20.1 Introduction

Image processing is a very important tool in improving the quantity and quality of information given by ultrasound (US), computed tomography (CT), and magnetic resonance imaging (MRI) of the liver. The liver is the largest organ in the body, has a very complex anatomy and can be affected by many different diseases, including diffuse and focal diseases. Among diffuse diseases, cirrhosis has the highest prevalence and can be associated with portal hypertension and hepatocellular carcinoma (HCC) (Bartolozzi and Lencioni 1999). Cirrhotic patients are even more often candidates for orthotopic liver transplantation (OLT), and need an accurate evaluation of the liver itself and of its vascularization. Post-processing with three-dimensional (3D) evaluation of surfaces, volumes and vessels is of crucial importance in surgical planning.

20.2 Lobar and Segmental Anatomy of the Liver

Three-dimensional image processing plays a crucial role in pre-treatment evaluation of patients who need to be added to the waiting list for either living donor or OLT, or who have to undergo surgery or other therapeutic procedures for hepatic tumors (Bartolozzi and Lencioni 1999; Togo et al. 1998). In all of these patients, conventional imaging implemented by 3D image processing is useful in assessing hepatic morphology and vascular anatomy, detecting focal liver lesions, calculating liver volume, and evaluating portal hypertension (Heath et al. 1995; Nghiem et al. 1999; van Leeuwen et al. 1995).

As far as surface anatomy of the liver is concerned, it can be shown by means of CT and MR surface shaded display (SSD) that allow one to identify the classical lobar anatomy of the liver (van Leeuwen et al. 1994a,b). A correlation between external landmarks (i.e., fissures) and internal landmarks...
(i.e., vessels) is possible with an overview on anatomical variations and a different course of internal and external landmarks. This information is very important for the surgeon because what he sees on the surface may not correspond to what he will find in the liver parenchyma. The H-shaped indentations on the visceral faces of the liver divide it into four externally defined lobes: the right, left, quadrate and caudate. The right-hand limb of the H is formed by the fossa for gallbladder anteriorly and by a deep sulcus for the inferior vena cava posteriorly. The gallbladder fossa separates the anterior part of the externally defined right lobe from the quadrate lobe. The sulcus for the inferior vena cava separates the posterior portion of the right lobe from the caudate lobe. Between the gallbladder fossa and the sulcus for the inferior vena cava the right limb of the H is deficient where a caudate process connects the caudate lobe to the right lobe. The left limb of the H is formed by two deep fissures that contain true ligaments in their depths. Anteriorly it is formed by the deep fissure for the ligamentum teres, which separates the anterior part of the externally defined left lobe from the quadrate lobe. Posteriorly it is formed by the fissure for the ligamentum venosum, which separates the posterior part of the left lobe (Friedman and Dachman 1994).

Segmental anatomy is crucial in order to precisely localize a focal lesion, evaluate the possibility of a resection, find the adequate technique for resection, and to estimate the ease or difficulty of a biopsy or any other percutaneous maneuver. Segmental anatomy is the basis of modern hepatic surgery (Togo et al. 1999). Planes of resection in liver surgery, and the correct positioning of devices for interventional treatment, are largely determined by the precise position of the tumor relative to the individual segmental anatomy. Consequently, localization of liver lesions, and pre-operative evaluation of resection planes, require consideration of the significant anatomic variations in the segmental anatomy of the liver (Crocetti et al. 2005).

Each segment is supplied by a sheath containing branches of the hepatic artery and portal vein, as well as a draining bile duct, which enters the middle of the segment. The venous drainage is by hepatic vein, which tends to run between segmental divisions (Coutaud 1957; Healy and Schroy 1953; Healy 1970; Michels 1996; Goldsmith and Woodburne 1957; Bismuth et al. 1988).

The left portal vein divides into three branches: lateral posterior, lateral anterior and medial. The lateral posterior feeds segment 2. The lateral anterior feeds segment 3. The medial branch feeds segment 4.

The right portal vein divides into two branches, one anterior and one posterior. The anterior branch divides into a superior branch for segment 8, and inferior branch for segment 5. Segment 8 is localized between the middle hepatic vein (left), the right hepatic vein (right), and the inferior vena cava (superior and posterior). It lies over segment 5. Segment 5 is localized between the middle hepatic vein and the gallbladder fossa (left), the right hepatic vein (right), and the surface of the liver (inferior and anterior). It lies under segment 8. Segment 5 does not reach the inferior vena cava. The posterior branch divides into a superior branch for segment 7, and inferior branch for segment 6. Segment 7 is localized behind the right hepatic vein (right), and the inferior vena cava medial. It lies over segment 6, and is hidden by segment 8 when looking at the liver from the front. Segment 6 is localized behind the right hepatic vein and the surface of the liver (inferior and anterior). It lies under segment 7. Segment 6 does not reach the inferior vena cava, but is usually located in front of the right kidney.

Segment 1 is not fed by a single portal vein, and drains through multiple short hepatic veins into the inferior vena cava. Segment 1 is located between the portal trunk (anterior), the inferior vena cava (posterior), and the liver surface (left), and is in complete continuity with segment 7 on its right side (Fig. 20.1).

Spiral CT allows the acquisition of consistent volumetric data of the entire liver during the peak of vascular enhancement. From these volumetric data,