A Text and Atlas of Liver Ultrasound

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Foreword

The modern approach to the investigation and treatment of diseases of the liver relies upon close co-operation between hepatologist, surgeon and radiologist and each must be aware of the other's problems. In particular, the surgeon should know to what extent the radiologist can help him in preoperative diagnosis, the assessment of resectability, the choice of surgical procedure and the detection of postoperative complications. On the other hand, the radiologist must be aware of the needs of the surgeon and be able to provide a preoperative diagnosis which is as accurate as possible and to convey detailed anatomical information about the location of the lesion. In order to achieve the latter, radiologist and surgeon must speak a common language – the language of Couinaud and segmental liver anatomy.

The description of the segmental anatomy of the liver by the French surgeon Couinaud in 1957 heralded a new era in liver surgery spawning techniques which, while practised routinely by French surgeons for many years, have only relatively recently permeated across the English Channel. There is no greater exponent of segmental liver surgery than Professor Henri Bismuth who, along with Denis Castaing and other colleagues at Hôpital Paul Brousse in Paris, has been responsible for the popularization of these techniques of modern liver surgery. He would be the first to agree that none of this would have been possible without the use of ultrasound both preoperative and intraoperative and the expert interpretation of Francis Kunstlinger. It is entirely fitting, therefore, that these three pioneers of modern liver surgery and modern liver ultrasound should come together and share their vast experience with us.

This book presents an amazing amount of well-documented material in a succinct fashion and in a well-organized and readable style. The liberal use of illustrations and of actual case histories makes this a unique volume which will be of immediate practical use to radiologists, hepatologists and surgeons alike. To my knowledge, there is no other book like it in any language which brings this rapidly evolving field so up to date. I predict that this book will be adopted as essential reading for all practitioners of hepatobiliary surgery and hepatobiliary radiology.

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Preface

The liver is the largest organ in the body but despite this it remains, along with the pancreas, one of the most difficult abdominal organs to examine. As a solid organ, it is not amenable to classical radiological techniques such as opacification by contrast. Well before the advent of endoscopy, these techniques with their wealth of diagnostic interpretation, had provided gastroenterologists and surgeons with detailed information about the anatomy and the diseases of the gastrointestinal tract.

Prior to the 1960s, the main method of exploration of the liver was by clinical examination and the great physicians of the day were able to demonstrate an abundance of physical signs and glean a great deal of information by this technique. The only radiological investigation which gave any useful information about liver disease was intravenous cholangiography. The images of the intrahepatic ducts, however, were rarely clear and in any case only gave an indirect impression of any large liver lesion which might have been present. Laparoscopy allowed visualization of the external surface of the liver. As a last resort, exploratory laparotomy helped resolve any diagnostic uncertainty.

In the 1960s, liver scintigraphy and then splenoportography and arteriography undoubtably strengthened the arsenal of non-surgical liver investigation. The first of these modalities only gave rather crude information, even with the use of colour scintigraphy. The other two, while giving more accurate information, only examined the liver parenchyma in terms of its vascular supply and had the disadvantage of being invasive.

At the beginning of the 1980s, there was a virtual technological revolution with the appearance of several non-invasive techniques for the examination of the morphology of the hepatic parenchyma: firstly ultrasound, then CT scanning and finally nuclear magnetic resonance. Today, the refinement of these techniques has endowed liver investigation with imaging which is becoming increasingly accurate. Ultrasound has the advantage over the other two modalities of being less invasive (no X-rays), cheaper and easily repeatable.

It is perhaps paradoxical that the organ which for 20 years has been the hardest to examine preoperatively should become, with the advent of ultrasound, one of the most transparent. The clinician can now have information about the smallest intrahepatic structures at little risk and low cost. This being said, the radiologist must still exercise skill and judgement in the examination of hepatic lesions by ultrasound. While machine technology is more important in the quality of CT and MRI, in the case of ultrasound it is the examination technique itself which determines the usefulness of the investigation (the way in which the transducer is handled can be adapted to suit both the patient and the liver). The radiologist who performs ultrasound, therefore, needs to be experienced and should use the investigation to answer questions posed by the clinician.

In our experience, ultrasound should not be restricted to use as a diagnostic tool but should also be used to answer questions posed by the clinician, such as: 'What is the diagnosis? What are the consequences of this lesion and what are the possible treatment options?' Take the example of a large cystic lesion: 'What are the features in favour of this being a simple biliary cyst?' or, on the other hand, 'Are there any features, even subtle ones, which suggest that this may be a hydatid cyst?' In the case of a liver tumour where this is known to be a metastasis because of the past history of malignant disease and the presence of raised levels of tumour markers, the questions which need to be answered are as follows: 'Are there any other lesions within the liver or any involved lymph nodes? What is the relationship of the tumour to the intrahepatic vascular structures?' and if resection is contemplated, 'What is the volume of normal liver that will remain following resection?'

To answer these types of questions which go beyond simple diagnosis and start to have treatment implications (this is after all the final objective of the clinician), we tend to request a second ultrasound examination as the first is usually inadequate for this purpose and only of use for simple diagnosis.

Our experience of liver ultrasound has been acquired by close co-operation between surgeon and radiologist, looking to solve problems posed by the patient right from the start of the diagnostic process. Ultrasound has two objectives, diagnostic and therapeutic, and it is given priority here as it influences the choice of subsequent investigations.

This is the type of ultrasound which we would like to teach through the pages of this book. It is intended for the radiologist who would like to know more about what this examination can provide, for the clinician who would like to know how much he can demand of ultrasound and for the surgeon who would like to know how much help he can expect from ultrasound in selecting the patient and the appropriate surgical technique. For him, preoperative ultrasound is the prelude to intraoperative ultrasound, a magnificent tool of hepatic surgery which provides him with detailed knowledge of the organ upon which he is operating and guides his surgical performance.

Henri Bismuth

Contents

1

Ultrasonography and liver anatomy

Knowledge of the anatomy of the liver [4,10,14] and of its normal ultrasonographic appearance is an essential prerequisite to a study of the organ, which includes an analysis of liver size and the appearance of the parenchyma, the recognition of intrahepatic vascular and biliary structures, and the examination of the segmental anatomy [13,16].

THE APPEARANCE OF THE NORMAL LIVER ON ULTRASOUND

LIVER PARENCHYMA

On ultrasound, the hepatic parenchyma is made up of fine, evenly distributed echoes giving a homogenous appearance throughout, provided the instrument is correctly adjusted [16] (Figures 1.1, 1.2). This homogeneous appearance can be altered in the normal subject however, either as the result of posterior intensification behind a vessel, in particular behind the right hepatic vein (Figure 1.3) or alternatively as a result of attenuation of the ultrasound beam, for example in the region of the caudate lobe behind the portal bifurcation (Figure 1.4). Indeed, Glisson's capsule is thick and highly hyperechoic in this region and will thus reduce the intensity of the ultrasound beam. The echogenicity of the liver should be compared with that of the parenchyma of the right kidney, to which it should be equal or slightly greater (Figure 1.5). The echogenicity of the pancreatic parenchyma is too variable for use as a reference.

The liver surface is regular, smooth and surrounded by a very thin hyperechoic line which represents Glisson's capsule (Figure 1.6). This line appears thicker in the region of the dome of the liver because Glisson's capsule is in juxtaposition here with the diaphragm and interfaced with air in the

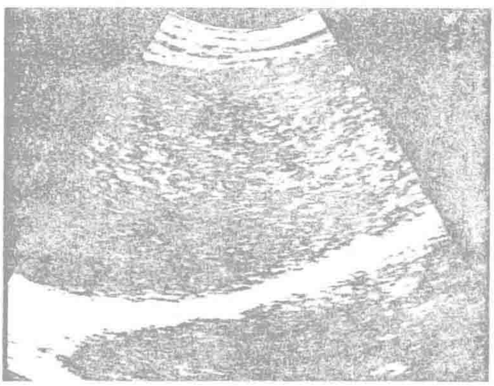


Fig. 1.1 Normal hepatic parenchyma
The ultrasonographic image is made up of fine, evenly distributed echoes giving a homogeneous appearance from superficial to deep.

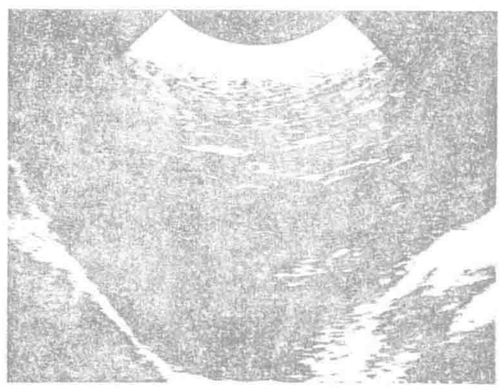


Fig. 1.2 A badly adjusted instrument
The ultrasonographic image is much too intense at the surface compared with the deeper part of the liver, due to poor adjustment of the instrument.

Fig. 1.3 Posterior intensification behind a vessel
Strengthening of the echo intensity (*arrows*) is seen behind the right hepatic vein, resulting in a non pathological heterogeneous appearance.

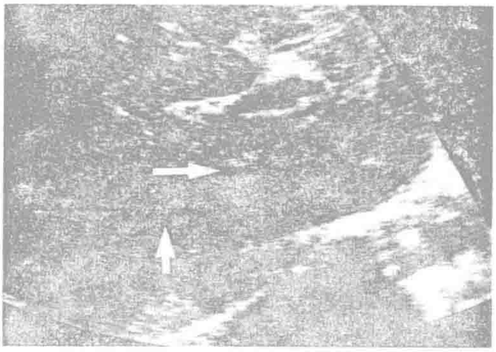


Fig. 1.4 Attenuation of the ultrasound beam
Reduced echogenicity of part of the hepatic parenchyma (*horizontal arrow*) due to attenuation of the ultrasound beam behind the left branch of the portal vein. Note the presence of an inferior right hepatic vein (*vertical arrow*).

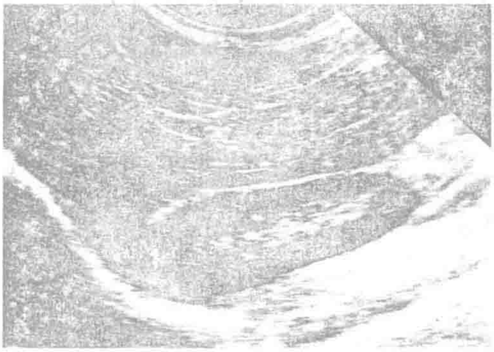


Fig. 1.5 Comparison of the echo intensity of the liver with that of the right kidney
The echogenicity of the liver tissue here is scarcely different from that of the normal kidney (1).

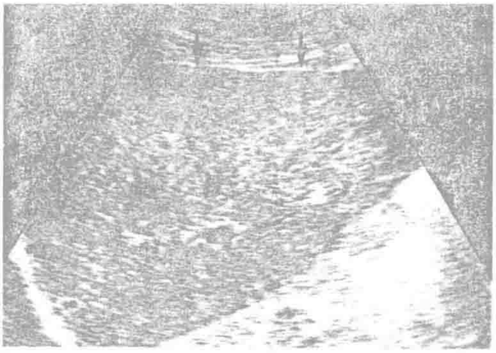


Fig. 1.6 Glisson's capsule
The thin echogenic line at the surface of the liver (*arrows*) corresponds to Glisson's capsule.

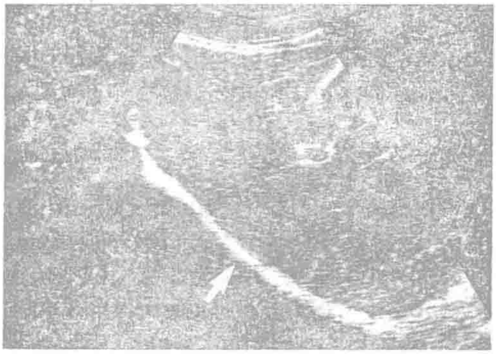


Fig. 1.7 The dome of the liver and the diaphragm
The thick hyperechoic line (*arrow*) situated in the upper part of the liver seen in this right sagittal cut, is formed by Glisson's capsule, the diaphragm and the interface with air in the lung.

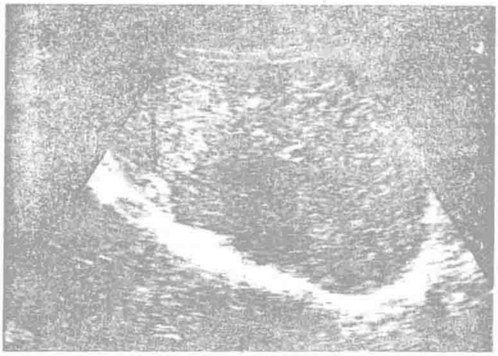


Fig. 1.8 Right triangular ligament
The right triangular ligament sometimes shows as a small notch at the point where it is attached to the liver surface (*arrow*).

lung (Figure 1.7). A small fissure is sometimes present on the right border of the liver at this level which interrupts the regularity of its surface and marks the insertion of the right triangular ligament (Figure 1.8).

NORMAL LIVER SIZE

The morphology of the liver is very variable and accounts for the difficulty in estimating normal liver size. Indeed, the thickness of the right liver (i.e. its anteroposterior diameter) may double, depending on the build of the patient: following on from this therefore, with a constant liver volume, great variation may occur in the usual measure of liver size – namely the craniocaudal diameter. Thus, craniocaudal liver measurements or measurement of various angles of the liver as described by others [16] would appear to be of little use. In contrast, comparative measurements made during the course of liver disease are more useful: we aim to estimate the anteroposterior and craniocaudal dimensions of the liver on sagittal sections – one passing through the left liver at the level of the aorta and the other through the right liver at the level of the bifurcation of the right branch of the portal vein.

The estimation of liver volume [12] is both difficult and approximate. To do this, sagittal sections are taken centimetre by centimetre and the surface area of each section measured directly by the instrument: the sum of the surface areas then approximates to the volume of the liver. The technique is lengthy and cannot be automated. Ultrasound is most often useful in the investigation of hepatomegaly (which is sometimes difficult to assess clinically in obese patients) and in the detection of global atrophy or segmental abnormalities such as segmental hypertrophy, especially involving the caudate lobe.

Finally, a small projection of the right liver extending down to below the inferior pole of the right kidney is occasionally observed, particularly in females (Figure 1.9). This part of the liver has a rounded inferior border and represents Riedel's lobe; it should not be mistaken for hepatomegaly.

INTRAHEPATIC VASCULAR AND BILIARY STRUCTURES

During examination of the normal hepatic parenchyma, vascular and biliary structures are clearly visible within the liver: these consist of the hepatic veins, portal branches and bile ducts.

The hepatic veins

These are easily recognized as they run towards the inferior vena cava. Their diameter is very variable and changes with respiration. These veins give an anechoic image as their thin walls are either invisible [3] or simply formed by very fine hyperechoic lines (Figure 1.10).

The portal branches

These are easily distinguished from the hepatic veins by their location within the liver – starting in the hilar region as a continuation of the portal trunk – and by the appearance of their walls [3] which give a typical thick ultrasonic image representing the prolongation of Glisson's capsule which surrounds the portal pedicles (Figure 1.11).

The bile ducts

The right and left hepatic ducts and their confluence are normally visible. They are situated in front of the portal bifurcation and are never more than 5 mm in diameter (Figure 1.12). More peripherally, the ducts are not usually visible. When the technical conditions of the examination are optimal, however, it is sometimes possible to identify non-dilated segmental bile ducts [1], especially within the left lobe, accompanied by their corresponding portal venous branches which together give a non-pathological double image (Figure 1.13).

Fig. 1.9 Riedel's lobe
Right sagittal cut. A small tongue of the right liver extends below the lower pole of the right kidney (1). This corresponds to a Riedel's lobe and is not hepatomegaly.

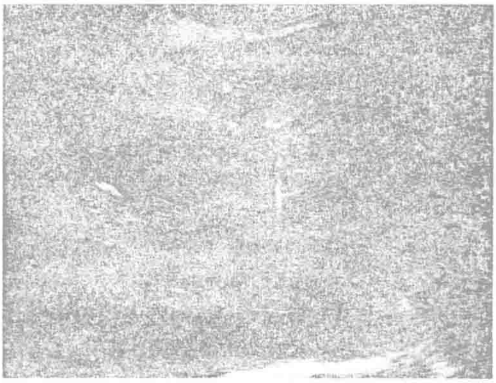


Fig. 1.10 Hepatic veins
Right oblique subcostal cut showing the three hepatic veins, the fact that their walls are not visible, and their entry into the inferior vena cava (*arrow*).

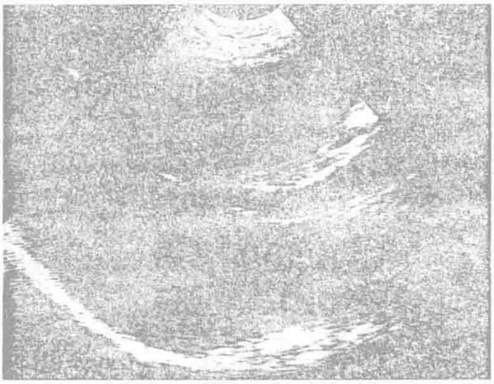


Fig. 1.11 Portal branch
Axial cut in the axis of the portal trunk (1) and the right branch of the portal vein (2). The vein wall surrounded by a fibrous sheath of Glisson's capsule is clearly seen (*arrow*).

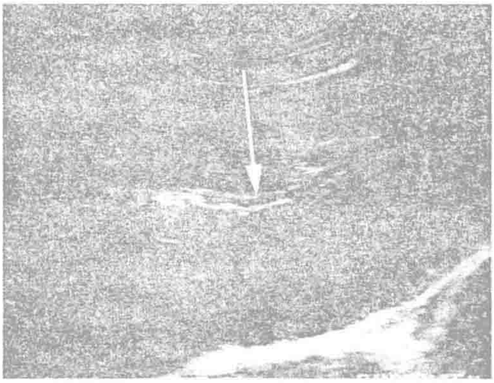


Fig. 1.12 Bile duct confluence
Right oblique subcostal cut showing the bile duct confluence (*arrow*) in front of the portal bifurcation. Its diameter here is 2 mm.

The arteries

These are not normally visible. Under certain pathological conditions, however, where the vascularity of the liver is increased, or sometimes following hepatectomy, the arteries can be identified and should not be confused with dilated intrahepatic bile ducts.

ULTRASONOGRAPHY AND LIVER SEGMENTS

SEGMENTAL ANATOMY OF THE LIVER

The anatomical description which we shall be using is based upon that of Couinaud [4] and hence the nomenclature will be different from that used by English-speaking authors in the past [10,14]. The liver is divided into two main parts – the left liver, supplied by the left branch of the portal vein and the left hepatic artery, and the right liver, supplied by the right branch of the portal vein and the right hepatic artery (Figure 1.14). To these two parts of the liver must be added the caudate lobe, also termed the Spiegelian lobe or segment I by French authors, which has its own blood supply.

The junction between the left and right livers is formed by the principal fissure (Cantlie's line or the main boundary fissure of English authors), which is not an anatomical structure. Indeed, there are no surface markings to indicate its location. It is formed by a plane passing through the fundus of the gallbladder, the portal bifurcation, and the left border of the inferior vena cava at the point where the hepatic veins enter. It is also the plane which separates a right from a left hepatectomy and it conveys the middle hepatic vein.

The left liver is composed of three segments – segments II and III forming the left lobe, and segment IV whose anterior part corresponds to the quadrate lobe and is situated in front of the portal bifurcation. Segment II is posterior and segments III and IV are anterior. The left hepatic vein runs within the left lobe but does not serve to separate the two segments. Segment III is separated from segment IV by part of the left branch of the portal vein and by the fissure containing the round ligament (ligamentum teres), which separates the left and right lobes of the liver, the right lobe being formed by the right liver plus segment IV.

The right liver is divided into two sectors and four segments: the paramedian sector, formed by segment V inferiorly and segment VIII superiorly, and the lateral sector (which is actually posterior) formed by segment VI inferiorly and segment VII superiorly. The paramedian and lateral segments are separated by the plane of the right portal fissure. This fissure conveys the right hepatic vein and like the principal fissure it is not an anatomical structure.

Segment I or the Caudate lobe is a separate and somewhat unique segment [2] in that its arterial and portal blood supply comes from both right and left branches. In addition, the three or four hepatic veins which drain this segment are independent of the three main hepatic veins and enter the left side of the inferior vena cava below them.

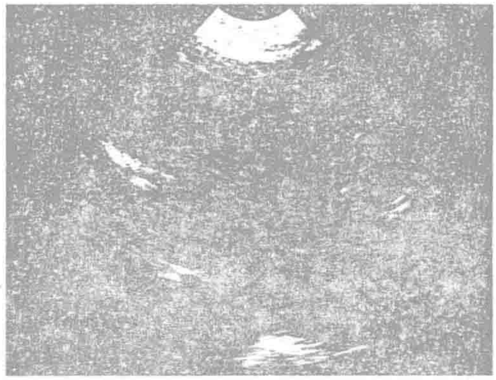
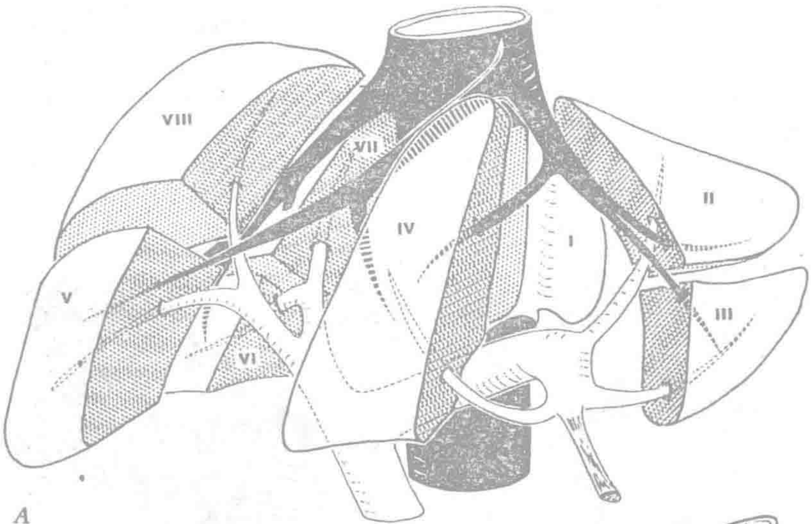


Fig. 1.13 Bile duct
Axial cut passing through the left liver showing a double duct image formed by the portal branch to segment III, and behind it the bile duct of the same segment, clearly seen even though it is of normal diameter.



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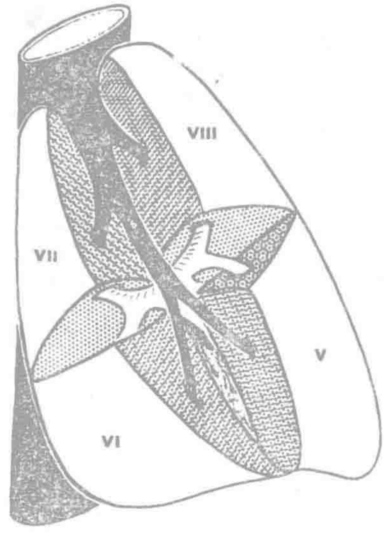

B

Fig. 1.14 The liver segments according to Couinaud
A Frontal view; **B** Lateral view. The left liver comprises segments II and III (left lobe) and segment IV. The right liver consists of two anterior segments (V and VIII) and two posterior segments (VI and VII). Segment I or the Caudate lobe is independent.