

## Technical Tricks to Start Exploring the Liver with Ultrasound

## 2

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The IOUS should always be carried out personally by the surgeon in charge of the surgical procedure, rather than by an assistant, radiologist, or technician. Optimally, ultrasound and operation are done by the same person. Only the surgeon has the required skills and background in interpreting ultrasound images in a surgical perspective, and will be able to judge possible surgical maneuvers by personally guiding the echoprobe. As mentioned in [Chap. 1](#), the ultrasound system has to be positioned opposite the chief operator who should be facing the screen ([Fig. 2.1](#)). The screen has to be large enough for allowing optimal visibility at that distance and lights should be positioned with caution not to obscure the surgeon's visibility of the ultrasound screen. An unscrubbed team member should be at hand to manipulate the keyboard or a transparent and sterile keyboard pad may allow a scrubbed assistant to handle the keyboard directly ([Fig. 2.2](#)).

After entering the abdominal cavity and preceding IOUS exploration, the liver should be mobilized dividing the round and falciform ligaments ([Fig. 2.3a](#)) and eventual adhesions should be dissected to free the anterosuperior and

inferior surfaces of the liver ([Fig. 2.3b](#)). Of course, adhesions with other organs or structures should not be severed as to possible tumor infiltration. In that case, IOUS can be helpful in ruling out or confirming the tumor invasion and allow for changing the surgical strategy accordingly. Palpation of the organ needs to precede the exploration with IOUS; indeed, as recently demonstrated [[1](#)], inspection and palpation of the liver are still of paramount importance.

By pulling the round ligament, the liver surface is widely exposed and following the portal branches and the hepatic veins, the liver can be entirely studied ([Fig. 2.4](#)). The probe should be managed using a pressure sufficient to ensure a good contact with the liver surface but not to compress the intrahepatic vascular structures and in particular the hepatic veins. Generally, at the onset one should not move the probe extensively over the liver surface but identify a vascular landmark which is generally represented by the main portal bifurcation. Then, once identified (see [Chap. 3](#)), just a minimal shifting of the probe on the liver surface would allow following all the portal pedicles, and exploring all liver segments by IOUS ([Fig. 2.5a, b](#)).

The hard and irregular surface of cirrhotic liver ([Fig. 2.6](#)), scars due to previous resection or strong adhesions in reoperated patients ([Fig. 2.3b](#)), or simply a heterogeneous ultrasound pattern make it somewhat difficult to detect small nodes both by palpation and IOUS exploration. Under such circumstances, searching a scanning window opposite the site of an

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**Fig. 2.1** Positioning of the ultrasound system in the operative theater: the operator faces the screen, which can be managed by the second or third assistant

unsuitable exploration to provide a deeper access than the initial superficial one would be essential to increase the chance to detect these lesions by IIOUS (Fig. 2.7a, b). This maneuver can be further improved by keeping the fingertip on the liver surface opposed to that in contact with the probe, paying attention to match the fingertip plane with that of the scanning window (Fig. 2.7c, d).

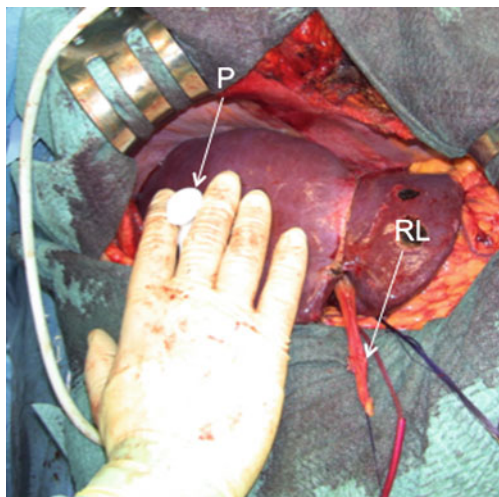
The above example illustrates that the rationale of liver exploration with IIOUS needs to follow each step of a surgical procedure, and should be repeated using different probes (Fig. 2.8a). If initially a mid-low-frequency probe (3.5–5 MHz) has been used to explore the deep structures prior to liver mobilization (Fig. 2.8a, b), a more detailed study of those areas of the organ initially not exposed could subsequently be achieved by a high-frequency probe (5–10 MHz). This is done by directly applying the probe on the liver surface once this

is exposed after mobilization (Fig. 2.8a, c, d). In case of a rough surface (cirrhotic liver, scars from previous surgery, or strong adhesions) for which exploration should be carried out on the opposite side, a mid-low frequency would be preferred (Fig. 2.9a–d). Structures as the caval confluence which initially should be explored prior to full exposure (Fig. 2.10a), would best be explored again upon full exposure of the organ in spite of the artifacts generated by surgical dissection. Here, small probes should be used which are able to detail particular anatomical aspects (Fig. 2.10b) which may be useful for further refinement of the surgical strategy. This is specifically useful in the event of lesions at the caval confluence, which may generate artifacts that could mask the pattern of the confluence of the hepatic veins at initial exploration.

As described in detail in the next chapter, the liver should be explored using as landmarks the glissonian pedicles (inflow) or the hepatic veins

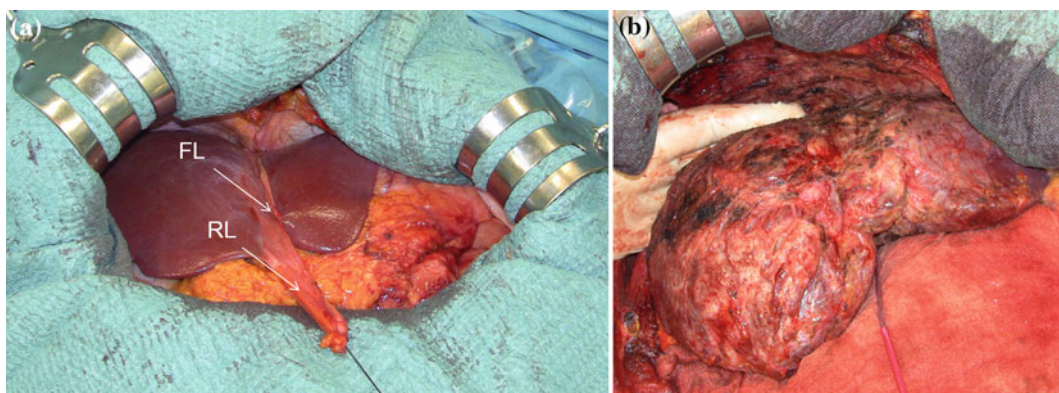


**Fig. 2.2** An ultrasound system with a sterile pad covering the keyboard to allow its management by the surgical team directly



**Fig. 2.4** A surgeon handling a probe and initially exploring the liver; round ligament (RL)

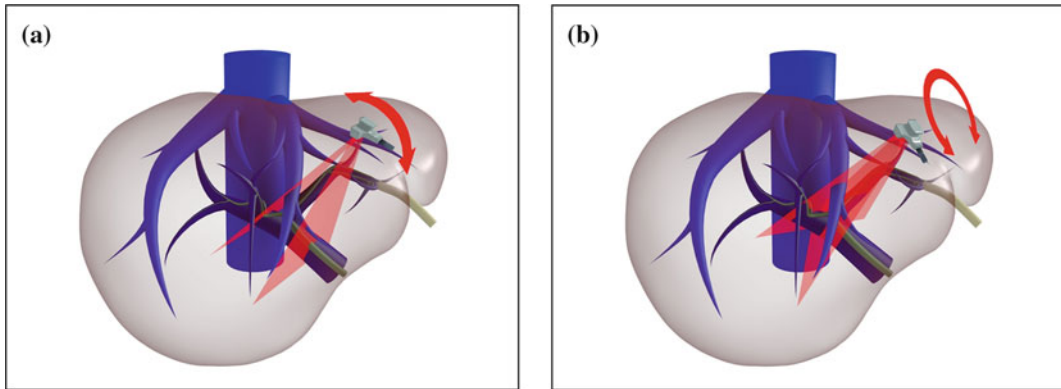
(outflow). To avoid ambiguity, in the following we use the *Brisbane terminology* for liver anatomy [2]. Prerequisite to the study of liver anatomy by IOUS (Chap. 3) one needs to acquire full knowledge of ultrasound semiology for distinguishing glissonian pedicles from hepatic veins. Glisson's capsule effects that the portal



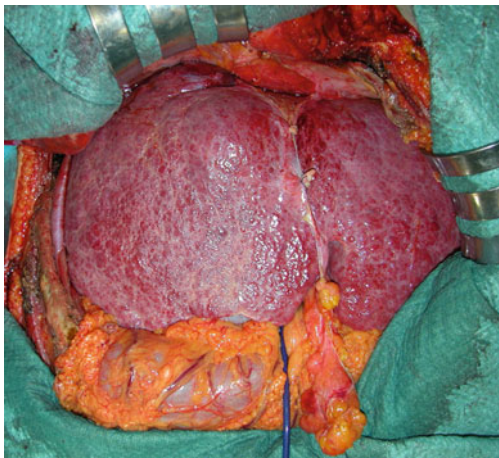
**Fig. 2.3** **a** The liver is exposed for initial exploration once the falciform ligament (FL) has been cut and the caval confluence has not been exposed yet for avoiding

artifacts upon IOUS; **b** liver exposed after extensive adhesions have been removed; round ligament (RL)





**Fig. 2.5** Moving the probe while exploring the liver. This consists in minimal upward and downward tilting (a) or rotation (b) of the probe, avoiding its extensive shifting on the liver surface

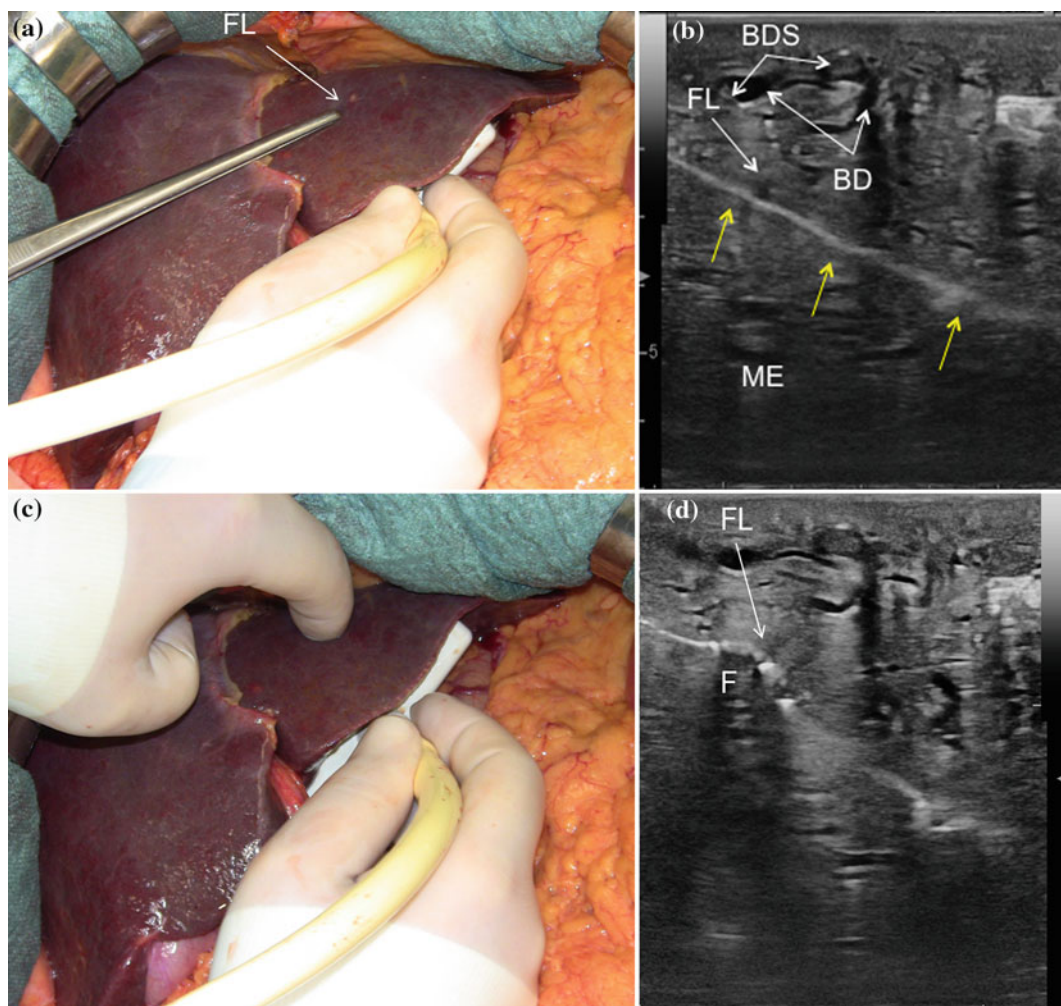


**Fig. 2.6** Cirrhotic liver after initial exposure

pedicles, which run together with the arteries and the bile ducts, have thicker vessel walls than hepatic veins and for this reason they appear in IOUS as echo-free zones surrounded by a thicker hyperechogenic layer (Fig. 2.11a, b).

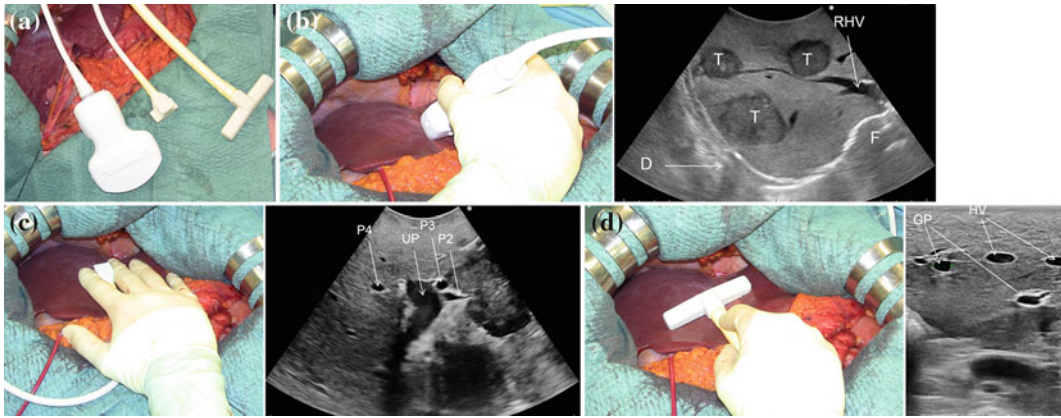
Furthermore, other parallel, thinner vascular structures are visible, being the artery and the bile duct of the glissonian triad (Fig. 2.11c). The new sensitive color-flow modalities allow for differentiation of arterial, portal, and biliary elements also within thin glissonean sheets (Fig. 2.12). Hepatic veins appear as echo-free zones inside the liver parenchyma with the vessel wall appearing as a thin hyperechogenic line (Fig. 2.11a–c): hepatic vein wall can be thicker in cirrhotic liver and its lumen thinner due to stiffness of the organ (Fig. 2.13a, b). However, in principle distinction between hepatic veins and portal branches should be based not only on their appearance but mainly on their anatomy.

Bile duct appearance in IOUS is particular: normally they present as thin echo-free zones in the glissonian triad (Figs. 2.11c, 2.12, and 2.14); once dilated though, they appear as more evident echo-free zones with a serpiginous path (Fig. 2.15).



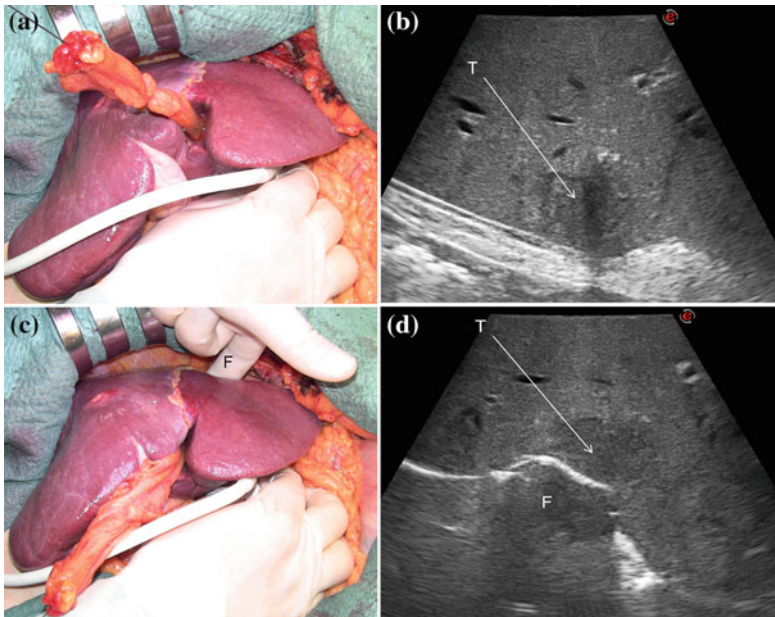
**Fig. 2.7** Procedure of scanning superficial lesions without adopting water-filled gloves (see also [Chaps. 1](#) and [4](#)). The lesion visible at inspection (*FL*), indicated by the forceps, is searched for ultrasound confirmation having the probe scanning at the opposite side (**a**). In this case, the lesion could not be confirmed with certainty due to inhomogeneous liver bile duct dilation (*BD*) and the presence of biliary sludge (*BDS*) (**b**). For this reason a

simultaneous finger palpation of the lesion (**c**), concurrently with IOUS, enables to precisely put in relation the suspected lesions at IOUS with the surgeon's fingertip (*F*) then confirming its existence and ultrasound appearance (**d**), which in this case is compatible with a fore site of a perihilar bile duct cancer; mirror effect (*ME*) (see [Chap. 4](#)); yellow arrows indicate the interface between the liver surface and the adjacent structures



**Fig. 2.8** Various probes (a) can be used for exploration taking advantage of their respective working frequencies, occasionally with improved panoramicity or more details. Indeed, a convex probe for percutaneous exploration can advantageously be used even intraoperatively (left) for enhanced panoramicity (right) of the scan (b). A microconvex probe (left) providing a wide scanning window when working at mid-frequencies also may enable sufficient panoramicity (right) (c).

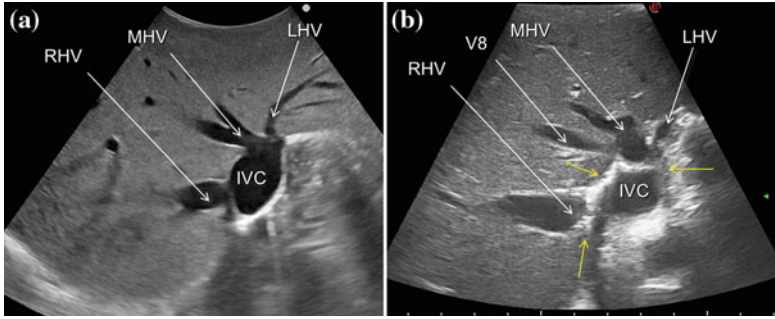
Conversely, a T-shaped linear array (left), generally working at higher frequencies and having a high density of crystals, is superior for providing detailed scans (right), though with reduced panoramicity (d); diaphragm (D); finger (F); glissonian pedicle (GP); hepatic vein (HV); portal pedicle to segment 2 (P2); portal pedicle to segment 3 (P3); portal pedicle to segment 4 (P4); right hepatic vein (RHV); tumor (T); umbilical portion (UP)



**Fig. 2.9** Scanning of superficial lesions without adopting water-filled gloves, as in Fig. 2.7 (see also Chaps. 1 and 4). Lesion not visible, but superficial and palpable, is

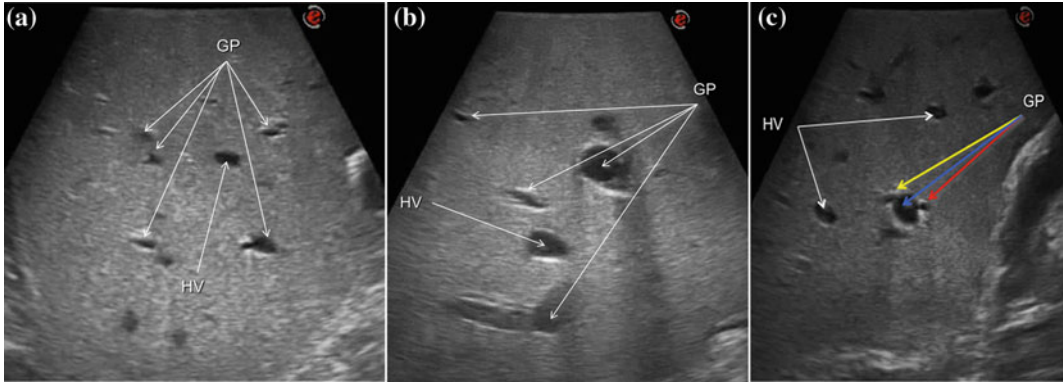
searched with the probe scanning at the opposite side (a), and is well depicted in IOUS (T), without (b), or with aid of fingertip palpation (c, d); surgeon's fingertip (F)





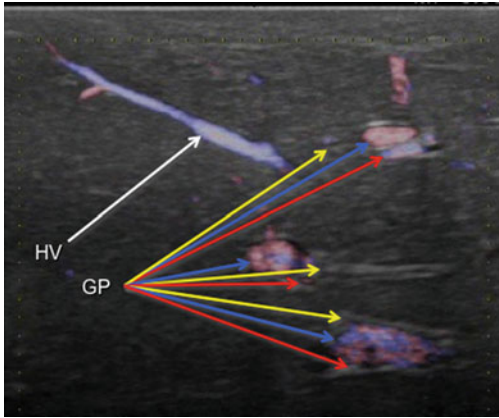
**Fig. 2.10** **a** The caval confluence before onset of dissection; **b** upon exposure, artifacts due to air bubbles (yellow arrows) may affect the exploration during IOUS, though this does not generally compromise the disclosure of peculiar aspects as a thick vein draining segment

8 (V8) and flowing into the middle hepatic vein (MHV) close to its confluence or the existence of a left hepatic vein (LHV) which is flowing into the inferior vena cava (IVC) very laterally; right hepatic vein (RHV)

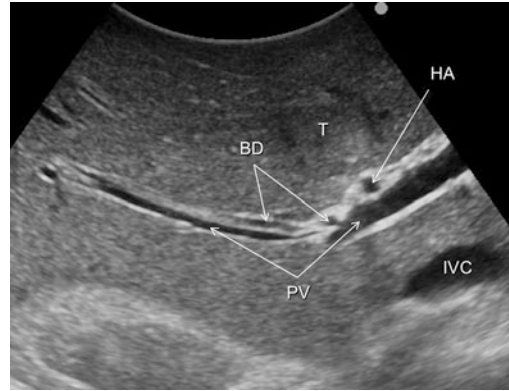


**Fig. 2.11** **a** Tiny branches of the hepatic vein (HV) and glissonean pedicles (GP): despite the small diameters, they can be discerned by the different thickness of the hyperechogenic layer surrounding the anechoic area of the vessel lumen; **b** similar to the previous, here the different thickness of the hyperechogenic layer

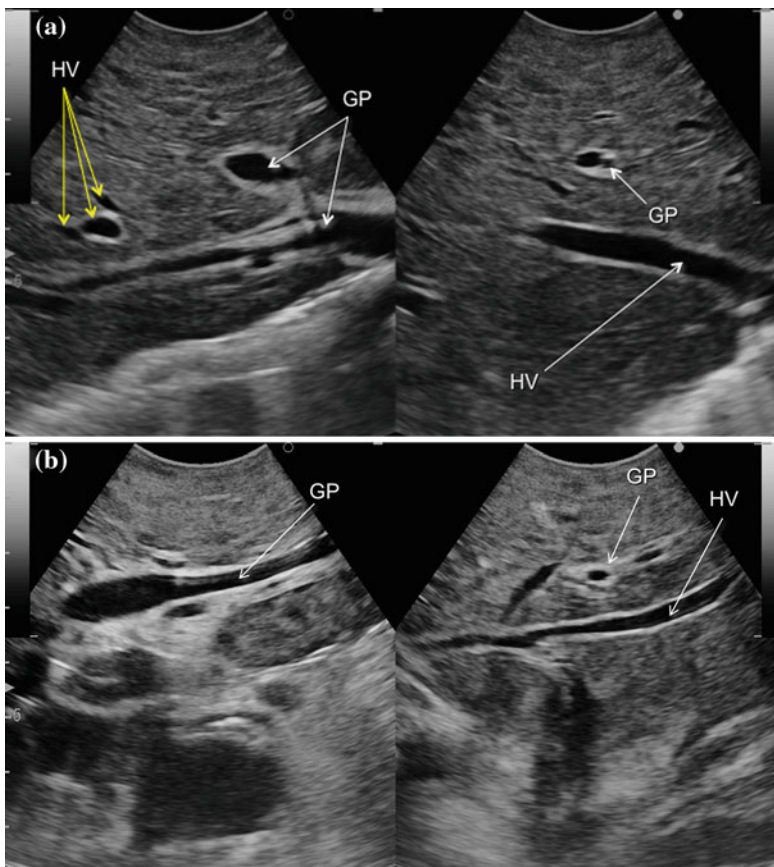
surrounding the vessel lumen in the case of GP and HV also is clearly seen; **c** triad composing a GP is disclosed by blue arrows for the portal branch, red for the artery, and yellow for the bile duct: a close look reveals the mickey-mouse pattern of the GP



**Fig. 2.12** Triple composition of the glissonian pedicle (GP) disclosed in color-flow IOUS, *colored arrows* indicating the various elements. The *color filling* the vessel lumen indicates the flow direction rather than the type of vessel; portal veins (*blue arrows*), arteries (*red arrows*), bile ducts (*yellow arrows*); hepatic vein (HV)



**Fig. 2.14** A normal bile duct (BD) running straight and parallel to the other elements of the glissonian pedicle, despite adjacency to the tumor (T)—portal vein (PV); hepatic artery (HA); inferior vena cava (IVC)



**Fig. 2.13** Sometimes, particularly in fibrotic liver, as in cirrhotics, vessel wall thickness can be misleading (**a**, **b**), and even the triad could lead to a wrong interpretation. Indeed, sometimes an hepatic vein (HV), once the scan

catches the confluence of multiple branches, could mimic a glissonian pedicle (GP), even mimicking the mickey-mouse pattern (to the left of the *yellow arrows* in **a**)





**Fig. 2.15** Slightly dilated bile ducts (*BD*) due to the presence of a tumor (*T*), eventually compressing or infiltrating their confluence: the ducts become more evident in IOUS and assume a serpiginous trajectory

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<http://www.springer.com/978-88-470-5509-4>

Ultrasound-Guided Liver Surgery

An Atlas

TORZILLI, G. (Ed.)

2014, XVI, 280 p. 344 illus., 293 illus. in color.,

Hardcover

ISBN: 978-88-470-5509-4