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VESSEL-BASED DEFORMABLE REGISTRATION FOR ASSESSMENT OF LIVER SHIFT AND DEFORMATION IN AN ANIMAL MODEL DUE TO PNEUMOPERITONEUM IN LAPAROSCOPY

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Laparoscopic liver resections require careful planning and accurate guidance to achieve an acceptable resection margin. The planning is usually performed with preoperative CT or MR images. However, the intraoperative usefulness of preoperative CT or MR images is limited in laparoscopic liver surgery as the liver is shifted due to respiratory motion and heartbeat, pneumoperitoneum, and surgical manipulation. Laparoscopic ultrasound (LUS) together with navigation based on preoperative images can reduce many of the drawbacks of minimally invasive interventions, like reduction of free sight and lack of dexterity and tactile feedback. The shifts introduced during surgery require updating the registration of the preoperative data to the intraoperative setting.

This study makes use of the vessels in the liver to determine the amount of shift and deformation introduced by pneumoperitoneum and respiration in laparoscopy. A non-rigid registration method was used to measure this shift. Data from an animal trial with vessel contrast injected during 3D cone beam CT imaging before and after pneumoperitoneum was used for the study. The centerlines of the liver vessels were extracted using our in-house research navigation system software (SINTEF, Trondheim, Norway). The centerlines were used to drive a thin plate spline based algorithm to obtain the shift and deformations introduced by the pneumoperitoneum. The algorithm tries to find the best fit of the vessel centerlines before and after gas insufflation using a modified Iterative Closest Point approach.

We found that the rigid shift due to pneumoperitoneum was in the range 10-15 mm, mainly in the cranio-caudal and anterior-posterior direction. The deformation was less than 5 mm, which represents the difference between the two centerlines after the rigid shift.

The results are encouraging and the future plan is to explore the possibility of updating the initial registration based on the first 3D intraoperative Power Doppler ultrasound scan of the region of interest in the liver.