## Impact Objectives

- Test and evaluate new technology in artificial valves designed for congenital heart disease
- Studying the effects of a newly designed paediatric pulmonary heart valve on hemodynamic function

# A spotlight on congenital heart disease

*Paediatric cardiac surgeon **Senior Assistant Professor Kenji Suzuki** talks about some of the big gaps in our knowledge of congenital heart disease and his dedication to testing the effects of devices to help patients who require right ventricular outflow tract reconstruction*

**Can you talk about your role as a Paediatric Cardiac Surgeon?**

I am based at the Medical Center for Maternal & Child Health at Nippon Medical School Musashikosugi Hospital which is equipped with experienced staff and cutting-edge facilities. We are planning to use the developed artificial valves for diseases such as congenital heart disease in the near future. Working within this facility allows my team and I to conduct important research and test the devices that, if successful, will help countless patients long into the future.

**From your perspective, what are some of the big gaps in our knowledge about congenital heart disease?**

Congenital heart diseases range from mild diseases that cause no symptoms to severe diseases that do not survive the neonatal period. The diagnosis and treatment of these diseases is an area that is still being developed by paediatric cardiologists and cardiac surgeons who are both thoughtful and bold in their endeavours. There is much that we still do not know, but our current research seeks to test the devices that are being developed to help patients. The most important thing to remember is that all children are important whether they have congenital heart disease or not. We treat everyone as an equal which enables our research to progress at a timely pace.

**You are working closely with an engineering research institute. How is this helpful to your studies?**

We are collaborating with Associate Professor Hirohito Sumikura of the School of Science and Engineering at Tokyo Denki University in Japan on the analysis of hemodynamics of a newly designed conduit. It is very useful for us to share their research techniques and experiences – their input is invaluable to our work as surgeons. Of course, collaborating with people who are as enthusiastic as us about making a positive difference to children's lives – and their families – is of paramount importance and it is pleasing to work with others in the pursuit of our aims.

**What challenges did you face in these experiments?**

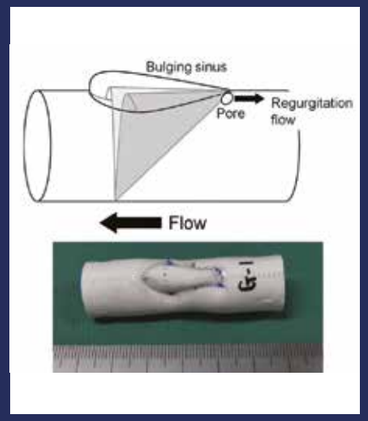
The difficulty in this particular experiment was the establishment of the experimental system, especially the creation of a simulated circuit that mimics the right heart system. This was solved by working with Sumikura who is one of the best, most experienced scientists in this field. Together, we have achieved much that we can be proud of, although there is still some way to go in our collaborative research.

**Have you had any results that you are particularly pleased with?**

What is especially gratifying about this experiment is that the pulsatile flow study showed that the valve functioned as well as commercially-available biological prosthetic valves. This gives us a platform on which we can build in the future and shows that our investigations are headed in the right direction.

**You are planning to develop a smaller diameter prosthetic valve. What else are you hoping to work on in the near future?**

The next step in this research is to develop a smaller diameter prosthetic valve. In addition, we would like to develop a mitral valve prosthesis with a smaller diameter. This has the disadvantage that the long diameter needs to be shortened and there is less supporting tissue. However, through our efforts we hope to overcome these challenges and make a real difference to the lives of many patients.






# Testing a new paediatric pulmonary heart valve

*A team based within the **Nippon Medical School Musashikosugi Hospital** is studying the effects of a newly designed paediatric pulmonary heart valve on hemodynamic function*

Congenital heart disease is a term denoting a range of birth defects that impact the different ways a heart works, with the word congenital meaning that the condition is present at birth. The condition is one of the most common types of birth defect and affects almost 1 in every 100 babies born in the UK.

When there is an obstruction of the right ventricular outflow tract in congenital heart disease patients, it is often necessary to provide a reconstruction of this outflow tract - this is a procedure that is normally performed during the neonatal period of infancy. However, in Japan there is currently no commercially-available prosthetic valve of the appropriate size. In addition, the use of recently introduced bovine-derived valved conduits are limited by institutional standards. For that reason, institutions within Japan make their own pulmonary valve prostheses for reconstruction. However, there are many cases of valve dysfunction due to thrombus formation or reduced mobility of the valve leaflets after implantation.

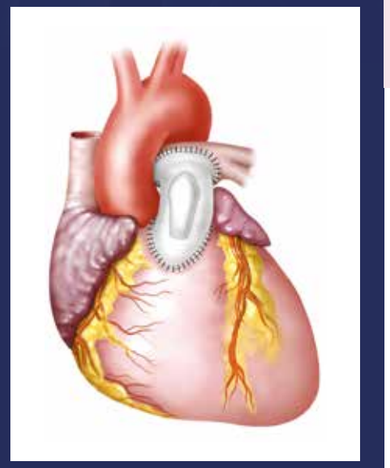
## DESIGNING PULMONARY VALVE PROSTHESIS

It is with these challenges in mind that Senior Assistant Professor Kenji Suzuki has embarked on a project seeking to investigate the effects of a newly designed paediatric pulmonary heart valve on hemodynamic function. Suzuki is a paediatric cardiac surgeon based within the Nippon Medical School Musashikosugi Hospital in Japan. His team is working on the development of a new design of pulmonary valve prosthesis that avoids dysfunction such as thrombus formation and reduced mobility of valve leaflets. 'After implantation, the mobility of the valve leaflets is reduced due to thrombus formation or adherence of an organising thrombus, resulting in narrowing of the blood flow path and valve dysfunction in some cases,' outlines Suzuki. 'Therefore, the development of a pulmonary valve prosthesis in the paediatric field is considered to be an urgent issue and one that we are addressing in the course of our studies,' he says.

## FINE-TUNING THIS LIFE-SAVING DEVICE

The new device avoids dysfunction in several ways. 'Firstly, the valve cusp hinge is placed on the posterior wall of the prosthesis, and the valve cusp opens by folding to the centre during systole and closes by expanding during diastole to adhere to the lumen of the prosthesis as outlined by GR Nunn in 2008,' explains Suzuki. 'The coaptation zone is composed of the valve leaflets and the prosthesis, which is expected to reduce regurgitation. Next, a bulging sinus, which mimics the shape of valsalva, is formed on the anterior wall of the prosthesis to promote adequate closure of the valve leaflets during diastole by capturing diastolic blood flow in the same area,' he outlines. Finally, a small hole is placed at the extreme end of the valve leaflet near the right ventricle to allow a small amount of blood to flow back through the hole to the right ventricle during closure, thereby eliminating blood stasis and preventing thrombus formation.

To reveal the hemodynamics of the newly designed paediatric pulmonary heart valve, the team will construct a circulatory simulator that mimics the right heart system. 'The right ventricular pressure and pulmonary artery pressure waveform are measured, and the regurgitation rate is calculated from the flow waveform,' confirms Suzuki. In addition, valve leaflet motion will be observed by video recording. He explains that the pressure gradient and regurgitation rate under hydrostatic pressure will also be evaluated. 'Preliminary experiments have already shown that the regurgitation rate and pressure gradient are lower than those of the prosthetic valve we had previously developed,' he observes. 'In the near future, we would like to accumulate more data and fine-tune the structure.'



## Project Insights

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