Einsatz virtueller Resektionen für die präoperative Planung und Riskoanalyse in der Onkologischen Leberchirurgie

Virtual Tumor Resection for Preoperative Planning and Risk Analysis in Oncological Liver Surgery

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Purpose

In major tumor resections, the amount of residual liver parenchyma which remains after complete tumor removal often reaches a critical limit, and the question about sufficient postoperative liver function becomes crucial. It is well known that devascularization of the remnant liver, due to necessary transsection of intrahepatic vessels, is an important pitfall leading to possible impairment of postoperative liver function. Since nowadays the computation of patient individual liver territories with respect to parenchymal blood supply and drainage is possible, one may ask to simulate various resection strategies prospectively, in order to find one with both safe tumor resection and minimal risk for devascularization. We present a software tool which enables the surgeon to simulate oncological resections in a quasi-realistic way, and which is designed to be practically used in clinical routine.

Material and Methods

The simulations are based on prior analysis of contrast enhanced CT scans acquired with standard examination protocols. The liver, tumors, and all intrahepatic vessels are segmented and for each liver voxel the supplying/draining vascular branches with respect to each vascular system are identified by the use of mathematical models. Those calculations are not part of the simulator and may be processed by a distant service provider. For the virtual resection planning, models of the liver, vessels, and tumors are displayed both in a 3D view as shaded surfaces and in a 2D view as transparent overlays to the original image data. In a preliminary stage, safety margins around the tumors can be defined. The resected volume consists of two parts. First the parenchyma within the safety margin around the tumor that has to be resected (Fig.1).

Second, the parenchyma drained or supplied by vascular branches affected by resection with this safety margin that will have an impaired blood supply or drainage (Fig.2). Within the virtual model the surgeon dissects the liver by drawing lines or landmarks both on the liver and vascular surfaces using the mouse pointer. By interpolation, one or more resection surfaces are created which can be manually modified (Fig.3). Continuously updated display of the distance between the resection surfaces and tumors guarantees that an adequate safety margin is achieved. Finally, the remnant liver volume taking into account the territories at risk of insufficient blood supply or drainage is calculated for the defined resection surfaces. In an advanced step, singular vascular branches can be marked and the benefit of their possible reconstruction is evaluated.

Results

The software was employed in two hospitals in combination with a distant service for prior image analysis. Virtual planning of about 30 clinical cases showed to have a significant influence on the selected surgical approach and the patient individual decision making process for resectability.

Conclusion

Planning of liver resections including the risk analysis allows for a better estimation of the remaining functional liver volume. This allows selecting the optimal resection strategy from a number of different strategies. Furthermore, unnecessary explorative laparotomies can be avoided in patients with unresectable tumors due to proximity of the tumor to vascular structures.

Acknowledgement

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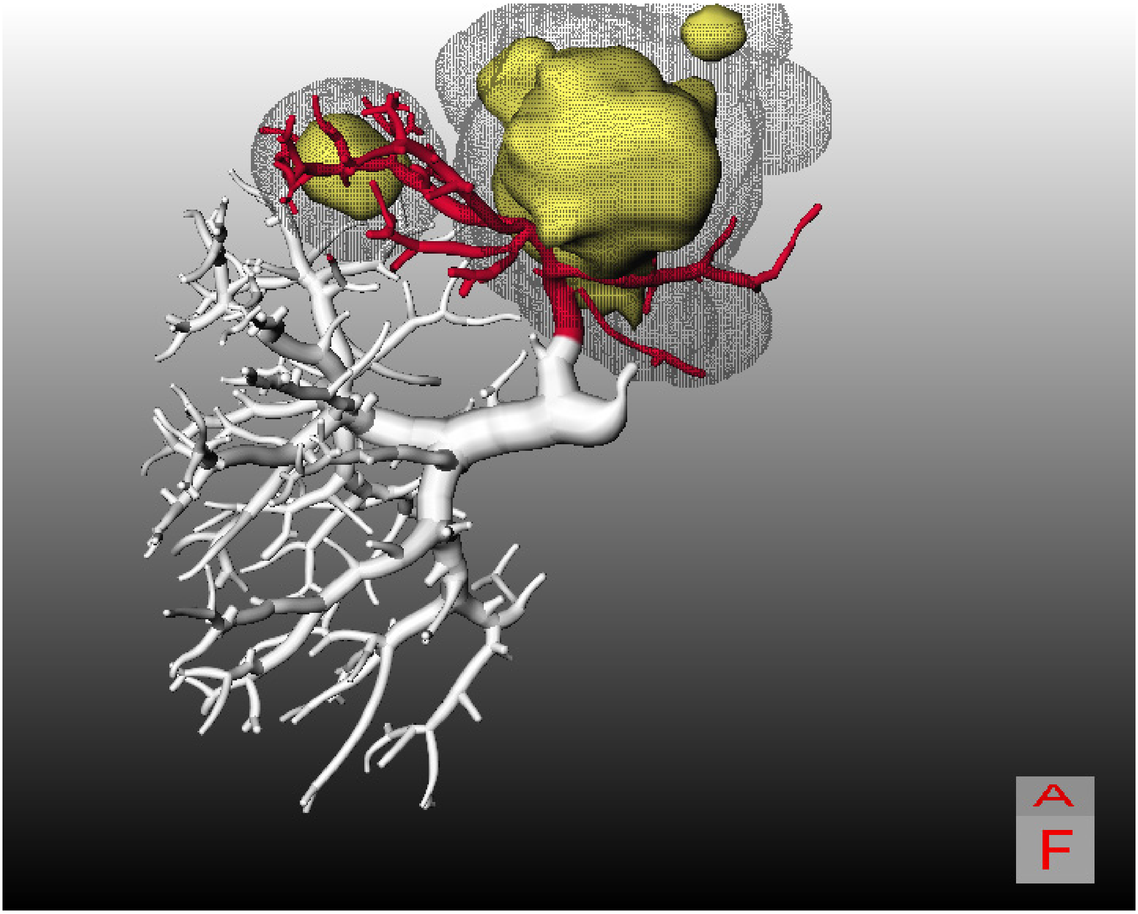
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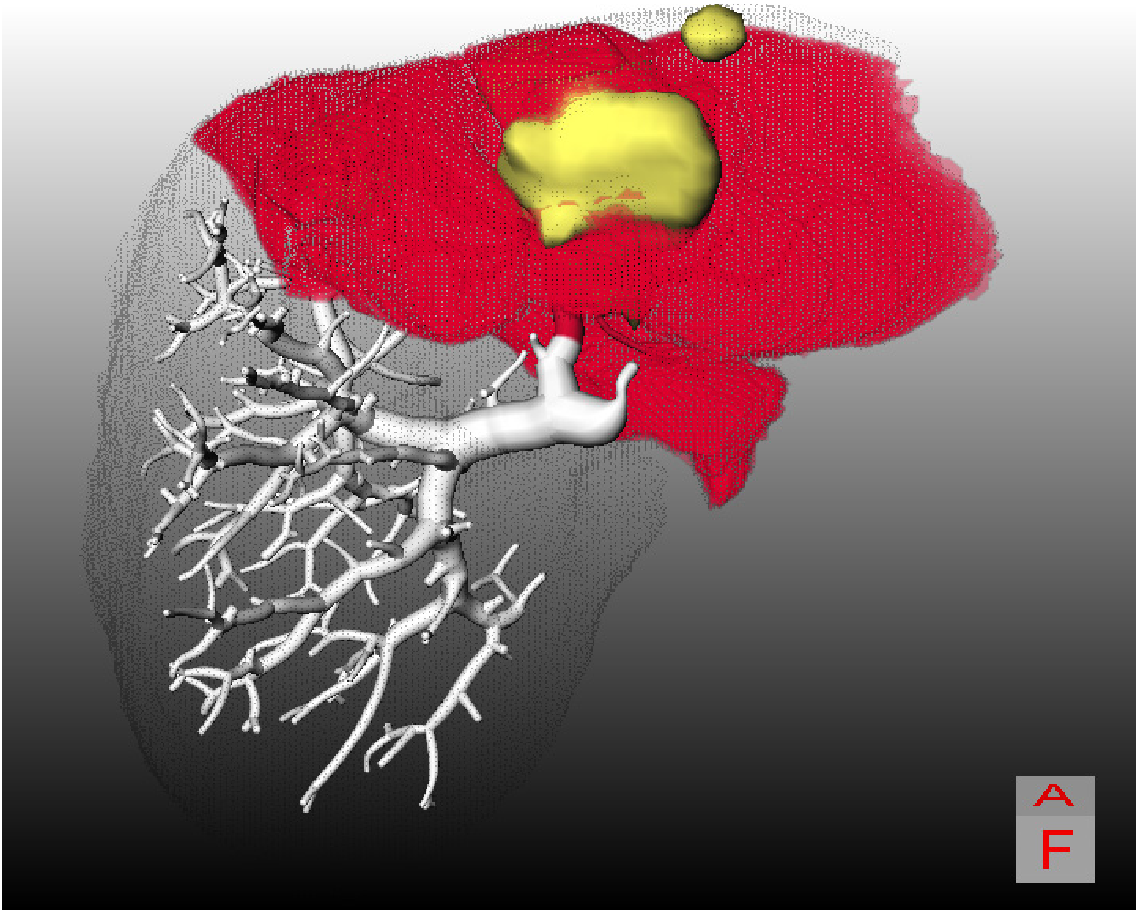
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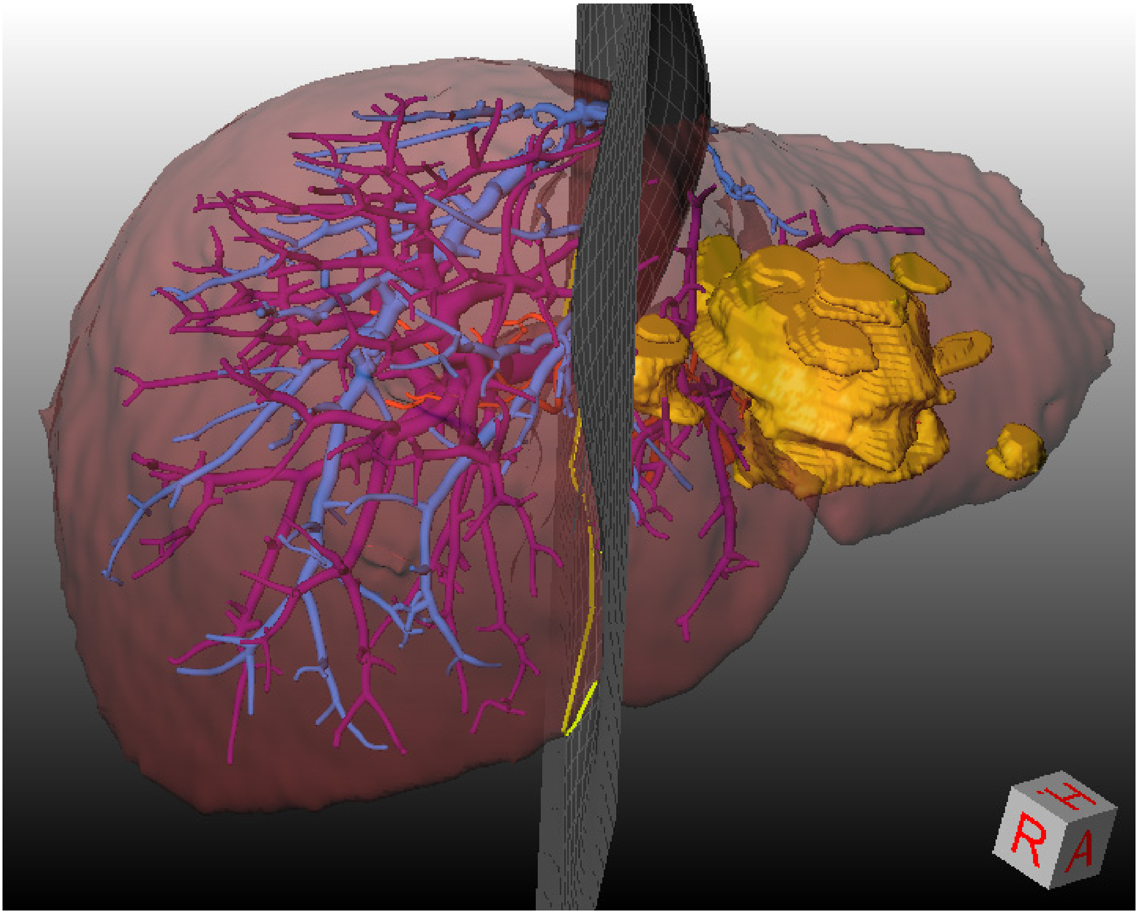
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