Preliminary Trial of Augmented Reality Performed on a Regular and a Robot-Assisted Laparoscopic Partial Nephrectomies

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Introduction. Augmented Reality (AR) aims at improving the vision of the anatomy in laparoscopy. AR works with regular, robot-assisted and 3D laparoscopy. It modifies the intraoperative vision to provide the surgeon with effects such as a virtual transparency of the organ, in order to reveal the organ's inner structures, namely tumours and the major vessels [1,2,3,4,5]. AR is a technical challenge and only very recently has the first AR software capable of handling soft tissue deformation on a mobile organ been proposed [1]. This AR software has been developed by an interdisciplinary research team involving surgeons and computer scientists. The software works by fusing a preoperative MR or CT volume with the laparoscopy video. It is image-based: it does not require a special hardware nor the use of artificial markers. It can thus be used very easily in any standard laparoscopy equipped operating room. Its benefits were evaluated in an ex-vivo preclinical study for guiding tumour resections with porcine kidneys [2]. Performance was measured with the negative margin rate across 59 resected pseudo-tumours. This was 85.2% with AR guidance and 41.9% without, showing a significant improvement. We present the first two cases of using the AR software [1] in laparoscopic PN.

Materials and methods. Both PN cases concerned the resection of a partly exophytic tumour near the arterial pedicle. The procedures used robot assisted and regular laparoscopy respectively. First, we created the preoperative 3D model of the kidney from the CT using MITK [6], including the tumour and arterial pedicle. Second, we intraoperatively filmed a checkerboard to calibrate the laparoscope and recorded the surgery video. Third, we postoperatively aligned the preoperative 3D model to a laparoscopy image roughly using a tactile screen. The AR software then automatically refined the alignment and augmented the video by overlaying the kidney with the tumour and the arterial pedicle.

Results. The AR software performed very successfully in both cases. The kidney was highly mobilized but the AR software coped and rendered the expected virtual transparency effect. The kidney was not detected at times because of strong occlusions but AR always resumed quickly and automatically as soon as the part of the kidney nearby the tumour was sufficiently visible. The display of the inner anatomical structures is customizable and we found that they were made greatly visible using virtual transparency. Although the tumours were already partly visible outside the organ, AR revealed their internal extent and rich information on the organ's inner anatomy.

Conclusion. These two successful case studies belong to a first series aiming to show AR feasibility in laparoscopic PN. They show that AR in laparoscopic PN may fruitfully complement endo-ultrasonography. The latter is the current gold standard but has a substantially higher deployment cost than the AR software [1]. Much work remains to be done, including running AR intraoperatively and evaluating on a cohort of patients with representative endophytic and exophytic tumours in PN.

References

1. T. Collins, P. Chauvet, C. Debize, D. Pizarro, A. Bartoli, N. Bourdel et al.: A System for Augmented Reality Guided Laparoscopic Tumour Resection with Quantitative Ex-vivo User Evaluation. In Computer-Assisted and Robotic Endoscopy. Springer International Publishing, 2017, pp. 114–126.
2. P. Chauvet, T. Collins, C. Debize, A. Bartoli, M. Canis and N. Bourdel: Augmented reality in a tumor resection model. Surg Endosc. Epub ahead of print 15 August 2017. DOI: 10.1007/s00464-017-5791-7.
3. P. Phutane, E. Buc, K. Poirot, E. Özgür, D. Pezet, A. Bartoli et al.: Preliminary trial of augmented reality performed on a laparoscopic left hepatectomy. Surg Endosc. 2018; 32: 514–515.
4. S. Nicolau, L. Soler, D. Mutter, J. Marescaux: Augmented reality in laparoscopic surgical oncology. Surg Oncol. 2011,20:189-201.
5. A. Hughes-Hallett, P. Pratt, E. Mayer, S. Martin, A. Darzi, J. Vale et al.: Augmented Reality Partial Nephrectomy: Examining the Current Status and Future Perspectives. Urology 2014, 83:266-273.
6. I. Wolf, M. Vetter, I. Wegner, M. Nolden, T. Bottger, M. Hastenteufel et al.: The Medical Imaging Interaction Toolkit (MITK). http://www.mitk.org/.