

Overall research theme:

Hemodynamics, biomechanics, heart valves, robotic cardiac surgery, cardiac imaging (MRI, ultrasound), bioacoustics, self managed oral anticoagulant therapy, mitral valve dynamics

Latest update:

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Characteristics of the research group:

Cardiovascular surgical research is conducted in our unit as collaboration between Department of CardioThoracic and Vascular Surgery and Institute of Experimental Clinical Research. Our research activities are conducted as collaboration between senior and younger researchers with either medical/surgical or engineering background. Our research group has dealt with experimental heart valve research for more than 20 years. This area is therefore considered as one of our core research areas. We have been working on natural heart valves as well as biologic and mechanical heart valve prostheses.

Running projects: Titles and abstracts:

Investigations of hemodynamic performance of prosthetic heart valves

Using ultrasound, magnetic resonance imaging and various pressure recordings we investigate hemodynamic characteristics of prosthetic heart valves implanted in experimental animals or in patients. Data sampling is predominantly performed intraoperatively followed by excessive post processing of data. These data comprise temporal and spatial display of velocity distribution and turbulence downstream of the valves.

Assessment of acoustic properties of mechanical heart valves

Mechanical heart valve prostheses produce short clicking sounds during closure. Some patients and their partners are annoyed by the sound, which often causes sleeping disorders or social embarrassment. In order to investigate heart valve sounds we have developed a technique to evaluate and quantify the closing sounds using psychoacoustic parameters. We are now in the process of characterizing sounds from a broad spectrum of mechanical heart valves

Cavitation studies of mechanical heart valves

Cavitation is formation of vaporous/gaseous microbubbles that may occur at locations near mechanical heart valves where pressure locally can decrease below the vapour pressure of the blood. As soon as the pressure increases again the microbubbles collapse (implode) during release of high energies. These energies are sufficiently high to cause valve material deterioration and most likely also cause damage of the formed elements in the blood. Accordingly generation of cavitation bubbles should be at the lowest possible level. Therefore, we investigate cavitation formation in vitro by high speed cinematography and high frequency pressure fluctuations in order to characterize prosthetic heart valve performance in this respect. Formation of cavitation is also investigated in animal experimental settings as well as clinically.

Turbulence and HITS after mechanical valves exposed to different hemodynamic conditions

As a specialized subject of hemodynamic evaluation of prosthetic heart valves we sample Doppler velocity signals downstream of prosthetic heart valves in experimental animals - as well as in patients - for turbulence measurements.

Using a specialized application of Doppler ultrasound transducers we record High Intensity Transient Signals (HITS) which represent micro-embolic material transported in the arteries. HITS is not seen before valve implantation and we therefore use them as an indicator of micro-emboli's induced by prosthetic heart valves.

Long term performance of mitral valve replacement using different chordal sparing techniques in pigs

Mitral valve replacement has earlier been performed by complete removal of the diseased native mitral valve. In recent years the trend has shifted to preserve the posterior leaflet and remove its anterior counterpart completely. In order to preserve the ventricular-valvular interaction mediated through the chordae tendineae we implant prosthetic heart valves in pigs using a new approach where only secondary chordae are preserved in order to remove space demanding valve material and at the same time preserve the mechanical connection between the left ventricle and the mitral annulus. The study entails implantation of prosthetic heart valve and long-term follow up of heart function in pigs.

3-D imaging and tissue characterization of the female breast by means of ultrasound

Ultrasound based diagnosis of breast lesions is most often performed by recognizing characteristic ultrasonic properties of the findings, such as shape, orientation, border characteristics and echogenicity.

A system for systematic 3D scanning of the uncompressed breast has been developed. During examination, the patient lies prone on an examination bed, with the breast immersed in a water filled cup. A transducer is moved in a systematic rotational pattern, covering the full breast. Compound imaging techniques are used to minimize shadow- and enhancement artefacts prior to 3D reconstruction.

Validation of a new microsensor for monitoring tissue perfusion pO₂ and pCO₂

A new flexible mikrosensor (1 mm in diameter) has been developed by the company Unisense, and tested in laboratory animals by our research groups. The probe respond adequately to deprived blood supply (lowered pO₂ increasing pCO₂ and reduced tissue flow). In the spring 2004 the sensor will be evaluated in muscular tissue of patients undergoing peripheral vascular surgery. This project is undertaken by the BIOFLOW consortium.

Evaluation of patient self managed oral anticoagulant therapy

Prevention of thrombo-embolic events by means of coumadines is a socially burdensome therapy for the patients due to frequent blood sampling and dosage regulations. New technology has enabled patients to make blood specimen analysis at home and decide dosage adjustment themselves. There are a number of issues where patient self management can be improved by enhanced interaction with the patient training centre. We are in the process of evaluating clinically the treatment quality of self managing patients versus conventionally managed patients.

Biomechanical evaluation of heart valve tissue using scanning acoustic microscopy (SAM)

SAM utilizes ultrasound in the Giga Hertz range to investigate the speed of sound through histological slices of biological tissue. Tissue elasticity and stiffness can be derived from the speed of sound and density. Using advanced imaging technology it is feasible to display the distribution of biomechanical properties in the issue. We have applied the technique to mitral valve tissue and succeeded to characterize the different layers in normal human mitral valves. The SAM investigations will be extended to other cardiac structures to study normal and pathological conditions.

3-D reconstruction of thoracic cavity and congenital cardiac defects using Magnetic Resonance Imaging (MRI)

Using MRI it is possible to make image slices of the human body with significant resolution. It is furthermore possible to make image acquisition triggered by respiration and cardiac function. These modalities allow us to process 3-D reconstructions of the thoracic cavity and the heart chambers and structures. By applying advanced 3-D display tools it is possible for the cardiac surgeon to make imaginary travels inside the heart and study morphology of the cardiac anatomy and pathological conditions. The image tools are used for preoperative evaluation of children with congenital heart disease and as a surgical planning tool in conjunction with robotic surgery.

Intraoperative 3-D imaging of the beating heart by ultrasound

During open heart surgery it is some times useful to have detailed display of the cardiac anatomy before closing the chest. Pediatric cardiac surgery is especially challenging in this context both due to small sizes, high pulse rates and often very complex congenital malformations. We have developed a mechanical traversing system which can automatically move the ultrasound transducer along the anterior surface of the heart during the operation. Using fast data acquisition and 3-D reconstruction software we are able to display the cardiac anatomy to the surgeon with a delay of less than 5 minutes.

Imaged based Computational Fluid Dynamics (CFD) as a tool for investigation of vascular anastomoses

Based on non-invasive Magnetic Resonance (MR) generated geometry and velocity boundary conditions it is possible to investigate the influence of geometry variations, compliance and other hemodynamic factors to velocity profiles and Wall Shear Stress. The finite volume method is applied to solve the complex Navier-Stokes flow equation (FLUENT 6.1.22 - FLUENT AB Sweden).

Prevention of atrial fibrillation after coronary artery bypass surgery (CABG)

Postoperative atrial fibrillation occur in about 25% of CABG cases. Apart from discomfort and hemodynamic instability this complication often leads to extended hospital stay and additional cost. In a prospective randomized trial we investigate the value of trading CABG patients prophylactically with amiodarone.

Assessment of the impact of ischemic preconditioning on myocardial stunning.

Myocardial dysfunction (stunning) is frequently seen after an ischemic insult as e.g. after warm ischemia during beating heart coronary artery bypass operations. In order to diminish the extent of stunning we investigate the effect of exposing either the target organ (the heart) or a remote organ e.g. an extremity to transient ischemia. The studies are being performed in pigs which have myocardial movement abnormalities evaluated by microsonometry and tissue velocity imaging (TVI). The preconditioning ischemia is exerted by obstructing blood flow to the lower extremity.

Recent publications related to the projects described above:

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