Department of Cardiac Surgery

Division of Pediatric Cardiac Surgery

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Research focus
- Organ protection: cerebral perfusion / beating-heart-surgery / distal thoracic aorta perfusion (descendens perfusion)
- Heart valve surgery
- Extracorporeal circulatory support
- Thymus immunology
- Migration of plasticizers into patient's blood

Structure of the Division

- Professorship: 1
- Personnel: 9
- Doctors (of Medicine): 4
- Graduate students: 15

Clinical focus areas
- Surgery for children and adult patients with congenital heart disease
- Extracorporeal support for children with severe heart and/or lung failure
- Surgical reconstruction of cardiac valves and "physiological" cardiac valve replacement

Research

The aim of our research efforts is to achieve highest possible level of safety for our patients especially in the context of complex operations. The same goal applies for routine operations in order to optimize outcomes of congenital cardiac procedures with special focus on organ protective methods during cardiopulmonary bypass.

Organ protection: cerebral perfusion / beating-heart-surgery / distal thoracic aorta perfusion (descendens perfusion)
Organ protective management during aortic arch surgery has become a major focus of the Division of Pediatric Cardiac Surgery.
After experimental validation of selective brain perfusion as an intraoperative measure for cerebral protection, the cerebral perfusion could now be determined and compared in both hemispheres with the use of intraoperative transfontanellar ultrasound.
An additional focus of previous animal experiments was about the overall cardioprotective management. After validation of the „beating heart" method, in which the heart is constantly perfused and beating during the entire aortic arch operation, a modified form of blood cardioplegia has been adapted to pediatric physiology and was shown to preserve cardiac contractility better than conventional cardioplegic solutions. It was then successfully implemented into everyday clinical practice.
Selective perfusion of the distal thoracic aorta during aortic arch reconstruction (descending aortic perfusion) represents a further strategy improvement. This method serves to continuously and optimally care for all subdiaphragmal organs during surgical therapy of congenital heart defects with aortic arch hypoplasia – or interruption. Based on our primary clinical data, this technique seems to improve outcomes of newborns and infants. This critical patient group is particularly sensitive for insufficient perfusion during cardiopulmonary bypass. Continuous perfusion of the descending aorta, via a separate arterial pump on cardiopulmonary bypass, together with selective cerebral perfusion and/or selective myocardial perfusion represents an essential and consistent advancement towards a functional total body perfusion during complex aortic arch operations.

Heart valve surgery
A large number of patients with congenital heart defects require surgical reconstruction of the right ventricular outflow tract, which can be achieved with or without surgical placement of a pulmonary valve (pulmonary valve replacement). Pulmonary homografts are still supposed to be the "Goldstandard", but are only limited available. Existing xenogenous pulmonary valve prostheses offer an alternative, but are only available in limited sizes due to their diameter. Particularly for patients after Fallot correction, markedly dilated pulmonary arteries and an aneurysmatic enlarged right ventricular outflow tract due to long-term pulmonary valve regurgitation are present. In this case, existing large-sized manufactured xenogenic prostheses are proposed which are actually intended for aortic valve replacement, but can also be used as a pulmonary conduit after sewing into a Dacron prosthesis. The advantage of this method are low transvalvular gradients and an ideal „landing zone" for later transfemoral pulmonary valve interventions or replacement.
Decellularized aortic homografts (cell-free aortic full roots from human donors) for aortic valve replacement have been used clinically in children and young adults since 2002. The 10-year clinical study data had proven very good mid-term results without calcification as compared to conventional homografts. Since 2018, we have been implanting decellularized aortic homografts as a valid alternative to Ross procedures in young children and adults who required aortic valve replacement. A relevant advantage of decellularized aortic homografts as compared to mechanical heart valves is that patients do not need any long-term anticoagulation therapy. The valves also seem to have the potential to grow. Meanwhile, decellularized pulmonary valve homografts are available for our patients as well.

Extracorporeal circulatory support
Extracorporeal circulatory support systems are used for patients with acute or chronic terminal cardiac and or pulmonary failure. Novel diagonal pumping systems have been introduced into clinical practice since 2013. These systems provided an improved management and regulation of the applied device for patients on support by a more intensive monitoring of pump-specific characteristics. It was demonstrated that overall improvement in the management results in more safety and improved outcomes for patients on support.

Thymus immunology
In cooperation with the Department of Dermatology (Prof. Dr. D. Dudziak), a project related to the differentiation of immunocompetent cells of children with congenital heart defects has been established. Routinely removed thymus tissue is processed systematically in order to examine its immune-competent cells. The same characterizations are carried out in the peripheral blood of patients. Research is focused on thymus subpopulations in order to gain information related to the natural maturation of the immune system.

Migration of plasticizers into patient's blood
A recent research focus is the investigation of phthalate plasticizers (Di-Ethyl-Hexyl-Phthalate) migration from the tubes of the heart-lung machine into blood. These plasticizers have toxic

potential in the blood of patients, especially in children. In a joint project with the Institute and Outpatient Clinic of Occupational, Social, and Environmental Medicine (Prof. Dr. T. Göen), the Division of Pediatric Cardiac Surgery investigates alternative emollients with regard to their washout and alternative materials which do not use those toxic plasticizers. The topic has a health-political relevance. In recent years, for example, toxic plastic particles contamination has been found in children's plastic toys, baby bottles, and pacifiers. It has been shown that plasticizers as „endocrine disruptors", especially in children, cause a change in the development of reproductive organs and fertility.

Teaching

Main lectures, internships, electives and final year clinical rotations are being held throughout the year.
Special surgical techniques, anatomic considerations, and pathogenesis of congenital heart disease are being taught in small group student tutorials.
Teaching is supported by modern technical equipment. All surgical steps could be followed on additional screens in the operating room.
We supervise Bachelor's and Master's theses as well as MD and PhD theses.

Selected publications

Rüffer A, Tischer P, Munch F, Purbojo A, Toka O, Rascher W, Cesnjevar RA, Jungert J. Comparable Cerebral Blood Flow in Both Hemispheres During Regional Cerebral Perfusion in Infant Aortic Arch Surgery. Ann Thorac Surg. 2017, Jan;103(1):178-185

Ambarsari YA, Purbojo A, R. Blumauer, Glockler M, Toka O, Cesnjevar RA, Ruffer A. Systemic-to-Pulmonary Artery Shunting Using Heparin-Bonded Grafts. Interact Cardiovasc Thorac Surg. 2018 Oct 1;27(4):591-597

Heger L, Balk S, Luhr JJ, Heidkamp GF, Lehmann CHK, Hatscher L, Purbojo A, Hartmann A, Garcia-Martin F, Nishimura SI, Cesnjevar RA, Nimmerjahn F, Dudziak D. Clec10a Is a Specific Marker for Human Cd1c(+) Dendritic Cells and Enhances Their Toll-Like Receptor 7/8-Induced Cytokine Secretion. Front Immunol. 2018 Apr 27;9:744

Kellermann S, Janssen C, Munch F, Koch A, Schneider-Stock R., Cesnjevar RA, Ruffer A. Deep Hypothermic Circulatory Arrest or Tepid Regional Cerebral Perfusion: Impact on Haemodynamics and Myocardial Integrity in a Randomized Experimental Trial. Interact Cardiovasc Thorac Surg. 2018 Apr 1;26(4):667-672

Stonawski V, Vollmer L, Kohler-Jonas N, Rohleder N, Golub Y, Purbojo A, Moll GH, Heinrich H, Cesnjevar RA, Kratz O, Eichler A. Long-Term Associations of an Early Corrected Ventricular Septal Defect and Stress Systems of Child and Mother at Primary School Age. Front Pediatr. 2018 Jan 15;5:293

Münch F, Hollerer C, Klapproth A, Eckert E, Ruffer A, R. Cesnjevar RA, Goen T. Effect of Phospholipid Coating on the Migration of Plasticizers from Pvc Tubes. Chemosphere. 2018 Jul;202:742-749

International cooperations

Prof. M.D. Rodefeld, MD, Department of Surgery, Indiana University School of Medicine, Indianapolis: USA

Dr. O. Miera, EEPIG (European Excor Pediatric Investigator Group): multicentric