



## Viewing a Child's Sick Heart

The Children's Heart Center of the University Hospital Gießen, Germany, implemented one of the world's most modern diagnostic and therapeutic facilities to simplify the detection and treatment of congenital heart defects. *Medical Solutions* spoke with Jürgen Bauer, MD, about his experiences.

By Hildegard Kaulen, PhD

FDA: The safety of imaging infants under two years has not been established.

For heart transplants in babies, the Children's Heart Center in Gießen, Germany, has taken a leading position Europe-wide. In 1988, the center performed the first of these interventions in Germany. Now, the little patients benefit from noninvasive, radiation-free cardiac assessment before surgery with the center's new MRI system.



The Children's Heart Center Gießen, a division of the University Hospital Gießen and Marburg, is one of the largest and most important of its type. The first heart transplant on an infant in Germany was performed here 20 years ago. Recently, the center acquired its own MAGNETOM® Verio 3 Tesla (3T) magnetic resonance imaging (MRI) system. In conjunction with the adjacent cath lab for diagnostic and interventional procedures, two operating rooms exclusively reserved for pediatric heart surgeries, and the intensive care unit, University Hospital Gießen now has one of the world's most modern diagnostic and therapeutic facilities for children with congenital and acquired cardiac diseases.

**Dr. Bauer, no other center in the world has a 3T MRI system exclusively for pediatric cardiac examinations. How did you come into such a fortunate situation?**

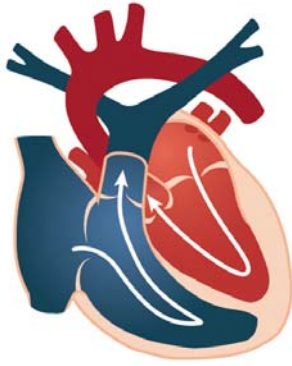
BAUER: We worked for years toward this objective because we realized early on

the importance of cardiac MRI sequences for diagnosing congenital heart diseases. Previously, I made appointments every Tuesday at the Kerckhoff Heart Center in Bad Nauheim, which is 30 kilometers away, for our pediatric patients and examined them there using a 1.5T MRI system. The Fördergemeinschaft Deutsche Kinderherzzentren [Association for the Support of German Pediatric Heart Centers] helped us in acquiring the MAGNETOM Verio. This nonprofit association supports the expansion of pediatric heart centers in Germany. Now, we can quickly obtain an overview of the anatomical and hemodynamic situation of a child's heart, even in emergency cases. We just examined a premature infant with complex cardiac malformations. In this case, the surgeons wanted to know the position of the aortic arch and the course of the outgoing vessels in order to better plan the surgery. A diagnostic cardiac catheterization would have been extremely difficult and risky with such a premature infant.

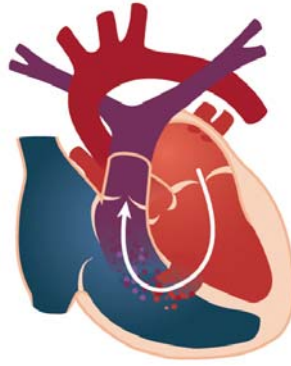
**Why did you decide in favor of a 3T system?**

BAUER: A 3T MRI system, such as MAGNETOM Verio, provides a very high spatial and temporal resolution. An infant's heart beats very fast at a rate of around 150 beats per minute. In comparison, the heart rate in adults is around 60 beats per minute. Additionally, the pediatric vascular tree is very small. With MAGNETOM Verio, we generate a complete angio data set every 1.3 seconds with a spatial resolution of 1.2 millimeters. Congenital malformations and post-operative residues are therefore very well presented. We can then decide: Does the patient need an intervention in the cath lab or cardiac surgery? Another advantage of MAGNETOM Verio is its 70-centimeter Open Bore. This provides us with space for the breathing tube as well as for personal attendance, and it enables us to

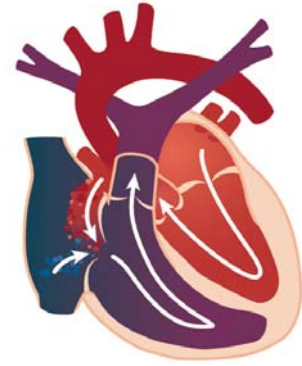
FDA: The safety of imaging infants under two years has not been established.



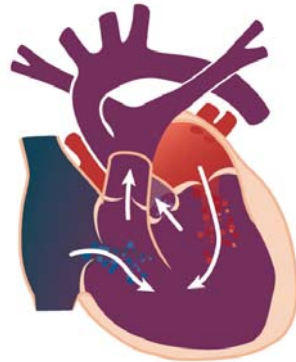
1 Normal heart



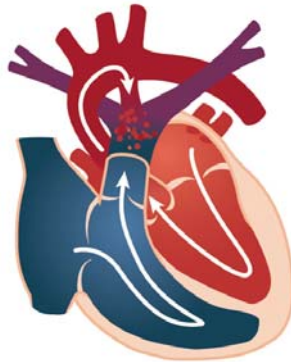
2 Ventricular septal defect



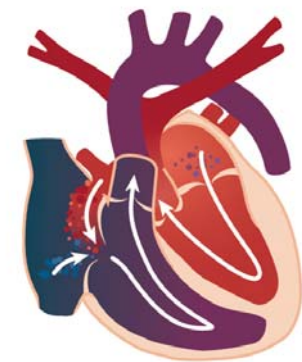
3 Atrial septal defect



4 Univentricular heart



5 Persistent ductus



6 Transposition of the great vessels

**The most frequent congenital cardiac defects**

2. Ventricular septal defect: Through a hole in the ventricular septum, a high amount of blood flows from the left ventricle (higher pressure) into the right ventricle and subsequently into the lung.
3. Atrial septal defect: Through a gap between both atria, blood flows constantly from left to right atrium (pressure gradient) and into the right ventricle.
4. Univentricular heart: There is only one sufficiently sized ventricle for the pump function. The degree of the defect may vary from a missing septum to a considerably underdeveloped atrium.
5. Persistent ductus: The fetal shunt connection between the pulmonary artery and the aortic arch, normally closed after birth, persists.
6. Transposition of the great vessels: The great vessels are transposed – the aorta originates from the right, and the pulmonary artery from the left ventricle.

better monitor the children because we can see them better.

**What are your experiences with the 3T MRI within your diagnostic and therapeutic facility so far?**

BAUER: We have been working with the system for six months. In that time, we have examined 500 children. Normally, we do 600 to 700 catheterizations per

year. Based on the last six months, we reduced them by around 30 percent. One of our objectives is to see how many diagnostic cath lab procedures we can save through preselection. An MRI examination has the advantage of being non-invasive as well as free of ionizing radiation. Since we are currently comparing the two modalities, we perform MRI and a cardiac catheterization on all children

whose condition allows a double examination and where it is medically indicated. Within our diagnostic and therapeutic facility, the sedated child is simply moved from the MRI suite to the adjacent cath lab. This sequential approach provides us with an optimum workflow. And, we

FDA: The safety of imaging infants under two years has not been established.



## Summary

Even for a rapidly beating child's heart, 3T MRI generates cardiac MRI sequences with high spatial and temporal resolution and good contrast between blood and myocardium. This allows for a thorough evaluation of the morphology and function of the heart and helps in deciding whether a therapeutic catheter intervention or cardiac surgery is required.

### Challenge:

- In cases of congenital cardiac defects, complex morphology and postoperative residues make the evaluation of anatomy and function more difficult
- Today, much higher survival rates of children with congenital heart disease and the need to check their cardiac functions at regular intervals increase the need for noninvasive procedures such as cardiac MRI

### Solution:

- 3T MRI as a reliable instrument to diagnose pediatric cardiac diseases
- Versatility and high quality of cardiac 3T MRI enables answers to even advanced scientific questions, e.g., chronic rejection of donor hearts or organic brain consequences

### Result:

- Cardiac MRI may be used more frequently to evaluate the efficiency of pharmacological, interventional, and surgical therapies for pediatric cardiac diseases

FDA: The safety of imaging infants under two years has not been established.



### Jürgen Bauer, MD

Graduated in medicine at the Universities of Freiburg and Gießen, specialist in pediatrics and pediatric cardiology. Advanced training in neonatology and pediatric intensive care medicine, positions at Usingen Hospital and in Cusco, Peru. Has worked at University Hospital Gießen since 1978, currently as senior executive physician. Responsibilities include MRI diagnostics and the transplant program. Bauer was Associate Editor of *Pediatric Transplantation*.



can access and edit the results of both examinations on one and the same database.

### Can you name a few clinical parameters you currently determine using MAGNETOM Verio?

BAUER: We evaluate cardiovascular morphology and function using cardiac MRI. For children with a sick heart, this means we look for vascular and cardiac anomalies and display the whole spectrum of vascular and cardiac malformations. We frequently use MR angiography for the display of arteries and veins. We also determine the ventricular mass, the ventricular blood volume, the ejection fraction, and the shunt volume. We measure myocardial perfusion and examine the viability of muscle tissue using Late Enhancement. Also, acute myocarditis can be detected in this manner.

### Beyond routine, you also use the 3T MR for research and education. Which research projects are you pursuing?

BAUER: I have already mentioned our database, which we use to compare the results of the cardiac catheterization and MRI examination. We are also develop-



Young patients in Gießen are spared multiple and stressful interventions. They can be moved from their MRI examination directly to the adjacent angiography room – which is particularly appropriate for infants, because they only have to be sedated once. The center's cardiac surgeons can discuss the findings with Dr. Bauer before they perform the transplant.

FDA: The safety of imaging infants under two years has not been established.

ing standardized protocols and reference values for various applications. It is not only about establishing initial diagnoses, we also want to objectively evaluate the efficiency of pharmacological, interventional, and surgical therapies. Additionally, we are pursuing various scientific questions. We are working, for example, on transplant vasculopathy. This refers to the fibrosis of the donor heart due to chronic rejection of the transplant. As a result, the vessels become so narrow that perfusion declines. When using echocardiography, only the final stage can be detected. With MRI perfusion measurements, we want to track the process of chronic rejection over time. We are also interested in studying whether children being treated with the latest generation of immunosuppressives, the mTOR inhibitors, show lower chronic rejection. The degree of chronic rejection will also be verified by taking tissue samples from the right ventricle.

**In Germany, some 6,000 children are born annually with a congenital heart defect. Due to the fundamental progress in treatment, 90 percent reach**

**adulthood, which has resulted in a substantial number of patients. For many, regular follow-ups are required because there is no cure available. How do you see their care situation?**  
BAUER: You have to look at the type of malformation and then make a decision regarding therapy. One fourth of those children have a mild disorder. A single cardiac procedure or catheter intervention is sufficient in such cases. Residual defects or arrhythmia are rare. Forty percent of them have a moderate cardiac defect. Within these patients, residual defects sometimes remain or other changes requiring surgery occur. Later, arrhythmias can also occur. These patients should be examined at least once every year by a specialist in congenital cardiac defects. Finally, there are severe cardiac defects. Approximately 35 percent of the patients belong in this category. They require lifelong care and have to be examined on a regular basis. We need standardized protocols for these follow-up examinations, and we are working on this. With our diagnostic and therapeutic facility, we are optimally prepared to care for all congenital or acquired cardiac

diseases and can make the right decisions quickly. We have also established a research project where we are looking at the neurological development of these children and their quality of life. We test the children, question the parents, and acquire an MRI image of the brain to see whether the earlier trauma of severe illness has left visible traces in the brain. With the 3T MRI system, we can perform these examinations at a better spatial and temporal resolution.

*Hildegard Kaulen, PhD, is a molecular biologist. After positions at Rockefeller University in New York and the Harvard Medical School in Boston, Massachusetts, USA, she has worked since the mid-1990s as a freelance science journalist for leading newspapers and scientific journals.*

#### Further Information

[www.siemens.com/  
cardiovascular-mri](http://www.siemens.com/cardiovascular-mri)

## Cardiac Magnetic Resonance: Differences in Adults and Children

Congenital heart disease patients require comprehensive and repetitive examinations, including imaging procedures, throughout their lives. Although called pediatric cardiologists, these physicians see patients over a very large age range – from fetuses and newborns to children and adults. Siemens addresses this challenge in cardiac magnetic resonance by providing solutions that seamlessly adapt to the respective patient's needs. Highly flexible

and lightweight Tim® (Total imaging matrix) coils, Open Bore MRI scanners such as MAGNETOM® Verio and MAGNETOM Espree that provide access to the sedated patient or allow parents to lie next to the newborn in the scanner support these physicians in their daily work. When imaging infants, applications providing high spatial and temporal resolution need to be used to adequately visualize the smaller-scale anatomical structures.

Pediatric cardiologists continuously improve clinical workflow, for example, by validating new modalities with which they can gain more data with less or no invasiveness and lowest possible radiation exposure. Collaborations with those experts help Siemens optimize its products for the benefit of all patients and users.

FDA: The safety of imaging infants under two years has not been established.