In situ patient-specific simulation of complex cardiac surgery: A simulation-based observational study with 3D heart models

Format: Research Studies - Oral Presentations and Short Communications
Topic: Surgical and Psychomotor Skills Training

Authors

Frank Halfwerk	Medisch Spectrum Twente
Karin Smits	Maastricht University
Edsko Hekman	University of Twente
Jan van Es	Medisch Spectrum Twente
Maaike Koenrades	Medisch Spectrum Twente
Jutta Arens	University of Twente
Ron Speekenbrink	Medisch Spectrum Twente

Title

In situ patient-specific simulation of complex cardiac surgery: A simulation-based observational study with 3D heart models

Introduction

Low volume and high complex cardiac surgery such as resection of excess heart muscle (myectomy) has proven to be effective, yet, serious complications such as a ventricular septal defect, and complete heart block leading to pacemaker implantations may occur even for experienced surgeons.

In situ simulation-based practice before actual surgery might improve patient outcomes. As simulation and clinical practice becomes more and more intertwined, we aimed to develop and implement three-dimensional (3D) heart models in preoperative planning and training to improve pre-operative patient-specific anatomy insights and surgical technique in an observational study to ultimately improve surgical outcome.

Methods

Eight consecutive patients scheduled for surgical myectomy received cardiac Magnetic Resonance Imaging (MRI) based 3D-planning from September 2020 to August 2022. The dedicated cardiac MRI examination resulted in a high resolution 3D sequence of the heart and thoracic blood vessels. Models increased in complexity over time from a) an in silico anatomical model, to b) 3D-printed septal myectomy planning, to c) pre-operative in situ surgical practice on a silicone model, and to d) intraoperative assessment of actual heart muscle resection compared to pre-operative planning. The models were also used for patient consultation and surgical informed consent. Our small sample size was deemed too small for quantitative analysis of patient outcomes.

Results & Discussion

An in silico 3D anatomical model of the heart with height map is visualised in Figure 1a. Thickened heart tissue exceeding 15 mm was printed in red for visual guidance of surgical resection (Figure 1b). In situ simulated resection of excess heart tissue was simulated on the silicone model one day before the actual surgery (Figure 1c), and allowed for adjustment of the planned resection. The pre-operative surgical plan and actual resected myocardial tissue volume and size were compared intraoperatively (Figure 1d).
Since introduction of the patient-specific models, surgeons feel better prepared, more confident, and feel better supported making pre- and intra-operative decisions. Additionally, patients feel better informed about the actual procedure during outpatient consultation.
In situ patient-specific simulation of complex cardiac surgery has become regular surgical practice in our hospital. It is recommended to implement and evaluate the presented workflow in other cardio-thoracic surgery centres, and for other disciplines to demonstrate improvement in patient outcomes.

Keywords

High Fidelity Simulation Training; Heart surgery; Three-Dimensional Imaging; Just-in-time simulation

References/Acknowledgements

Aggarwal R. Just-in-time simulation-based training. BMJ Quality & Safety 2017;26:866-868. https://dx.doi.org/10.1136/bmjqs-2017-007122
Ralph-Edwards A, Vanderlaan RD, Bajona P. Transaortic septal myectomy: techniques and pitfalls. Annals of Cardiothoracic Surgery 2017;6(4):410-415. https://doi.org/10.21037/acs.2017.07.08

Figure/Table