV. Left transverse scissure
V. Scissure between dextro-anterior subsegments
1. Segmentum laterale sup. sin.
2. Segmentum lat. inf. sin.
3. Segmentum med. ant. sin.
4. Segmentum med. ant. d. (upper and lower subsegments)
5. Segmentum lat. post. d.

Fig. 8. Sketch of hepatic structure

only. — The next step is to open the right scissure by a cut made along the line of the right hepatic vein at an acute angle which is likewise open to the right (Fig. 6). The area between the main and the right scissure receives its blood supply from the dextro-anterior trunk coming from the direction of the porta hepatis. Its efferent veins empty into the right hepatic vein. The area in question forms the segmentum mediale anterius dextrum. Immediately after its origin, the dextro-anterior trunk divides into an upper and a lower branch. Considering its portal supply, the segment might be divided into two additional parts; as, however, it lacks independent draining veins, all we can do is to divide it into an upper and a lower subsegment by a horizontal plane which traverses the division of the dextro-anterior Glisson capsule. The hepatic area situated laterally from the right scissure, including — in the main — the posterior surface of the right lobe, constitutes the segmentum laterale posterius dextrum. Its portal supply is through the latero-posterior Glisson capsule, and its efferent veins empty into the right hepatic vein branch. The latero-posterior portal trunk divides comblike toward the right border of the liver. The divisions are, however, so variable that a definition of subsegments would not be justified. KÁDÁR's experiments with corroded casts seem to justify a division of the right lobe in two portions; studying his casts, he found the right lobe of the liver to consist of two parts, one being the mirror image of the other. These two portions correspond to the segmentum laterale posterius dextrum and the segmentum mediale anterius dextrum, respectively; between the two is running, the right main branch of the hepatic vein (Fig. 4, 5, 6).

A special mention should made of the caudate lobe. Portally, this area is supplied by means of capsules arising from the upper border of the portal aponeurosis, the number and arrangement of which show a considerable diversity. Its efferent veins empty into the inferior vena cava. According to the situation of its Glisson capsules, it belongs now to the left, now to the right lobe of the liver, sometimes even to both. Because of the variability of its blood supply, and on account of its lack of practical importance, it does not seem justified to regard it as a separate segment (Fig. 7, 8).

Summary

Our investigations have led us — in agreement with several other authors — to the conclusion that the so-called Rex-Cantlie line should be regarded as the boundary between the lobes of the liver. In dividing the liver into separate segments, care was taken to define as segments only independent bilio-vascular units. Following this principle, the right lobe was found to consist of two genuine and two subsegments, the left lobe to be composed of three genuine segments. The segmentation of the liver means a valuable assistance in interpreting portographs and cholangiographs with respect to localization. A familiarity with segment boundaries and the topography of venous branches running in the intersegmental scissures, as well as Glisson's capsules, enables the surgeon to perform operations (e. g. segment resection; hepato-digestive anastomoses) without any unnecessary destruction of parenchyma. A dissection of the liver according to segment boundaries constitutes a fundamental part of the localizationalpathology of hepatic lesions.

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СЕГМЕНТЫ ПЕЧЕНИ

Г. КОИШШ и ДЬ. СЕЧЕИ

Резюмируя свои результаты, авторы установили, что они определили границу между долями печени на линии Рекс—Кэнтлей, что находится в полном согласии с результатами других авторов. При разграничении отдельных сегментов они тщательно следили за тем, чтобы все описанные ими сегменты образовали самостоятельные билиоваскулярные единицы. Принимая это во внимание они установили, что правая доля состоит из двух настоящих и двух подсегментов, а левая доля из трех настоящих сегментов. Разделение печени на сегменты оказывает большую помощь в деле портографической и холангиографической локализационной оценки. Зная топографию отдельных сегментарных границ, или же проходящих в межсегментарных щелях стволов печеночной вены, также как и глиссоновых капсул мы имеем возможность проводить хирургические вмешательства без потери паренхимы (резекция сегментов, печеночно-пищеварительные анастомозы). Вскрытие печени по отдельным сегментарным границам является основой локализационной патологии при изменениях печени.

DIE LEBERSEGMENTE

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In Übereinstimmung mit anderen Autoren wurde die Grenze zwischen den Leberlappen in der Rex-Cantlie Linie gefunden. Bei der Abgrenzung der einzelnen Segmente wurde darauf geachtet, dass jedes umschriebenes Segment eine selbständige biliovaskuläre Einheit bilde.

Unter Berücksichtigung dieses Gesichtspunktes wurden im rechten Lappen zwei echte und zwei Subsegmente, im linken jedoch drei echte Segmente festgestellt. Die Aufteilung der Leber in Segmente soll die Lokalisationsauswertung der Portographie und Cholangiographie erleichtern. In Kenntnis der einzelnen Segmentgrenzen, bzw. der in den intersegmentalen Spalten verlaufenden Stämme der V. hepatica, sowie der Topographie der Glissonschen Kapsel, ist die Möglichkeit zur Durchführung chirurgischer Eingriffe ohne überflüssigem Parenchymverlust geboten (Segmentresektion, hepato-digestive Anatomosen). Die Zerlegung der Leber der einzelnen Segmentgrenzen gemäss bildet eine entsprechende Grundlage für die Lokalisationspathologie der Leberveränderungen.

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