

Abstract

Development of dynamic heart and coronary artery models to train anastomoses for cardiac surgery

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The growing difficulty of cardiac surgery due to the increasing complexity of pathologies demands high levels of motor and cognitive expertise from heart surgeons [1,2]. Training on models can help to teach and improve the necessary competences, thereby increasing patient safety [2]. In particular, cardiac anastomoses are common and demanding procedures [3], as they serve to revascularize the coronary arteries. Therefore, this work aims to develop a training model for cardiac anastomoses using synthetic vessels fabricated from silicone. For the fabrication of the vessels and the heart model, casting molds made of clear resin were printed with a Form 4 (Formlabs, Somerville, USA) using masked stereolithography. The mold for casting coronary arteries consists of a two-piece mold and a core. The mold has cavities of varying diameters in each half that correspond to a cavity in the other mold component, allowing for the creation of a cylindrical form. Stainless steel wires were used to realize the lumen and act as the core of the mold. Vessels with wall thicknesses ranging between 0.2 mm and 0.5 mm and inner diameters of 1.5 mm and 2 mm can be cast from silicone using this mold. To imitate the elastic properties of coronary arteries, Dragon Skin® 10 and 20 (Smooth On, Inc., Pennsylvania, USA) were utilized. The vessels can be placed on the heart model which also consists of Dragon Skin® 10. The construction of the heart mold was based on a model created by using data from a CT scan provided by the University Hospital of Groningen. For the integration of a heartbeat-simulating pump a cavity was created by inserting a core into the two-part mold and dissolving it after the cast. The core was printed with a Stratasys F370 (Stratasys Ltd., Minnesota, USA) via FDM using the soluble material QSR Support (Stratasys Ltd., Minnesota, USA). Finally, feedback was obtained from four senior physicians and three assistant physicians of Cardiac Surgery. The proof-of-feasibility feedback suggested that the training model can be suitable for learning and improving cardiac surgical anastomoses. The model also achieved 84 points on the System Usability Scale (SUS). These results should be confirmed by studies with a larger number of participants and scientific questionnaires.

AUTHOR'S STATEMENT

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