Oslo University Hospital

The Intervention Centre
Annual report 2014

Oslo University Hospital and
Facility of Medicine, University of Oslo

UiO : University of Oslo

ANNUAL REPORT 2014

The Intervention Centre

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The Intervention Centre – professional and safe introduction of new procedures and technologies in health care

The Intervention Centre was established in 1996 as a common resource for all medical disciplines in their work to improve and change practice in diagnostics and treatment. The Intervention Centre has attracted several medtech companies to the hospital and consequently we established a section dedicated for industrial collaboration. The section is responsible for helping industry that need testing of new devices in our hospital. This test-bed function was established in collaboration with the organization Oslo Medteh.

Since 2002 the clinical section of the Centre has consisted of a combined angiography and surgical suite, an endoscopic surgical suite and a combined MR lab and surgical suite with dedicated staff for nurses and doctors.

The aim was to aid the clinical departments in their endeavours to improve their fields of expertise with new procedures developed in a safe and professional environment.

As the Intervention centre is a common toolbox for all clinical departments and also is used as a toolbox by several institutes at the university as the Institute of physics, the institute of informatics and the institute of psychology, our technology is used extensively. It has therefore been possible to exchange the expensive, heavy equipment on a regular basis.

Thus, in 2014, through collaboration with the Institute of psychology, we acquired a new 3 T magnet as substitute for the 3T magnet that was installed in 2007.

A number of procedures developed over the last years, require the hybrid approach to equipment and organization adapted by the Intervention Centre. Some examples of this are stentgraft procedures for aortic aneurysms, transcatheter aortic valve implantation (TAVI), some cochlear implants and some laparoscopic procedures. Thus These procedures can not easily be transferred from the Intervention Centre to standard operation suites or cath labs once the development phase is over. This a gain has lead to a reduced capacity for development and research. In 2014 planning to the expand the Intervention Centre thus began.

The number of new technology dependent procedures in hospital is increasing all over the world. In 2013 the Norwegian Health authorities issued new regulations on how new technologies and methods are introduced in hospital. Before adapting a new method a Health Technology Assessment should be made, to ensure that the method is well documented. Often important issues like economic consequences of the new method and the patients' experience is not well documented. It is then important for the clinicians to provide this information themselves.

In order to meet the increasing demand for controlled studies both inside the hospital and in collaboration with the med-tech industry, the Intervention Centre established a section for method development and industrial collaboration (SMI). The new section will help coordination the resources and establish protocols when new methods and technologies are tried. This will help the hospital to be better prepared for the future and secure safe access to new methods and technologies for our patients.

Erik Fosse
Head of Department

Main goals and objectives

THE INTERVENTION CENTRE

TASKS

- **Develop new procedures**
- **Develop new treatment strategies**
- **Compare new and existing strategies**
- **Optimizing and developing advanced imaging techniques**
- **Study the social, economic, and organisational consequences of new procedures on health care**
- **Administration of radiation protection for all departments in the hospital and affiliated institutions**

RESEARCH AREAS

- **MR guided intervention and surgery**
- **X-ray, CT, ultrasound, video-guided interventions and surgery**
- **Robotics and simulators**
- **Sensor technology, data management and communication technology**
- **Physics in MR, CT, X-ray, US, PET and nuclear medicine**

FACILITIES

The Centre is physically located close to the general operation room area at Oslo University Hospital, Rikshospitalet. In addition to clinical procedures, The Intervention Centre has approval for in vivo animal trials, following the strict Norwegian regulations of such activities. The staff is experienced in performing such operations. Advanced imaging equipment is integrated in an operation room environment. At present there are three such suites, according to plans three more will be added due to the increased pressure on present facilities.
In 2007, all advanced imaging equipment was renewed. In the combined surgical and radiological suite, the conventional angiographic equipment was substituted by a Siemens Zeego system, based on robotic technology. The Intervention Centre is a test site for this system. The MRI suite was rebuilt into a dual room suite where a Philips 3 Tesla MRI was installed connected to a state-of-the-art Operation theater. The MRI was funded as a joint effort by the Norwegian Research Council, the University of Oslo and Rikshospitalet. In the videoscopy room all systems are equipped with state of the art Olympus HD equipment.

STAFF

The multi-disciplinary staff includes 45 full time positions (doctors, nurses, radiographers, medical physicists and technologists). Four professors and two associate professors, employed at the Faculty of Medicine and the Faculty of Mathematics and natural sciences of University of Oslo (UiO) and the Department of Electronics and Telecommunication of the Norwegian University of Technology (NTNU), are included among the staff.

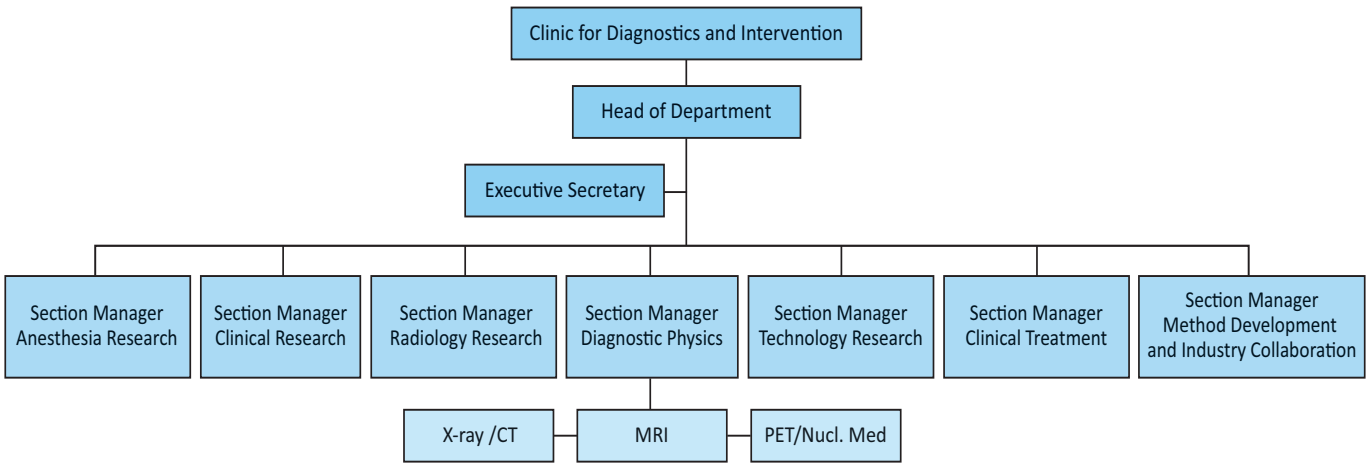
ORGANIZATION

The Intervention Centre is organized in The Clinic for diagnostics and intervention in Oslo University Hospital.

To facilitate effective management of multi-disciplinary projects, personnel and equipment at the Centre are allocated to five sections. Projects are assigned to one of the sections, and the project manager is reporting to one section leader. The operating rooms are managed by the unit nursing officer, reporting directly to the department-head.

In 2005, Oslo University Hospital established a group of medical physicists specialized in diagnostic radiology, nuclear medicine and intervention. The establishment was supported by both the Southern and the Eastern Norway regional health authorities.

From 2010, the section for diagnostic physics was incorporated in the Intervention Centre, providing hospitals in the South-Eastern Norway Regional Health Authority physic services and physics research infrastructure.



Section for Diagnostic Physics

Section Manager Associate professor Anne Catrine Trægde Martinsen, PhD

ACTIVITY

The Intervention Centre employs 23 full-time physicists, covering the full range of imaging modalities and associated technologies; CT, X-ray, intervention and radiation protection, PET-CT and MRI. This is the largest department for diagnostic physics in Norway, offering regional services to 38 departments of radiology and nuclear medicine in the South Eastern Health region of Norway.

In addition to quality assurance and radiation protection, the section is co-responsible for daily follow-up and management of the MR core facility at Oslo University Hospital, and is heavily involved in a wide range R&D areas, including MR- and CT physics, mammography, nuclear medicine including PET-CT, image processing and radiation protection. In addition, multi/modal comparative studies, interventional radiology and internal dosimetry are also active fields of research.

REGIONAL PHYSICIST SERVICE

Since 2014, the Intervention Centre provides service to all Radiology and nuclear medicine departments in Oslo University Hospital and to the following 15 hospitals and radiological institutes at 38 locations within the South-Eastern health region:

Akershus Universitetssykehus HF
ALERIS
Diakonhjemmet sykehus
Feiringklinikken
Glittreklinikken
Helsehuset Kongsberg
Lovisenberg Diakonale sykehus
Martine Hansens hospital
Sunnås sykehus HF
Sykehuset Innlandet HF
Sykehuset Østfold HF
Telemark Sykehus HF
Unilabs
Vestre Viken HF
Volvat

This is a not-for-profit service and contracting hospitals pay for direct costs of the physicists support (salary, travel and accommodation). Recognizing that multi-disciplinary teamwork is a key factor for success, the service is organized such that, whenever possible, each hospital has one contact physicist working together with radiologist and technicians in the radiology department.

Services offered as part of the regional service:

- System acceptance tests
- Annual quality assurance (QA) tests
- Optimisation of image quality and radiation dose
- Multidisciplinary image quality optimization projects
- Teaching programs for surgical personnel using X-ray equipment
- Teaching programs in imaging physics and dosimetry for radiologists and technicians/ radiographers
- Dose measurements and dose estimates
- Consultancy in purchases of new imaging equipment in radiology- and nuclear medicine

The establishment of a regional physicist service provides several key advantages. First, a central pool of up-to-date educational material, reports and expertise is available to all parties. Further, centralizing purchase of expensive measuring devices and equipment available to all hospitals leads to significant cost-savings. Finally, the collaboration between hospitals resulting from such services result in improved knowledge exchange between hospitals and departments. By centralizing major QA and analysis services to one expert unit, it becomes much easier to compare the performance

of modalities and systems between hospitals, and thereby detect sub-optimal performance (in terms of image quality or radiation exposure) by comparison to a constantly increasing database of historical data, collected from a large number of comparative instruments in the health region.

COURSES

The section is responsible for three master/PHD courses in imaging physics at the University of Oslo: "FYS 4760 Physics in diagnostic X-ray", "FYS-KJM 4740/9740 MR-theory and medical diagnostics", "FYS 9750 Medical imaging" and one CT post educating course ("ViCT") for radiographers at the University college in Oslo and Akershus (HiOA).

QUALITY ASSURANCE

Methodology for acceptance tests and quality assurance for the modalities MR, PET-CT, nuclear medicine, CT, fluoroscopy and X-ray were revised and further developed. In 2014, QA was performed on 371 imaging systems, including equipment from all the major vendors.

STAFF

CT and conventional X-ray physics
Hilde Kjernlie Andersen, Msc (head of unit)
Kristin Jensen, MSc
Bjørn Helge Østerås, MSc
Siri Fløgstad Svensson, MSc
Ellen Marie Husby, MSc
Anette Aarsnes, MSc
Kristin Forså, MSc
Alise Larsen, MSc
Camilla Walle Serkland, MSc
Anikken Dybwad, MSc Medical physicist
Ingrid Helen Ryste Hauge, PhD
Nikolas Sogge, MSc
Ragnhild Smistad, MSc

Nuclear medicine and PET-physics
Caroline Stokke, PhD (head of unit)
Jon Erik Holtedahl, MSc
Lars Tore Gyland Mikaelsen, PhD
Trine Hjørnevik, PhD

MR Physics
Professor Atle Bjørnerud, PhD (head of unit)
Kyrre Eeg Emblem, PhD
Tryggve Holch Storaas, PhD
Øystein Beck Gadmar, PhD
Wibeke Nordheøy, PhD
Oliver Marcel Geier, PhD
Tone Elise Døli Orheim, MSc
Magne Mørk Kleppestø, MSc
Robin Bugge, MSc

PhD students
David Volgyes, MSc
Endre Grøvik, MSc
Ingrid Digernes, MSc
Jonas Vardal, MD
Christopher Larsson, MD
Paulina Due-Tønnessen, MD
Tomas Garcia Saiz, MSc
Kristin Jensen, MSc
Bjørn Helge Østerås, MSc

PostDoc`s
Tuva R. Hope, PhD
Inge Groote, MD PhD
Sandra Tecelao, PhD
Siri Leknes, PhD

Master students
Johan Blakkisrud

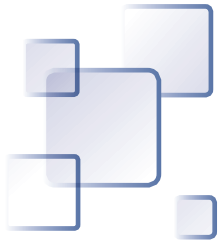
Research Area

CT PHYSICS AND TECHNOLOGY | *Section Manager Associate professor Anne Catrine Trægde Martinsen*

ACTIVITY

The group was established in 2012 with an ambition to create a leading centre for CT physics and technology research in Norway. There has been little focus on CT research in Norway to date, but given a steady increase in the number of CT examinations, with about 80% of the total population radiation exposure from medical procedures stemming from CT, an increased research effort is clearly needed. The research topics addressed by the group include the development of new imaging methods, clinical implementation, radiation dose reduction and development of new image reconstruction algorithms and image post processing tools, such as CT perfusion, CT spectral imaging and iterative reconstruction techniques.

The CT physics and technology research group focuses on the development and implementation of advanced image reconstruction and processing techniques with specific focus on improved patient diagnostics combined with reduced radiation dose. Future objectives include validation of new methodology, such as iterative image reconstruction, spectral imaging, CT organ perfusion, in terms of improved diagnostic outcome and socioeconomic value.



ONGOING PROJECTS

Spectral imaging and iterative reconstruction in CT imaging: Image quality and radiation doses

The aim of the study is to introduce new applications in the clinic using new CT reconstruction techniques to improve image quality and lowering radiation doses to the patient. Comparison of lesion conspicuity for five different iterative reconstruction algorithms from four different vendors have been performed, and studies evaluating iterative reconstruction in chest, liver and brain are ongoing.

Optimization of diagnostic image quality and radiation dose of radiological tomography techniques using advanced post processing reconstruction algorithms

The aim of the project is to introduce new applications to improve image quality and potentially lowering radiation doses to the patient. Diagnostic image quality and radiation dose for the new Hologic tomosynthesis mammography imaging system has been evaluated in this project. Besides, density classification by Quantra II has been compared to the radiologists' BIAS score for density in mammography screening. The projects are part of the large, ongoing Oslo tomosynthesis screening trial, project leader Professor Per Skaane (UiO).

New method for liver metastasis diagnostics in patients with colorectal cancer (part of the Oslo Comet study)

The aim of the study is to improve the diagnostics of liver metastasis using new features like CT liver perfusion and iterative reconstruction algorithms. The study is part of the ongoing Oslo Comet study, project leader Professor Bjørn Edwin.

CT quality assurance test methodology

The aim of the study is to analyze the characteristics of the most commonly used QA phantoms, Catphan 500/504/600 (The Phantom Laboratory, NY), examine possible interphantom and interscanner variations in HU, homogeneity and low contrast detectability and to further develop methodology and phantoms and sophisticated analysing tools for CT image quality assurance tests. This study is performed in collaboration with the Phantom Laboratory (US) and Radforin (Iceland).

Lifetime quality of CT scanners from all vendors on the Norwegian market

The aims of the study are: Establishing a complete overview of image quality and radiation dose for CT scanners from all vendors on the Norwegian market, estimate lifetime quality performance for different types of CT scanners from all vendors and evaluate the rec-

ommended quality assurance tests and the frequency necessary to ensure safe patient examinations.

Ultralow dose chest CT

The aim of this study is to compare image quality, radiation dose and laboratory time for chest radiography (CR) with ultra low dose chest CT (ULD-CT) reconstructed with adaptive iterative dose reduction (AIDR 3D). Preliminary results from the pilot was presented on RSNA, and demonstrated that the diagnostic information from ultra low dose CT is superior to that of CR. The corresponding radiation dose and laboratory time leave cost as the only reasonable argument in favour of CR.

HyPerCept

– Color and Quality in higher dimensions: *Optimizing visual and diagnostic image quality in radiography.* In collaboration with the University College of Gjøvik, we will investigate the transfer of knowledge from color imaging in the media industry to the radiography/radiology arena. The goal is to develop new models, and re-use established models, for predicting the diagnostic quality of images in terms of the sensitivity and specificity of diagnostic protocols.

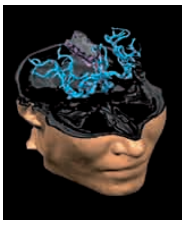
MR IMAGING AND ANALYSIS GROUP | *Group leader: Professor Atle Bjørnerud, PhD*

AIMS

The research focus of the MR Imaging and Analysis (MRIA) Group is related to the application of novel functional MRI methods for improved disease detection and characterization. There is currently a particular focus on MR based imaging for diagnosis, prognosis and treatment response in oncology.

A second focus is the application of multi-modal imaging for early detection of dementia. Finally, the group has a strong track record in implementing and testing novel imaging techniques and in the development of advanced image processing tools with the aim of improving the diagnostic value of new imaging methods in a clinical setting.

The MRIA Group is a multi-disciplinary effort and is collaborating closely with many other groups both internally within the OUS and externally with world-class research groups in Europe and the US. The group also has a close link to industry through collaboration/ co-development with software companies (NordicNeuroLab, Bergen, Norway and CorTechs Labs, SanDiego, USA).
The group has filed several patent applications related to novel image processing techniques which have been sublicensed to our industrial partners.
The MRIA group members are involved in a large number of imaging studies ongoing in the Oslo-region.
In particular, the group provides MR expertise in several morphometric MR studies where high resolution MRI is used to assess neuro-structural changes related to neurodegenerative disease, Alzheimer's disease and normal aging.



The MRIA group been central in the development of an extensive software package for advanced image processing in MRI, with special focus on dynamic analysis. The software package, called nordicICE, is now a commercial product sold in more than 20 countries through our industry partner NordicNeuroLab AS (www.fmri.no).

nordicICE is one of very few medical image analysis software packages for advanced perfusion analysis with full FDA-approval (510K). At Rikshospitalet, nordicICE has been fully integrated into (Sectra) PACS and is now an integral part of routine diagnostic MR procedures, including BOLD fMRI, DTI and perfusion analysis. The MRIA has recently completed a major upgrade of the nordicICE software package for integration into the next generation Sectra PACS (IDS7) and is currently focusing on expanding the functionality of the package towards automated tumor segmentation and implementation of advanced statistical methods for computer aided diagnosis (CAD).

ONGOING PROJECTS

Evaluation of functional Magnetic Resonance in the Diagnosis of Brain Tumors for Assessment of Clinical Efficacy – EMBRACE

This project, financed by the Norwegian Research Council (NRC) and the Southern and Eastern Norway Regional Health Authority, has been the cornerstone of much of our ongoing brain tumor research, resulting in several key publications over the last five years. The project focuses on developing novel methods for improved diagnostics in patients with primary brain tumors.

As part of EMBRACE we are also in the process of completing a two-center study (in collaboration with Harvard/MGH) to investigate if perfusion MRI provides additional relevant radiological information to the neuro-radiologist to the extent that it affects the diagnosis or decision making in brain tumor patients.

A third project is related to the application of perfusion MRI for early detection of malignant transformation of low-grade gliomas. Given the fact that the latency time for malignant transformation of gliomas can be many years, this study is a long-term effort, but the aim is to have preliminary data for publication by end of 2015.

Serial Diagnostic Assessments in Glioblastoma Therapy – SAILOR

This project aims at identifying MRI derived biomarkers for detection of treatment response in patients with glioblastomas. We have established a comprehensive MR protocol including most state-of-the-art imaging techniques used for serial imaging pre-, during- and post- radio-chemo therapy. A total of 27 patients have been followed closely with serial MRI over 1-3 years and the study is now close to completion. To date, we have published several articles focusing on the methodology used, but expect to have analyzed outcome data by the end of 2015.

Mapping the vessel architecture of cancer – LOOPS

This project focuses a novel MRI analysis method termed 'Vessel Architectural Imaging' (VAI), which is a unique method for non-invasive micro-vessel characterization (vessel diameter, type and function) and may in addition provide information about oxygen extraction. This information is of critical importance in brain tumor patients and we have shown that VAI based imaging provides unique biomarkers for stratification of patients with aggressive brain tumors undergoing anti-angiogenic treatment. The main aim of the LOOPS project (supported by the Southern and Eastern Norway Regional Health Authority) is to implement the VAI method on key centers across Norway and to test the method as a means of predicting treatment response in patients with brain metastases and finally to validate the technique against complimentary analysis methods, The project with be performed in close collaboration with researchers at Harvard University and Massachusetts General Hospital i Boston, USA.

Automated white matter lesion quantification

This project conducted in collaboration with the Dept of Neurology at Akershus University Hosptial and Department of Artificial Intelligence, UNED, Madrid, Spain with the aim of developing fully automated methods for segmentation and characterization of white matter lesions (WML) in the brain from MR images. WML is known to be an early marker for many pathological processes related to neurodegeneration and dementia and quantification of WML extent is therefore of significant clinical importance. Manual WML segmentation is time consuming and prone to user bias and automated methods are therefore greatly needed. Trough our collaboration with colleagues in Madrid, we have developed a comprehensive toolbox named AMOS for automated WML segmentation. The tool is being tested in large patient cohorts and further developments are in progress to extend its application to segmentation of MS lesions and brain tumors.

The OxyTarget study – Functional MRI of Hypoxia-mediated Rectal Cancer Aggressiveness

The primary objective of this project is to establish a reliable method for detection of rectal cancer patients who have aggressive tumors at risk for early metastatic disease and death using functional MRI.

Single Bolus Split Dynamic MRI: A Novel Method for Combined Morphologic and Functional Assessments of Breast Masses

This project tests, using simulations and clinical data, the feasibility of combining high temporal resolution dynamic sequence for quantitative assessments of both T1-weighted and R2* characteristics in breast masses interleaved with a high spatial resolution acquisition following a single CA injection.

MRI-derived Cellularity Index as a Potential Non-invasive Imaging Biomarker for Prostate Cancer

The purpose of this project is to improve prostate tumor diagnosis and patient stratification by delivering novel non-invasive diagnostic MR techniques providing increased sensitivity and tumor grade specificity to help predict tumor malignancy and extraprostatic extension.

Prediction of radiation therapy response by MRI and PET

This is a substudy to ANCARAD – prospektive study of anal cancer at OUS and the aim of the study is to assess the value of Intra voxel incoherent motion (IVIM-) and DWI-measurements in predicting response to radiation therapy.

MyoGlu

A study addressing the effects of physical activity on insulin sensitivity, body composition and some hormones from adipose tissue and skeletal muscle – a 12 weeks training intervention in normal weight controls and overweight subjects with prediabetes. Total body fat fraction and fat distribution pre and post training intervention was assessed by whole body MRI. Liver, pancreas and muscle fat fractions were measured by MRS.

Prevention of cardiac dysfuntion during adjuvant breast cancer therapy (PRADA)

A study adressing the use of cardio-protective medicination in relation to cytostatic treatment of breast cancer. Cardiac function is measured by MRI (CMRI). An MRI based quantitative assessment of extracellular volume is tested as an early marker of cardiac dysfunction.

Pre-clinical genotype-phenotype predictors of Alzheimer's disease and other dementias (APGeM).

Multi-institutional project, supported by the EU joint programme on neuro-degenerative disease research (JPND) with the overall aim to establish genotype-phenotype matching in incipient Alzheimer's disease and Lewy-body diseases. IVS is a collaborating partner in the project in charge of the image and analysis work-package.

Section of Anesthesia Research

Section manager: Steinar Halvorsen MD, PhD

RESEARCH AREA

Clinical and experimental cardiovascular monitoring

The research group`s aims is to develop and test new technologies for cardio-vascular monitoring and to evaluate hemodynamic response of new and advanced cardiovascular image guided procedures and advanced treatment for end stage heart failure with ventricular assist devices (VAD). New technologies developed or investigated for measuring cardiac function and hemodynamic status include implantable 3D accelero-meters, miniaturized ultrasound sensors, biosensors and radar technology. The sensors are tested in both clinical and experimental models in cooperation with many departments at OUS and external institutions.

AIMS

- **To detect regional and global myocardial ischemia with implantable sensor systems**
- **Evaluate left and right ventricular function by use of implantable sensors**
- **Monitoring of VAD with accelerometer**
- **Evaluate the effect of therapeutic hypothermia on cardiac function**
- **Evaluate the role of extra corporeal membrane oxygenation after cardiac arrest**
- **Describe cardiovascular response to trans aortic valve implantation (TAVI)**
- **Establish new prognostic markers for mortality and morbidity after the TAVI**

ONGOING PROJECTS

- Intraoperative monitoring during TAVI: can immediate improvement in longitudinal systolic motion predict short and long term outcome after TAVI?
- Accelerometer for detection of thrombo-embolic events in VAD
- Accelerometer for monitoring changes in pre- and after-load to VAD
- Accelerometers for monitoring left and right ventricular function after aortic valve replacement
- Can therapeutic hypothermia improve left ventricular function after cardiac arrest: an experimental ECMO study
- Can beta-blockers improve survival after cardiac arrest: an experimental ECMO study
- Left and right ventricular dysfunction in severe sepsis: the role of upstream and down stream immune activation

COLLABORATORS

OSCAR research network at Oslo University Hospital: Professor K. Sunde

Complement Research Group at IMMI, Oslo University Hospital: Professor Tom Eirik Mollnes

Biosensor Research Group at Department of Anesthesilogy and Critical Care Medicine: Professor T. I. Tønnessen and Professor Erik Fosse, MD, PhD, The Intervention Centre

Professor Thor Edvardsen, MD, PhD, Dept of Cardiology

Professor Arnt Fiane, Dept of Cardiothoraic Surgery

Professor Svend Aakhus, MD, PhD, Dept of Cardiology

Jan Fredrik Bugge, MD, PhD, Dept of Anesthesilogy and Critical Care Medicine

Helge Skulstad, MD, PhD, Dept of Cardiology

STAFF

Clinical staff

Anesthesilogists

Steinar Halvorsen, MD, PhD
Jan Hovdenes, MD, PhD

Nurse anesthetists

Anton A. Josephmary
Kari Westby
Kjersti Wendt
Torill Schou

PhD students

Viesturs Kerans, MD
Ole-Johannes Grymyr, MD
Harald Bergan, MD
Jo Eidet, MD
Stefan Hyler, MD
Siv Hestenes, MD
Itai Scalit, MD
Kristin Wissløf-Aase, MD

Post Doc

Andreas Espinoza, MD, PhD

Section for Method Development and Industrial Cooperation (SMI) *Section manager: Jacob Bergsland MD, PhD*

RESEARCH AREA

The section was established in 2013 to focus on the IVC s role as a department for developing and testing new minimally and less invasive therapies.

The section facilitates cooperation with Norwegian and International MedTech Industry. This activity spans the scope from assisting entrepreneurs to performing contract research with large corporations in the medical sector. The projects are usually performed in cooperation with the other sections and with external partners.

AIMS

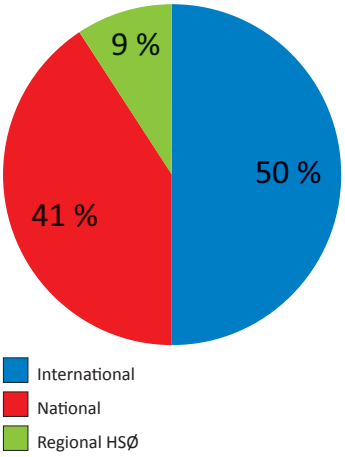
- **Development and Implementation of Departmental Quality Control Systems**
- **Assist in IVCs Certification and Accreditation Process**
- **Industrial and Grunder MedTech Development Projects**
- **Participant in Health Technology**
- **Assessment Initiatives**
- **Consulting related to Health Economy**

STAFF

Section Manager, Jacob Bergsland, MD, PhD
Project Leader, Karl Øyri, RN, PhD
Research Coordinator, Leif-Petter Rustad
Quality Coordinator, Bjørn Tjønnås
Health Economist, Milena Lewandowska, M.Sc (until oct 2015)

IVS / TESTBED ACTIVITIES

Request´s origin



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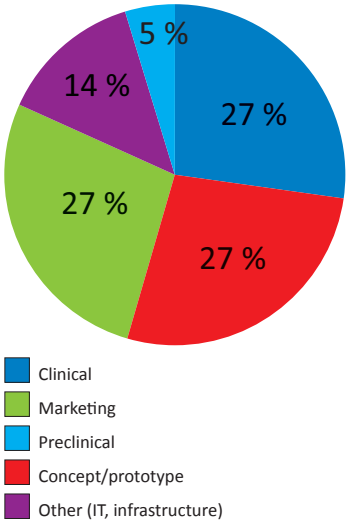


Section for Clinical Research

Section manager professor Bjørn Edwin, MD, PhD

ACTIVITY

The Section for Clinical Research is responsible for the ongoing clinical projects at The Intervention Centre.

Several new techniques in laparoscopic surgery have been introduced in Norway through this group. Some of the methods are now routine procedures, The group validates new procedures and establishes effective training.

Education programs in minimally invasive surgery in both gastro-, intestinal- and urological surgery are organized in collaboration with other hospitals in Norway, Sweden, Denmark, Finland, Germany, Armenia, Belgium, Palestine and UK.

The Department of Surgery is one of our main collaborators with research projects ongoing in:

- Minimal invasive surgery on the liver, pancreas, adrenal gland and colon/rectum
- Minimal invasive techniques in children
- Thermal liver ablation (HIFU and RF)

IMAGE-GUIDED SURGERY AND MINIMAL INTERVENTION | *Leader prof. Bjørn Edwin, MD, PhD*

ACTIVITY

Development and assessment of minimal invasive therapy in all surgical fields.

Development and assessment of local ablation in liver malignances, Cryotherapy, Radio frequency ablation and High Intensity focused ultrasound (HIFU).

Development of and assessment of Implants from Bio-medical material, (percutaneus implants for stomas).

Development and assessment of a 3D map for liver and pancreas used to navigate before and during the navigation.

Development and assessment of a new database platform including possibilities to make data from this platform anonymous and use them in public search engine, e.g. PubGen.

Development and assessment of training programs for laparoscopic and single port surgery (LESS).

LONG TERM GOALS

Completion of above mentioned research program. Initiate, stimulate and assess more advanced minimal invasive procedures, e.g. Whipple's procedure and advanced liver resections. Assessment of 3D vision to see if 3D will simplify laparoscopic surgery. Assess use of robots in surgery.

ONGOING PROJECTS

OsloCoMet-study:

Oslo randomized laparoscopic vs. open liver resection for colorectal metastases – study.

Study 1: **Surgical stress and Immunosupression**

To compare stress and immunosuppression following laparoscopic and open liver resection.

Study 2: **Immediate and short term outcomes**

To compare intraoperative and early postoperative outcomes, and immediate oncologic outcomes.

Study 3: **Postoperative pain and quality of life**

- To compare health related quality of life before the procedure, on 2nd postoperative day and in 4, 8, 12 months after the procedure.
- To compare pain on the 2. postoperative day and after 1 month.

Study 4: **Repeat resections**

To define and compare surgical outcomes and major oncologic indexes between sub-groups of repeat resections.

Studies 5-6: **Long term oncologic outcomes**

- To define and compare major oncologic indexes in the 3 and 5 year follow-up period (study 5).
- To define and compare major oncologic indexes in 10 year follow-up period (study 6).

Study 7: **CoMet Mol**

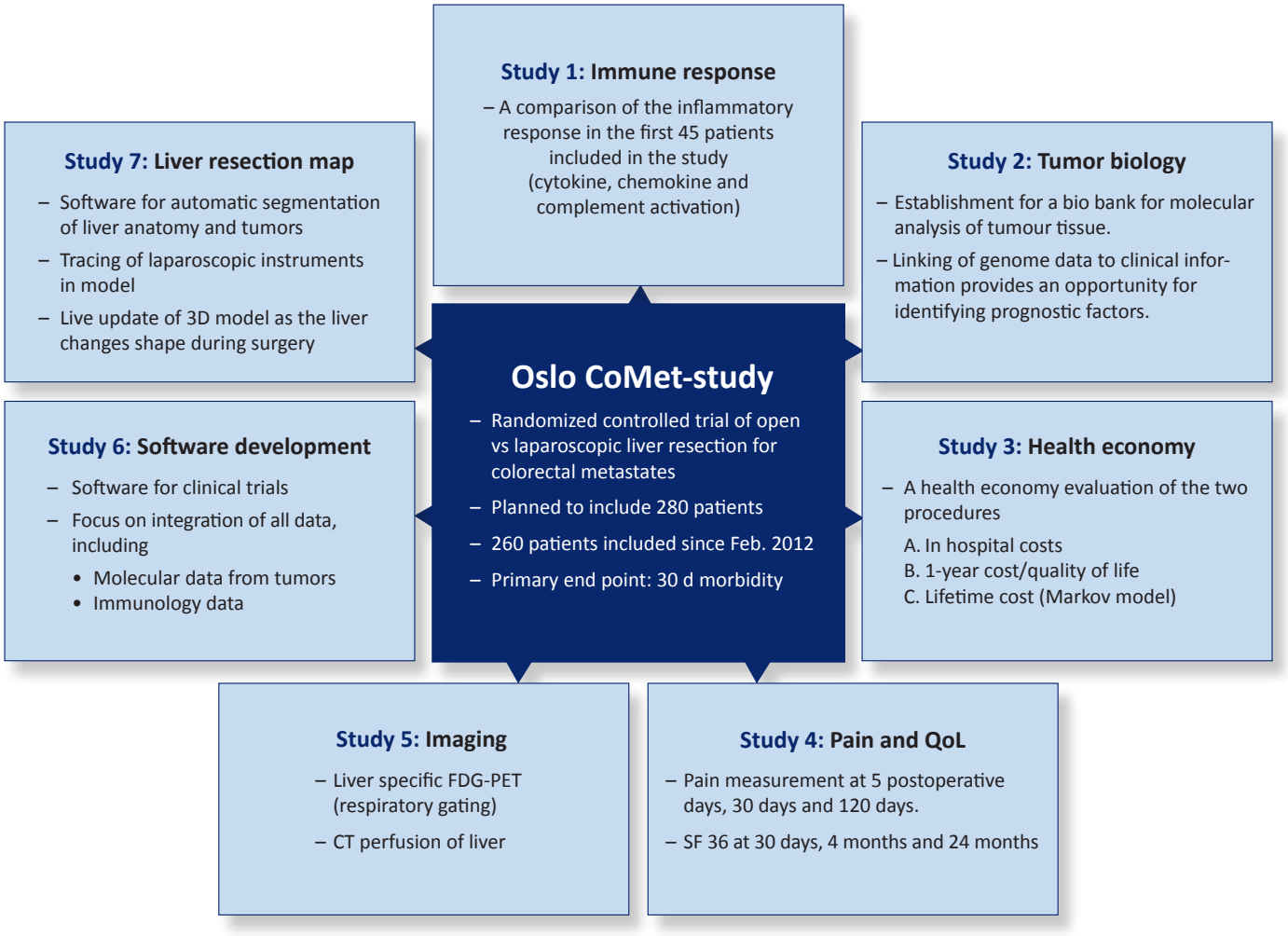
The aim is to perform molecular characterization of biological samples harvested perioperatively (Biobank) and during follow-up and results correlated with clinical end points.

Study 8: **CoMet anti-tumor immunology**

The aim is to evaluate immunological parameters related to anti-tumour immunity and inflammatory factors.

Study 9: **CoMet Imaging**

The aim is to compare CT perfusion to conventional CT and MRI, with respect to the detection of liver metastases from colorectal carcinoma.



***Project* TAVI**

***Project* MitraClip**

***Project* MecMed**
(COREMINE/Metajournal)

***Project* 3D map and navigation** (liver and pancreas)

PHD CANDIDATES

Åsmund Avdem Fretland
Kim Ånonsen
Milan Spasojevic
Sven Petter Haugvik
Leonid Barkhatov
Martin Johansson
Rahul P. Kumar
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Jens Marius Næssgård
Musheg Sahakyan
Gudrun Waaler Bjørnelv
Vegar Dagenborg
Rafael Palomar

COLLABORATION

SimSurgery, Oslo

Nasjonalt kompetansetjeneste for ultralyd og bilde-veiledet behandling, Trondheim

Tumorbiologi, Radiumhospitalet, OUS

PubGen, Oslo

A strong cooperation between the different research groups in The Intervention Centre:

Prof Robert Troisi, Dept. of General and Hepato-Biliary Surgery and Liver Transplantation Service, Ghent University Hospital Medical School, Belgium.

Ass. Prof Mohammad Abu Hilal, Faculty of Medicine, Southampton University, Research and development lead for Surgery, Southampton University hospital – Great Britain.

Prof Luca Aldrighetti Chief of Liver Unit, Department of Surgery,Scientific Institute San Raffaele, University Vita-Salute San Raffaele, Milan, Italy.

Prof Alessandro Ferrero, Direttore f.f. S.C. Chirurgia Generale ed Oncologica Ospedale Mauriziano, Torino, Italy.

Section for Radiology Research

Section Manager Professor Per Kristian Hol, MD, PhD

RESEARCH AREA

A number of research projects using the 3T MR scanner or the combined angiographic suite are performed in corporation with different academic partners, including Departments of Neuropsychiatry and Psychosomatic Medicine, Department of Nutrition, Oncology, Ear Nose and Throat, Neurosurgery, Neurology, Anesthesiology and Radiology.
The research topics cover brain, spine, liver, prostate, brachial plexus and inner ear.
High Intensity Focused Ultrasound (HIFU)-therapy is a completely non-invasive ablation method, 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. At the Intervention Centre focus has been on both basic and clinical MR-guided HIFU research projects. Organs to be studied have been uterus (uterine fibroids), liver and prostate.

AIMS

The aim is to be nationally and internationally leading research environment in MR- and hybrid angio-guided treatment, including MR-guided High Intensity Focused Ultrasound therapy.

ONGOING PROJECTS

MR-guided HIFU of the prostate
MR-guided HIFU of the liver
MR-guided HIFU of uterine fibroids
Axillary plexus block assessed by MRI
The vulnerable carotid artery plaque
Bipolar disorders and cortical thinning
MR-guided neurosurgery
Nutrition, growth and development of premature children
Cochlea implants in hybrid operating room

STAFF

Scientific staff
Per Kristian Hol, Professor, MD, PhD
Grethe Løvland, BSc
Svein Are Vatnehol, MSc
Hilde Korslund, BSc

Affiliated scientific staff
Frederic Courivaud, PhD
Tryggve Storås, PhD
Bjørn Edwin, Professor, MD, PhD
Eric Dorenberg, MD, PhD
Torstein Meling, MD, PhD
David Russell, Professor, MD, PhD
Ulrik Malt, Professor, MD, PhD

PhD students
Ulrik Carling, MD
Trygve Kjelstrup, MD

Affiliated PhD students
Karolina Ryeng Skagen
Erlend Bøen

Affiliated post doc student
Einar Vik-Mo

COLLABORATIONS

- Philips Medical System
- Siemens Healthcare
- Research group of cognitive and clinical neuroscience, Dept of Psychology
- Norwegian School of Veterinary Science (Professor Lars Moe)

Section for Technology Research

Section manager professor Ole Jakob Elle, associate professor, PhD

CLINICAL ACTIVITY

The Section for Technology Research at The Intervention Centre aims to develop cutting edge technological solutions which support minimally invasive procedures and intraoperative monitoring.

In addition to the research group members, the section has 4.3 permanent employees with various technological backgrounds supporting research at the operating suites, all with PhD degree and 20% academic positions as professors or associate professors.

The R&D covers a span of different technologies like bio-sensor technology and communication technology including wireless communication, image processing and visualisation, navigation technology and robotics. Lately also 3D printing of organs for patient specific planning of treatment has become an activity.

What is a common aim is that our technology is mainly addressing solutions for planning preoperatively and for intra-operative update. The solutions should give more information to the surgeon, such as sensor information and image information, during intervention and presenting this information by realtime visualization.

MEDICAL ROBOTICS VISUALISATION AND NAVIGATION

Group leader Associate professor Ole Jakob Elle, PhD

RESEARCH PROFILE

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 ultrasound or endoscopic images to be able to monitor the surgery 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. The research focus is on image processing methods that 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. Visualization and navigation is required to present the medical images to the surgeon intra-operatively. We are developing visualization systems which use advanced techniques such as augmented reality and volume rendering for this purpose.

Robotic surgery which so far primarily has been tele-manipulators like Da Vinci, will in the future in addition to use real-time sensors like force/torque, inertia (accelerometer/gyro) and 3D video be more and more cross-linked with medical image information and move toward automation of surgical procedures. The research group is doing research in all these fields of technology facilitating minimally invasive surgery.

LONG TERM GOALS

The research group aims to be nationally and internationally leading research environment for technological solutions for image guided minimally invasive treatment. The group will strive to have competent personnel within the following technological areas:

- Real-time Image-processing (image- and video analysis, segmentation)
- Real-time volume visualisation
- Navigation technology
- Robotic technology
- Real-time sensing
- Technology support to Minimally Invasive Treatment in the hybrid OR's in general

PROJECTS

The section is partly financed through the hospital (permanent staff), but to a larger extent through projects funded by NFR and EU. We are currently participating in 3 EU-projects as well as several NFR-projects and projects financed by Innovasjon Norge.

Projects:

Ended EU-projects:

- IIIOS (Integrated Intra-operative Imaging Operating System)
- SCath (Smart Catheterization)

Ongoing EU-project:

- I-SUR (Intelligent Surgical Robotics)

Ongoing NFR:

- NorMIT, National Research Infrastructur for Minimally Invasive Treatment
- HyperCept, Colour and Quality in Higher Dimensions, SHP-project financed by NFR, Coordinated by The Norwegian Colour and Visual Computing Laboratory at Gjøvik University College

Ongoing Helse Sør-Øst:

- Hepa-Navi, Liver Navigation platform (Postdoc)
- Fast vessel segmentation algorithm (Innovation)
- Multi-modal Visualization Tool for monitoring heart patients (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
- exploring 3D printing of organs for planning and training

Media:

- NRK Østlandssendingen, on automatic surgery and semi-autonomous ultrasound robot (December 2014)
- TV2 Frokost TV, 3D printing of organ models (December 2014)

NorMIT
Coordination of a sub-project of NorMIT (National Navigation Platform for image guided threatment) for the establishement of a common national navigation platform for image guided treatment. NFR funded the two-node project NorMIT (St.Olavs Hospital (FOR) and The Intervention Centre, OUS) national infrastructure for minimally invasive therapy.

HyperCept
The research group has a collaboration on video processing in Video assisted surgery with Norwegian Colour and Visual Computing Laboratory, Faculty of Computer, Science and Media Technology Gjøvik University College. Two PhD fellows are connected financed through the HyperCept-project (NFR), one with main supervision from the research group and the other co-supervised from the same.

I-SUR (Intelligent Surgical Robotics)
This project addresses a very complex problem that can be expressed in a very simple form: is it possible to automate surgery? To explore the feasibility of a solution to this problem, in this project we develop general methods for cognitive surgical robots capable of combining sensing, dexterity and cognitive capabilities to carry out autonomously simple surgical actions, such as puncturing, cutting and suturing.

GROUP MEMBERS

Ole Jakob Elle, *Section Manager – Technology Research /Associate. Prof., PhD*
Frederic Courivaud, *Senior Researcher, PhD*
Espen Remme, *Senior Researcher, PhD*
Laura Slaughter, *Senior Researcher/Ass. Prof., PhD*
Hugues Fontenelle, *Senior Researcher, PhD*
Phuong Nguyen, *Postdoc, PhD*
Rafael Palomar, *PhD fellow, MSc, co-supervised at University College Gjøvik and Univ 13 of Paris*
Rahul Kumar, *PhD fellow, MSc*
Dilla Handini, *PhD fellow, MSc*
Magnus Krogh, *PhD fellow*
Kim Mathiassen, *PhD fellow, MSc (also at ROBIN-group at IFI/UIO)*
Ralf Greisiger, *PhD fellow, MSc (also at ROBIN-group at IFI/UIO)*
Egil Utheim, *Researcher, MSc*
Bilel Sdiri, *PhD fellow co-supervised together with University College Gjøvik and Univ 13 of Paris*

COLLABORATIONS

- 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
- 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

WIRELESS SENSOR NETWORK RESEARCH | *Group leader Professor Ilangko Balasingham*

CHALLENGES

The research group performs fundamental research and development on wireless sensors and systems for applications in diagnostics, minimal invasive therapies, 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 (coding. modulation, antenna, etc.), low power sensor data compression, and signal and image processing algorithms for anomaly detection, data fusion, etc.

Special interest topics are in wireless pacemaker, capsule endoscopes, brain machine interface, and nano scale communication technologies using nanomaterials and synthetic biology.

PROJECTS

European Commission
Coordinator/PI of Wireless In-Body Environment Communications (WiBEC), (H2020- MARIE Skodowska-CURIE ACTIONS (MSCA-ITN-2015), 01.01.2016-31.12.2019, budget €3.957 mill)

Research Council of Norway
Work Package Leader/PI of Holistic Monitoring of Indoor Environment (HOME) (Idea Lab Program, 01.09.2014 - 31.12.2016, budget NOK 10 million)

Project Manager/PI of Medical Sensing, Communications, and Localization Using Ultra Wideband Technology (MELODY, Phase II) (VERDIKT/ ICT2015 Program, 01.01.2013 - 31.07.2017, budget NOK 14.7 million)

Co-PI Adaptive Security for Smart Internet of Things in eHealth (ASSET) (VERDIKT Program, 02.01.2012 - 31.12.2015, budget NOK 13.2 million)

The Norwegian Ministry of Foreign Affairs
PI of Norway Balkan Project (NORBAS), (The HERD/ICT Balkan Program, 01.01.2012 - 31.12.2015, budget NOK 6.25 million)

Health South East
Project Manager/PI of Medical Cloud and Cancer Diagnostic APP, (Innovation Grant, 01.09.2014 - 31.12.2015, budget NOK 1.5 million)

GROUP MEMBERS

Ilangko Balasingham, *prof., group leader*
Pål Anders Floor, *Postdoc*
Raul Chavez-Santiago, *Postdoc*
Fabio Mesiti, *Postdoc*
Miloud Bagaa, *Postdoc*
Juan Felipe Miranda Medina, *Postdoc*
Kasif Habib Sheik, *PhD student*
Bjørn Rustad, *PhD student*

COLLABORATIONS

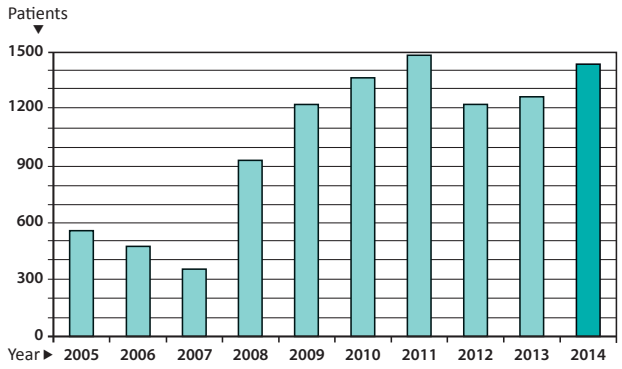
Signal Processing Group, Dept. of Electronics and Telecom.
NTNU, Trondheim, Norway

Øyvind Janbu, *PhD student*
Mladen Veletic, *PhD student*
Hamed Fouladi, *PhD student*
Karl Øyri, *PhD student*
Lars Erik Solberg, *PhD student*
Anders Bjørnevik, *MSc student*
Alicja Kwaśniewska, *MSc student*

Scientific statistics

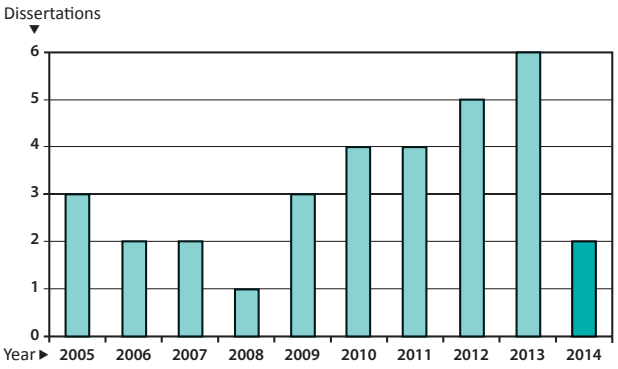
The Intervention Centre 2014

PATIENTS AT THE INTERVENTION CENTRE 2005 – 2014



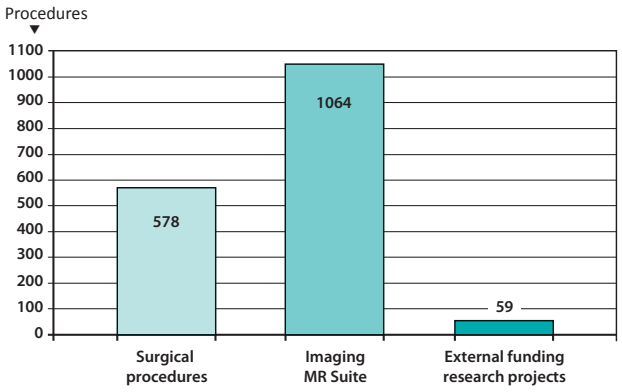
Source: Datacor

DISSERTATIONS AT THE INTERVENTION CENTRE 2005 – 2014 n: 32



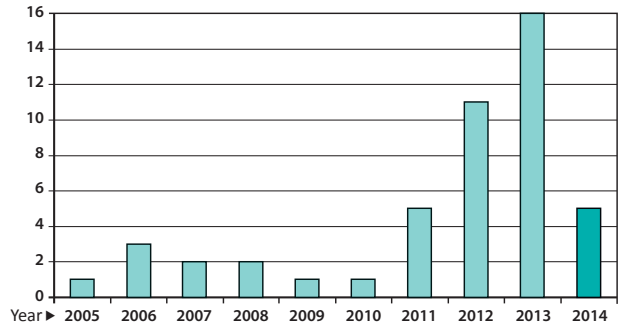
Source: Datacor

ACTIVITIES IN THE SURGICAL AND DIAGNOSTIC SUITES AT THE INTERVENTION CENTRE IN 2014

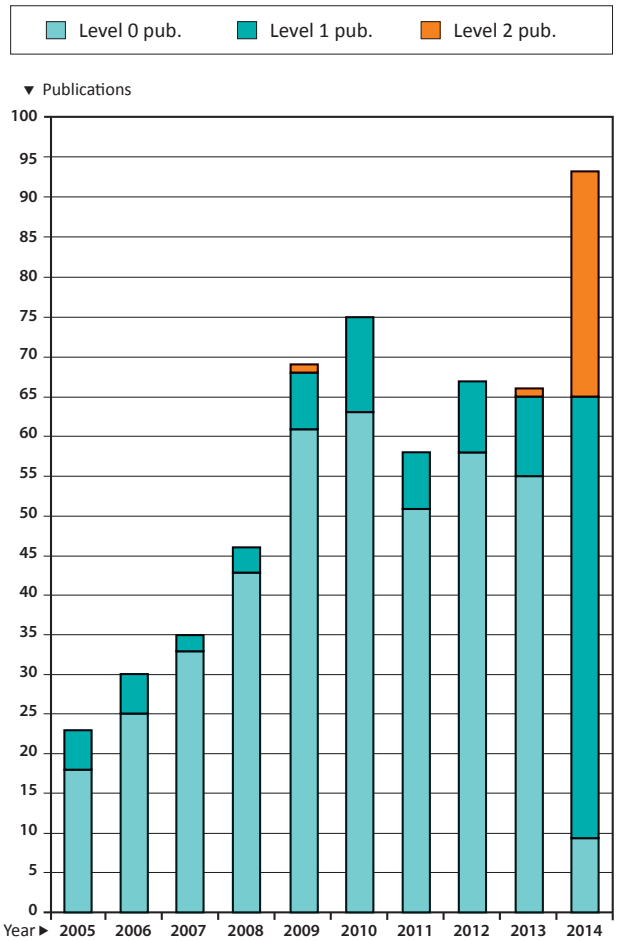


DESCRIPTION OF INVENTION (DOFI´s) SUBMITTED TO INVEN2

Inven2 is the Technology Transfer Organisation of Oslo University Hospital and University of Oslo



PEER REVIEWED SCIENTIFIC PUBLICATIONS 2005 – 2014




ALM
OLYMPUS
SONY
MAQUET

Budget and expenditures

Internal hospital funds administered by the Intervention Centre in 2014

	ALLOCATED	INCOME	RESULT
Total	**39.915**	**6.679**	**697**

External funds administered by the Intervention Centre in 2014

SOURCE		AWARDED GRANTS 2014	RESEARCH EXPENDITURES
Research of Norway	NFR	11 481 921	5 158
Regional Health Authority	HSØ	11 649 998	8 436
European Commission	EU	1 232 800	1 675
University of Oslo	UiO	62 500	163 000
Norwegian Cancer Society		1 657 000	778
Norsk Designråd		520 000	60 000
Others		711 667	221 000
Total in NOK:		**27 315 886**	**16 157**

Publications

Scientific publications[1] from The Intervention Centre 2014

1 Scientific channels are journals, series and publishers that fulfill specific criteria given by the Norwegian register for scientific journals, series and publishers (NSD: *www.dbh.nsd.uib.no/kanaler*). There are two levels: **Ordinary publication channels** (level 1) and **highly prestigious publication channels** (level 2).

LEVEL 2

1. *Anzai D, Katsu K, Chavez-Santiago R, Wang Q, Plettemeier D, Wang JQ, Balasingham I.*
Experimental Evaluation of Implant UWB-IR Transmission With Living Animal for Body Area Networks.
IEEE Trans. Microw. Theory Tech.62(1):183-192.

2. *Auning E, Selnes P, Grambaite R, Šaltytė Benth J, Haram A, Løvli Stav A, Bjørnerud A, Hessen E, Hol PK, Muftuler Løndalen A, Fladby T, Aarsland D.*
Neurobiological correlates of depressive symptoms in people with subjective and mild cognitive impairment.
Acta Psychiatr Scand.131(2):139-47.

3. *Brabrand K, de Lange C, Emblem KE, Reinholt FP, Saugstad OD, Stokke ES, Munkeby BH.*
Contrast-enhanced ultrasound identifies reduced overall and regional renal perfusion during global hypoxia in piglets.
Invest Radiol.49(8):540-6.

4. *Byun SS, Balasingham I, Vasilakos A, Lee H.*
Computation of an equilibrium in spectrum markets for cognitive radio networks.
IEEE transactions on computers.2014;63(2):304-16.

5. *Bøen E, Westlye LT, Elvsåshagen T, Hummelen B, Hol PK, Boye B, Andersson S, Karterud S, Malt UF.*
Smaller stress-sensitive hippocampal subfields in women with borderline personality disorder without posttraumatic stress disorder.
J Psychiatry Neurosci.39(2):127-34.

6. *Courivaud F, Kazaryan AM, Lund A, Orszagh VC, Svindland A, Marangos IP, Halvorsen PS, Jebsen P, Fosse E, Hol PK, Edwin B.*
Thermal fixation of swine liver tissue after magnetic resonance-guided high-intensity focused ultrasound ablation.
Ultrasound Med Biol.40(7):1564-77.

7. *Elvsåshagen T, Moberget T, Bøen E, Hol PK, Malt UF, Andersson S, Westlye LT*
The surface area of early visual cortex predicts the amplitude of the visual evoked potential.
Brain Struct Funct.220(2):1229-36.

8. *Emblem KE, Due-Tonnessen P, Hald JK, Bjornerud A, Pinho MC, Scheie D, Schad LR, Meling TR, Zoellner FG.*
Machine learning in preoperative glioma MRI: survival associations by perfusion-based support vector machine outperforms traditional MRI.
J Magn Reson Imaging.2014 Jul;40(1):47-54.

9. *Emblem KE, Pinho MC, Zöllner FG, Due-Tonnessen P, Hald JK, Schad LR, Meling TR, Rapalino O, Bjornerud A.*
A generic support vector machine model for preoperative glioma survival associations.
Radiology.275(1):228-34.

10. *Grøvik E, Bjørnerud A, Kurz KD, Kingsrød M, Sandhaug M, Storås TH, Gjesdal KI.*
Single bolus split dynamic MRI: Is the combination of high spatial and dual-echo high temporal resolution interleaved sequences useful in the differential diagnosis of breast masses?
J Magn Reson Imaging.42(1):180-7.

11. *Grøvik E, Bjørnerud A, Storås TH, Gjesdal KI.*
Split dynamic MRI: single bolus high spatial-temporal resolution and multi contrast evaluation of breast lesions.
J Magn Reson Imaging.2014 Mar;39(3):673-82.

12. *Hestenes SM, Halvorsen PS, Skulstad H, Remme EW, Espinoza A, Hyler S, Bugge JF, Fosse E, Nielsen EW, Edvardsen T.*
Advantages of strain echocardiography in assessment of myocardial function in severe sepsis: an experimental study.
Crit Care Med, 42(6):e432-40.

13. *Hope TR, Vardal J, Bjørnerud A, Larsson C, Arnesen MR, Salo RA, Groote IR.*
Serial diffusion tensor imaging for early detection of radiation-induced injuries to normal-appearing white matter in high-grade glioma patients.
J Magn Reson Imaging.41(2):414-23.

14. *Huber-Lang M, Barratt-Due A, Pischke SE, Sandanger Ø, Nilsson PH, Nunn MA, Denk S, Gaus W, Espevik T, Mollnes TE.*
Double blockade of CD14 and complement C5 abolishes the cytokine storm and improves morbidity and survival in polymicrobial sepsis in mice.
J Immunol.192(11):5324-31.

15. *Jensen K, Martinsen AC, Tingberg A, Aaløkken TM, Fosse E.*
Comparing five different iterative reconstruction algorithms for computed tomography in an ROC study
Eur Radiol.
24(12):2989-3002.

16. *Kalpathy-Cramer J, Gerstner ER, Emblem KE, Andronesi OC, Rosen B.*
Advanced magnetic resonance imaging of the physical processes in human glioblastoma.
Cancer Res.74(17):4622-37.

17. *Kleppestø M, Larsson C, Groote I, Salo R, Vardal J, Courivaud F, Bjørnerud A.*
T2*-correction in dynamic contrast-enhanced MRI from double-echo acquisitions.
J Magn Reson Imaging. 2014 May;39(5):1314-9.

18. *Krogsrud SK, Tamnes CK, Fjell AM, Amlien I, Grydeland H, Sulutvedt U, Due-Tønnessen P, Bjørnerud A, Sølsnes AE, Håberg AK, Skrane J, Walhovd KB.*
Development of hippocampal subfield volumes from 4 to 22 years.
Hum Brain Mapp.35(11):5646-57.

19. *Krogvold L, Edwin B, Buanes T, Frisk G, Skog O, Anagandula M, Korsgren O, Undlien D, Eike MC, Richardson SJ, Leete P, Morgan NG, Oikarinen S, Oikarinen M, Laiho JE, Hyöty H, Ludvigsson J, Hanssen KF, Dahl-Jørgensen K.*
Detection of a low-grade enteroviral infection in the islets of langerhans of living patients newly diagnosed with type 1 diabetes.
Diabetes.64(5):1682-7.

20. *Larsson C, Kleppestø M, Grothe I, Vardal J, Bjørnerud A.*
T1 in high-grade glioma and the influence of different measurement strategies on parameter estimations in DCE-MRI.
J Magn Reson Imaging.42(1):97-104.

21. *Nilsen LB, Fangberget A, Geier OM, Engebraaten O, Borgen E, Olsen DR, Seierstad T.*
Associations between tumor vascularization assessed by in vivo DCE-MRI and the presence of disseminated tumor cells in bone marrow in breast cancer patients at the time of diagnosis.
J Magn Reson Imaging.40(6):1382-91.

22. *Schoultz BW, Hjørnevik T, Reed BJ, Marton J, Coello CS, Willoch F, Henriksen G.*
Synthesis and evaluation of three structurally related ^{18}F-labeled orvinols of different intrinsic activities: 6-O-[^{18}F]fluoroethyl-diprenorphine ([^{18}F]FDPN), 6-O-[^{18}F]fluoroethyl-buprenorphine ([^{18}F]FBPN), and 6-O-[^{18}F]fluoroethyl-phenethyl-orvinol ([^{18}F]FPEO).
J Med Chem. 57(12):5464-9.

23. *Vardal J, Salo RA, Larsson C, Dale AM, Holland D, Groote IR, Bjørnerud A.*
Correction of B0-distortions in echo-planar-imaging-based perfusion-weighted MRI.
J Magn Reson Imaging.2014 Mar;39(3):722-8.

24. *Walhovd KB, Tamnes CK, Bjørnerud A, Due-Tønnessen P, Holland D, Dale AM, Fjell AM.*
Maturation of Cortico-Subcortical Structural Networks-Segregation and Overlap of Medial Temporal and Fronto-Striatal Systems in Development.
Cereb Cortex.25(7):1835-41.

25. *White NS, McDonald CR, Farid N, Kuperman J, Karow D, Schenker-Ahmed NM, Bartsch H, Rakow-Penner R, Holland D, Shabaik A, Bjørnerud A, Hope T, Hattangadi-Gluth J, Liss M, Parsons JK, Chen CC, Raman S, Margolis D, Reiter RE, Marks L, Kesari S, Mundt AJ, Kaine CJ, Carter BS, Bradley WG, Dale AM.*
Diffusion-weighted imaging in cancer: physical foundations and applications of restriction spectrum imaging.
Cancer Res.2014 Sep1;74(17):4638-52.

LEVEL 1

1. *Afridi SA, Kazaryan AM, Marangos IP, Røsok BI, Fretland ÅA, Yaqub S, Edwin B.*
Laparoscopic surgery for solid pseudopapillary tumor of the pancreas.
JSLS.18(2):236-42.

2. *Andersen HK, Jensen K, Berstad AE, Aaløkken TM, Kristiansen J, von Gohren Edwin B, Hagen G, Martinsen AC.*
Choosing the best reconstruction technique in abdominal computed tomography: a systematic approach.
J Comput Assist Tomogr.38(6):853-8.

3. *Andresen B, Andersen MH, Lindberg H, Døhlen G, Fosse E .*
Perceived health after percutaneous pulmonary valve implantation: in-depth interviews of patients and next-of-kin.
BMJ Open.4(7):e005102.

4. *Auning E, Kjærvik VK, Selnes P, Aarsland D, Haram A, Bjørnerud A, Hessen E, Esnaashari A, Fladby T.*
White matter integrity and cognition in Parkinson's disease: a cross-sectional study.
BMJ Open.4(1):e003976.

5. *Bergsland J, Elle OJ, Fosse E.*
Barriers to medical device innovation.
Med Devices (Auckl).7:205-9.

6. *Byun SS, Kansanen K, Balasingham I, Gil JM.*
Achieving Fair Spectrum Allocation and Reduced Spectrum Handoff in Wireless Sensor Networks: Modeling via Biobjective Optimization. Modelling and Simulation in Engineering.
Article ID 406462.12.

7. *Chavez-Santiago R, Balasingham I.*
Propagation Models for In-Body Sensors. General Assembly and Scientific Symposium (URSI GASS) XXXIth URSI.
IEEE Communications Society.2014;p.1-4.

8. *Chavez-Santiago R, García-Pardo C, Fornes-Leal A, Vallés-Lluch A, Balasingham I, Cardona N.*
Ultra Wideband Propagation for Future In-Body Sensor Networks. 2014 IEEE 25th Annual International Symposium on Personal, Indoor, and Mobile Radio Communications (PIMRC).
IEEE Communications Society.2014;pp.2183-2186.

9. *Chavez-Santiago R, Jankunas D, Fomin VV, Balasingham I.*
Dual-Band Cognitive Radio for Wearable Sensors in Hospitals. 2014 8th International Symposium on Medical Information and Communication Technology (ISMICT).
IEEE Communications Society.2014;pp.1-4.

10. *Chavez-Santiago R, Balasinghann I.*
Ultrawideband Signals in Medicine.
IEEE Signal Process. Mag.31(6):130-136.

11. *Chavez-Santiago R, Khaleghi A, Balasingham I.*
Matching Layer for Path Loss Reduction in Ultra Wide-band Implant Communications.
IEEE ENG MED BIO.6989-6992.

12. *Dagher I, Gayet B, Tzanis D, Tranchart H, Fuks D, Soubrane O, Han HS, Kim KH, Cherqui D, O'Rourke N, Troisi RI, Aldrighetti L, Edwin B, Abu Hilal M, Belli G, Kaneko H, Jarnagin WR, Lin C, Pekolj J, Buell JF, Wakabayashi G.*
International experience for laparoscopic major liver resection.
J Hepatobiliary Pancreat Sci.21(10):732-6.

13. *Due-Tonnessen P, Rasmussen I, Berntsen EM, Bjornerud A, Emblem KE.*
Identifying the central sulcus in patients with intra-axial lesions: a multicenter study comparing conventional presurgical MRI to topographical analysis and BOLD-fMRI.
J Comput Assist Tomogr.38(1):1-8.

14. *Eldirdiri A, Courivaud F, Palomar R, Hol PK, Elle OJ.*
Catheter tip tracking for MR-guided interventions using discrete Kalman filter and mean shift localization.
Int J Comput Assist Radiol Surg.2014 Mar;9(2):313-22.

15. *Emblem KE, Farrar CT, Gerstner ER, Batchelor TT, Borra RJ, Rosen BR, Sorensen AG, Jain RK.*
Vessel caliber – a potential MRI biomarker of tumour response in clinical trials.
Nat Rev Clin Oncol.11(10):566-84.

16. *Fossum-Raunehaug S, Helgesen E, Stokke C & Skarstad K.*
"Escherichia coli SeqA Structures Relocalize Abruptly upon Termination of Origin Sequestration during Multi-fork DNA Replication."
PLoS ONE.2014;9(10):e110575.

17. *Fouladi SH, Chavez-Santiago R, Floor PA, Balasingham I, Ramstad TA.*
Sensing, Signal Processing, and Communication for WBANs.
ZTE Communications.2014;12(3):3-12.

18. *Gulliksrud K, Stokke C, Martinsen AC.*
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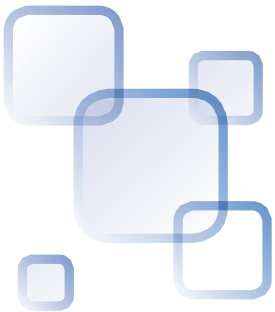

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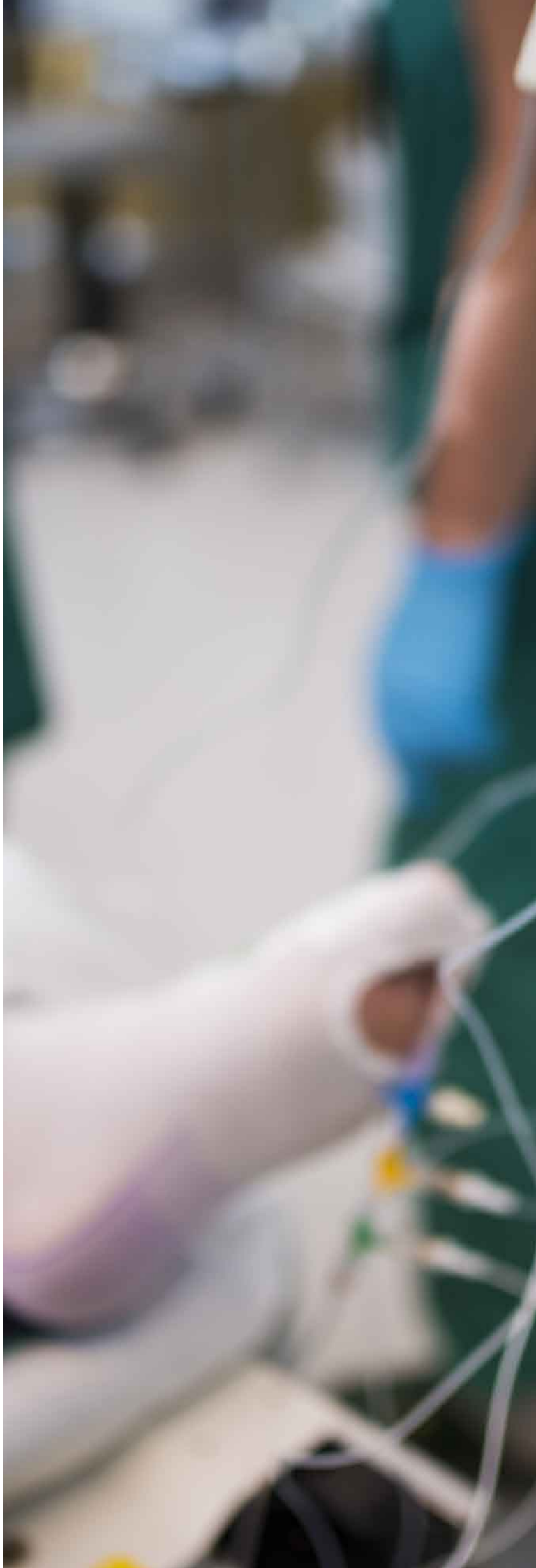


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