MedTech Labs

Karolinska Institutet
KTH Vetenskap och Konst
Region Stockholm

ANNUAL REPORT
2023

At MedTechLabs, researchers from KTH collaborate with clinically active researchers from Karolinska Institutet to develop diagnostics and improve treatments for our most common diseases and medical needs. The objective is primarily on research with a potential to reach clinical studies and/or trials within five years. Another objective is to create conditions required for implementing and disseminating new knowledge and methods in Region Stockholm, and also nationally and internationally.

MEDTECHLABS 2023

Turnover, SEK million: 18

Number of research leaders: 14

Physical environment: BioClinicum, adjacent to Karolinska University Hospital Solna

CONTENTS

RESULTS 2023

HIGHLIGHTS

- MedTechLabs Fellows Mats Persson and Johan Lundberg accepted as docents at KTH and KI.
- Mikael Sandell did his doctorate at KTH and KI.
- Yinxi Wang and Philip Weitz did their doctorate at KI and Marcus Nordström at KTH.
- Clinical study ScreenTrustMRI completed.
- Johan Hartman and Mattias Rantalainen were awarded the Prize for Innovation and Usefulness at the Karolinska Institutet.

Peter J Arduini, CEO GE Healthcare, visits MedTechLabs.

IMPACT

- Hybrid course Acute Stroke, diagnostics and treatment launched, 39 ST doctors was trained.
- ClearscanAI founded by Fredrik Strand and Kevin Smith.
- Extendo Medical founded by Staffan Holmin and Niclas Roxhed.
- Magnephy founded by Hans Blom, David Unersjö-Jess and Robin Ebbestad.

INCREASED AWARENESS

During the year, we have continued to work with increased knowledge of MedTechLabs and Stockholm by hosting 12 high level from different parts of the world, often as part of visits to Karolinska University hospital or KI. In early autumn, GE Healthcare's top management visited MedTechLabs, followed by the GE User meeting where over 90 radiologists from Europe visited Stockholm. MedTechLabs was responsible for part of the program.

The Medical Technology Days took place in Stockholm where MedTechLabs was a sponsor and gave start-ups founded by MedTechLabs researchers an opportunity to participate in the exhibition. In October, the Presidents at KI and KTH invited private foundations to a breakfast seminar on the theme - Medical technology research and innovation for better health, where three MedTechLab research programs were presented by six researchers.

IDENTITY AND CULTURE

MedTechLabs Research Day took place in January, where 36 researchers participated. During the year, eight MedTechLabs pubs and a number of seminars and workshops were arranged. Among others a workshop on patient data that resulted in positioning Clara Hellner's meeting with Swedish EU parliamentarians about EHDS together with the seminar Strategies and tactics for protecting digital IP such as AI applications, 40 participating researchers.

TWO NEW RESEARCH PROGRAMS

The 2023 call for a total of SEK 35 million resulted in two new research programs. In the first, a new method is developed to monitor the oxygenation of the fetus during delivery. The second is to develop a new method for early diagnosis of brain diseases using MR elastography.

AI PROJECT

During the year, Professor Magnus Boman has worked on mapping needs in healthcare with regard to AI, identifying synergies between research initiatives and proposing training in the area that MedTechLabs should be responsible for.

COMMUNICATION – OUTREACH

	2021	2022	2023
Social media – LinkedIn			
Followers	445	794	1094
Post views	43 998	67 492	45 208
Social media – Youtube			
Number of videos	15	15	15
Views	1 160	1 476	1 145
Newsletter			
Subscribers	251	248	268
Mailshots	11	8	9
Website			
Users:	n/a	n/a	1 646
Page views	n/a	n/a	15 781

Articles, editorial 2023:

Reumatikervärlden: 1
MedTechMagazine: 3
Karolinska Institutet 5
Placera: 1
Life Science Sweden: : 2
Dagens Diabetes: 1
Läkemedelsvärlden: 1
Min Medicin: 1

"Swedish innovations such as the pacemaker, the Gamma Knife, the ultrasound and the Seldinger technique were all developed to meet the needs of healthcare. MedTechLabs manages and develops our proud heritage of innovation."

Johan Schuber, Executive director

MedTechLabs management team: Niclas Roxhed, Staffan Holmin, Lena Lewin, Elisabet Rendahl and Johan Schuber.

MedTechLabs is an interdisciplinary centre for medical technology research that carries on this proud legacy to create better conditions for patient survival and improved quality of life for those with cancer, cardiovascular and other non-communicable diseases. We create the conditions for healthcare to offer patients much more secure diagnoses and better treatment, at a lower cost.

The centre is a long-term investment initiated in 2018 and managed by KTH, Karolinska Institutet and Region Stockholm with the intention of contributing to the development of medical technology or medical needs from a national and international perspective. New knowledge and implementable solutions also contribute to the development of the Stockholm region's life science ecosystem, making the region an attractive investment for global companies. The objective is primarily on research with a potential to reach clinical studies and/or trials within five years. Another objective is to create conditions required for implementing and disseminating new knowledge and methods in Region Stockholm, and also nationally and internationally.

The hallmarks of MedTechLabs should be quality, excellence and innovation. Our wish is to attract the best researchers who want to collaborate on translational research. The fact that our research takes the needs of the healthcare sector as its point of departure provides Region Stockholm with excellent conditions for offering the very best care to tomorrow's patients."

Clara Hellner, Director of Research and Innovation at Region Stockholm, Chair of MedTechLabs Board

VISION, GOALS AND WAYS OF WORKING

To increase patient survival and improve quality of life for our most common diseases and medical challenges, by giving access to state-of-the-art technology achievements.

GOALS

1. To become a top interdisciplinary centre globally for medical technology research.
2. Projects within MedTechLabs shall aim for clinical trials within five years.
3. Research leaders funded by, and/or affiliated to, MedTechLabs will generate significant external grants from national and European funding agencies and private foundations that evolve the medtech field even further.

WAYS OF WORKING

- Calls directed to Research pairs, PI´s from Karolinska Institutet and from KTH.
- Support personell and certain infrastructure to facilitate testing of medtech inventions in in vivo translational setting.
- Communicate the centre´s achievements in relevant channels.
- Boost junior researchers, attract talents.
- Encourage implementation by clinical trials by support in regulatory questions.
- Attract non-funded research pairs to be
- affiliated to centre – to broaden the centre´s networks and increase impact.
- Support during application procedures to attract additional external funding.
- Support healthcare professionals by educational activities.
- Networking, research and knowledge exchange, boosting the community.

"One prerequisite for research results to achieve their potential for implementation in healthcare is that it is easy to conduct translational research, all the way from initial experiments on animals to human clinical studies. And then, that the technique is verified with clinical trials. The collaboration at MedTechLabs provides excellent opportunities to achieve this."

Niclas Roxhed, Director, Associate Professor at division for micro- and nanosystems, KTH

GOVERNANCE

Board: Clara Hellner, Region Stockholm, (Chair), Martin Bergö, KI, Amelie Eriksson Karlström, KTH, Helena Erlandsson Harris, KI, David Konrad, Karolinska University hospital, Linda Lindskog, Karolinska University hospital, Peter Savolainen, KTH, Birgitta Janerot Sjöberg, Karolinska University hospital.

Management: Niclas Roxhed, Director, KTH, Staffan Holmin, Vice Director, KI, Lena Lewin, KI, Elisabet Rendahl, Region Stockholm, Johan Schuber, Executive Director, KTH.

Communications & Media: Håkan Sandberg, Communication Officer

Patient Council: Barbro Wong, Rheumatism Association Stockholm, Elisabet Schesny, Swedish Breast Cancer Association, Sara Norman, Swedish Kidney Association and Lennart Håwestam, Stockholm Disability Rights Federation, Stockholm Stroke Association.

INFRASTRUCTURE FOR TRANSLATIONAL RESEARCH

The CT with the new detector technology was installed in Fall 2021 at MedTechLabs, BioClinicum, Karolinska University Hospital.

R&D LAB IN BIOCLINICUM

MedTechLab's infrastructure in BioClinicum is part of Karolinska University Hospital. Companies can hire to test and develop prototypes in early product development in a fully equipped hospital environment where clinical studies are an important part of the development process of a new technology. MedTechLab's model creates the opportunity for the company's development engineers to work with the prototype on site. We also offer office spaces to collaboration partners as well as opportunities to demonstrate technology and results. MedTechLabs also hosts workshops and other important events, which are needed to achieve the best project results. Cooperation with industry takes place in project form.

PHOTON-COUNTING DETECTOR TECHNOLOGY FOR CT (PCCT)

In 1979, Godfrey Hounsfield and Allan Cormack received the Nobel Prize for their work with CT technology, which today has become one of the most common routine examinations worldwide.

The CT technology that became available during the 1970s opened up a whole new world for us doctors.

This, the next stage in development, offers unbounded possibilities. Here at Karolinska University Hospital, in various ways we treat over one million patients every year. Our aim is that the hospital should constantly progress and provide better care and treatment and I believe that we have demonstrated that we can do so. The fact that we are now the first in the world with this new technology also affirms both that Karolinska Institutet is ranked among the best environments for clinical research in the world, and that Karolinska University Hospital is advancing as one of the best hospitals in the world. Our machinery and its relationship to how we work as Europe's smartest hospital means that we must constantly move forwards. To do so together with others is a success factor, and the CT laboratory is an excellent example of this. The strength

in working together has been made particularly apparent during the pandemic. It means a great deal to the hospital and the hospital's patients that clinical studies are now underway to ensure that the next generation of computed tomography benefits patients and the health service.

Speech by Björn Zoëga, then CEO Karolinska University Hospital, at the inauguration of the CT lab in 2021.

CLINICAL STUDIES

In 2021, a clinical study began on behalf of GE Healthcare to verify the new PCCT technology.

– We are the first in the world to test this technology, which we are very proud of.

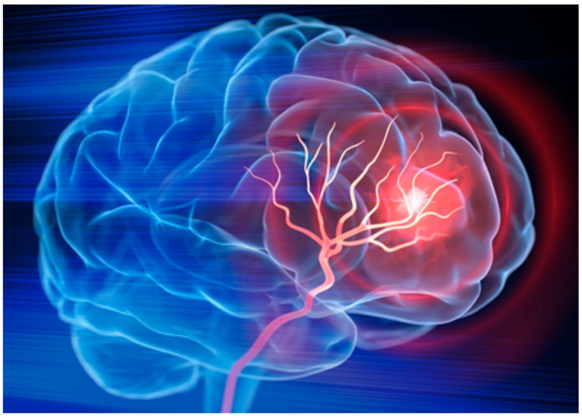
The international competition from the best universities is tough and many were interested in conducting the study. The pilot study will be followed by another clinical trials with greater number of participants and further optimization of the image quality before the technology can be introduced in healthcare, says Staffan Holmin, clinical trial leader at

Karolinska University Hospital. The technology has a wide range of application areas where several different organ systems can be imaged. In the study we compare the images from the participants' surveys with images taken with standard CT´s. The study also provides a larger image material that is used for further image processing optimization.

TRAINING

ACUTE STROKE, DIAGNOSTICS AND TREATMENT

In recent years, acute stroke care has seen rapid development, especially in radiological diagnostics and reperfusion treatment. This training is Lipus-certified and is aimed at ST doctors and specialist doctors who are interested in learning more about stroke and cerebral ischemia.



BACKGROUND

More than 18,000 people in Sweden are affect by an acute ischemic stroke annually. Correct and prompt handling of stroke saves lives and reduces disability, with increased quality of life and reduced societal costs as a result. The treatment possibilities have developed rapidly in the last decade and require more advanced technology, with new radiological examination methods. The use of advanced examinations and treatments is recommended nationally in personalized and integrated care flow Stroke and TIA as well as in the National Board of Health and Welfare's guidelines.

Incorrect or insufficiently updated investigations of a suspected stroke can lead to life- and function-saving treatments being omitted or delayed. This requires skill development in healthcare and routines to be changed to take advantage of the opportunities that exist today. This takes place advantageously through continuing education of ST doctors and specialist doctors in radiology and neurology. There is currently a lack of courses with a neuroradiological focus in stroke, which slows down the spread and implementation of new working methods. The course intends to cost-effectively train a large group of specialists in order to widely promote good working methods based on the latest evidence-based knowledge.

PROGRAM

The course consists of two parts:
Part 1 On-line studies (approx. 2 days)
31 lectures of between 5-30 minutes (approx. 8 hours) in the areas;
• Basic radiology
• Basic neurology
• Neurointervention
• Basic DT technique
• CTP – Five cases late thrombectomy
• After endovascular reperfusion

Extra material on bleeding and 19 case studies (approx. 8 hours).

Part 2 – Mandatory full-day on-site seminar at MedTechLabs, Karolinska University Hospital Solna

All course teachers participate in the on-site seminar where case studies are discussed. The seminar requires active participation, which also includes a knowledge check. For those who need a ST certificate, this is provided by the course team.

EARLY RESULTS

The course was introduced in 2023 and was appreciated. The 39 participants' general assessment on a 6-point scale was 5.5 p for the whole and 5.6 p for recommending a colleague to take the course.

The course is free of charge and is open to participants from all over Swedenn, employees at Region Stockholm have priority. The course is also given in Spring and Fall 2024.

FACTS

Teachers: Håkan Almqvist, Senior physician, Neuroradiologist, Capio St Göran Radioloy

Åsa Kuntze Söderqvist, Senior physician, PhD, Neuroradiologist Neurointerventionist. ME Neuroradiology, Karolinska University hospital

Michael Mazya, Senior physician, Docent, Neurologist. ME Neurology, Karolinska Universitetssjukhuset

NEW RESEARCH PROGRAMS

2023 call for SEK 35 million resulted in two new research programmes. The first will develop a new method for monitoring fetal oxygenation during labour. The second programme will develop a new method for early diagnosis of brain diseases using MR elastography.

Current fetal monitoring methods have weaknesses and the researchers in this new programme aim to improve them to reduce the risk of organ failure in the baby during delivery. This is an important area of research that affects many patients and maternity services, not only in Sweden but also worldwide.

The program 'Continuous lactate measurement and prevention of fetal hypoxia during delivery' is led by Malin Holzmann, Karolinska Institutet, and Saul Rodriguez Duenas, KTH. Malin Holzmmann is a senior physician at the Unit for Pregnancy and Childbirth at Karolinska University Hospital in Solna, Sweden, and docent at KI. Saul Rodriguez Duenas is associate professor at the Division of Electronics and Embedded Systems at KTH. The goal is to achieve continuous lactate measurement during labour, which would represent a completely new technology in healthcare with the potential to fundamentally change fetal monitoring.

The second research program focus on understanding how brain tissue changes when exposed to diseases such as Alzheimer's, Parkinson's, MS, or brain tumours. With the increasing availability of drugs to treat these diseases, early detection of the diseases in time is becoming more important to slow down disease progression as effectively as possible.

The program"Clinical application of next-generation brain magnetic resonance elastography for neurodegenerative diseases and brain tumours" is led by Rodrigo Moreno, KTH and Tobias Granberg, Karolinska Institutet. Rodrigo Moreno is associate professor and at the Department of Biomedical Engineering and Health Systems at KTH. Tobias Granberg is associate professor at the Division of Clinical Neuroscience at Karolinska Institutet. MR-Elastography (MRE) is already used today to diagnose liver diseases, but its complexity has so far hindered its clinical use for the diagnosis of brain diseases. The main objective of this multidisciplinary program is to enable MRE to be performed also for the brain and to evaluate its clinical utility in neurodegenerative diseases and brain tumours. The project covers MRE technology from image acquisition and analysis to its use and evaluation in clinical trials. The goal is to enable clinical implementation in Region Stockholm within five years, thus contributing to better treatment for patients.

Research in both programs start in January 2024.

FACTS

Funding 2024–2028: 20 MSEK

Program Directors:

Rodrigo Moreno, Associate Professor, Medical imaging at KTH

Tobias Granberg, Associate Professor, Neuroradiology at Karolinska Institutet

FACTS

Funding 2024–2028: 15 MSEK

Program Directors:

Malin Holzmann, Docent, Unit for pregnancy and childbirth at Karolinska Institutet

Saul Rodriguez Duenas, Associate Professor in Electronics and embedded systems at KTH

RESEARCH PROGRAMS

SPECTRAL CT-IMAGING AND ENDOVASCULAR TECHNIQUES

MedTechLab's first program started in 2018 and is based on the world-leading X-ray technology developed at KTH and top-notch research in the field of endovascular techniques. The work to refine and implement the new x-ray technology in healthcare requires both research and development and constitutes a significant part of the research program. This includes both issues around pattern recognition (AI) and data management, as well as what type of visual information the radiologist needs when assessing disease states for various parts of the body.

"researchers from KTH and Karolinska Institutet can study patients in a hospital environment with the capacity for advanced care when required."

Higher image resolution and lower doses of radiation provide healthcare with many benefits when diagnosing and treating. It makes it easier to distinguish between different tissues and materials. Early-stage tumours and inflammatory conditions will become easier to detect. Greater detail may make it possible to avoid invasive procedures and we hope to be able to more effectively diagnose strokes in the cerebellum and brain stem. This is the underlying strategy of MedTechLabs, where researchers from KTH and Karolinska Institutet can study patients in a hospital environment with the capacity for advanced care when required.

Endovascular techniques, which uses X-rays to navigate inside the body's vessels in order to, for example, extract blood clots or treat vasoconstriction. The technology also makes it possible to take samples and inject or deposit drugs locally in organs that are otherwise difficult to reach. It is also possible to use these techniques to diagnose and treat cancer and cardiovascular diseases, including strokes.

The program will contribute to Stockholm becoming a node for the development of next-generation technology for photon-counting computed tomography to the benefit of millions of patients worldwide.

FACTS

Funding 2019–2023: 35 MSEK

Program Directors:

Mats Danielsson, Professor of Medical Imaging at KTH

Staffan Holmin, Professor of clinical neuroimaging at Karolinska Institutet, Consultant neuroradiologist at Karolinska University Hospital

BREAST CANCER IMAGING POWERED BY ARTIFICIAL INTELLIGENCE DIAGNOSTICS

The main objective of the program is to develop and test AI-based models for radiological and histopathological image analysis. The research program contributes to faster and better diagnosis and thus the possibility of detecting cancer earlier in the course of the disease and curing more patients. Thanks to Sweden's unique access to comprehensive and quality-assured patient data, the program can use decoded data (images and samples) from all patients diagnosed with breast cancer through mammography in the Stockholm region between the years 2005 and 2019.

Radiological image analysis

Within the sub-area of radiological image analysis, two clinical studies are ongoing since 2021. The first study, ScreenTrust MRI, was completed 2023 at Karolinska University Hospital with magnetic resonance imaging (MRI). There, a commercial AI model is combined with two in-house developed models to select a group of women who, after an unobjectionable screening mammography, are offered to supplement with a magnetic camera. The goal is to minimize the percentage of undetected cancer. The second study, ScreenTrust CAD, is performed at Capio St Göran Hospital using the best commercial AI model. We want to investigate the possibility of supplementing or replacing one of the two radiologists who review each screening mammogram.The goal is to develop computational methods that automatically analyze and understand images of biological processes, using microscopic images as the primary source of information. We use methods from machine learning, statistics and bioinformatics to quantify image data. The methods we develop must be scalable in order to handle very large data sets.

Pathological examination

Through careful analysis by a pathologist, a breast cancer can be divided into three groups; grade 1 with the lowest aggressiveness, grade 3 with the highest aggressiveness and grade 2 as a gray area in between. Patients with grade 3 tumors often benefit from adjunctive chemotherapy. We have created an AI model that can detect cancer in the images and stratify tumors of intermediate grade (NHG2) into high or low grade. In the program, an own AI model is developed that will serve as decision support for the pathologist. Today there is great variation in the assessments of images because pathologists assess differently. An AI must be able to find information in the images that we humans cannot detect. This will lead to more patients receiving a clearer diagnosis and thus the right treatment.We have developed a system for breast cancer detection and grading (submitted manuscript) based on AI image analysis. We have created digital histopathology images by digitizing microscope slides from the hospital archives in Stockholm. All images undergo rigorous quality assurance, processing and normalization. This constitutes a clinically important task that can contribute to reduced gray areas and to identify patients who need additional treatment with chemotherapy after surgery.

FACTS

Funding 2020–2024: 20 MSEK

Program Directors:

Johan Hartman, Professor of Pathology at Karolinska Institutet, Pathologist at Södersjukhuset

Kevin Smith, Associate professor in Computer vision and Biomedical image analysis, KTH

BIOELECTRONIC MEDICINE

Inflammatory diseases cause a great deal of suffering for patients all over the world, as well as creating challenges for healthcare. Stimulation of the vagus nerve may be the anti-inflammatory treatment of the future.

The focus of the programme is on being able to monitor and stimulate the vital vagus nerve with short electrical pulses in order to treat inflammatory diseases in a targeted manner. This is the first programme in the world to clinically implement bioelectronic medicine to treat inflammatory diseases at the point of care. Beginning in January 2020, this interdisciplinary collaboration brings together physicians, immunologists, engineers and mathematicians. Research is primarily focused on studying how signals are transmitted between nerves and immune cells at a molecular level and which parts of the long vagus nerve communicate with the immune system, because, even if clinical data is available to demonstrate the potential of the method.

Bioelectronic medicine could reduce the use of anti-inflammatory drugs and also direct the treatment directly to the part of the body where the inflammation is located.

New technology for minimally invasive nerve stimulation

There is currently no atlas of the neurophysiology of inflammation regulation – something that is needed if we are to study these mechanisms in detail, understand them and, eventually, target treatment with more precision. We are developing a method for wirelessly activating specific, small peripheral nerves in experimental inflammation and creating an atlas of the functional anatomy of neuroinflammation.

Automated inflammation intensity monitoring

By analysing large amounts of data from the vagus nerve during experimental inflammation, we can identify signal patterns representing inflammation intensity. The aim is to create a lexicon of signal patterns from which to extract detailed information on inflammation. We use data available in the literature, as well as our own data, to develop methods in the field of machine learning, based on autoencoders and clustering, in order to identify nerve signals that can be linked to cytokines. Proinflammatory cytokines are produced by the immune system and secreted in the event of injury, stress or inflammation. Although results demonstrate that the new technologies are effective at identifying relevant signal types, especially tumour necrosis factor (TNF), there are also considerable variations between recordings. It is therefore very important that controlled experiments with improved signal quality are conducted.

Longitudinal patient monitoring

Clinical data, measurements and patients' own reports are collected longitudinally over the course of inflammatory bowel disease. We plan to use mathematical modelling to attempt to predict the course of inflammation. We anticipate that, through improved prognostication of relapses in inflammatory diseases, we will be able to optimise treatment, alleviate symptoms and shorten the episodes of the disease.

FACTS

Funding 2020–2024: 15 MSEK

Program Directors:

Peder Olofsson, Head of Division of Cardiovascular Medicine, Department of Medicine at Karolinska Institutet

Henrik Hult, Professor in Mathematical Statistics at KTH

OPTICAL 3D-MICROSKOPY FOR MORE EFFECTIVE DIAGNOSIS OF KIDNEY DISEASES

Chronic kidney disease is a growing global threat to public health. About 10% of the world's population is affected, but in the elderly and people with high blood pressure, cardiovascular disease and diabetes, over 35% are affected. The proportion of people who die from chronic kidney diseases is expected to increase in the coming years, unless more countries invest in preventive measures and early treatment. With an early diagnosis of the development of kidney disease, one can stop or reverse the course of the disease, and prevent costly kidney dialysis or kidney transplantation.

Our method will deliver both 2D and 3D images of kidney biopsies and through image analysis ('machine learning', 'deep-learning', AI) we intend to develop support for more efficient diagnosis and earlier detection of common kidney diseases. Automatic image analysis of morphological changes in the kidney will provide a faster, safer and quantitatively improved analysis of the development of kidney diseases. Through 3D microscopy, the filter structures of the kidney can be visualized with light microscopy. It enables a simple automatic analysis and quantification of the health status of the kidney. Introduction of super-resolution optical pathology will make it possible to replace today's electron microscopy analysis, which takes place in extremely thin layers, to 3-D morphologically follow the development of kidney diseases in situ.The project is a collaboration between pioneers in super-resolution optical microscopy at KTH and clinical kidney researchers at Karolinska University Hospital and Danderyd Hospital.

FACTS

Affiliation to MedTechLabs 2021–2026, other funding

Program Directors:

Hans Blom, Docent in Biophysics at KTH

Sigrid Lundberg, Research leader at Department of Nephrology, Karolinska Institutet, Consultant, Kidney Medicine, Danderyd University Hospital

IMPACT

MONITORING THE QUALITY AND IMPACT OF RESEARCH

The analyzes carried out since 2020 show that MedTechLab's research leaders are world class. Our goal, that the research should be useful in healthcare already within five years tkrough clinical studies and/or trials, gives us reason to work systematically so that the ecosystem with education, innovative startups and industrial collaborations works well.

For academic research, two main aspects of impact are relevant: the scientific impact, the impact of our work in terms of citations and similar accepted indicators, and the societal benefit, i.e. the extent to which the scientific results are brought to health care, through training and patents that can lead to new products and services. Analyzes of research quality and impact for research leaders associated with MedTechLabs show high values that stand up well in international competition.

COMMERCIALIZATION OF RESEARCH

Almost all of MedTechLab's researchers are co-founders of one or more companies that commercialize the research results. During the year, three companies were founded: Extendo Medical with Staffan Holmin and Niclas Roxhed as founders. ClearscanAI, with Fredrik Strand and Kevin Smith as founders and Magniphy with Hans Blom, Davis Unnersjö-Jess and Robin Ebbestad as founders.

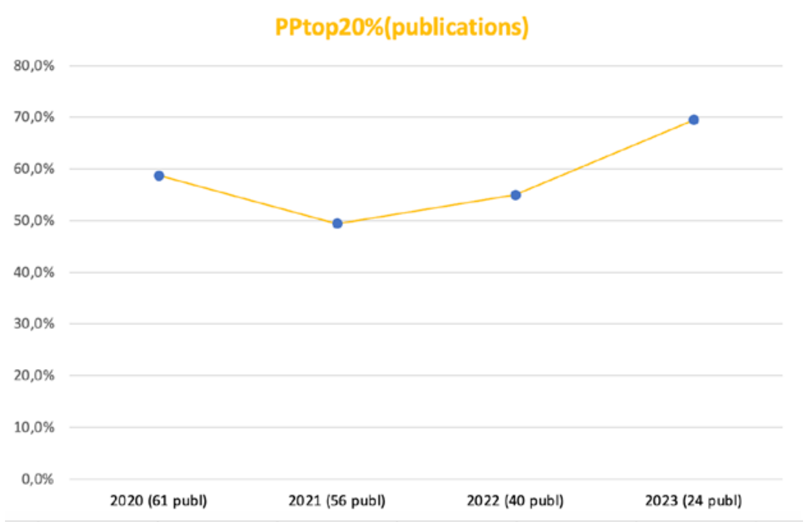
Overall, the analyzes show that MedTechLabs has succeeded well in attracting excellent researchers who are motivated by the fact that their research will benefit healthcare and patients. The researchers are doing well in the international competition and the relative value is increasing at all levels.

COMPLEMENTARY EXTERNAL GRANTS

During the years 2020–2023, MedTechLab's researchers recieved SEK 137 million in supplementary external grants in competition. MedTechLab's funding was SEK 56 million.

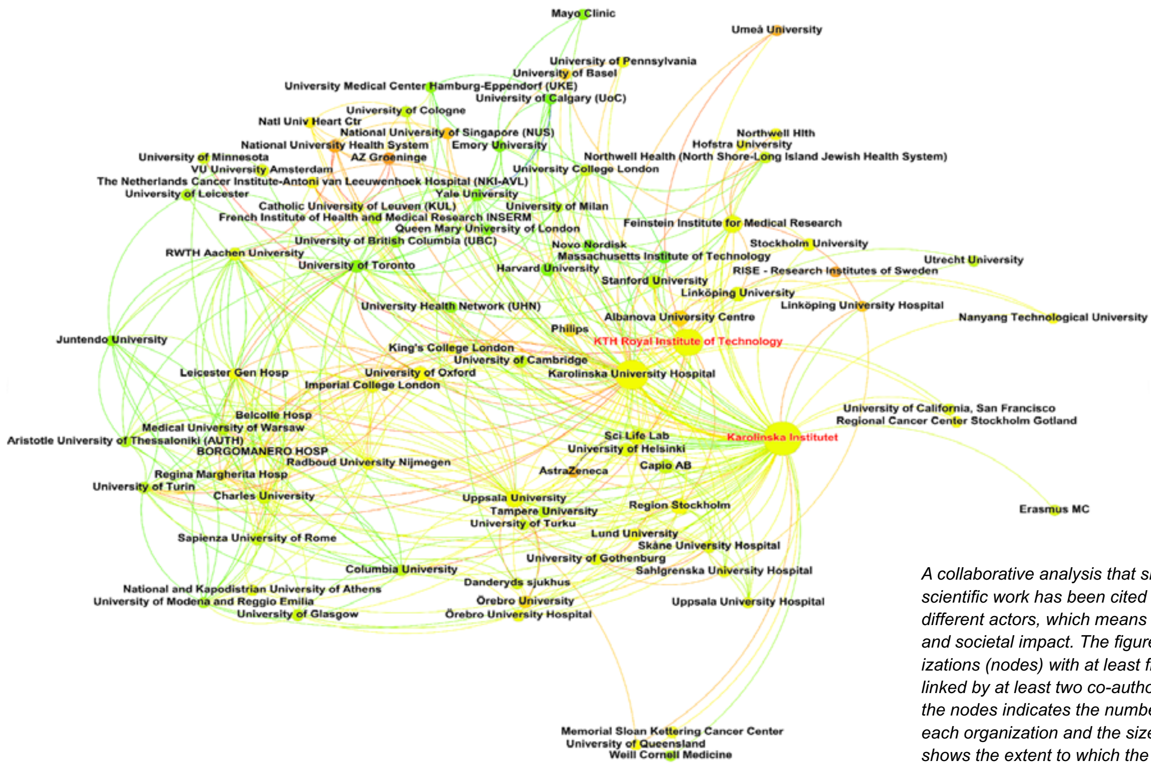
Visibility and impact

The year 2023 resulted in 24 publications, (2022, 40 publications). The percentage of publications accepted in the most reputable (top 20%) journals was 69.4 percent. The field-standardized citation rate, Cf, reflects an article's citation rate compared to the citation rate of comparable publications, i.e. publications of the same document type, from the same year and within the same subject. Cf, in 2021 amounted to 1.68 (in 2020 Cf was 2.24). Share of publications that, compared to other publications in the same field and in the same year, belong to the top 10% most often cited in 2021 23.4 percent.



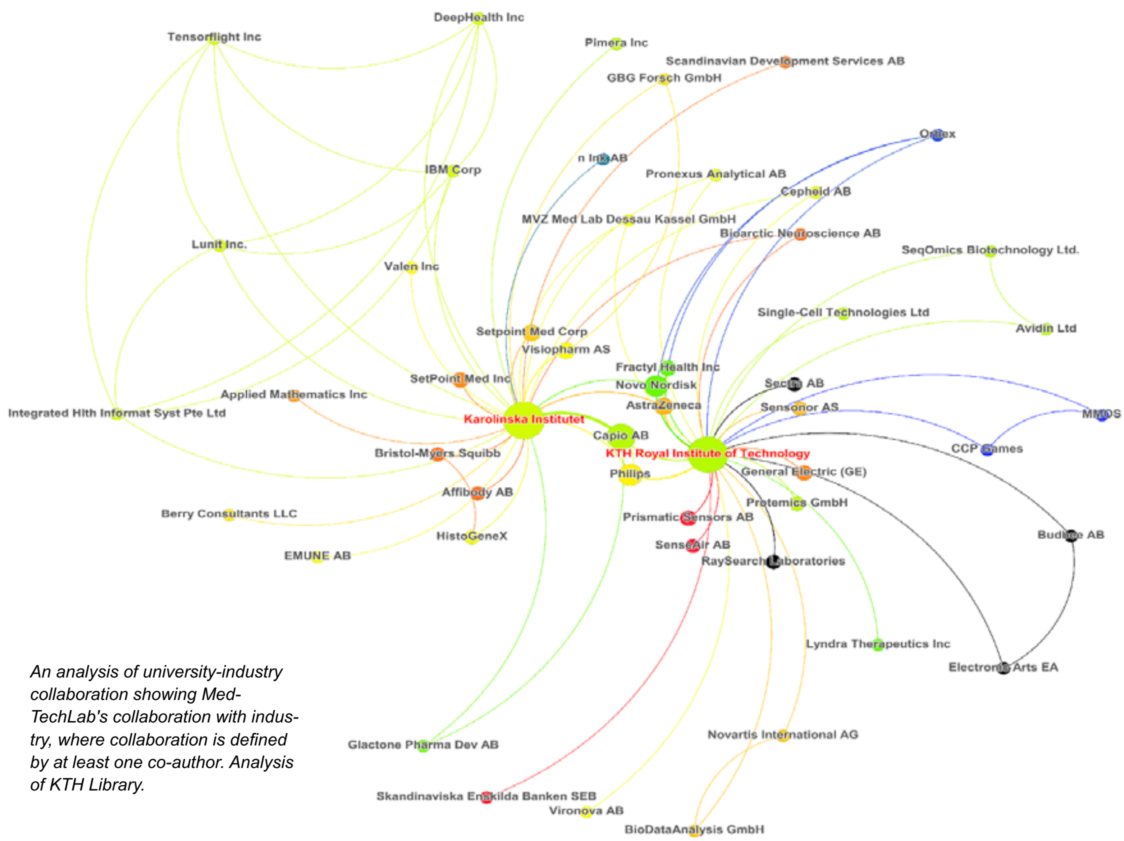
MedTechLab's research has an excellent scientific impact. PPtop20% indicates the share of publications in the 20% most cited journals in a WoS category, compared to publications in the same category and year. Only articles and reviews are considered.

Most frequent collaboration partners 2011-2023 (Color by visibility, JCf).



A collaborative analysis that shows how scientific work has been cited between different actors, which means both scientific and societal impact. The figure shows organ-izations (nodes) with at least five articles and linked by at least two co-authors. The size of the nodes indicates the number of papers in each organization and the size of the lines shows the extent to which the organization collaborates. Analysis of KTH Library.

Collaboration between the MedTechLabs-members and industry (U-I) 2011-2023 (Color by visibility,JCf).

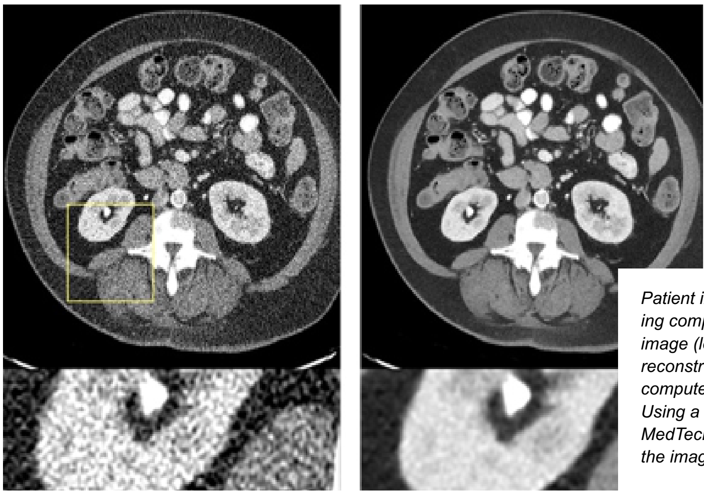


An analysis of university-industry collaboration showing Med-TechLab's collaboration with indus-try, where collaboration is defined by at least one co-author. Analysis of KTH Library.

SPECTRAL CT-IMAGING AND ENDOVASCULAR TECHNIQUES

With the aid of this technology, significantly improved diagnoses and treatments will be available to patients with cancer and cardiovascular disease, including stroke.


InfuseIT
Pressure Infusor
1000 ml
PHILIPS



Patient images illustrating a method to reduce noise in photon-counting computed tomography developed within the program. The original image (left) from a photon-counting computed tomography scanner is reconstructed with thinner sections than is possible with conventional computed tomography and therefore has a relatively high noise level. Using a neural convolutional network, developed by Dennis Hein at MedTechLabs, it is possible to greatly reduce the noise, which gives the image on the right.

PROJECTS WITHIN SPECTRAL CT IMAGING AND ENDOVASCULAR TECHNIQUES

ANALYSIS OF LUNG CHANGES IN POST-COVID PATIENTS USING COMPUTED TOMOGRAPHY AND AI.

Research leader: Mats Persson.

Chest x-rays and computed tomography play a major role in the care of patients with covid-19 and the follow-up of patients who have residual problems after the disease. At the same time, knowledge of how the X-ray images should be interpreted is still limited. Together with Karolinska University Hospital, we are developing an AI tool based on deep neural networks to automatically classify computed tomography images with regard to different types of lung damage. In a first step, we train neural networks to distinguish between healthy lungs, two different types of pulmonary fibrosis and other lung changes. In the next step, we will apply these networks to computed tomography images of patients with lung damage from covid-19. In this way, we will be able to compare lung damage from covid-19 with fibrosis diseases, which can provide information on long-term prognosis and treatment methods for patients with remaining symptoms after the covid-19 examination.

This project has been made possible by donaions to Professor Mats Danielsson from Einar Mattsson, the Allba Foundation and the Stockholm Pandemic Resilience foundation.

NEW IMAGE RECONSTRUCTION METHODS FOR PHOTON-COUNTING COMPUTED TOMOGRAPHY

Research leader: Mats Persson.

In order for the new photon-counting computed tomography technology to reach its full potential, the newly developed hardware needs to be supplemented with improved data processing algorithms so that the measured data is fully utilized and provides the best possible image quality. Within this project, we are developing next-generation image reconstruction methods for photon-counting computed tomography and evaluating the resulting image quality. In collaboration with the Department of Mathematics at KTH, we have developed an image reconstruction method based on deep neural networks, deep learning, which can greatly reduce the noise in the images, especially in images that show the material composition of the tissue. Furthermore, we have developed a new type of deep learning model, posterior poisson flow model, which can reduce the noise in computed tomography images, and demonstrated that it can provide greatly reduced noise in virtual monoenergy images from photon-counted computed tomography. We have also developed methods to use deep learning to remove errors in the image that arise from physical imperfections in the image acquisition or from the tissue moving during the image acquisition. In a few years' time, the combination of photon-counting computed tomography with next-generation image reconstruction can take image quality in computed tomography to a completely new level.

COUNTING COMPUTED TOMOGRAPHY

Research leader at KTH: Mats Persson.

Using proton radiation for the treatment of cancer tumors is advantageous as this type of radiation makes it possible to localize the radiation dose to the tumor tissue in a more precise way compared to photon radiation. However, this also means that planning proton beam treatment places high demands on the tissue's ability to stop radiation being known with high precision. Compared to today's radiation therapy planning, which is based on conventional computed tomography, photon-counting computed tomography is expected to lead to more accurate tissue characterization and thereby more reliable dose planning. We participate in a collaboration with Umeå University, Chalmers University of Technology, Skandion Clinic, RaySearch and GE Healthcare which aims to develop a better methodology for dose planning based on energy-resolved computed tomography images. Within the framework of this project, we have developed an improved method for calculating the SPR, a measure of how effectively the tissue stops proton radiation, using photon-counting computed tomography and deep neural networks. We have also evaluated this method in a simulation study.

NEW PERFORMANCE MEASURES AND VIRTUAL CLINICAL TRIALS FOR EVALUATING IMAGE QUALITY IN PHOTON-COUNTING COMPUTED TOMOGRAPHY

Research leaders: Mats Persson and Erik Fredenberg.

As photon-counting computed tomography begins to be used clinically, the need to be able to compare the image quality that can be obtained with different techniques or imaging protocols increases. We develop simulation models for different detector technologies and develop methodology to calculate how the image quality in a reconstructed image depends on properties of the detector and image acquisition parameters, based on the framework based on linear system theory that Mats Persson developed as a postdoctoral fellow at Stanford University.

A closely related project has been started in 2022 by Erik Fredenberg, who is an adjunct professor at KTH on a part-time basis. In close collaboration with Mats Persson and with Prismatic Sensors AB (part of GE Healthcare) where Erik Fredenberg works in parallel with the position at KTH, he develops a methodology for virtual clinical trials of photon-counting computed tomography.

With this technology, in the future it will be possible to use advanced simulation models to evaluate the performance of an imaging system for various imaging tasks, which reduces the need for costly and ethically sensitive clinical studies.

AN ULTRA-HIGH RESOLUTION PHOTO-TRACKING DETECTOR

Research leader: Mats Danielsson.

The central component of the photon-counting spectral computed tomography technique is a newly developed photon-counting silicon detector. Even the version of the detector that is currently being evaluated in a computed tomograph represents a major improvement compared to previously used detector types, but at the same time it represents only a first step towards the full potential of silicon detector technology. In this project we develop a new detector version with micrometer resolution and the ability to not only count but also track the photons as they move through the detector. In addition to significantly higher resolution, this detector technology can provide lower noise and better sensitivity to the spectral composition of the X-ray radiation.

A potential application is also the ability to efficiently image with phase contrast, an imaging technique that can provide new types of information about imaged tissues. During the year, a first prototype detector was developed and characterized at the MAX IV and compared to simulations, which has led to two scientific papers now accepted for publication. Work is now underway to develop an improved prototype that will be used to evaluate what resolution can be achieved, and to investigate with simulations how the new detector technology can improve the image quality in phase contrast imaging.

TISSUE ACCESS USING ENDOVASCULAR TECHNIQUES

Research leaders: Staffan Holmin, Johan Lundberg.

We have continued with the development of the concept of placing a thin instrument (so-called Extruder) inside the vessels and now have, among other things, managed to create access to the brain parenchyma in pigs via veins. This enables studies around transplantation of cells and potentially around sampling. We have published results of heart and kidney access as well as modified technique for access to the pancreas. We have further developed, tested and patented a microbiopsy tool to enable minimally invasive cardiac sampling for all parts of the heart and developed and verified tissue handling protocols for analysis of RNA in these small samples. Ongoing tests of the heart biopsy instrument for verification in human tissue take place in collaboration with Sahlgrenska University Hospital. A new company, Microcardix AB, has been formed around the technology and it has been accepted as a DRIVE project at Karolinska Institutet Innovations. We are conducting a study with the technology together with the microarray analysis company One Lambda. Development and testing of a microbiopsy tool for use inside the Extruder is ongoing. We have applied for a patent for the technology. We have recently developed and are testing a new instrument dedicated to sampling endothelial cells in various disease states. We have applied for patent protection for the technology. Furthermore, we have published results of clinical studies of dual energy CT scanning after thrombectomy (where blood clots are removed with thin tools via blood vessels) and during thrombolysis (dissolution of blood clots). We have also done a data analysis and published the results from the Stockholm Triage Study, which meant that patients with suspected blood clots in the large vessels of the brain were transported directly to Nya Karolinska. In addition, we have published new experimental MR and PET-based concepts to identify threatened brain tissue in acute ischemic stroke

ENDOVASCULAR TECHNIQUE – CELL TRANSPLANTATION

Research leaders: Staffan Holmin, Johan Lundberg.

VWe have also worked on four additional projects in endovascular technology. First, we focused on endovascular delivery of non-enhanced mesenchymal stem cells (MSCs) to the heart. Four pigs were administered 24 million cells each and sacrificed at 24 hours post injection (n = 2) and 72 hours post injection (n = 2). To understand and measure the retention of the transplanted cells to the heart, we compared injections with a larger (OD = 0.450 mm) or smaller (OD = 0.194 mm) device. Six pigs were administered 15 million Zr89 radiolabeled cells each and imaged with a PET/MRI camera two hours after injection. Finally, we compared vascular endothelial growth factor (VEGF) protein expression in the heart after injection of naïve MSCs (n = 2), MSCs genetically modified to express VEGF (n = 2), or modified mRNA encoding VEGF (n = 2). In parallel, we developed a myocardial ischemia model. We injected microspheres at various concentrations into the coronary arteries of 7 pigs and assessed ejection fraction and infarct size using cardiac MRI to develop the model. Tissue processing is nearing completion and articles will soon be submitted as one or more manuscripts to peer-reviewed journals.

Beyond the endovascular techniques, we have developed a pulse sequence and post-processing for dynamic susceptibility contrast magnetic resonance imaging (DSC-MRI). We have scanned 80 patients in Solna, of which 10 were healthy controls and one subarachnoid hemorrhage patient. We have procured a model-based oxygen extraction fraction calculation within a 10-year innovation collaboration between the neuroradiology department and Cercare A/S where intellectual property rights developed in this joint venture will be owned by the commercial partner and they will manufacture CE-marked Products.

Results from the year 2023: the concept of MSC+modRNA coding for any protein, e.g. VEGF, continues to be successful and we have now shown that VEGF levels in the heart are 200 – 500 times higher 1 and 3 days after injection of the amplified cells compared to modRNA co-injected with carrier. The same result is achieved in the kidney. The entire trial is performed with Extruder injections. The concept thus constitutes a highly interesting platform technology for efficient and long-term protein production in solid organs. This technique can solve the problem of high cost and short duration of protein production after modRNA injection. Three part-time doctoral students are involved in the project

ENDOVASCULAR TECHNIQUE REMOTE CONTROLLED DRUG CAPSULES

Research leader: Niclas Roxhed.

The blood-brain barrier is one of the most challenging aspects of drug delivery to the brain. With the Extruder technology, we can bypass the barrier, but the procedure is difficult to do several times. Therefore, we want to use the Extruder technology to achieve remote, sequential and selectively triggered drug release in the brain using ultrasound. The goal is to develop an ultra-miniaturized controllable drug delivery system (microcapsules) in size 100um*100um*1mm that can be selectively triggered using different ultrasound frequencies.

Two main methods have been used by our team to manufacture and control this process. Initially, we investigate the biocompatibility of the microcapsules by implanting them in the brain of mice and assessing their effect on the brain. Magnetic Resonance Imaging (MRI) and a number of histological/cell marker stains (astroglial etc.) have been performed which do not show no effect of these microcapsules in mouse brain (=negative control), supporting the notion of biocompatibility of these microcapsules. In addition to biocompatibility studies, marker-filled microcapsules have also been implanted in mice and we have been able to selectively release the drug with external ultrasound signals well below regulatory limit values.

These initial results present a non-surgical approach to the treatment of brain diseases. Biocompatible microcapsules containing drugs can now be implanted in the brain through the vascular system and opened on command via remote control.

Results from the year 2023: Doctoral student Mikael Sandell completed his dissertation with double degrees from KI and KTH. A new company was started – Extendo Medical AB.

MOLECULAR IMAGING/ RADIOCHEMISTRY

Research leaders: Staffan Holmin, Jeroen Goos.

The main focus of our research is with the delivery of radiopharmaceuticals to brain tumours. Brain tumours are difficult to reach using traditional medicine. Therefore, we are developing smart radiopharmaceuticals that are capable of targeting brain tumour cells after a simple injection into the blood circulation, after which the tumour cells are killed through a very high, very local radioactive dose. By using innovative, Nobel prize-winning click chemistry that can occur within a living organism, we aim to obtain a high local radiotherapeutic dose without damaging healthy tissues. In a first strategy, we are using a peptide derived from scorpion venom, designed by nature to target sites in the central nervous system. It has a strong preference for binding to tumour cells rather than healthy brain cells. We demonstrated in three-dimensional brain tumour organoid models that it was indeed able to cross the artificial blood-brain barrier and penetrate deep into the core of the organoids. Our first in vivo data demonstrate a specific, persistent uptake by brain tumour cells after an intratumoural injection. Next, we plan to increase the local radiotherapeutic dose by administering the radiopharmaceutical intratumourally using the Extroducer®. In a second strategy, we are using an innovative, radiolabelled bispecific antibody that we engineered to cross the blood-brain barrier and then bind specifically to brain tumour cells. We demonstrated that it has a high affinity for its molecular target which is overexpressed by the majority of brain tumour cells. These results are currently being validated in murine models of brain cancer. In addition, we are designing cutting-edge methodology to improve cell tracking technology. Cell-based therapies, such as immune cell therapies and stem cell treatments, are showing great promise in tumour management and tissue regeneration. However, a critical challenge lies in understanding the fate of injected cells: Do they reach the target site? And do they stay there? This uncertainty hampers early therapy assessment, risking an undesirable continuation of ineffective treatments. Addressing this, we are designing innovative cell radiolabelling technology, enabling us to follow the therapeutic cells after injection for prolonged periods using positron emission tomography (PET) imaging. Notably, our novel methodology has allowed us to track human decidual stromal cells, rat macrophages, natural killer cells, human peripheral blood mononuclear cells and mesenchymal stem cells in the body of small and large animals up to two weeks after injection. Moreover, we confirmed the retention of implanted stem cells in heart tissue after endovascular implantation using the transvessel wall technique. Ultimately, we expect that these innovative nuclear medicine techniques will lead to improved, minimally invasive, personalised therapy strategies with a minimal risk of side effects. During 2023, a new doctoral student has been recruited in international competition.

SCIENTIFIC PROGRESS UNTIL 2023

- MedTechLabs Fellow **Mats Persson**, accepted as docent at KTH in 2023.
- MedTechLabs Fellow **Johan Lundberg** was accepted as a docent at KI in 2023.
- **Dennis Hein,** doctoral student at KTH, was awarded a 182 kSEK scholarship in 2023 to conduct guest research on image reconstruction for photon-counting computed tomography at Stanford University in the spring of 2024.
- **Mikael Sandell** has a PhD in the program with degrees from both KTH and KI
- **Jeroen Goos** was awarded funds from Hjärnfonden 2023 for the project "Tearing down the walls of brain cancer: delivery of radiopharmaceuticals across the blood-brain barrier"
- **Jeroen Goos** was awarded funds from Åke Wiberg's Foundation in 2023 for the project "Tearing down the walls of brain cancer: delivery of radiopharmaceuticals across the blood-brain barrier"
- **Staffan Holmin** was awarded by Karolinska Institutet the newly instituted Prize for Innovation and Utilization in 2022
- **Mats Danielsson** was awarded the Hans Wigzell Foun-da-tion Science Prize in 2022
- **Erik Fredenberg**, GE Healthcare, was appointed in 2022 as adjunct professor at KTH.
- **Mats Danielsson** and Mats Persson are members of a consortium that has been awarded SEK 8 million over four years for the project "Emerging CT technology for advancing proton therapy". Within this project, which is led from Umeå University, spectral computed tomography and deep learning will be used to improve dose planning for proton therapy.
- **Jeroen Goos** was awarded a Starting Grant from Strat-Neuro (Strategic research area neuroscience at Karolin-ska Institutet, Umeå University and KTH) in 2022 for the project ”Tearing down the walls of brain cancer: delivery of radiopharmaceuticals across the blood-brain barrier” (”Hitta vägen till hjärntumören: transport av radio-farmaka över blod-hjärnbarriären”)
- **Jeroen Goos** was awarded KID funding from Karolinska Institutet in 2022 for the partial financing of a doctoral student on the project ”Tearing down the walls of brain cancer: delivery of radiopharmaceuticals across the blood-brain barrier” (”Hitta vägen till hjärntumören: trans-port av radiofarmaka över blod-hjärnbarriären”)
- **Mats Persson** was awarded Göran Gustafsson's big prize for young researchers in 2021 (a total of SEK 2.75 million over three years) from Göran Gustafsson's Foundation
- **Mats Persson** was awarded the Swedish Research Coun-cil's establishment grant in 2021 for the project "Pho-ton-counting computed tomography with high accu-racy for improved cancer diagnostics"
- **Jereon Goos** was awarded the Swedish Research Coun-cil's establishment grant in 2021 for the project "Devel-op-ment of a non-invasive treatment therapy against brain cancer in children".
- **Staffan Holmin** recipient of the Hans Wigzell research foundation's scientific prize 2020
- **Mats Persson** was selected together with 24 young researchers from all over the world to give a talk at Online Science Days 2020, organized by The Lindau Nobel

TRAINING

Course in acute stroke, diagnostics and treatment has been updated and LIPUS certified The course uses the interactive cloud service platform Collective Minds Radiology. Evalua-tion of the first course session, (39 participants) as part of the ST medical education received high marks.

CLINICAL TRIALS/ START-UPS

- Part of the work for cell tracking technology selected as a Karolinska Institutet Innovations AB (KIAB) project and the patent application is ongoing.
- Company Extendo Medical AB started for commercializa-tion of the technology for endothelial cell biopsies. Clinical key opinion leaders in endovascular intervention at UCSF and the University of Calgary very interested and commit-ted to the company.
- The work with Microcardix AB continues and we have shown that samples taken with the technology can be analyzed with proximity extension assay (OLINK) for proteomics. The technology also works for transcriptom-ics and commercial microarray analyses. We have shown that the Microcardix technique can also be used to take samples from the liver and lung.
- The extruder technology has proven to work well for the delivery of various types of biological drugs and cells to the heart muscle - tested both in-house and by external partners.
- Work on refining sampling technology via the Extruder continues. The technique works in the liver, kidney and pancreas. We are working to make it work in the brain as well.

THE PROGRAMME'S RESEARCHERS MEDTECHLABS AFFILIATES

Mats Danielsson, Program Director and research leader, KTH

Mats Perssson, research leader, KTH

Dennis Hein, doctoral student, KTH

Ruihan Huang, doctoral student, KTH

Karin Larsson, doctroral student, KTH

Rickard Brunskog, doctroral student, KTH

Erik Fredenberg, adj. professor, KTH

Håkan Almqvist, doctoral student, KI

Alma Eguizabal, postdoctoral fellow, KTH

Fredrik Grönberg, doctoral student, KTH

Staffan Holmin, Program Director and research leader, KI, K

Jeroen Goos, research leader, KI

Stefan Milton, post-doc, KI

Iman Zafar, PhD student, KI

Johan Lundberg, research leader, KI, KUH

Niclas Roxhed, research leader, KTH

Jonathan Al-Saadi, PhD student, KI

Arvin Chireh, affiliated PhD student, KI

Rikard Grankvist, aff doctoral student, KI

Theocharis Iordanidis, PhD student, KTH

Mikael Sandell, affiliated doctoral student, KTH

Göran Stemme, professor, KTH

Argyris Spyrou, postdoctoral fellow, KTH

Göran Stemme, professor, KTH

KI = Karolinska Institutet.
KS = Karolinska Universitetssjukhuset.

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Z. Jin, *"First experimental evaluation of count-rate performance for micrometre resolution deep silicon detector"*, Phys. Med. Biol., Accepterad för publikation **C. Sundberg, M. Persson, JJ. Wikner, M. Danielsson.** *"Timing resolution in double-sided silicon photon-counting computed tomography detectors"*, J Med Imaging 2023 Mar;10(2):023502, 2023

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BREAST CANCER IMAGING POWERED BY ARTIFICIAL INTELLIGENCE DIAGNOSTICS

Every year around 1,500 women in Sweden die from breast cancer. More and more cases are being discovered, while the relative mortality in the disease has decreased.

PROJECTS WITHIN BREAST CANCER IMAGING POWERED BY ARTIFICIAL INTELLIGENCE DIAGNOSTICS

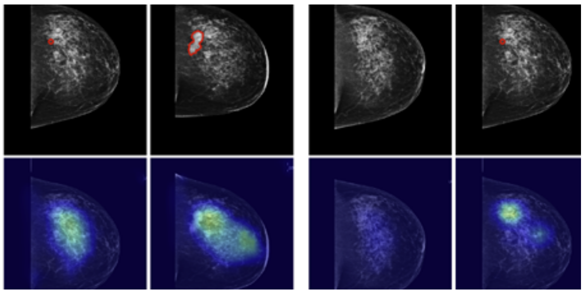
Research leaders: Johan Hartman, Mattias Rantalainen, Kevin Smith och Fredrik Strand.

The radiology part of the program has so far developed an AI pipeline (AISmartDensity) that has been used for all women undergoing mammography screening at Karolinska University Hospital within the framework of the ScreenTrustMRI study. The study enrolled its first patient in April 2021 and its last patient in April 2023.

Women whose mammograms were judged normal by radiologists but still had a high AI score were invited to participate in a magnetic resonance imaging (MRI) study. Just over 30 percent of the respondents chose to participate. Preliminary results show that the developed AI method is approximately four times as effective in identifying women at risk of having undetected cancer after screening mammography. At the same time, Fredrik Strand has acted as scientific leader for a national platform for the validation of AI for the detection of breast cancer (VAI.B). This is a collaboration between Stockholm, Linköping and Malmö where they created one to evaluate AI models. Three regions and three companies have been involved in the pilot phase. One of the most important results is that it was discovered that the AI score is higher for mammograms from certain devices, which can lead to unexpected clinical results. Work is currently underway to transfer VAI.B from the pilot phase to operational operations.

A publication reporting the results of the study is currently under review at Nature Medicine.

The histopathology part of the program has completed a large-scale retrospective validation study with >2700 patients of the regulatory CE-IVD marked Stratipath breast solution based on Rantalainen and Hartman research. Stratipath Breast has also been implemented for clinical use in three regions in Sweden during 2023. Research is still focused on building large-scale studies based on digitized images of microscope slides and developing AI models for precision diagnostics in-house. The research has focused on further development of previous AI-based prognostic models, especially towards including new prognostic parameters that take into account heterogeneity in tumors.



The top two rows (in black and white) show mammography images with an emerging tumour outlined (TTD = time till diagnosis): 4.2 years before diagnosis, 2.1 years before diagnosis and on diagnosis. The two bottom rows (in blue) show how two different AI networks assessed the image: the top three images illustrate an AI network trained to detect general risk information (inherent risk model), while the bottom three illustrate another AI network trained to detect changes to tumours (cancer signs model). The risk of developing cancer is a constant presence, as shown in the lower left-hand images, while tumour changes are first detected 2.1 years before diagnosis and are fully developed on diagnosis, as shown in the lower right-hand images.

SCIENTIFIC PROGRESS

- The clinical study ScreenTrustMRI within the BCAIND project included the last patient in April 2023
- Yinxi Wang doctorate at KI
- Philippe Weitz doctorate at KI
- Johan Hartman and Mattias Rantalainen was awarded the Prize for Innovation and Usefulness at the Karolinska Institute in 2023, because they "improve cancer diagnostics with innovative research and inspiring work methods".

CLINICAL TRIALS/ START-UPS

- ClearscanAI AB was founded in 2023 to commercialize the AISmartDensity model and bring it to more clinics. ClearscanAI was awarded funding by the Knut and Alice Wallenberg Foundation from the Proof of Concept Grant Program to Ignite Life Science Innovation.

THE PROGRAMME'S RESEARCHERS MEDTECHLABS AFFILIATES

Kevin Smith, Program Director and Research leader, KTH

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Rudan Xiao, KI/KS

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Emelie Karlsson, Coordinator, KI

Yanlu Wang, MR physicist, KS

Francisco Pena, Post-Doc, KI

Fredrik Gustafsson, Post-Doc, KI

Yujie Xiang, PhD student, KI

KI = Karolinska Institutet.
SS = Södersjukhuset.
KS = Karolinska Universitetssjukhuset.
CStG = Capio Sankt Görans Sjukhus

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BIOELECTRONIC MEDICINE

Inflammatory diseases cause a great deal of suffering for patients all over the world, as well as creating challenges for healthcare. Stimulation of peripheral nerves,including thevagus nerve, may be the anti-inflammatory treatment of the future.


Training VAE
ELBO
Clustering
SGD

PROJECTS WITHIN BIOELEKTRONIC MEDICINE

DEVELOPMENT OF AUTONOMIC NERVE STIMULATION FOR INDIVIDUALIZED TREATMENT OF INFLAMMATORY DISEASES

Research leaders: Peder Olofsson and Henrik Hult.

Specific peripheral nerves regulate inflammation and implanted nerve stimulators are used in clinical treatment studies of rheumatoid arthritis and inflammatory bowel disease. MedTechLab's project in bioelectronic medicine aims to 1) better understand the nerve signals and mechanisms that regulate inflammation and 2) develop methods to apply the knowledge clinically.

Knowledge of the neurophysiology of inflammation regulation is limited both in terms of anatomical conditions and signaling mechanisms, which limits clinical applications.

The project has developed new methods to study neurophysiology in inflammation regulation in greater detail, for example to selectively activate or record electrical activity from peripheral nerves in model systems. The methods are now applied in disease models.

As part of this, we have developed a method to wirelessly activate peripheral nerves with much higher precision than previous solutions and are now conducting the first human studies with this technology (https://news.ki.se/ki-researcher-awarded- erc-poc-grant-for-non-invasive-treatment-of-inflammatory-diseases).

Collected data, primarily from the implantable electrodes, are analyzed with proprietary methods in machine learning, based on auto-encoders and clustering, for the identification of nerve signals in inflammation regulation.

SCIENTIFIC PROGRESS

- A professorship in bioelectronic medicine was established at KI.
- Brand new head of department in the department of Probability Theory, Mathematical Physics and Statistics
- Olofsson was awarded the Heart-Lung Fund's large grant.
- Hult/Olofsson received a research grant of SEK 4M from WASP/DDLS.
- Hult received research funding from SeRC SEK 3.2M, for postdoc from the Verg foundation SEK 2M, for Digital Future's focus period (co-applicant) SEK 1M
- Marcus Nordström defended his dissertation (Hult supervisor)
- Two new PhD students were hired (Hanqing Xiang, Max Oliveberg)
- A new researcher was hired (Gul-Jhen Wu)
- A new postdoc was hired (Oskar Allerbo)
- Hult worked on the development of a new Master's program in "Biostatistics & Data Science" within Stockholm Trio.
- Olofsson delivered the 24th Broegelmann Lecture (https://www.uib.no/en/rg/broegelmann/161472/24th-broegelmann-lecture-peder-olofsson)
- Biorealistic neurons were noticed by TV4.TV channel
- Henrik Hult cluster leader for application clusters within WASP.
- Henrik Hult, director of Brummer & Partners MathDataLab.
- Henrik Hult receives a 4-year project grant from SeRC, SEK 3.2M, November 2022.
- Henrik Hult arranges conference: "Mathematics for Complex Data" with 110 participants, KTH, June 2022.
- Peder Olofsson's doctoral student Alessandro Gallina completed his dissertation in April 2022.
- Peder Olofsson is working with KI Innovations to prepare a clinical study based on an invention/patent application from 2021.
- Peder Olofsson received a project grant from the Heart-Lung Foundation and others.
- Peder Olofsson co-published the discovery that nerve signals regulate atherosclerosis (Nature, 2022) and small intestinal inflammation (Frontiers in Neuroscience, 2022).
- Peder Olofsson & Henrik Hult published a mechanism for neural regulation of inflammation healing (PNAS, 2022).

THE PROGRAMME'S RESEARCHERS MEDTECHLABS AFFILIATES

Peder Olofsson, Program Director and research leader, KI, K

Henrik Hult, Program Director and research leader, KTH

April Caravaca, postdoctoral fellow, KI

Michael Eberhardson, consultant, researcher, KI, K

Laura Tarnawski, assistant professor, KI

Fredrik Viklund, professor, KTH

Adam Williamson, researcher, KI

Vladimir Shavva, assistant professor, KI

Wanmin Dai, PhD student, KI

Oscar Allerbo, post-doc, KTH

Wanmin Dai, PhD student, KI

Qi Guo, doktorand, KI

Jeromine Vacquie, PhD student, KI

KI = Karolinska Institutet.
KS = Karolinska University Hospital..

PUBLICATIONS 2023

D'Haens, G., Eberhardson, M., Cabrijan, Z., Danese, S., van den Berg, R., Lowenberg, M., Fiorino, G., Schuurman, P. R., Lind, G., Almqvist, P., Olofsson, P. S., Tracey, K. J., Hanauer, S. B., Zitnik, R., Chernoff, D., & Levine, Y. A. (2023). **Neuroimmune modulation through vagus nerve stimulation reduces inflammatory activity in Crohn's disease patients: a prospective open label study.** *J Crohns Colitis 2023.*

Ahmed, O., Caravaca, A. S., Crespo, M., Dai, W., Liu, T., Gou, Q., Leiva, M., Sabio, G., Shavva, V. S., Malin, S. G., Olofsson, P. S. **Hepatic Stellate Cell Activation Markers Regulated by the Vagus Nerve in Systemic Inflammation** *Bioelectronic Medicine. 2023. Mar 31;9(1):6.*

Tarnawski, L., Shavva, V. S., Kort, E. J., Zhuge, Z., Nilsson, I., Gallina, A. L., Marinez-Enguita, D., Heller Sahhlgren, B., Weiland, M., Caravaca, A. S., Schmidt, S., Chen, P., Abbas, K., Wang, F. H., Ahmed, O., Eberhardson, M., Färnert, A., Weitzberg, E., Gustafsson, M., Kehr, J., Malin, S. G., Hult, H., Carlström, M., Jovinge, S., & Olofsson, P. S. **(2023). Cholinergic regulation of vascular endothelial function by human ChAT+ T cells.** *Proc Natl Acad Sci U S A, 2023.*

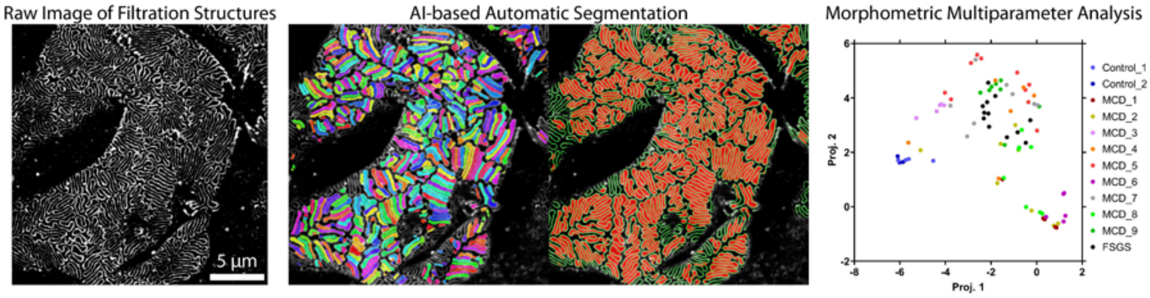
Harikesh PC, Yang CY, Wu HY, Zhang S, Donahue MJ, Caravaca AS, Huang JD, Olofsson PS, Berggren M, Tu D, Fabiano S. **Ion-tunable antiambipolarity in mixed ion-electron conducting polymers enables biorealistic organic electrochemical neurons.** *Nature Materials 2023.*

CLINICAL STUDIES/COLLABORATIONS WITH HOSPITALS AND COMPANIES

- Results of a clinical study in collaboration with SetPoint-Medical, Karolinska University Hospital and others of vagus nerve stimulation in Crohn's disease were published in 2023.
- Prototype development of a hand-held device for non-invasive precision stimulation of peripheral nerves was started in collaboration with Emune AB.
- Planning for a clinical study of non-invasive vagus nerve stimulation in collaboration with Tema Hjärta-Kärl, Karolinska University Hospital, Danderyds sjukhus and Emune AB.
- NovoNordisk funded a post-doc in the project during 2020-2023.

OPTICAL 3D-MICROSKOPY FOR MORE EFFECTIVE DIAGNOSIS OF KIDNEY DISEASES

Chronic kidney disease is a growing global threat to public health. About 10% of the world's population is affected, but in the elderly and people with high blood pressure, cardiovascular disease and diabetes, over 35% are affected.



Imaging, segmentation and quantification of filtration structure pathology in kidney samples. Images of nanometer-scaled kidney filtration structures are generated using new sample preparation and optical imaging methods (left panel). A trained deep learning network is used for automatic segmentation of structures (middle panel). Several quantitative parameters are extracted which describe pathological alterations in the kidney filter, and a multi-parameter umap projection reveals morphometric grouping of human patients with minimal change disease (MCD) and focal segmental glomerulosclerosis (FSGS) (right panel).

PROJECTS IN OPTICAL 3D MICROSCOPY FOR MORE EFFICIENT DIAGNOSIS OF KIDNEY DISEASES

Research leaders: Sigrid Lundberg och Hans Blom.

During its second year of operation, the project has had the following focus:

A. Clinical validation of optical 3D renal pathology using AI-assisted diagnostics.
B. Spin-off of the deep-tech company Magnephy.
C. Interaction with AIDA regarding medical image analysis with artificial intelligence.
D. Further development and research application.

In subproject A, we have continued to clinically validate our method with optical 3D renal pathology. In collaboration with two German kidney clinics, we have shown that the method can quantify and stratify kidney disease with AI analysis support (see publication I). In the study, approximately thirty patients from Sweden and Germany with different diagnoses and treatments were validated. During 2024, we intend to further validate 100 diagnosed Swedish kidney patients.

Our long-term goal is to introduce optical 3D pathology in Swedish healthcare. More precise and quantitative personalized diagnostic support (so-called precision health) has the opportunity to modernize and streamline pathology (see publication II). Through a newly started company, we now also support the pharmaceutical sector with more precise and quantitative renal pathology. KTH Innovation and Vinnova support our deep-tech company, which builds its business on cutting-edge technology (see publication I). Within sub-project C, we have also continued our collaboration with the national arena for research and innovation around artificial intelligence for medical image analysis (AIDA). Arena's focus is that AI technology should provide patient benefit in the form of clinically useful tools. Our method is selected as a clinical fellow project, and the project collaboration takes place with technical innovators mainly around the development of AI-based decision support.

In sub-project D, further development of our optical 3D method takes place, as well as further application in the kidney research field (see publication III).

SCIENTIFIC PROGRESS

- Sigrid Lundberg, Hannes Olauson and David Unnersjö-Jess received a grant from the Kidney Foundation to improve kidney diagnostics.
- Robin Ebbestad received extended AIDA support as a clinical fellow
- Optical 3D kidney pathology can automatically quantify and stratify kidney disease with AI analysis support.
- Project support has been obtained to further develop analysis of disease mechanisms in intact kidney.

CLINICAL TRIALS/ START-UPS AND COLLABORATION WITH HOSPITALS

- Clinical validation of optical 3D kidney pathology has continued in collaboration with the kidney medicine clinic at Danderyd Hospital and with the pathology department at Karolinska University Hospital.
- Magnephy AB, Magniphy founded – an improved kidney diagnostics with AI and 3D microscopy spun off as a deep-tech company - supported by KTH Innovation and Vinnova- to support the pharmaceutical sector with more precise and quantitative pathology.

[1] https://medtech4health.se/aida/fellowships/

PUBLICATIONS 2023

I. Unnersjö-Jess et al (2023). Deep learning–based segmentation and quantification of podocyte foot process morphology suggests differential patterns of foot process effacement across kidney pathologies. Kidney International 103(6):1120–1130.

II. På språng mot modern njurbiopsianalys. Njurfunk 2:16-17 (2023) .

III. Unnersjö-Jess et al (2023). Advanced optical imaging reveals preferred spatial orientation ofpodocyte processes along the axis of glomerular capillaries. Kidney International 104(6):1164–1169.

THE PROGRAMME'S RESEARCHERS MEDTECHLABS AFFILIATES

Sigrid Lundberg, Program Director and research leader, DS, KI

Hans Blom, Program Director and research leader, KTH

David Unnersjö-Jess, post-doc, KTH, UniK

Robin Ebbestad, PhD student and MD, KI, DS.

Hannes Olauson, MD, Clinical patology, KI, KS

Hjalmar Brismar, Professor, KTH, KI

Jaakko Patrakka, Adjunct Professor, clinical patologi KI, K

Annika Östman Wernerson, Professor Kidney and transplant science KI, K

DS = Danderyds sjukhus.
KI = Karolinska Institutet.
KTH = Kungliga Tekniska Högskolan.
KS = Karolinska Universitetssjukhuset.
UniK = Universitetet i Köln, Tyskland.

[2] *https://issuu.com/njurforbundet/docs/njurfunk_2-2023*

FINANCIAL RESULTS

ECONOMIC OUTCOME 2023

Accrued unspent funds at the start of the year are largely due to the recruitment of the three assistant professors. It took longer than expected. This was regulated for 2020 and 2021 through a lower contribution from the parties than what the actual business requires. From 2022, the business will have a turnover of SEK 18 million per year. The administration costs for the center amounted to 8,5 % of the total costs.

Opening balance 2023	1 933 000
Revenue 2023	
Region Stockholm	12 000 000
Karolinska Institutet	3 000 000
KTH	3 000 000
Costs 2023	
Research area Imaging and Minimally Invasive methods	
Clinical infrastructure for translational research	**1 076 000**
Rental BioClinicum,R&D lab and work space	316 000
Research engineer 40%	240 000
Support staff – Imaging nurse	470 000
Day-to day operations	50 000
Research programme Spectral CT-imaging and Endovascular Techniques	**7 000 000**
Research area Artificial Intelligence in Healthcare	
Research programme Breast Cancer Imaging Powered by Artificial Intelligence Diagnostics	**4 000 000**
Research area Bioelectronic Medicine	
Research programme Bioelectronic Medicine	**3 000 000**
Projects 2023	**2 425 000**
Launch of online course Acute stroke, diagnostics and treatment	597 000
Increased awareness of MedTechLabs	550 000
New call 2023	100 000
AI project	900 000
Seminars and outreach	278 000
Administration	**1 618 000**
Payroll Management team	1 285 000
Meetings costs	22 000
Communikations (Communition Officer)	211 000
Other Costs	100 000
Total Costs	**19 119 000**
Closing balance 2023	814 000

All figures in SEK

MedTechLabs

MedTech Labs is an interdisciplinary centre for medical technology research that develops diagnostics and improved treatments for our most common diseases. The objective is also to develop MedTechLabs into a leading centre of excellence internationally.

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