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Three Dimensional Printed Models For Surgical Planning Of Complex Congenital Heart Defects: An International Multicenter Study

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INTRODUCTION: Three-dimensional printed models (3D-models) provide an unrivalled spatial appreciation of patient-specific cardiovascular structures. However, the impact of this technology on surgical planning in complex congenital heart disease (CHD) is yet to be demonstrated.
METHODS: A prospective, observational, case-crossover study involving 10 international centres and 40 patients with complex CHD (median age 3 years, range 1 month- 34 years) was conducted. Magnetic resonance imaging and computed tomography were used to acquire and segment the 3D cardiovascular anatomy. Models were fabricated by fused deposition modelling of polyurethane filament. We sought to evaluate (1) 3D-model dimension accuracy by comparison with medical images, (2) utility of the 3D models by evaluation of subjective satisfaction questionnaire and (3) incremental diagnostic value of 3D-models to plan surgery, comparing decisions made in two scenarios: During routine clinical practice and after inspection of a 3D-model.
RESULTS: 3D models accurately replicate anatomy with a mean bias of -0.27 ± 0.73 mm. 13 surgeons and 30 paediatric cardiologists completed a satisfaction survey. 96% agree or strongly agree that 3D models provided better understanding of CHD morphology and reduced the chance of complications. 3D models changed the surgical decision in 45% of the cases. Consideration of a 3D-model refined the planned biventricular repair, achieving an improved surgical correction in 20% of cases. In 15% of cases initially considered for conservative management or univentricular palliation, inspection of the 3D-model enabled successful biventricular repair.
CONCLUSIONS: 3D models are accurate replicas of the cardiovascular anatomy and improve the understanding of complex CHD. This results in a change in the surgical decision making in 45% of the cases, allowing a better refinement of surgical strategy and surgical correction in cases that would conventionally be considered technically infeasible.