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Submitting author: Dr Shuk Han LEE
Post title: Consultant, Queen Elizabeth Hospital

The First Percutaneous Pulmonary Valve Implantation in Hong Kong for a Patient with Complex Congenital Heart Disease involving the use of Customized 3D-Printed Heart Models

Lee SH (1), Chan LK (2), Luk NH (2), Lee MKY (2), Shiu CK (3), So EHK (4), Ng GWY (4), Stone YH (4), Lo ACY(5), Ziyad M Hijazi (6)
(1)Department of Paediatrics, (2)Department of Medicine,
(3)Department of Radiology, Queen Elizabeth Hospital, Hong Kong
(4)Multi-Disciplinary Simulation and Skills Centre, Queen Elizabeth Hospital
(5)Cluster Chief Executive, Kowloon Central Cluster
(6)S

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Introduction

With the advances in surgical skills, children suffering from complex congenital heart disease are surviving longer but their needs for cardiac intervention to treat residual lesions are also increasing. Pre-intervention planning and simulation using customized heart models, depicting accurate and detailed cardiac anatomy, is of paramount importance to increase the success rate of interventions.

Objectives

To assess the usefulness of customized 3D-printed heart models to increase the success rate of percutaneous cardiac intervention for complex congenital heart disease.

Methodology

A 30 year old woman had congenital heart disease: tetralogy of Fallot (TOF), post-surgery in China at the age of 5. She had severe left pulmonary artery (LPA) stenosis with a left to right lung differential perfusion ratio of 3% to 97%. Two prior attempts of angioplasty and stenting of the LPA stenosis at 13 and 18 years, based on 2D angiographic imaging, were unsuccessful. Having defaulted follow up she returned recently for advice on pregnancy. Imaging including catheter angiography, cardiac CT and MRI showed that the LPA course was distorted and tortuous; the LPA stenosis was very tight and just at its origin. She also had dilated right ventricle and bi-ventricular dysfunction due to severe pulmonary valve regurgitation post TOF repair. Following a multidisciplinary discussion, it was agreed she would benefit from percutaneous stenting of the LPA stenosis and percutaneous pulmonary valve implantation. These would be very difficult interventional procedures, given the

complex anatomy and the proximity of the lesions. In preparation for this challenge, 1:1 customized heart models based on the patient's cardiac CT images were produced by 3D printing technique to accurately depict her heart lesions. Measurements of the lesions and related cardiac dimensions on the 'blood volume' heart model were undertaken and simulation of the procedures on the hollow heart model was performed prior to the actual intervention.

Result

The 3D-printed heart models were invaluable in choosing the right size of stent and valve and determining the precise site of implantation according to the patient's unique cardiac anatomy. The possible problems encountered during the procedures could be anticipated. Patient and staff communication were greatly enhanced. Both procedures were performed successfully in the same setting. Our patient is not just the first case of successful percutaneous pulmonary valve implantation undertaken in Hong Kong but also the first case using 3D printing technique to aid intervention for complex congenital heart disease locally. 3D printing provides cutting edge technology to help increase the success rate of percutaneous cardiac intervention in complex congenital heart disease and our case may pave the way for development of such technology in paediatric cardiology in Hong Kong.