Study on the segmentation of the right anterior sector of the liver

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Background. *The segmentation of the right anterior sector of the liver still is debatable due to the lack of an anatomic landmark of the boundary between Couinaud segments V and VIII (cranio-caudal segmentation). Some authors have proposed the concept of a ventro-dorsal segmentation. The aim of this study was to evaluate which concept of segmentation better reflects the anatomy.*
Methods. *Using 3-dimensional computed tomography software, the ramification pattern of the right anterior portal vein was examined in 100 patients. A thick, hepatic, venous branch that passes through Couinaud segment VIII was termed V8, and its course was investigated using a virtual hepatectomy.*
Results. *Regarding the anatomy of the portal vein in the right anterior sector, the cranio-caudal type was found in 53 patients, the ventro-dorsal type in 23 patients, and the trifurcation type in 13 patients. The remaining 11 patients had miscellaneous patterns of ramification. In the cranio-caudal type, the volume of the cranial segment was greater (*$P < .001$*) than that of the caudal segment. In the ventro-dorsal type, the volume of the ventral segment was greater (*$P = .007$*) than that of the dorsal segment. The V8 was identified in 81 of the 89 (91%) patients analyzed. The proportion of cases in which the V8 functioned as a landmark of the border between the ventral and dorsal segments was 63% (56/89 patients).*
Conclusion. *Regarding the segmentation of the right anterior sector of the liver, the cranio-caudal segmentation introduced by Couinaud is dominant (53%), while ventro-dorsal segmentation is less common (23%). Therefore, universalization of the concept of the ventro-dorsal segmentation is unrealistic. (Surgery 2016;■:■-■.)*

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The liver segmentation proposed by Couinaud[1] involves dividing the liver into 8 operatively relevant segments based on the anatomy of the portal vein (PV) and hepatic vein and is used in everyday clinical practice. The boundaries between Couinaud segments, however, are not always clear. The boundary between segments V (caudal part of the right anterior sector) and VIII (cranial part of the right anterior sector) often is vague due to the lack of a clear anatomic landmark. Some authors have proposed the right anterior sector should be divided into ventral and dorsal segments.[2-6] In particular, Cho et al[4-6] stressed that this ventro-dorsal segmentation of the anterior sector should be applied universally in all cases and that the "anterior fissure vein" (AFV) is important as its landmark. Some authors have affirmed Couinaud's segmentation,[7,8] while others have supported Cho's classification.[9] Therefore, the method of segmentation still is debatable.

The aims of the present study were to investigate the segmentation of the right anterior sector according to the anatomy of the PV, to evaluate which concept of segmentation, ie, cranio-caudal (Couinaud) or ventro-dorsal (Cho), is most common, and in turn, to enable safe and precise segmentectomy of the right anterior sector of the liver. Therefore, we analyzed the branching pattern of the right anterior PV and evaluated the course of the so-called AFV using a virtual hepatectomy produced by 3-dimensional (3D) image-processing software.

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PATIENTS AND METHODS

Among all patients with suspected hepato-biliary-pancreatic disease who underwent multidetector-row computed tomography (MDCT) with dynamic enhancement at Nagoya University Hospital, patients who met all of the following criteria were

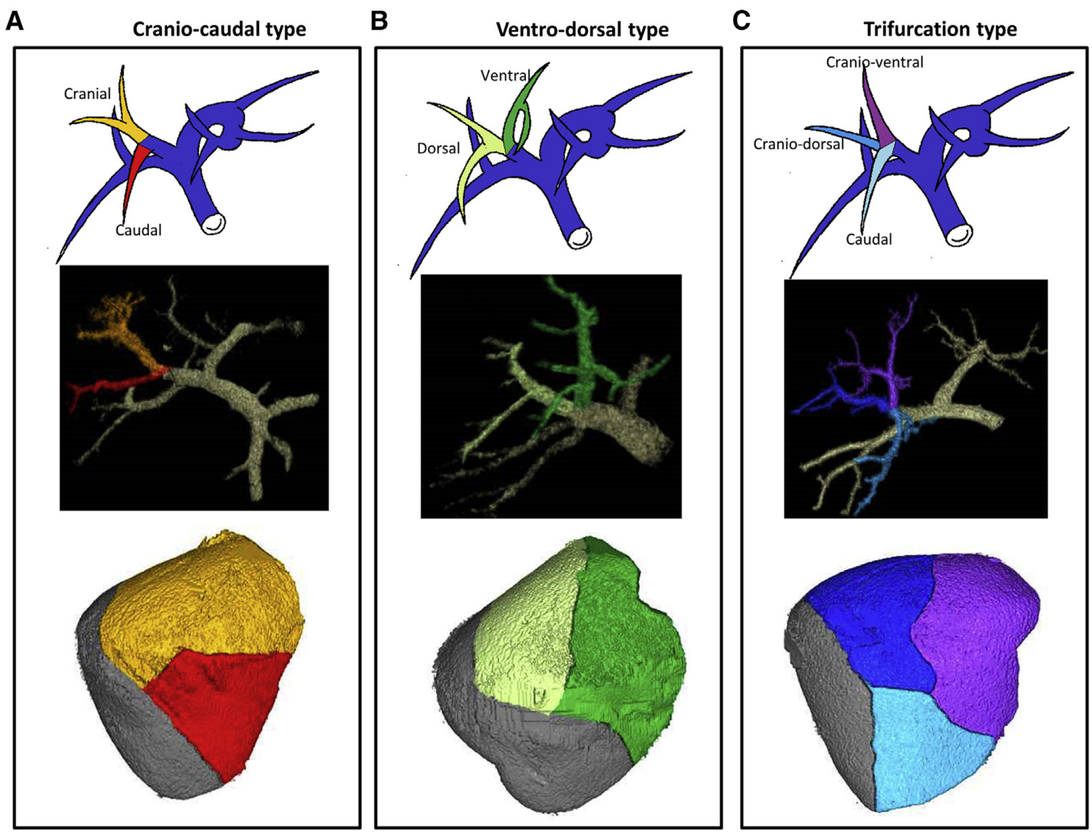

Fig 1. Segmentation of the right anterior sector according to the PV anatomy. A scheme of the anatomy of the PV (top), a 3D-portogram (middle), and the segmentation of the right anterior sector (bottom).

included for this study: 1) no liver tumor or cirrhosis and 2) no vascular invasion by the tumor.

All MDCT examinations were performed using a scanner with 64 rows of detectors (acquisition 64; Toshiba Medical Systems, Tokyo, Japan). A series of scans without a contrast agent was obtained throughout the liver and biliary tree. Then, 100–150 mL of nonionic contrast material with an iodine content of 300 mg/mL was administered via the antecubital vein at a rate of 0.07–0.08 mL/kg/s for 30 s with a power injector before the second, third, and fourth helical scans (early arterial, late arterial, and portal phases) were obtained (26, 45, and 68 s after contrast injection). The scanning parameters for the portal phase were 16 × 1.0 mm collimation, 1.0 mm slice thickness, 0.8 mm reconstruction interval, a table advancement of 30 mm/s, a rotation time of 0.5 s, a pitch ratio of 15:1, 120 kV, and 500 mA.

The MDCT data sets were transferred to a workstation for image analysis using specialized software (Synapse Vincent; Fuji Film Co, Tokyo, Japan). The liver parenchyma was extracted semiautomatically from consecutive MDCT images. Three-dimensional, volume-rendered images of the PV and hepatic vein were generated from late arterial or portal phase data using the automatic algorithm of the software. The extracted PV and hepatic vein were overlapped, and the reconstructed images were viewed from several angles on a workstation. The ramification pattern of the right anterior PV was examined, and the volume of the segments according to the right anterior PV anatomy was calculated.

A thick, hepatic venous branch that passes through Couinaud hepatic segment VIII was termed V8, and its characteristics were investigated. To determine whether V8 runs along the boundary between the ventral and dorsal areas of the right anterior sector (ie, whether V8 functions as a landmark of the boundary), a virtual hepatectomy (left hepatectomy + resection of the ventral area of the right anterior sector) was performed, and exposure of V8 on the virtual transected plane was examined. The virtual hepatectomy was performed by extracting the perfusion area of the target PV followed by its subtraction from the whole liver. The vascular perfusion area was calculated using an algorithm based on the Voronoi tessellation, a calculation method to partition