Intraoperative Adaptation of Preoperative Risk Analysis in Oncological Liver Surgery

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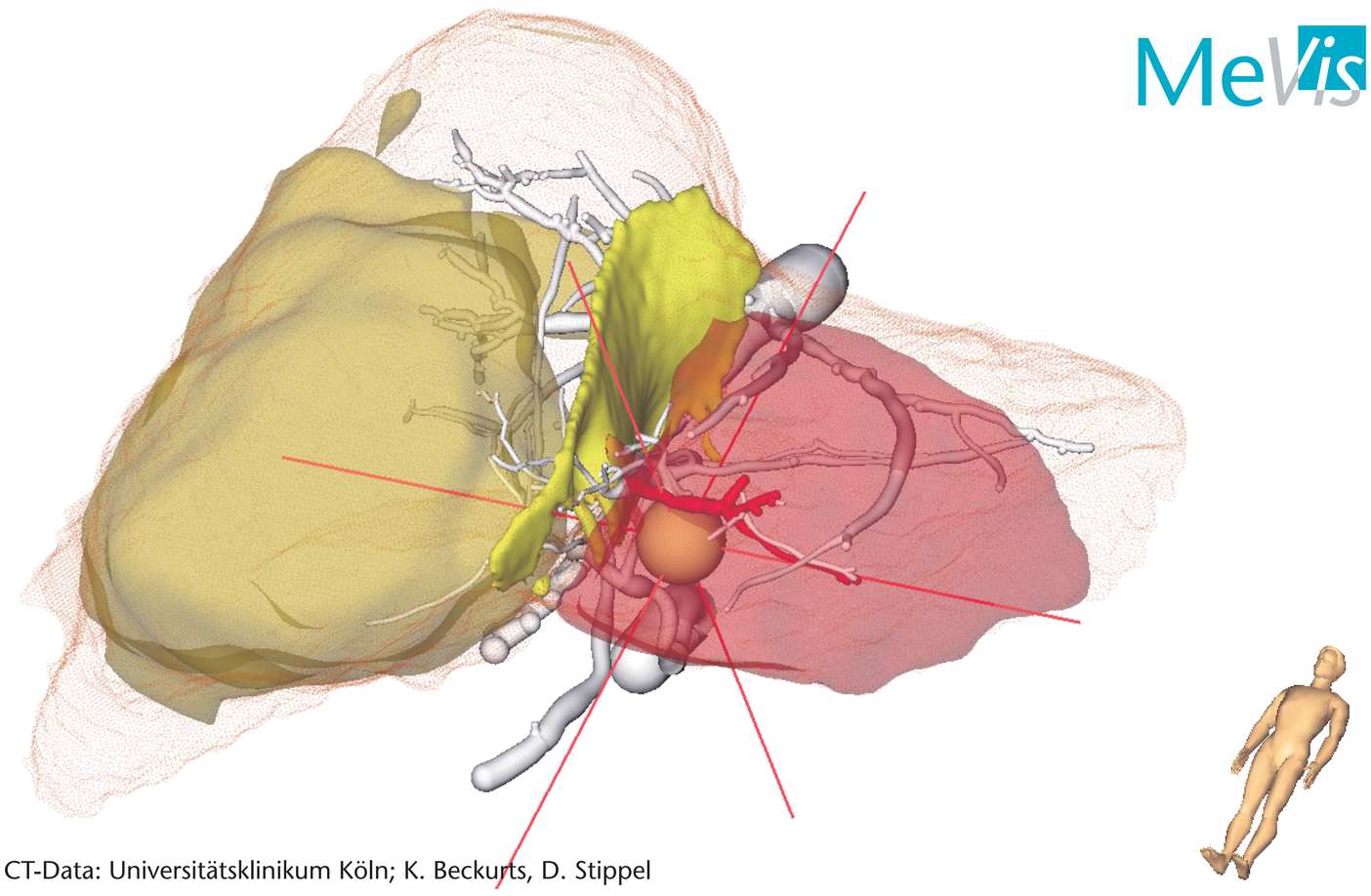
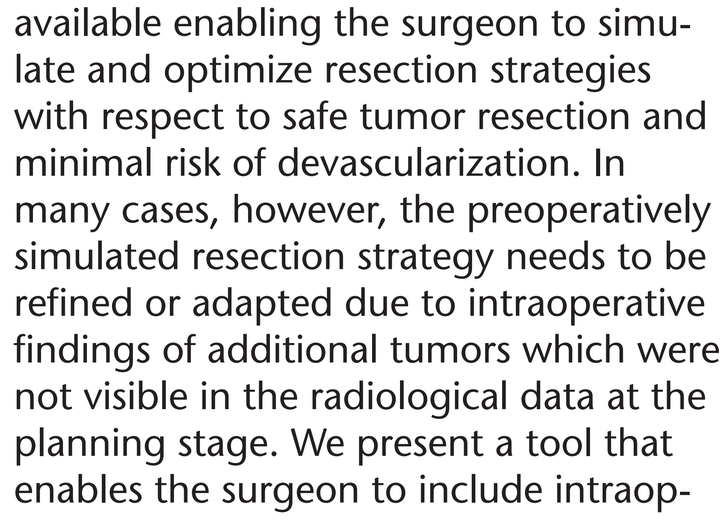
Purpose

Recently, the computation of patient individual liver territories dependent on the blood supply and drainage became available enabling the surgeon to simulate and optimize resection strategies with respect to safe tumor resection and minimal risk of devascularization. In many cases, however, the preoperatively simulated resection strategy needs to be refined or adapted due to intraoperative findings of additional tumors which were not visible in the radiological data at the planning stage. We present a tool that enables the surgeon to include intraoperatively detected tumors into an already existing resection simulation with minimal interaction. The newly computed loss of functional liver parenchyma supports the surgeon with a more precise estimation of the operational risk and assists in developing a resection strategy for critical cases.



CT-Data: Universitätsklinikum Köln; K. Beckurts, D. Stippel



Material and Methods

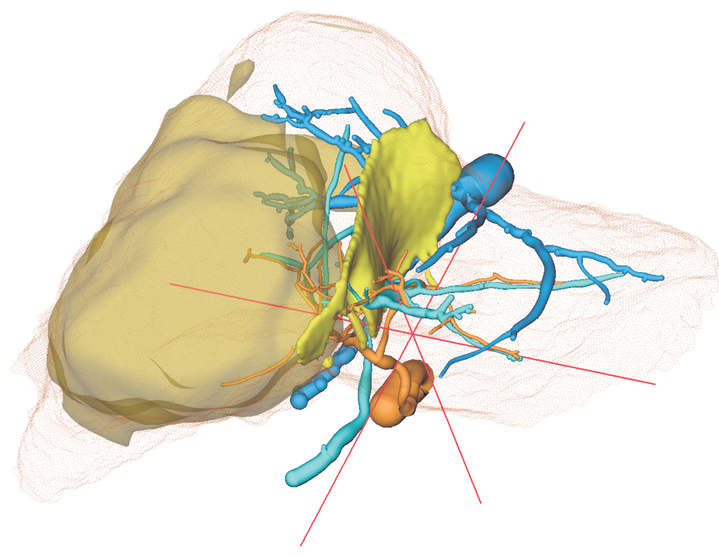
The preoperative simulations are based on contrast enhanced CT scans acquired with standard examination protocols. All relevant intrahepatic structures are visualized in a three-dimensional, surface shaded reconstruction of the patients liver as well as transparent overlays to the original CT scans.

The supply/drainage of the liver parenchyma is computed with respect to each vascular system by the use of mathematical models. For the planning of the therapeutic procedure tumor sizes and volumes may be quantified as well as the total liver volume. Based upon safety margins around each tumor, the affected vascular branches are identified and the parenchyma supplied or drained by those branches is computed, quantified, and displayed.

To estimate the need for changing the prior resection strategy, the preoperative planning results have to be related to the intraoperative simulations. For this purpose, the planned cutting plane can be overlayed to the virtual scenario. Impairment of the primarily presumed functioning liver remnant is computed and additional areas of risk are highlighted within the liver model. User interaction is minimized by the implementation of a default workflow composed of consecutive steps as follows:

1. Denote the location of newly found tumors within a single slice of the original CT data by mouse click.
2. Choose an estimated radius for each tumor including the presumed safety margins. For simplification, tumors are assumed to be approximately spherical in shape, as we focus especially on tumors of small size.
3. Start the computation of risk analysis.
4. Optionally include the resection proposal preoperatively made.

The software has been developed on the MeVisLab prototyping platform. As a preliminary step, it is installed on a standard notebook inside the operation theater. The user-interface is designed to be used by simple mouse interactions. Viewports for 2D and 3D displays are arranged equally in size and are synchronized with respect to selected tumor positions. As input device, we found best to use a track-ball system, which is also in common use for intraoperative 3D ultrasound navigation. The performance of the software with regard to user interaction and computation time is suitable to be used during a standard oncological intervention without causing appreciable delays.



Conclusion

Intraoperative refinement and adaptation of a preoperatively computed risk analysis supports the surgeon with a more precise estimation of the operational risk in case of newly discovered tumors. As the presented tool is simple in use and requires only minimal hardware extensions it easily can be integrated into the operational workflow of oncological interventions in liver surgery.

Selle D, Preim B, Schenk A, Peitgen H-O. *Analysis of vasculature for liver surgery planning*. IEEE Trans Med Imaging 2002; 21:1344-1357

Bourquain H, Schenk A, Link F. HepaVision 2: *A software assistant for preoperative planning in living-related liver transplantation and oncologic liver surgery*. Proc CARS 2002, Springer, 341-346

Van Ooijen PMA, Wolf R, Schenk A. *Recent developements in organ-selective reconstruction and analysis of multiphase liver CT*. Imaging Decisions 2003; 7:37-43

Lang H, Radtke A, Hindennach M, Schroeter T, Frühauf NR, Peitgen. *Impact of Virtual tumor resection and computer-assisted risk analysis on operation planning and intraoperative strategy in major hepatic resection*. Arch Surg 2005; 140: 629-