



The future of surgical simulation

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It is well investigated that it takes years of experience to mentally reconstruct a 2D CT or MRI scan for anatomical orientation in the liver (1,2). In addition, other disciplines can benefit from 3D reconstructions such as neurosurgery, plastic surgery and cardiothoracic surgery (3). We would like to thank Jun Yang and co-authors for their interest in our work and share their opinion about the importance of new technologies for surgical and anatomical education as well as the improvement of current clinical practice (4). The authors see also a great benefit of 3D reconstructions for anatomical education during medical school. We absolutely support this idea of implementing 3D modeling techniques in medical education.

One more addressed aspect in their comment is the limited use of new technologies due to a technical difficulties and financial costs. We believe that with increasing digitization and rapidly advancing technical innovations, surgeons will have less reticence towards new technologies. Furthermore, healthcare providers will hopefully see the benefits of these technical innovations and enable financing. Furthermore, hard- and software costs for these technologies will be reduced over time. Nonetheless, innovation always require a scientific evaluation of the new technical possibilities according to IDEAL criteria (5). Therefore, we started a prospective randomized clinical trial to evaluate the influence of 3D reconstruction and its visualization technologies on resection planning in liver surgery that includes 3D PDF, 3D PR and 3D VR and a control group (6). Since our own experiences confirm the authors' opinion that 3D reconstruction is not beneficial in simple minor resections, inclusion criteria for the i-LiVR-Trial are major liver resections or minor resections with high complexity. The aim of this study is to evaluate the

influence of 3D visualization on volumetry, procedural planning as well as surgical teaching.

The future of medical education lies in the field of virtual and augmented reality. Other professions such as pilots have established VR training for decades. Nevertheless, in surgery structured simulation training prior to operating on patients has still not been fully implemented, yet (3).

In our opinion, for all surgical specialties, realistic and patient-specific procedural simulation will be the key to overcome (parts of) learning curves even in highly demanding procedures. This means not only the mere planning of a procedure, but an actual "test" on individual patient datasets, combined with realistic tissue modelling algorithms and a possibility for complication management. Technological innovations and collaborative efforts will be the only way to reach this level as a new dimension of surgical simulation and preoperative planning.

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