

Research Article – Basic and Applied Anatomy

Review of the nomenclature of the liver anatomical and functional areas by three-dimensional volume rendering 64-multislice computed tomography. Proposal for an update of the terminology

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Abstract

In the last centuries, the anatomy of the liver has been the object of increasing interest. The International Anatomical Terminology tries to unify the terminology of liver anatomy, making it a living language. A single, worldwide-accepted classification of the liver still does not exist. In fact, definition of segments according to Couinaud's nomenclature is different from that of Goldsmith and Woodburne. The aim of this paper was to revise the liver topography by 64-Multislice Computed Tomography, in patients who had undergone repair of cholelithiasis, starting from classifications based on the efferent venous system or on the Glissonian system. This technique allows to remove virtually the liver parenchyma, and, together with the subsequent three-dimensional reconstruction of images, represents the best tool to visualise the hepatic ducts and segments. Through this approach, we propose a new terminology, which considers the liver divided into five lobes and seven segments plus one caudate lobe. In conclusion, this paper can represent a working hypothesis for a possible and future revision of the nomenclature of the hepatic functional territories and can be useful for clinical and didactic aims.

Key words

64-MSCT, liver classifications, lobar nomenclature of liver, liver terminology.

Introduction

Since the end of the XIX century, segmental anatomy of the liver was the object of increasing interest, to make resections of small hepatic portions easier. Traditional gross anatomy divided the liver into four lobes, with the falciform ligament visible on the front (anterior side) and the transverse and sagittal fissures of the liver on its posterior side.

Beside this classical description of liver anatomy, which does not consider the vascular and biliary planes important for liver surgery, a second, more recent description involves functional anatomy (Bismuth, 1994). It considers the internal liver structure and is based on the efferent venous system or on the Glissonian system. It was initiated by Rex in 1888 and Cantlie in 1897; works of Hjortsjo (1951),

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Healey and Schroy (1953), Couinaud (1954), Goldsmith and Woodburne (1957), and Bismuth (1994) followed.

The classification based on the efferent venous system is previous to the Glissonian one, because the efferent venous system is anatomically more evident and can be more easily used as a point of reference. It is important to notice that the absence of scissurae, present in the lung, has made the classification of the anatomico-functional areas of the liver more complicated. The scissurae have been substituted by virtual lines on the surface of the organ, which are useful both for the didactic field and for the clinical one. In particular, we refer to the Cantlie's line. It is an extrapolated line from the posthepatic inferior vena cava across the diaphragmatic surface of the liver, to the site where the fundus of the gallbladder typically contacts the inferior margin of the liver, passing through the right axis of the caudate lobe. It can be considered a plane dividing the liver into a right and left hemiliver. According to the efferent venous system classification, the liver is divided into four sectors: right lateral anatomical sector (drained by the right vein); left lateral anatomical sector (drained by the left vein); medial sector (drained by the central vein); and caudate lobe (drained by its own system) (Fig. 1). Caudal, medial, and cranial segments are identified in the right liver; lateral-dorsal and lateral-ventral segments are detected in the lateral part. A principal scissura, between the right and the medial parts of the liver, and a lateral scissura, between the medial and the lateral parts of this organ, are supposed to exist. Many authors worked out the Glissonian system, using spatial references or numbers, from 1 to 8, to indicate the segments of liver (Fig. 2). In Table 1, we report the summary of liver classification. No author uses the term lobe, except for the caudate one.

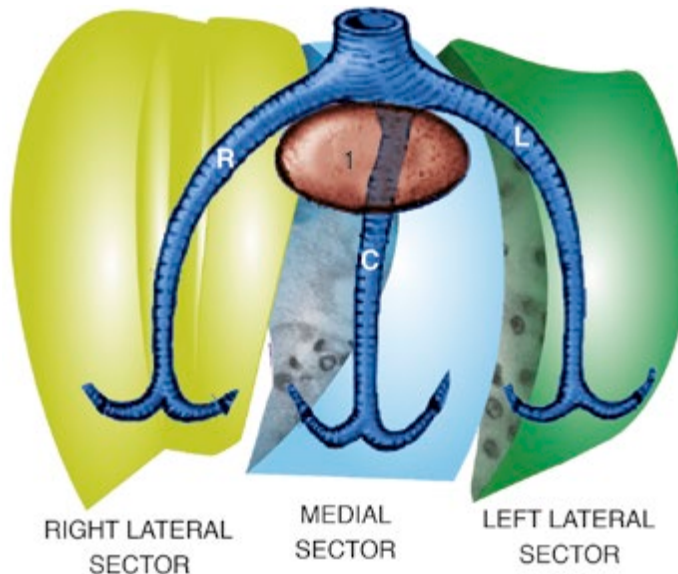


Figure 1 – Efferent venous system classification. R: right hepatic vein; C: central hepatic vein; L: left hepatic vein; 1: caudate lobe.

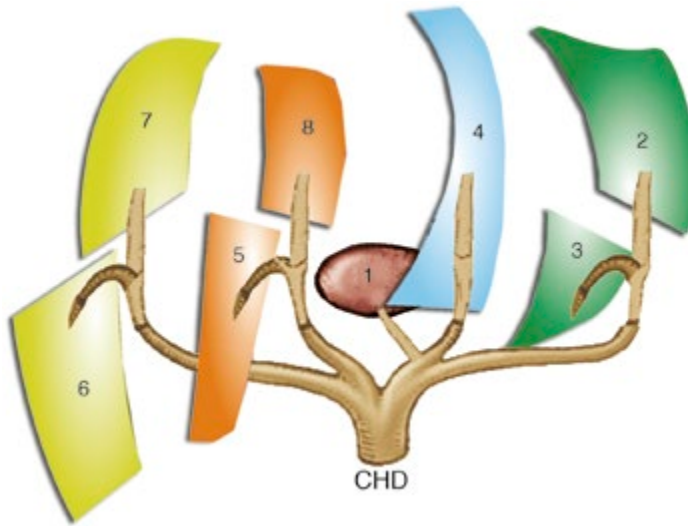


Figure 2 – Glissonian classification. 1-8: liver segments; CHD: common hepatic duct.

Aim

Currently, several image acquisition and processing techniques permit the depiction of normal anatomy, as well as disease processes affecting the biliary ducts, including endoscopic retrograde cholangiopancreatography (ERCP) (Barkun et al., 1993; Erickson et al., 1995), percutaneous transhepatic cholangiography (PTC) (Upadhyaya et al., 2006), magnetic resonance cholangiography (MRC) (Meakem et al., 1995), and multislice computed tomography (MSCT) (Schroeder et al., 2002).

We have transferred our large experience on coronary imaging (Castorina et al., 2007, 2008, 2009, 2010) to the study of biliary tree by MSCT. This technique allows us to visualise, more directly and truly respect to other approaches, the hepatic regions, offering a better didactic demonstration of hepatic territories.

Materials and Methods

Eight patients, both males and females, with an average age of 30 to 80 years, referred to our surgical department for cholelithiasis, were recruited for this study. Exclusion criteria included age of less than 18 years, known allergy to iodinated contrast material, renal insufficiency (creatinine level >2.0 mg/dl), and hyperbilirubinaemia (bilirubin level >4.0 mg/dl). All the patients gave written informed consent to the procedure. After repair of cholelithiasis, a Kehr's T-tube drainage was surgically introduced into the ductus choledocus. Through the tube, a contrast medium (iopromide) was injected during analysis with a 64-MSCT scanner (Somatom Sensation, Siemens Medical Solution, Germany). Scanning was performed using the following parameters: rotation 0.5 seconds; scanner time 2.7 seconds; 187 effective tube current-

Table 1 – Summary of liver classifications.

Part	Classification											
	Healey and Schroy (1953)		Goldsmith and Woodburne (1957)		Couinaud (1957)		Bismuth (1982)		Federative Committee on Anatomical Terminology (1998)			
	Segment	Subsegment	Segment	Subsegment	Sector	Segment	Sector	Segment	Sector	Segment	Sector	Segment
Dorsal	Caudate	Right	Caudate lobe	Caudate lobe	Caudate lobe	I	Caudate lobe	I	Caudate lobe	I	Caudate lobe	Posterior, I
	Lateral	Left	Lateral	Lateral	Lateral	II	Posterior	II	Lateral	II	Lateral	Posterior, II
Left	Medial	Superior	Superior	Superior	Paramedian	IV	Anterior	IVa, IVb	Medial	IV	Medial	Medial, IV
		Inferior	Inferior	Inferior	Inferior	V	Anteromedial	V	Anterior	V	Medial	Anterior, V
	Anterior	Superior	Superior	Anterior	Paramedian	VIII	Anteromedial	VIII	Medial	VIII	Medial	Posterior, VIII
		Inferior	Inferior	Posterior	Inferior	Lateral	VI	Posterolateral	VI	Lateral	VI	Anterior, VI
Right	Posterior	Superior	Superior	Superior	Lateral	VII	Posterolateral	VII	Lateral	VII	Posterior, VII	

time product (mAs) ; volumetric computed tomography dose index 12.67 mGy; pitch 1.4; 120 kV; slice thickness on acquisition 21 x 1.2 m; slice thickness on reconstruction 1.0 mm, window level W400, and slice width C60. Axial data were reconstructed into three-dimensional volume-rendered images using Syngo InSpace workstation and image-rendering software (Siemens Healthcare). The images were evaluated by two experienced radiologists.

Results

The virtual removal of the liver parenchyma, performed by the program that digitally subtracts anatomic planes, represents a surprisingly efficient device to obtain three-dimensional images of first-, second- and third-order biliary ducts. The best projections, which allowed us to obtain these images, were the following:

- right-lateral-anterior projection, which allowed us to visualise at best the ducts of the right hemiliver and the cholecyst (Fig. 3);
- right-lateral-posterior projection, which showed at best the ventral and dorsal lobes of the right hemiliver (Fig. 4) and the third-order biliary ducts corresponding to segments V, VIII, VI, and VII;
- left-lateral projection, which showed at best the lobar ducts of the left hemiliver corresponding to segments II, and III of the lateral lobe, and to segment IV of the medial lobe (quadrate lobe, according to English authors, or VI segment of Couinaud) (Fig. 5);
- posterior projection, which allowed to visualise the left hemiliver territory (Fig.6);
- upright projection, which showed the ducts of the caudate lobe (Fig. 7).

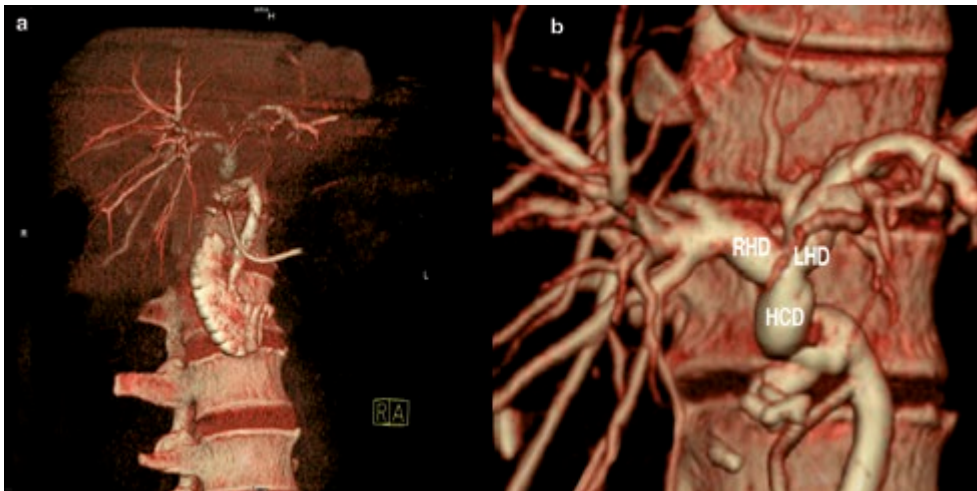


Figure 3 – MSCT image of right-lateral-anterior projection of liver showing the cholecyst (a) and the hepatic common duct (HCD) with the left and right hepatic ducts (LHD and RHD) of the two hemilivers (b).

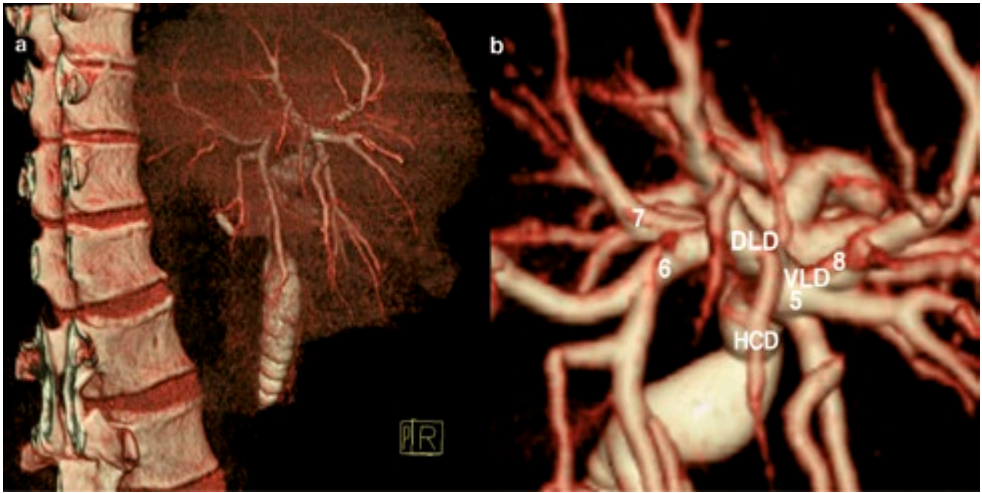


Figure 4 – MSCT image of right-lateral-posterior projection of liver, showing the ventral and dorsal lobes of the right hemiliver and the third-order biliary ducts (a); in particular, the ducts corresponding to segments V, VIII, VII, and VI (numbers 5, 8, 7, 6), the hepatic common duct (HCD), the dorsal lobe duct (DLD) and the ventral lobe duct (VLD) are evident (b).

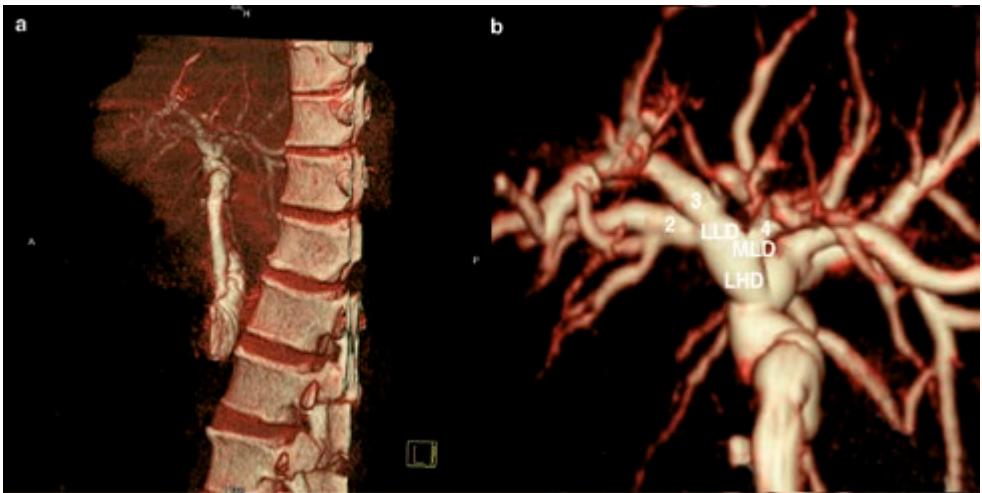


Figure 5 – MSCT image of left-lateral projection of liver, showing the lobar ducts of the left hemiliver (a); in particular, the ducts corresponding to segments II, III, and IV (or quadrate lobe) (numbers 2, 3, 4), the medial lobe duct (MLD) and the lateral lobe duct (LLD) are evident (b).

Our proposal of lobar definition is compared with Couinaud and Bismuth classifications in Tables 2 and 3.

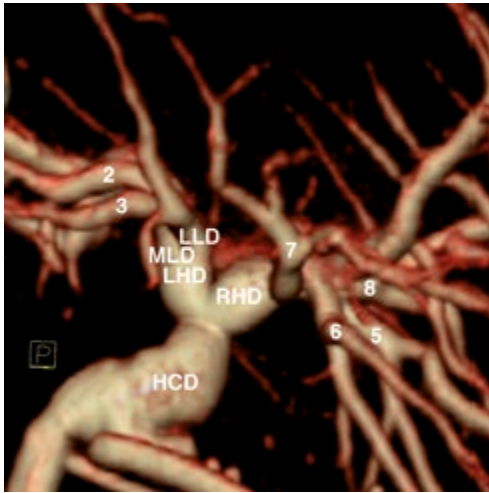


Figure 6 – MSCT image of posterior projection of liver, showing the hepatic common duct (HCD), the left and right hepatic ducts (LHD and RHD), the ducts corresponding to segments II, III, VI, V, VII and VIII (numbers 2, 3, 5, 6, 7, 8), the medial lobe duct (MLD) and the lateral lobe duct (LLD) of the left hemiliver.



Figure 7 – MSCT image of upright projection of liver, showing two ducts for the caudate lobe (1), emerging from the left hepatic duct (LHD) and from the lateral lobe duct (LLD).

Table 2 – Comparison of old classifications with our proposal for the right hemiliver.

Coinaud’s classification	Bismuth’s classification	Proposal for a nomenclature based on lobar classification
Right paramedian sector Segments V–VIII	Anteromedial sector Segments V–VIII	Ventral lobe Segments V–VIII
Lateral sector Segments VI–VII	Posterolateral sector Segments VI–VII	Dorsal lobe Segments VI–VII

Table 3 – Comparison of old classifications with our proposal for the left hemiliver.

Coinaud’s classification	Bismuth’s classification	Proposal for a nomenclature based on lobar classification
Left paramedian sector Segments III-IV	Anterior sector Segments IIIIVa-IVb	Medial lobe
Lateral sector Segment II	Posterior sector Segment II	Lateral lobe Segments II–III
Caudate lobe Segment I	Caudate lobe Segment I	Caudate lobe Segment I

Discussion

The introduction of a univocal terminology, based on lobe and segment, makes the study of liver anatomy easier. It also makes the terminology uniform to that of other mammals, similar to that already used in pulmonary surgery and in other examples of mammalian anatomy. The existence of multiple fissures makes the rat liver, for example, multilobed (Aller et al., 2009). The rat liver is organised in two right lobes (anterior and posterior), a medial lobe, a left lobe, and two caudate lobes (anterior and posterior).

The volume-rendered MSCT images in our study show the division of each hemiliver in ventral and dorsal lobes, on the right area of liver, and in medial and lateral lobes on the left one; dorsally, the caudate lobe is present and the position of segments I, II, III, and IV on the left, and of segments V, VI, VII, and VIII on the right is confirmed.

In surgery, it could be more useful to refer to the lobe. In this way, if we compare the classifications of Couinaud and Bismuth with our lobar nomenclature we can rename some surgical approaches. According to our new proposal, the right paramedian sectoriectomy becomes right ventral lobectomy (segments V–VI) (Fig. 8); the right lateral sectoriectomy becomes left dorsal lobectomy (segments VI–VII) (Fig. 9); the medial resection becomes ventro-medial bilobectomy (segments IV–V–VIII) (Fig. 10); and the left lateral sectoriectomy becomes lateral lobectomy (segments II–III) (Fig. 11). Using this new nomenclature, the analogies with lung surgical resections are evident.

Therefore, even if we acknowledge the two main liver systematisations already in use, we propose a lobar nomenclature (Fig. 12), according to which we recognise a right ventral, a right dorsal, a left medial, a left lateral and a caudate lobe.

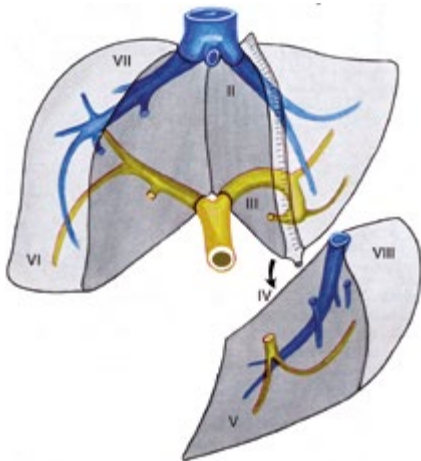


Figure 8 – Image of right paramedian sectoriectomy (reprinted from *Tecnica Chirurgica*, vol. 7, UTET Torino, 1979, with permission) which, according to the new proposed nomenclature, becomes right ventral lobectomy.

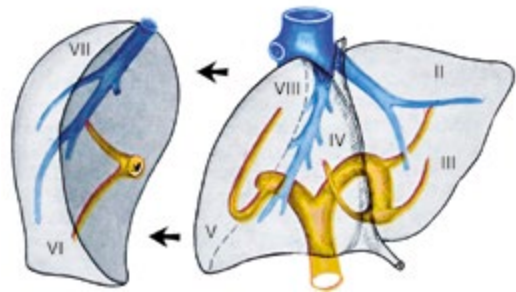


Figure 9 – Image of right lateral sectoriectomy (reprinted from *Tecnica Chirurgica*, vol. 7, UTET Torino, 1979, with permission) which, according to the new proposed nomenclature, becomes left dorsal lobectomy.

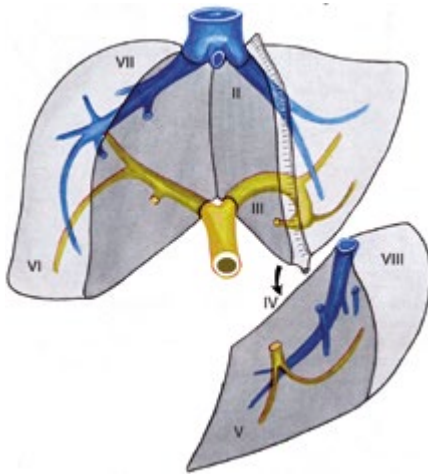


Figure 10 – Image of medial resection (reprinted from “Tecnica Chirurgica”, vol. 7, UTET Torino, 1979, with permission) which, according to the new proposed nomenclature, becomes ventro-medial bilobectomy.

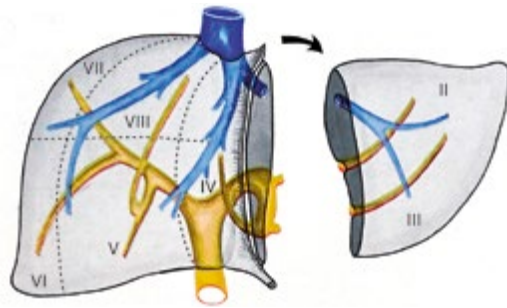


Figure 11 – Image of left lateral sectoriectomy (reprinted from “Tecnica Chirurgica”, vol. 7, UTET Torino, 1979, with permission) which, according to the new proposed nomenclature, becomes lateral lobectomy.

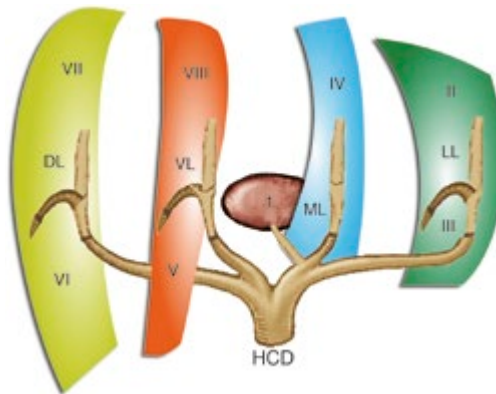


Figure 12 – Image of our proposal for a lobar nomenclature. HCD: hepatic common duct; DL: dorsal lobe; VL: ventral lobe; ML: medial lobe; LL: lateral lobe; 1: caudate lobe; II-VIII: hepatic segments.

Transhepatic cholangiography by MSCT represents a precious technique and an original resource to obtain important images of didactic usefulness. The associated software provides, by progressive digital subtraction of anatomic planes, a virtual dissection. The virtual removal of liver parenchyma shows the organisation of the liver in lobes and segments, making real the scissural plane indicated virtually by the scissural lines drawn on the liver surface (Cantlie’s line, central scissura line, and lines of right and left lateral scissurae).

Our contribution to liver topography may be considered an update in liver imaging, allowing to image the liver with five lobes and seven segments plus one caudate lobe. The quality of MSCT images and the ability to perform three-dimensional reconstruction provide innovative results for clinical and didactic aims. Finally, we hope that this paper can represent a working hypothesis for a possible and future revision of the nomenclature of the hepatic functional territories (Federative Committee on Anatomical Terminology, 1998).

Acknowledgements

We are grateful to the UTET Publishing House for its permission to reproduce the following images from the treatise *Tecnica Chirurgica: Fegato - Vie Biliari - Ipertensione Portale*, UTET, Torino, 1979: figure 79 from page 109, figure 81 from page 111, figure 83 from page 112 and figure 95 from page 124.

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