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THE INTRAHEPATIC ANATOMY AND ITS REPERCUSSIONS ON SURGERY

(Preliminary Report)

by

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THE knowledge and study of the intrahepatic structures is certainly not new, though a revival of interest is noticeable, especially from a surgical point of view. This is understandable if we take into account the development of an analogous situation, namely the lungs.

Although the anatomy of the intrapulmonary structures has been known for a long time—many anatomical museums keep bronchial trees produced at a time when there was no thought of lung surgery—it had to wait until advances in anaesthesia and surgery were adequate for the purpose.

This study was undertaken to determine surgical methods of approach to the liver. To do this we produced over thirty multicoloured plastic casts—each colour for a different intrahepatic structure—of normal livers, and several of livers invaded by a gall bladder cancer.

It is important, that the knowledge of the normal anatomy of the intrahepatic structures might prove to be as significant for diagnostic and surgical purposes as it has been—and still is—for the lungs.

Anatomy

The liver develops out of the endoderm of the foregut. The first 'anlage' of both liver and pancreas is paired and segmental, consisting of a number of swellings from the endoderm, which are seen over three or four segments. Some of the swellings grow out and become diverticula from the foregut. The liver as a paired organ can still be seen in the turtle and in certain birds and reptiles.

At the end of the last century, SÉRÉGÉ showed by physiological experiments that the human liver is a paired organ. After injecting the portal vein with plastic, a fissure can be seen which divides the bed of the right portal vein from that of the left (*Fig. 1*). The localization of this fissure does not correspond with the division into the anatomical left and right lobe. It runs from the middle of the gall bladder bed of the liver upwards to the left side of the inferior vena cava. The plane of

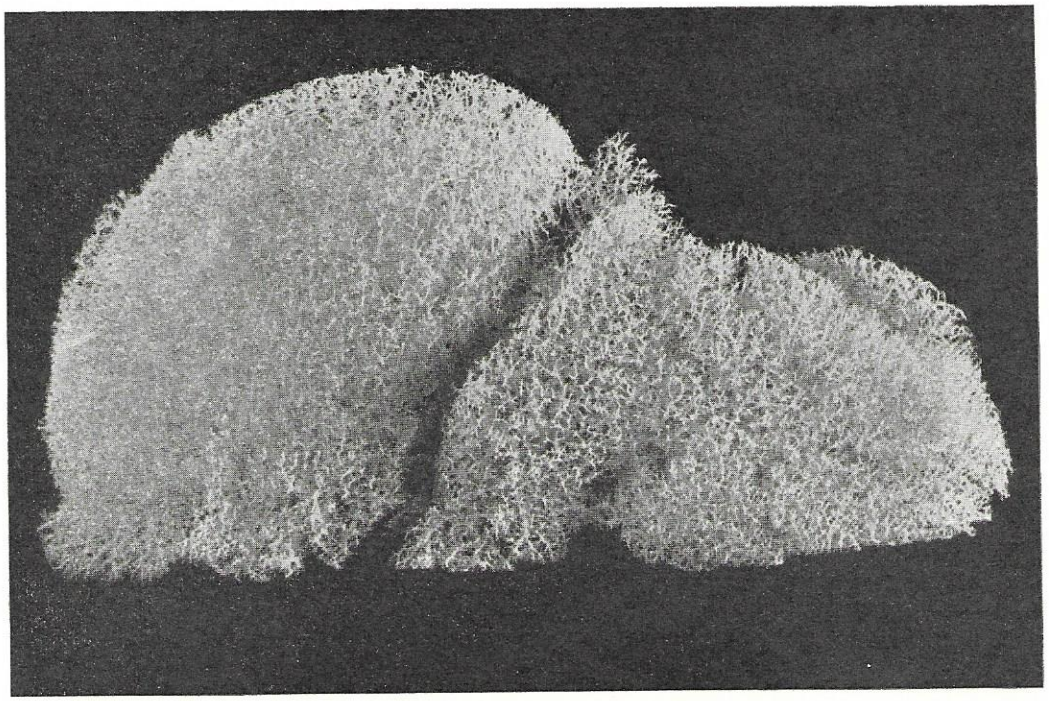

Fig. 1. SÉRÉGÉ's plane.

this fissure makes an angle with the horizontal of approximately 60°, with the opening to the left (*Fig. 3*). To the right and left of this plane there can be distinguished another sagittal fissure (*Fig. 2*). To the left is the left sagittal fissure which forms the division between the anatomical left and right lobe. To the right is the right sagittal intersegmental fissure which originates at the lower margin of the liver at a point between SÉRÉGÉ's plane and the right liver margin at a distance of approximately one-third of the latter, running upwards over a distance of 5–7 cm. parallel to the right liver margin, after which it curves to the left and terminates at the right side of the inferior vena cava. This plane has an angle with the horizontal varying between 30°–60°, with the opening to the right (*Fig. 3*).

SÉRÉGÉ's plane divides the gall bladder bed. The capillaries beneath the serosal surface of the gall bladder anastomose freely and widely with the small intrahepatic branches of the portal vein, located on both sides of SÉRÉGÉ's plane (*Fig. 4*). In our casts these vessels show up after injection of the portal vein. Local involvement of the liver in cancer of the gall bladder causes a complete obstruction of the tiny vessels and capillaries (from pressure from without and/or occlusion from within these vessels) located on either side of SÉRÉGÉ's plane. The larger vessels, especially the arteries, are pushed over by the malignancy and can be found back at the border of the tumour.

All structures entering the hilum of the liver run together with the branches of

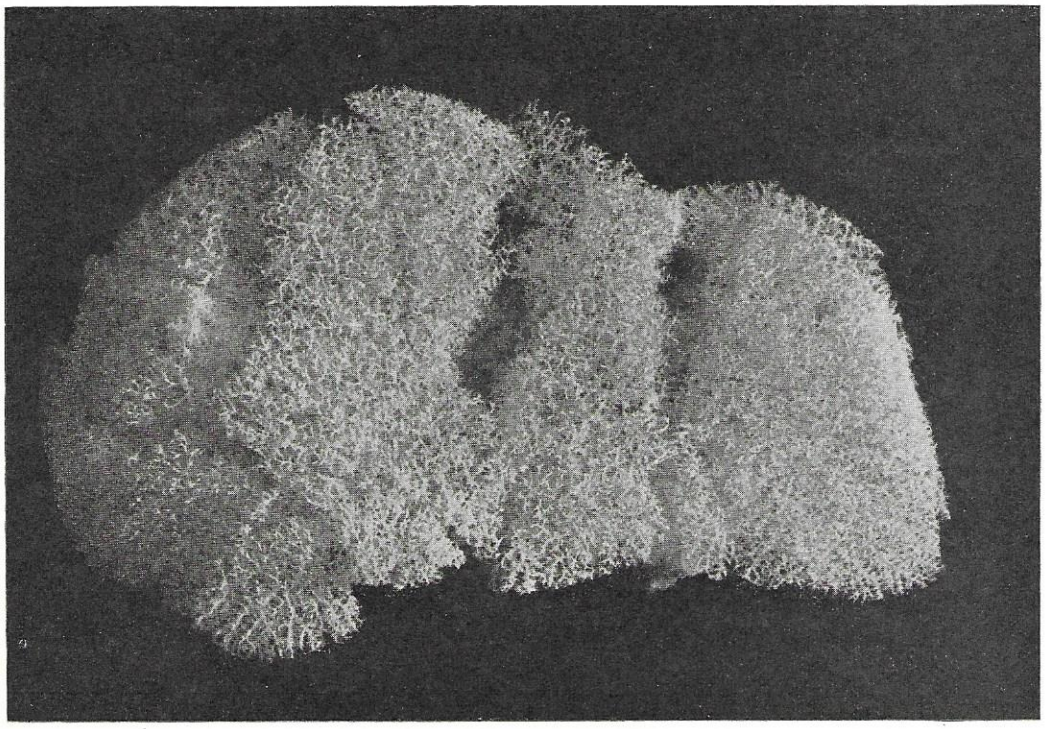

Fig. 2. The three sagittal fissures.

the portal vein (GLISSON, KIERNAN) so that these can be looked upon as the carriers for both the bile ducts and the hepatic artery (*Fig. 5*). At the hilum, after removal of all loose connective tissue, the portal vein can be seen over a relatively large distance; even segmental branches can be distinguished extrahepatically. This is because the portal veins are the most posterior structures of the hilum.

The left and right hepatic arteries, located immediately below the portal vein, are more anteriorly located and can be seen only over a relatively short distance.

The bile ducts are located below the arteries. They are the most anteriorly situated structures which nearly immediately disappear into the hilum after their bifurcation.

The course of the left portal vein is the same in nearly all the casts (see *Diagrams Figs. 6–20*). The main branch runs immediately above the undersurface of the liver and can be reached easily after removing the capsule and the loose connective tissue, that lie beneath it. It divides near the falciform ligament, after which the main branch directs itself inferiorly. From the transverse part of the left portal vein, which can be seen at the hilum, two or three branches run upwards to the caudate lobe. Where the main vessel curves anteriorly, a large branch originates, running to the left and cranially (ramus angularis sinistra). The main branch divides into two vascular trees, one directed medially to the surface of the left liver lobe (ramus sinistro-caudalis), the other to the right to the lobus quadratus

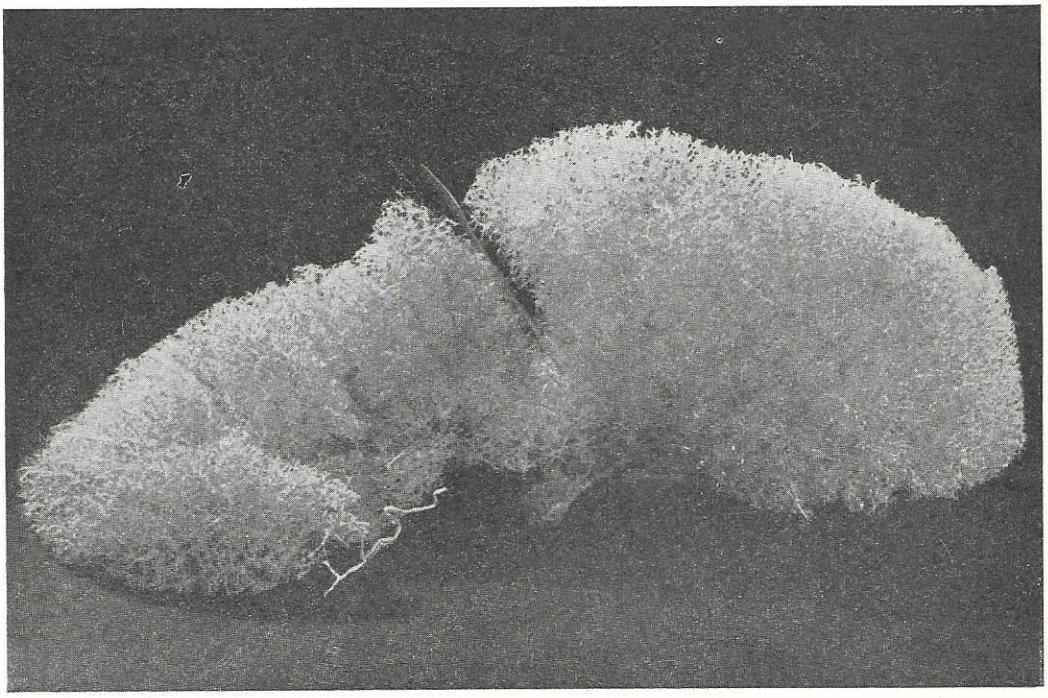

Fig. 3. The angle between SÉRÉGÉ's plane and the horizontal marked by a piece of board.

and the left side of the gall bladder bed of the liver (ramus quadratus). In this way, the liver part, left of SÉRÉGÉ's plane, can be divided into four segments:

(1) caudate lobe. In this segment there are some small anastomoses between the branches of the hepatic arteries and portal veins on both sides of the mentioned plane. We could confirm the observation of SCHALM & BAX, in that no anastomoses are present between the bile ducts of the left and right sides.

(2) Lateral sinistro-cranial segment; small branches of the intrahepatic hepatic artery anastomose freely and widely with those of the surroundings by way of the hepato-duodenal ligament and left coronary ligament.

(3) Lateral sinistro-caudal segment.

(4) Lobus quadratus and left side of the gall bladder bed.

In the right part of the liver, the right portal vein runs transversally over a distance of 1–3 cm. before it divides into two branches, the ramus centralis and the ramus dextro-caudale.

The bed of the rami centrales is the region located between SÉRÉGÉ's plane and the right sagittal intersegmental fissure. In this part some variations occur in the number, direction and calibre of the different branches.

This, however, had hardly any influence on the size or form of the segment as such. It is possible, for example, that instead of two rather heavy rami running into the direction of the lower margin, three, four or even five small branches are

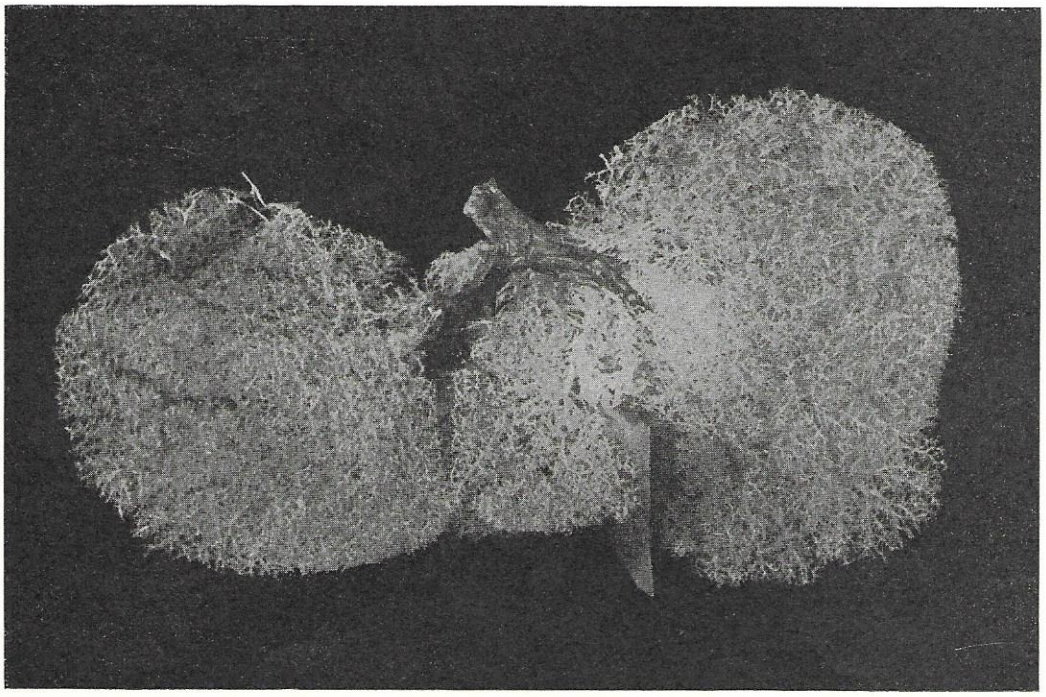

Fig. 4. Relationship of the gall bladder (subserosal vessels) and SÉRÉGÉ's plane

present which vascularize this region. I should like to discuss here the common denominator of the different variations. The diagrams (*Figs. 6–20*) will give a better insight into some of these variations than would a long and tiresome description.

Immediately after its origin, the ramus centralis runs approximately 1 cm. to the right and laterally, after which it curves anteriorly at which point a number of larger branches originate, while the main branch runs anteriorly and cranially, directed somewhat to the right. The site of this bifurcation is approximately three or four cm. from the bifurcation of the portal veins in the hilum. As a rule, four to six branches can be seen to arise from the ramus centralis. The first, at the bifurcation of the ramus centralis and the ramus dextro-caudale, runs cranially and somewhat towards the right. The arborization of this vessel, together with the end of the main branch, occupies the cranial portion of the region between SÉRÉGÉ's plane and the right sagittal intersegmental fissure, the right cranial paramedial segment.

At the side where the ramus centralis curves anteriorly, originate the branches of the right caudal paramedial segment, one running medially to SÉRÉGÉ's plane, and several in the direction of the inferior margin.

The bed of the ramus dextro-caudalis is restricted to the most lateral, right part of the liver and the dorsal part of the lateral, right side. Where it curves caudally,

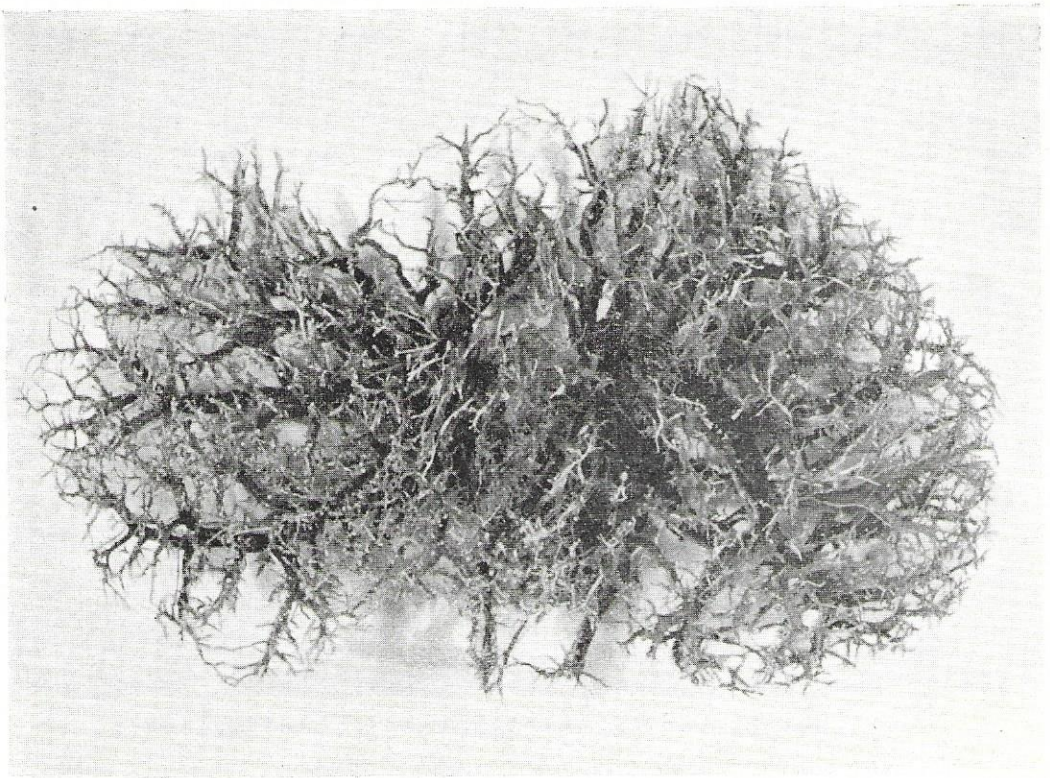

Fig. 5. The portal vein (dark colour) and the bile ducts (light colour)

a large trunk is born, running dextro-cranially: the ramus angularis dextra. Its arborization forms the right cranio-lateral segment.

To the right, one large trunk (sometimes several), the vena marginalis dextra, runs to the right liver margin.

The arborization of these branches, together with the end trunk, forms the right caudo-lateral segment.

Altogether eight segments can be distinguished in this way, by three sagittal planes (described above) and a transverse plane through the hilum.

The arteries and bile ducts keep to the portal vein, though a number of variations may occur at the hilum, as shown in a number of diagrams (*Figs. 6–20*).

By injecting the inferior vena cava, all hepatic veins filled in a number of our casts. I shall describe them briefly in retrograde direction. A variable number of branches spring directly from the inferior vena cava, running to the undersurface of the liver (on both sides!). Two major branches, one to the right, one to the left, originate at the most cranially, centrally located area of the liver.

The one to the right, sends finger-like projections into the region located to the right of the right sagittal intersegmental fissure, and occasionally into the right paramedial segments.

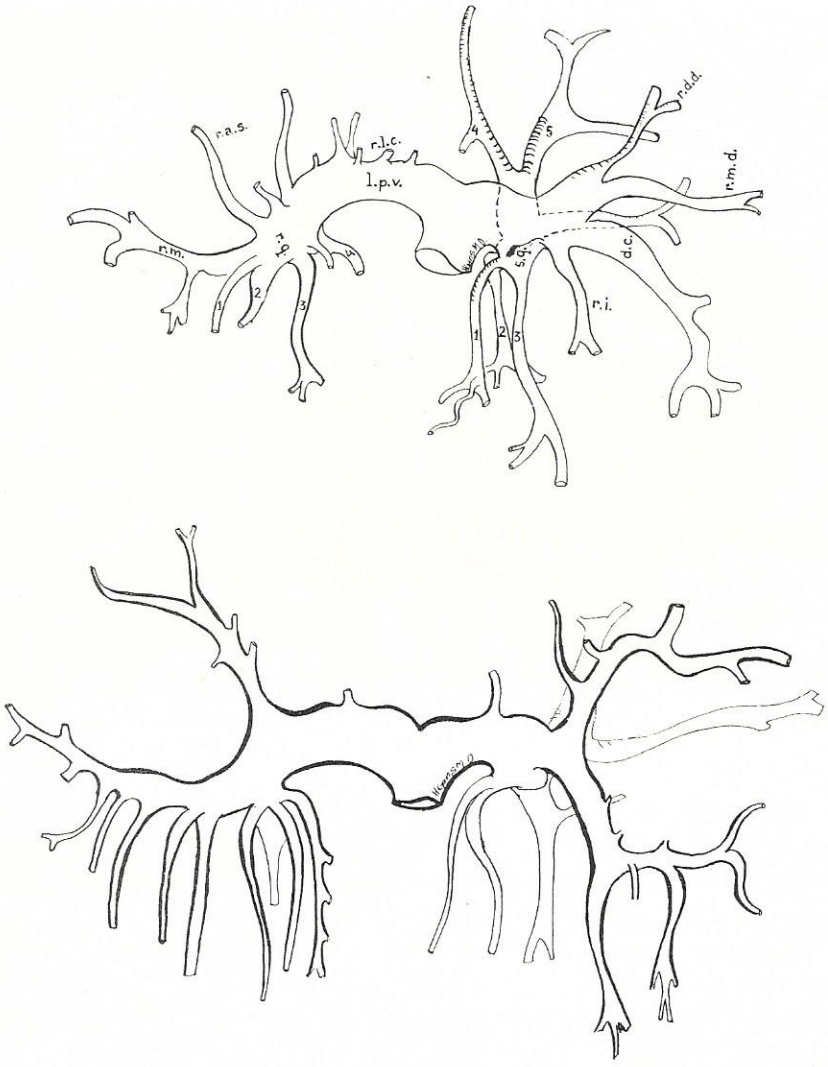

Fig. 6 and *7*. Portal vein casts (Nos. 1 and 2).

Portal vein

Hepatic artery

Hepatic vein

Bile duct

All casts are represented in dorsal aspect

ABBREVIATIONS

l.v.p.: left portal vein — r.l.c.: ramuli lobi caudati — r.a.s.: rami angulares sinistri — r.m.: ramus sinistro caudalis — r.q.: ramus quadratus, *viz.*: (1) ramus sinister, (2) ramus anterior, (3) ramus dorsolateralis, (4) ramus SÉRÉGÉ — s.q.: ramus centralis, *viz.*: (1) ramus medialis, (2) ramus anterior, (3) ramus dorsolateralis — r.i.: ramus intermedius — d.c.: ramus dextrocaudalis — r.a.d.: ramus angularis dexter — r.m.d.: ramus marginalis dexter.

Fig. 8. Anterior aspect of a portal vein cast. Note the relationship of the sagittal vein and SÉRÉGÉ's plane.

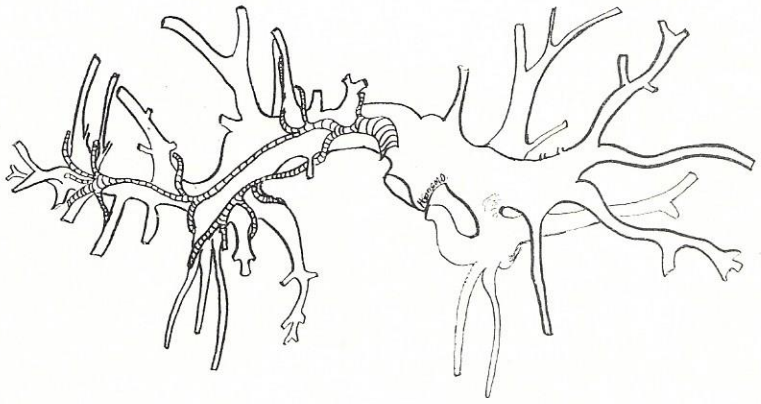

Fig. 9. Cast No 3.

Just to the left or right in SÉRÉGÉ's plane a large vein, an offspring of the left hepatic vein, originating some millimetres from the left side of the inferior vena cava, runs caudally, sending several heavy branches to the right paramedial segments, *crossing* SÉRÉGÉ's *plane*.

Both paramedial segments drain most of their blood into the left hepatic vein.

The left hepatic vein divides itself into a number of finger-like projections, restricted to the region left of SÉRÉGÉ's plane.

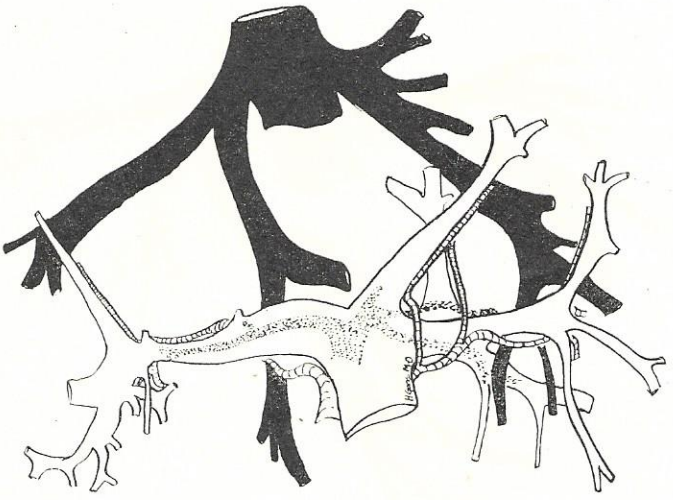

Fig. 10. Cast No. 17

Surgical consequences

Since the beginning of liver surgery (VON EISELSBERG, 1893), two complications have arisen which have resulted in failures in this field.

(1) Occlusion of one of the intrahepatic structures causes atrophy (in cases of the hepatic artery, degeneration, NARATH; TICHOW) of the liver part or segment receiving from or draining into one of these structures (OEHLECKER; SCHALM & BAX, and other authors). In necrosis of large parts of the liver, hepatic failure occurred. To a certain extent penicillin seems to be beneficial if administered in large doses.

(2) Bleeding and bile leakage occurred frequently during surgery and post-operatively, as surgery was not performed along anatomical planes of dissection.

Surgical procedures

(*a*) *Hemihepatectomy.* Ligation of the hilar structures on one side might carry away one part (the right or left of the liver after division of the liver along SÉRÉGÉ's plane). A right hemihepatectomy, after division of the right hepatic artery, right hepatic duct and right portal vein at the hilum, and incision of the liver along SÉRÉGÉ's plane have been reported. As shown in the diagrams, anomalies of the right hepatic artery may occur. In these two specimens a branch from the right hepatic artery runs to the left side (in both cases to the quadrate lobe and the left side of the gall bladder bed). During a hemihepatectomy, their intrahepatic course can be determined by pinching this branch for a short time. A discoloration of the segment receiving blood from this branch may occur. The right hemihepatectomy, in which the liver is divided along SÉRÉGÉ's plane, causes hardly any bleeding, while at the same time none of the remaining intrahepatic structures will be divided. I do not consider, however, that a left hemihepatectomy should be

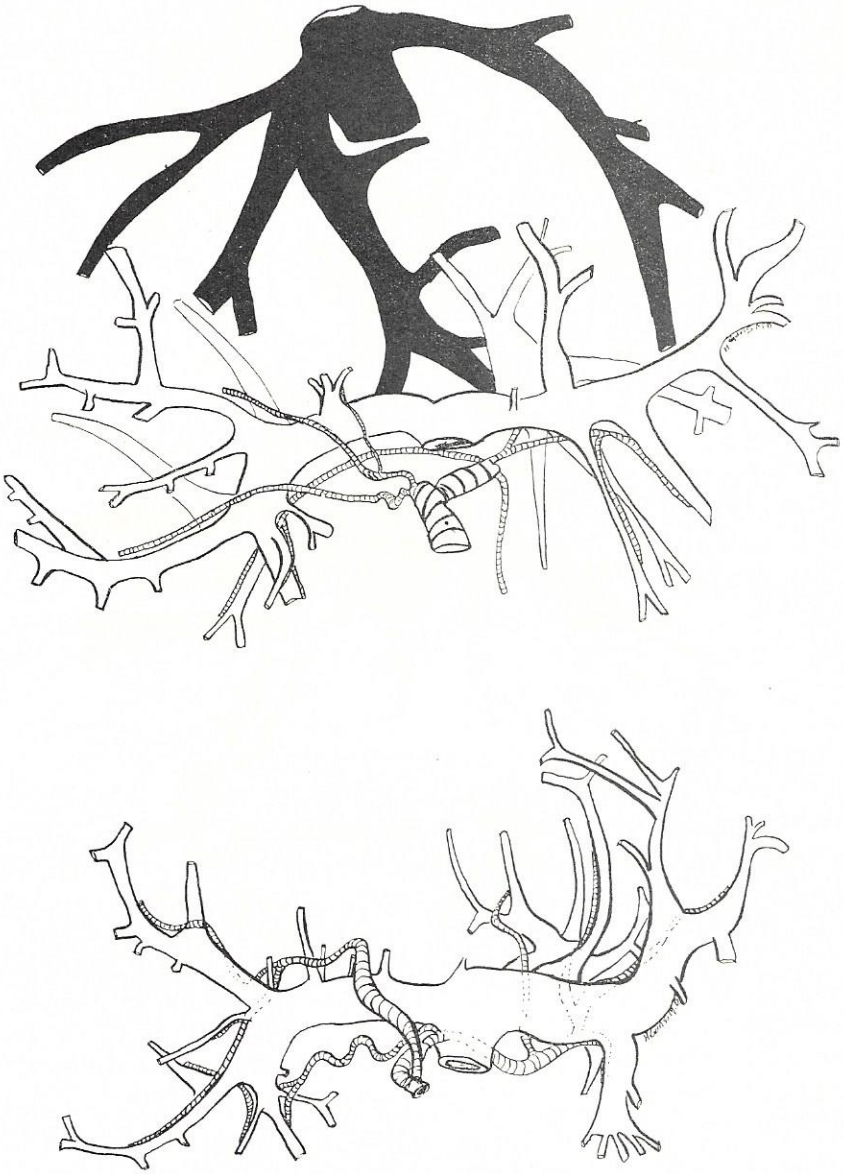

Fig. 11 and *12.* Cast No. 6 (portal vein and hepatic artery), and Cast No. 24 (portal vein, hepatic vein, and hepatic artery), both seen against the hilum (dorsal aspect). Several branches of the hepatic artery can sometimes be distinguished at the hilum, whose number and course may vary. In these two specimens a branch from the right hepatic artery runs to the left side, in both cases to quadrate lobe and the left side of the gall bladder bed of the liver. During hemihepatectomy their intrahepatic course can be determined by pinching these branches for a short time. A discoloration of the segment receiving blood from this branch may develop.

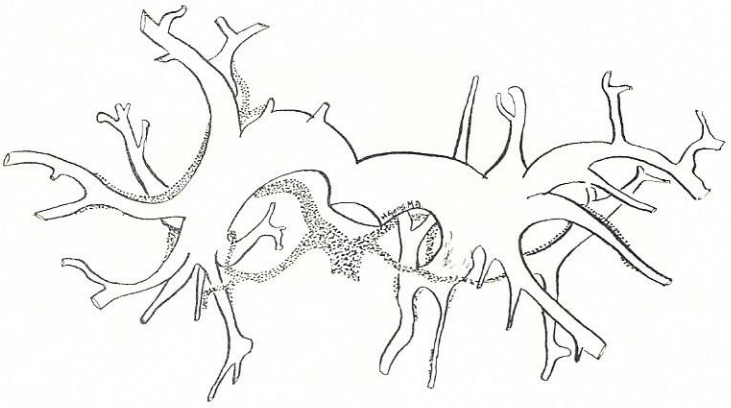

Fig. 13. Cast No. 5

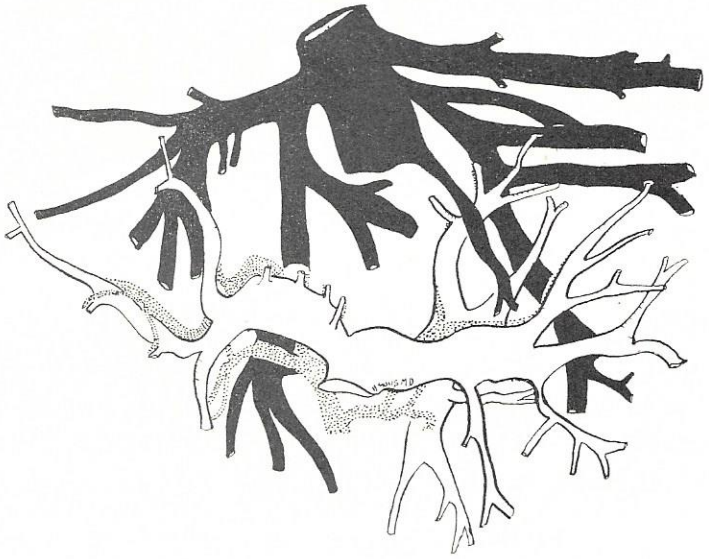

Fig. 14. Cast No. 28

performed along SÉRÉGÉ's plane as the remaining right side drains its blood partly by way of the sagittal vein. How large this part is, might be established (at least when the liver is approached by means of the abdomino-thoracic incision) by pinching off the right hepatic vein. The part that drains its blood by way of the right hepatic vein congests the rest of the right part of the liver draining its blood by way of the sagittal vein.

With a left hemihepatectomy, therefore, instead of running the incision from the middle of the gall bladder bed upwards to the left side of the inferior vena cava, it is advisable to direct the incision to a point 1–1.5 cm. to the left of the left side of the inferior vena cava. A part of the caudate lobe, which anatomically belongs

Fig. 15. Cast No. 18.

to the left side, will stay behind, but it has sufficient anastomoses (see anatomy) across SÉRÉGÉ's plane with the right side to keep up vitality.

There will be no bleeding as ligation of all the glissonian structures precede the cleavage of the liver.

(*b*) *Resection of every segment separately* can be done, except those of the caudate lobe and the right paramedian cranial segment. Resection of these segments would cause a CHIARI syndrome on the site of resection (bouts of abdominal pain, tender swollen liver, progressive ascites, oedema of the lower extremities, dilated abdominal veins).

Technically, ligation of the main segmental branches of the glissonian structures must precede the resection. This can be done by means of the 'intrahepatic mass ligation' after THÖLE, or as described by PAYR (see the literature). I am convinced, however, that following the glissonian structures from the hilum by means of blunt dissection into the liver, the main segmental structures can be ligated at their origin. Exact knowledge of the intrahepatic anatomy is a necessity. After ligating the glissonian structures, the liver can be incised bluntly along the margins of discoloration, resulting from the occlusion of the hepatic artery. The hepatic veins that cross the border of the segments can be identified, clamped and ligated.

The study of our casts of cancer of the gall bladder shows a local involvement of this organ on either side of SÉRÉGÉ's plane. In early cancer of the gall bladder, *en bloc* resection of the gall bladder, together with the right paramedian caudal segment and the lobus quadratus, should result in a complete cure. Here again ligation of the vessels must precede the resection.

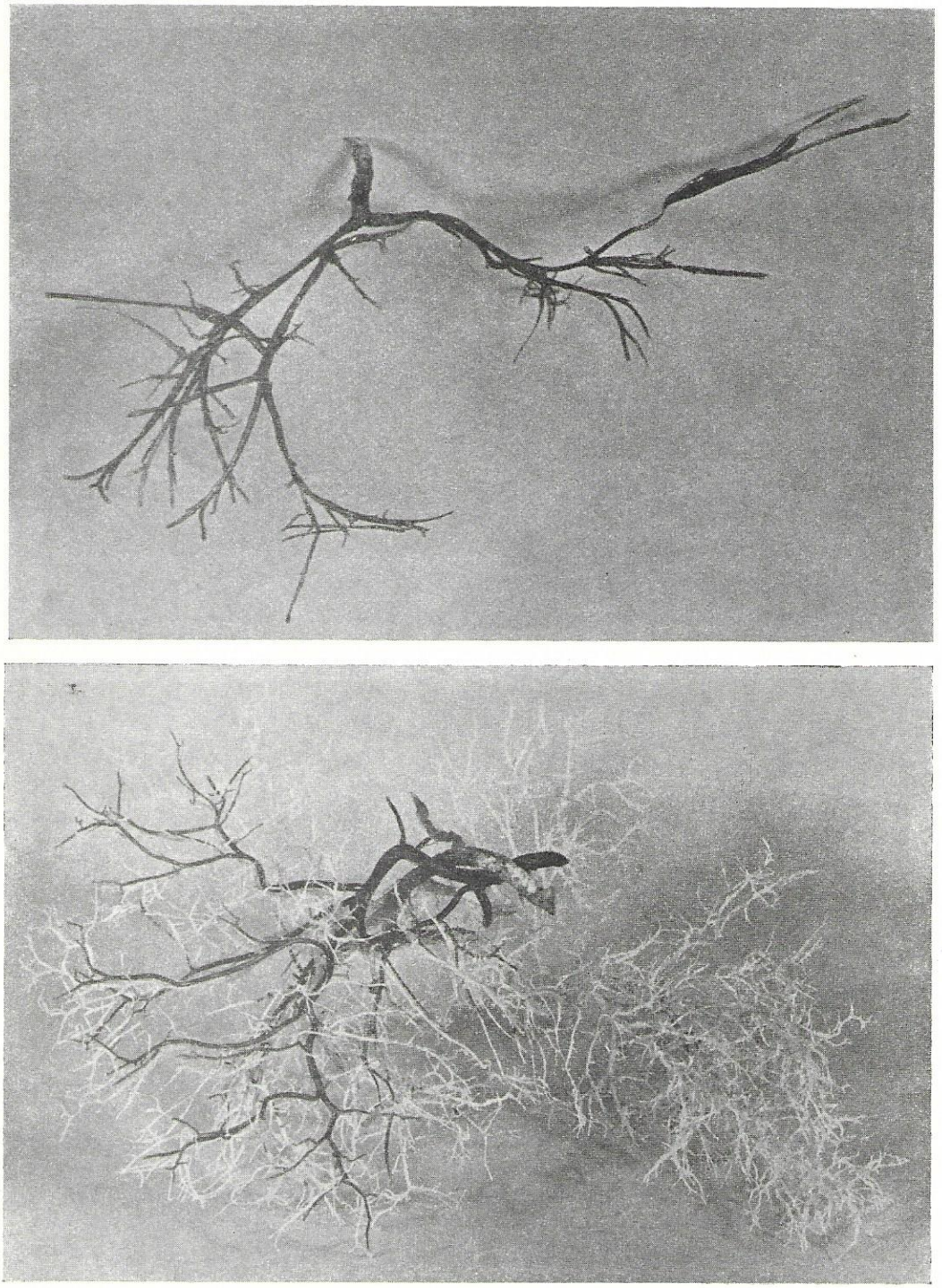

Fig. 16 and *17.* The main bile ducts.

Fig. 18. The intrahepatic bile ducts (white) and the hepatic artery on one side. Injection after ligating one hepatic artery.

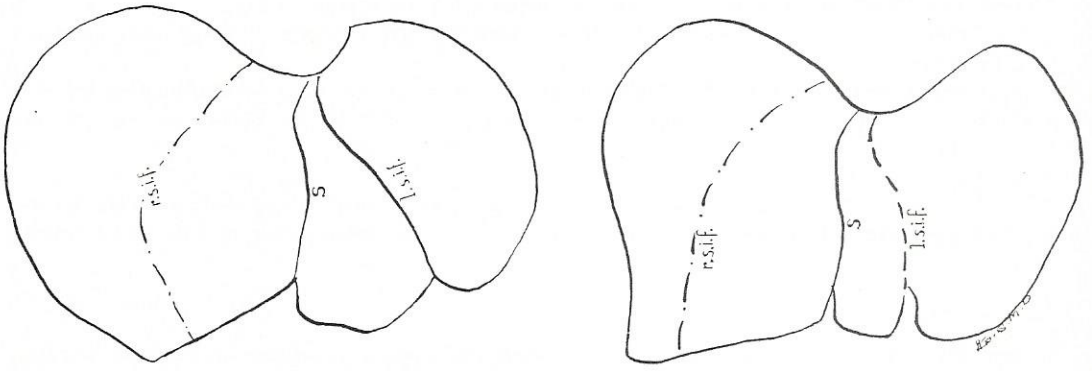

Fig. 19 and *20.* Casts No. 1 and 2. Localization of the fissures on the anterior aspect of the liver.

Summary

The normal anatomy of the intrahepatic structures and the most frequent variations are described. The relationship between the subserosal vessels of the gall bladder and the intrahepatic portal branches is studied, in connection with the invasive growth of gall bladder carcinoma into the liver.

The surgical consequences of this anatomical study are:

(1) Hemihepatectomy. In view of the course of the vena sagittalis, it is recommended, in a left hemihepatectomy, not to carry out the resection along SÉRÉGÉ's plane.

(2) Segmental resections.

(3) An *en bloc* resection of the gall bladder with the two adjoining segments is described in case of gall bladder carcinoma, with only local invasive growth into the liver.

Résumé

Déscription de l'anatomie normale des vaisseaux intrahépatiques et les variations les plus courantes. On étudie le rapport entre les petits vaisseaux sous-séreux de la vésicule biliaire et les petites branches intrahépatiques de la veine porte par rapport à la propagation dans le foie du cancer de la vésicule biliaire.

Les conséquences chirurgicales de cette étude anatomique sont les suivantes:

(1) L'hémihépatectomie. On déconseille la résection le long du plan de SÉRÉGÉ en cas d'hépatectomie gauche à cause du cours de la veine sagitale.

(2) Résections segmentaires.

(3) On décrit une résection en bloc de la vésicule biliaire avec les deux segments avoisinants en cas de cancer de la vésicule biliaire seulement accompagné d'infiltration locale du foie.

Zusammenfassung

Beschreibung der normalen Anatomie der intrahepatischen Strukturen und der am meisten vorkommenden Variationen. Um die Frage des Einwachsens von Gallenblasenkarzinomen in die Leber aufzuklären, wurden die feinen Verbindungen zwischen den subserösen Blutgefässen der Gallenblase und den intrahepatischen Verzweigungen der Vena portae verfolgt.

Als Ergebnis dieser anatomischen Untersuchungen werden folgende chirurgischen Eingriffe vorgeschlagen:

(1) die Hemihepatektomie. Mit Rücksicht auf den Verlauf der Vena sagittalis empfiehlt der Verfasser, die Resektion bei einer linken Hemihepatektomie *nicht* in der Ebene von SÉRÉGÉ vor zu nehmen.

(2) Segmentresektionen.

(3) Eine *en bloc* Resektion der Gallenblase plus zweier angrenzenden Segmente wird als chirurgischer Eingriff beschrieben bei Gallenblasenkarzinomen, mit nur lokalem Einwachsen in die Leber.

Samenvatting

De normale anatomie der intrahepatische structuren, en de meest voorkomende variaties worden beschreven. De relatie der subsereuse vaatjes van de galblaas en de intrahepatische portaetakjes worden nagegaan, in verband met de invasieve groei van het galblaas carcinoom in de lever.

De chirurgische consequenties van deze studie der anatomie zijn:

(1) de hemihepatectomie. Met het oog op het verloop van de vena sagittalis verdient het aanbeveling de resectie bij een linker hemihepatectomie niet langs het vlak van SÉRÉGÉ te doen plaats vinden.

(2) Segmentresecties.

(3) Een *en bloc* resectie van de galblaas met de twee belendende segmenten wordt beschreven bij het galblaas carcinoom, met slechts locale ingroei in de lever.

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