Transactions on Additive Manufacturing Meets Medicine
Trans. AMMM, 2024, Vol. 6, No 1, Suppl. 1, Article ID 1871, 1 Page

Abstract

3D-printed cholecystectomy model for robotic surgery training

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Robot-assisted surgery (RAS) has grown to become commonplace in various surgical disciplines, due to the enhanced precision, visualization, and dexterity that these systems allow. To train operators in using RAS systems to perform surgeries, virtual and augmented reality simulation, animal or cadaver models, or synthetic organ models can be used. Augmented and virtual reality training is a necessary part of training operators, yet it is often not tailored to a specific surgery, nor does is adequately simulate instrument function. Cadaver and animal models are commonly used to develop and improve user competency in RAS systems, but their use is limited and complicated by accessibility, ethical concerns, lack of reusability, and high cost. In recent years, 3D-printed synthetic organ models have been developed to train operators in performing robot-assisted surgeries on specific organs [1]. Cholecystectomy, or gallbladder removal, is a commonly performed laparoscopic surgery in general surgery. Additionally, the cholecystectomy is regarded as an operation that lends itself to educating general surgeons in the beginnings of their robotic surgery learning curve [2, 3]. Thus, we have developed a 3D-printed model to allow users to train performing a cholecystectomy on a RAS system. Our model is comprised of the gallbladder, cystic duct, cystic artery, as well as surrounding organs, including segments of the liver and intestine. The gallbladder and surrounding organs are realized using hard polymer Vero materials of various colors to allow for realistic visuals, printed with a Stratasys J850 PolyJet 3D printer (Stratasys, Ltd., Eden Prairie, Minnesota, United States). During a cholecystectomy, the cystic duct and cystic artery leading to the gallbladder are clipped or sutured and divided, and are realized with soft, tissue-mimicking materials. We have 3D printed the cystic duct and artery using a Keyence Agilista 3200, using a soft silicone-like printing material, AR-G1L, which has a Shore hardness of 35A (Keyence Corporation, Osaka, Japan). The soft components can quickly be removed and exchanged, allowing for several successive cholecystectomies to be performed in small timeframe, circumventing the need for animal or cadaver models, and providing interventionalists with a realistic training experience and paving the way for the development of new curricula for training robot-assisted surgery operators.

AUTHOR'S STATEMENT
Conflict of interest: Authors state no conflict of interest.
Funding: This project has been partially funded by the European Union–European Regional Development Fund (ERDF), the Federal Government and Land Schleswig Holstein, Project No. 12420002 (IMTE1), Project No. 12422005 (Lübeck Innovation Hub for Robotic Surgery (LIROS), and the University of Lübeck, TANDEM III-CIC: Grant: 124 20 003 / LPW-E1.1.1/1521.

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DOI: 10.18416/AMMM.2024.24091871