Oslo University Hospital

Annual report 2016

The Intervention Centre

Oslo University Hospital and
Institute of Clinical Medicine, University of Oslo

ANNUAL REPORT 2016

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Twenty years of innovation

The sixth of June 1996 King Harald officially opened The Intervention Centre at Rikshospitalet in the centre of Oslo. For one year prior to the opening we had built two futuristic suites for surgery, intervention and imaging in the park outside the main block of the hospital.

In one room GEs Signa SP open MR designed for doing surgery on patients inside the magnet, and in the other we integrated Angiographic equipment in a room designed as an operation theatre. Soon after the opening medical staff from a number of departments started intracranial tumor surgery, open heart surgery, cardiac interventions, advanced laparoscopic procedures. In between the patients we did advanced animal experiments.

We had fulfilled the dream of Frode Lærum and Arvid Stordal, a radiologist and a surgeon who together wrote a master thesis in health administration postulating that all the advance technology being integrated in treatment of patients, also required a dedicated organization.

The Intervention Centre became a toolbox not only for doctors and nurses from the whole medical spectre, but for economists, sociologists, psychologists, physicists, cybernetics, informatics and robotics engineers. All were involved in developing new treatment methods for patients in a safe environment and studying how the new methods best could be implemented.

In 2000 Rikshospitalet moved into a new location at Gaustad, and The Intervention Centre was expanded and became a world renowned test centre for new techniques and technologies.

When all the hospitals in Oslo were merged into Oslo University Hospital in 2009, all imaging physicists were employed in a section for diagnostic physics in the Intervention Centre. The section delivered services to most hospitals in the South east region. The activities in all fields at the Intervention Centre expanded rapidly.

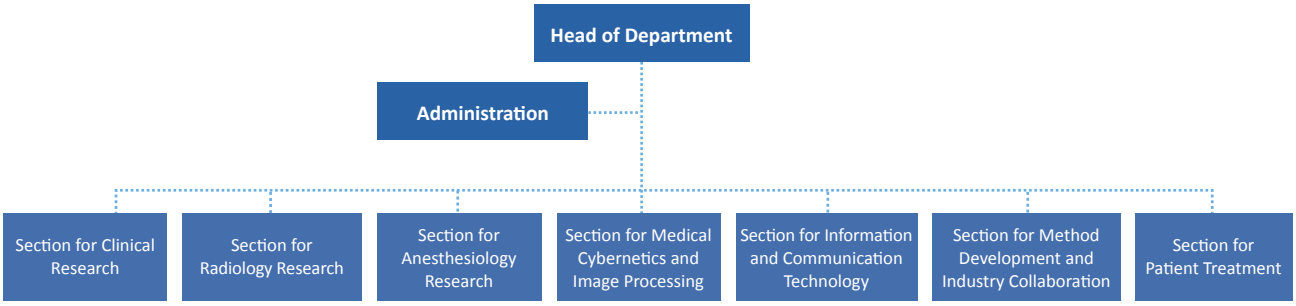
In 2016, the hospital was reorganized, and the time was right to divide the Centre, and organize the imaging physics in a separate department in the clinic for radiology, while the Intervention Centre was located in the Division of emergencies and critical care. At the same time the building of an expansion of the Intervention Centre was started. When the expansions are finished by the end of 2017, the Intervention Centre will double its capacity for patient treatment and research and for animal research. We will also be able to expand our function as test centre for med tech industry.

During the first 20 years the Intervention Centre performed 9478 MR imaging procedures in patients and test persons, 6694 minimally invasive surgeries and interventions in patients, 1562 animal experiments resulting in 732 scientific publications, 42 PhDs and more than 50 patents.

We thank all our collaborators within and outside Oslo university hospital for exciting 20 years, and are looking forward to what the next twenty years will bring.

Erik Fosse
Head of The Intervention Centre

2.1 ORGANIZATION MAP



2.2 SECTIONS

2.2.1 Section for Clinical Research

Section Manager: Bjørn Edwin, Professor, MD

Staff

Linda Engvik, Nurse Manager
Bjørg Scheele, OR nurse
Anne Hege Andreassen, OR nurse
Jennifer Teruel Tamson, OR nurse
Victoria Juhasz, Laboratory assistant

Delivery

- Research and development in minimally invasive surgery in the premises of The Intervention Centre
- Development and education in new techniques at Oslo University Hospital and other hospitals in Norway
- Clinical R&D in all medical domains
- Perform minimally invasive treatment of patient groups where the volume of patients within these disease groups is too low to develop secure new treatment strategies on many sites
- Perform minimally invasive treatment of patient groups requiring established multiprofessional collaboration and infrastructure currently uniquely found at The Intervention Centre. Examples are; laparoscopic pancreas and liver surgery, laparoscopic endocrine surgery, laparoscopic endometriosis surgery, laparoscopic back surgery

Main Objectives

- The section's activities are focused on minimally invasive treatment in all surgical specialties
- The section shall be leading both nationally and internationally within its focus area within research and development
- The section shall assist and initiate research minimally invasive therapy projects
- The section promotes education locally, regionally, nationally and internationally
- The section stimulates multiprofessional collaboration because
- Minimally invasive therapy is performed in many professional settings by various specialists and thereby a common field of interest across specialties
- Minimally invasive therapy depends on development within technology and radiology

2.2.3 Section for Radiology Research

Section Manager: Per Kristian Hol, Professor, MD

Staff

Hilde Sofie Korslund, radiographer
Grethe Løvland, radiographer
Siv-Eli Simonsen, radiographer
Svein Are Vatnehol, radiographer
Kenneth Nordstrand, radiographer

Deliveries

- Radiological examinations of animals and patients treated at The Intervention Centre
- Training and supervision of healthcare personnel in new image-guided treatment techniques
- Research group in the field of MR guided High Intensity Focused Ultrasound Treatment

Main Objectives

- Have a highly qualified staff
- To be nationally and internationally leading environment for image guided treatment
- Strengthen interdisciplinary research and increase number of regional, nationally and internationally joint projects
- Contribute to innovation and secure intellectual property

2.2.4 Section for Anesthesiology Research

Section Manager: Per Steinar Halvorsen, MD, PhD

Staff

Per Steinar Halvorsen, anesthetist
Viesturs Kerans, anesthetist
Kjersti Wendt, nurse anesthetist
Anton Amalathasan Josephmary, nurse anesthetist
Kari Westby, nurse anesthetist
Torill Schou, nurse anesthetist

Deliveries

- Anesthesia service to all clinical and experimental projects at the Intervention Centre
- Training/supervision of healthcare personnel in new cardiovascular monitoring techniques
- Innovation/DOFI/patents
- Research group in the field of cardiovascular monitoring

Main Objectivess

- Contribute to improved quality of experimental and clinical research
- Have a highly qualified staff
- Interdisciplinary research and increase the number of joint projects
- Contribute to increased innovation and secure intellectual property

2.2.5 Section for Medical Cybernetics and Image Processing

Section manager: Ole Jakob Elle, Associate professor, PhD

Staff

Frederic Courivaud, Senior Researcher, PhD
Espen Remme, Senior Researcher, PhD
Rafael Palomar, PhD fellow (HiG/OUS, MSc)
Rahul Kumar, Postdoc, PhD
Louise Oram, Software developer in NorMIT , MSc.
Magnus Leon Reinsfelt Krogh, PhD fellow

Deliveries

The Section for Section for Medical Cybernetics and Image Processing at The Intervention Centre aims to develop cutting-edge technological solutions supporting the whole chain in patient diagnostic and treatment. such as user interaction and information exchange in the operating suites, procedure planning, patient monitoring, and technology for minimally invasive therapies including intra-operative model update. This R&D covers a span of different technologies like monitoring technology, image and video processing, visualization, navigation technologies, biomechanical organ modelling and robotics. The solutions should give more information to the surgeon, such as sensor information and image information, during intervention and presenting this information by real-time visualization. With the ability to adapt and compensate to the deformations and motions, this information can be used to effectively guide the clinician throughout the procedure or update a robotic path to perform the desired action. This means that when you develop algorithms for diagnostics and preoperative use, less effort is put into making the algorithm fast and effective. Intra-operative use means that the algorithms used should be able to run in real-time or close to real-time. Image and video processing methods are key elements in any software system which supports minimally invasive procedures. In particular, we are focused on developing real-time image-segmentation and -registration methods where segmentation methods finds important anatomical structures such as tumors and vessel structures in images, while registration methods enables fusion of images and images to patient. Visualization and navigation is required to present the medical images to the surgeon intra-operatively.

Increased accuracy and safety may result by cross-linking medical image information with robotic systems in so-called semi-autonomous robotic systems. Biomedical models and simulation technology are developed, intended for clinical decision support such as if, when and type of surgery should be performed.

In order to be able to lead large research projects in the forefront internationally, the section should at all time have the needed competence and in-depth knowledge within medical informatics, such as software engineering, computer graphics and visualization, signal processing, image and video processing, robotics, cybernetics and mechanics. The head of section as well as the research group leaders should have high scientific qualifications, if possible at a professor or associate professor level and work in the intersection between technology and medicine. The section should work closely with different clinicians within the hospital as well as collaborating with well-known research institutions and industry both nationally and internationally. It is a goal that senior researchers have adjunct positions at UIO or NTNU.

Main Objectives

It aims to be a nationally and internationally leading research environment in technological solutions for in the following research areas:

Main research areas:

- Developing new building block for navigation technology in different surgical disciplines like laparoscopic liver resection, neurosurgery and catheter-based interventions.
  Such building blocks rely on new preoperative and intra-operative image analysis/processing algorithms, where the intra-operative methods need to consider real-time or near to real-time constraints such as segmentation, volume visualization and co-registration.
- Robotic technology ranging from haptic feedback and augmented reality in tele-surgical systems, semi-autonomous systems for support in the operating theatre and miniaturized robotic systems on the tip of a catheter or in a pill-cam system.
- Explore more research in areas like targeted treatment, new imaging techniques and micro technology.
- Biomedical modelling of organs like heart, liver etc., using advanced mathematical models like finite element (FEM) describing tissue properties, flow pattern for prediction and simulation.
- Development of new monitoring technology e.g. accelerometer and gyro sensors including advanced signal processing for detection of changes in heart conditions.

The section for Medical Technology Research aims for supporting the clinicians in the OR with new technological methods and new technology

2.2.6 Section for Information and Communication Technology

Section Manager: Ilangko Balasingham, Professor

Staff

Sr. Researcher
Jacob Bergsland, MD, PhD
Associate Professor Ali Khaleghi, PhD
Associate Professor Laura Slaughter, PhD

Project Leader

Knut Korsell

Delivery

- Research and publication
- Innovation in medical signal processing and communication technology
- Development of technological solutions, prototypes and demonstrators
- Intellectual property and management methods
- Multidisciplinary expertise in medical signal processing and communication technology
- Supervising students and fellows
- Teaching

Main Objectives

- to be at the forefront nationally and internationally in research and development of medical signal processing and communication technologies, and to advise on operational and acquisition projects at the center
- to lead advanced research projects that are in the forefront of international research to develop technological solutions for patient monitoring and new treatments, including minimally invasive and image-guided therapy
- to encourage their employees have academic adjunct positions outside hospital shall at all times have sufficient staffing and expertise to assist various projects initiated by other communities and contribute to a seamless collaboration between technologists and clinicians
- to provide any necessary technical manpower and expertise to participate in the multidisciplinary projects in Intervention Centre and support patient care where necessary shall have the following target areas during the period:
- develop new medical sensors based on bio-nano technologies (biological nano electronics)
- develop communication and computing systems based on biological organisms, such as molecules, cells and organs that can communicate with the Internet and cloud services for storing and processing large amounts of data
- develop new algorithms for processing and understanding of complex, large amounts of data from sensors, germplasm, medical records, test results, images, etc. in conjunction with high precision diagnosis, treatment and follow-up
- perform research and development of basic research in the form of new theories, mathematical modeling, computer-aided simulations and prototype development to preclinical testing and validation - “from bench two bedside”

2.2.7 Section for Method Development and Industry Collaboration

Section Manager: Karl Øyri, PhD

Staff

Leif-Petter Rustad, Research Coordinator
Bjørn Willy Tjønnås, Quality Coordinator
Sandre Svatun Lirhus, MSc, Health Economist

Delivery

- Coordination of the commercial Test-Bed function at The Intervention Centre
- Collaboration with Inven2 and negotiate with companies who intends to explore new technologies and collaborate with industrial partners about development protocols
- Involves relevant clinical groups at Oslo University Hospital in projects
- Make sure that all test projects are made in compliance with guidelines at Oslo University Hospital and the health authorities regarding animal and human research
- Project management support and health economy evaluation support to clinical groups who establish new technology dependent treatment methods
- Update of the project database at The Intervention Centre
- Edit the Annual Report at The Intervention Centre
- Responsible for the communication strategy at The Intervention Centre
- Responsible for the Quality System at The Intervention Centre

Main Objectives

- Is a gateway to the hospital for companies who need testing of new technologies. At least five new collaboration agreements are made with industrial parties annually
- Assists project leaders with organization, contracts and required documentation
- The Annual Report is published in the spring semester
- Regular updates of the webpage
- Responsible for Quality System maintenance including editorial responsibility
- Monthly updates of project database
- Responsible for health economy competence at The Intervention Centre

Research Groups
Clinical Testing Work Group

2.2.8 Section for Patient Treatment

This is an administrative section.

3.1 SECTION FOR CLINICAL RESEARCH

3.1.1 Image guided general surgery and intervention

Group Leader: Bjørn Edwin, professor, MD

Group Members

Mushegh Sahakyan, PhD student
Anne Waage PhD, Surgeon
Knut Jørgen Labori PhD, Surgeon
Stig Ronny Kristiansen, IT-researcher
Karl Øyri, PhD, Researcher
Dejan Ignatovic Ph.D, Surgeon
B.A. Bjørnbeth PhD, Surgeon
Trond Buanes, professor
Bård Røsok PhD, Surgeon
Airazat Kazaryan PhD, Researcher
Åsmund Avdem Fretland, PhD-student
Kjersti Flatmark, professor
Leonid Barkhatov, PhD-student
Sven Petter Haugvik, PhD-student
Davit Aghayan, PhD-student
Vegard Dagenborg, PhD student

Background

Minimally invasive surgery is evolving rapidly, and the need for systematic development and evaluation of these methods is great. Our group focuses on research on the results of new minimally invasive surgical techniques in addition to development of new procedures. Most of the research is conducted in the field of HPB-surgery (diseases in liver, bile ducts and pancreas) and adrenal surgery.

Ongoing Projects

- The Oslo CoMet-study (Oslo randomized laparoscopic vs open liver resection for colorectal liver metastasis – study). In addition to the evaluation of surgical and oncological results, several translational studies are performed, such as bio banking of tumour tissue, studies on the inflammatory response, health economy evaluation and pain/quality of life studies.
- Multicentre studies on laparoscopic liver surgery
- Research on pancreatic cancer: Examining the Role of Laparoscopic Distal Pancreatectomy in the Treatment of Pancreatic Cancer: From a Consensus Study to Randomized Controlled Trials. The main aim is to assess the oncologic outcomes of Laparoscopic Distal Pancreatectomy (LDP) in patients with Pancreatic Distal Adeno- Carcinoma, determine the prognostic factors and provide justified recommendations for its use.
- The research group also does research on MRI-guided High Intensity Focused Ultrasound (HIFU) of lesions in liver and prostate.
- Together with the University of Gothenburg, we do research on biomaterials in implants.
- Research on imaging of liver tumours (CT, MRI, PET-CT) is conducted with other research groups at the IVS and OUS.
- In a joint project, a method for automatic segmentation of liver anatomy including tumours is developed. The final goal is to create an interactive map for liver surgeons that will greatly ease both planning and the actual surgery.
- Research on reasons to onset of type 1 diabetes, DiVid study.
- Research on D3 resection of colon cancer
- The Group is also involved in many major projects e.g. HiPerNav, (EU prosjekt), NorMit, MetAction and BigMed.
- In all the projects, the group has a large international network of collaborators.

Collaborations

- Active externally funded projects.
- HSØ: Economic evaluation of laparoscopic versus open liver resection for colorectal metastasis. A cost utility analysis alongside the Oslo CoMet prospective RCT.
- Prospective randomized study of laparoscopic versus open liver resection for liver metastasis (final phase).
- Laparoscopic liver resection: 3 randomized trials.
- Kreftforeningen: HIFU: High Intensity Focus Ultrasound Ablation of the Liver under 3T MR Guidance (Refinement experimental study). (final phase)
- European Association of Endoscopic Surgery: Pancreas consensus project:
- Kvote programmet Pancreatic research

3.2 SECTION FOR RADIOLOGY RESEARCH

3.2.1 MR guided High Intensity Focused Ultrasound treatment

Group Leader: Per Kristian Hol, Professor, MD

Group Members

Bjørn Edwin, Professor MD PhD,
The Intervention Centre (researcher)

Eric Dorenberg, MD PhD, Dept of Radiology,
OUS Rikshospitalet (researcher)

Frederic Courivaud, The Intervention Centre
(researcher)(until Q1 2016)

Tryggve Storås, PhD, The Intervention Centre
(researcher)

Grethe Løvland
(technician)

Svein Are Vatnehol
(technician)

Kenneth O Pedersen
(technician)

Ulrik Carling, MD
(PhD candidate)

Associated group members

Viktor Berge, MD PhD, and Eduard Baco, MD,
Dept of Urology, OUS Aker (researcher)

Professor Aud Svindland, MD PhD, Dept of Pathology,
OUS Radiumhospitalet (researcher)

Kirsten Hald, MD, PhD, Dept of Gynecology,
OUS Ullevål (researcher)

Background

High Intensity Focused Ultrasound (HIFU)-therapy is completely non-invasive as the ultrasound energy is delivered outside the body, but focused in defined areas in an organ. MR provides three-dimensional treatment planning and real-time temperature feedback. Integrating HIFU in MR-scanners melds the technology for visualization and treatment, optimize the procedure and increase the therapeutic potential of HIFU treatment. The 3 T MR at the Intervention Centre has integrated HIFU equipment as part of a research agreement with Philips Medical Systems. Focus has been on both basic and clinical research projects.

Projects

- MR guided HIFU in the treatment of uterine fibroids
- Basic research on MR guided HIFU of liver
- Basic research on MR guided HIFU of prostate

Collaborations

Philips Healthcare, Nederland: Dr Thomas Andrea

3.3 SECTION FOR ANESTHESIOLOGY RESEARCH

3.3.1 Clinical and experimental cardiovascular monitoring

Group Leader: Per Steinar Halvorsen, MD, PhD

Research group members

Senior researchers

Jan Fredrik Bugge, Dep. of Anesthesia and Critical Care Medicine,

Andreas Espinoza, Dep. of Anesthesia and Critical Care Medicine,

Helge Skulstad, Dep. of Cardiology,

PhD-candidates

Viesturs Kerans, The Intervention Centre, HYPOTHERMIA

Jo Eidet, Dep. of Anesthesia and Critical Care Medicine

Harald Bergan, Dep. of Anesth. and Critical Care Medicine, ECMO

Ole-Johannes Grymyr, The Intervention Centre, SENSORS

Stefan Hyler, The Intervention Centre and Sørlandet sykehus

Itai Schalit, The Intervention Centre, LVAD/SENSORS

Kristin Wisløff-Aase, Dep.of Anesthesia and Critical Care Medicine, HYPOTHERMIA

Siv Hestenes, The Intervention Centre/Sykehuset Akser og Bærum, SEPSIS

Hilde Karlsen, Dep.of Anesthesia and Critical Care Medicine, ECMO

Marte Sævik, The Intervention Centre/Dep. Of Cardiology, TAVI

Pengfei Lu, The Intervention Centre, PACEMAKER/CRT

Mohammad Albatat, The Intervention Centre, PACEMAKER/CRT

Associated group members

Professor Erik Fosse, The Intervention Centre,

Professor Thor Edvardsen, Department of Cardiology,

Professor Arnt Fiane, Department of Cardiothoracic Surgery,

Ass. professor Ole Jacob Elle, The Intervention Centre,

Professor Svend Aakhus, Department of Cardiology,

Lars Aaberge, Department of Cardiology,

Jan Otto Beitnes, Department of Cardiology,

Espen Remme, Department of Cardiology/ The Intervention Centre,

Background

A trend in cardiovascular therapies involves development of minimal invasive surgical techniques for valve repair and treatment of severe heart failure by biventricular pacing. Even though a method can be classified as minimal invasive, the procedural risks still may be high, as demonstrated by treatment of severe aortic stenosis by catheter technique (TAVI) instead of open chest surgery. Another trend in severe heart failure treatment is implantation of mechanical pumps, as either bridge to transplantation or as destination therapy as an alternative to heart transplantation. In contrast to the other therapies, implantation of a mechanical pump is a highly invasive procedure and justifies more invasive monitoring of the patient. In both cases, assessment of cardiovascular status is equally important, but requires different approaches which need to be adapted to the risks and invasiveness of the procedures. New methods for cardiovascular monitoring in the operative setting may also be used to guide and optimize treatment in hemodynamically compromised patients in the intensive care unit, such as in patients with septic or cardiogenic shock, and patients treated with therapeutic hypothermia after cardiac arrest.

Main aims

- Develop and test new technologies in cardiovascular monitoring
- Cardiovascular response to new cardiovascular therapies
- Myocardial function in therapeutic hypothermia and severe sepsis

This includes evaluating hemodynamic responses of 1) new cardiovascular image guided procedures, 2) ECMO strategies, 3) treatment for end stage heart failure with ventricular assist devices (VAD). Technologies under investigation for cardiac function monitoring include implantable 3D accelerometers, gyro, magnetometer, miniaturized ultrasound sensors, biosensors and radar. The sensors are tested in both clinical and experimental models in cooperation with other research groups at The Intervention Centre, departments at OUS and external institutions.

Ongoing research projects

- TAVI: is myocardial reserve related to long term outcome?
- Accelerometer for detection of thromboembolic events in LVAD
- Accelerometer/gyro/magnetometer for monitoring changes in right and left ventricular load and detection of graded myocardial ischemia
- Can betablockers improve survival and cardiovascular function after cardiac arrest: an experimental ECMO study
- Left and right ventricular dysfunction in severe sepsis; the effect of pulmonary hypertension and interventricular septal shift
- Myocardial effects of therapeutic hypothermia in cardiac surgery
- Effects of epinephrine and betablockers on systolic and diastolic left ventricular function during therapeutic hypothermia
- Multifunctional pacemaker systems for cardiac resynchronization therapy (CRT)

Collaborations

- OSCAR research network at Oslo University Hospital: Professor K. Sunde
- Complement Research Group at Oslo University Hospital: Professor Tom Eirik Mollnes
- Biosensor Research Group at Oslo University Hospital: Professor T. I. Tønnessen
- WiBEC EU-project at The Intervention Centre: Professor Ilangko Balasingham,
- University College of Southeast Norway: Professor Kristin Imenes //

3.4 SECTION FOR MEDICAL CYBERNETICS AND IMAGE PROCESSING

3.4.1 Medical Robotics, visualization and navigation

Group Leader: Associate professor Ole Jakob Elle, PhD

Group members

Frederic Courivaud, Senior Researcher (until Q1) 2016)
Espen Remme, Senior Researcher in 30% (shared IVS/Kirurgisk forskning)
Laura Slaughter, Senior Researcher/Associate Professor
Rafael Palomar, PhD-fellow/Software developer (Permanent position from 01.09.2016)
Rahul Kumar, Postdoc
Louise Oram, Software developer in NorMIT
Kim Mathiassen, PhD fellow (also at ROBIN-group at IFI/UIO)
Egil Utheim, Researcher/Mektron
Ralf Greisiger, PhD fellow
Magnus Krogh, PhD fellow
Liubov Nikitushkina, PhD fellow (UIO/OUS/Simula/UCSD)

Background

Most minimally invasive procedures restrict the access and direct vision to the regions which require surgery. Such procedures require intra-operative image modalities such as x-ray, ultrasound or endoscopic images to be able to monitor the procedure in real-time. In many cases this information is not sufficient to perform the procedure accurately and safely. Merging information acquired pre-operatively, mainly from for instance MRI, CT or PET, with intra-operative data can increase the basis for decisions and thereby improve the safety and accuracy of the procedure. The Medical Robotics, visualization and navigation group develops cutting edge technological solutions which support minimally invasive procedures. In particular, the group is focused on developing real-time image-segmentation and - registration methods. Visualization and navigation is required to present the medical images to the surgeon intra-operatively. 3D video will be more and more cross-linked with medical image information and move toward robotics and automation of surgical procedures. The research group is doing research in all these fields of technology facilitating minimally invasive surgery.

Ongoing Projects

Ongoing NFR:

- NorMIT, National Research Infrastructur for Minimally Invasive Treatment

Ongoing Helse Sør-Øst:

- Hepa-Navi, Liver Navigation platform (Postdoc)
- Fast vessel segmentation algorithm (Innovation)
- Service at OUS – 3D printing of organ models (Innovation)
- Modulbasert Operasjonslys for Hybride Operasjonsstuer (Innovation)
- Måling av hjertefunksjon ved hjelp av en ny miniatyrisert bevegelsessensor (Innovation)
- Mimiq: Tilpasningsdyktig LED sporing for navigasjon og medisinsk robotikk (Innovation)

Other ongoing projects:

- Planning and navigation platform for Laparoscopic Liver Resection
- Modell based catheter navigation and Catheter tip tracking and catheter navigation in MR
- Semi-autonomous ultrasound robot for nedle insertion
- User interface/Interaction design projects

New EU-project funded:

- As coordinator of the Marie Curie ITN-project: HiPerNav (High Performance soft-tissue Navigation), start date 01.11.2016

Collaborations

- University of California, San Diego (UCSD)
- University of Dundee
- University of St. Andrews
- Norwegian University of Science and Technology
- University of Homburg, SAAR
- Delft University of Technology
- MR Comp GmbH
- University of Lubeck
- Fakultni Nemocnice u sv. Anny v Brne
- GE Medical Systems
- Katholieke Universiteit Leuven, Leuven, Belgium
- Oslo Universitetssykehus HF, Oslo, Norway
- Zürcher Hochschule für Angewandte
- Wissenschaften, Winterthur, Switzerland
- Imperial College London, London, United Kingdom
- Institute of Biomechanics, Center of Biomedical Engineering, Graz, Austria
- Endosense SA, Geneva, Switzerland
- Scuola Superiore Sant'Anna, Pisa, Italy
- University of Verona
- Oslo University Hospital
- Tallin University
- San Raffaele Hospital
- Yeditepe University
- ETH Zurich
- King's College London
- University of Oxford
- GE Vingmed
- Cascination
- Sintef Medical Technology
- Sheffield Hallam University
- Universidad de Zaragoza
- Universidad politecnica de Madrid

3.5 SECTION FOR INFORMATION AND COMMUNICATION TECHNOLOGY

3.5.1 Wireless Biomedical Sensor Network Research Group

Group Leader: Professor Ilangko Balasingham

Signal Processing Group
Dept. of Electronic Syst. NTNU

Group members

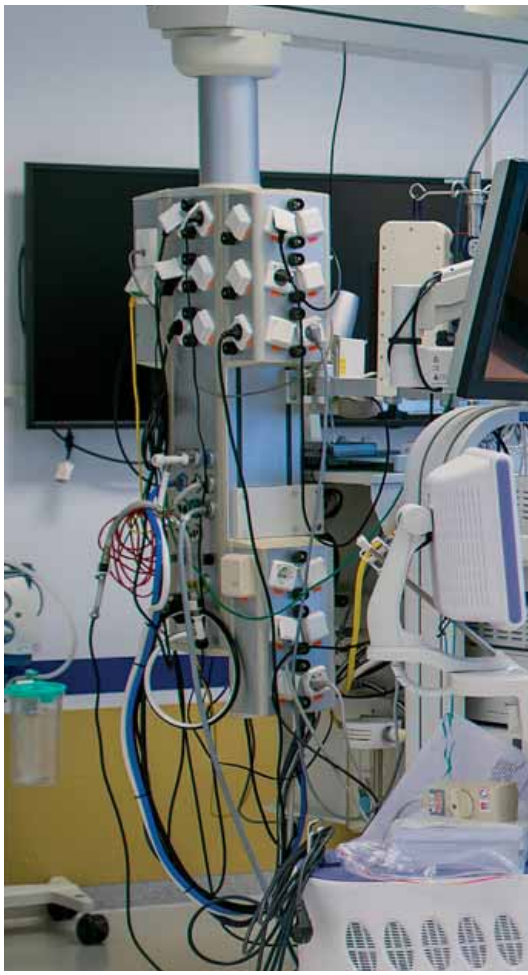
Jacob Bergsland (Sr. Researcher)
Ali Khaleghi (Sr. Researcher)
Ali Chelli (Postdoc)
Younghak Shin (Postdoc)
Nabiul Islam (Postdoc)

Øyvind Janbu (PhD student)
Mladen Veletic (PhD student)
Hamed Fouladi (PhD student)
Mohammad Albatat (PhD student)

Pritam Bose (PhD student)
Pengfei Lu (PhD student)
Hemin Qadir (PhD student)
Reza Shakeri (PhD student)

Background

The research group performs fundamental research and development on information and communication technologies specifically in wireless sensors and systems for applications in diagnostics, minimal invasive therapy, and ambient point of care monitoring. One of the technological focused areas is on ultra low power and reliable wireless sensor networks, where the research is on novel transceiver design, low power data compression, and processing algorithms for anomaly detection, data fusion, etc. Special interest topics are in implantable/ingestible sensors like cardiac pressure sensors, capsule endoscopes, bio-nano scale communications, and nanomachine-to-cell interfaces for stimulation for applications in cardiac, gastrointestinal, and neurodegenerative diseases. Moreover, the group also performs research in patient record and data mining, signal and image processing, and developing novel sensing and imaging systems using electromagnetic waves.



International collaboration

- Prof. Jianqing Wang, Nagoya Institute of Technology, Japan
- Prof. Narcis Cardona, Universitat Politècnica de València, Spain
- Prof. Ram Narayanan, Penn State University, USA
- Prof. Wout Joseph, Ghent University, Belgium
- Prof. Dirk Plettemeier, Technical University of Dresden, Germany
- Prof. Ian F. Akyildiz, Georgia Institute of Technology, USA
- Prof. Chris Contag, Stanford University, USA //

Selected Externally Funded Research Projects

1. Coordinator/Principle Investigator of Wireless In-Body Environment (WiBEC), (Funded by the European Commission, H2020- MARIE Skodowska-CURIE ACTIONS (MSCA-ITN-2015), 01.01.2016-31.12.2019, budget €3.957 million)
2. Principle Investigator/Work Package Leader of HOME, (Funded by the Research Council of Norway, Idea Lab program, 01.06.2014 - 31.12.2016, budget NOK 10 million)
3. Project Manager/Principle Investigator of MELODY II, (Funded by the Research Council of Norway, VERDIKT program, 01.01.2013 - 31.07.2017, budget NOK 14.7 million)
4. Co-Principle Investigator of NORBAS, (Funded by the Ministry of Foreign Affairs under the HERD/ICT for Balkan, 01.01.2012 - 31.12.2016, budget NOK 6.25 million)
5. Co-Principle Investigator of ASSET - Adaptive Security for Smart Internet of Things in eHealth, (Funded by the Research Council of Norway - VERDIKT program, 02.01.2012 - 30.06.2016, budget NOK 13.2 million)

3.6 SECTION FOR METHOD DEVELOMENT AND INDUSTRY COLLABORATION

3.6.1 Clinical Testing Work Group

Group Leader: Karl Øyri, PhD

Group Members

Sandre Svatun Lirhus, MSc

In 2016 11 new requests from companies were made to the Test-Bed. Four of the requests ended up in new projects, and four projects continued from earlier years. The figure below illustrates the product categories of service request the section has received from med tech industry since the opening in 2013. Request concerning early phase products are dominating. 47% of the requests originate from international companies, 43% from national companies, and 10% from regional companies.

Ongoing Projects:

The Nordic Network of Testbeds funded by Nordic Innovation. The project objective is to harmonize clinical and administrative standards and operations, and together develop a professional service for testing of new and innovative healthcare products in the Nordic. With a “one point of contact” for all the test beds we also aim to match the companies with the testing facility that best fit their need.

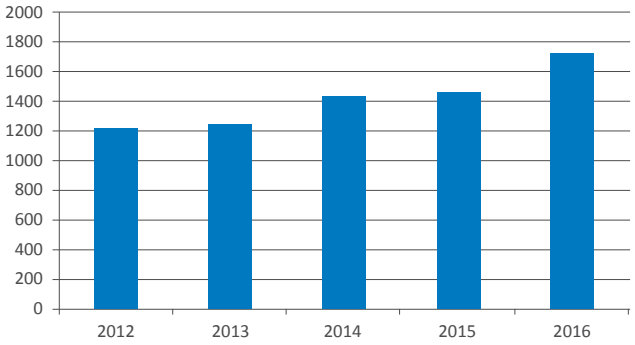
Collaborations

- Oslo Medtech
- Sunnaas Sykehus
- Nordic Medtest, Karlstad, Sweden
- SLL Innovation, Stockholm Läns Landsting, Stockholm, Sweden
- Innovationsplatsen , Karolinska University Hospital, Stockholm, Sweden
- HUS, Hospital District of Helsinki and Uusimaa, Helsinki, Finland
- Region H, Capital Region of Denmark, Copenhagen, Denmark

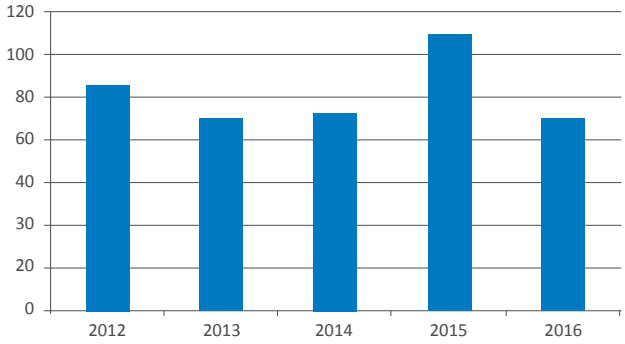
4 STATISTICS

4.1 Clinical activity

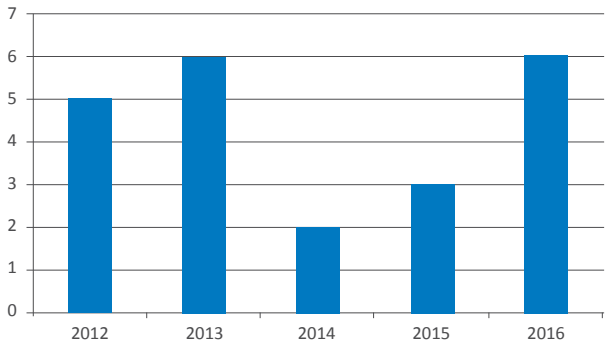
PATIENTS AT THE INTERVENTION CENTRE LAST 5 YEARS



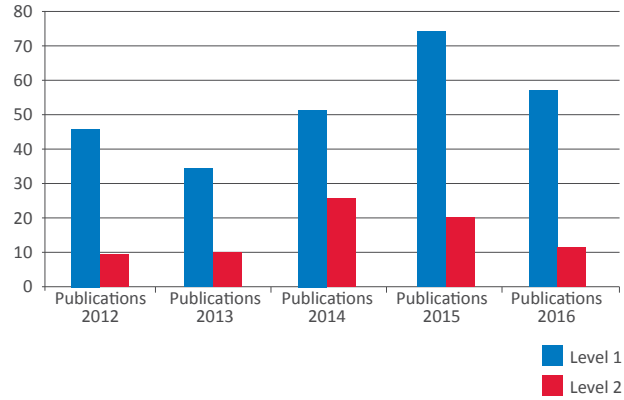
PRECLINICAL PROCEDURES LAST 5 YEARS



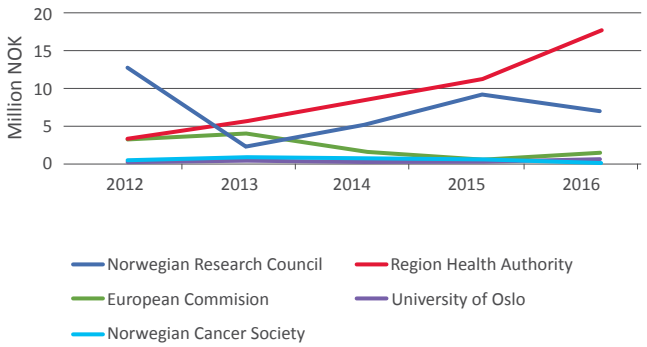
PhD'S AT THE INTERVENTION CENTRE LAST 5 YEARS



PUBLICATIONS LAST 5 YEARS



RESEARCH SPENDING FROM EXTERNAL SOURCES



4.2 Financial statements

EXPENDITURES FUNDED BY HOSPITAL AND SALE OF SERVICES IVC EXCL DIAGNOSTIC PHYSICS (NOK)

CATEGORY	BUDGET
Operating expences	4 247 000
Payroll expences	24 471 000
Total	28 718 000

EXPENDITURES FUNDED BY HOSPITAL AND SALE OF SERVICES FOR DIAGNOSTIC PHYSICS (NOK)

CATEGORY	BUDGET
Operating expences	165 000
Payroll expences	19 114 000
Total	19 279 000

RESEARCH FUNDED EXPENDITURES (NOK)

SOURCE	RESEARCH EXPENDITURES
Norwegian Research Council NFR	7 054 813
Regional Health Authority HSØ	17 722 553
European Commission EU	1 458 574
University of Oslo UiO	722 993
Norwegian Cancer Society	183 679
Other public foreign sources	80 797
Other public Norwegian sources	509 348
Other private Norwegian sources	38 745
Total	27 771 502

OF A TOTAL EXPENDITURE OF NOK 75 768 502, 37% WAS RESEARCH FUNDED.

5 PUBLICATIONS

5.1 Peer reviewed scientific papers

Level 1 and 2 publications The Intervention Centre 2016

(Level 2 publications in **bold)**

1. *Arnesen MR, Rekstad BL, Stokke C, Bruheim K, Løndalen AM, Hellebust TP, Malinen E.*
Short-course PET based simultaneous integrated boost for locally advanced cervical cancer.
Radiat Oncol. 2016 Mar;12:11-39.

2. ***Blakkisrud J, Løndalen A, Martinsen AC, Dahle J, Holtedahl JE, Bach-Gansmo T, Holte H, Kolstad A, Stokke C.*** **Tumor-Absorbed Dose for Non-Hodgkin Lymphoma Patients Treated with the Anti-CD37 Antibody Radionuclide Conjugate 177Lu-Lilotomab Satetraxetan.**
J Nucl Med. 2016;58(1):48-54.

3. *Barkhatov L, Fretland ÅA, Kazaryan AM, Røsok BI, Brudvik KW, Waage A, Bjørnbeth BA, Sahakyan MA, Edwin B.*
Validation of clinical risk scores for laparoscopic liver resections of colorectal liver metastases: A 10-year observed follow-up study
J Surg Oncol. 2016;114(6):757-763.

4. *Berg A, Fasmer KE, Mauland KK, Ytre-Hauge S, Hoivik EA, Husby JA, Tangen IL, Trovik J, Halle MK, Woie K, Bjørge L, Bjørnerud A, Salvesen HB, Werner HM, Krakstad C, Haldorsen IS.*
Tissue and imaging biomarkers for hypoxia predict poor outcome in endometrial cancer.
Oncotarget. 2016;7(43):69844-69856.

5. *Bergan HA, Halvorsen PS, Skulstad H, Fosse E, Bugge JF.*
Does therapeutic hypothermia during extracorporeal cardiopulmonary resuscitation preserve cardiac function?
J Transl Med. 2016;14(1):345.

6. *Brænne KR, Flinder LI, Almenning Martiniussen M, Jensen K, Reisse CH, Julsrud L, Martinsen AC.*
A Liver Phantom Study: CT Radiation Dose Reduction and Different Image Reconstruction Algorithms Affect Diagnostic Quality. J Comput Assist Tomogr. 2016;40(5): 735-9.

7. *Chahibi Y, Akyildiz IF, Balasingham I.*
Propagation Modeling and Analysis of Molecular Motors in Molecular Communication.
IEEE Transactions on Nanobioscience. 2016;15(8):917-27.

8. *Chelli A, Bagaa M, Djenouri D, Balasingham I, Taleb T.*
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IEEE Wireless Communications Letters. 2016;5(4):448-51.

9. *de Rooij T, Besselink MG, Shamali A, Butturini G, Busch OR, Edwin B, Troisi R, Fernández-Cruz L, Dagher I, Bassi C, Abu Hilal M;*
DIPLOMA trial group.Pan-European survey on the implementation of minimally invasive pancreatic surgery with emphasis on cancer.
HPB (Oxford).2016 Feb;18(2):170-6.

10. *Eidet J, Dahle G, Bugge JF, Bendz B, Rein KA, Aaberge L, Offstad JT, Fosse E, Aakhus S, Halvorsen PS.*
Long-term outcomes after transcatheter aortic valve implantation: the impact of intraoperative tissue Doppler echocardiography.
Interact Cardiovasc Thorac Surg. 2016;23(3):403-9.

11. *Eidet J, Dahle G, Bugge JF, Bendz B, Rein KA, Aaberge L, Offstad JT, Fosse E, Aakhus S, Halvorsen PS.*
Intraoperative improvement in left ventricular peak systolic velocity predicts better short-term outcome after transcatheter aortic valve implantation.
Interact Cardiovasc Thorac Surg. 2016 Jan;22(1):5-12.

12. ***Emblem KE, Jain RK.***
Improving treatment of liver metastases by targeting nonangiogenic mechanisms.
Nat Me. 2016;22(11):1209-1210.

13. *Goderstad JM, Sandvik L, Fosse E, Lieng M.*
Assessment of Surgical Competence: Development and Validation of Rating Scales Used for Laparoscopic Supracervical Hysterectomy. J Surg Educ. 2016;73(4):600-8.

14. *Gottås A, Arnestad M, Halvorsen PS, Bachs LC, Høiseth G.*
Pharmacokinetics of heroin and its metabolites in vitreous humor and blood in a living pig model.
Forensic Toxicol. 2016;34(2):277-285.

15. *Grindheim G, Eidet J, Bentsen G.*
Transpulmonary thermodilution (PiCCO) measurements in children without cardiopulmonary dysfunction: large interindividual variation and conflicting reference values.
Paediatr Anaesth.2016:26(4):418-24.

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Detection of intraoperative myocardial dysfunction by accelerometer during aortic valve replacement. Interact Cardiovasc Thorac Surg. 2017 Feb 1;24(2):188-195.

17. ***Gulati G, Heck SL, Ree AH, Hoffmann P, Schulz-Menger J, Fagerland MW, Gravdehaug B, von Knobelsdorff-Brenkenhoff F, Bratland Å, Storås TH, Hagve TA, Røsjø H, Steine K, Geisler J, Omland T.*** **Prevention of cardiac dysfunction during adjuvant breast cancer therapy (PRADA): a 2 × 2 factorial, randomized, placebo-controlled, double-blind clinical trial of candesartan and metoprolol.**
Eur Heart J. 2016; 37(21):1671-80.

18. *Heck A, Emblem KE, Casar-Borota O, Bollerslev J, Ringstad G.* Quantitative analyses of T2-weighted MRI as a potential marker for response to somatostatin analogs in newly diagnosed acromegaly. Endocrine. 2016 May;52(2):333-43.

19. *Heck A, Emblem KE, Casar-Borota O, Ringstad G, Bollerslev J.* MRI T2 characteristics in somatotroph adenomas following somatostatin analog treatment in acromegaly. Endocrine. 2016 Jul;53(1):327-30.

20. *Hellstrøm T, Westlye LT, Server A, Løvstad M, Brunborg C, Lund MJ, Nordhøy W, Andreassen OA, Andelic N.* Volumetric and morphometric MRI findings in patients with mild traumatic brain injury. Brain Inj.2016;30(13-14):1683-1691.

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22. *Jensen K, Aaløkken TM, Tingberg A, Fosse E, Martinsen AC.* Image Quality in Oncologic Chest Computerized Tomography With Iterative Reconstruction: A Phantom Study. J Comput Assist Tomogr. 2016;40(3):351-6.

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25. *Kalheim LF, Selnes P, Bjørnerud A, Coello C, Vegge K, Fladby T.* Amyloid Dysmetabolism Relates to Reduced Glucose Uptake in White Matter Hyperintensities Front Neurol. 2016;7:209.

26. ***Knatten CK, Kvello M, Fyhn TJ, Edwin B, Schistad O, Aabakken L, Pripp AH, Kjosbakken H, Emblem R, Bjørnland K. Nissen* fundoplication in children with and without neurological impairment: A prospective cohort study. J Pediatr Surg. 2016.Jul;51(7):1115-21.**

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29. *Krogvold L, Wiberg A, Edwin B, Buanes T, Jahnsen FL, Hanssen KF, Larsson E,Korsgren O, Skog O, Dahl-Jørgensen K.* Insulitis and characterisation of infiltrating T cells in surgical pancreatic tail resections from patients at onset of type 1 diabetes. Diabetologia. 2016 Mar;59(3):492-501.

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Learning curve of self-taught laparoscopic liver surgeons in left lateral sectionectomy: results from an international multi-institutional analysis on 245 cases.
Surg Endosc. 2016 Aug;30(8):3618-29.

37. *Ringstad G, Emblem KE, Eide PK.*
Phase-contrast magnetic resonance imaging reveals net retrograde aqueductal flow in idiopathic normal pressure hydrocephalus. J Neurosurg. 2016 Jun;124(6):1850-7.

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Laparoscopic Resection of Recurrence from Hepatocellular Carcinoma after Liver Transplantation: Case Reports and Review of the Literature
Case Rep Oncol Med. 2016;8946471

39. ***Sahakyan MA, Røsok BI, Kazaryan AM, Barkhatov L, Lai X, Kleive D, Ignjatovic D, Labori KJ, Edwin B.***
Impact of obesity on surgical outcomes of laparoscopic distal pancreatectomy: A Norwegian single-center study.
Surgery. 2016;160(5): 1271-1278.

40. *Sahakyan MA, Kazaryan AM, Pomianowska E, Abildgaard A, Line PD, Bjørnbeth BA,Edwin B, Røsok BI.*
Laparoscopic Resection of Recurrence from Hepatocellular Carcinoma after Liver Transplantation: Case Reports and Review of the Literature.
Case Rep Oncol Med. 2016;2016:8946471.

41. *Sahakyan MA, Yaqub S, Kazaryan AM, Villanger O, Berstad AE, Labori KJ, Edwin B, Røsok BI.*
Laparoscopic Completion Pancreatectomy for Local Recurrence in the Pancreatic Remnant after Pancreaticoduodenectomy: Case Reports and Review of the Literature. J Gastrointest Cancer. 2016;47(4): 509-513.

42. *Schulz A, Viktil E, Godt JC, Johansen CK, Dormagen JB, Holtedahl JE, Labori KJ, Bach-Gansmo T, Kløw NE.*
Diagnostic performance of CT, MRI and PET/CT in patients with suspected colorectal liver metastases: the superiority of MRI. Acta Radiol. 2016 Sep;57(9):1040-8

43. *Ševo I, Avramović A, Balasingham I, Elle OJ, Bergsland J, Aabakken L.*
Edge density based automatic detection of inflammation in colonoscopy videos. Comput Biol Med. 2016; 72:138-50.

44. *Skagen K, Evensen K, Scott H, Krohg-Sørensen K, Vatnehol SA, Hol PK, Skjelland M, Russell D.*
Semiautomated Magnetic Resonance Imaging Assessment of Carotid Plaque Lipid Content.
J Stroke Cerebrovasc Dis. 2016;25(8):2004-10.

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An Implantable Accelerometer-based Heart Monitoring Device with Improved Positional Stability.
J. Med. Devices. 2016;10(4):045002-045002-6.

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J Int Neuropsychol Soc. 2016;22(4):436-52.

47. *Trovik J, Vikanes Å.*
Hyperemesis Gravidarum is associated with substantial economic burden in addition to severe physical and psychological suffering. Isr J Health Policy Res. 2016;5:43.

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Optimal differentiation of high- and low-grade glioma and metastasis: a meta-analysis of perfusion, diffusion, and spectroscopy metrics. Neuroradiology. 2016;58(4):339-50.

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50. ***Veletic M, Floor PA, Babic Z, Balasingham I.***
Peer-to-Peer Communication in Neuronal Nano-Network.
IEEE Trans. Commun. 2016;64(3):1153-1166.

51. ***Veletic M, Floor PA, Chahibi Y, Balasingham I.***
On the Upper Bound of the Information Capacity in Neuronal Synapses. IEEE Transactions on Communications. 2016;64(12):5025-36.

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Neurodevelopmental origins of lifespan changes in brain and cognition.
Proc Natl Acad Sci U S A. 2016;113(33):9357-62.

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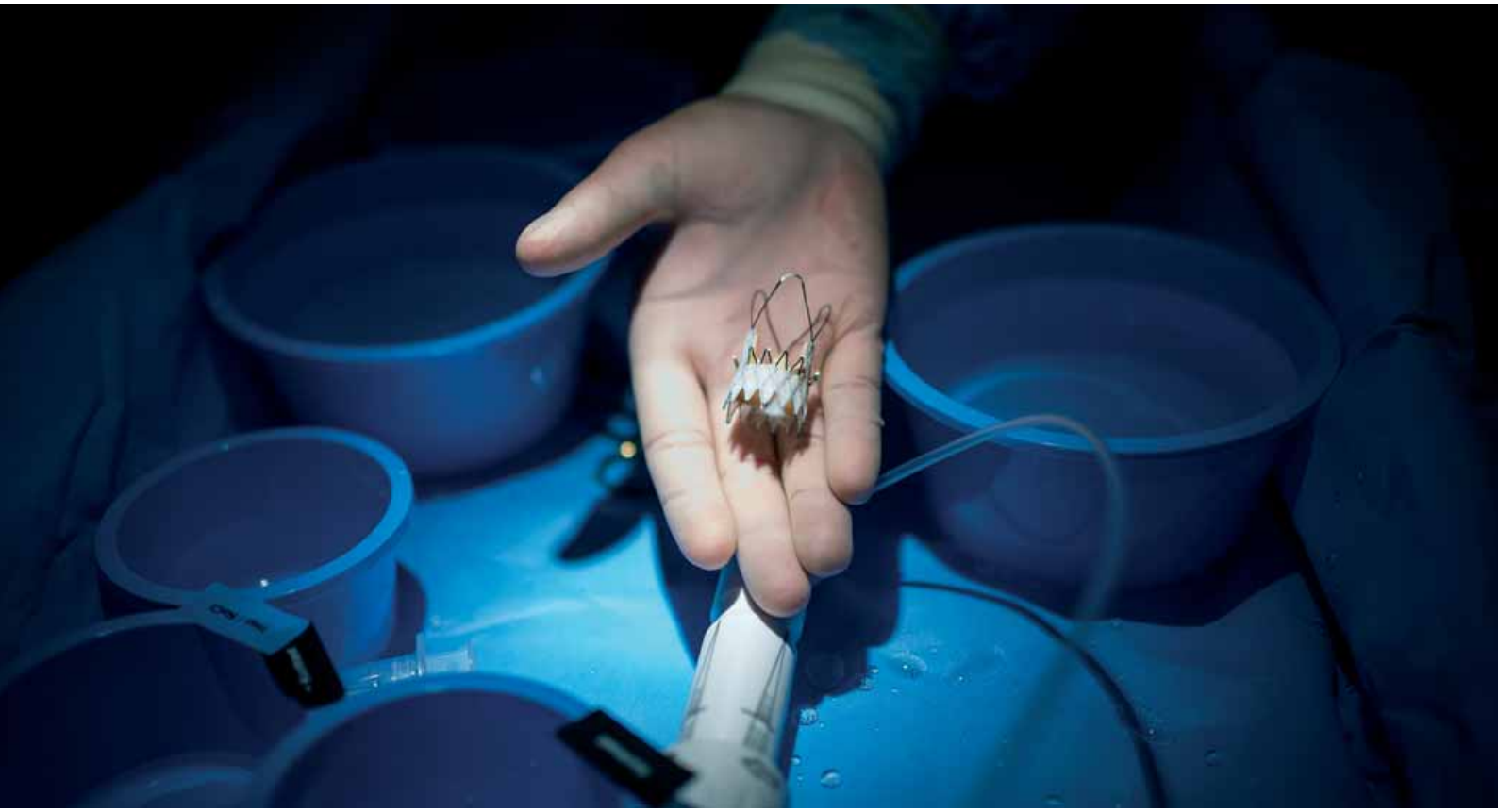
Trends in Abdominal Aortic and Iliac Aneurysm Repairs in Norway from 2001 to 2013.
Eur J Vasc Endovasc Surg. 2016 Feb;51(2):194-201.



54. *Østerås BH, Heggen KL, Pedersen HK, Andersen HK, Martinsen AC.*
Can use of adaptive statistical iterative reconstruction reduce radiation dose in unenhanced head CT?
An analysis of qualitative and quantitative image quality.
Acta Radiol Open. 2016; 5(8):2058460116645831.

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BI-RADS Density Classification From Areometric and Volumetric Automatic Breast Density Measurements.
Acad Radiol 2016;23(4):468-78.

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Classification of fatty and dense breast parenchyma: comparison of automatic volumetric density measurement and radiologists' classification and their inter-observer variation. Acta Radiol. 2016;57(10):1178-85.

Level 1 Conference papers

1. *Bagaa M, Ksentini A, Taleb T, Jantti R, Chelli A, Balasingham I.*
An efficient D2D-based strategies for machine type communications in 5G mobile systems. IEEE Wireless Communications and Networking Conference : Communications Society; September 2016. p. 1-6.

2. *Djenouri D, Bagaa M, Chelli A, Balasingham I.*
Energy Harvesting Aware Minimum Spanning Tree for Survivable WSN with Minimum Relay Node Addition. IEEE Global Communications Conference, Exhibition, & Industry Forum (GLOBECOM): IEEE Communications Society; December 2016. p. 1-4.

3. *Fouladi SH, Balasingham I, Kansanen K, Ramstad TA.*
Remote Photoplethysmogram Signal from Endoscopy Videos for Vessel and Capillary Density Recognition. 38th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC'16): IEEE EMBS; August 2016. p. 227-230.

4. *García-Pardo C, Chavez-Santiago R, Fornes-Leal A, Brovoll S, Aardal Ø, Bergsland J, et al.*
Experimental Ultra Wideband Path Loss Models for Implant Communications. IEEE 27th Annual International Symposium on Personal, Indoor, and Mobile Radio Communications Workshops (PIMRC) : IEEE Communications Society; September 2016. p.1- 6.

5. *Ksentini A, Bagaa M, Taleb T, Balasingham I.*
On using bargaining game for Optimal Placement of SDN controllers. IEEE International Conference on Communications (ICC 2016): IEEE Communications Society; June 2016. p. 1-6.

6. *Nguyen HT, Balasingham I, Ramstad TA.*
Layered Source-Channel Coding for Uniformly Distributed Sources over Parallel Fading Channels. 2016 IEEE 27th Annual International Symposium on Personal, Indoor, and Mobile Radio Communications Workshops (PIMRC): IEEE Communications Society; September 2016. p. 1-6.

7. *Rawat N, Shin Y, Balasingham I.*
EEG Based Image Encryption Via Quantum Walks. 38th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC'16): IEEE EMBS; August 2016. p. 231-234.

8. *Secerbegovic A, Bergsland J, Halvorsen PS, Suljanović N, Mujčić A, Balasingham I.*
Blood pressure estimation using video plethysmography. IEEE International Symposium on Biomedical Imaging. IEEE EMBS; June 2016. p.461-464.

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Fast L1-based Sparse Representation of EEG for Motor Imagery Signal Classification. 38th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC'16): IEEE EMBS; August 2016. p. 223-226.

10. *Zhou H, Narayanan RM, Balasingham I.*
Microwave reconstruction method using a circular antenna array cooperating with an internal transmitter. Proceedings of SPIE, the International Society for Optical Engineering. May 2016. 9829:p. 1-12.

11. *Vega-Gorgojo G., Slaughter L.*
Easy-to-use semantic search of pharmacological data. In: Proceedings of the 9th Semantic Web Applications and Tools for Life Sciences International Conference, Amsterdam, NL, December 5-8, 2016. CEUR Workshop Proceedings, CEUR-WS.org 2016. p. 1-12.

12. *Vega-Gorgojo G., Slaughter L., Giese M., Heggestøyl S., Klüwer J.W., Waaler A.*
PepeSearch: Easy to Use and Easy to Install Semantic Data Search. In: Sack H., Rizzo G., Steinmetz N., Mladenić D., Auer S., Lange C. (eds) The Semantic Web. ESWC 2016. Lecture Notes in Computer Science, vol 9989. Springer, Cham; 2016. p. 146-150.

5.2 Editorials and other scientific publications

1. *Ebens B, Fosse E,l Niechzial M, Rentzsch O.*
Strategy, in the short, mid and long term responsiveness and preparedness of the Syrian health care system.. Document WHO/SYR/028/E 2016. http://applications.emro.who.int/docs/COPub_SYR_2016_EN_18985.pdf?ua=1

2. *Bugge JF, Espinoza A, Halvorsen PS* (2016)
Hypothermia Is Not an Inotropic Drug
Crit Care Med, 44 (12), e1258

5.3 PhD Theses 2016

PH.D STEFAN HYLER (01.03.2016)
Microsensors allow continuous monitoring of myocardial ischemia in Cardiac surgery
The Intervention Centre
Oslo University Hospital HF, Rikshospitalet
Institute of Clinical Medicine
Faculty of Medicine
University of Oslo
2016
ISBN 978-82-8333-174-5

PH.D WASIM ZAHID (06.10.2016)
Myocardial function by echocardiography for risk stratification in patients with heart disease
The Intervention Centre
Department of Cardiology
Centre for Cardiology
Oslo University Hospital HF, Rikshospitalet
Faculty og Medicine
University of Oslo
2016
ISBN: 978-82-8333-240-7

PH.D LARS ERIK SOLBERG (10.10.2016)
Radar based central blood pressure estimation
The Intervention Centre
Oslo University Hospital HF, Rikshospitalet
Institute of Clinical Medicine
Faculty of Medicine
University of Oslo
2016
ISBN 978-82-8333-253-7

PH.D TRYGVE KJELSTRUP (15.11.2016)
Evaluation of a Multiple Injection Axillary Block Tachnique by Clinical Assessment and MRI
The Intervention Centre
Department of Anaesthesiology
Oslo University Hospital HF, Rikshospitalet
Department of Anaesthesiology
Diakonhjemmet Hospital
Institute of Clinical Medicine
Faculty of Medicine
University of Oslo
2016
ISBN 978-82-8333-296-4

PH.D JO EIDET (02.12.2016)
Left Ventricular Function During Transcatheter Aortic Valve Implantation.
The Impact of Tissue Doppler Imaging
The Intervention Centre
Oslo University Hospital HF, Rikshospitalet
Institute of Clinical Medicine
Faculty of Medicine
University of Oslo
2016
ISBN 978-82-8333-311-4

PH.D RALF GREISIGER (19.12.2016)
Objective Measurement and Cochlear Implants Imaging
Department of Ear Nose Throat
The Intervention Centre
Oslo University Hospital HF, Rikshospitalet
Institute of Clinical Medicine
Faculty of Medicine
University of Oslo
2016
ISSN 1501-7710/No. 1785

Oslo University Hospital

THE INTERVENTION CENTRE

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