CI 0.26–1.36, P=0.22). In 2 trials including 686 patients, significantly more patients were free of angina at 1 year, defined as Canadian Cardiovascular Society grading of angina pectoris grade 0, in the CTO PCI group compared to the no intervention group (OR 0.52, 95% CI 0.35–0.76, P<0.001). Meta-regression analyses based on various trial-level covariates (gender, diabetes, previous myocardial infarction, PCI or CABG, SYNTAX or J-CTO scores, and CTO-related artery percentages) did not suggest any statistically significant relationships.

Conclusions CTO PCI appears to have a similar efficacy profile compared to no intervention at long-term follow up, but with a significant improvement of angina favoring PCI-treated patients. Further adequately powered and long-term trials are required to identify the best management strategy of patients with coronary CTO.

Conflict of Interest Non

DEVELOPMENT OF NOVEL COST-EFFECTIVE CMR-CONDITIONAL 3D PRINTED CARDIAC PHANTOM FOR SIMULATED RIGHT HEART CATHETERISATION

Enhui Yong, Yaxi Wang, Nina Karia, Daniel Knight, Helge Wurdemann, Vivek Muthurangu. 1UCL Institute of Cardiovascular Science, Gower Street, London, LND WC1E 6BT, United Kingdom; 2Department of Mechanical Engineering, University College London; 3UCL Institute of Cardiovascular Science; 4Department of Mechanical Engineering, University College London; 5UCL Institute of Cardiovascular Science

Introduction Invasive catheter assessment of pulmonary haemodynamics is necessary for optimal management of pulmonary hypertension. Our unit routinely performs CMR-guided right heart catheterisation although now required a cardiac phantom
for further procedural simulation in the MR suite. Yet, cardiac phantoms for right heart catheterisation are relatively rare. The aim of this study was to utilise 3D printing techniques to develop an anatomically accurate CMR-conditional cardiac phantom for simulated right heart catheterisation in pulmonary hypertension. Design criteria were anatomical accuracy, MR-compatibility, leak-proof, visualisation of the catheter within, cost-effectiveness and low maintenance.

**Methods** Standard acquisition of a 3D whole heart sequence was performed on a 1.5T CMR scanner. Image acquisition was from a patient with pulmonary hypertension and elevated right heart chamber dimensions who had consented for anonymised research. Segmentation was semi-automated on OsiriX and MiaLite plugin using its propagation level-set algorithm (Figure 1). The left heart, aorta and superior vena cava were cropped manually as only the geometric right heart, pulmonary trunk, pulmonary arteries and inferior vena cava were of interest. DICOM images were exported as an STL mesh to obtain a digital model. Post-processing was performed on Meshmixer. Inlet and outlet pipes of 19 mm diameter were added to allow connection to a flow loop. To make a hollow blood space, the model was hollowed with 1.2 mm thickness. The final mesh was smoothed and repaired. A computer aided design (CAD) mock-up was created in TinkerCad to design the housing box and flow loop. A rapid prototype was 3D printed with a fused deposition modelling (FDM) printer Creality EnderV3 for speed and low cost. This confirmed an accurate and viable model, however the direction of the tubular outlets were repositioned to allow better seating and orientation. The phantom was commercially printed on a stereolithography (SLA) FormLabs3 printer. SLA was chosen for its high detail and dimensional resolution. To obtain a hollow, visually translucent watertight model, clear rigid resin material was chosen. The phantom was assembled in a plastic box with drilled sideholes. Custom PLA connectors were designed with O-rings to enable watertight connection to 0.5 inch hose connectors which was used with standard vinyl tubing and a 6Fr sheath to simulate vasculature and a femoral access port.

**Results** An anatomically accurate model was successfully developed and final dimensions were 13x14x17cm (Figure 2). There were no ferromagnetic components, permitting CMR conditionality. The model was watertight and translucent allowing visualisation of the pulmonary artery catheter in the fluid-filled working device. This was achieved in a cost-effective manner. All software was free, the FDM prints negligible, and the SLA print was £50. An experienced operator was able reach the pulmonary arteries in a simulated right heart catheterisation. All design criteria were met.

**Conclusions** A novel, cost-effective, CMR-conditional cardiac phantom was developed and 3D printed for simulated right heart catheterisation in pulmonary hypertension. Advances in cornerstone techniques are rapidly occurring and realistic phantoms are no longer prohibitively expensive. The model can be used for training minimising radiation exposure. Limitations include loss of systolic pulsatility due to its rigid walls. However the model will be connected to a pulsatile blood pump (Harvard Apparatus) and will serve its purpose to be utilised for further experiments to develop robotic-assisted catheterisation in the MR suite.

**Conflict of Interest** No