Annual report 2017
Operating Room of the Future
The Operating Room of the Future (FOR) is a research infrastructure facilitating research and development within the surgical disciplines. The main focus is image guided minimally invasive therapy. However, FOR is also taking part in research on workflow, visualisation and communication technology.

FOR has now its basis in six operating rooms at the new St. Olavs hospital, one at each of the operating departments. The operating rooms with the available research tools are actually research laboratories designed for development, testing and implementation of new technology and new treatment modalities. Here, prototypes can be developed and tested in safe and controlled environments.

Recently important research tools have become available at FOR because of the NorMIT cooperation. FOR-NorMIT – Norwegian center for Minimally Invasive image guided Therapy and medical technologies-is a collaboration between FOR and the Intervention Center at Oslo University Hospital (OUS). This infrastructure will contribute to improved technological and clinical research, which again will improve the patient treatment nationally as well as internationally.

FOR is taking part in several research projects and many of them, but not all, are led by FOR. In the present annual report we have included some projects where FOR and its staff has represented a prerequisite for the completion of the project.

The Operating Room of the Future is a collaboration between St. Olav’s hospital HF, University Hospital of Trondheim and the Norwegian University of Science and Technology (NTNU), Trondheim, Norway. FOR is an interdisciplinary arena for clinical research and for the development of medical technology.

FOR is set up to promote a close collaboration between clinicians, technologists, researchers and industrial partners who play a role in the development and innovation of the health care sector. This collaboration is reflected in the present annual report.

The principal activity at FOR is research to provide safer and better treatment, more efficient logistics and flexible architecture in the construction of new operating rooms. FOR has also become a center of competence for the construction of operating rooms outside St. Olav’s hospital.

The FOR concept demonstrates synergy effects in letting representatives from various disciplines and medical specialists use equipment, areas and competence together.

Minimally invasive image guided treatment is an important research field at FOR. The scientific advisory board at FOR is going through all projects to ensure that a good quality of the research is obtained. FOR has excellent facilities for research projects based on a multidisciplinary approach. Investigations are performed by PhD-candidates, as well as students on a bachelor and master level. In addition FOR is running its own innovation-and research projects.

The tasks of the University Hospital is defined in the specialist health care act and include treatment of patients, teaching of patients and their relatives as well as teaching of health care personnel.

Summary

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Trondheim has a particular responsibility for research within the field of medical technology.

Lecturing in the application of electro-medical equipment has become an important task for FOR. On behalf of the clinics FOR is organising courses and certification in the use of electro medical equipment. These courses are compulsory for all doctors in the FOR clinics and they are arranged via the so called “Portal of competence” at St. Olavs hospital. Patient safety is an important part of the FOR activity and so is the work to reduce the incidence of hospital infections.

We want to thank all our collaborators for their contributions at FOR and NorMIT. And we hope that you will enjoy our annual report of 2017!
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St. Olavs hospital HF

St. Olavs hospital HF University Hospital of Trondheim, is integrated with NTNU, Norwegian University of Science and Technology, and is owned by Central-Norway Regional Health Authorities RHF. Treatment of patients, teaching of patients and their relatives as well as research and teaching of health care personnel, are the main tasks of the hospital as defined in the specialist health care. The hospital covers psychiatry as well as somatic health care.

St. Olavs hospital is running centers several places in Sør-Trøndelag county. In addition to the institutions in the center of Trondheim, hospital activity is taking place at:

- Orkdal Hospital
- Røros Hospital, Røros
- Departments of psychiatry at Ørmarka and Brøset in Trondheim
- Three district centers for psychiatry: Orkdal DPS in Orkdal, Nidaros DPS and Tiller DPS in Trondheim
- Several psychiatry outpatient clinics for children and young patients in Sør-Trøndelag
- Department of psychiatry for children and youth at Lian
- Habilitation unit for adult patients at Brøset, Trondheim
- Several outpatient clinics for psychiatry in Sør-Trøndelag

St. Olavs hospital is the university clinic of Central Norway for a population of 720 870 inhabitants, and local hospital for a population of 317 363 per 01.01.17.

Through excellent cooperation with the local authorities and the primary health care, we aim at optimal patient care in the hospital as well as the primary health care. Excellent cooperation with the primary health care has led to the establishment of district medical centers at Fosen and Værnes. In the Trondheim region such centers have been established at Øya health center and at Søbstad health center.

Our core values are integrity, equality, respect and co-determination, forming the background for our clinical activity and our students, colleagues and collaborators. St. Olavs hospital is integrated with the Norwegian University of Science and Technology, NTNU, and students, teachers and scientists are representing natural parts of the hospitals’ activity. Within teaching and research we are collaborating closely with several other institutions in central Norway.

In addition to the scientific activity, The University Hospital is responsible for the training of medical students and other health care professionals. It is also responsible for the training of medical specialists in central Norway.

In 2017 we had:

- 10 483 employees
- 43 operating rooms at St.Olavs hospital, Trondheim. In addition 5 operating rooms at Orkdal Hospital and 2 operating rooms at Røros hospital
- A total of 486386 somatic outpatient consultations
- 737 beds (somatic)
Operating Room of the Future - a health catapult for the future

The health care sector and the demand for health care service is steadily increasing. Digitalisation is playing an important role also within health care, and “big data” is giving the possibility for every citizen to have their own “data-twin” and demanding individually tailored medical treatment. The demand and pressure from the patients regarding application of new pharmacological agents and new technology in our health care is increasing, even when Norway is supposed to have a health care service among the best in the world. In the near future we will need more hands in within the health care service to relieve today’s personnel and to teach the patients to help themselves to a greater extent. There is need for more knowledge and new solutions to make the health care service more expedient, smarter and better.

It is also our aim to promote a health care industry in Norway. This is a political goal which will be emphasized in a white paper from the Norwegian Parliament. We need more workplaces and more productive labour in Norway and at the same time we have visions about a better health care service.

To fulfil these goals, we have to rely on some Norwegian advantages: We have a population which is easily adapted to new technology. We have a strong and well established public health care sector and finally we have authorities who are supporting development and digitalisation of public service in general. We have excellent data on our health care and good clinical registers and biobanks as well as strong academic and professional traditions which can support the development of new technology and new methods, and we also have strong traditions within health services research. We furthermore have a culture for cooperation between the various professions promoting a multidisciplinary approach to challenges addressed by piloting arenas like Operating Room of the Future.

There is great potential for innovation through collaboration between health professions, clinical medicine and the technologists, but also between scientists, clinicians and industry. FOR is important as an arena to bring forward this innovation potential and is a safe infrastructure where scientists, industry and health care workers together can develop and test new solutions based on the needs of the health care sector. Therefore, FOR has become a national infrastructure for research and innovation through the establishment of NorMIT (NORwegian center for Minimally invasive image guided Therapy and medical technologies).

In Norway we have extensive research generating new and important knowledge and competence which should be transferred into innovation projects. Through close collaboration with NTNU within “The integrated university hospital”, Operating Room of the Future is representing a unique “health catapult” for cooperation between various professional groups for the development of new competence and for translating knowledge from research into practical solutions. This is the core in the work to develop a Norwegian health care industry and to improve the health care service.

Operating Rooms of the Future - FORever young

From the start in 2005 the infrastructure FOR is now getting mature. And it is perhaps time to look forward to the year 2030. This is the “target year” for the vision which is forming the basis for the request from the Norwegian Ministry of Health and Care for a development plan. The department of research and development, St. Olavs hospital, and particularly FOR have contributed significantly to our local development plan which was sent to the Health Authorities of Central Norway in February 2018. Even at an age of 14 years FOR is FORever young with its staff of committed and curious employees in a professional unit. New projects are emerging in cooperation with scientists, innovators and the industry: High resolution visualisation, holograms, robotics, artificial intelligence and recently 3D printing. FOR is always at the front edge with new technology, to provide better service to our patients.

In 2017 it was decided that FOR, together with The Intervention Center, University of Oslo should start the process with a second application to The Norwegian Research Council for financial support for a second NorMIT project. The application will include the university hospitals of Bergen and Tromsø. Thereby the NorMIT cooperation will really become a national research platform.

I have enjoyed the journey from the start of FOR in the ”old days”, and especially I have enjoyed to have FOR on the team when I was leading the department of research and development at St. Olavs hospital. I know for sure that FOR will contribute in order to let tomorrow’s patients enjoy the most advanced technology. I want to thank FOR for excellent cooperation, and I wish you good luck for the future.
It is with great pleasure that we have followed FOR’s increased focus on innovation at their annual Røros seminar, through presentations at scientific conferences by appointing a new innovation developer and during their work with the assignment document for innovation activity at St. Olavs hospital HF, with Operating Rooms of the Future as a key infrastructure.

The Operating Rooms of the Future (FOR) is an important infrastructure and contributor for interdisciplinary approach to medical problems and challenges. FOR is a collaboration between St. Olavs hospital and NTNU based on operating rooms which are constructed for the testing, development and implementation of new technology and new treatment modalities. This infrastructure is important for a close cooperation between the health care sector, the university and the industry. FOR will be developed further as an infrastructure for the promotion of innovation projects at our hospital.

Innovation can be regarded as a relatively new field of activity within the health care service. We support the work which is made to develop this further, to improve our competence within the area, and to promote the formation of an innovation culture. Similar developmental work is going on in other areas at NTNU’s Faculty of Medicine and Health Science where innovation has been a focus area since 2015, and which also has supported several innovation projects at FOR.

According to the assignment document from the Ministry of Health and Care to The Health Authorities of Central Norway 2016-2020, innovation projects should strengthen clinical practice and the health care service in general, and have consequences for patient care through increased regional, national and international cooperation.

Further development of Operating Rooms of the Future as an infrastructure for research, teaching and innovation as well as for cooperation with the industry, is desirable and in line with the goals of NTNU, where the strategy “Knowledge for a better world” was approved for the years 2018-2025.

It has been documented that there is a strong relationship between good research and good patient care. Therefore good cooperation between academia, the health care service and the industry is mandatory. Last year the Health authorities of Central Norway established an innovation network of innovation developers and advisers from HMN, St. Olavs hospital, HEMIT and NTNU with the purpose of cooperating to promote innovation while NTNU Technology Transfer has the responsibility for commercialization of all technology which is developed at HMN and NTNU. The aim is more and better research and innovation, and an easier way for new knowledge to improve health and health care. Through United Nations, one has agreed on 17 sustainable goals which is including good health, good education and to stimulate innovation and robust infrastructures. NTNU and The Faculty of Medicine and Health Science will continue to contribute to health and knowledge for a better world both through research, education and innovation.

The Operating Rooms of the Future is an important partner and we look forward to further cooperation.
An important task for the Operating Room of the Future (FOR) is to improve the quality and quantity of clinical research. Therefore the scientific advisory board is going through all research protocols, giving advice to those who are doing projects under the direction of FOR. FOR has special guidelines for projects, including the tasks of the scientific advisory board as well as a description how to make research protocols (Professor Per Farup). These documents are forming the basis for the collaboration between FOR and those who are conducting research projects there. In addition we are making separate agreements between FOR and the project leaders. The scientific advisory board has assisted in the period with the work and protocols 2 PhD, 3 Master students and 5 Bachelor students with relationship to FOR. FOR additionally contributes a great deal to students for the research line at The faculty of Medicine (NTNU), an offer for medical students who are interested in research and a possible future research career possibly parallel to clinical activities.

Two meetings were held in the 2017

The scientific advisory board has the following members
Assistant professor Ivar Rossvoll (leader)
Emeritus professor Hans Olav Myhre
Professor Per Farup
Professor Olav Haraldseth
Professor Ståle Nordgård
Assistant professor Frode Manstad-Hulaas
Assistant professor Knut Haakon Stensæth
Research director Thomas Lange

Scientific advisory board
Highlights of 2017

NorMIT

NorMIT is a national collaboration where the aim is to establish an infrastructure which will contribute to the improvement of technological and clinical research. It will also contribute to the building of competence and innovation and thereby lead to improved patient safety. Although the main focus area for the infrastructure is minimally invasive image-guided therapy, the research will also include topics like logistics, workflow, communication, organization and transmission of high-quality images.

The operating rooms included in NorMIT are actually modern research laboratories for developing, testing and application of new technology, new treatment modalities and new pharmacological agents. The cooperation and different profiles of the centres will form them into one national infrastructure for image-guided treatment and technology. The research units in Trondheim and Oslo represent two of the strongest research groups in Norway within their fields, and they play an important role in the development of methods and technology also from an international point of view.

The Intervention Center at Oslo University Hospital and Operating Rooms of the Future are planning to make NorMIT one common infrastructure for research and innovation with two nodes; one in Trondheim and one in Oslo. This infrastructure will strengthen research significantly in several areas with great strategic significance for Norway: medical technology, ICT, nanotechnology, translation research and health innovation.

Activity in 2017

In 2017, NorMIT has been featured in 58 lectures, seminars, workshops and more to provide information about the project and how it can be used in research projects. In 2017 all health agencies in the region have been visited and introduced to NorMIT research infrastructure and how it can be used. At NorMIT in Trondheim in 2017: 12 PhD and 65 researchers (permanent, postdoc etc.), 5 Master students and 5 Bachelor students at NTNU, in collaboration with NTNU. An important partner is “Norwegian National Advisory Unit For Ultrasound and Image Guided Therapy” which is a national competence service created by the Ministry of Health and Care. NorMIT activity in Oslo 2017: 30 PhD, 5 Master / Bachelor students, 24 researchers, 31 users from business, 62 projects.

The navigation platform NorMIT Nav

In the sub-project NorMIT IGT, the navigation platform is separated in two parts: NorMIT-Plan (A planning module with a 3D model based on preoperative imaging data indicating the planned resection) - and NorMIT-Nav; which is a navigation module where a 3D model from NorMIT plan is included and where spatial information about the positioning of the instruments is shown in the model during the operation. Both parts of this project involve the manipulation of intraoperative data and indicate how these are updating the 3D model in the most effective way. The navigation module will be an integrated part of the NorMIT infrastructure, and will be ready at the new hybrid operating room at the Intervention Center during the autumn 2018.

NorMIT has numerous potential users and aims at an extensive cooperation between academic units, the industry and clinical center both from a national as well as an international point of view.

Please visit www.normit.no for more information!

New appointments

Alexander Moen is recently appointed as innovation developer at the Operating room of the Future. He has been setting up a website for innovation www.stolav.no/innovation, implemented a tool for handling ideas https://stolav.induct.no/, and contributing to the creation of an innovation network in Health Central Norway. Alexander has education from the Royal Norwegian Airforce Academy and a master in organization and management from NTNU.

Technoport

Operating Room of the Future had an exhibition at Technoport and a session of lectures and live transmission from a neurosurgery operation. This session was one of the most visited at Technoport day two session, and had the title: “Surgery - Will The Surgeon Be Redundant?” Chairman of the conference Leo Johnson attended this session and broadcasted directly on BBC radio.

TEKNA Health technology conference 2017, Førnebu, 16.03.17

Tekna in cooperation with Oslo Medtech and Norwegian Smart CareCluster held a conference in health and welfare technology where the main theme was the health care system of the future. New ground breaking technology focusing on innovation strategies in specialist health services and welfare technology with the user in the center was presented. FOR was invited to hold a lecture entitled “The Operating Room of the Future: Visualization for minimally invasive surgery ”. We had lots of exciting discussions related to virtual and expanded reality.

Live Transfers FOR

Also in 2017, FOR-NorMIT was involved in several live transfers:

- TECHNOPORT 9th March 2017
- Neurosciences 15th-16th June 2017

New projects

In connection with the Starmus event, Operating Room of the Future was asked if they could show any of the infrastructure and demonstrate the Multiguide. Ståle Nordgård assisted this, and impressed the visit with the technology. Urologist Peter Schulam from Yale University visited St. Olavs hospital. Dr. Schulam is the founder of CBIT - Center for Biomedical Innovation and Technology (http://cbit.yale.edu/) at Yale University. They catalyze innovation within health and mainly in medical technology. He became very impressed by how the operating room at Ear-Noose-Throat was built up, and not least, he was impressed by the Multiguide and the navigation platform that provided precise and good information to the operator.

Technology Conference Technoport 2017 - The Human Factor

was designed as a meeting place where startup companies, researchers, investors and the public sector could meet and exchange ideas. At day 2 there was a live transfer from the FOR operating room at the Neurosurgery department to the conference center at Technoport. The title of this session was "Surgery - Will the surgeon be redundant?". This was a session that raised great insight and impression. The picture above shows Jan Gunnar Skogås, Managing director of FOR in dialogue with Geirmund Unsgård, professor at the neurosurgery department, St. Olavs hospital.

In connection with the “9th International Training Course: Ultrasound in neurosurgery “, 15th-16th June 2017, which was hosted by the Competence Center for ultrasound and imaging guided treatment St. Olavs hospital, NTNU and SINTEF – FOR had a successful live transmission from the neurosurgical department to the operating room. The surgeons at the operating room had an interactive session with participants at the course.

Photo: FOR
NFA
Norwegian Society of Electric and Automatic Control conducted its autumn meeting at St. Olavs hospital. In that connection, they wanted a lecture about the Operating room of the Future and a small visit at the hospital. Before the visit, the participants were divided into two groups and led by the employees at FOR. The tour consisted of a visit at The Simulator Center where Head of department Stine Gundrosen welcomed us and informed about The Simulator Center followed by a practical demonstration inside the simulator room. There was also a visit to the FOR-operating theatre at AHL. Frode Manstad-Hulaas lead this session and demonstrated the operating room.

Camilla Berge Jacobsen - Disputation
Camilla defended her thesis the 31th of May 2017. The title of her thesis was "Abdominal aortic aneurysm repair - Factors influencing early and late mortality ". The thesis deals with conditions that affect early and long-term mortality after surgery for abdominal aortic aneurysm. It includes both open surgery and endovascular treatment. In particular, focus is placed on female patients. Supervisors were T orbjørn Dahl, Hans Olav Myhre and Anne Irene Hagen.

Congratulations to Camilla!

Daniel Fossum Bratbak - Disputation
Botulinum toxin Type A injections in sphenopalatine ganglion with a new image technique was investigated. Dissertation found place March 31th 2017.

Chronic headache and chronic migraine are conditions associated with significant disability and reduced functional capacity in early adulthood, the most productive decades of life. Many have non satisfactory effect of available treatment, or choose to discontinue treatment due to side effects.

The sphenopalatine ganglion is involved in the pathophysiology of both cluster headache and migraine. We believe that this ganglion can be blocked by botulinum toxin and thus relieve headache. In order to perform such injections they have developed a new image technique and a new surgical instrument. In the thesis, research was conducted which aimed to evaluate the initial development of possible new treatment method for patients with refractory headache and chronic migraine. Two studies found an acceptable side effect profile. In a third study, the sphenopalatine ganglion was visualized on MRI.

The most important findings in the dissertation were:

• Botulinum toxin blocked the sphenopalatine ganglion as one possible new treatment for chronic cluster headache and chronic migraines show promising results and there is a need to implement randomized, placebo-controlled studies to look at safety and efficacy.
• The new method in which the injection is carried out using a new image-surgical instrument seems feasible and, compared to existing methods, expose patients and health personnel to less radiation.
• The treatment seems possible to perform on an awake patient at the outpatient clinic.
• The sphenopalatine ganglion can be identified on MRI, and can thus giving better accuracy of the injection.

Congratulations to Daniel!

The annual Røros FOR seminar 2017
The annual FOR seminar 2017 was arranged at Røros 02.–03 February. Participation was great and it is inspiring to see the number of participants increases for each year. Participants represent different environments like St. Olavs hospital, NTNU, SINTEF, industry partners and other partners in FOR research network. Theme for the seminar was FOR-NORMIT research infrastructure, medical technology, innovation, new treatment and research tools. Geirmund Unsgård, clinic manager, head of the Department of Neurosurgery, held a great lectures on the future visualization of live medical images - a project in collaboration with FOR where they combine navigation and ultrasound. Senior Vice President Runa Heimstad talked about "Excellent treatment" the main strategy for quality work and improvement programs 2017. Guest lecturer Karl-Arne Johannessen from Hospital Partner held a great lecture and Erik Fosse, IVS / OUS held an exciting lecture on Big data as well as war surgery and international health work. Professor Christian Doeller, Cave Institute, NTNU held a multilingual lecture entitled "From grid cells two Alzheimer’s disease: fMRI, virtual reality and machine learning as tools for translational neuroscience”. Other topics were ultrasound technology at TTO / NTNU and ISB / NTNU, advanced drawing equipment and infection protection, clinical-technological cooperation in image processing at SINTEF and innovation in the health sector at HMN. Feedback from participants is that the annual FOR seminar is of great importance and it is nice to meet each other to discuss and exchange experiences and ideas. In this way new ideas and relationships will create and as well as the research infrastructure will strengthened.

Welcome again to the annual FOR seminar!
BODY WORLDS Vital

It was an event that the exhibition BODY WORLDS Vital reported the arrival to Trondheim - as the only place in Norway. Therefore FOR's employees chose to visit this spectacular exhibition. More than 44 million people have experienced BODY WORLDS in over 115 cities around the world. The exhibition was a collaboration between NTNU Science Museum, The Science Center in Trondheim and The Royal Norwegian Science Society. BODY WORLDS Vital was a rare opportunity to experience a truly unique exhibition giving an insight into the raffinement and the fragility of our own bodies. BODY WORLDS unveils the human body through its groundbreaking scientific method plastering. It shows the body with detailed anatomical models, complicated dissections and original compositions on an easily understandable basis manner. The authentic human organs displayed work were a bridge for recognition and reflection.

A spectacular exhibition that shows the body in well-being, pain and disease - the exhibition wanted to teach us about the human body and inspire us to live life with joy and to its full potential.

If you would like to read the newsletters please visit this link: https://stolav.no/for

Newsletters FOR

In October 2014 the first newsletter from FOR was available. So far the newsletters have been a great success. Three-four newsletters are distributed annually. They are focusing on the activity at the FOR operating rooms and are including visits at FOR, meetings, courses and information about scientific projects. In each issue we try to focus particularly on one of our clinics. We think this is a useful way of inform about FOR and we hope you will enjoy it.

Newsletters 2017

Innovation and research are fundamental elements for success in the future integrated university hospital. By hiring an innovation developer which will contribute to increased quality of services, strengthens patient safety and develop more effective services, FOR will increase the focus on innovation efforts. The innovation developer shall contribute to the creation of a culture of innovation in the health service. FOR represents an infrastructure that facilitates innovation work and that is why a culture for innovation already has been established within some units at the hospital.

In the long run, it is desirable to establish innovation agents in the clinics and the divisions, which assist in the efforts to create a healthy innovation culture. Innovation is a relatively new term, so here follows what we put into it: Innovation means for us innovations with a positive effect for those involved, done in such a way that others will follow. In practice we can handle the use of new technology, new ways to treating how we organize patient training and relatives, collaborates with other or new products (experiences). Innovation can also be to do what we already do / use a different way.

The innovation developer is here for you

During 2017 a website has been established www.stolav.no/innovation. Here you can read more about the work being done as well as submitting your ideas. Part of the job is to encourage colleagues to innovate, assist or be in the process of initiating innovation projects. It can also be to assist projects along the way and coordinate work towards internal and regional actors and resources. Do you have an innovative thought, share it with me so we can create something together.

To ensure equal treatment of all ideas, an idea reception https://stolav.induct.no has been implemented. When you choose to share your idea, in this system you will always have an overview of the process that goes on and contribute or invite people to contribute to your idea. Your idea is safe in the idea reception, all information is confidence. It is only those you choose to invite into the team who will have access the information which is shared here. It is supposed to assist you in the process and hopefully to be a contributor during the process. At the website you can also search for innovative solutions that are developed or being developed in other health enterprises.

If you want to know more about innovation or discuss your idea you just have to contact me. I am looking forward to the cooperation.

Alexander Moen
Innovation developer, FOR
Alexander.moen@stolav.no
Photo: St. Olavs hospital

"Take care of your body. It’s the only place you have to live."
Jim Rohn (1930-2009)
American entrepreneur and author

Photo: Adressa.no
Activity at the FOR operating rooms

FOR activity in the Surgical Clinic

There was a significant increase in endovascular procedures for aneurysms in 2017, and the number of endovascular treatments for thoracic abdominal aortic aneurysms increases. Aortic disease is becoming increasingly complex, but at the same time the possibilities for endovascular treatment have been improved. The TAVI activity and procedures for removing pacemaker wires and the like are also in place in the FOR operating room. Through the NORMIT collaboration, researchers from the Rikshospitalet have conducted animal experiment studies in the FOR-operating room, and there was very positive feedback on our infrastructure for such studies. There have also been other experimental studies using navigation in endovascular treatment, and this work will continue in 2018.

The use of navigation and ultrasound for biopsy during bronchoscopy will be further developed through studies at FOR. This shows that the competence service for ultrasound and image guided therapy treatment is an important arena in the FOR-operating room. The operation team for endovascular procedures is still training at the angiosimulator the day before surgery, and it is generally agreed that such exercise is very useful, although the effect may not be as easy to document. However, the group will sum up the experiences of its studies in 2018. The FOR-operating room continues to play an important role for clinical activities in endovascular procedures, providing excellent work for experimental studies both for St. Olavs hospital and cooperating institutions in Norway.

![Birger H. Endreseth, Head of Surgical Clinic](Photo: St. Olavs hospital)
FOR activity in the Clinic for Medical Imaging

There has been a very active year at the FOR-operating room in AHL in 2017. The collaboration with other clinics involved and FOR has been close, which has helped to promote productivity and a good working conditions. This is important for implementing both advanced treatment methods and for research.

A major project of pre-operative planning of EVAR on the Angio simulator is about to be completed these days. It will be interesting to see the results; this is a multidisciplinary collaboration, focusing on several areas, including: economy, quality and quantitative goals. The articles from this work are included in the Ph.D. work of Cecilie Våpenstad, and are representing a collaboration project between the Clinical Diagnostics Department (KBD), Surgical Clinic and Medical Simulator Center.

A project with the development of a new type of steerable catheters, which has been tested in animal models in 2017. The catheter is thought to be further developed and with specifications that can allow clinical use.

A patient study that looks at the possibility of using preoperative CT images during stent graft procedures using electromagnetic tracking technology is in the process will be completed. The study is part of the project for researcher Erik Nypan. There is also a collaboration between FOR and KBD in a master’s thesis on uterine embolization. Geir Andre Pedersen is a radiographer and employed at FOR, and Knut Haakon Stensæth from KBD is his supervisor in a work where 60 patients are followed up. The thesis is to be submitted in June 2018.

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In addition, 4 thoracoabdominal stent grafts with side branches were inserted, and 10 various stent graft repairs and 9 embolizations due to leak.

Through our close collaboration with the endovascular surgeons, 46 combined procedures have also been performed combining traditional open surgery with image-guided endovascular techniques on the pelvic and lower limb arterial system. Physicians from KBD are also involved in the planning of the TAVI procedures that take place at the AHL FOR-operating room in collaboration with cardiologists and thoracic surgeons.

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FOR activity at the Department of Women and Children’s Diseases

The Clinic of Women and Children’s Diseases has had a good cooperation with FOR over several years. At the FOR-operating room in the Clinic of Women and Children’s Diseases, mainly laparoscopic surgery is performed today. An Endo Alpha system has been installed including HD technology for imaging and visualization. Advanced platform for electro surgery with focus on vessel sealing is available.

Gynecological department is active in robot surgery, and robot is currently used both for the operation of general gynecology patients and for gynecological cancer. The da Vinci robot at St. Olav hospital was obtained through FOR. In 2012, a second da Vinci robot was placed at Orkdal Hospital - as a gift from the Norwegian women’s public health association. Gynecologists operate with the da Vinci robot two days a week at St.Olavs hospital and one to two days a week at Orkdal Hospital. Robot surgery is a good example of FOR activity; High-tech, innovative and has a great potential for the future.

The department has conducted prospective studies related to ovarian cancer surgery (tumor reductive surgery) and surgical techniques in hysterectomies. Doctors at the department have recently concluded a prospective study on primary lymph nodes in endometrial and cervical cancer. Fluorescence camera attached to the da Vinci robot provides the opportunity to study this.

FOR assists the clinic with the mandatory EMU certification of The Clinic of Women and Children’s Diseases. This is placed in the competence portal so that the individual doctor can follow his own plan for EMU training and follow up when it is time for renewal.

We look forward to continuing the good cooperation with FOR in 2018.

FOR activity at the Department of Women and Children’s Diseases

Kjell Åsmund Salvesen
Head of Clinic of Women and Children’s diseases
Photo: St.Olavs hospital

<table>
<thead>
<tr>
<th>Maternity unit</th>
<th>19 patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>IVF</td>
<td>7 patients</td>
</tr>
<tr>
<td>Gyn Cancer</td>
<td>39 patients</td>
</tr>
<tr>
<td>Gyn General</td>
<td>34 patients</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>99 patients</strong></td>
</tr>
</tbody>
</table>

Operating Room of the Future at the Department of Women and Children’s diseases
Photo: Gabriel Kiss, FOR
FOR activity at the Clinic of Neurosurgery

The Neurosurgical Clinic has a FOR-operating room where active clinical research is performed. The research at the neurosurgery department is conducted in cooperation with the "Center for Ultrasound and Image guided Treatment". Research is directed by clinical needs and through a multidisciplinary clinical and technological approach, a more optimal patient treatment is developed.

With regards to research activity at the FOR-operating room at the Neurosurgical Clinic, the research activity is integrated into daily operative activities.

The department’s most important research profile is the use of 2D and navigated 3D ultrasound in image-controlled minimal invasive neurosurgery. The technology is adapted to multiple applications, including pituitary surgery, brain tumor surgery, AVM surgery and hydrocephalus surgery. Also, in 2017, several research projects investigated the use of 3D ultrasound navigation for such interventions.

In 2017 we have continued to test the suitability of the BK 5000 ultrasound scanner to record ultrasound data during surgery. Development and testing of the new scanner setup was performed in cooperation with SINTEF and FOR-NorMIT. In cooperation with BrainLab we have started a pilot project to compare BrainLab’s method for 3D ultrasound based intraoperative navigation with Sonowand’s solution and FOR has contributed during testing.

The «Visualization Project» is a project that tests new imaging technology specifically designed for image guided minimally invasive surgery and is performed in cooperation with FOR. The project was continued in 2017 and the main purpose was to test our hypothesis that an endoscope with a 4K camera could be an alternative to today’s optical microscope. A robust arm that holds the endoscope steady was tested and showed promising results. Testing of such setup during surgery is the next step in the project.

FOR also assisted in 2017 with live transmission in connection with the annual international course for neurosurgeons “9th International Training Course - 3D Ultrasound and Neuro navigation” 15-16. June - arranged by the Competence Center for Ultrasound and Image guided Therapy at St. Olavs hospital, NTNU and SINTEF. A successful live transmission in full HD and with bi-directional audio communication was carried out.

On behalf of the clinics, FOR has been given the task of arranging the compulsory courses in electromechanical equipment (EMU course). Training and courses in electromechanical equipment for doctors are well established and all surgeons receive continuous offers and invitations to courses that are systematically registered and documented under the auspices of FOR. These EMU courses fulfill the requirements for EMU training for all LIS doctors and surgeons.

The cooperation with FOR has been positive and we look forward to continuing this good cooperation in 2018.
FOR activity at the Clinic of Ear-Nose-Throat, Eye- and Maxillofacial Surgery

The FOR-operating room at Department of ENT is a modern operating room that incorporates high tech technical solutions, with special lighting and a cockpit solution. It is a popular place to work and is a central arena for tonsillectomy and the use of navigation equipment.

Since the opening of the operating room in 2013, the FOR concept has focus on research projects within medical technology, good audiovisual solutions, testing of new technological equipment and good logistics around the patient.

We consider FOR an important team-builder and by facilitating cooperation and bringing together different disciplines it promotes creativity and innovation. We have experienced that FOR is responsible for a smooth cooperation with medical industry. Not least, we are pleased that our FOR contacts participate in the clinic’s research committee and contribute with input and innovative ideas as well as information about opportunities within research support. We hope that this cooperation will evolve further.

Examples of ongoing projects were we have in close cooperation with FOR:

- **Botox injections against ganglion sphenopalatine by nasal polyps**: This is currently a pilot project, 7/10 patients are included.
- **One project that is in the planning phase: Injection of Botox against the sphenopalatine ganglion in patients with persistent idiopathic facial pain.** This is a study of 30 patients where half get a placebo injection. There is a crossover after 6 months, patients undergo new injection round but the opposite substance to the initial injection is given, thus a total of 60 injections.
- **Sialoscopy (tools for diagnosing tumors and stones in the salivary glands)**: Currently, ENT is the only department in Norway next to Stavanger that offers this minimally invasive method. We therefore receive references from the entire country. The number of examinations increased in 2017 to 27, of which 25 were clean examinations with/without calcification/dilatation and 2 examinations with biopsy.

We thank the FOR organization for a good cooperation in 2017 and look forward to the continuation.

Marit Fagerli
Head of Clinic
Photo: Private

Operative activity at the FOR operating room 1
Department of ENT, Maxillofacial and Eye diseases in 2017

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Functional endoscopic sinus surgery (FESS)</td>
<td>71</td>
</tr>
<tr>
<td>Septal plasty</td>
<td>42</td>
</tr>
<tr>
<td>Concha plasty</td>
<td>14</td>
</tr>
<tr>
<td>Sialoscopy</td>
<td>24</td>
</tr>
<tr>
<td>Arthroscopy</td>
<td>28</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>179</strong></td>
</tr>
</tbody>
</table>

FOR operating room at ENT, and Maxillofacial surgery
Photo: Geir Mogen / NTNU
FOR activity at the Clinic for Orthopedic-, Rheumatology and Skin Diseases

The Clinic for Orthopedic, Rheumatology and Skin Diseases uses the research infrastructure Future Operating Room, FOR.

The FOR-operating room is used for example to major routine activities within prosthetic surgery. The operating room is equipped with LAF ceiling. In international research, it is a paradox that operations performed in LAF operating rooms seem to have a higher incidence of infections when one should expect the opposite. An important work that has started to investigate how different devices, such as the operation lamps, affect turbulence in the airflow.

Measurements of airflows under laminar airflow roofs have been performed since 2015, considering whether operating lights and screens hanging in the field can affect airflow and if heat from patient and operator / personnel can affect airflow. Particle measurements and CFU were performed. So far, 3 articles have been published from this work that has attracted great interest internationally: 1 PhD and 1 master student are working on the subject and 1 master’s thesis is completed.

In the meantime, a grant has been received for cooperation with SINTEF Applied Economics, around improvement of operational planning, investigating whether different algorithms or action rules can lead to higher operating room utilization. This work is going on, and is primarily a collaboration between SINTEE, Department of Patient Logistics and the Operating Department in Orthopedic surgery. In spite of a lot of research on these issues, the practical application in most cases is rather unclear, and it is hoped that this project can lead to a concrete improvement in our activity.

A new Navigation System (Brainlab) has been used for insertion of pedicle screws in back surgery. The system has been established by collaboration between FOR, National Competence Service for surgical treatment of neck and back disease and St. Olavs hospital. By using optically navigated instruments, the screws can be inserted into the correct position in the vertebrae based on image examinations taken prior to surgery (CT or review). This increases the safety of the correct screw position while at the same time improving working conditions as one avoids use of screening / lead protection during operation.

We hope that the technology in the FOR-operating room at our clinic will be optimized and improved emerging as a good innovation arena for further development of the orthopedic area. Development of new treatment methods and medical technology is of great importance in the field of orthopedics. Over the past few years, several different research and development projects have been reported; indicating that FOR is a useful infrastructure. FOR, on behalf of the clinics, is leading the mandatory training and checkout of electro medical equipment for the surgeons and LIS. FOR arranges the courses and manages this registry through the competence portal.

Vigleik Jessen
Head of Clinic for Orthopedic, Rheumatologic and Skin Diseases
Photo: St. Olavs hospital

Operative activity FOR operating room 8
Clinic of Orthopedic Surgery 2017

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary hip prosthesis</td>
<td>92</td>
</tr>
<tr>
<td>Revision of hip prosthesis</td>
<td>31</td>
</tr>
<tr>
<td>Knee prosthesis</td>
<td>198</td>
</tr>
<tr>
<td>Other operations</td>
<td>14</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>335</strong></td>
</tr>
<tr>
<td>Research days</td>
<td>15 days</td>
</tr>
</tbody>
</table>

Mainly total prostheses of the knee are included in the fast-track project.

The pictures show simulation of an operating situation in connection with Air flow measurements project that has taken place in the FOR-living room in 2017.

Photo: Professor Guangyu Cao, NTNU
FOR-NorMIT is an established research infrastructure at the University Hospital in collaboration with NTNU. Under the auspices of FOR-NorMIT, different professional environments can try out new technology in a safe way. The NorMIT initiative emphasizes that FOR is a research infrastructure that will benefit the entire health region - and beyond it, nationally and internationally. It is interesting for the health care companies that there will be a lot of new technology that requires testing in clinical practice. It will also be rational in the future that some heavy technological investments are concentrated to make the most out of the resources.

FOR-NorMIT is it interesting that there will be a lot of new technology that requires testing in clinical practice. Through co-operation with environments and forums where development in the future is a topic, FOR-NorMIT can capture trends / new technologies at an early stage. For example, mention:

- Nanotechnology
- Biotechnology (Gene therapy / diagnostics)
- IT technology that will only continue (Big Data)
- Neurotechnology
- Quantumtechnology

Much like before had to be treated at larger clinics, can eventually be done at the local hospital level. There will be more technological equipment in the operating rooms. Operation of this requires considerable investment and operating costs with the robotizations. In the future, there will be a centralization of the most complicated interventions. Other conditions that do not require much multidisciplinary collaboration between many different specialists can be done at the local hospital level. Analysis and interaction technology can provide very good opportunities for comprehensive innovation in mental health care and TSB.

The trend towards 2035 will be more personalized medicine, technology that enables even more decentralized treatment, as well as better utilization of health data from various sources. Conditions of this may be that with more accessible research data, time from research to results will be shortened and clinical practice may become even more adaptable. Advanced digital image processing and large data power provide new ways of storing and image production with higher information value with even better resolution and shorter recording time. Development on equipment and software increases diagnostic precision combined with lower amount of ionizing radiation. Other non-ionizing diagnostic equipment gets new applications. Both 3D printing and holography provide better possibilities for modelling and simulation. Large amounts of diagnostics and reproprocessing of data for new image representations are largely in proprietary software.

Therefore, it is important that such systems are integrated so that documentation comes in the patient’s chart directly.

Navigation with electromagnetic tracking system in the endovascular system is in development. The effect reduced the use of radiation and is time saving. You depend on good visualization in the treatment situation. The development in MR spectroscopy could replace the need for biopsy in many situations.

Intervention radiology improves and utilizes all imaging modalities and combinations of them for increasing precision with many treatment technologies, such as thermal-, radio frequency-, microwave- and laser abnormalities.

Future focus will be even more use of high-resolution camera systems and visualization equipment combined with 3D ultrasound and radar technology will make use of holograms and hololens in hybrid operating rooms.

Medical robots are already being used and medical personnel and robots will be expected to work even closer together in the near future. Medical robots can include help improve surgical precision, reduce the need for labor-intensive tasks, including disinfection of hospital rooms and surgical rooms. Used correctly the biggest effect is release of health personnel time spent on routine tasks. Robotization will also be able to streamline administrative and technical tasks in the health services. Many argue that anything that can be robotized if labor costs exceed investment and operating costs with the robotizations. In the health context, such a cost/benefit assessment will be too simple. Consider the cost of patients and quality of care.

Robotic parts attached to the body can speed up rehabilitation of injured patients or allow people with paralysis to go again. Robots come in all sizes and shapes, today's miniature robots are in millimeters of magnitude. These robots can be swallowed and allow for less invasive surgical procedures and targeted drug delivery. However, it is expected that nano-size robots will be developed and these can be placed in the bloodstream. They can be used to repair damaged cells or to help the body fight bacteria or infections.

Human contact will nevertheless be the core of good patient care. The development plans should include how medical personnel and robots can work together, and how patients can best adapt to the presence of a robot in the healthcare sector.

Artificial intelligence (AI). The data produced daily in the clinic and stored digitally in PACS systems doubles every other year. The vast amount of information makes it impossible for healthcare professionals to keep up with all that is stored or to use this information in daily practice. However, artificial intelligence-based (AI) tools can help to keep track of and extract relevant information from the database and adapt it to the particular situation they face. AI in medical education will improve the learning process and enable the students to have a much wider experience than they encounter in the traditional period of stay at the clinic.

It is expected that AI will have a beneficial effect in all areas of the health sector. Patient logistics, treatment planning, drug development or surgical procedures can all benefit from using AI, using intelligent medical information systems and devices. Access to large data will allow more accurate decision making and targeted medication. The decision on treatment and medication will be tailored for each patient and based on the outcome of those with a similar medical history. AI will enable to establish a correlation between a disease and genetic information, medical records or DNA mutations.

These new developments will also require the public to be informed and accustomed to AI. Furthermore, a new set of ethical standards must be developed to update existing guidelines and ensure that AI is used appropriately in the healthcare sector.
FOR-NORMIT infrastructure

Several new publications utilizing the NorMIT infrastructure were published in 2017. A preoperative module for the NorMIT Navigation Platform was released and can be downloaded from NorMIT’s website (www.normit.no). In addition, an advanced surgical navigation platform and a surgical transducer have been added to the infrastructure in 2017.

A BrainLab Curve image-driven operating system has been acquired and has become part of the NorMIT infrastructure. It optimizes intraoperative navigation as it seamlessly combines preoperative planning and surgical visualization. This increases patient safety by giving the surgeons more pictures, which in turn increases their base of decision.

Vermon LAP7 is a surgical transducer designed for minimal invasive surgery with 128 channels and 7 MHz frequency (see figure below). It is sterilizable and bio-compatible according to ISO 10993 and FDA requirements. The probe is designed to provide picture guidance under minimal invasive procedures such as liver surgery. Our probe will be expanded with magnetic tracking so its position can be accurately determined and the images are recorded with preoperative images.

The HIFU Verasonics scanner was sent to Canada as part of a research collaboration between the Hospital for Sick Kids in Toronto and the Department of Circulation and Medical Imaging at NTNU. The main purpose of the study is early detection of myocardial fibrosis. To better understand myocardial fibrosis, an animal model has been developed in Toronto, and the Verasonics scanner will be used for image acquisition purposes. A custom cutting wave image protocol is developed and will be used in the project. The next step is to apply similar techniques to humans.

The first edition of the NorMIT newsletter was published in October 2017 and presented the latest news and research results based on NorMIT equipment. It is planned at least 3 editions per year for the newsletter. We will continue to present the latest research results and useful information about the infrastructure. All FOR-NORMIT partners are welcome to submit relevant texts and images.

The NorMIT node in Trondheim

<table>
<thead>
<tr>
<th>The amount of users and projects at the NorMIT node in Trondheim in 2017 (Operating Room of the Future)</th>
<th>2017</th>
</tr>
</thead>
<tbody>
<tr>
<td>Users</td>
<td></td>
</tr>
<tr>
<td>Total number of users</td>
<td>131</td>
</tr>
<tr>
<td>Total number of internal users</td>
<td>89</td>
</tr>
<tr>
<td>Total number of external users</td>
<td>33</td>
</tr>
<tr>
<td>Students (6 MSc, 12 BSc)</td>
<td>10</td>
</tr>
<tr>
<td>PhD-students</td>
<td>12</td>
</tr>
<tr>
<td>Researchers (full time employees, post doc., etc.)</td>
<td>65</td>
</tr>
<tr>
<td>Number of users from industry / industry</td>
<td>9</td>
</tr>
<tr>
<td>Type of projects (funding) where the infrastructure is used</td>
<td>2017</td>
</tr>
<tr>
<td>Total number of projects</td>
<td>36</td>
</tr>
<tr>
<td>Number of projects with international funding (EU, Nordic, etc.)</td>
<td>0</td>
</tr>
<tr>
<td>Number of projects with external national funding</td>
<td>0</td>
</tr>
<tr>
<td>Number of projects with funding from host institution (eg via basic grant)</td>
<td>30</td>
</tr>
<tr>
<td>Number of projects financed by industry</td>
<td>6</td>
</tr>
</tbody>
</table>

The research infrastructure the Operating room of the Future focuses on the development of new treatment methods in the image industry, minimally invasive surgery and medical technology. It is today well established within all surgical areas at St. Olavs hospital, and the table shows figures from the project. Here we see a large number of users of the infrastructure, as well as the number of projects, PhD candidates and how many users come internally or externally. In 2017, NorMIT has held information meetings with user groups at the Health Center in Norway, Alesund, Yolde, Kristiansund and Molde. Information meetings have also been held in Levanger and Namsos. In 2017, measures is taken to make NorMIT more known by mainly focusing on informing the health region of Central Norway about the infrastructure.
**Medicine and media technology**

Medicine and Media Technology derives from the AV Arena Norway resource network at the Operating room of the Future, which since the start of 2005 has had a strong focus on the development of imaged guided surgery and image processing. Digital media technology is an important driver in the development of these disciplines. This type of resource network is important for building a bridge between digital media technology and health care tasks in learning and interaction and establishing projects to trigger medical and operational benefits in the healthcare sector. The Resource Network's portfolio in 2017 has largely focused on improved health communication and telemedicine as well as building capacity for innovation in the public sector. The interaction with the oil sector is still an important factor for future telemedicine activity.

FOR has a good advantage as we have a strong media technology focus and are used to working with both Norwegian and international industry partners and research communities. The media technology infrastructure is closely linked to clinical specialist environments, which makes it easy to extract the transfer value between the environments, where we also play a key role in the planning of operating rooms and its design with focus on infrastructure and medical technology. Medicine and media technology will be enriched in many areas, which will make us more attractive to many actors - and reinforce the organization's position as an important research and innovation arena in health care.

**Future telemedicine**

In June 2014, the project "The Future of Telemedicine in O & G" was finished. The project is based on pre-projects that were completed in 2013. Partners in the project were ConocoPhillips, Petrobrás, IBM, St. Olavs hospital: The Operating Room of the Future, and Emergency Medicine Clinic, Medical Imaging Laboratory (MiLab), NTNU, Albert Einstein Hospital, Brazil and Center for Integrated Operations in the oil sector at NTNU / IFE / SINTEF.

The project conducted studies of today’s workflow in telemedicine and explored opportunities for developing future telemedicine. This was through both the development and demonstration of prototype for new telemedicine solution, as well as investigations of both safety aspects, as well as aspects of planning and implementation of new telemedicine practice offshore. The project was developed based on user necessities on the Norwegian and Brazilian shelf. The project provided a good basis for assessing future telemedicine solutions in the land-based healthcare system. The result of the project was the introduction and demonstration of a virtual examination room. This virtual examination room is now in a phase 4. The other phases are discussed in last year’s edition of the annual report.

Phase 4 runs in the period 2017-2018. Its goal is to integrate the in ambulances in the Røros region into the project. There will also be focus on design (GUI) in the solution itself to facilitate the user experience and make it intuitive.

Master student Kristine Fry (featured in the annual report in his own section) focused on user experience and design of the virtual examination room, and prepared a proposal on how the system should be built with regard to the user experience (GUI) in order for the users to better benefit from the system, as well as a faster workflow. The project in phase 4 will implement this new GUI and focus on feedback from the users. The collaboration room, the virtual examination room, will be driven by HEMIT and it will be an application that is implemented in the HEMIT system. All users will be able to use this on their pulse PC after a request to HEMIT
Courses arranged by FOR

EMU-courses arranged in 2017:

16th March: EMU-course for Department of Surgery:
- Irradiation protection and use of C-arm for fluoroscopy

28th March: EMU-course for ENT/ Maxillofacial/ eye:
- Laser

30th March: EMU-course for Department of Surgery:
- Irradiation protection and use of C-arm for fluoroscopy
- Irradiation protection and use of C-arm for fluoroscopy

10th May: EMU-course for Department of Women and Children’s Diseases:
- High energy equipment

13th September: EMU-course for Department of Women and Children’s Diseases:
- Endoscopy

EMU courses

On behalf of the operating clinics FOR is conducting compulsory courses in the use of electro-medical equipment. In 1999 a new regulation regarding “Use and maintenance of electro-medical equipment” was passed. This regulation has its background in law on medical equipment from 1995. According to § 13 training and instruction in the application of such equipment is necessary because:

- Personnel who are going to use electro-medical equipment must have training and instruction in the application of such equipment.
- They should know potential side-effects connected to the application of electro-medical instruments and know how to prevent them.
- The training program must be systematic and include documentation.

The Systematic training program must include:

- Training when new equipment is introduced.
- Training of new employees.
- Maintenance of the knowledge achieved during this training program.

At present the training program including the documentation is well established at all operating clinics at St. Olavs hospital. All surgeons, including surgeons in training as well as staff surgeons, are getting invitation to the courses as part of the continuing medical education.

Competence portal

All courses in electromechanical equipment and infection protection are now assigned to the individual doctor and LIS in the competence portal. Everyone can now see which courses are valid and what courses need to be renewed. When you click on the course in the competence portal, you will automatically come to the course in the learning portal, if it is an e-learning course. Initially, this applies to infection protection and parts of the radiation protection course. High-energy devices and endoscopy, as well as the use of C-arm is still classroom teaching.

Staff

Medical personnel affiliated to FOR is going through annual certification in compliance with national regulations regarding use and maintenance of electro-medical equipment. All surgeons at St. Olavs hospital are also going through courses on an annual basis regarding the use and maintenance of electro-medical equipment. The personnel at FOR is including so-called super-users having special focus on modern, advanced medical technology. They need to go through refreshing courses on a regular basis.

The personnel at FOR is contributing to training of personnel from other departments at St. Olavs hospital as well as personnel from institutions focusing on clinical procedures, research and application of medical technology.

FOR has through visits and hospitants from other hospitals in Norway helped to provide important information and training on new technologies, methods and integration of laparoscopic / endoscopic surgery. Organization and design of operating rooms has also been the subject. At the simulator course organized by the National Center for Advanced Laparoscopic Surgery (NSALK), FOR has been used as a venue for transmission of operating procedures and information on the integration of new equipment.

Students

Since 2005 FOR has had excellent cooperation with University College of St-Trondelag (HST). On a regular basis we had presentations for students at the Department of Health and Social Work, for operating room nurses and anaesthesia nurses as well as radiography students and students within bio-engineering. This has resulted in several bachelor degrees, which have been performed as a cooperation with FOR in our operating rooms. FOR is also taking care of teaching the use of electro-medical equipment for several of these students.

Experimental surgery

All FOR operating rooms are authorized for experimental surgery including animal research. Such experimental procedures can be ordered at FOR who will then organize them. This arrangement is well established among clinicians and scientists. We have a “package” where FOR is organizing and planning the animal experiments in collaboration with Department of Comparative Medicine (AKM). FOR has trained and authorized personnel assisting during the whole process.

Personnel who is planning or taking part in animal experiments must go through courses in animal experiments approved by the Norwegian Food Safety Authority. An important part of this course is to understand laws and regulations connected with the use of animals in medical experiments. The regulation regarding animal experiments assumes that all persons planning or performing such experiments should have passed the courses and be registered in the electronic system (FOTS) of the board for animal research. Both the responsible scientist and his co-workers involved in the practical performance of the experiments, including those who are taking care of the animals, should be included in the registration and have documentation that they have passed the course in animal experiments, category C.

Seven days of experimental surgery were completed in 2017:

- Testing of controllable bronchoscopy
  - 10th February - Tore Amundsen

Three Dimensional Visualization and Navigation in Endovascular Procedures
  - March 17th - Erik Nypan
  - March 24th - Erik Nypan
  - March 27th - Erik Nypan
  - April 3rd - Erik Nypan
  - April 24th - Erik Nypan
  - May 15th - Erik Nypan

Preparing for the project “Three Dimensional Visualization and Navigation in Endovascular Procedures”

To the left: Erik Nypan and Trude Mittet
To the right: Erik Nypan and Frode Mainstad-Hulaas
Photo: Liv-Inger Stenstad, FOR
Research Collaboration

National and international partners

Together with the Intervention Center (IVS) at Oslo University Hospital, FOR has established a series of national research initiatives, including projects at the national center of competence for Ultrasound and image guided therapy (www.USIGT.org). SINTEF is one of FOR’s most important collaboration partners. The cooperation is among other things built around the "National Center of competence for Ultrasound and Image guided Therapy" and the "National Center of competence for Ultrasound and Image guided Therapy and medical technologies, which now has its infrastructure in place with several ongoing projects. The NorMIT infrastructure is available both nationally and internationally.

During 2017 we have concentrated on cooperation with partners in our own health region: Nord-Trøndelag county, the health register HUNT and Møre and Romsdal county where the FOR-NorMIT infrastructure is available and where new research projects have been established.

SINTEF is one of FOR’s most important collaboration partners. The cooperation is among other things built around the "National Center of competence for Ultrasound and Image guided Therapy". FOR has also a very good collaboration with NTNU through the MH faculty, the Department of Circulation and Medical Imaging, Department of Energy and Process Engineering, Department of Design, Department of Mathematical Sciences, Department of Electronic Systems and the Department of Technical Cybernetics and the AI lab. The students at the Faculty of Health Sciences at NTNU use the FOR infrastructure for tasks related to their bachelor’s and master’s degree in collaboration with FOR. Various competence centers such as the "National Center of competence for Ultrasound and Image Guided Therapy" and the "National Center for Advanced Laparoscopic Surgery", NTNU Technology Transfer (TTO) and the "National Center for Interdisciplinary Research in Space (CIRS) are important partners and it is important to maintain the synergy effect of this collaboration.

Furthermore, FOR has a good cooperation with a number of industrial partners: Sony, Medtronic, Brainlab, Intuitive, Siemens, Stryker, Karl Storz, IBM, Apple, ConocoPhillips, Total, Olympus, and Smith & Nephew. Good practice and guidelines for cooperation with industrial partners have been developed together with experts in this area.

FOR has established joint research projects with several international partners such as Vanderbilt University Medical Center in Nashville, TN, USA. Together we investigate what is the impact of new treatment modalities on technological solutions and decisions made in the operating room. We also want to collaborate on efficient use of ICT in the operating rooms in order to optimize workflow and patient flow. We also work with Albert Einstein Hospital in Sao Paulo, Brazil, mainly focusing on telemedicine and "decentralization of specialist healthcare services". There are several other international partners who wish to cooperate with FOR. So far, we have focused on establishing research collaboration with the Massachusetts General Hospital in Boston, the Operating Room of the Future in Tübingen and research groups at Krakow University Hospital in Poland. A collaboration with the Yonsei University Health System, Seoul, Korea has also been established. Handling of the increasing number of elderly patients, the intelligent hospital and the transmission of high quality medical information are some of the projects that have been initiated, and which we want to focus on in the next few years. In 2016 a collaboration project was initiated with UFF Universidade Federal Fluminense in Brazil, where telemedicine via holograms is the main focus. This cooperation has been continued in 2017. FOR also collaborates with organizations such as the European Association for Endoscopic Surgery (EAES), the Society for Minimally Invasive Therapy (SMTI) and Technoport in Trondheim.

The cooperation is among other things built around the "National Center of competence for Ultrasound and Image guided Therapy" and the "National Center of competence for Ultrasound and Image guided Therapy and medical technologies, which now has its infrastructure in place with several ongoing projects. The NorMIT infrastructure is available both nationally and internationally. St. Olavs hospital at FOR and SINTEF have a good cooperation in the USIGT competence center. The competence center has a broad national and international network and extensive activity related to the development and dissemination of expertise and knowledge, one of the core tasks of the service. Through participation in several EU projects: VECTOR, HICOS Marie Curie Initial Training Network, SMICRON, FUSIMO, MISTELA, RASIMAs, TRANS-FUSIMO, and the recently awarded project HiPerNav ITN. Thus, important expertise from international academic environments has been "imported", while at the same time generating and contributing to the dissemination of local expertise both nationally and internationally. St. Olavs hospital at FOR and SINTEF have applied for a new EITN EU project, ORCconnect, in 2017, in collaboration with 11 other European research groups.

Research and development in cooperation with SINTEF and Norwegian national center of competence for ultrasound and image guided therapy

The Operating Room of the Future (FOR) is the arena and infrastructure provider for several ongoing research projects, including projects at the national center of competence for ultrasound and image guided therapy (www.USIGT.org). SINTEF is a key and important research partner and partner for FOR and USIGT. Thomas Langa at SINTEF has a coordinator position at St. Olavs hospital related to this center. One of the largest activities in 2017 was linked to activities of the above-mentioned competence center, which is national and appointed by the Ministry of Health and Care. The center uses FOR as the arena for a number of clinical and technological research and development projects ranging from technology development, prototyping and clinical trials / studies of new solutions which improve patient care. In 2017 there were 10 PhD projects in progress and 6 ongoing Postdoc research projects. About half of these have a workplace at SINTEF, having a shared position between SINTEF and NTNU. Often, a technologist and a clinician are working together on PhD projects related to the same topic, which illuminates the problem from both a clinical and a technical perspective. 26 scientific papers with peer review at were published at USIGT in 2017, some from projects conducted at FOR, St. Olavs hospital.

Through several user-driven projects supported by the Research Council and EU, the USIGT competence center has been an important competence environment for innovation and industrial cooperation. The competence center has a broad national and international network and extensive activity related to the development and dissemination of expertise and knowledge, one of the core tasks of the service. Through participation in several EU projects: VECTOR, HICOS Marie Curie Initial Training Network, SMICRON, FUSIMO, MISTELA, RASIMAs, TRANS-FUSIMO, and the recently awarded project HiPerNav ITN. Thus, important expertise from international academic environments has been "imported", while at the same time generating and contributing to the dissemination of local expertise both nationally and internationally. St. Olavs hospital at FOR and SINTEF have applied for a new EITN EU project, ORCconnect, in 2017, in collaboration with 11 other European research groups.

Thomas Langa
Head of Research, Department of Medical Technology, SINTEF
Photo: SINTEF
Operating Room of the Future and Institute of Circulation and Medical Imaging, Faculty of Medicine and Health Sciences, NTNU

An expectation of increased clinical research and innovation in the future.

Digitization and introduction of new medical technology will be central to Norwegian healthcare in the future. Then there will be a need for a safe and secure arena for development and testing of new technology and new solutions. The Operating Room of the Future and NoMIT is an infrastructure that allows piloting and testing of new technologies for better patient treatment, logistics and collaboration between different professions with a common goal of good patient care. Support and good infrastructure for research and innovation are crucial for clinicians to be able to make use of research as a tool for their own competence building. In 2017, a lot of interesting and good research was done in the Operating Room of the Future, both in collaboration with industry and through various clinical research projects and PhD work. At the same time, we see that there are opportunities to do more, especially in terms of innovation and cooperation in a merged NTNU. We are therefore looking forward to an exciting 2018, where we can increasingly realize interdisciplinary cooperation that can develop new solutions for better patient care. With new health education under the same NTNU umbrella, we also see great opportunities for better education including practice placements and especially the increase in MSc and BSc assignments having a basis in the needs and challenges observed at the workplace and addressed within this infrastructure. We hope for the years to come that the Operating Room of the Future and Institute of Circulation and Medical Imaging will be an even more important partner for international cooperation and EU research. An active researcher easily enters the research front and acquires important competence through his own research work, reading of scientific articles, is active in academic discussions in research networks and through conference participation nationally and internationally. For a researcher, import and development of new knowledge is ongoing in cooperation with good colleagues and partners nationally and internationally. We wish through the infrastructure to be attractive for importing good knowledge and expertise as well as contributing to developing new knowledge and technology that is competitive internationally. Developing new ideas for industrialization and cooperation with existing business is important in order to offer the best patient treatment. Also in this area, we have high expectations for the Operating Room of the Future and NoMIT in the coming years.

FOR in the future

Research and development towards clinics doing operating activities in the field of image guided minimal invasive treatment has been the main focus of FOR. This has proved to be a real bet, and minimally invasive techniques now feature more and more medical specialties. The image guided minimally invasive treatment represents one of the major innovation areas within the specialist health service. Such procedures have been an important factor in creating a more efficient and gentle treatment. Several surgical procedures are now being carried out as day surgery, and the patient is faster back in everyday life and into working life. It is likely that this trend will continue in the years to come, and that open operations will increasingly be replaced by minimally invasive procedures. The work to involve new disciplines will continue in 2018, and it is particularly pleasing that navigation technology has received entry into the ENT department and the lung department. Everything indicates that new technology will give us better opportunities for earlier diagnosis of tumors in the lungs. Evaluation of robot surgery is a field for which the attention has been directed. Work is continuing on new techniques for the treatment of patients with morbid obesity.

There are increasing numbers of older people in the population. Open surgery in elderly patients presents specific challenges because the risk of complications is higher than in younger patients. In addition, it takes longer before the patient is back to everyday life after treatment. Particularly with regard to these patients, the minimally invasive treatment is an advantage if conditions are appropriate.

It is being built, renovated and planned a significant number of hospitals in Norway and in other countries. The operating rooms are expensive to build and expensive in operation. We want to make experience and lead in the field so that one can optimize the investments. We focus on architecture, material use, ergonomics, ICT solutions, logistics and health economics, so we can build more affordable and drive more rationally. It is important to do this in a systematic manner so that we get a lasting knowledge of different conditions at the operating departments. There is still a need to structure the testing of equipment and techniques in operating departments, and FOR will continue to contribute support for the creation of contracts, implementation and evaluation of the projects.

The infrastructure of FOR currently consists of operating rooms, with the overlay of an AV-ICT structure that enables live transfer and interactive communication in full 4K. Further refinement of intraoperative imaging will take place. 3D manufacturing and holography may be a routine after all. At the same time, the disease perspective will change over time.

The need for multifunctional intervention rooms and the El-Phys lab is increasing, but the capacity of today’s FOR-operating room at AHI is now fully utilized. There is a strong desire for hybrid multifunctional FOR operating rooms, in several disciplines, because there is an increasing need for hybrid interventions in radiology, cardiology, surgery, thoracic surgery and pulmonary medicine. It will have significant consequences for future operation capacity within minimal invasive imaging intervention at the hospital if you do not prepare for increased capacity within this type of business.

We aim to get more international fellows at FOR. FOR has set a realistic and sobering goal by obtaining two PhD and four master’s degrees a year. We notice that there is an increasing need for master’s degree assignments and bachelor assignments and this will increase in the coming years. By creating main tasks (Medical Student’s Research Programme) for medical students, you can also get in touch with future candidates for fellowships. Here, FOR can be a good platform.

FOR has also continued and further developed a systematic and documented program for the training of doctors at the operational clinics in the field of electo medical equipment; EMU, in 2017. The introduction of new medical technology in patient treatment results in an increased need for personnel training. Such training is also required by law, and systematic training of those who operate the equipment involves, among other things, training on new acquisitions, training of new employees / temporary staff and maintenance of the training given. All physicians at operating departments are now offered and invited to systemically registered and documented. The training is now included in the established Expertise Portal, so that the employee himself and the respective management have a full overview of the status. The system has the possibility of integration with other systems. Training in radiation protection and infection protection is now available as e-learning. This is an innovation project that has great transfer value to other health institutions and health regions.

FOR has a close cooperation with many different actors. It concerns international industry, clinical environments and technological environments. The main actors are St. Olav’s hospital, the Faculty of Medicine at NTNU and SINTEF Technology and Society. Various competence centers such as the “Center for Advanced Ultrasound and Image Guided Treatment” and “National Center for Advanced Laparoscopic Surgery”, the Health Sciences Education at NTNU, NTNU Technology Transfer (TTO) and the Center for Interdisciplinary Research in Space (CIRiS) are important partners. The synergy effect of this collaboration is important to take care of in the future. The cooperation with SINTEF on navigation technology equipment continues, and we have great hopes for the use of steerable vessels and catheters for endovascular treatment of diseases in the endovascular system. Within lung medicine, one has used navigation in conjunction with endoscopy and endobronchial procedures. The operating space of the future has been, and is, an internationally preferred collaborator in the design of imaging and visualization technology for medical use in the image guided, minimally invasive treatment. We want to strengthen international cooperation, and many international players want to cooperate with FOR. So far we have concentrated on the Massachusetts General Hospital in Boston, the Future’s Operations Room in Tubingen and research groups at the Krakow University Hospital in Poland. We cooperate with the Vanderbilt University Medical Center, Nashville, TN. FOR also cooperates with organizations like EAES and SMIT. Furthermore, cooperation with Yonsei University Health System, Seoul, Korea.

Oystein Risa
Head of the Department of Circulation and Medical Imaging
Faculty of Medicine and Health Sciences, NTNU
Photo: NTNU
has been established. Collaboration with UFF Universidade Federal Fluminense in Brazil has begun, which has resulted in a MoU and collaboration in telemedicine and the use of holograms. The work will be given priority in 2018 and will be seen in connection with projects related to Hololens and VER decision support.

NorMIT «Norwegian Center for Minimally Invasive Image Guided Therapy and Medical Technologies» as a common infrastructure and platform will bring us wider nationally and internationally. This platform was developed between FOR and the Intervention Center, OuR Rikshospitalet and supported by funding from the Norwegian Research Council. Both Helse-Nord and Helse-Vest have now participated in this cooperation and are represented on the board. The purpose of the collaboration is to improve patient treatment and raise the quality and scope of research and innovation in such a way that it puts Norway on the map internationally. During 2017, the activity has started well. Focusing on research and development based on the established infrastructure and research tools now available at the Intervention Center and FOR.

We wish FOR to be a research infrastructure of good international quality. The goal is, among other things, to increase the quality and scope of research relevant to FOR. FOR will also be at the forefront of internationally regarding image-controlled minimal invasive treatment, partly as a result of cooperation with the R & D environments of the international industrial partners. St. Olav’s hospital and FOR is therefore an international pioneer in the intersection of a digital media technology industry and the development of new medical technology and new applications in the field of image guided minimally invasive treatment. FOR has helped set the standard for minimal invasive treatment in an international context.

3D printing is being investigated and established at FOR in 2018. The technology offers exciting possibilities. Within the development of implants, instruments and planning of complicated interventions. Technological development in areas such as gene therapy, nanomedicine, artificial intelligence and big data will be reflected in diagnostics and treatment in the future. These are areas that FOR orientate themselves towards through a multidisciplinary approach.

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Postdoctoral staff affiliated with FOR

2017

Juan A. S. Margallo, Minimally Invasive Surgery Center (Caceres, Spain) / SINTEF

Postdoc in the Department of Medical Technology of SINTEF. The main objectives of this project were:

1. Development, integration and validation of a surgical navigation model for assistance in pancreatic surgery. This model will provide a set of surgical training and assistance tools in order to improve the patient safety, as well as the accuracy and surgical outcomes obtained in this type of laparoscopic interventions.

2. Development of a realistic multimodal liver phantom for teaching, training and equipment development purposes in the field of laparoscopic ultrasound and surgical navigation technology.

3. To evaluate the visibility of various percutaneous needles in US images, including new needle designs and innovative echogenic coating technology. An accurate needle placement during percutaneous needle interventions such as biopsy or radio frequency ablation was sought with this study.

Juan A. S. Margallo
Photo: Private

Tina Stromdal Wik
Head of the PAFFA-project

Project manager TPO150: Torbjørn Rian. In the PAFFA project we look at pain and function after surgery with total prosthesis in the hip or knee. Prosthetic surgery in the hip and knee joint is common procedure, and only in Norway more than 9000 patients annually operate with new hip or knee joint. Long-term results after these operations are well-known, but many patients still have a lot of pain right postoperatively and the first time after surgery. The PAFFA project focuses on periprosthetic conditions that affect pain, function and quality of life. One of the studies in the project is TPO150, headed by a senior doctor at the Anesthesiology Department, project manager Torbjørn Rian. We know that multimodal pain treatment is effective for postoperative pain. It is known that patients with knee injury have more pain than patients with hip prosthesis. It has therefore been a goal to further optimize the pain treatment for this group. By testing an opioid that has two mechanisms of action (Tapentadol), the hypothesis is that the analgesic effect is at least as good as other morphine preparations, but that the drug is tolerated better due to minor side effects. The study is a randomized controlled three-arm study that compares Tapentadol with gold standard oxycodone and placebo. It is so far included 110 out of 150 patients in the study, and we expect that patients will be completed in 2018.

Reidar Brekken, NTNU / SINTEF

“Real-time 3D ultrasound for guidance of endovascular aortic repair” Endovascular treatment is a more gentle alternative to open surgery. It is usually used X-ray imaging to guide endovascular treatment. In this study, we worked on developing ultrasound-based guidance methods, which could reduce the use of X-ray and, in particular, the use of X-ray contrast agents that could pose a major strain on the kidneys for some patients. Using 3D real-time image also provides depth information that can help during the operation, compared with two-dimensional review. The main focus of the project has been to develop solutions to combine real-time ultrasound information with preoperative CT images that provide a better overall overview of blood vessels.

Reidar Brekken
Photo: SINTEF
Lungs have myriads of small branches, and it’s easy to get lost when lung cancer. Small lung tumors can be difficult to find when you try to control equipment down to the tumor. We are developing a tracking system that remind you of the GPS systems used in cars. As a map we use the patient’s own CT images. From 2018 we have started a European cooperation with centers in the Netherlands and Ireland, and the purpose is to develop a complete navigation system for the lungs. This was presented recently in Adresseavisen (https://www.adressa.no/pluss/nyheter/2018/02/26/slik-vil-kreftlegene-finne-skumle-lungesvul-ster-16158295.ece) and Gemini (https://gemini.no/2018/02/teknologivurkiling-gir-nytt-bap-pasienter-lungekreft/).

Two of our co-researchers, Hanne Sorger, chief physician at the hospital in Levanger, and engineer Pall Jens Reynisson (PhD dissertation in March 2018), and a young specialist in pulmonary medicine who recently started his PhD run, Arne Kildahl-Andersen 2018 will become an exciting and interesting year for the research group.

### Postdoc

**Heidi Gilstad**

Researcher and postdoc at the Department of Health Informatics, Department for Neumedicine and movement science, NTNU. In the project "Health communication in a digital life", which is developed in collaboration with the Operating Room of the Future, she studies the patients experience with communication during a patient progress. The project has a discourse analysis perspective on information dissemination and communication on health. Heidi is involved in a number of communication science research projects, and she is a project manager for research and development in the development project "Smart digital health communication", and in one SINTEF project that evaluates the development in the development project "Smart digital health communication", and in one SINTEF project that evaluates the implementation of the "package process" for cancer in Norway.

### PhD Student

**Håkon Olav Leira**

50% postdoc over 6 years at ISB, DMF, NTNU and at the same time as consultant at the Department of pulmonary diseases. The focus is research on lung cancer, especially bronchoscopy navigation system as part of USIGT, FOR and NorMIT. In our project we develop advanced diagnostics equipment for lung cancer. Small lung tumors can be difficult to find when you want to sample them. The reason for this is that the airways in the lungs have myriads of small branches, and it’s easy to get lost when you try to control equipment down to the tumor. We are developing a tracking system that remind you of the GPS systems used in cars. As a map we use the patient’s own CT images. From 2018 we have started a European cooperation with centers in the Netherlands and Ireland, and the purpose is to develop a complete navigation system for the lungs. This was presented recently in Adresseavisen (https://www.adressa.no/pluss/nyheter/2018/02/26/slik-vil-kreftlegeme-finne-skumle-lungesvulster-16158295.ece) and Gemini (https://gemini.no/2018/02/teknologivurkiling-gir-nytt-bap-pasienter-lungekreft/).

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### Ultrasound Contrast Bubbles at High Frequencies

### Sigrid Berg and Rune Hansen, NTNU / SINTEF

Imaging of ultrasound contrast bubbles at high frequencies. Microbubbles, consisting of thin lipid shell and gas core, are used in the clinic to provide better images of microcirculation in echocardiography and cancer diagnostics. With clinically available ultrasonic machines, bubbles can be depicted at relatively low frequencies (2-5 MHz) and low pressure (MI = 0.1). At high frequencies, one must typically use higher pressures to activate bubbles, and thus it will no longer be possible to suppress the signal from the tissue in a satisfactory manner. We have been working on implementing a new method for depicting bubbles at high frequencies on the research scanner Versaonics (Normita). By combining high frequency imaging pulses with low-frequency manipulation pulses, we achieve both a high signal from the bubbles and a good suppression of the tissue. The method is a patenting proceeding and has been implemented on linear transducers with frequencies from 5 to 25 MHz, this includes transducers from Versaonics, GE and Visualonics. When methods for imaging bubbles are developed, it is important to have validated information about the pressures and frequencies of the transducer transmits. To characterize transducers we have used NorMIT’s Onda AIMS III system.

### Erik Smistad, Postdoc ISB, NTNU / Researcher SINTEF

Use of navigation technology in combination with 3D models X-rays partially overcome the difficulties with minimal invasive intervention, such as reduction of field of vision, deficiency on agility and tactile feedback. Erik is working with automatically segmentation of the respiratory tract used in visualization procedures in navigation bronchoscopy. This technology for data mapping is used during dataassisted navigated virtual bronchoscopy. His research interests includes: image segmentation, machine learning and neural networks, parallel and GPU processing and ultrasound.

### David Bouget, NTNU(ISB/CIUS)

### 3D CT Image Processing for Automatic and Enhanced Detection of Lymph nodes.

For estimation of disease prognosis and to select the correct treatment for lung cancer, it is important to label and classify lymph nodes in mediastinum. While the primary tumor is usually easy to identify in the lungs, it is a challenge to figure out if the cancer has spread to nearby lymph nodes. Therefore, the goal of this project is to develop methods to improve auto-detection of lymph nodes from 3D CT images. To this we propose a computer program that will perform organ segmentation with image registration. Then the computer program focus on remaining areas without internal organs using deep learning and classifying methods. Finally an overview of identified lymph nodes will be presented for the surgical team.
Sebastien Muller, NTNU / INM / SINTEF

Project Title: Multiguide; Development and Safety.

The main focus is implementation of feasibility and usability (human-machine interaction) studies for quality assurance and documentation of the operating procedures. An automatic detection of surgical phases based on machine learning have been completed and published. Technical validation of the new display device being developed for the Multiguide is on its way with a special focus on navigation accuracy related to different elements of the navigation system (hardware and software). Furthermore, the clinical validation for each application is carried out in close cooperation with clinicians. For each clinical study, the postdoc will be responsible for registration of adverse device effects (ADEs). We have shown that we can estimate the bloodstream direction on clinical important blood vessels during surgery. This is harmful events that occur due to error or lack of cooperation with clinicians. For each clinical study, the postdoc will be responsible for registration of adverse device effects (ADEs).

Multiguide prototype

Photo: SINTEF

Sébastien Muller, NTNU / INM / SINTEF

3D Ultrasound imaging for improved detection and quantification of blood flow. The primary goal of this project is to develop methods to improve 3D ultrasound based imaging of blood vessels. In surgery, the information about blood flow is important to identify and to avoid damage to important blood vessels. Estimation of blood flow direction has been tested for neuro operations and the results are accepted for publication in JCARS. We have shown that we can estimate the bloodstream direction on clinical important blood vessels during surgery.

Multiguide prototype

Photo: Private

Daniel Høyer Iversen, NTNU / SINTEF

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Multiguide prototype

Photo: SINTEF

Sébastien Muller

Photo: SINTEF

Scientific production

Camilla Berge Jacobsen

"Abdominal aortic aneurysm repair
Factors influencing early and late mortality”

Dissertation took place 31th May 2017

Clinical PhD candidate

The thesis focus on conditions affecting early and long-term mortality after surgery for abdominal aortic aneurysm. It includes both open surgery and endovascular treatment. In particular, focus is placed on female patients. They have higher mortality in surgery for rupture than men. And the aneurysms rupture at lower diameter in women than in men. Long-term survival generally improved over time. Accompanying conditions such as cerebrovascular disease, diabetes, COPD and renal failure affected the long-term survival in a negative way. Female patients had more autoimmune diseases than men. However, there were otherwise no differences in comorbidity or the occurrence of postoperative complications that could explain the higher early mortality in women. Patients with elevated white blood cell count preoperatively generally had higher mortality than those who had normal white blood cell count.

Supervisors: Torbjørn Dahl, Hans Olav’s Myhre and Anne Irene Hagen

Camilla Berge Jacobsen

PhD degrees - completed in 2017

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Supervisors: Torbjørn Dahl, Hans Olav’s Myhre and Anne Irene Hagen

Camilla Berge Jacobsen

Supervisors: T orbjørn Dahl, Hans Olavs Myhre and Anne Irene Hagen

The most important findings in the thesis were:

- Botulinum toxin blockade of sphenopalatine ganglion is a possible new treatment for chronic cluster headache and chronic migraine showing promising results, but it is necessary to perform randomized, placebo-controlled studies to assess safety and efficacy.
- The new method in which the injection is performed using a new image-surgical instrument seems feasible and, compared to existing methods, can expose patients and healthcare professionals to less radiation.
- The treatment appears to be possible on awake patients in an outpatient department.
- The sphenopalatine analgesia can be identified on MRI, thus giving better accuracy of the injection.

Andreas Åslund

MR-guided opening of the blood-brain barrier.

In this project we wanted to investigate if Cabazitaxel, a chemotherapy, encapsulated in polymeric nanoparticles, could be used in the treatment of glioblastoma in mice. Combining our nanoparticles with ultrasound and gas-filled microbubbles, we can use MRI to guide the treatment to the tumor in the brain without any invasive procedures.

Andreas Åslund

Photo: Private

Daniel Fossum Bratbak

Botulinum toxin Type A injections against sphenopalatine ganglion in primary headache with a novel image guided technique.

Dissertation took place 31th March 2017

Chronic headache and chronic migraine are conditions associated with significant disorder and reduced functioning and affect most in early adulthood. Several patients do not have satisfactory effect of available treatment, or choose to discontinue treatment due to side effects. The sphenopalatine ganglion is involved in the pathophysiology of both cluster headache and migraine. We believe that this ganglion can be blocked with botulinum toxin and thus relieve the headache. In order to perform such injections, we developed a new image technique and a new surgical instrument. In the thesis, research was conducted aiming at evaluating the initial development of a possible new treatment method for patients with treatment refractory cluster headache and chronic migraine. In two studies, a chronic cluster headache study and a chronic migraine study, the safety of botulinum toxin blocking the sphenopalatine ganglion was assessed with two different approaches. Both studies found an acceptable side effect profile. In a third study, one identified the sphenopalatine ganglion on MRI.

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Daniel Fossum Bratbak

Photo: NTNU

Camilla Berge Jacobsen

Photo: NTNU

Supervisors: T orbjørn Dahl, Hans Olavs Myhre and Anne Irene Hagen

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PhD degrees – Ongoing

Cecilie Våpenstad

“Tools and methods for skills training in minimal invasive surgery – using simulators, ultrasound and navigation.”

Technological PhD candidate.

Looking at how general and patient-specific simulation can improve and ensure quality on surgical skills and surgical teamwork within endovascular and laparoscopic procedures.

Supervisors: Torild A. Nagelhus Hernes, Ronald Mårvik and Petter Aadahl

Kent Are Jamtøy

Botulinum toxin type A blocked by sphenopalatine ganglion by chronic pain and inflammatory conditions in the craniofacial region.

Jontom is a research group based at St. Olavs hospital and the Norwegian University of Science and Technology (NTNU) in Trondheim. A new method of blocking ganglion sphenopalatum (SPG) with botulinum toxin type A (BTA) has been developed. This is done using a navigation-based instrument (MultiGuide) to ensure accurate deposition of BTA. The method is performed in 10 patients with headache pains with transnasal access under the anesthesia of the endoscopic block of the sphenallatine ganglion in intractable cluster headache. A pilot study on chronic migraine has also been published, where the injection is done with lateral access (through the cheek). This study also shows acceptable side effects and good potential for effect. In addition, there is also a pilot study on the injection of botulinum toxin against SPG by trigeminal nevralgia. In this PhD project, Jamtøy will inject botulinum toxin against SPG by chronic rhinosinusitis with nasal polyps and atypical facial pain. Jamtøy plans to complete his research with a 50% position over 6 years.

Geir Arne Tangen

“Enhanced Minimally Invasive Therapy”. Technological PhD candidate.

He works with development / testing of controllable catheters integrated with navigation technology for endovascular procedures. He has also conducted a study to investigate methods that ensure accurate navigation with catheter and guidewire in blood vessels. He also plans to complete his research with a 50% position over 6 years.

Anna Rethy

Supervisor ENT: Ståle Nordgård.

“Navigated 3D laparoscopic ultrasound in treatment of liver tumours.”

Clinical PhD candidate.

Research of the use of laparoscopic ultrasound in primary tumors and metasteses in the liver. She has also investigated position changes in solid organs by establishing air in the abdominal cavity for laparoscopy, and how navigation technology can be used as well. She has worked with multimodal liver models to simulate tumors and test multimodal image formation and training with laparoscopy and navigation instruments.

Supervisors: Ronald Mårvik and Thomas Lango

Mads Henrik Strand Moxness

Modeling of Obstructive Sleep Apnea by Fluid-Structure Interaction in the Upper Airways – “Modellering av øvre luftveier ved obstruktiv søvnapne”.

The Norwegian Research Council has allocated NOK 10 million to a research project between DMF, Faculty of Engineering and Technology and SINTEF to develop a 3D model and data simulation of the upper respiratory tract in patients with obstructive sleep apnea before and after nasal surgery. The model should be based on CT and MR images and airway measurements in patients. In a part of the project, 25 patients will be operated at FOR and the results will be correlated between postoperative measurements on patients and results from the model.

Amar Aganovic

As a part of the PhD study on “Control of airflow distribution methods enabling better indoor environment in health-care facilities” we investigated the impact of surgical lights on the velocity distribution and airborne contamination level in two operating rooms equipped with laminar airflow systems at the orthopaedic department of St. Olavs hospital. The work was carried out in collaboration with Liv-Inger Stenstad and Jan-Gunnar Skogås from FOR and under supervision of Guangyu Cao from the department of Energy and Process Engineering at NTNU. The study [1] showed that the wakes created behind the three differently shaped surgical lights were characterized by relatively high turbulence intensities and by velocities low enough for microbial particles to deposit on critical surfaces such as wounds. This was confirmed in the same study by the occurrence of bacterial counts in the sterile field during mocked surgeries performed under surgical lights. An additional mock surgery that was performed without lights did not record a single bacteria count. The conclusion was that medical equipment such as surgical lights may impede the ventilation system’s ability to clear contaminants from the sterile field. We are currently analysing the combined effect of surgical lights and the fluoroscopy imaging device on the airborne contamination in operating rooms with laminar airflow systems.


Supervisor: Prof. Guangyu Cao
Lars Eirik Bø

Image-guided back surgery.
In this PhD project, new methods have been considered to guide surgeons in back surgery. Today many interventions use X-ray imaging, but he wants to develop methods that allow a combination of ultrasound and MRI imaging to be used instead. In this way, the surgeon gets three-dimensional and more detailed images to navigate, as well as reducing the use of X-rays in the operating room. In 2017, Bo has worked on methods for imaging bone beads in the back with ultrasound and recording of MR images to such images. The results are promising, but not enough to be tested at the operating room. The PhD project has now been completed, but this work is further worked on in other projects. Disputas are scheduled by mid 2018.

Rita Elmvist-Nilsen

“Mapping Brain Plasticity”
Rita Elmvist-Nilsen’s PhD project examines the formative role of newer imaging technologies playing as knowledge-producing, diagnostic and therapeutic tools in neuroscience research practice. The project addresses newer approaches in cognitive neuroscience that considers the brain as an adaptive and dynamic body of plastic potential and, through diffractive reading, actualizes recent human-scientific perspectives on human perception and cognition as bodily rooted, relational, situational, action-oriented and shaped by technological media.
Supervisors: Aud Sissel Hoel and Anne Beaulieu

Hanne Sorger

PhD project title: Development of a navigation system for bronchoscopy.
The main objective of the project is to improve minimally invasive lung cancer diagnostics using a new image guidance system based on electromagnetic navigation and multimodal image fusion. In the case of lung cancer, the patient’s prognosis is most important if the disease has spread to mediastinal lymph nodes, which excludes healing surgery. Endobronchial ultrasound with aspiration using a thin needle from lymph nodes (EBUS-TBNA) is the first choice in the stage division. New clinical guidelines now recommend systematic EBUS-TBNA also of small (<5 mm) mediastinal lymph nodes if the patient may be appropriate for curative lung cancer treatment. Future EBUS-TBNA will therefore become increasingly technically challenging, requiring an effective and gentle procedure so that the patient can be investigated outpatient and in a wakeful state. We have developed a prototype EBUS bronchoscope, where a millimeter sensor mounted on the tip allows tracking of the ultrasound head position in an electromagnetic field around the patient’s chest. The patient’s own preoperative images (usually CT) are imported into the navigation program, automatically registered to the patient’s position on the operation table, thus serving as a 3D map for the sampling equipment. The ultrasound images from the EBUS bronchoscope are merged with preoperative CT images in the navigation program, and provide real-time information during the survey (see figure).
The bronchoscope can navigate quickly and accurately to each single lymph node for sampling. Diagnostic precision and success rate for EBUS-TBNA can be increased. More precise and effective selection of curable lung cancer patients will be possible without the need for invasive methods with higher complication rate. The defense of the submitted and approved PhD thesis March 8th 2018.
Main supervisor: Håkon Olav Leira
Assistant supervisors: Thomas Lango and Tore Amundsen

Pall Jens Reynisson

The thesis presents a development and evaluation of a new visualization method for planning and guidance in bronchoscopy, anchored to the Centerline Curved Surface (ACCuSurf), which consists of more complete viewing for navigated bronchoscopy in tube-like structures. The technology can also be combined with other methods such as VB, PET and ultrasound images by adding these data sources on the screen. At the same time as giving an overview of the lungs and tools, ACCuSurf can be zoomed in and display more anatomical details than the conventional endoluminal display. First, a comparison of different approaches to airway segmentation was performed to establish a route to the target. Second, ACCuSurf was developed by slitting the segmented respiratory tract in half and creating a 3D volume representing surrounding anatomy along the way to the target. Finally, the ACCuSurf method was evaluated by pulmonologists who used it as a planning tool before performing bronchoscopy on a phantom with a mixed data set from a patient and phantom. Conventional 2D (axial, sagittal, coronal) visualization was comparative reference. The study is an attempt to facilitate and simplify visualization for navigation in bronchoscopy.
Disputed March 20th 2018.
At the Faculty of Medicine and Health Sciences, NTNU, a separate research programme has been established around the ordinary study in medicine. The research programme involves two additional semesters devoted only to research, and that research is organized in parallel with the medical studies. Admission to the research programme takes place after two or three years of medicine studies at NTNU. From the autumn of 2002, the research programme was established at all four medical faculties in Norway, based on a wish to recruit more medical students to research, improving the organization of research education, and promoting scientific attitude towards medical business.

**Erik Nypan**

Three-dimensional visualization and navigation in endovascular procedures. The project deals with navigation systems for use in endovascular navigation, especially with regard to the aorta. The goal is to compare Navigation Systems iPilot (Siemens) and CustusX (SINTEF) for endovascular use. iPilot is based on conventional X-ray in combination with intraoperative and preoperative CT, while CustusX use electromagnetic tracking catheter and guidewire in combination with preoperative CT. The project is divided into several parts, and is performed on phantom, pig and patients.

During 2017 we have completed a study on pigs and have tested out a new steerable catheter. We compared the use of the catheter under the guidance of traditional review against electromagnetic tracking-guided procedure. We also started to include patients who will receive stent graft endovascularly for aortic aneurysm. On these patients we collected electromagnetic tracking data that we are going to connect to the preoperative CT images to see if it is possible to navigate these (CustusX). The data should be compared to a conventional vision system, iPilot. Last patient is scheduled to be included in February 2018. The project is being carried out in the FOR-operating room at AHL in collaboration with the surgery department.

**Main supervisor:** Frode Manstad-Hulaas  
**Assistant supervisor:** Reidar Brekken

**Henrik Runde**

The study "Mortality, Physical Function and Quality of Life in Patients Treated in the Standardized Patient Progress Fixed Hypothyroidism" is a prospective cohort study. The purpose of the study is to investigate how altered biomechanics in the hip after hip fractures affect physical fitness and independence in patients treated as fast track hip fractures. The study follows a group of 100 patients treated at the Orthopedic Department, St. Olavs hospital. When the patient was present at the department, prefracture functionalities and quality of life with EuroQol EQ-5D-5L were measured and two days post-operatively, short physical performance battery (SPPB) was carried out with physiotherapist. Other information, such as medical history, x-ray findings and information related to the treatment, were recorded in the registry for hip fracture patients. The patient group will be followed up with X-ray during spring 2018. EQ-5D-5L and SPPB are performed, in addition to other goals we want to correlate to biomechanics in the hip.

**Main supervisor:** Lars Gunnar Johnsen  
**Assistant supervisor:** Trude Basso

**Javier Pérez de Frutos**

Intraoperative registration techniques for improved ultrasound based navigation in laparoscopic soft tissue surgery. Technological PhD linked to the HiPerNav EU project (ITN). SINTEF/NTNU/IDI.

One-click registration method Lab study of the feasibility of the one-click registration method, implemented in the foundations of NorMIT-navigation software, before doing clinical tests. This study will be presented in CARS 2018 conference.

Assessment of tracking systems target registration error This study aims to assess the performance of optical and electromagnetic tracking systems in terms of target registration error. For this, both tracking systems where tested in a real OR environment using a phantom made specifically for such tests. This study was carried out as a collaboration between The Intervention Center in Oslo and SINTEF Medical Technology research group. Pending of acceptance in EMBC 2018 conference.

**Javier Pérez de Frutos**

Photo: Private

**Henrik Runde**

Medical student, NTNU  
Photo: Private

**Erik Nypan**

Medical student, NTNU  
Photo: Private

**Javier Pérez de Frutos**

Photo: Private
Several cases of postoperative wound infections have been registered at modern hospitals. This may be because air with increased bacterial content is spread uncontrollably in turbulent airflows during an operation. Therefore, under infection-sensitive surgery, ventilation systems are used with ultra-high air, such as LAF roofs. However, disturbances from light fixtures, surgeons and other factors in the room may prevent the ultrasonic laminar currents from reaching the operating field. In the spring of 2017, she wrote a master thesis in collaboration with the Operation Room of the Future. The aim of the master’s thesis was to characterize the air flow pattern under a LAF ceiling in an operating theater, and investigate how the currents were affected by factors necessary to be present during surgery, such as a surgeon. The task was solved experimentally, and air currents were measured in several scenarios; over a patient, and with operating lights in different positions, to select someone. The results from the measurements showed that convective airflow generated by hot surfaces in the operating field may have a significant impact on airflows from the ventilation system. It was the location of the lamps that had the greatest impact on air currents, which was natural as the lamps’ location blocked the currents. Turbulence intensity above the operating table also increased significantly when using lamps. The trials also showed that convective airflow generated at the surface of a bedside patient affected the air currents from the LAF ceiling. This master thesis therefore shows the importance of assessing convective air currents in designing operating rooms to ensure that particulate air does not reach the operating field. 

Supervisor: Prof. Guangyu Cao

**Kristine Rise Fry**

In order to reduce the number of patients unnecessarily referred to the specialist health service, there is a need for decentralization of specialist competence. The Operating Room of the Future future, a research arena at St. Olavs hospital, has developed a digital tool that will make it easier for district hospitals to seek decision support from hospital specialists in cases where interaction is necessary. The tool is called the Virtual Examination Rooms (VER) and is an interactive telemedicine solution that can share patient data in real-time.

**Goal**

The aim of the master’s thesis is to take into account the user needs and the context the doctors are in to discover the need for a redesign of the VER user interface and specify how the solution should be designed to meet the needs.

**Results**

User studies and analyzes reveal an undefined concept where there are unclear guidelines for using the system. Two primary users were defined: district employee and specialist. District employees are the user who initiates the use of VER, so it is essential that they trust the system to function and that there is a specialist available to provide decision support. The need chart shows that the system is not so logical and efficient to be used actively. The project resulted in a redesign of VER. The solution proposal has been developed in view of a given, future usage scenario.

**Future**

Ane A. Kielland

How is compliance with guidelines for the administration of antimicrobial prophylaxis by surgery.

Bjørnar Larsen og Vegard Vingsæth

Mapping the connection between radiation doses and working methodology under EVAR procedures using RaySafe i2 Real-time ™ dosimeter

Karina Kruskov og Karoline Haugberg

Faculty of Medicine and health sciences – Bachelor in nursing: ‘Administration of antimicrobial prophylaxis by surgery’

Marta Havåg Ranestad

This master thesis attempted to develop a fast, elastic and diffeomorphic image capture implementation. Elastic diffeomorphic imaging has already been used in many diagnostic and research-related medical situations, but is used as a post-processing tool due to the high amount of time spent. This master thesis focused most on how elastic diffeomorphic imaging could be used with 3D echocardiography to estimate a vector field representation of cardiac movement, preferably in real time. Image compression and image capture required a lot of matrix multiplication and invert. This made the algorithm suitable for parallel programming, so the implementation was written full-time on the GPU using OpenCL with good results for time usage. Theoretical diffeomorphic vector field was generated to test the accuracy and time of the code, and an optimal setup was found and used to test real 3D in echocardiographic images. The actual images showed estimated deformation fields as were diffeomorphic over almost the entire field, indicating that the code calculated realistic deformation fields. By comparing the time usage of the code when it was run on a laptop and desktop computer, it became clear that real-time application of this method would be very dependent on the hardware it was run on. Despite this, both the actual and theoretical test results showed that the accuracy was high even for major deformations. It is therefore reasonable to assume that in high-image situations it will be possible to skip some images to obtain an accurate estimate in real-time.

Assand supervisor: Gabriel Hansen Kiss

Marta Havåg Ranestad

Department of Electronic Systems, NTNU

Photo: Private
Other projects

It is an important part of the Operating Room of the Future’s mandate to develop RD&I projects and initiatives where researchers, clinical health professionals and industry/business partners can cooperate. FOR’s goal is to create new knowledge and new solutions that are useful and used for the benefit of patients/relatives and healthcare providers. We are located at the intersection between research and innovation – between building new knowledge and new solutions and taking it into everyday use. Innovation is for us: Development of new products, services or organizational forms that contribute to strengthening health service, in terms of increased quality, improved work processes, increased safety for patients and employees, and thus contributes to value creation.

The interaction with the clinical partners is very important in order to ensure that the newly developed solutions, methods, processes and new knowledge is actually taken into use. We have our own infrastructure for testing of new medical technology and new treatment methods to ensure the bridge between the new and what is already routine. The Operating Room of the Future also carries out intensive cooperation with industry partners and international partners through various research and development projects. Cooperation with industry and business is an important part of creating good applications for the results of the research and development projects.

By funding NorMIT, the Norwegian Research Council has acknowledged that the Operating Room of the Future has methods and systems to be able to collaborate effectively with industry/business and clinical professionals and to create applications for new knowledge. The Norwegian Research Council as well as the EU’s framework programs for research and development emphasize that the use of research results is an important criterion for the allocation of research funding development programs. The allocation of NorMIT, which is now well underway, we see as a recognition of our focus on innovation and new applications. This also constitutes an important landmark in our strategic focus on new international research and development projects. In an international perspective we are experiencing great interest for our work and for us: Development of new products, services or organizational forms that contribute to strengthening health service, in terms of increased quality, improved work processes, increased safety for patients and employees, and thus contributes to value creation.

Quality register for nasal sinus surgery and "Fast-track"

St. Olavs hospital established a quality and research register on 1st of January 2012 for patients undergoing endoscopic sinus surgery, where the quality of life is measured before, and 6 months after treatment. All endoscopic and open interventions are recorded on a continuous basis with regards to procedures and results.

Fast-track is a standardized patient course for specific groups undergoing nasal sinus surgery that includes patient training, scheduling and follow-up. This allows for an efficient and socioeconomic patient care. Furthermore, all this data is included in the quality register.

Sialography - an aid in the diagnosis of tumors in salivary gland

Sialography is the inspection of the salivary gland with a thin, flexible instrument. The project aims to study the benefits of this method in the investigation of salivary stones, tumors and others diseases of the salivary glands. Currently St. Olavs hospital is the only place in Norway that performs these minimally invasive procedures, so patients are referred to us from all over the country. The number of procedures increased in 2017 to 27, of which 25 had clean results with/without stone /dilation and 2 biopsy procedures. The indication was sialedithesis (stone disease) for 17 patients and sialodentits (chronic infection) or other sialo secretion disorders for 10 patients. In 2018, it is expected that we will perform around 50 procedures.

Botulinum toxin type A blocking of sphenopalatine ganglion in persistent idiopathic patients facial pain: a randomized, double-blind, placebo controlled pilot study

The aim of the study is to investigate the effect and safety of injecting botulinum toxin A in the sphenopalatine ganglion in patients with persistent idiopathic facial pain. Patients with persistent idiopathic facial pain have a significantly decreased quality of life due to pain. 7 out of 10 scheduled patients are included in this study.

Injection of botox against SPG by persistent idiopathic facial pain:

A study of 30 patients with half receiving placebo injection, then crossover after 6 months where patients will receive a new round of injections but with the opposite substance. Thus, a total of 60 injections are planned. This study will start in 2018.

TPO-150 study - Use of depot-oploid as pre- and postoperative pain relief in primary knee joint prosthesis

A double-blinded randomized controlled study: Tapentadol vs. Oxycodone vs. placebo

As a FOR project, a trial is currently underway for different “pain packages” for patients who undergo knee replacement surgery. Currently, inclusion and testing are in progress, inclusion is planned until mid-2018. The aim of the study is to develop better pain management systems for patients being treated, also for other types of surgery than knee prostheses and for subjects other than orthopedics. Follow-up of patients occurs at home with reporting of effect and symptoms via tablets. The testing of this tool can also benefit other patient groups in the long term.

Project Manager Torbjørn Rian, Senior anesthetiologist, Anesthesia Dept. St. Olav Hospital. Head of the PAFFA project, supervisor: Tina Strømdal Wik, Project Manager TPO150: Torbjørn Rian.

In the PAFFA project we look at pain and function after surgery with total prosthesis in the hip or knee. Prosthetic surgery in the hip and knee joint are common procedures, and only in Norway more than 9000 patients are operated annually. Long-term results after these procedures are consistently good but still many patients have a lot of pain postoperatively and short-term after surgery. ThePAFFA project (Pain and function after fast track arthroplasty) focuses on perioperative conditions that affect pain, function and quality of life. One of the studies in the project is TPO150, led by chief physician at the anesthesia department Torbjørn Rian. We carry out our cooperation with medical professionals from national and international partners through various research and development projects. Cooperation with industry and business is an important part of creating good applications for the results of the research and development projects.

Photo: Fujifilm

New light and imaging technology in endoscopy

Over the last few years, many technological advances have taken place in endoscopic diagnosis and treatment. Fujifilm is one company that is at the forefront of this development. By using LED light as light source, researchers and product developers at Fujifilm have shown that by processing different wavelengths of light the visualization of digestive tract lesions can be significantly improved when compared with conventional light sources. The different light modes used are BLI (Blue Light Imaging) and LCI (Linked Color Imaging) – see photos and images below. The potential of this technology is related to the earlier discovery of malignant tumors, and more accurate diagnosis and treatment of disorders of the digestive tract. Several controlled studies are under way internationally, which hopefully will clarify the usefulness of the method. FOR in collaboration with gastro-lab performs a 6-month evaluation project of this technology, primarily aimed at the investigation and treatment of Barrett’s esophagus. The condition of the esophagus is characterized by the development of an abnormal mucosa which can develop into cancer. The evaluation is led by Professor Reidar Fossmark. The project started in December 2017 and ends at the end of May 2018.
"One step back". Radiation Hygiene Project

This project deals with radiation protection for the employees who work with X-ray equipment in an operating room. We have acquired a dosimeter system that will increase awareness of staff in the operating room when it comes to radiation protection. The dosimeter system shows on a screen how much radiation an individual gets exposed to at any time, and how the pattern of movement, distance and time can decrease or increase the received radiation dose. There is a strong focus on radiation protection at St. Olavs hospital, but there is a lack of awareness about the subject. There are many occupational groups in an operating room, including anesthesia staff, surgical nurses, surgeons, radiologists, cardiologists, radiographers etc. Many of these may be exposed to radiation. This project focuses on radiation protection for all those who are close to the X-ray equipment in an operating room, including anesthesiology staff, surgical nurses, surgeons, radiologists, cardiologists, radiographers etc. The project aims to improve the utilization of operating rooms and personnel at the orthopedic department at St. Olavs hospital (St. Olavs), by developing a prototype for a new decision support tool. Existing planning methods are manual and are different for the three locations Trondheim, Røros and Orkdal. The innovation project is limited to a department at St. Olavs, however the results will provide insight into resource improvement potential at several locations and departments. The prototype will be based on a master's thesis at the Department of Industrial Economics and Technology Management (IØT) at Norwegian University of Science and Technology (NTNU). Planning methods based on optimization methodology that take into account the uncertainty in the duration of the surgery and the arrival of unscheduled emergency patients are considered. The models can be used to plan the order and the start time for surgeries in an operating room for a given day. However, it has become clear during the project that not all the prerequisites for the model are included in the master thesis, so that the direct application of the model is difficult. The project will therefore concentrate on preparing a better forecast for the time used (time matrices) for a section at the orthopedic department and evaluate the use of this, both through tests against historical data and by testing against the planning of operations at this section for a period of time.

Visualization project at Neurosurgery

The Operating Room of the Future at St. Olavs hospital has conducted a test using 4K image capture and visualization in neurosurgery during the removal of brain tumors and aneurysms in 2016. The images were taken using an optical microscope and shown on an 85-inch 4K display and a CLEIDS panel from Sony. The next steps in the project were to test it if possible to replace the microscope with an endoscope combined with a 4K camera to capture the images. It turned out to be possible, but we needed an arm to hold the endoscope. We have tested an option from Karl Storz that uses high pressure air and can be easily repositioned as needed. The combination was tested at the neurosurgery operating room using a set up that simulated a realistic scenario. The solution was robust enough so that it can be tested during operations, which will be the next step in the project.

Pilot for computerized operation planning at orthopedic department

The project aims to improve the utilization of operating rooms and personnel at the orthopedic department at St. Olavs hospital (St. Olavs), by developing a prototype for a new decision support tool. Existing planning methods are manual and are different for the three locations Trondheim, Røros and Orkdal. The innovation project is limited to a department at St. Olavs, however the results will provide insight into resource improvement potential at several locations and departments. The prototype will be based on a master's thesis at the Department of Industrial Economics and Technology Management (IØT) at Norwegian University of Science and Technology (NTNU). Planning methods based on optimization methodology that take into account the uncertainty in the duration of the surgery and the arrival of unscheduled emergency patients are considered. The models can be used to plan the order and the start time for surgeries in an operating room for a given day. However, it has become clear during the project that not all the prerequisites for the model are included in the master thesis, so that the direct application of the model is difficult. The project will therefore concentrate on preparing a better forecast for the time used (time matrices) for a section at the orthopedic department and evaluate the use of this, both through tests against historical data and by testing against the planning of operations at this section for a period of time.

Scientific articles

Reynisson PJ, Leira HO, Lange T, Tangen GA, Haslen P, Amundsen T, Hofstad EF.

A new ct visualization for guidance to peripheral lung tumours: evaluation of bronchoscopic performance. Submitted to Minimally Invasive Therapy and Allied Technologies (MITAT), October 2017

Pham K D-C, Havre RF, Lange T, Hofstad EF, Tangen GA, Mårvik R, Pham T, Gilja OH, Hattelbach JK, Viste A


Anthropomorphic liver phantom with flow for multimodal image-guided liver therapy research and training. Int J CARS. DOI 10.1007/s11548-017-1669-3. Published online: 19 September 2017. PMID: 28929364 Open access: https://link.springer.com/content/pdf/10.1007%2FEl1548-017-1669-3.pdf

Hofstad EF, Sørger H, Bakeng JBL, Gruionu L, Leira HO, Amundsen T, Lange T.


Sánchez-Margallo JA, Lange T, Hofstad EF, Mårvik R, Sánchez-Margallo FM.


Lelu S, Afadai M, Berg S, Åslund AKO, Torp SH, Sattler W, de L Davies C.


Tystad Lund K, Tangen GA, Manstad-Hulaa F.

Electromagnetic Navigation vs. Fluoroscopy in Aortic Endovascular Procedures - a Phantom Study.


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Khan, Naiad Hossain; Tegnander, Eva; Dreier, Johan Morten; Eik-Nes, Sturla; Torp, Hans; Kiss, Gabriel. Automated Detection and Measurement of Fetal Biparietal Diameter and Femur Length — Feasibility on a Portable Ultrasound Device. Open Journal of Obstetrics and Gynecology 2017 :Volumn 7 (8) s. 922-936, NTNU STO

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Virtual bronchoscopy method based on marching cubes and an efficient collision detection and resolution algorithm. Ciência & Tecnologia dos Materiais, 28 (2016) 162–166, 2017

Våpenstad C, Hofstad EF, Bo LE, Kuhry E, Johnsen G, Mårvik R, Lange T, Hernes TAN.

Lack of transfer of skills after virtual reality simulator training with haptic feedback. Minimally Invasive Therapy & Allied Technologies (MITAT), Pages 1-9. Published online May 9, 2017. PMID: 28486087 Online access: http://dx.doi.org/10.1080/13645706.2017.1319866

Reynisson PJ, Hofstad EF, Leira HO, Askeland C, Lange T, Sørger H, Lindseth F, Amundsen T, Hernes TAN.


Sørger H, Hofstad EF, Amundsen T, Lange T, Bakeng JBL, Leira HO.

A multimodal image guiding system for navigated ultrasound bronchoscopy (EBUS): A human feasibility study. PLOS ONE. Published February 9, 2017. PMID: 28182758 Online access: https://doi.org/10.1371/journal.pone.017142017
October 17th, Lecture on innovation at St. Olavs hospital at the management team meeting at the Clinic for Physical Medicine and Rehabilitation, by Alexander Moen and Joseph S. Schultz.

October 23rd, Lecture FSTL, Autumn meeting 2017, Scandinavian Nidelven.NorMIT, development of new methods and medical technology based on clinical needs, by Jan Gunnar Skogås.

October 25th, Lecture at Seminar for Innovation in mental health, Stavmarka. FOR a unit of innovation at St. Olav hospital / NTNU. What can PH learn from somatics when it comes to innovation? by Jan Gunnar Skogås.

October 25th, Lecture Workshop St. Olavs hospital, Development Plan 2035. A presentation of the work of the technology plan HMN, by Jan Gunnar Skogås.

November 2nd, Lecture on innovation at St. Olavs hospital at the department meeting at the Department of Photographic Services, by Alexander Moen.

November 2nd, Lecture on innovation at St. Olavs hospital at Leadership Meeting at the Cancer Clinic, by Alexander Moen.

November 9th, Lecture on innovation at St. Olavs hospital at a meeting for researchers at the anesthesia department at St. Olavs hospital and ISB, by Alexander Moen.

November 15th, Lecture on innovation at St. Olavs hospital at the Women’s Clinic, by Alexander Moen.

December 7th, FOR-NorMIT Infrastructure for medical and technological development and research, opportunities and limitations. Deloitte, Oslo, by Jan Gunnar Skogås.

December 6th, Lecture on innovation at St. Olavs hospital at the Cancer Clinic, by Alexander Moen.

December 6th, Presentation FOR-NorMIT Biobank1, by Jan Gunnar Skogås, Gabriel Kiss, Liv-Inger Stenstad, Geir Andre Pedersen and Alexander Moen.

December 18th, Lecture on innovation at St. Olavs hospital at the KCL meeting at the Clinic for Anesthesia and Intensive Medicine, by Alexander Moen.

October 5th, Lecture to the management team at the Department of neuromedicine and movement science. Future Health Workers from FOR standpoint, by Jan Gunnar Skogås.
Course arranged by Norwegian National Advisory Unit for Ultrasound and Image Guided Therapy

1. Training course in Ultrasound and Image Guided Therapy, Trondheim 25-29 September 2017. Course in connection with the HiPerNav ITN project, 16 PhDs, 6 from Norway, 3 Norwegian health regions.


2. Training course in HiPerNav, Oslo, 4-8 September, 2017. Several talks provided by USIGT, Trondheim, in collaboration with Oslo University hospital.

3. The 9th course in Ultrasound in Neurosurgery is arranged on June 15 - 16 (Thursday-Friday), 2017.

For more information please use the course menu above. Contact: Tormod Selbekk. http://www.sintef.no/projectweb/usigt/kurs/program/

Studies and multi-center studies at the Norwegian National Advisory Unit for Ultrasound and Image Guided Therapy


4. Does the location of brain tumors (left-right) have a pre-operative effect on the patient’s quality of life? REK nr. 2015/213

5. 3D ultrasound assisted drain insertion, REK nr. 2013/1108


7. Improved ultrasound based angiography in neurosurgery, REK nr. 2013/270

8. Elastographic imaging of brain tumors with ultrasound, REK nr. 2013/1611

9. 3D-atlas for functional neuro-anatomy

Visits at FOR

April 4th - NTNU Department of Electronic Systems (IES), master students. Presentation of the FOR infrastructure, visit at the Clinic of Ear-Nose-Throat, Eye and Maxillofacial Surgery (ØNH). Jan Gunnar Skogås and Alexander Moen

June 20th – Dr. Peter Schulams co-founder of CBIT – Center for Biomedical Innovation and Technology (http://cbit.yale.edu/) at Yale University and Pål Richard Romundstad (NTNU). Introduction about FOR and demo of Multiguide at the FOR operating room at ØNH. Ståle Nordgård, Irina Aschehoug, Alexander Moen

June 29th - Emanuel Pastereich associate professor at Kyung Hee University and director of The Asia Institute in Seoul. Alexander Moen held a presentation of FOR.

September 26th – Organized visit for Norsk Forening for Automasjon, NFA, with the occasion of the annual autumn meeting. Visits to the Medical Simulator Center and FOR operating room at AHL. Alexander Moen, Gabriel Kiss, Liv-Inger Stenstad, Jan Gunnar Skogås and Marianne Haugvold

November 27th – Klaus Klausen Espedal, Marked leader at Independence Gr. Demo and discussion regarding the Dignum product. Alexander Moen

December 6th – Visit from Biobank1 Presentation of FOR-Nor-MIT. Alexander Moen, Gabriel Kiss, Liv-Inger Stenstad, Jan Gunnar Skogås, Marianne Haugvold and Geir Andre Pedersen

Conference participation

- Technoport - 08-09.03.17
- Microsoft conference - 01.06.17
- Regional research conference - 06.-07.06.17
- Azets meeting Trondheim - 08.06.17
- Global Health Day 2017 – Sustainable Development Goals (SDG) – Maternal health and Equity health
- Innovation conference - 23.11.17
FOR media contributions


4. Gemini: Pris for oppfinnelse som kan lette jakt på hjernesvulstvev. Author: Svein Tønseth, Published 03.05.17 https://gemini.no/kortnytt/pris-oppfinnelse-let-te-jakt-pa-hjernesvulstvev/

5. NTNU-TechZone, 01.03.2017: http://www.ntnutechzone.no/2017/02/inneklima-og-infeksjonsrisiko-med-lyset-fra-operasjonslampa-i-oyene


7. Teknisk Ukeblad: NorMIT – IVS og samarbeid til FOR-NorMIT https://www.ntnu.no/article/ma-bruker-norske-kirurger-braker-hologram-for-a-planlegge-operasjoner/37716415xtparams_s

