The Center for Cardiological Innovation (CCI) was established to develop improved methods for triage of patients at risk of sudden cardiac death or suffering from heart failure. The approach taken involves linking advanced imaging techniques, patient specific computer simulation and multi-modal visualization. The results will be embodied in the next generation of ultrasound systems for cardiology as well as in other potential innovations. An intra-disciplinary and intra-sectorial consortium was established to achieve these goals consisting of Oslo University Hospital, Simula Research Laboratory, the University of Oslo, GE Vingmed Ultrasound AS, Kalkulo AS, CardioSolv Inc. and Medtronic Bakken Research Center B.V.

The CCI has during its initial years of operation made significant contributions to the field and demonstrated capabilities to produce high-level research results as well as to translate these results into commercial products. Two OUH patents regarding mechanical dispersion and regional cardiac work estimation have been licensed to GEVU during 2014. These concepts will be integrated as software packages into Echopac during 2015. Research breakthroughs made by the CCI include new understanding of risk stratification for sudden cardiac death based on timing analysis of the segmental strain curves summarized in the index Mechanical Dispersion. Also the concept of cardiac work estimation has been developed and shown to provide new insight in patients with left bundle branch block as well as acute coronary syndrome.

Throughout 2014 research has resulted in 57 published scientific articles in peer-reviewed journals. Over 80 presentations, including abstracts, have been held at various national and international conferences within cardiology and biomedicine. Five new PhD students and a new administrator started working at the Center in 2014. A total of 27 PhD students and two Postdoc fellows have participated in the Center projects during 2014. They receive funding from the center, center partners, or through other public funding.

Center Director Professor Thor Edvardsen
Sudden cardiac death (SCD) has during the last few years emerged as a topic of immense interest. The limitations of current prediction tools have become evident and the new tool, mechanical dispersion, developed by the CCI has gained international attention. During the last few years, other centers have adapted the technique and published positive studies showing the value of mechanical dispersion and strain echocardiography in predicting malignant arrhythmias and death in a variety of patient populations.

Recent studies emphasize the importance of cardiac scars in life-threatening arrhythmogenesis in several cardiac diseases including patients after myocardial infarction, hypertrophic cardiomyopathy and arrhythmogenic right ventricular cardiomyopathy. Still, the gold standard for detecting cardiac scars is by cardiac MR, a technique not widely available. To find alternative methods to detect cardiac scars is of uppermost importance.

The evolving genetic technology by whole exome sequencing has provided completely new possibilities for detecting genetic diseases. The field is changing rapidly and techniques assessing the risk of arrhythmias and sudden cardiac death are growing even more important.

OBJECTIVES AND RESEARCH PLANS

The centre was established to enable the creation of the next generation of ultrasound technology, combining expertise in industrial development, clinical science, and advanced mathematical techniques. The main objectives of the centre are focused on developing new tools to help the triage of patients suffering from heart failure (HF) or at risk of sudden cardiac death (SCD).

To find responders to CRT still remains a challenge in current cardiology. Despite almost 10 years of intense global research on this topic, the responder rate remains at 65% of all implanted patients. Further knowledge is needed.

The role of the right ventricle has emerged in current state of the art, both regarding impact on CRT response and the role in other diseases. Accurate imaging and assessment of the RV dimensions and functions has been challenging, and requires better techniques. Newer studies have elucidated that patients with diastolic heart failure may also have systolic heart failure, identified by sensitive strain echocardiographic methods. However, the mechanisms and the picture of diastolic heart failure need to be further elaborated.

The CCI stands well posed to create innovation in these challenging clinical areas. Industrial partners GEVU and Medtronic continue to produce better products to image and treat cardiac disease. In the field of cardiac modeling more powerful computing resources, together with improved methods, have made complex simulation based on imaging tractable in clinical time frames. New techniques for methodically linking highly complex simulation data with patient metrics are also emerging.

In contrast to simply adding a new set of measurement indices to an already impressive list of diagnostic guidelines, or prescribing treatment based on those guidelines, the CCI will instead combine and extend currently isolated technologies into novel, integrated tools and applications. We propose to combine electrical and mechanical information into a new integrated scanning system, which we will then couple with advanced techniques to diagnose pathology and prescribe treatment tailored for the individual patient. This approach is entirely novel, as integration of these modalities combined with the use of patient-specific simulation has never before been achieved. This innovation has the potential to change the paradigm of diagnostic cardiology and will represent a substantial market edge for the industrial partners.
ORGANIZATION

The CCI is hosted by Oslo University Hospital. The consortium consists of six partners from both research and industry, in addition to the host institution.

The research partners are Simula Research Laboratory and the University of Oslo.

The user partners are GE Vingmed Ultrasound AS, CardioSolv Inc., Kalkulo AS and Medtronic Bakken Research Center B.V.

The CCI is located in Oslo, thus Oslo University Hospital, Rikshospitalet and the University of Oslo, Domus Medica (DM4) at Sognsvannsveien 9 (entrance from Gaustadalléen 34), constitutes as the physical hub for the CCI research activities.

BOARD OF DIRECTORS

CCI is governed by a Board of Directors, for which representatives have been appointed by each of the partners. The Board comes together twice a year for an overview of the Center’s development, financial updates and administrative issues.

Many of the board members participate actively in the Center’s research activity and their expertise is of uttermost importance for the development of future technology within the CCI.

The Centers Board of Directors consists of the following members appointed by the consortium participants:

Gunnar Hansen, GE Vingmed Ultrasound, Chair
Molly Maleckar, Simula Research Laboratory
Are Magnus Bruaset, Kalkulo
Theis Tønnessen, Oslo University Hospital
Brock Tice, CardioSolv
Drude Merete Fugelseth, University of Oslo
Lars Ove Gammelsrud, Medtronic

Figure 1: Organization structure
The CCI has established a Scientific Advisory Board (SAB) to receive feedback by a panel of experts who are not directly involved in the center activities. The SAB was established in 2012 and consists of: Professor Olaf Dössel, Professor Luigi Paolo Badano, Professor James D. Thomas and Dr. Steven Niederer. The CCI will expand the Scientific Advisory Board with one more member in 2015.

The 2014 Scientific Advisory Board meeting was held on June 2nd at the CCI location, Sognsvannsveien 9, Oslo. The SAB evaluation in 2013 focused on cardiology aspects, providing the Center a thorough evaluation and follow-up suggestions within this field. This year’s meeting focused on cardiac modeling. The SAB members present at this meeting were Professor Olaf Dössel and Doctor Steven Niederer.

Professor Olaf Dössel is the Head of the Institute for Bio-medical Engineering at Karlsruhe Institute of Technology, Germany. His research areas include computer models of the human heart and modeling and measuring of electrophysiological properties of myocardial cells and myocardial tissue.

Doctor Steven Niederer is a senior lecturer in the Division of Imaging Sciences and Biomedical Engineering at King’s College, UK. Dr. Niederer’s research aims to combine experimental and clinical data with biophysical computational models to better understand cardiac physiology and pathology.

Prof. Dössel and Dr. Niederer were provided with relevant written documentation, a series of presentations about research and innovation activities in addition to having lunch with the Center’s PhD students.

The Scientific Advisory Board gave the CCI management team a review report with their main observations, rating and suggested follow-up actions. The main conclusions from the SAB were

- The overall performance is very good, including numerous publications in scientifically important journals with high impact factor.
- The collaboration between the Center Partners is good.
- The PhD students have a strong understanding of their research topics and their regular get-togethers are of importance for the interdisciplinary research.
- The SAB would however like to see a stronger link between the research in electro-mechanical modeling of the heart and the research on speckle tracking based markers (mechanical dispersion and wasted work ratio). In addition there could be an improvement in using the electromechanical models to better understand generation and perpetuation of arrhythmias and CRT therapy.

The overall score on each topic that was assessed is given in the table below:

<table>
<thead>
<tr>
<th></th>
<th>Average: 5.2</th>
<th>1 (weak) - 6 (excellent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quality of research</td>
<td>5.5</td>
<td></td>
</tr>
<tr>
<td>Partner collaboration</td>
<td>5.0</td>
<td></td>
</tr>
<tr>
<td>Organization</td>
<td>5.0</td>
<td></td>
</tr>
<tr>
<td>Innovation</td>
<td>5.0</td>
<td></td>
</tr>
<tr>
<td>Total Project score</td>
<td>4.8</td>
<td></td>
</tr>
</tbody>
</table>
MANAGEMENT TEAM

The Center’s Director, **Professor Thor Edvardsen**, is a board certified specialist in Internal Medicine and Cardiology and has been a senior staff member at Dept. of Cardiology at Oslo University Hospital, Rikshospitalet since 2002. He became chief of the Dept. of Cardiology in 2012. He worked at John Hopkins Hospital, Baltimore, USA in 2003-2004. Edvardsen has been an elected Board member of the European Association of Cardiovascular Imaging (EACVI) since 2010 and is the Chair of the EACVI Scientific Documents Committee (2012-16). He has more than 180 international scientific publications and more than 10 book chapters. He is active in clinical and experimental research in the area of myocardial function and has extensive knowledge of cardiac ultrasound, MRI, CT and hemodynamics.

**Kristina Hermann Haugaa** is the Center Director of Cardiology Research. Kristina Hermann Haugaa, MD, PhD, FESC, is an Associate Professor and consultant Cardiologist at the Dept. of Cardiology, Oslo University Hospital, Rikshospitalet. She is also the Director of the Outpatient Clinic and Genetic Cardiac Diseases at Rikshospitalet. Dr. Haugaa is a board certified specialist in Internal Medicine and Cardiology. She finished her PhD thesis in 2010 which included electromechanical studies in patients with cardiac genetic disorders and patients after myocardial infarction. Dr. Haugaa worked at the Mayo Clinic, Rochester, MN, USA in 2012 and at Pittsburgh University Hospital in 2013. Her research is focused on developing risk stratifying tools for life threatening ventricular arrhythmias and sudden cardiac death. Dr. Haugaa is a Board member and Treasurer of the Norwegian Society of Cardiology and that of the Nordic ARVC registry.

**Eigil Samset** is the Center Coordinator. Representing the largest user partner, GE Vingmed Ultrasound, he will help drive the center to ensure that the innovation objectives are met. Eigil Samset also holds a Professor II position at the Department of Informatics at the University of Oslo. He has his Master from NTNU in engineering cybernetics with focus on medical applications. His PhD was conducted at the Medical Faculty of the University of Oslo, where he developed new methods for utilizing MRI as an intra-operative imaging modality. He was invited to Harvard (Brigham and Women’s Hospital) to perform his Postdoc on MRI guided cardiac ablation. He has also been a visiting researcher at Stanford University Hospital where he worked on intravascular ultrasound. Prof. Samset has worked academically with medical image processing, visualization, navigation and robotics for 11 years, managing research teams in Norway and across Europe. He also has 3 years experience as a product and technology manager in the oil & gas business, managing a software development team focused on developing cutting edge applications for simulation and visualization.

**Samuel Wall** is the Center’s Deputy Director of Scientific Computing, representing the research partner Simula Research Laboratory. Samuel Wall received his PhD in Bioengineering jointly from the University of California, Berkeley and the University of California, San Francisco, where his work focused on ventricular modeling and basic research into cellular therapies of the heart. He currently leads the Cardiac Modeling (CaMo) group at Simula, which explores methods of predictively simulating cardiac function across a wide range of temporal and spatial scales, from the subcellular calcium dynamics to the electromechanical pumping action of the entire heart.

**Piritta Nyberg** is the Administrative Coordinator of the SFI-CCI. She provides administrative support and manages responsibilities of the Center with respect to the Research Council of Norway and Oslo University Hospital. Piritta Nyberg has a Bachelor in Media and Communication from the University of Oslo and has previously worked as the administrator for the SFI-CAST. She has more than 10 years of experience within coordination and customer service, both nationally and internationally.
INNOVATION PROCESS

One of the most important success criteria for a SFI is the ability to bring research results into use. Typically this will mean to make a commercial product of the results, but it may also mean to change development or manufacturing processes, or to change patient care. An industrial company and a basic or clinical research organization measure success very differently and may have different understanding of what steps are involved to succeed in exploiting a research result commercially. The research performed by the CCI has the health of heart patients in focus, and as a cross-disciplinary consortium we have realized that our common goal to improve patient care can only be achieved by making the research results available through new and improved products.

In order to create a common understanding within the consortium about how we can best usher an idea all the way from conception to a commercial product, we have defined an innovation process. This process provides transparency for the on-going innovation projects and allows us to focus on giving momentum to these activities. It will also help to determine if an innovation project does not meet the required milestones and to consider termination for non-sustainable projects.

All innovation projects go through three initial steps where the exploitation opportunity is identified along with the main stake holders for the exploitation opportunity and an exploitation champion (a person taking ownership of the opportunity). Subsequently, activities in four different areas are tracked as the project continues: market intelligence, clinical value, intellectual property issues and technical/commercial development activities. Once a step in the innovation process has been started it will be assigned traffic-light colors: yellow = on-going, green = completed, red = problem/show-stopper (see example figure above).
COOPERATION BETWEEN THE CENTER’S PARTNERS

The partners in the CCI bring key competences to the joint projects, enabling everyone in the CCI to effectively pursue the collective goals. A premise behind the CCI research is to provide personalized health and care through analysis, modeling and treatment that is tailored to the individual patient. Measurements from the patient’s heart (e.g. ultrasound imaging or ECG) are analyzed to extract anatomical, functional and geometrical information. This information can be used directly in clinical studies or be further analyzed and combined using cardiac modeling and simulation. The intelligent fusion of this information provides decision support that will influence diagnosis, triage and treatment. The CCI also runs clinical studies to validate and investigate the impact of new prognostic parameters.

The research and innovation work in the CCI is organized in projects with multi-partner involvement.

The innovative nature of the center results in continuous generation of new ideas and projects. In order to foster and fuel idea generation, the CCI has instituted meeting places of cross-disciplinary nature. These meeting places include journal clubs (where research results originating from both within the CCI and outside are being presented and discussed), work package review meetings (where CCI project achievements and challenges are being discussed) and workshops (where disruptive ideas and out-of-the-box thinking are being encouraged). New project ideas are discussed by the management team to establish feasibility as well as resource allocation. An implementation plan is then put in place.

In April 2014 the entire CCI was gathered for a work package review meeting. This meeting involved presentations on project status in the different work packages as well as research updates on applications of regional cardiac work estimations for both cardiac resynchronization therapy and myocardial infarct. Furthermore, progress on computational models for ARVC and acute feedback on left ventricular lead implantation were presented.

Motivated by the upcoming midterm evaluation of the CCI, we organized a workshop at Lysebu, Oslo on October 30th 2014. The workshop was highly interactive, and allowed all team members in the center to contribute to an analysis of the center’s strengths, weaknesses, opportunities and threats. The workshop also included forward looking sessions which resulted in the emergence of many good ideas for future innovation.

CCI members paying attention to a presentation at the work package review meeting at Lysebu, Oslo.
SCIENTIFIC ACTIVITIES AND RESULTS

AREA OF RESEARCH: MECHANICAL DISPERSION AND WASTED WORK RATIO

Sudden cardiac death (SCD) is still a challenge in cardiology. Mechanical Dispersion (MD) assessed by myocardial strain from speckle tracking echocardiography can be used to predict risk for SCD in post-MI cases and genetic myocardial diseases. Cardiac genetic diseases predispose to SCD in young individuals. Ongoing research in the CCI is focusing on predicting life threatening ventricular arrhythmias and exploring cardiac function in patients at risk of SCD.

It is well known that the work performed by the heart can be estimated as the area of the pressure-strain loop. This project in WP1 builds on a background invention of a method to estimate LV pressure non-invasively and thereby enable estimates of cardiac work as a function of time for each segment in the heart. A further development of these ideas has resulted in the principles of Wasted Work Ratio (WWR). WWR may serve as a means to identify patients who will benefit from CRT.

ONGOING PROJECTS

Echocardiography can be used as a tool to determine which patients with Lamin A/C mutations that are at risk of sudden cardiac death
Main contributors: Haugaa KH, Hasselberg NE, Edvardsen T

Sudden death may be the first symptom of heart disease in patients with heart muscle disease. Patients with mutations in the lamin A/C gene (LMNA) constitute one of several familial heart muscle diseases in the group of dilated cardiomyopathies (DCM). This condition can lead to both electrical disease as heart block, life threatening arrhythmias and sudden cardiac death. In addition the disease can lead to heart failure. The arrhythmic events are very difficult to predict. To reduce the risk of sudden death, high risk patients can receive implantable cardioverter defibrillator (ICD) therapy. However, to decide the correct timing of ICD implantation is very challenging.

We used mechanical dispersion (an index which can be defined from ultrasound deformation analysis of the heart) to investigate if this marker may help to determine the risk in patients with LMNA mutations. Mechanical dispersion was the best marker of life threatening arrhythmias in LMNA patients when the normal pump function (ejection fraction) of the heart was still relatively preserved. These results indicate that mechanical dispersion can be used as a tool in determining the risk and to improve selection of candidates for primary ICD therapy among LMNA patients.

Myocardial Work measurements using echocardiography can identify acute coronary occlusion in Patients with Non-ST-segment elevation – acute coronary syndrome
Main contributors; Espen Bøe, Kristoffer Russell, Christian Eek, Morten Eriksen, Espen Remme, Otto Smiseth, Helge Skulstad

Acute coronary artery occlusion (ACO) occurs in approximately 30% of patients with non-ST-segment elevation–acute coronary syndrome (NSTE-ACS). These patients may be in the need of prompt mechanical or pharmacological reperfusion as early as possible, and additional diagnostic tools are therefore needed to identify these patients.

We used an echocardiographic method, estimating myocardial work (MW), to identify the impaired myocardium supplied by a possible occluded artery in 126 patients presenting with NSTE-ACS.

The presence of a region of reduced MW identified patients with ACO, and was superior to all other parameters. MW was able to account for the influence of systolic blood pressure. Although further studies are needed, this method may be an important tool to identify ACO in patients with NSTE-ACS in the emergency department.
Arrhythmogenic right ventricular cardiomyopathy (ARVC) is a genetic heart muscle disease with an increased risk of life-threatening arrhythmias and sudden cardiac death. Sudden death may be the first devastating symptom in apparently healthy young individuals, which is a tragedy for their families. The mechanism behind the disease is complex and involves dysfunction in the glue between the heart muscle cells, which ultimately leads to severe damage of the cardiac muscles with potentially severe consequences. Athletic activity may increase the risk of life-threatening arrhythmias in individuals with ARVC and these individuals are recommended to restrain from competitive sports. However, the impact of high level exercise on heart function is not fully understood. We investigated 110 ARVC individuals of which almost half had a history of athletic activity. We showed that athletes with ARVC had reduced cardiac function compared to non-athletes in ARVC subjects. Interestingly, the amount and intensity of exercise activity was associated with impaired function of both heart chambers. Athletic activity may accelerate the development of heart disease in patients with ARVC. This finding adds to current guidelines for sports recommendation in ARVC patients to restrain from competitive sports.

Echocardiography may replace exercise testing in certain clinical settings
Main collaborators: Hasselberg NE, Haugaa KH, Sarvari SI, Gullestad L, Andreassen AK, Smiseth OA, Edvardsen T.

A subset of patients suffering from heart failure have preserved ejection fraction, defined as heart failure with preserved ejection fraction (HFrEF). HFrEF patients constitute around half of the heart failure population and have as poor prognosis as those with reduced ejection fraction. However, these patients are difficult to detect and to diagnose. Cardiopulmonary exercise testing is a strong predictor of mortality but it remains underutilized clinically because of costs and lack of trained personnel and equipment. Previous studies have failed to find a relationship between cardiac pump function and exercise capacity. We explored the relationship between exercise capacity and myocardial mechanics in heart failure patients with preserved and reduced EF. We found that deformation of the left ventricle measured as strain by echocardiography was closer related to exercise capacity than EF. These results indicate that echocardiographic strain may replace cardiopulmonary exercise testing in certain clinical settings.

Athletic activity impairs myocardial function in ARVC subjects

Arrhythmogenic right ventricular cardiomyopathy (ARVC) is a genetic heart muscle disease with an increased risk of life-threatening arrhythmias and sudden cardiac death. Sudden death may be the first devastating symptom in apparently healthy young individuals, which is a tragedy for their families. The mechanism behind the disease is complex and involves dysfunction in the glue between the heart muscle cells, which ultimately leads to severe damage of the cardiac muscles with potentially severe consequences. Athletic activity may increase the risk of life-threatening arrhythmias in individuals with ARVC and these individuals are recommended to restrain from competitive sports. However, the impact of high level exercise on heart function is not fully understood. We investigated 110 ARVC individuals of which almost half had a history of athletic activity. We showed that athletes with ARVC had reduced cardiac function compared to non-athletes in ARVC subjects. Interestingly, the amount and intensity of exercise activity was associated with impaired function of both heart chambers. Athletic activity may accelerate the development of heart disease in patients with ARVC. This finding adds to current guidelines for sports recommendation in ARVC patients to restrain from competitive sports.

Area of research; Image guidance and fusion

There is an increasing need for combining multiple information modalities and visualize these in an intuitive manner for both diagnostic use and for intra-procedural guidance. Today’s interventional procedures are heavily relying on imaging, acquired both before and during the procedure. Images are important for planning, monitoring, guidance, navigation and evaluation. This research area will tackle image acquisition, processing, fusion and presentation as a horizontal activity in the CCI.

Ongoing projects

Echo-guided placement of leads for cardiac resynchronization therapy
Main contributors: Aleksandar Babic [GE], Hans Henrik Odlund [OUH], Olivier Gerard [GE] and Eigil Samset [GE]

Patients suffering from heart failure, a condition where the heart is not able to supply the body with enough blood, can often benefit from cardiac resynchronization therapy. This therapy involves implanting a special pacemaker with leads going into the right ventricle and the coronary veins (blood vessels on the outer surface of the heart, draining blood away from the heart muscle). Despite that many patients experience very good improvements after this therapy, about 30% does not experience this benefit and some can even get worse. The reasons for this are not fully understood and are probably a combination of several factors including patient selection (some patients could have been excluded from this therapy) and failure to put the leads in the most optimal positions.

We have developed a guidance system that allows the treating cardiologist to co-visualize coronary veins (from x-ray) and which part of the heart that needs to be activated first by the pacemaker (from ultrasound strain analysis). The cardiologist can find the best position to place the lead based on echo-findings done before the implantation and image-guidance used during the implantation.
Area of Research: Cardiac Modeling

In recent years, the field of computational cardiac modeling and simulation has matured in both scope and methodology such that it can contribute significantly to the present understanding of heart physiology and disease. The computational cardiac modeling effort involves mathematicians and computer scientists working collaboratively with both experimentalists and clinicians to address current challenges in cardiology through basic research and industrially driven innovation projects.

Ongoing Projects

Population-based Structural and Functional Analysis of the Ventricles in ARVC Patients

Author: Kristin McLeod

Analyzing both the shape and function of the heart across many patients can provide useful insight into a disease. This can aid clinicians with diagnosis and therapy planning. More specifically, automatic methods for identifying regional abnormalities (either structural or functional) could be used to classify patients according to disease and disease state, therefore guiding the diagnosis and treatment by providing complimentary information to already available clinical data. We study population-relevant abnormalities to provide a deeper understanding of cardiac disease by computing the relationships between clinical indices and the structural/functional abnormalities. Previous work has highlighted the trend for global enlargement of the right ventricle in ARVC patients (mode 1 in the figure on the right), and our work will further investigate these findings and compare them with an asymptomatic control group. In terms of studying functional abnormalities, we will develop 3D maps of cardiac motion patterns from individual patients that could be used to determine population-wide cardiac motion patterns.

Virtual Human Atrial Models

Author: Jussi Koivumäki

Atrial fibrillation is a good example of a complex disease that may have several different underlying causes. To understand the mechanisms that promote and maintain the disease, it may be helpful to perform advanced computer simulations. We have recently developed a comprehensive human atrial cell model that takes into account the changes in electrical, contractile and ultrastructural properties of human atrial cells in chronic atrial fibrillation. Continuing from that work, we are now developing a model that can recapitulate corresponding cellular level changes in paroxysmal or short-term atrial fibrillation. These extended and novel methods will bring insights to the abnormalities in electrical automaticity and conduction. Ultimately, the aim is to develop a 3D virtual human atrial simulator that can, hopefully, provide additional information for doctors making decisions related to ablation procedures.
AREA OF RESEARCH: CARDIAC RESYNCHRONIZATION THERAPY

The aim of this work package is to define acute response parameters that can be used to optimize cardiac resynchronization therapy (CRT). With the current worldwide empiric implantation practice of CRT, a 50-60% responder rate is expected. Through clinical studies and innovative study design novel acute response parameters are investigated in order to pick optimal response parameters that can be used to characterize cardiac electric, mechanic and tissue properties to predict long-term response of CRT.

An important work of this group is the development of the Pacertool and the transition of this tool into clinical practice.

Cardiac resynchronization therapy (CRT) is an effective treatment in severe heart failure patients, and leads to decreased mortality, less hospitalizations and relief of symptoms. But not all CRT patients benefit from therapy. Different novel echocardiographic indices by tissue Doppler imaging (TDI) and speckle tracking strain have been proposed to improve selection, but have failed to increase responder rates in randomized trials. Therefore, wide QRS duration, impaired LV function and symptoms of heart failure remain the only guideline criteria for selection of patients for CRT. Following these criteria, however, approximately 30% of implanted patients will not respond to therapy. OUH has partnered with Medtronic to address several aspects of device treatment in Heart Failure.

By maximizing the benefit of CRT across the continuum of care, we believe even more patients will respond to this therapy.

ONGOING PROJECTS

CCI Impact Study and CRT

In the ongoing study CCI Impact, OUH and Medtronic try to leverage on all recent advances within the field of CRT research. The patient selection process has shifted from a mere HF treatment focus to a more proactive approach, where CRT is used to prevent HF progression in mildly symptomatic patients or patients in need of cardiac pacing. Appropriate patient selection is essential to achieving CRT therapy success, and OUH has taken a leading role in developing consensus documents which comment, summarize and endorse the most current European and US guidelines for CRT. When the appropriate patient is selected for CRT, we need to streamline the pre-planning phase. The other Research Partners, GEVU and Simula, have and will continue to work on the collected imaging data (cMR and Echo) to find the optimal way of presenting crucial patient-specific information to the implanting physician before he enters the operation room.

The CCI Impact study was designed to give insight to the CRT implant procedure. Enrollments are expected to be finished in 2014, and the data analysis has started. We hope the results will help us better understand the acute mechanisms at play during device delivered resynchronization therapy. There are several factors that may affect the final LV lead location: varied venous anatomies, LV lead delivery and stability challenges, presence of phrenic nerve stimulation and high LV pacing thresholds. There is an unmet need of a parameter quantifying and/or confirming acceptable therapy delivery at any given lead position, and the CCI Impact study will assess the predictive properties of a set carefully selected parameters. The recruitment of a PhD in Medicine, Stian Ross in spring 2014 has helped the study progress, and he will coordinate the analysis efforts in the next phase of the study. Medtronic has utilized staff from both Bakken Research Center in Maastricht NL and the HQ Research Center in Minneapolis, MN US to support the research tasks in this study. On local level, Lars Ove Gammelsrud has been the Medtronic representative in Work Package 4 and provided the day-to-day support needed. In parallel to the clinical study, Medtronic and OUH have also partnered in projects addressing other aspect of the implant procedure. During 2014 OUH has tested and evaluated new therapy delivery systems and leads(1).
Pacertool

Pacertool is software that is developed in collaboration between Kalkulo and OUH. The software is a part of a system that will provide feedback to the operator when implanting a cardiac resynchronization device (CRT) and represents the interface between measured parameters and the operator. The aim of this system is to improve the current 50-60% responder rate of CRT.

Individualized medicine
The pacertool software will allow the implanter to individualize pacing lead positions to optimize the resynchronization effect of the CRT device. Parameters that are measured during implantation will be collected and displayed to highlight the optimal site of electrode placement. Imaging from pre-implantation studies, as echocardiography and magnetic resonance imaging can be incorporated to display patient specific cardiac geometry. When coronary sinus angiography is performed during the implantation procedure, the patient specific anatomy can be segmented and utilized during the procedure. When incorporated in research different positioning can be compared and analyzed.

Predictive patient specific simulation
The data from any procedure can be used for predictive patient specific simulation. With different electrode positions data from every patient is stored together with geometry. This will allow for validation of simulation algorithms and for calculating predictive reverse remodeling. When performed during the implantation procedure, optimal sites for lead placement can be highlighted and compared to acute study hemodynamic parameters. This may provide validity to the simulation protocol and possibly provide insight into patient specific reverse remodeling processes.

Closed-loop biofeedback during surgery
When used in combination with bioimpedance studies, this system will provide the operator with acute feedback from each electrode position and allow the operator to move the electrodes into different positions until optimal sites of stimulation are found. During this process biofeedback will guide positioning in a closed-loop fashion. Bioimpedance as measured in collaboration with the medical engineering section at OUS will provide insight into hemodynamic and mechanical characteristics of the heart during each procedure.
INTERNATIONAL COOPERATION

CCI has established collaborations with several world leading medical centres and the CCI host, Oslo University Hospital (OUH) is the leading center in several international multicenter studies. One of these studies is a prospective study on arrhythmias after myocardial infarction in collaboration with the University Hospital of Leuven, Belgium, Rigshospitalet, Copenhagen, The Gentofte Hospital, Copenhagen and Sykehuset Sørlandet, Arendal. Other important studies include recent papers published together with Mayo Clinic, Rochester, MN, University of Pittsburgh, PA and John Hopkins University, Baltimore, MD, USA.

OUH is also participating in the DOPPLER-CIP study, funded under EU’s 7th framework program. This project will include 676 patients with suspected coronary artery disease and is performed in collaboration with hospitals in Leuven, Madrid, Pisa, London, Linköping and Turku. OUH has recently published an emerging prospective study on ventricular arrhythmias in athletes in collaboration with Lund University Hospital, and is collaborating in ongoing studies on this topic with several University Hospitals in Denmark. Important collaborations have also been established to Maastricht University Hospital, the Netherlands, with recent publications. A multicentre study including patients with heart failure was performed in the CCI in collaboration with Rennes, France.

Simula has close ties with several academic groups in the USA and Europe including University of California, San Diego (UCSD), University of California, San Francisco (UCSF), King’s College London, University of Utah, INRIA Sophia Antipolis, and Karlsruhe Institute of Technology, Germany.

In particular, UCSD remains a strong research and educational partner, with researchers in Cardiac Modeling Group at Simula Research Laboratory engaging in active collaboration with the Cardiac Biomechanics Research Group at UCSD. This university conducts world-class research within the core areas of Simula research, including scientific computing and biomedical problems and in 2015, Simula together with UiO, will begin a joint PhD program with this institute.

GEVU has an extensive global network and engages actively in research collaborations with luminaries globally including KU Leuven (Belgium), University of Padova (Italy), UCSF (California) and University of Tasmania (Australia). Many of these research collaborations are related directly to research in the CCI within topics such as functional ultrasound imaging for assessment of heart failure and risk of sudden cardiac death. GEVU is also coordinating a EU-funded Marie Curie project where OUH is an associated partner. The project is an industrial doctorate project that will train 5 PhD students and focus on improved ultrasound imaging for guidance of treatment for patient with cardiac arrhythmia.

Medtronic is found in 140 countries around the world, hosts 26 research centers and has direct presence in most European countries. With an industry leading research portfolio, Medtronic has partnered with a large number of hospitals to drive innovation in the field of medical technology. Major European Research facilities include: Bakken Research Center in Maastricht/BRC (The Netherlands), Therapy and Procedure Training Center in Tolochenaz (Switzerland), and Vascular Manufacturing and Customer Innovation Center in Galway (Ireland).

BRC has more than 20 large international multicenter studies running within the field of Cardiac Rhythm and Heart Failure in Europe.

Around 60 projects are ongoing in the Nordic area. Support for the CCI initiated CRT research is mainly provided by the R&T department at BRC, but with a strong link to the research dept. at Medtronic HQ in Minneapolis US. At an early phase of WP4 OUH staff had a visit to Queen Elizabeth Birmingham (UK) to exchange knowledge on CRT pre-operative planning. Medtronic is currently facilitating for cooperation with The Libin Cardiovascular Institute of Alberta (Calgary, Canada) to enhance the selection of post-MI patients for primary prevention ICD therapy.
Glenn Terje Lines and other researchers from Simula were featured in META Magazine with their study on subcellular calcium dynamics.

Supercomputing-enabled study of subcellular calcium dynamics
META Magazine, Issue 01/2014, pages 14-17

Center Director for Cardiology Research, Kristina Haugaa was interviewed by Cardiostim Times for her study on gender differences in cardiomyopathies and ion channel disorders.

Gender matters
Cardiostim Times, Issue 2, Friday 10.06.2014, page 16

Jørn Bersvendesn, a PhD student at GE Vingmed Ultrasound, was interviewed together with Center Coordinator Eigil Samset by the Research Council of Norway. Bersvendesn works on developing a geometrical 3D data model that can accurately describe cardiac function.

Hjertelig samspill    www.NFR.no, 03.06.2014

The chair of EACVI Scientific Documents Committee, Professor Thor Edvardsen, writes about the publication and guidelines policy of the Committee in the EuroEcho-Imaging Congress News.

Scientific Document Committee grapples with need for CV imaging evidence-base
EuroEcho-Imaging, Congress News. Friday 5th December 2014

Other articles where CCI members have featured

Nina Hasselberg [OUH], Petter Storsten [OUH], Trine Håland [OUH]
Norske hjerteforskere gjorde seg bemerkt i Barcelona
www.unikard.org, 03.09.2014

Kristina Haugaa [OUH]
Kan ha funnet gener som forårsaker plutselig død
www.NRK.no, 18.08.2014

Aslak Tveito (Simula)
Simula får 10 mill. i statsbudsjettet
www.budstikka.no, 07.10.2014
PARTNERS

Each partner represents a unique and required element in the research and development chain leading to the industrial innovations targeted by the CCI.

**Oslo University Hospital**

- **Role:** Host institution
- **Objective:** Improve procedures and services related to patient treatments. Obtain new diagnostic and therapeutic approaches to the benefit of patients suffering from cardiac diseases.
- **Contribution:** World class cardiology research group, access to hospital infrastructure and facilities.

**UiO: University of Oslo**

- **Role:** Research Partner
- **Objective:** Strengthen quality of research in the field of cardiology and medical imaging. Contribute to research training (completed PhD program) and transfer of knowledge (publication, innovation)
- **Contribution:** Research infrastructure, senior personnel in both clinical research and computer science.

**[ simula . research laboratory ]**

- **Role:** Research Partner
- **Objective:** Develop patient-specific simulation models to reveal mechanisms underlying cardiac disease, improve diagnostic techniques, and predict treatment outcome.
- **Contribution:** A research foundation for development of innovative, computationally efficient, and reliable algorithms and software.

**cardiosolv**

- **Role:** User Partner
- **Objective:** Become world leader in software development for cardiac electromechanical applications. Bring state-of-the-art cardiac simulation out of academia and to the bed-side.
- **Contribution:** Access to mesh-creation tools, simulators, visualization tools, simulation analysis tools and consultations on cardiac simulation and arrhythmias.

**kalkulo**

- **Role:** User Partner
- **Objective:** Develop products (as modules or applications) that can be commercialized. Extend current software application framework to strengthen presence in the medical market.
- **Contribution:** Expertise and software tools for advanced computations and visualization.

**Medtronic**

- **Role:** User Partner
- **Objective:** Contribute to human welfare by application of biomedical engineering in the research, design, manufacture, and sale of instruments or appliances that alleviate pain, restore health and extend life.
- **Contribution:** Extensive expertise in the field of medical technology, research infrastructure and global reach. Risk stratification for sudden cardiac death in the implantable cardioverter defibrillator population and maximized response to cardiac resynchronization therapy. Medtronic will be involved in research tasks directly or indirectly related to patient selection, cardiac device optimization, implant tools, therapy delivery and feedback.
One of the major challenges today is related to the treatment of cardiological diseases and to predict optimal therapy. Today, many unexpected events could probably have been avoided if better diagnostic tools were available. One such tool is predicted to be the combination of cardiac ultrasound and electrocardiographic methodologies combined into a joint diagnostic modality. It is predicted that such methodology could provide a powerful tool to tailor individual patient therapy.

Oslo University Hospital (OUH), is owned by the South-Eastern Regional Health Authority and consists of the former health trusts of Rikshospitalet University Hospital, Aker University Hospital and Ullevål University Hospital. The hospital is, with its roughly 20,000 employees and more than 1.2 million patient treatments per year, Scandinavia’s largest hospital and also one of the largest hospitals in Europe. OUH is responsible for approximately 50 percent of all medical and healthcare research conducted in Norway. This is resulting in about 1500 peer review publications and more than 100 PhD graduates annually. The driving force for all research investments at OUH is to improve patient care, both short- and long-term. The continuous need to improve patient care is also based on development and implementation of new procedures, targeting diseases that still represent a major burden to the health system as well as to the patients themselves.

Our main objective in hosting the CCI is to improve procedures and services related to patient treatments, i.e. by developing and utilizing current and new competence and results to obtain new diagnostic and therapeutic approaches to the benefit of patients suffering from cardiological diseases.
The Faculty of Medicine has approximately 3300 students (incl. PhD students) attending their study program and consists of five institutes: Institute for Forensic Medicine, the Regional Committees for Research Ethics in Medicine and Health Care, the Institute of Health and Society, the Institute of Basic Medical Sciences and the Institute of Clinical Medicine.

The research and education carried out at the Faculty of Medicine is based on a close partnership with the South-Eastern Norway Regional Health Authority and the two hospitals Akershus University Hospital and Oslo University Hospital. Approximately 50 percent of the academic staff at the faculty is also employed at one of the university hospitals. This ensures a close connection between medical theory and clinical practice for students and researchers. The faculty also collaborates with local hospitals and general practitioners in teaching medical students.

The Faculty of Medicine in collaboration with the Department of Cardiology, Oslo University Hospital has two key research areas: myocardial function/cardiac imaging and heart failure. This collaboration has been a strong scientific contributor in order to establish modern cardiac imaging principles for assessment of regional and global left ventricular function.

Moreover, research in cardiology has been defined as one of the main medical research areas at the University of Oslo. The University of Oslo will together with Oslo University Hospital, constitute the hub of the Center for Cardiological Innovation (CCI). University of Oslo will act as a research partner in the CCI and host PhD students on the PhD program at either the Faculty of Medicine or the Faculty of Mathematics and Natural Sciences.

University of Oslo (UiO) is currently ranked as the best university in Norway. UiO is the largest university in Norway and has 7000 employees and 27000 students.
Simula Research Laboratory, established in 2001, is a non-profit, public utility enterprise, organised as a limited company of 140 exceptional minds and owned by the Ministry of Education and Research. Simula is dedicated to tackling scientific challenges with long-term impact on real-world problems and promoting basic research at a top international level in collaboration with global leaders, excellence in postgraduate education, and application-driven innovation and commercialisation.

Basic research at Simula is focused in the fields of communication systems, scientific computing, and software engineering. Endeavours in all these areas have been successful: Simula is ranked by the Journal of Systems and Software as the world’s most productive institution in systems and software research, Simula serves as the host for the Center of Biomedical Computing, a Centre of Excellence (SFF), as well as the Certus Centre for Software Verification and Validation, a center for research-based innovation (SFI) (both awarded by the Research Council of Norway). Simula is also a main research partner in the Centre for Cardiological Innovation (SFI), with primary participation through its Department of Cardiac Modeling (CaMo). CaMo features a range of competencies in cardiac modeling.

These include the development of methods to study electrophysiology and mechanics in heart tissue, and the use of these tools to study select questions related to cardiac dysfunction and arrhythmia. Complex mathematical models are required to accurately simulate heart physiology, which creates a series of research challenges. First, it is necessary to approach problems via mathematical theory, which can lead to advanced understanding but may require novel analytical approaches. Solving models of cardiac electrophysiology and mechanics on a computer also requires stable, rapid numerical methods. There are additional challenges related to how such complex systems can be implemented in software in efficient, yet flexible ways. CaMo research has and will continue to focus on developing and applying these sophisticated numerical models and software tools, as well as creating quantitative, human-specific models of the heart.

Targeted models can then be applied to elucidate responsible mechanisms and potential medical consequences of cardiac pathologies. Key application areas for the CCI within our research group focus on using advanced models and simulation to gain insight into the key drivers of sudden cardiac death (SCD) and heart failure (HF). CaMo’s partnership will contribute concretely to the CCI by providing a basic research foundation for the development of patient-specific modeling techniques and software development for their implementation in commercial systems.
Kalkulo is a Norwegian software company providing software solutions for technical applications. The company was founded in 2006 and currently has 15 employees. Kalkulo is owned by Simula Research Laboratory and develops services and products within three markets: computational biomedicine, oil&gas exploration and renewable energy. The business idea is to provide tailored solutions based on expert competence.

Type of expertise brought to the CCI

Geometric modeling.
This type of expertise deals with how to represent, construct and manipulate geometries (shapes) on a computer. Types of relevant geometries involve curves, surfaces, volumetric grids and scalar/vector fields.

Computer visualization.
Important aspects of this expertise are:
1) transformation of data into information
2) choosing the right level of detail
3) highlighting of important features of the data
4) handling large and inhomogeneous data sets efficiently.

Software application development.
Realizing many of the commercial ambitions of the CCI rely on this type of expertise. This includes the development of user friendly, efficient, robust and re-usable software. Relevant skills are software and user interface design, handling of large data sets, data communication, software integration and data conversion.

Type of activities within the CCI

Kalkulo’s main activities are focused on software development. We will collaborate with the other partners in order to develop software for:

Generation of tailored geometric models.
One of the main goals of the CCI is to simulate patient specific effects of treatment of cardiac diseases. Kalkulo will develop software that generates patient specific 3d models, suitable for simulation, in terms of surfaces, volumes and vector fields.

Data visualization and integration.
Kalkulo will develop software representing an interface for both clinicians and researchers. The software shall provide access to different simulation models, as well as all relevant data types, such as surface geometries, vector fields (fiber directions), 3d imagery and simulation results.

In the end, Kalkulo aims at developing products either being modules or stand-alone applications, that can be commercialized.
GE Vingmed Ultrasound

GE Vingmed Ultrasound (GEVU) is a world-leading provider of ultrasound systems for cardiovascular applications. GEVU is recognized as a center of excellence for cardiac ultrasound within GE Healthcare – a ~$18B revenue business area within General Electric Corporation. GE Vingmed Ultrasound has 200 employees with headquarters in Horten, Norway and offices in Oslo and Trondheim. GEVU collaborates closely with medical and technological research institutions in Norway and abroad, and close to 100 PhD theses have been published based on work related to development or use of equipment produced by GEVU.

Business areas

GEVU designs a range of products for cardiac ultrasound imaging. The high-end scanner, Vivid E9, is used in hospitals for diagnostic examinations of patients suffering from different heart problems. Vivid E9 is a powerful ultrasound system, designed for performing complex examinations with an easy workflow. The system gives excellent image quality in 2D as well as 3D, and allows for quantitative analysis of images acquired as rest and during stress. GEVU was the first to introduce a pocket sized ultrasound scanner. The innovative VScan is considered the “new stethoscope” that addressed the primary care in the local doctor’s office as well as a handy tool to bring ultrasound to the patient’s bedside in hospitals. In the most recent release of VScan the small scanner is equipped with the first of a kind “dual probe” enabling multiple examination types with a single probe.

Type of expertise brought to the CCI

GEVU brings a substantial body of expertise in development, manufacturing and applications of cardiovascular ultrasound systems. The R&D team at GEVU is highly skilled with competence spanning electronics, ultrasound acoustics, software engineering, image processing, visualization, quantitative analysis of cardiac function and clinical applications.

Type of activities within the CCI

GEVU is supporting the CCI with research ultrasound scanners implementing new research results from the CCI. GEVU is particularly interested in methods that can help predict sudden cardiac death as well as predicting how the treatment for patients who can benefit from cardiac resynchronization therapy (a new generation of pacemakers) can be optimized. GEVU will also perform research on methods for advanced cardiac analysis and new imaging techniques, including new imaging probes.
Founded in 1949, Medtronic has grown to become the world’s largest independent medical technology company. At the core of all we do is our Mission: to alleviate pain, restore health and extend life.

The company employs more than 49,000 people. In the past year, more than 10 million people worldwide relied on Medtronic therapies, which treat many conditions including cardiac and vascular diseases, diabetes, and neurological and spinal conditions. Many of these therapies are the result of collaboration with physicians, scientists, engineers and others passionate about advancing medical technology. Medtronic’s 5,800 scientists and engineers, pursuing research and innovation have resulted in more than 28,000 patents in the field of medical technology. Medtronic continually seeks innovative solutions to improve the lives of patients through the application of device therapy. Both ICD treatment as primary and secondary prevention for sudden cardiac death and CRT in the heart failure population have been established as effective treatments with Medtronic as the leading research partner.

Business areas and type of expertise brought to the CCI

While waiting for the results from CCI Impact, CRT response rate can still be improved by ensuring optimal therapy delivery from already implanted CRT systems. OUH participated in the clinical investigation of the AdaptivCRT feature in Medtronic devices. All CCI Impact patients have received devices capable of delivering this relatively new type of resynchronization therapy. AdaptivCRT is a dynamic, physiologic pacing algorithm which enhances CRT by adjusting CRT parameters automatically with changes in patient activity levels and conduction status continuously. Clinical data has showed that patients similar to our CCI Impact patients (LBBB, intact AV conduction) experience significantly higher response rate (81% vs 69%) when treated with AdaptivCRT compared to standard CRT. Late 2014 Medtronic also partnered in on another focus area of CCI. The stratification of sudden cardiac death risk in post-MI patients with preserved EF (36%-50%) will be evaluated in the REFINE-ICD study, which Medtronic sponsors. Initiation steps are ongoing, and CCI Work Package 1 is leading this process.

Patient care is always a focus for both OUH and Medtronic. All CRT (-D) patients at OUH are followed by remote monitoring. Patients with Medtronic devices upload their device data to the CareLink® Network. This can then be used as a powerful tool to identify patients at risk of sub optimal response. Medtronic works with OUH to find the best way of easy, user-friendly access to objective, trended data for heart failure management.
CardioSolv Inc. is a private scientific services and consulting company founded in 2008 specializing in predictive cardiac modeling and simulation.

CardioSolv’s goal is to be the world leader in software development for cardiac electromechanical applications and to provide computational biomechanics engineering analysis to the academic research community, biomedical technology companies, and the cardiology profession. Our services include medical device design and optimization, virtual cardiac electrophysiology and electromechanics solutions, and personalized-medicine planning tools for anti-arrhythmia therapy. The mission of CardioSolv, Inc., is to bring the state of the art in cardiac simulation out of academia and to the bedside.

The founders of CardioSolv, Inc., come from leading labs in their fields, and have extensive background in cardiac electrophysiology and mechanics, cardiac modeling, image processing, image-based model reconstruction, numerical analysis, computer science, and high-performance computing. We generate personalized heart models from medical imaging data, simulate electrical and mechanical activity, and interpret the results of such simulations. We are using our expertise to develop intuitive solutions for those who could benefit from our services, while continually striving to increase model detail, reduce turnaround time, and increase model accuracy.

Within the CCI, CardioSolv is providing access to our mesh creation tools, simulators, visualization tools, and simulation analysis tools. We are also providing consultation to other members of the CCI regarding cardiac simulation and arrhythmias. In particular:

CardioSolv has developed a fast, simple, and unique algorithm for assigning anatomically-accurate fiber orientations in arbitrary heart geometries, accurate to within 95% of histological measurements. This capability is needed for several of the simulation projects within the CCI. CardioSolv will provide and support the use of this algorithm and associated software.

CardioSolv also owns and develops the fastest, most sophisticated known cardiac simulator available, CARP. The CARP simulator is capable of running human-heart meshes at appropriate mesh resolutions, and scales well on thousands of CPU cores. CCI partners will be able to use CARP secure in the knowledge that it has been thoroughly tested and compared against numerous experimental and clinical studies, and used to publish hundreds of peer-reviewed publications in the cardiac electrophysiology field over the last six years. The CARP simulator interoperates with our other tools including the Meshalyzer visualization package, the CepMods parallel post-processing suite.

Analyzing simulation results with the Meshalyzer visualization and analysis package. Shown is a trace of transmembrane potential from a transmural cutaway view of a rabbit ventricular mesh.
COMMUNICATION & DISSEMINATION OF ACTIVITIES

The CCI has published 41 scientific articles during 2014 and dissemination activities count 71 at present, including posters, abstracts, speeches and lectures at national and international conferences.

PhD students Stian Ross, Trine Håland and Jørg Saberniak together with Associate Professor Kristina Haugaa at the ESC conference in Barcelona, Spain in September 2014.

PhD student Espen Bøe in front of his poster at the autumn meeting for the Norwegian Society of Cardiology in Oslo, Norway.

The Cardiac Modeling Department of Simula Research Laboratory hosted an international workshop on Cardiac Modeling from the 5th to the 7th of November at Simula Research Laboratory, Oslo.

Center Directors Thor Edvardsen, MD, PhD and Kristina Haugaa, MD, PhD together with PhD student Ida Skrinde Leren and Marcio Barros, MD, PhD during his stay at the CCI. Dr. Marcio Barros is a collaborator in a joint study on Mechanical Dispersion and Chagas disease.

CCI participated at Holmenkollstafetten 10th of May. The team placed number 348 out of 1522 within the category ‘A1, mixed teams, most male participants’ with a total time of 1:13:45.

The CCI was well represented at the autumn meeting for the Norwegian Society of Cardiology in Oslo, Norway. From the left; Eike Nagel, MD, PhD, Kristina Haugaa, MD, PhD, Nine Eide Hasselberg, MD Ida Skrinde Leren, MD, Thor Edvardsen, MD, PhD, Espen Remme, Dr. ing., Jørg Saberniak, MD, Lars Gunnar Klaeboe, MD, and Petter Storsten, MD.
RECRUITMENT

In 2014 five new PhD-students and one administrator were recruited to the CCI.

PHD- STUDENTS:

Stian Ross  
Research topic: Cardiac resynchronization therapy. Evaluation of acute response parameters.  
Affiliation: Oslo University Hospital

Øyvind Senstad Andersen  
Research Topic: Left ventricular filling mechanics and left bundle branch block  
Affiliation: Oslo University Hospital

Lars Gunnar Klaebøe  
Research topic: Medical radar and imaging in patients with moderate heart failure  
Affiliation: Oslo University Hospital

Henrik Finsberg  
Research Topic: Patient Specific Simulation for Improved Cardiac Resynchronization Therapy (CRT)  
Affiliation: Simula Research Laboratory

Espen Bøe  
Research topic: Hemodynamic changes during pacing interventions in the failing heart  
Affiliation: Oslo University Hospital

ADMINISTRATOR

On August 11th Piritta Nyberg took over as the new administrator for the Center for Cardiological Innovation.  
Affiliation: Oslo University Hospital

ANNUAL ACCOUNTS

<table>
<thead>
<tr>
<th>Funding</th>
<th>Amount*</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Research Council</td>
<td>10 484</td>
</tr>
<tr>
<td>The Host Institution (Oslo University Hospital)</td>
<td>4 269</td>
</tr>
<tr>
<td>Research Partners</td>
<td>5 503</td>
</tr>
<tr>
<td>Enterprise partners</td>
<td>6 644</td>
</tr>
<tr>
<td>Total</td>
<td>26 900</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Costs</th>
<th>Amount*</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Host Institution [Oslo University Hospital]</td>
<td>8 925</td>
</tr>
<tr>
<td>Research Partners</td>
<td>8 881</td>
</tr>
<tr>
<td>Enterprise partners</td>
<td>7 778</td>
</tr>
<tr>
<td>Equipment</td>
<td>1 316</td>
</tr>
<tr>
<td>Total</td>
<td>26 900</td>
</tr>
</tbody>
</table>

*All figures in 1000 NOK
# Personnel

## Key Researchers

<table>
<thead>
<tr>
<th>Name</th>
<th>Institution</th>
<th>Main Research area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thor Edvardsen</td>
<td>OUH/OiO</td>
<td>Myocardial function and cardiac imaging.</td>
</tr>
<tr>
<td>Kristina Haugaa</td>
<td>OUH</td>
<td>Ventricular arrhythmias and prediction of SCD. Mechanisms of arrhythmias, impact of imaging in risk assessment of SCD and cardiogenetics.</td>
</tr>
<tr>
<td>Morten Eriksen</td>
<td>OUH</td>
<td>Development and validation of methods for analysis of myocardial strain recordings, with emphasis on assessment of mechanical work.</td>
</tr>
<tr>
<td>Lars Aaberge</td>
<td>OUH</td>
<td>Invasive cardiology and intensive coronary care.</td>
</tr>
<tr>
<td>Thorbjørn Holm</td>
<td>OUH</td>
<td>Inflammatory mediators and endothelial function as markers of prognosis in heart failure and after heart transplantation.</td>
</tr>
<tr>
<td>Helge Skulstad</td>
<td>OUH</td>
<td>Mechanisms of myocardial function, Cardiac Imaging and Adult Congenital Heart disease.</td>
</tr>
<tr>
<td>Ole-Gunnar Anfinsen</td>
<td>OUH</td>
<td>Electrophysiology.</td>
</tr>
<tr>
<td>Espen Remme</td>
<td>OUH</td>
<td>Cardiac mechanics, cardiovascular function, diastolic function/dysfunction/heart failure, dyssynchrony, myocardial deformation in the ischemic heart, mathematical heart modeling, cardiac miniaturized motion sensors.</td>
</tr>
<tr>
<td>Einar Hopp</td>
<td>OUH</td>
<td>Dynamic magnetic resonance imaging in the assessment of myocardial infarct.</td>
</tr>
<tr>
<td>Otto Smiseth</td>
<td>OUH</td>
<td>Cardiovascular function, imaging and biomechanics.</td>
</tr>
<tr>
<td>Christian Eek</td>
<td>OUH</td>
<td>Invasive cardiology. Echocardiographic stratification of patients with acute coronary syndrome.</td>
</tr>
<tr>
<td>Einar Gude</td>
<td>OUH</td>
<td>Cardiovascular function, imaging and biomechanics.</td>
</tr>
<tr>
<td>Hans Henrik Odland</td>
<td>OUH</td>
<td>Cardiovascular function, imaging and biomechanics.</td>
</tr>
<tr>
<td>Arne Kristian Andreassen</td>
<td>OUH</td>
<td>Cardiovascular function.</td>
</tr>
<tr>
<td>Kristoffer Russell</td>
<td>OUH</td>
<td>Dyssynchrony in the heart and novel methods for assessing global and regional myocardial function.</td>
</tr>
<tr>
<td>Svend Aakhus</td>
<td>OUH</td>
<td>Echocardiography/Cardiology.</td>
</tr>
<tr>
<td>Margareth Ribe</td>
<td>OUH</td>
<td>Cardiac imaging, ventricular function.</td>
</tr>
<tr>
<td>Håvard Kalvøe</td>
<td>OUH</td>
<td>Medical technology and bioimpedance.</td>
</tr>
<tr>
<td>Jan Olav Hegtveit</td>
<td>OUH</td>
<td>Medical technology and bioimpedance.</td>
</tr>
<tr>
<td>Morten Flattum</td>
<td>OUH</td>
<td>Medical technology and bioimpedance.</td>
</tr>
<tr>
<td>William Louche</td>
<td>OUH</td>
<td>Calcium homeostasis and the failing heart.</td>
</tr>
<tr>
<td>Erlend Aune</td>
<td>OUH</td>
<td>Cardiovascular function.</td>
</tr>
<tr>
<td>Ole Seiersted</td>
<td>OUH</td>
<td>Calcium homeostasis and the failing heart.</td>
</tr>
<tr>
<td>Martin Reimers</td>
<td>UIO</td>
<td>Geometrical modeling.</td>
</tr>
</tbody>
</table>
# PERSONNEL

## Key Researchers

<table>
<thead>
<tr>
<th>Name</th>
<th>Institution</th>
<th>Main Research area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gunnar Hansen</td>
<td>GEVU</td>
<td>Ultrasound acquisition, processing and visualization.</td>
</tr>
<tr>
<td>Eigil Samset</td>
<td>GEVU</td>
<td>Ultrasound acquisition, processing and visualization.</td>
</tr>
<tr>
<td>Andreas Heimdal</td>
<td>GEVU</td>
<td>Ultrasound acquisition, processing and visualization.</td>
</tr>
<tr>
<td>Fredrik Orderud</td>
<td>GEVU</td>
<td>Ultrasound acquisition, processing and visualization.</td>
</tr>
<tr>
<td>Olivier Gerard</td>
<td>GEVU</td>
<td>Ultrasound acquisition, processing and visualization.</td>
</tr>
<tr>
<td>Jakub Czana</td>
<td>GEVU</td>
<td>Ultrasound acquisition, processing and visualization.</td>
</tr>
<tr>
<td>Christian Tarrou</td>
<td>Kalkulo</td>
<td>Geometric modeling.</td>
</tr>
<tr>
<td>Marek Gayer</td>
<td>Kalkulo</td>
<td>Geometric modeling and computer visualization.</td>
</tr>
<tr>
<td>Yvon Halbwachs</td>
<td>Kalkulo</td>
<td>Geometric modeling and computer visualization.</td>
</tr>
<tr>
<td>Joakim Berdal Haga</td>
<td>Kalkulo</td>
<td>Geometric modeling and computer visualization.</td>
</tr>
<tr>
<td>Lars Øve Gammelsrud</td>
<td>Medtronic</td>
<td>Biomedical engineering.</td>
</tr>
<tr>
<td>Alfonso Aranda Hernandez</td>
<td>Medtronic</td>
<td>Biomedical engineering.</td>
</tr>
<tr>
<td>Trent Fischer</td>
<td>Medtronic</td>
<td>Biomedical engineering.</td>
</tr>
<tr>
<td>Richard Cornelussen</td>
<td>Medtronic</td>
<td>Biomedical engineering.</td>
</tr>
<tr>
<td>Brock Tice</td>
<td>CardioSolv</td>
<td>Computational cardiac simulation methods and tools.</td>
</tr>
<tr>
<td>Robert Blake</td>
<td>CardioSolv</td>
<td>Computational cardiac simulation methods and tools.</td>
</tr>
<tr>
<td>Molly Maleckar</td>
<td>SRL</td>
<td>Computational cardiac electrophysiology (multiscale).</td>
</tr>
<tr>
<td>Samuel Wall</td>
<td>SRL</td>
<td>Computational cardiac electromechanics; development of geometric models from echocardiographic data.</td>
</tr>
<tr>
<td>Glenn Lines</td>
<td>SRL</td>
<td>Computational cardiac electrophysiology (multiscale).</td>
</tr>
<tr>
<td>Joakim Sundnes</td>
<td>SRL/UIO</td>
<td>Computational cardiac electromechanics.</td>
</tr>
<tr>
<td>Bjørn Fredrik Nielsen</td>
<td>SRL</td>
<td>Inverse solutions and identification of ischemic regions from ECG recordings; extension of this solution for other applications.</td>
</tr>
<tr>
<td>Aslak Tveito</td>
<td>SRL</td>
<td>Computational cardiac electrophysiology (multiscale).</td>
</tr>
<tr>
<td>Marius Lysaker</td>
<td>SRL</td>
<td>Inverse solutions and identification of ischemic regions from ECG recordings; extension of this solution for other applications.</td>
</tr>
<tr>
<td>Sjur Gjerald</td>
<td>SRL</td>
<td>Inverse solutions and identification of ischemic regions from ECG recordings; extension of this solution for other applications.</td>
</tr>
</tbody>
</table>
**PERSONNEL**

### Postdoctoral researchers at the centre

<table>
<thead>
<tr>
<th>Name</th>
<th>Nationality</th>
<th>Period</th>
<th>M/F</th>
<th>Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kristin McLeod</td>
<td>New Zealand</td>
<td>01.10.2013-30.09.2015</td>
<td>F</td>
<td>Development of clinically useful cardiac models and indices from patient specific data that will bridge the gap between highly detailed biophysical simulations of the heart and empirical clinical relationships. These include developing a reduced-order bi-ventricular model using patient data and working on statistical growth models to help predict disease progression.</td>
</tr>
</tbody>
</table>

### PhD students at the centre

<table>
<thead>
<tr>
<th>Name</th>
<th>Nationality</th>
<th>Period</th>
<th>M/F</th>
<th>Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nina E. Hasselberg</td>
<td>Norwegian</td>
<td>06.06.2011-05.05.2016</td>
<td>F</td>
<td>Left ventricular function and risk of arrhythmia in patients with cardiomyopathies. Echocardiographic studies.</td>
</tr>
<tr>
<td>Aleksandar Babic</td>
<td>Serbian</td>
<td>01.10.2012-30.09.2015</td>
<td>M</td>
<td>CRT LV lead placement optimization.</td>
</tr>
<tr>
<td>Ida Skrinde Leren</td>
<td>Norwegian</td>
<td>04.03.2013-02.03.2016</td>
<td>F</td>
<td>Myocardial function and prediction of ventricular arrhythmias in patients with genetic cardiac diseases.</td>
</tr>
<tr>
<td>Espen Bæ</td>
<td>Norwegian</td>
<td>01.05.2014-31.10.2014</td>
<td>M</td>
<td>Hemodynamic changes during pacing interventions in the failing heart.</td>
</tr>
<tr>
<td>Jørn Bersvendsen</td>
<td>Norwegian</td>
<td>01.06.2012-31.05.2015</td>
<td>M</td>
<td>Cardiac modeling.</td>
</tr>
<tr>
<td>Raja Bandaru</td>
<td>Indian</td>
<td>01.08.2013-31.07.2016</td>
<td>M</td>
<td>Detection of catheters in ultrasound.</td>
</tr>
<tr>
<td>Pedro Santos</td>
<td>Portuguese</td>
<td>01.08.2013-31.07.2016</td>
<td>M</td>
<td>Fast 3D ultrasound imaging.</td>
</tr>
<tr>
<td>Margot Pasternak</td>
<td>French</td>
<td>01.06.2013-30.05.2016</td>
<td>F</td>
<td>Temperature monitoring of EP ablation with U/S.</td>
</tr>
<tr>
<td>Adriyana Danidubro</td>
<td>Indonesian</td>
<td>01.08.2013-31.07.2016</td>
<td>F</td>
<td>Image registration and fusion for extended field of view.</td>
</tr>
</tbody>
</table>
# PERSONNEL

## PhD students at the centre

<table>
<thead>
<tr>
<th>Name</th>
<th>Nationality</th>
<th>Period</th>
<th>M/F</th>
<th>Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Siri Kallhovd</td>
<td>Norwegian</td>
<td>27.10.2012-26.10.2015</td>
<td>F</td>
<td>Cardiac modeling.</td>
</tr>
<tr>
<td>Gabriel Balaban</td>
<td>Czech-Canadian</td>
<td>01.02.2013-01.05.2016</td>
<td>M</td>
<td>Optimization of computational cardiac models.</td>
</tr>
<tr>
<td>Sigve Karlsen</td>
<td>Norwegian</td>
<td>18.03.2012-18.03.2015</td>
<td>M</td>
<td>Diagnostic and therapeutic stratification of acute coronary heart disease.</td>
</tr>
<tr>
<td>Daniela Melichova</td>
<td>Norwegian</td>
<td>01.04.2014-01.04.2017</td>
<td>F</td>
<td>Improved prediction of clinical outcome with the use of global strain and mechanical dispersion in patients with myocardial infarction, heart failure, and patients who receive primary prophylactic internal cardioverter defibrillator.</td>
</tr>
<tr>
<td>Thuy Mi Nguyen</td>
<td>Norwegian</td>
<td>01.04.2014-01.04.2017</td>
<td>F</td>
<td>Improved prediction of clinical outcome with the use of global strain and mechanical dispersion in patients with myocardial infarction, heart failure, and patients who receive primary prophylactic internal cardioverter defibrillator.</td>
</tr>
</tbody>
</table>

## Visiting Researchers

<table>
<thead>
<tr>
<th>Name</th>
<th>Nationality</th>
<th>Period</th>
<th>M/F</th>
<th>Topic</th>
</tr>
</thead>
</table>

## Master students

<table>
<thead>
<tr>
<th>Name</th>
<th>Nationality</th>
<th>Period</th>
<th>M/F</th>
<th>Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thomas M. Stokke</td>
<td>Norwegian</td>
<td>05.01.2012-05.01.2016</td>
<td>M</td>
<td>Focused cardiac ultrasound in the hands of medical students.</td>
</tr>
</tbody>
</table>
PUBLICATIONS 2014

SCIENTIFIC ARTICLES

1. The diagnostic performance of imaging methods in ARVC using the 2010 Task Force criteria.
doi: 10.1093/ehjci/jeu109
PMID: 24939949

J Am Coll Cardiol. 2014 Jul 29;64(4):422
doi: 10.1016/j.jacc.2014.05.017
PMID: 25060383

3. Measurements of left ventricular volumes and ejection fraction with three-dimensional echocardiography: feasibility and agreement compared to two-dimensional echocardiography.
Ruddox V, Edvardsen T, Bækkevar M, Otterstad JE
doi: 10.1007/s10554-014-0478-9
PMID: 24972778

4. Focus cardiac ultrasound: the European Association of Cardiovascular Imaging viewpoint.
Eur Heart J Cardiovasc Imaging. 2014 Sep;15(9):955-960
doi: 10.1093/ehjci/jeu081
PMID: 24866902

5. Early systolic lengthening may identify minimal myocardial damage in patients with non-ST-elevation acute coronary syndrome.
Zahid W, Eek CH, Remme EW, Skulstad H, Fosse E, Edvardsen T
doi: 10.1093/ehjci/jeu101
PMID: 24866900

doi: 10.1093/ehjci/jeu088
PMID: 24855216

7. The year 2013 in the European Heart Journal--Cardiovascular Imaging. Part II.
doi: 10.1093/ehjci/jeu089
PMID: 24837260

Manotheepan R, Saberniak J, Danielsen TK, Edvardsen T, Sjaastad I, Haugaa KH, Stokke MK
Am J Cardiol. 2014 Jun 1;113(11):1829-33
doi: 10.1016/j.amjcard.2014.03.012
PMID: 24837260

Espinoza A, Edvardsen T
doi: 10.1016/j.echo.2014.04.003
PMID: 24774223

10. Updated standards and processes for accreditation of echocardiographic laboratories from The European Association of Cardiovascular Imaging.
doi: 10.1093/ehjci/jeu039
PMID: 24662444

doi: 10.1093/ehjci/jeu031
PMID: 24639554

12. Early assessment of strain echocardiography can accurately exclude significant coronary artery stenosis in suspected non-ST-segment elevation acute coronary syndrome.
doi: 10.1016/j.echo.2014.01.019
PMID: 24612899

Hetland M, Haugaa KH, Sarvari SI, Eriksen G, Kongsgaard E, Edvardsen T
doi: 10.1111/anec.12152
PMID: 24612066

doi: 10.1093/ehjci/jeu022
PMID: 24596053

doi: 10.1093/ehjci/jeu015
PMID: 24554131
Goebel B, Haugaa KH, Meyer K, Otto S, Jung C, Lauten A, Figulla HR, Edvardsen T, Poerner TC  
Int J Cardiovasc Imaging.  
2014 Mar;30(3):505-13  
doi: 10.1007/s10554-014-0361-8  
PMID: 24477357  

17. Can exercise echocardiography help optimal timing of surgery in patients with aortic regurgitation?  
Haugaa KH, Edvardsen T  
Scand Cardiovasc J.  
2014 Feb;48(1):2-3  
PMID: 24475789  

18. Resting heart rate as predictor for left ventricular dysfunction and heart failure: MESA (Multi-Ethnic Study of Atherosclerosis).  
J Am Coll Cardiol.  
2014 Apr;63(12):1182-9  
doi: 10.1016/j.jacc.2013.11.027  
PMID: 24412444  

Almaas VM, Haugaa KH, Strøm EH, Scott H, Smith HJ, Dahl CP, Geirán OR, Endresen K, Aakhus S, Amlie JP, Edvardsen T  
Heart.  
2014 Apr;100(8):631-8  
doi: 10.1136/heartjnl-2013-304923  
PMID: 24468281  

Woie L, Målay F, Effestel T, Engan K, Edvardsen T, Kvalay JT, Ørn S  
J Cardiovasc Imaging.  
2014 Feb;30(2):339-47  
doi: 10.1007/s10554-013-0329-0  
PMID: 24249515  

21. Impact of left ventricular hypertrophy on QT prolongation and associated mortality.  
Haugaa KH, Martijn Bos J, Borkenhagen EJ, Tarrell RF, Morlan BW, Caraballo PJ, Ackerman MJ  
Heart Rhythm.  
2014 Nov;11(11):1957-65  
doi: 10.1016/j.hrthm.2014.06.025  
PMID: 24956189  

22. Mechanical dyssynchrony after cardiac resynchronization therapy for severely symptomatic heart failure is associated with risk for ventricular arrhythmias.  
Haugaa KH, Marek JJ, Ahmed M, Ryo K, Adelstein EC, Schwartzman D, Saba S, Gorcsan J 3rd  
J Am Soc Echocardiogr.  
2014 Aug;27(8):872-9  
doi: 10.1016/j.echo.2014.04.001  
PMID: 24798865  

23. [New Norwegian guidelines for resynchronization therapy in heart failure]  
Holm T, Kongsgård E.  
Tidsskr Nor Laegeforen.  
2014 Aug 5;134(14):1346-7  
PMID: 25096427  

24. [Cardiac resynchronization therapy in heart failure--Norwegian guidelines]  
Tidsskr Nor Laegeforen.  
2014 May 27;134(10):E1-17  
doi: 10.4045/tidsskr.13.0628  
PMID: 24865744  

25. A computational pipeline for quantification of mouse myocardial stiffness parameters.  
2014 Aug 2;53C:65-75  
doi: 10.1016/j.compbiomed.2014.07.013  
PMID: 25129018  

26. Cardiac responses to left ventricular pacing in hearts with normal electrical conduction: beneficial effect of improved filling is counteracted by dyssynchrony.  
Boe E, Russell K, Remme EW, Gjesdal O, Smiseth OA, Skulstad H.  
Am J Physiol Heart Circ Physiol.  
2014 Aug;307(3):H370-8  
doi: 10.1152/ajpheart.00089.2014  
PMID: 24906920  

27. Bioimpedance monitoring of 3D cell culturing-Complementary electrode configurations for enhanced spatial sensitivity.  
Biosens Bioelectron.  
2014 Jul;44C:72-79  
doi: 10.1016/j.bios.2014.07.020  
PMID: 25058941  

28. Advantages of strain echocardiography in assessment of myocardial function in severe sepsis, an experimental study.  
Critical Care Medicine.  
2014 Jun;42(6):e432-440  
doi: 10.1097/CCM.0000000000000310  
PMID: 24633187  

29. Left ventricular function can be continuously monitored with an epicardially attached accelerometer sensor.  
Hyder S, Espinoza A, Skulstad H, Fosse E, Halvorsen PS.  
Eur J Cardiothorac Surg.  
2014 Aug;46(2):313-20  
doi: 10.1093/ejcts/ezt653  
PMID: 24423930  

Reislien J, Samset E  
Stat. med.  
2014, jan, 30;33(2):319-329  
doi: 10.1002/sim.5927  
PMID: 23946159  

31. Automatic measurement of aortic annulus diameter in 3-dimensional transoesophageal echocardiography.  
Bersvensen J, Beintes JO, Urheim S, Aakhus S, Samset E.  
BMC Med Imaging.  
2014 Sep 8;14(1):31  
doi: 10.1186/1471-2342-14-31  
PMID: 25200865  

32. Group-wise construction of reduced models for understanding and characterization of pulmonary blood flows from medical images.  
R. Guibert, K. S. Mcleod, A. Caiazzo, T. Mansi, M. A. Fernàndez, M. Sermesant, X. Pennec, I. E. Vignon-Clementel, Y. Boudjemline, and Jean-F. Gerbeau  
Med. Image Analysis  
2014 Jan;18(1):63-82  
doi: 10.1016/j.media.2013.09.003  
PMID: 24148257  

Koivumäki JT, Clark RB, Belke D, Kondo C, Fedak PW, Maleckar MM, Giles WR.  
Front Physiol.  
2014 Aug 7;5:275  
doi: 10.3389/fphys.2014.00275  
PMID: 25147525


40. Vigorous physical activity impairs myocardial function in patients with arrhytmogenic right ventricular cardiomyopathy and in mutation positive family members. Saberniak J, Hasselberg NE, Aasum E. **Eur J Heart Fail.** 2014 Dec;16(12):1337-44. doi: 10.1002/ejhf.181. PMID: 25319773


50. Non-invasive cardiac imaging evaluation of patients with chronic systolic heart failure: a report from the European Association of Cardiovascular Imaging (EACVI).
doi: 10.1093/eurheartj/ehu433
PMID: 25416326

51. Brief Group Training of Medical Students in Focused Cardiovascular Ultrasound May Improve Diagnostic Accuracy of Physical Examination.
Stokke TM, Ruddox V, Sarvari SI, Otterst JE, Aune E, Edvardsen T
J Am Soc Echocardiogr
2014 Nov;27(11):1238-46
doi: 10.1016/j.echo.2014.08.001
PMID: 25266446

52. Carotid artery intima-media thickness is closely related to impaired left ventricular function in patients with coronary artery disease.
Evensen K, Sarvari S, Ronning O, Edvardsen T, Russell D
Cardiovascular Ultrasound
2014 Sep 29;12(11):39
PMID: 25266446

53. Attenuated development of cardiac fibrosis in left ventricular pressure overload by SM16, an orally active inhibitor of ALK5.
Engebretsen KV, Skårdal K, Bjørnstad S, Marstein HS, Skrbic B, Sjaastad I, Christensen G, Bjørnstad JL, Tønnesen T
J Mol Cell Cardiol. 2014 Nov;76:148-57
doi: 10.1016/j.yjmcc.2014.08.008
PMID: 25169971

54. Identifying pathogenic processes by integrating microarray data with prior knowledge.
BMC Bioinformatics. 2014 Apr 24;15:115
PMID: 24758689

55. European Association of Cardiovascular Imaging (EACVI) position paper: Multimodality imaging in pericardial disease.
PMID: 25248336

56. A systematic review of diastolic stress tests in heart failure with preserved ejection fraction, with proposals from the EU-FP7 MEDIA study group.
Erdel T, Smiseth OA, Marino P, Fraser AG
Eur J Heart Fail. 2014 Dec;16(12):1345-61
doi: 10.1002/ejhf.184
PMID: 25393338

57. Hypokalemia induces Ca2+ overload and Ca2+ waves in ventricular myocytes by reducing NKAa2 activity.
doi: 10.1113/jphysiol.2014.279893
PMID: 25262449

ABSTRACTS, PRESENTATIONS & LECTURES

Localization and not extent of fibrofatty infiltration is the primary factor determining conduction disturbance in a computational model of arrhythmogenic cardiomyopathy.

2. Thor Edvardsen; What happens to myocardial mechanics in hypothermia?

3. Otto Smiseth; CRT in patients with narrow QRS – is there a rationale?

4. Kristina Haugaa; Electromechanics in cardiomyopathies.

Patient specific models of cardiac electro-mechanics
Seminar at Ecole des Mines, St Etienne, France, 27.2.2014.

Pregnancy outcome in women with repaired tetralogy of Fallot.

7. Espen Remme; Condition Monitoring of the Heart - A Miniaturized Accelerometer Attached to the Heart Surface for Monitoring of Cardiac Motion

8. Thor Edvardsen; Assessment of LV longitudinal function in HCM.

9. Kristina Haugaa; Arrhythmogenic right ventricular cardiomyopathy – echo findings in the right, in the left, in both or in none of the ventricles

Right ventricular diameter is superior to right ventricular outflow tract to predict ventricular arrhythmias in subjects with ARVC

Excercise impairs myocardial function assessed by magnetic resonance in subjects with arrhythmogenic right ventricular cardiomyopathy
J Am Coll Cardiol. 01. April 2014;63[12_S] (Abstract)

Adaptive Servo-Ventilation Decreased Mortality and Admission Rates in Heart Failure Patients with Cheyne-Stokes Respiration in a 18 Months Prospective Study
J Am Coll Cardiol. 01. April 2014;63[12_S] (Abstract)

13. Haland T, Saberniak J, Leren IS, Edvardsen T, Haugaa KH
Speckle Tracking Echocardiography Can Help to Distinguish Non-Compaction from Hypertrophic Cardiomyopathy
J Am Coll Cardiol. 01. April 2014;63[12_S] (Abstract)

Improvement of Echocardiographic Circumferential Mechanical Dispersion by Cardiac Resynchronization Therapy is Related to Less Ventricular Arrhythmias in Heart Failure Patients.
J Am Coll Cardiol. April 01. 2014;63[12_S] (Abstract)

Cheyne-Stokes Respiration Is Associated With a Higher Mortality than Obstructive Sleep Apnea in Heart Failure Patients.
J Am Coll Cardiol. April 01. 2014;63[12_S] (Abstract)
16. Ida Skrinde Leren; Mechanical alterations in Long QT syndrome CHFR-workshop 03.04.14, Ullevål Hospital. Lecture.

17. Helge Skulstad; Secrets of post systolic shortening: The relation between deformation and function EACVI Teaching Course advance myocardial function imaging in clinical practice; from Doppler to deformation State-of-the-art in 2014, Sofia, Bulgaria, 3-5 April, 2014. Invited speaker.

18. Helge Skulstad; Should we assess mechanical dys synchrony in the RV EACVI Teaching Course advance myocardial function imaging in clinical practice: from Doppler to deformation State-of-the-art in 2014, Sofia, Bulgaria, 3-5 April, 2014. Invited speaker.


32. Leren IS, Hasselberg NE, Saberniak J, Haland TF, Kongsgård E, Smiseth OA, Edvardsen T, Haugaa KH Patients with long QT syndrome have altered systolic timing and electro-mechanical time difference. ESC August 2014, Barcelona, Spain. Poster.


37. Saberniak J, Hasselberg NE, Borgquist R, Platonov PG, Sarvari S, Ribe M, Smith HJ, Edvardsen T, Haugaa KH Ventricular arrhythmias in subjects with ARVC are associated with increased cardiac volumes but not with ejection fraction by cardiac magnetic resonance imaging. Eur Heart J. August 2014 (Abstract)

38. Haland TF, Saberniak J, Leren IS, Edvardsen T, Haugaa KH Assessment of regional cardiac function might improve discrimination between left ventricular non-compaction and hypertrophic cardiomyopathies. Eur Heart J. August 2014 (Abstract)


42. Saberniak J, Hasselberg NE, Leren IS, Haland TF, Bovquist R, Platonov PG, Edvardsen T, Haugaa KH Ventricular arrhythmias in subjects with ARVC are associated with increased cardiac volumes but not with ejection fraction by cardiac magnetic resonance imaging. Jørg Saberniak, ESC 19.9.2014, Barcelona, Spain. Moderated Poster.


51. Kristin McLeod, Marcus Noack, Jørg Saberniak, Kristina Haugaa Structural Abnormality Detection of ARVC Patients via Localised Distance-to-average Mapping MICCAI September 14–18 2014, Boston, USA.

52. Haland TF, Saberniak J, Leren IS, Edvardsen T, Haugaa KH Left ventricular non-compaction and hypertrophic cardiomyopathies can be discriminated by regional LV function. CHFR September 18th 2014, Oslo, Norway.


54. Hasselberg NE, Haugaa KH, Bernard-Brunet, Kongsgård E, Donal E, Edvardsen T Longitudinal myocardial function by echocardiographic strain predicts mortality in heart failure patients with cardiac resynchronization therapy. CHFR September 18th 2014, Oslo, Norway.


60. Jørg Saberniak: Right ventricular diameter is superior to right ventricular outflow tract to predict ventricular arrhythmias in subjects with ARVC Norwegian Society of Cardiology, Annual Meeting, Oslo, Norway, 17.10.2014. Oral presentation.


67. Thor Edvardsen: Strain and acute Coronary Syndromes. 1st Meeting of the Multinational Chapter of the IU3 in conjunction with the XXIV Congress of the MLAVS, Palermo, Italy. Oct 2014. Invited speaker.

Improved Longitudinal Function is Closely Related to Reverse Remodeling in Cardiac Resynchronization Therapy

Nadolol Decreases Incidence and Severity of Ventricular Arrhythmias

Right ventricular free wall and septal contribution to ventricular work.

Three-dimensional strain in heart failure: far beyond left ventricle.

Current and Evolving Applications of Myocardial Strain Imaging: An Update.

Plaque blockades reduces porcine myocardial infarction size and improves cardiac function.

BOOKS, Chapters/Articles in BOOKS/REPORTS & WEB Publications


