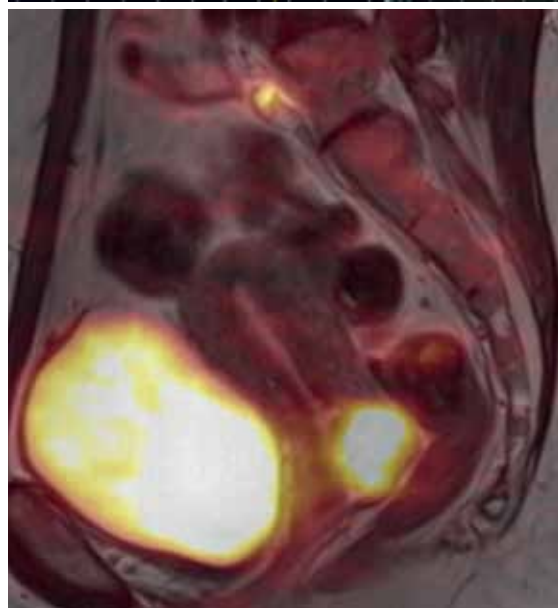


Department of Clinical Physiology, Nuclear Medicine & PET

Annual Report 2011



Rigshospitalet

King Frederik V founded Rigshospitalet in 1757. Today, it has 1,200 beds, 8,500 employees and an annual budget of 5 billion DKK. Research at Rigshospitalet is published in more than 2,000 peer review papers per year, including around 90 higher academic theses (PhD and Doctor of Medical Science). Rigshospitalet is part of The Capital Region of Denmark and is a Copenhagen University Hospital.

University Of Copenhagen

The University of Copenhagen was founded in 1479. The Faculty of Health Sciences has 4,000 students and 10 bachelor- and master educations, including medicine and bioengineering in collaboration with The Technical University of Denmark, DTU. The University of Copenhagen is member of IARU, The International Alliance of Research Universities. www.ku.dk

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Preface



Liselotte Højgaard and Linda M. Kragh

Department of Clinical Physiology, Nuclear Medicine & PET was graced by a generous donation from The John & Birthe Meyer Foundation for a new simultaneous whole body PET/MRI scanner. It was opened at a Grand Occasion with an international symposium "The John & Birthe Meyer PET Symposium in Copenhagen" 14th of December 2011. The generous donation of 35 mio DKK was highly acknowledged by the department and the hospital on the occasion, graced by the presence of Birthe Meyer, Gitte Meyer Brandt and Søren Drost-Nissen from the foundation. You can read more about the celebration on page 12. We are immensely grateful to The John & Birthe Meyer Foundation.

Our year 2011 was a busy year with 52,275 patient investigations, a significant rise compared to the year previously. The research effort resulted in 133 publications, 5 theses (Ph.D. and Doctor of Medical Science) and 1 patent. We had a tough January 2011 with a dramatic budget cut. Thank you to every one in the department for an amazing tenacity and hard work to overcome the difficult beginning of the year.

It is the aim of our department that our patients should receive the best and most correct patient investigation without delay for each and every patient. To reach our goals we need to focus on research, innovation, education and quality.

We would like to convey our most sincere thank you to all staff members for making it possible. Our aim is also to be a nice place to work. In line with that we were one of the

best departments in the year 2011 questionnaire "TrivselOP" describing how the staff perceived their daily work. We were also among the best departments in the hospital in the evaluation of our leadership competences. Thank you to every one for the great effort.

Apart from the grand opening of the PET/MR we got a new 64 slice PET/CT "mCT" from Siemens Spring 2011 and we now have 4 PET/CT scanners in the department and the brain PET research tomograph HRRT+.

In Nuclear Medicine the treatment with ^{177}Lu -Dotatate in patients with neuroendocrine tumors continued to grow with now more than 100 treatments per year. Clinical Physiology, Nuclear Medicine & PET is a Global Excellence department and the neuroendocrine tumor program is accredited by The European Neuroendocrine Tumor Society (eNETS). A warm thank you to Professor Andreas Kjær who is head of the research in the department and a warm thank you to all the researchers and the staff teaming up to make research the basis for the best patient diagnosis and treatment throughout all activities in the department. A warm thank you to Professor Gitte Moos Knudsen and her team at CIMBI for the enthusiastic and productive collaboration in neurobiology and research. (www.cimbi.dk) A warm thank you to Head of Clinical Engineering Ole Bergsten for helping us with equipment.

A big thank you to our directors at Center of Diagnostics, Rigshospitalet, Center Director, Dr. Bettina Lundgren and Leading Chief Technologist Karin Nørgaard and their team for positive and helpful collaboration.

Our department has kept the budget now for the last 12 years. We acknowledge the needed budget cuts, it was however a challenge to deliver a rising production of 10% for both patient investigations and R & D and at the same time implement the significant budget cuts. Thank you to the Board of Directors, Rigshospitalet, where Torben Stentoft, Chief Executive Officer, Jannik Hilsted, Chief Medical Officer and Helen Bernt Andersen, Chief Nursing Officer have been helpful in many ways throughout the year.

Thank you to the Department of Radiation Therapy for patience throughout the installation of the PET/MR scanner and for the daily great collaboration on research and patient treatment. A special warm thank you to Professor Svend Aage Engelholm, Chief Nurse Kirsten Amsinck and Chief Physicist Jens Peter Bangsgaard.

Internationally the EMRC, the European Medical Research Councils, with the office at ESF in Strasbourg are thanked warmly for the great effort for strengthening medical research in Europe and globally as seen on the last page of this report. Thank you to Dr. Stephane Berghmans, Dr. Kirsten Steinhausen and Mrs. Janet Latzel and the whole team at EMRC. Thank you to all staff members and collaborators in Denmark and internationally. Our aim is to deliver the best patient treatment and the best research and education. Without your great help we would not have made it.

Liselotte Højgaard
Professor, Head of Department

Linda M. Kragh
Chief Techonologist

Mission and objectives

The mission of Rigshospitalet is to be the leading hospital in Denmark for patients in need of highly specialized treatment.

The general objectives are:

- » to be at the forefront of highly specialized diagnostic treatment and nursing
- » to carry out research and development at an advanced international level
- » to educate staff in the health services to a highly specialized level
- » to contribute with professional advice and exchange of knowledge and expertise to the wider healthcare community
- » to be characterized by openness and human respect

The objectives of the Department of Clinical Physiology, Nuclear Medicine & PET are:

- » to provide optimal clinical physiology and nuclear medicine for patient investigation
- » to carry out research at the highest international level in clinical physiology and nuclear medicine with special emphasis on molecular imaging, isotopes and radiopharmaceuticals
- » to deliver undergraduate and postgraduate education for all relevant professionals within the relevant expert clinical fields, nationally and internationally
- » to provide a good patient experience and ensure the wellbeing of the staff

The staff have participated in very many congresses, symposias, meetings and workshops with invited lectures, oral presentations, abstracts and posters. We have a comprehensive program for all staff members at the department, and frequent visits from Danish and international research groups.

In 2011 more than 300 groups and individuals visited the department.



Organisation and staff

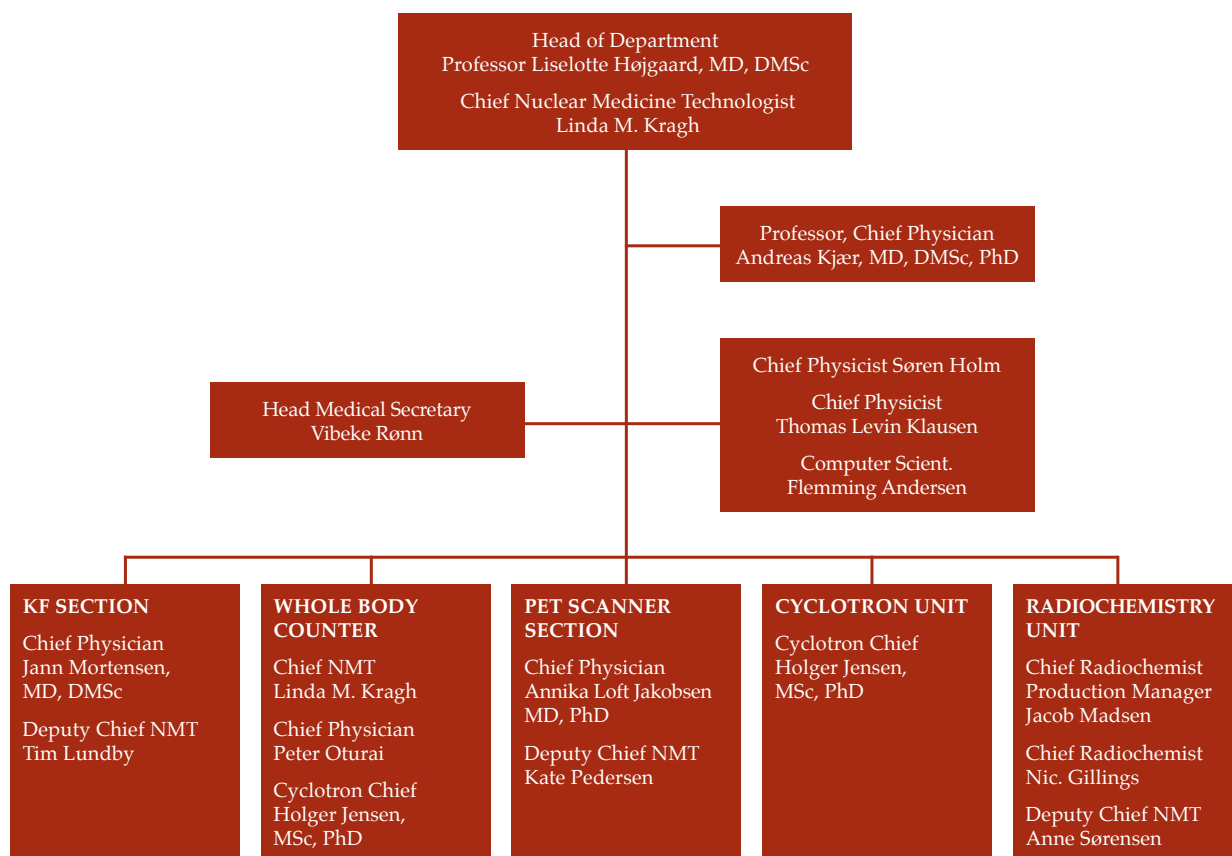


Physicians

Benzon, Eric von, MD, Chief Physician., Berthelsen, Anne Kiil, MD, Chief Physician., Borgwardt, Lise, MD, PhD, Chief Physician., Christensen, Charlotte Birk, MD, Senior Registrar., Costa, Junia, MD, Senior Registrar., Fischer, Barbara Malene, MD, Registrar., Ghotbi, Adam Ali, MD, Registrar., Hansen, Tine Willum, MD, Senior Registrar., Hasbak, Philip, MD, Chief Physician., Hesse, Birger, MD, DMSc, Chief Physician., Højgaard, Liselotte, MD, DMSc, Head of Department, Professor., Høyer, Alice Outzen Widding, MD, Consultant., Jakobsen, Annika Loft, MD, PhD, Chief Physician., Jørgensen, Simon Møller, MD, Registrar., Kjær, Andreas, MD, DMSc, PhD, MBA, Chief Physician, Professor., Korsholm, Kirsten, MD, Registrar., Law, Ian, MD, PhD, Chief Physician., Löfgren, Johan, MD, Chief Physician., Markova, Elena, MD, Chief Physician., Marner, Lisbeth, MD, Registrar., Mladenovic, Maja, MD, Registrar., Mortensen, Jann, MD, DMSc, Chief Physician, Ass. Professor., Oturai, Peter, MD, Chief Physician., Özdemir, Zehra, MD, Registrar., Rønne, Frederik, MD, Registrar., Winkler, Christine, MD, Senior Registrar.

PhD students, postdocs & clinical assistants

Andersen, Julie Bjerglund, MD, PhD Student., Andersen, Valdemar Lykke, Pharmacist, PhD Student, Cimbi Researcher, Binderup, Tina, MSc, PhD Human Biology, postdoc, Malene M. Clausen, MD, PhD Student, da Cunha-Bang, Sophie MD, PhD Student, NRU Researcher, Ettrup, Anders, MSc Human Biology, PhD, NRU Researcher, Fisher, Patrick, PhD, NRU Researcher, Frøkjær, Vibe, MD, PhD, NRU Researcher, Grüner Julie Marie, MD, PhD Student., Hag, Anne Mette Fisker, MSc Human Biology, PhD Student., Haahr, Mette, MD, PhD Student, NRU Researcher., Hansen, Hanne Demant, PhD Student, NRU



Department of Clinical Physiology, Nuclear Medicine & PET is part of The Diagnostic Center headed by Bettina Lundgren, Director, MD, DMSc and Karin Nørgaard, Vicedirector.

Researcher, Hansen, Martin, MSc, PhD Student., Herth, Matthias, PhD, Cimbi Researcher, Hollensen, Christian, PhD Student., Jensen, Mette Munk, MSc Human Biology, Research Fellow., Johnbeck, Camilla Bardram, MD, PhD Student., Jørgensen, Jesper Tranekær, MSc Human Biology, Research Fellow., Knudsen, Jesper Andreas, MD, PhD Student., Kristoffersen, Ulrik Sloth, MD, Research Fellow, PhD Student., Li, Fan, MSc Med Tech, PhD Student., MacMahon, Brenda MD, PhD Student, NRU Researcher, Marthin, June, MD, PhD Student., Nedergaard, Mette Kjølhed, MD, PhD Student, Nielsen, Anna Pors, MD, Research Assistant, NRU Researcher, Nielsen, Carsten Haagen, MSc Med Tech, PhD Student., Nielsen, Kristina Rue, MD, PhD Student., Olesen, Oline Vinter, MSc Med Tech, PhD Student., Persson, Morten, MSc Pharm, Research Fellow, PhD Student., Pedersen, Sune Folke, MSc Human Biology, PhD Student., Pfeifer, Andreas, MD, Research Fellow, PhD Student., Reichkender, Michala, MD, PhD Student., Ripa, Rasmus S, MD, DMSc, postdoc, Skovgaard, Dorthe, MD, PhD, Registrar., Zornhagen, Kamilla Westarp, DVM, PhD Student.

Physicists, pharmacists, chemists, technicians, engineers, computer scientists, QA-assistants

Andersen, Flemming, MSc, PhD, Computer Scientist., Boudreault, Ghislain, MSc, PhD, Substitute Cyclotron Physicist., Brandt-Larsen, Malene, MSc, PhD, Chemist., Christensen, Jan Damgaard, Cyclotron Technician., Dahan, Daniel, Cyclotron Technician., Dähnhardt, Andreas, Computer Assistant., de Nijs, Robin, Medical Physicist, MSc, PDEng, PhD., Denholt, Charlotte Lund, MSc, PhD, Chemist., Erlandsson, Maria, Chemist., Gillings, Nicholas, MSc, PhD, Chief Radio Chemist., Heilmann, Helene, QA-Pharmacist., Holm, Søren, MSc, PhD, Chief Physicist., Jensen, Björn Neumann, Electro Engineer., Jensen,



Holger, MSc, PhD, Physicist, Cyclotron Chief., Jensen, Tina Gade, QA-Assistant., Jørgensen, Jesper, MSc, Cyclotron Physicist., Keller, Sune Høgild, MSc, PhD, Computer Scientist., Klausen, Thomas Levin, MSc, Chief Physicist., Lehel, Szabolcs, MSc, PhD, Chemist., Madsen, Jacob, MSc, PhD, Chemist, Chief Production Manager., Schjøth-Eskesen, Christina, Chemist., Sibomana, Merence, IT-expert., Weihrauch, Per, Cyclotron Technician.

Nuclear medicine technologists (NMT), radiographers and nurses

Abrahamsson, Elisabeth, Radiographer., Albers, Mia C. Hjorth, NMT., Bojesen, Christina, NMT., Christensen, Camilla, NMT., Christensen, Pia, NMT., Cortsen, Annette, NMT., Dall, Bente, NMT., Dunbar, Douglas, NMT., Elkington, Sakeena, NMT., Federspiel, Marianne, NMT., Frederiksen, Mette Borggreen, NMT., Hansen, Anja Vallin, NMT., Hansen, Jon, Radiographer., Hansen, Lasse, NMT., Hassan, Mariam, NMT., Heiberg, Therese, Cand.scient.san, NMT., Holm, Stine, NMT., Jensen, Charlotte, NMT., Jensen, Martin Ravn, NMT., Jørgensen, Hanne, NMT., Jørgensen, Mette Møller, NMT., Kernchen, Ulla, Staff Nurse., Knudsen, Camilla Sloth, NMT., Kragh, Linda M., Chief NMT., Kronvall, Johanna, NMT., Lindell, Elin, NMT., Linnet, Solveig, NMT., Ljunggren, Anna, NMT., Lundby, Tim, Deputy Chief NMT., Lærke, Sonja Pedersen, Laboratory Technician., Magnusson, Linda, Technologist., Myschetzky, Rebecca, NMT., Nehme, Ghina, NMT., Osinska, Dorota, NMT., Osmani, Lume, NMT., Pedersen, Kate, Deputy Chief NMT., Pejtersen, Maria, NMT., Poulsen, Camilla Storm, NMT., Saxtoft, Eunice, NMT., Setterberg, Victoria, NMT., Sørensen, Anne B., NMT., Sørensen, Anne, Deputy Chief NMT., Sørensen, Louise Sørup, NMT., Stahr, Karin, NMT., Svalling, Susanne, NMT., Wikke, Tina, NMT., Yerst, Joo, NMT., Zulfovsk, Cejlan, NMT.



Medical secretaries and secretaries

Frydendall, Pia, Medical Secretary., Hansen, Lissa, Medical Secretary., Hildebrand, Sanne, Secretary., Marquardsen, Joan, Medical Secretary., Myltoft, Mette Gylling, Medical Secretary., Nielsen, Mariane, Service Assistant., Nielsen, Tina Vikmann, Medical Secretary., Runge, Gitte, Medical Secretary., Rønn, Vibeke, Head Medical Secretary., Semitoje, Gudrun, Medical Secretary., Stahlfest, Marianne, Medical Secretary.

Students

Christensen, Anders Nymark., Bothmann, Bianca., Dohn, Asmus Ougaard., Dyring, Maria., Henning, William Sebastian., Henriksen, Martin Romme., Husted, Frederik Agner., Ipsen, Niels Bruun., Jensen, Simon Bøgh., Larsen, Thorvald Wadum., Lassen, Martin Lyngby., Nielsen, Anders Bo., Nørgaard, Martin., Øberg, Mikkel., Paamand, Rune., Perez, Nicolas Palm., Petersen, Stefan Alaric., Savic, Dragana., Værg, Thorkil Kowalski., Weihrauch, Simone., Yildiran, Handan

Highlights 2011



Søren Holm, Master of Science PhD and Responsible Physicist at the department, celebrated his 25 years anniversary at Rigshospitalet on 11th of November 2011 with a symposium with lectures in Auditorium 2 and a fine reception followed the scientific program.



Oline Vinter Olesen, Bioengineer in Medicine and Technology, defended her PhD thesis: "Markerless 3D Head Tracking for Motion Correction in High Resolution PET Brain Imaging" on the 15th of December 2011. Oline has invented a new technology for motion correction in brain PET, tested at Yale in the US and at Rigshospitalet and developed in collaboration with Professor Rasmus Larsen, DTU Informatics, Technical University of Denmark, Siemens Healthcare and Rigshospitalet.

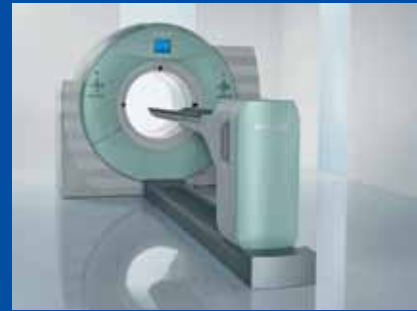
The department opened the new DEXA-scanner in 2011, so that routine clinical patients from Rigshospitalet can be referred directly to our department for investigations.



Consultant Birger Hesse, MD, DMSc, a world renowned capacity in nuclear cardiology, with a long duty for the speciality in Denmark and internationally, celebrated his Retirement Symposium on 14th of January 2011. A large group of invited guests and distinguished speakers made it a very successful day. From the department we would like to express our sincere gratitude to Birger Hesse for his long and important duty for the strengthening of clinical physiology and nuclear medicine, not only at our department here at Rigshospitalet, but also in Denmark and internationally.



The old PET/CT scanner from 2001, one of the first in Europe, was outdated and exchanged by a new PET/CT scanner a Siemens MCT with 64 slice CT. The department has now 4 PET/CT scanners of state of the art quality.



A new Siemens Symbia 16 slice SPECT/CT was opened November 2011.



The new textbook in clinical nuclear medicine was published in 2011 edited by Dr Charlotte Birk Christensen, Dr Annika Loft Jakobsen and Dr Birger Hesse from our department and with many contributions to chapters from the rest of the staff



The new advanced FDG production lab was opened in 2011.



Nuclear Medicine Technologist Susanne Svalling got the "Arbejdsmiljøpris 2011" at the "Arbejdsmiljødag 2011" on Rigshospitalet

Opening of the new PET/MR scanner 2011

- donated by the John and Birthe Meyer Foundation



The absolute Highlight of the year 2011 was the generous donation from the John and Birthe Meyer Foundation of 35 mio DKK for a new integrated PET /MR whole body scanner. The opening of the new scanner took place 14th of December 2011 under the presence of Birthe Meyer, Gitte Meyer Brandt and Søren Drost-Nissen from the foundation. It was a day of celebration and joy and the gratefulness from the whole department and the hospital was conveyed to the foundation. The gratitude from the whole community of researchers towards Birthe Meyer, Gitte Meyer Brandt and Søren Drost-Nissen and the John and Birthe Meyer Foundation was expressed very clearly from every one.

In the morning we had an international symposium on the use of PET and MR for research and clinical diagnosis, with our new collaborator Professor Bruce Rosen from the Martinos Center, Harvard Medical School. Bruce Rosen received the prestigious K.F.J. Award the next day, as a recognition of his cutting edge research in neuroimaging. Professor Gitte Moos Knudsen from CIMBI, Rigshospitalet is Visiting Professor there to establish and strengthen the collaboration between our two institutions. Both Gitte and Bruce gave inspiring talks about the future use of PET /MRI in the neurobiology research program. Professor Søren Bentzen from University of Madison Wisconsin is an expert on PET and MR in radiation therapy planning and medical physics and also adjunct profes-



sor here at the University of Copenhagen. He gave his vision for the use of PET/MR for radiation therapy planning in the future and stressed the importance of interdisciplinarity. Head of Department of Radiotherapy Professor Svend Aage Engelholm reported on the very successful synergy between radiotherapy and PET research in Copenhagen, where we have been game changers for the use of PET/CT planned radiotherapy. At present we perform 1000 clinical patients with PET/CT planning. Professor Lena Specht is a world authority on the use of PET/CT for radiation therapy planning in head and neck cancer and malignant lymphoma. She underlined the significance of PET/CT and PET/MRI for improved therapy in the future. Professor Andreas Kjær gave a state-of-the-art perspective on the use of molecular imaging PET/MR as a very important translational research tool. Dr. Ian Law reported on the future use of PET/MR for brain tumors and dementia. Dr. Annika Loft Jakobsen, Head of our PET section, and Dr. Anne Kiil Berthelsen gave an elegant presentation on the use of PET/CT and future use of PET/MRI for oncology in combined research and clinical investigations. Finally Dr. Lise Borgwardt reported on the use of PET/CT and future use of PET/MR in pediatric nuclear medicine. Head of Department Professor Liselotte Højgaard summarized the history of PET in Copenhagen: The first PET center in Denmark and the first of the Nordic countries with PET/CT and now PET/MRI.

Radionuclide therapy

^{131}I -Radioiodine and ^{177}Lu -DOTATATE



Peter Oturai and Jann Mortensen

For many years the department has successfully treated patients with benign thyroid diseases – goiter and hyperthyroidism – with ^{131}I -iodine.

Since May 2009 we have provided treatment with ^{177}Lu -DOTATATE in Denmark to patients with neuroendocrine tumor (NET) metastases. Until the end of 2011 58 patients have been given a total of 187 treatments. Being one of the two highly specialized centers using this treatment modality in Denmark we work in close collaboration with the Departments of Gastro Surgery, Oncology, Radiology, Pathology and Endocrinology at Rigshospitalet.

The NET-Center at Rigshospitalet has been accredited as Center of Excellence by the European Neuroendocrine Tumor Society (eNETS).

^{177}Lu -DOTATATE is synthesized and labelled at the Hevesy Laboratory at Risø, DTU. ^{177}Lu -DOTATATE is administered in our dedicated facilities in the department and the patients stay overnight at the surgical ward.

The rationale for the treatment, is that the radio labelled somatostatin analogue binds to neuroendocrine tumors expressing somatostatin receptors. The emitted beta-particles from the ^{177}Lu -isotope destroy the tumor cells. In addition the emission of gamma photons from ^{177}Lu allows for scintigraphic imaging and dosimetry.

The indications for ^{177}Lu -DOTATATE therapy are inoperable patients with neuroendocrine tumors that either show progression or cannot tolerate standard treatment. A prerequisite is an ^{111}In -octreotide scan demonstrating a high density of somatostatin receptors in the tumors.

Our experience is comparable to what we expect from the literature, i.e. some measurable effect in the majority of the patients, and only few side effects.



Nuclear medicine 2011



Jann Mortensen and Peter Oturai

The majority of our more than 30,000 patient examinations in the department are related to the diagnosis and monitoring of cancer patients. Hybrid SPECT/CT scans of neuroendocrine tumors, bone scans for primary and secondary malignant tumors, sentinel node scintigraphy for breast cancer, malignant melanoma and other malignancies, MUGA and ^{51}Cr -EDTA clearance measurements for monitoring side effects in chemotherapy treated patients are some examples.

The somatostatin receptor ligand ^{111}In -Octreotide imaging, most often combined with CT scans of diagnostic quality, is an important endocrine nuclear medicine imaging modality and is being increasingly used for evaluation and monitoring of therapy in patients with inoperable tumors.

Frequent indications for lung physiology measurements are control after chemotherapy and transplantation or pre- and postoperative evaluation and radioaerosol mucociliary clearance investigations for the diagnosis of primary ciliary dyskinesia.

Radioisotope leakage monitoring procedures are used during isolated limb perfusion with melphalan and tumor necrosis alpha for recurrent melanoma and soft-tissue sarcoma. To this end, we have eight gamma cameras for routine nuclear medicine imaging and research studies, three hybrid SPECT/CT cameras, one dual-head gamma camera and four single-head cameras. A new SPECT-16 slice-CT (Symbia, Siemens) was in-

stalled and replaced our Hawkeye hybridscanner. This new scanner will primarily be dedicated to the increasing number of pediatric nuclear medicine investigations in the department.

We use our ultrasound scanner for thyroid patients as a supplement to thyroid scintigraphy. For lung function testing we have two Jaeger body plethysmographs. At the end of the year we had our first DEXA scanner for bone mineral content and body composition assessment installed. Our animal facilities are equipped with SPECT and PET and CT scanners. Weekly receptor targeted radionuclide therapy against neuroendocrine tumors, initiated 2009, is now a routine function in our department. Read more about ^{177}Lu -DOTATATE therapy on page 14.

In 2011 we have had weekly and monthly conferences dealing with thyroid diseases, neuroendocrine tumors, pediatric oncology, pulmonary, cardiology, adrenal and orthodontic diseases.



Pediatric nuclear medicine



Lise Borgwardt

Each year we perform 1500 pediatric nuclear medicine investigations, thereof 300 PET scans, mainly for the large pediatric clinics at the hospital. It is a special focus area for our department to perform these investigations at the highest level of excellence, and at the same time make it a positive experience for both the child and its parents. The department is a member of the EANM Pediatric Committee, Pediatric Nuclear Medicine Network and the International Telemedicine Network for Second Opinion and Exchange of Ideas.

Our Pediatric Focus Group is still evolving. Education internally in the department, to the referring departments at the hospital, and also externally, is a high priority. This is why our Pediatric Focus Group this year contributed at the NML congress in Copenhagen and gave several talks on different angles of pediatric nuclear medicine with great success. Also as invited speaker at IPR, International Pediatric Radiology 2011, the group gave a talk on future perspectives on hybrid scanners in Pediatric Nuclear Medicine. The group contributed to the Danish book on Clinical Nuclear Medicine, naturally with the chapter on Pediatric Nuclear Medicine. Also the work in the Pediatric Committee has been very interesting and we will continue this process.

We have been performing PET/CT for radiotherapy planning in children since 2003, performed by our pediatric radiotherapy-planning-team Anne Kiil Berthelsen, Annika Loft Jakobsen, Charlotte Birk Christensen and Morten Jørgensen. We have now performed more than 60 PET/CT for radiotherapy planning in children. This year we received the prize for

the most important scientific work at the ESOPNM, European Society of Pediatric Nuclear Medicine, 2011 for our survey on our experience with PET/CT for radiotherapy planning in children. Together with the Department for Radiotherapy at Rigshospitalet and our new collaborators across the Øresund strait; Thomas Björk-Eriksson, Section for Radiotherapy, Skåne University Hospital in Sweden, the group received 450,000 DKK in fundings from the Danish Children Cancer Foundation to further develop this important area.

Diagnostics on children with Hodgkin's lymphoma follows the guidelines of the European protocol and we participate in the teleconferences in the European Pediatric Hodgkin's Network Group to increase the level of interpretation in Europe in general. On all children for PET scanning, including the children with lymphoma, we perform a heating procedure without medication in order to diminish uptake in activated fat, with great results.

Research in Pediatric Nuclear Medicine and PET is necessary, as we have an increasing amount of medical doctors, students and technicians involved in the field and we conduct research protocols in children with PET/CT in lymphomas, sarcomas, metabolism- and perfusion PET in neonatals, diagnostic value of HIDA-scintigraphy and the optimal preparation of the child with suspicion of biliary atresia, MIBG SPECT/CT and PET/CT of children with neuroblastomas in cooperation with Ludwig Maximilian University of Munich etc. In the beginning of the year we were visiting Chief Physician Thomas Pfluger, Ludwig Maximilian University of Munich for further collaboration in between our institutions.

In 2011 we received a new SPECT/CT scanner dedicated for the children. We have been performing highend hybrid SPECT/CT in children since 2003 and we look forward to develop this strategy even further with the new opportunity.

We are furthermore expecting an interesting year 2012 with the new PET/MRI scanners arrival in December this year and the very important possibilities for new studies in children on this new hybrid modality.



Cyclotron Unit



Holger J. Jensen

In 2011 we experienced, as in the previous years, an increase in our production of radioactive isotopes and ended up with approximately 1148 successful productions (602 and 546 productions for our Scanditronix MC32 and Siemens RDS Eclipse cyclotrons respectively) or 16.8% more than in 2010. During the last 6 years we have seen in average an increase of 6% more productions per year. The major production increase this year came from ^{11}C , which increased with 68.4%, whereas our production of ^{18}F only increased by 1.4%. All other isotopes stayed at a constant level. The year was relatively quiet without any major technical problems for the two cyclotrons and due to the high flexibility of running two cyclotrons we succeeded to have less than 1% cancelled productions in 2011.

Looking at the development in the produced activity, we have increased the activity by 16% per year in average since 2006. Despite of this we have managed to keep the doses to the employees in the cyclotron- and radiochemistry unit under control and managed to reduce the doses during the last few years as seen in figure 2.

Also for the release of radioactive gas waste from our production, we have seen a positive development. As seen in figure 3, we have managed to reduce the release despite of the increased production.

Figure 1. Development in productions since 2006

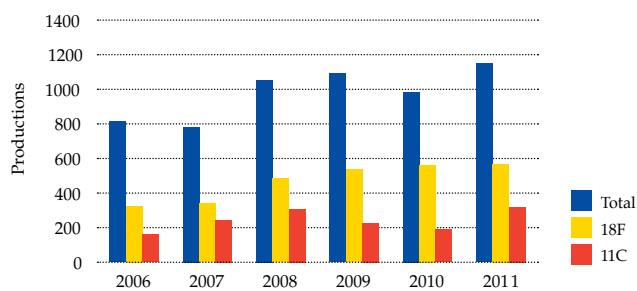


Figure 2. Average received doses for employee in the cyclotron and radiochemistry group since 2006

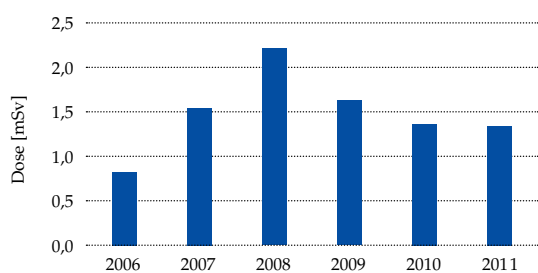
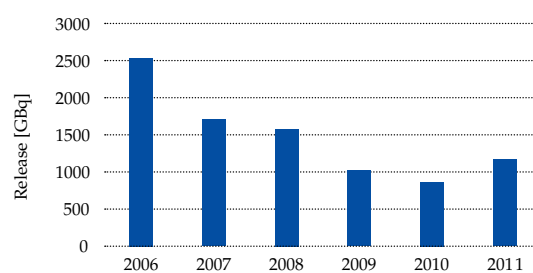


Figure 3. Release of radioactive gas waste from our production since 2006



Radiochemistry



Nic Gillings and Jacob Madsen

2011 has been a very productive year for the radiochemistry section. Overall productivity has increased considerably compared with previous years (see figures below) with a notable increase in productions for animal and in vitro studies (preclinical research). Three new PET radiopharmaceuticals were approved for human use in 2011, with a fourth expected in early 2012, which will bring the total up to 14. Implementation of several other new radiopharmaceuticals for human use is underway. Permanent staff currently consists of 4 medical laboratory technologists, 1 pharmacist (QA) and 5 radiochemists. In addition there are 2 post-docs and 3 Ph.D. students working in radiochemistry.

Routine production

The demand for ^{18}F -FDG increased slightly in 2011, with the total amount of radioactivity produced increasing by approximately 10%. A new FDG production laboratory has been built, validated and approved by the Danish Medicines Agency. Routine production is gradually being transferred to this laboratory in order free up space for production of new radiopharmaceuticals in the existing laboratory. ^{18}F -Fluoroethyl tyrosine (^{18}F -FET) is now produced on a weekly basis for clinical brain scans of up to 16 patients from each batch. Production of krypton-81m generators continued according to the well-established delivery schedule on Mondays, Wednesdays and Fridays.

Research production

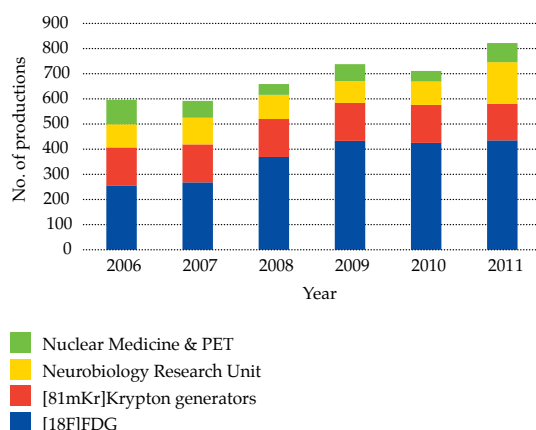
2011 was a busy year, with regular production of a large range of radiopharmaceuticals

for research use, both for humans, animals and in vitro studies. Productions for human neuroreceptor imaging increased dramatically in 2011 (up approx. 80%) and the number of animal studies also increased. Production of the Alzheimer tracer, ^{11}C -PIB continued at a similar level as in 2010. Production of radiopharmaceuticals for oncology research continues to increase. The cell proliferation tracer, ^{18}F -FLT, is now being produced routinely for clinical research studies and production of the neuroendocrine tumor tracer, ^{68}Ga -DOTATOC, for human use will commence in early 2012. Animal studies are ongoing using ^{64}Cu -ATSM (hypoxia tracer), ^{18}F -Annexin V (apoptosis tracer), ^{64}Cu -DOTA-AE105 (urokinase-type plasminogen activator receptor (uPAR) tracer) and radiolabelled RDG peptides (angiogenesis tracers).

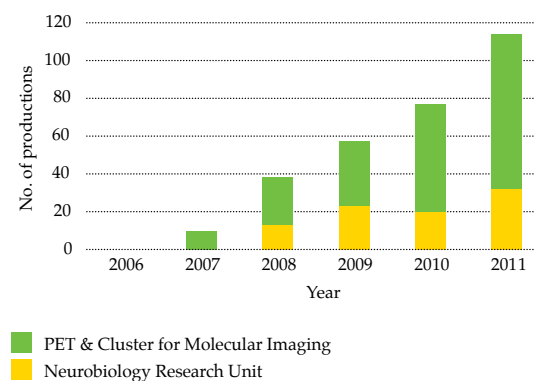
Radiopharmaceutical development

Collaboration with The Neurobiology Research Unit, Rigshospitalet and the Department of Medicinal Chemistry at PHARMA (University of Copenhagen) under CIMBI (Centre for Integrated Molecular Brain Imaging) continued in 2011. Production of ^{11}C -Cimbi-36, the very promising 5-HT_{2A} agonist PET tracer developed over the last few years, has been fully validated and we hope to get permission for human studies in early 2012. On the new development front, work is in progress on development of a 5-HT_7 PET ligand and a fluorine-18 analogue of ^{11}C -Cimbi-36. Initial results are encouraging and this work will continue in 2012. In 2011 a new Ph.D. student started to continue our program on development of labelled peptides for imaging the epidermal growth factor tyrosine kinase receptor (EGFR). This research is performed in collaboration with The Department of Natural Sciences, University of Copenhagen. Synthesis of the activated ester ^{18}F FSFB has been optimized, fully automated and used in the synthesis of ^{18}F -Annexin V. After initial challenges with the protein purification ^{18}F -Annexin V is now regularly synthesized in very high radiochemical purity. Another ongoing project involves development of a new tracer for uPAR imaging. Beside ^{64}Cu -DOTA-AE105 (mentioned above) alternative labelling strategies for the introduction of Gallium-68 or Fluorine-18 are being pursued.

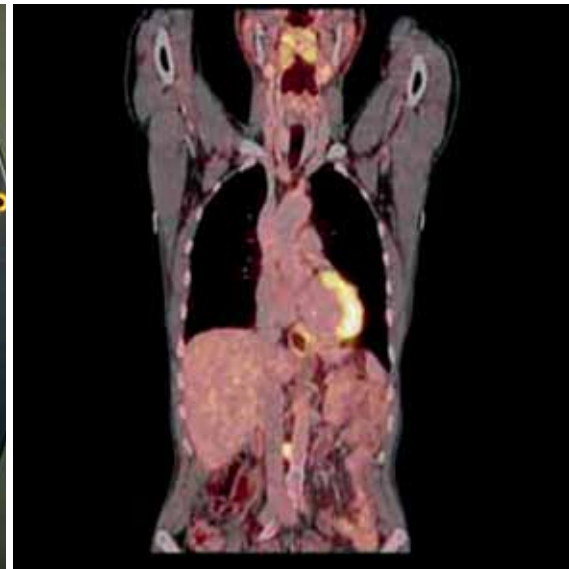
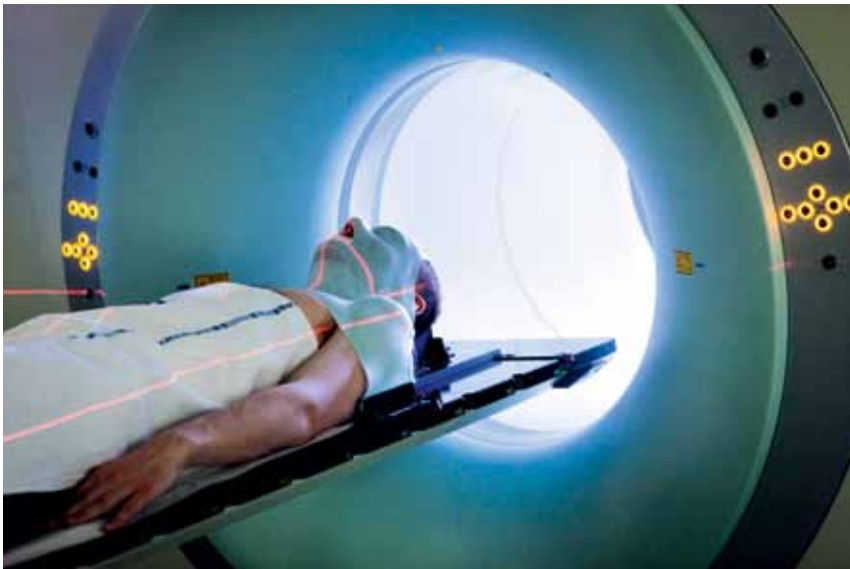
Radiopharmaceutical productions for human use



Radiopharmaceutical productions for animal and in vitro studies



PET/CT scanning in oncology



Positron emission tomography is now well established in oncology and plays a major role in the diagnostic work-up for many patients due to the high sensitivity and specificity for diagnosis and treatment response monitoring.

Our CT scans of PET/CT are performed as high quality diagnostic scans with the use of oral and intravenous contrast media. The PET- and the CT scans are initially interpreted separately followed by a joint interpretation of the fused images and a final, combined conclusion taking both examinations into account. This provides the clinician with a more precise PET result, a better CT result, and also a more useful conclusion. The CT result improves in quality because PET can help depicting small tumors that could easily have been overlooked even by a trained radiologist's eye. The PET positive foci are more precisely determined as correct or false positive with the help of the CT information. Finally, the combined PET/CT conclusion is superior to both scan results alone. Furthermore, the patient is spared from an extra CT examination at the Department of Radiology as well as an extra radiation dose.

In 2011 we performed 6000 PET/CT scans, and more than 90% were oncological. The indications are mainly diagnosis, staging, therapy monitoring and detection of recurrent disease in patients with a variety of malignant diagnoses. As a routine, we have included a supplementary CT of the lungs with breathhold technique to improve the diagnostic quality. Approximately 50% of our patients participate in clinical research protocols. Our



Annika Loft Jakobsen and Anne Kiil Berthelsen

main topics are gynecology, malignant lymphoma, neuroendocrine tumors and lung cancer. We have just completed a study investigating patients with metastases from an unknown primary. We are also studying patients with colorectal cancer in collaboration with Næstved Hospital as well as we have an ongoing multicentre-study with Odense and Aalborg University Hospitals investigating endometrial cancer.

We have 17 weekly multidisciplinary team conferences, where our PET/CT scan results are discussed with the clinical experts.

FDG is still the main tracer in oncology, but we also use ^{18}F -NaF, ^{18}F -FET and ^{18}F -FLT in clinical studies as well as in research protocols.

Working with PET/CT for many years now, we are convinced of the usefulness of PET/CT in the every day clinical work. However, clinical trials are still necessary to verify the usefulness of the method, refine the scanning protocols and to develop new indications.

PET/CT scanning in radiation therapy



Annika Loft Jakobsen and Anne Kiil Berthelsen

The use of PET/CT in radiotherapy planning of cancer patients has increased very rapidly since the method was introduced in 2001. The introduction of more advanced treatment methods, e.g. RapidArc and IMRT, the precise tumor delineation, has become even more critical.

We cooperate closely with the Department of Radiotherapy on the use of PET/CT for treatment planning of cancer and we perform 1000 PET/CT scans for the Department of Radiotherapy every year.

The demanding collaboration between mould technicians, nuclear medicine physicians and technologists, radiologists and radiology technologists, radiation oncologists, physicists, and dosimetrists must be emphasized.

The advantages are numerous: the anatomical localisation and the metabolic activity of the tumor are defined, especially when the tumor density in CT images is difficult to differentiate from that of the surrounding normal tissue, and the tissue heterogeneity can then be taken into account when choosing radiation technique and energy, and only one scan is necessary. All our PET/CT scanners have the possibility of performing PET/CT scans for radiotherapy planning. The nuclear medicine specialist delineates the viable tumors depicted by PET on the fused PET/CT images after interpretation together with the radiologist. We rely on visual analysis more than fixed threshold levels. The scans are always performed as whole-body examinations that give us the opportunity to depict unknown metastatic

disease. We have a 19% detection rate of metastases or new primary malignancies leading to change of treatment. The regions are exported to the radiation dose planning system together with the CT scan, and the information is incorporated in the treatment planning.

Research in this field is necessary, and we have conducted trials with nasopharyngeal- and cervical cancer and malignant lymphoma with encouraging results. PET/CT for radiotherapy planning is now used routinely for patients with brain, cervix-, head & neck-, lung-, oesophageal-, cardia-, rectum- and anal cancer as well as malignant lymphoma and mesothelioma. We have an ongoing study using breathhold PET in lymphoma of the mediastinum and we are collaborating in a multicentre study for lung cancer. We are looking into recurrent head and neck cancer related to the primary PET tumor delineation.

A new research area is PET/CT for radiotherapy for children. We have used PET/CT for radiotherapy planning for children for seven years and we are currently reviewing our data upon this issue. Together with the radiation oncologists we are concerned about the risk of developing secondary malignancies due to radiotherapy and we want to look into the possibilities of reducing the radiation fields and introducing dose painting by PET.

We strongly believe that PET/CT based radiotherapy planning will improve the therapeutic output in terms of target definition and non-target avoidance and will play an important role in future therapeutic interventions in many malignant diseases.



Cardiac PET



Philip Hasbak

Non-invasive assessment of myocardial function is an important domain of PET. Traditionally, cardiac PET images have been visually interpreted, using uptake as a measure of function. This approach, however, takes only a fraction of the full PET information into account. In contrast, the application of tracer kinetic modeling to dynamically measured data is able to extract objective measures of perfusion and /or metabolism, depending on the tracer. While such true cardiac quantification has been troublesome and time-consuming in the past, our new cardiac tool now makes this state-of-the-art technology readily available.

Research-wise we have a close and good cooperation with various clinical departments. Certain ongoing projects should be emphasized:

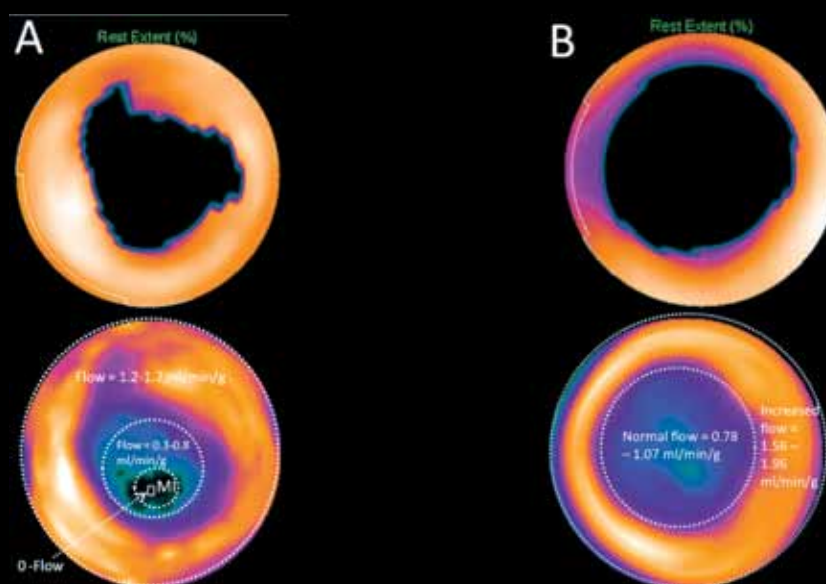
In collaboration with

- » Department of Cardiology: Molecular imaging in patients suspected of acute ST-elevation myocardial infarction (STEMI) with angiographically normal coronary arteries.
- » Department of Oncology and Radiation Therapy: Cardiac side effects in radiation therapy for breast cancer
- » Department of Vascular Surgery and Department of Anesthesiology: Buttock ischemia after endovascular abdominal aortic aneurysm repair

Cardiac SPECT

At Rigshospitalet there is a special need to provide cardiac SPECT every day, since a

How to differentiate acute myocardial infarction (MI) from takotsubo cardiomyopathy with quantitative cardiac PET



Quantification of myocardial blood flow in the acute phase of MI. Zero-flow in the MI-area. Reduced to normal flow in the tissue surrounding the MI (area at risk?) and normal to increased flow in the basal part of the left ventricle.

Quantification of myocardial blood flow in the very acute phase of takotsubo cardiomyopathy revealed normal flow between 0.78-1.07 ml/min/g (normal range 0.6-1.2 ml/min/g) in the apical ballooning part of the LV, whereas the perfusion in the basis was increased.

large proportion of our patients with ischemic heart disease need an acute or subacute work-up that requires quick decision making as to coronary revascularization strategy. Patients with unstable angina or non-STEMI should be revascularized with percutaneous coronary intervention (PCI) within 3 days after admission or with coronary artery bypass graft surgery (CABG) within 5-7 days according to The Danish National Board of Health.

We are participating in the following trials: CORE320 (Brigham and Women's Hospital), CAMARO (Mayo Clinic), PRECISE (Cardiovascular Core Lab) and ST-segment study (Cardiovascular Core Lab) and KAI (Cleveland Clinic)

Cardiac ¹²³I-MIBG

In 2010 we introduced cardiac ¹²³I-metaiodobenzylguanidine (¹²³I-MIBG). Radiotracer analogs of the sympathetic mediator norepinephrine have been investigated extensively, and are at the brink of potential widespread clinical use, especially after the presentation of the ADVANCE-HF trial. The most widely studied SPECT tracer, ¹²³I-MIBG has consistently shown a strong, independent ability to risk stratify patients with advanced congestive heart failure. One ongoing project should be emphasized:

In collaboration with Department of Cardiology: Cardiac sympathetic activity in terminal heart failure patients with and without "left ventricular assist device" (LVAD)

PET scanning of the brain



Ian Law

In 2011 the number of clinical PET and PET/CT scans grew even further than in 2010. The investigations cover the range from neurooncology, neurodegenerative disease, cerebrovascular disease and epilepsy.

In the autumn for 2011 we introduced, as the first site in Denmark, an exciting new and advanced PET tracer, ^{18}F -Flouro-Ethyl-Tyrosine (FET), in neurooncology. FET is an amino-acid analogue that is preferably targeting primary brain tumors and is particularly helpful in tumor delineation. The intended clinical use is in treatment planning presurgically and in radiation therapy, in tumor grading, in monitoring treatment effects and in differentiating viable tumor tissue and treatment damage. FET is ideal for large radiotracer production, and we have felt a lot of interest from the clinicians.

Rigshospitalet is treating and monitoring all brain tumors on Seeland. Thus, the implementation of this unique radiotracer is an important milestone in our efforts to secure the best clinical diagnostic methods available for our patients. Further, we have secured sufficient production capacity to accommodate the growing need in the future.

Continued development and research is one of our fundamental goals, and we will be conducting studies focusing on the optimized use of PET FET in the primary radiotherapy planning and in reirradiation, in surgical planning, in tumor grading, in pediatric brain tumors and in the use of PET/MRI.

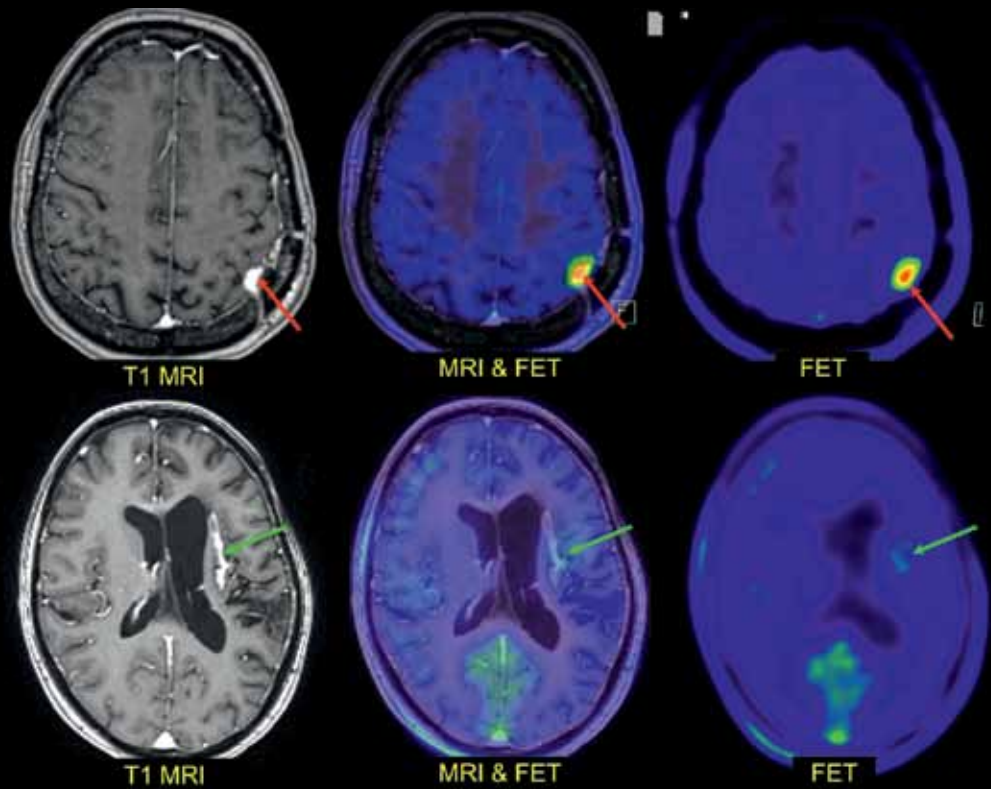


Fig 1. Two patients referred for the differentiation of recurrent high grade tumor or treatment damage? The top patient has recurrent and metabolically active tumor tissue (red arrow) and the bottom patient has treatment damage (green arrow). The images shown are T1 weight MRI after contrast, PET FET scanning and FET PET fused to MRI.

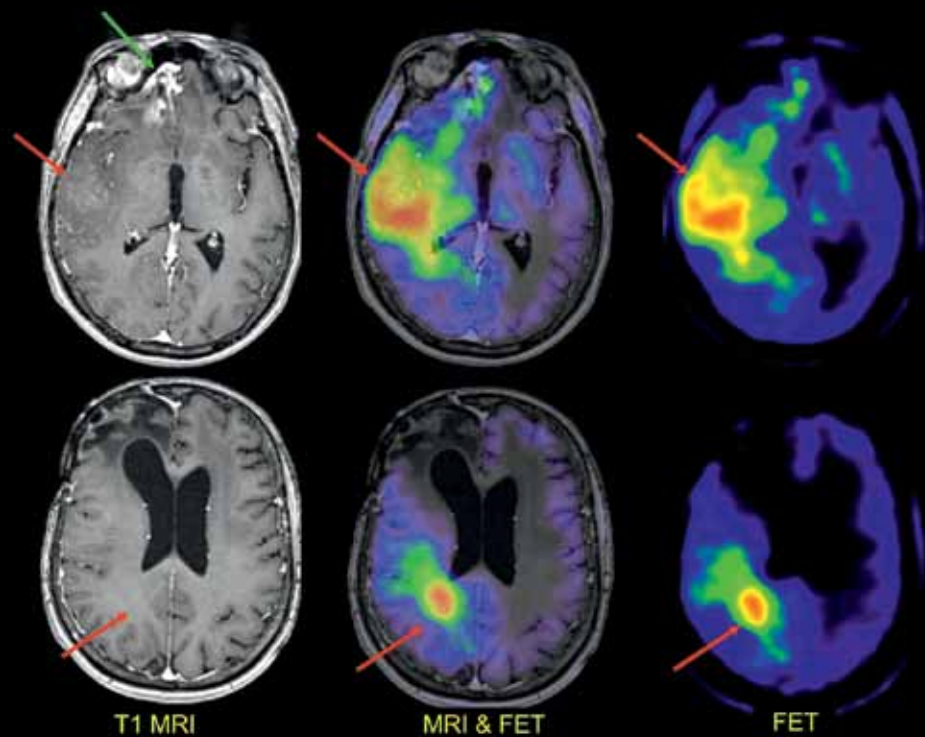


Fig 2. Patient with malignant high grade tumor treated with surgery, radiation-chemo-therapy and antiangiogenic treatment (Bevacizumab). There is a large recurrent metabolically active tumor (red arrow) that is only partly manifest on MRI. Other changes on MRI are not recurrent tumor (green arrow).

Collaboration with Landssygehuset, Faroe Islands



The Department of Clinical Physiology, Nuclear Medicine & PET, Rigshospitalet has a close collaboration with Landssygehuset in Tórshavn, Faroe Islands.

The hospital has a staff of 850 (the largest employer in Faroe Islands) and 180 beds. The 9,000 in-patients and 35,000 out-patients annually are taken care of by 29 specialities, of which 9 are via consultant collaborations, including collaboration in clinical physiology and nuclear medicine with Rigshospitalet.

In 2011 the Department of Clinical Physiology and Nuclear Medicine in Tórshavn performed more than 500 scintigraphies of lungs, bones, thyroid, kidneys, sentinel nodes and renography. The department has one 2-headed Skylight camera, a Norland DXA scanner and a Jaeger whole body plethysmograph. Second opinion on scintigraphy and lung function measurements is provided via a direct telemedicine connection. The responsible physician and physicist for Nuclear Medicine in Tórshavn is Consultant, DMSc Jann Mortensen and Physicist Thomas Levin Klausen.

Greenland - Iceland



*Jann Mortensen
and Thomas Levin Klausen*

Rigshospitalet receives the patients from Greenland who need highly specialized treatment. In our PET Center we also investigate patients from Iceland.



Academic activities

Andreas Kjær, Professor, Chief Physician, is the President of the Scandinavian Society of Clinical Physiology and Nuclear Medicine (SSCPNM), member of the Scientific Committee of the Danish Cancer Society, Editor-in-Chief of Open Neuroendocrinology Journal as well as for Diagnostics. Leader of the project Molecular Imaging for Testing of New Drugs funded by the Danish National Advanced Technology Foundation, Leader of a project on new PET tracers funded by the Strategic Research Council and Partner of the Danish Chinese Center for Proteases and Cancer funded by the National Natural Science Foundation of China and the Danish National Research Foundation, National Center Director and partner of EATRIS (the European Advanced Translational Research Infrastructure in Medicine) under the EU 7FP, and Head of the Cluster for Molecular Imaging and Director of the Postgraduate School for Medical & Molecular Imaging at the Faculty of Health Sciences, University of Copenhagen.

Anne Kiil Berthelsen, Chief Physician is a member of the ILROG, EORTC Lymphoma Group, the Danish Radiology Society, the Danish and the Nordic Society of Gynaecological Oncology, the Danish Society of Clinical Oncology and the Danish Society of Magnetic Imaging.

Annika Loft Jakobsen, Chief Physician, is a member of the "European Organisation for Research and Treatment of Cancer" (EORTC), the Functional Imaging Group. Member of the EANM, AMI, BIR and Oncoradiological Society and Danish Society of Clinical Physiology and Nuclear Medicine. Chair of the Diagnostic Imaging Group under Danish Lymphoma Group (DLG). Member of The Guideline Group for pharyngeal/laryngeal cancer. Member of Regional Working Groups for Cancer treatment: colorectal liver metastases, lymphoma, malignant melanoma, cancer of unknown primary, prostate cancer and unknown cancer. Member of National Working Groups for Lymphoma. Member of the Steering Group for Danish Liver and Biliary Cancer.

Birger Hesse, Chief Physician, a member of the European Council of Nuclear Cardiology (ECNC), a member of European Council on Nuclear Cardiology, a member of Nukleus I Working Group on Cardiac Imaging of the Danish Society of Cardiology, a member of editorial board I Eur J Nucl Med Mol Imaging, and a member of editorial board I Current Medical Imaging Reviews.

Jann Mortensen, Clinical Associate Professor, Chief Physician, is a member (vicepresident) of the board of "Dansk Selskab for Klinisk Fysiologi og Nuklearmedicin, DSKFNM" (Danish Society of Clinical Physiology and Nuclear Medicine) and the steering committee of "Dansk Lungecancer Gruppe" (Danish Lung Cancer Group). He is member of "Den Regionale Videnskabetiske Komite for Hovedstaden (Regional Ethics Committee)". He is member of the subcommittees for "Dansk Diagnostisk Lungecancer Gruppe" (Danish Diagnostic Lung Cancer Group) and "Lungecancer Screeningsgruppen" (Screening of Lung Cancer Group). Member of the supplementary training committee of the DSKFNM and representative for DSKFNM in "Lægevidenskabelige Selskaber" (Organisation of Danish Medical Societies). Member of the National Working Group for defining clinical guidelines for Lung Cancer workup and the Regional Working Group for implementation of clinical guidelines for Breast Cancer workup. He is responsible for the specialist course in "Clinical Respiratory Physiology" for nuclear medicine physicians and respiratory physicians. Section editor of The Clinical Respiratory Journal and on the editorial board of The Turkish Journal of Medical Sciences (Türkiye Klinikleri).

Julie Bjerglund Andersen, Clinical Assistant, Medical PhD Student, is Co-founder of and Member of PUFF, the organisation for young researchers at the Faculty of Health Sciences at the University of Copenhagen, (Panums Ungdoms Forsker Forening: puffnet.dk).

Kate Pedersen, Deputy Chief Technologist, member of "Fagligt udvalg for ledende og afdelingsbioanalytikere i Region Hovedstaden under Dbio"

and a member of the University Hospital Rigshospitalet Technologist Symposium Group.

Linda Kragh, Chief Nuclear Medicine Technologist, is member of "Sundhedsfagligt Råd i Klinisk Fysiologi og Nuklearmedicin i Region H", SFR, (the Speciality Advisory Committee in Clinical Physiology and Nuclear Medicine in the Capital Region). Uddannelsesrådet for Bioanalytikeruddannelsen i Region H, (the Speciality Council for the Education of Technologists in the Capital Region), and of Videnskabelig Komite til Nordisk laboratoriemedicin kongres (NML 2011) for Danske Bioanalytikere, (the Scientific committee fellow for The Nordic Medical Laboratory Group Congress 2011).

Lise Borgwardt, Chief Physician, is a member at the Pediatric Committee under EANM, member of the tumorboard for Pediatric Solid Tumors at Rigshospitalet, Chair of the Pediatric Network Group at Rigshospitalet and Chair of the Pediatric Focus Group at the Department of Clinical Physiology, Nuclear Medicine and PET.

Liselotte Højgaard, Professor, Head of Department, is Chair of the Standing Committee of the European Medical Research Councils (EMRC) at the European Science Foundation, Strasbourg and Member of Conseil d'Administration, INSERM, L'Institut National de la Santé et de la Recherches Médicales, Frankrig. Chair of of EC FP7 Science Advisory Board in Health Research. Member of the ESS European Spallation Source, Preparatory Group, University of Copenhagen. She represents the University of Copenhagen, Rigshospitalet in the Medicine and Technology Bioengineer program, The Technical University of Denmark (DTU), where she is also adj. professor. Member of ATV "The Danish Academy of Technical Sciences". Member of the advisory boards: Wonderful Copenhagen, Medico-Innovation, and member of the board of Arvid Nilssons Foundation and Tagea Brandt's prize.

Malene Fischer, Registrar, is Head of YNK (Yngre Nuklearmedicineres Klub), Member of the Board of DSKFNM (Danish Society of Clinical Physiology and Nuclear Medicine) and Young ENAM Delegate.

Marianne Federspiel, Nuclear Medicine Technologist, is a Member of EANM Technologists Committee.

Peter Oturai, Chief Physician, is responsible for the postgraduate education in the department.

He is Danish delegate, representing Danish Society for Clinical Physiology and Nuclear Medicine (DSKFNM), in the European Union of Medical Specialists (UEMS). He is a member of the UEMS - Accreditation of Nuclear Medicine Training Centers Committee, member of the board of the Danish Endocrine Society (DES), member of the board of the Danish Thyroid Association (DTS), and member of the Danish Thyroid Cancer Guideline Group. Member of the Doctors Clinical Physiology and Nuclear Medicine Training Committee of the DSKFNM. He is responsible for the specialist course in Endocrine Pathophysiology for nuclear medicine physicians.

Philip Hasbak, Chief Physician, is a Nucleus Member of Cardiac Imaging, Danish Society of Cariology, Co-author in the Writing Committee of the position statement on strategies for pre-intervention diagnosis and imaging in patients with recent onset chest pain or discomfort of suspected cardiac origin, Nucleus Member of National Pathways for Lifethreatening Cardiac diseases and Nucleus Member of Library Subscriptions in Denmark.

Robin de Nijs, MSc, PDEng, PhD, Specialist Medical Physicist, is a Member of European Association of Nuclear Medicine's Network of Excellence for Brainimaging.

Søren Holm, Chief Physicist, is President of the Danish Society for Medical Physics (DSMF), a delegate for the DSMF at the European Federation of Organisations in Medical Physics (EFOMP), a board member of the Nordic Society for Radiation Protection (NSFS), a member of an IAEA advisory group concerned with QA/QC and image artefacts affecting quantitation in PET/CT, a member of Sundhedsfagligt Råd i Klinisk Fysiologi og Nuklearmedicin in the Capital Region, the Specialty Advisory Committee (SFR) in Clinical Physiology and Nuclear Medicine, and an external lecturer at Copenhagen University.

Tine Willum Hansen, Registrar, is a Member of Editorial Board for Hypertension and Artery Research.

Patient investigations 2011

CNS and peripheral nervous system

Regional cerebral blood flow, DIAMOX, ^{15}O -H ₂ O	9
Regional cerebral metabolism, ^{18}F -FDG	432
Regional cerebral receptor, ^{11}C -PIB	64
Regional cerebral receptor, ^{18}F -FET	58
Regional cerebral metabolism, ^{18}F -Altanserin	1
Regional cerebral receptor, ^{11}C -DASB	96
Regional cerebral receptor, ^{11}C -SB	58
Regional cerebral receptor, ^{18}F -Florbetaben	3
Regional cerebral receptor, ^{18}F -Florbetapir	2
Regional cerebral receptor, ^{11}C -FLU (NRU)	12
Regional cerebral receptor, ^{11}C -CUMI	5
CT-scanning of cerebrum	1
Total	741

Respiratory organs

Lung function test, whole body plethysmography	1571
Lung function test, whole body plethysmography w / reversibility	137
Lung function test, spirometry	1431
Lung function test, spirometry w / reversibility	89
Lung function test, spirometry, physiological provocation	1
Lung function test, diffusion capacity (CO)	3175
Lung perfusion scintigraphy, $^{99\text{m}}\text{Tc}$ -MAA	53
Lung perfusion scintigraphy, regional, $^{99\text{m}}\text{Tc}$ -MAA	130
Lung perfusion scintigraphy, SPECT, $^{99\text{m}}\text{Tc}$ -MAA	207
Lung ventilation scintigraphy, SPECT, $^{81\text{m}}\text{Kr}$ -gas	222
Lung ventilation scintigraphy, $^{81\text{m}}\text{Kr}$ -gas	55
Lung ventilation scintigraphy, regional, $^{81\text{m}}\text{Kr}$ -gas	164
Lung ventilation scintigraphy, $^{99\text{m}}\text{Tc}$ -DTPA	1
Mucociliary clearance, $^{99\text{m}}\text{Tc}$ -venticolloid	33
Total	7269

Heart and cardiovascular system

Isotope cardiography, first pass, $^{99\text{m}}\text{Tc}$ -HSA	1
Isotope cardiography, LVEF, $^{99\text{m}}\text{Tc}$ -HSA	1414
Isotope cardiography, LVEF, $^{99\text{m}}\text{Tc}$ -erythrocytes	136
Isotope cardiography, LVEF + vol., $^{99\text{m}}\text{Tc}$ -HSA	2
Myocardial perf. scintigr. gated, $^{99\text{m}}\text{Tc}$ -MIBI, pharmacol. stress, dipy.	13
Myocardial perf. scintigr. gated, $^{99\text{m}}\text{Tc}$ -MIBI, pharmacol. stress, dobut.	1
Myocardial perf. scintigr. gated, $^{99\text{m}}\text{Tc}$ -MIBI, pharmacol. stress, adeno.	105
Myocardial perf. scintigr. gated, $^{99\text{m}}\text{Tc}$ -MIBI, physiological stress	46
Myocardial perf. scintigr. gated, $^{99\text{m}}\text{Tc}$ -MIBI, NTG	162

Myocardial perf. scintigr. gated, $^{99\text{m}}\text{Tc}$, MIBI	5
Myocardial Calcium score	61
Myocardial perf. scintigr. gated, ^{123}I -MIBG	27
Myocardial perfusion, ^{13}N -NH ₃	31
Myocardial perfusion, ^{13}N -NH ₃ , pharmacology. stress	6
Myocardial metabolism, ^{18}F -FDG	25
Exercise electrocardiography	25
Electrocardiography	1
Total	2061

Peripheral vessels

Isolated limb perfusion leakage monitoring, chemotherapy	11
Total	11

Gastrin intestinal tract, liver, biliary tract and pancreas

Salivary gland scintigraphy $^{99\text{m}}\text{Tc}$ -pertechnetat	55
Bleeding scintigraphy (abdomen), $^{99\text{m}}\text{Tc}$ -erythrocyt	3
Biliary tract scintigraphy, $^{99\text{m}}\text{Tc}$ -Mebrofenin	11
Meckels diverticulum scintigraphy, $^{99\text{m}}\text{Tc}$ -pertechnetat	3
Total	72

Kidneys and urinary tract

Glomerular filtration, ^{51}Cr -EDTA, several samples	192
Glomerular filtration, ^{51}Cr -EDTA, one sample	4671
Renal scintigraphy, $^{99\text{m}}\text{Tc}$ -DMSA	24
Renography, $^{99\text{m}}\text{Tc}$ -MAG, diuresis	67
Renography, $^{99\text{m}}\text{Tc}$ -MAG 3	1704
Renography, $^{99\text{m}}\text{Tc}$ -MAG 3, ACE-inhibitor	80
Renography, $^{99\text{m}}\text{Tc}$ -MAG 3, Graft	16
Total	6754

Bone and joint

Bone scintigraphy, $^{99\text{m}}\text{Tc}$ -HDP, regional, static	60
Bone scintigraphy, $^{99\text{m}}\text{Tc}$ -HDP, whole body, static	892
Bone scintigraphy, $^{99\text{m}}\text{Tc}$ -HDP, SPECT	161
Bone marrow, $^{99\text{m}}\text{Tc}$ -nanocolloid	1
Bone scintigraphy, ^{18}F -fluorid, whole body, static	15
Total	1129

Endocrine organs

Thyroid scintigraphy, $^{99\text{m}}\text{Tc}$ -pertechnetat	533
Thyroid scintigraphy, ^{123}I -jodid	1
Thyroid, ultrasound	293

Parathyroid scintigraphy, ^{99m} Tc-MIBI / ^{99m} Tc-Stamisis SPECT	51
Tumorscintigraphy, ¹²³ I-jodid	23
Adrenal marrow scintigraphy, ¹²³ I-MIBG	35
Scintigraphy after ¹⁷⁷ Lu- dotatate -therapy	98
Total	1034

Blood and lymph system

Erythrocyt volume, ^{99m} Tc-erythrocytter	13
Plasma volume, ¹²⁵ I - HSA	10
Lymph scintigraphy, extremities, ^{99m} Tc-HSA, stases	3
Lymph scintigraphy, extremities, ^{99m} Tc-nanocolloid, stases	3
Sentinel node, tumor drainage, ^{99m} Tc-nanocolloid	76
Sentinel node scintigr. tumor drainage, c. mammae, ^{99m} Tc-nanocolloid	15
Sentinel node scintigr. tumor drainage, mel. malign., ^{99m} Tc-nanocolloid	143
Sentinel node scintigr. tumor drainage, c. penis, ^{99m} Tc-nanocolloid	24
Sentinel node scintigr. tumor drainage, c. vulvae, ^{99m} Tc-nanocolloid	24
Peritumoral injection of ^{99m} Tc-nanocolloid for sentinel node	602
Spleen scintigraphy, ^{99m} Tc-erythrocyte, heated	4
Total	917

In vitro analysis

Plasma analysis	6503
Gene expression analysis	8736
Total	14239

Other diagnostic procedures

Tumor scintigraphy, ¹¹¹ In-Octreotide	334
Tumor scanning, ¹⁸ F-FDG	4130
Infection scanning, ¹⁸ F-FDG	46
Tumor scintigraphy, ⁶⁴ Cu-NET-tracer	29
White blood cell scintigraphy, ^{99m} Tc	55
White blood cell scintigraphy, ¹¹¹ In	119
Tumor scanning, ¹⁸ F-FLT	4
Whole body, contamination measurement	46
Image fusion (PET, SPECT, MRI, CT or planar)	5752
Diagnostic CT	4380
CT-therapy scanning (er talt som PET / FDG og CT)	680
Second opinions external PET, PET / CT, SPECT / CT, CT and MR investigations	679
Extra tumor delineation	111
Supplementary / repeated imaging	1538
Total	17903

Radiotherapy

Treatment with ¹³¹ I, benign thyroid	78
Isotope treatment with Zevalin ⁹⁰ Yttrium	1
Isotope treatment with ¹⁷⁷ Lutetium-dotatate	66
Total	145

Total number of investigations	52,275
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Animal Studies

Dogs

¹⁸ F-FDG	4
⁶⁴ Cu-ATSM	3
¹⁸ F-FLT	4

Pigs

¹⁵ O-H ₂ O	9
¹¹ C-CIMBI (NRU)	19
¹¹ C -S 35 (NRU)	4
¹⁸ F-Altanserin (NRU)	2
¹⁸ F-MH-Mz (NRU)	1

Rats

¹⁸ F-FDG	150
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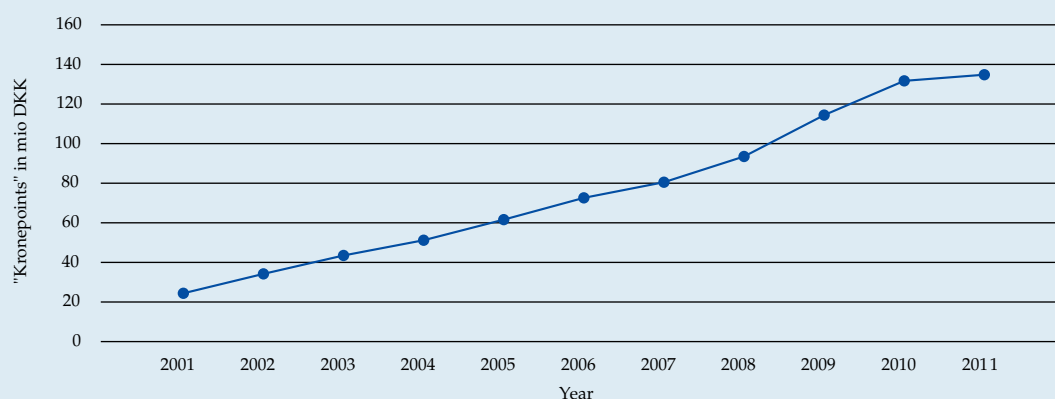
Mice

¹⁸ F-FDG	454
¹⁸ F-FLT	322
¹⁸ F-Annexin	27
¹⁸ F-NaF	178
¹⁸ F-FET	2
¹⁸ F-FALGEA	5
⁶⁴ Cu-AE105	150
⁶⁴ Cu Nanodisc	48
⁶⁴ CuCl ₂	65
⁶⁴ Cu-labeled compounds, other	103
⁶⁸ Ga-NODAGA-RGD	49
¹⁷⁷ Lu-labeled compounds	60

Total	1659
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Finance

Turnover



The increase in activities measured in "krone points" rose from 43.5 million in 2003 to 134 million in 2011.

"Krone points": price for each patient investigation multiplied with number of investigations, summarized for all patient studies performed during the year.

Balance 2011

Expenditure (DKK mio.)	
Running costs	19.8
Staff	47.1
In total	66.9
Receipts	22.1
Net sum	44.9



Publications 2011

Theses

Madsen K. PhD thesis: PET Imaging of Cerebral Serotonin 4 Receptors in Relation to Sex, Aging and Alzheimer's Disease. Copenhagen: Own publishing 2011:1-54. Defended 4th of April 2011, University of Copenhagen, Faculty of Health Sciences.

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Patents

WO2011006510-A1: Nanoparticle composition useful in cancer therapy comprises vesicle forming component, agent-entrapping component enclosed by vesicle-forming component; radionuclides entrapped on interior side of the composition.

As in previous annual reports we have listed scientific papers only and not the many abstracts and proceedings from the department.



Research



Andreas Kjær

A strong focus on research is a cornerstone of the department. We have an extensive research program and collaborate with several national and international partners. Our research focuses on development of new tracers for PET and SPECT, on clinical evaluation of new diagnostic methods, and on the use of methods from clinical physiology and nuclear medicine to study pathophysiology. Translational research in the area of molecular imaging is given special attention in order to accelerate translation of new tracers into use in patients. Some current areas of major research are detailed below.

New tracers

Numerous projects aimed at development of new, specific tracers for non-invasive tissue characterization are currently undertaken. These tracers are to be used for the diagnosis of different cancer types as well as for planning and monitoring of therapy. The projects, translational in nature, are carried out in collaboration with other departments and laboratories to ensure expertise in molecular biology, chemistry, radiochemistry, cancer biology and imaging. Currently several new tracers are at present evaluated. Examples of new tracers developed at the department are peptide-based PET tracers for imaging of the invasive phenotype and targeted nanoparticles for PET. For validation of new tracers, we have cell, molecular biology, histology and biomarker laboratory facilities at the department. In collaboration with a pharmaceutical company and supported by the Danish National Advanced Technology Foundation, we have established a molecular imaging platform for testing of new anti-cancer drugs and for tailoring anti-cancer therapy.

PET/MRI

With installment of the first integrated PET/MRI scanner in the Nordic Countries, we have started a comprehensive research program on the added value of combining PET and MRI. Examples of projects within this program are the combined use of the modalities for improved response monitoring in cancer treatment, pediatric studies and atherosclerotic plaque characterization.

Clinical PET/CT

A large number of prospective protocols are performed to evaluate the diagnostic and prognostic value of PET/CT with different tracers in various forms of cancer in children and adults. Head-to-head comparison studies of new PET tracers and established imaging methods are also performed. The use of PET/CT for the planning of radiation therapy (“dose-painting”) and the use of respiratory gating are also currently being evaluated. Several of the studies are now planned to include PET/MRI.

Pediatric nuclear medicine investigations

The department conducts many pediatric investigations. Several research protocols with the use of PET and SPECT are carried out in cooperation with clinical departments, particularly within oncology.





Neuro PET

With the use of PET/CT, including HRRT, studies on brain tumors are undertaken. Studies of brain perfusion using PET or DCE-CT are also performed. In addition, imaging of dementia with new tracers and brain tumors with FET is studied. In cooperation with Neurobiology Research Unit and Centre for Integrated Molecular Brain Imaging, neuro-receptor ligands have been developed and used for research in neurobiology. The focus has mainly been on the serotonergic system.

Atherosclerosis

With the use of PET/CT we non-invasively visualize atherosclerosis and predict vulnerability of atherosclerotic plaques. With this technique, several studies in different groups of patients at risk and with the use of new PET tracers are currently undertaken and planned.

Nuclear cardiology

With the use of PET, coronary flow regulation is studied in connection with a variety of cardiovascular diseases and the influence of interventions including gene therapy, pharmacological treatment and exercise. With the use of SPECT/CT or PET/CT the development of ischaemic heart diseases is studied in selected groups of patients. On basis of this, screening algorithms for detection of ischaemic heart disease are evaluated.

Lung studies

Research using lung function testing and lung scintigraphy in different patient groups, e.g. lung transplantation and endobronchial stenting for emphysema, are undertaken. The value of combined use of SPECT/CT for diagnosing pulmonary embolism has recently been evaluated. The value of biomarkers in combination with imaging is also studied. In addition, evaluation of the different ventilation tracers for assessment of ventilation inhomogeneity is undertaken. Research is also being conducted into mucociliary clearance of the nose and lungs.

Radionuclide treatment

Localized radiation therapy, using specific ligands binding to certain cancer forms, has recently been implemented. The department takes part in research within this area by testing new ligands and producing relevant isotopes. Cancers that are currently being targeted include neuroendocrine tumors and ovarian cancer. Treatment with radionuclides will in part be based on imaging using new tracers for molecular profiling for optimal outcome and fewer side effects.

Whole body counting

Together with external partners, whole body counting is used for exact measurements of body composition in a series of studies. In addition we are investigating absorption of certain minerals from the gastrointestinal tract.

Cluster for Molecular Imaging



Andreas Kjær

The new paradigm of individualized, tailored therapy has led to a need for diagnosing at the molecular level. Most of the molecular biology methods used today need tissue sampling for in vitro analysis. In contrast, molecular imaging allows for non-invasive studies at the molecular level in living, intact organisms. With PET it is possible to label bio-molecules with radioactive isotopes. This method can be used for non-invasive visualization of tumor specific receptors and tissue characteristics such as angiogenesis and ability to metastasize. Especially within cancer biology the technique is expected to lead to a break-through in diagnosing and treatment. Among the different techniques for molecular imaging, the nuclear medicine based technologies have the greatest potential for translational use since methods developed in animal models may directly be transferred and used in humans. In addition, successful imaging ligands may be developed into radionuclide therapy, such an imaging-therapy pair is known as theranostics.

In addition, we will develop successful imaging ligands into radionuclide therapy (theranostics).

Our current molecular imaging research program is aimed through use of molecular biology and imaging techniques in both animals and humans to develop, evaluate and use non-invasive molecular imaging for human tissue characterization. Major applications of these tracers are anticipated: 1) planning of individualized, tailored therapy, 2) testing of new drug candidates and 3) basis for development of radionuclide therapy.

The development of new molecular imaging tracers for PET is a very complex process that involves many steps from definition of target to final use of the tracer in patients.

Main steps involved in tracer development and use

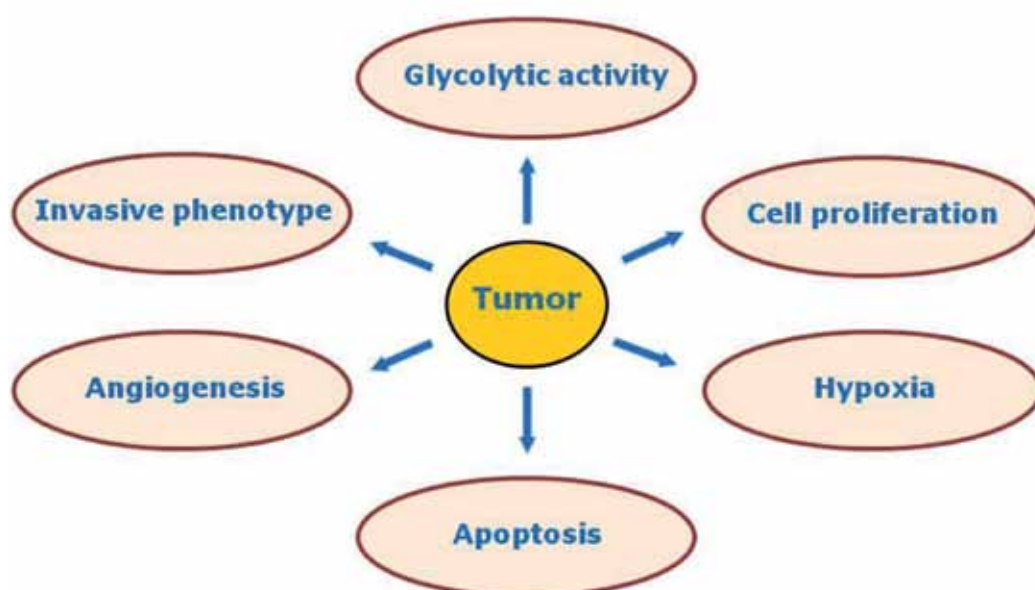
- » Selection of key-processes involved in the pathophysiology of the disease
- » Definition of relevant molecular targets of the key-processes
- » Design of specific ligands
- » Radioactive labelling of ligands
- » Test of imaging ligands in relevant animal models
- » Use of imaging data for therapy planning and monitoring of response
- » Use for diagnosing, therapy planning and monitoring in patients
- » Use of testing of new drugs

Through formation of Cluster for Molecular Imaging at the Faculty of Health Sciences, University of Copenhagen (headed by Professor Andreas Kjær) a core facility at the Panum Institute for molecular imaging in animals with PET, SPECT and CT has been established. This has improved our translational capacity since we are now able to test new tracers and radionuclide therapies in animal models prior to clinical use. In accordance with this we have currently several new tracers in pre-clinical testing in animal models that already have or soon will become available for human use.

Cluster for Molecular Imaging is imaging partner in the European Advanced Translational Infrastructure in Medicine (EATRIS) under EU 7FP.

Currently the main focus of the translational research in tracers for non-invasive tissue characterization is on the use in cancer and cardiovascular disease and new targeted radionuclide therapies for cancer. However, several other applications are also foreseen.

Some tissue characteristics currently targeted for imaging:





Danish Chinese scientific collaborations

The Department continued and extended in 2011 its collaborations with institutions in China. The research collaborations are focused on development of new molecular imaging probes for cancer and evaluation of anti-cancer therapies, including Traditional Chinese Medicine (TCM).

Professor Andreas Kjær is partner in the Danish Chinese Center for Proteases and Cancer. The Center that is funded by the The National Natural Science Foundation of China and the Danish National Research Foundation (Danmarks Grundforskningsfond) has just been evaluated and extended for another 4 years. The Center aims to strengthen cancer research leading to new tailored therapies and molecular imaging ligands. Our focus is to continue the work on new PET imaging ligands and to translate one or more into clinical use. Participants are in addition to Rigshospitalet, Aarhus University and Chinese researchers from the Chinese Academy of Sciences, Fuzhou and Soochow University, Suzhou.

In an ongoing collaboration with Shuguang University Hospital in Shanghai and funded by the Danish Ministry of Health we studied the effect of Chinese anti-cancer therapies using molecular imaging with PET. The results are very promising and have been presented at several international meetings.



Professor Andreas Kjær gave a keynote lecture on the use of PET for evaluation of therapies in cancer at the 2011 Shanghai International Integrative Medicine Conference.



*Danish-Chinese Centre for Proteases and Cancer
The Danish National Research Foundation and
The National Natural Science Foundation of China*

Ib Henriksen Award 2011

Head of Department Professor Liselotte Højgaard was awarded the prestigious “Ib Henriksen Award” 25th of November 2011. The prize was donated at a ceremony followed by a reception at the Carlsberg Academy, the previous home of the famous Danish physicist Niels Bohr. Professor Claus Bock who motivated the prize DKK 250,000 to Liselotte Højgaard emphasized her strong international position for strengthening of biomedical research in Europe and globally.



Pasteur Prize 2011

In 2011 Professor Andreas Kjær received the Pasteur Prize for exceptional project leadership from the Danish National Advanced Technology Foundation (Højteknologifonden). The award DKK 100,000 was handed over by Chairman of the board Jørgen Mads Clausen from Danfoss A/S.



Young investigator prizes

PhD student Camilla Bardram Johnbeck

NET-work Europe, Uppsala, Sweden, Jan. 2011. Best Abstract Award.

PhD student Anne Mette Hag

PhD Day, Faculty of Health Sciences, University of Copenhagen, May 2011. Best Poster Award.

PhD student Sune Folke Pedersen

World Molecular Imaging Congress, San Diego, USA, Sept. 2011. Student Travel Stipend Award.

PhD student Tina Binderup

World Molecular Imaging Congress, San Diego, USA, Sept. 2011. Student Travel Stipend Award.

PhD student Morten Persson

XV SSCPNM Congress, Copenhagen, Denmark, Sept. 2011. Best Abstract Award.



PhD student Anne Mette Hag (right) received an award for best poster at the PhD day of the Faculty of Health Sciences, University of Copenhagen.

The XV Scandinavian Congress of Clinical Physiology & Nuclear Medicine

The 15th SSCPNM Congress was held in Copenhagen on 28th - 30th of September 2011 in the beautiful Moltkes Palace from 1702. President of the congress was Professor Andreas Kjær. The major themes of the congress were molecular imaging and advanced function studies. The conference was attended by almost 200 delegates and exhibitors and over the 3 days more than 50 keynote lectures and oral presentations were given. The scientific committee awarded the prize for best abstract to Morten Persson, a PhD student from our department.



CIMBI

Center for Integrated Molecular Brain Imaging,
University of Copenhagen, Rigshospitalet

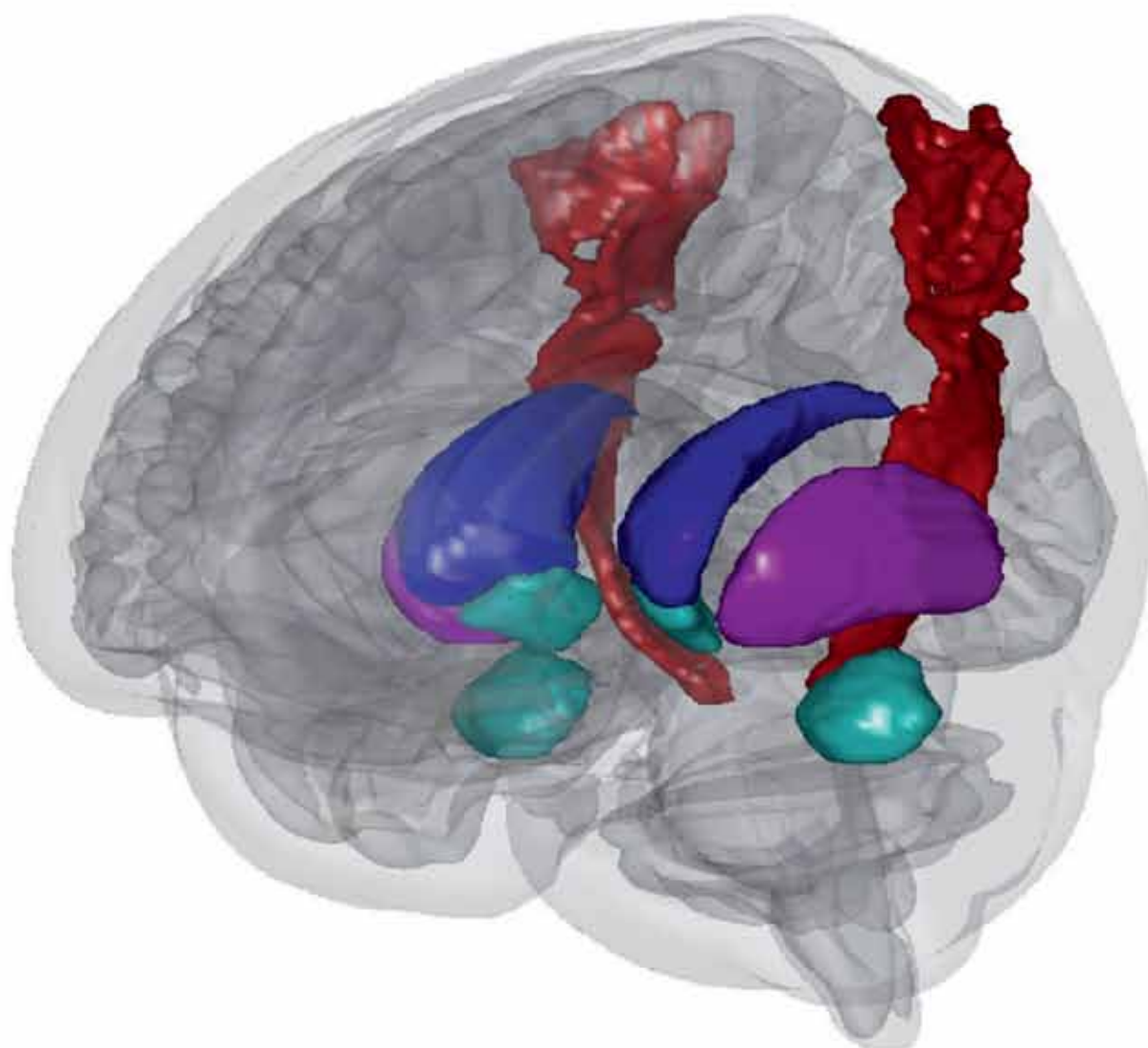


We are proud to contribute and collaborate with Professor Gitte Moos Knudsen, Chair of the Neurobiology Research Unit at Rigshospitalet, University of Copenhagen and also Director of the CIMBI, Center for Integrated Molecular Brain Imaging, funded by the Lundbeck Foundation. The focus of the research program is on neurobiology, physiology and pathophysiology, molecular imaging and neuroreceptor ligands with focus on the serotonergic system. Gitte Moos Knudsen and her research team are highly appreciated and we appreciate the excellent collaboration.



THE LUNDBECK FOUNDATION

Center for integrated molecular brain imaging



Education



For all staff members in the Department of Clinical Physiology, Nuclear Medicine & PET educational activities are part of their daily functions. The department delivers extensive training programs to staff from other nuclear medicine and radiological departments in Denmark and the Nordic countries.

The department is highly active in education at different levels of various health related professionals. Regarding undergraduate education, the department contributes to the activities of the Faculty of Health Sciences at the University of Copenhagen for medical students, human biology students in collaboration with DTU in many subjects, e.g. clinical physiology, nuclear medicine, theoretical physiology and medical technology. Nuclear medicine technologist students and radiographer students receive part of their education from the department.

In postgraduate education, the department plays an active role in the specialist education of physicians in clinical physiology and nuclear medicine in different ways. The dedicated courses in oncology, cardiology, pulmonology, endocrinology and pathophysiology for this specialist education are all held at our department and arranged by chief physicians, and the department has four educational positions for young physicians training to become specialists in clinical physiology and nuclear medicine. Furthermore, we contribute to the specialist education of physicians from other specialities such as urology, nephrology, radiology, oncology, haematology and thoracic surgery. A high number of PhD students are associated with the research activities in the department.



Peter Oturai and Jann Mortensen

An increasing number of study visits to our department from physicians and students for periods ranging from a few weeks to six months, from both Denmark and abroad, have been arranged. In the recent years we have had visits from England, Australia, Iceland, Italy, Sweden, Norway, the Faroe Island and Switzerland.

The departments educational activities have been accredited by the Danish National Board of Health and by the Accreditation of Nuclear Medicine Training Centres Committee of the Section of Nuclear Medicine of the European Union of Medical Specialists (UEMS).

Chief Physician Peter Oturai is responsible for the postgraduate education of physicians in the department. Clinical Associate Professor Jann Mortensen is responsible for the undergraduate education of medical students. Professor Liselotte Højgaard is responsible for under- and postgraduate education for bioengineers.

Nuclear medicine technologists



Tim Lundby, Kate Pedersen and Anne Sørensen

The nuclear medicine technologists, radiographers, nurses and laboratory technicians take care of many different tasks in the Nuclear Medicine Section, the clinical PET Scanner Section and the Radiopharmaceutical Section. Out of the 40 staff members in this group five were graced with newborn babies, and a warm congratulation from the department.

The number of investigations is still increasing, and we keep the waiting list acceptable by extending opening hours from 16 to 19 every second week. Thank you for the great effort.

Radiation dose and radiation protection to staff and patients is a special interest field of the nuclear medicine technologists and in spite of a rising number of patient investigations the annual radiation dose to each staff member has not increased. Nuclear Medicine Technologist Susanne Svalling has been the leader of this field for many years in our PET Scanner Section, and her great effort was rewarded with the annual prize for the best working environment in the hospital.

The medical speciality of nuclear medicine and physiology was for the first time invited to participate in the Nordic Medicine Laboratory Congress, held every second year in one of the Nordic countries. This year it was in Copenhagen, and the technologists from our department gave fine lectures. Many technologists participated also in the Scandinavian Society of Clinical Physiology and Nuclear Medicine (SSCPNM) in Copenhagen in September 2011.

KF Section

2011 was another busy year. The old SPECT/CT from 2001 broke down and until a new SPECT/CT was opened October 2011, everybody had to make an extra effort regarding the overbooking on the other cameras, extra work and great flexibility. Thank you for your willingness for working overtime. In October the Siemens Symbia T16 SPECT/CT camera was acquired and from end of November it was usable for patient investigations. The implementation of this Symbia was a demanding task also managed by the busy nuclear medicine technologists in the most impressive way. The number of diagnostic CT scans increased from 170 in 2010 to 370 in 2011 and with the new SPECT/CT camera a further increase in 2012 is anticipated. In 2011 the lung function tests was digitalized, and now the clinical departments can see the patient reports in WEB 1000/PACS. Our Deputy Chief Nuclear Medicine Technologist Tim Lundby has initiated the use of electronic planning of the daily workflow, for the nuclear medicine technologists. Thereby the right competences are available for the many different tasks.

All our nuclear medicine technologists participate in research projects, as very many of our patients are part of research protocols. A special engagement has been delivered to the projects regarding Tako-Tsubo Syndrome, including acute myocardial scintigraphies, blood sampling and analysis, ALECSAT is labelling of lymphocytes and later scintigraphies and studies on Technegas comparing Krypton for the diagnosis of pulmonary



embolism with ventilation scintigraphies, RHINO, the lung project where patients before going into surgery in head and neck are subjects to a reversibility test, and clearance projects investigating renal function after EPO.

In December 2011 the department got a DEXA, GE-Lunar Scanex which is a new investigation in our department, and it is already a busy scanner with a full schedule.

PET Scanner Section

In the PET Scanner Section we also had a busy year with an increasing number of investigations and many research projects. The old PET/CT scanner from 2001 broke down, had to give up and a new PET/CT scanner, a Siemens MCT with 64 slice CT was up and running by November 2011. The implementation of this scanner was a demanding task also managed by the busy nuclear medicine technologists in the most impressive way. In 2011 the use of ^{11}C -PIB for diagnosis of patients, with dementia were taken up as a routine investigation. For patients with brain tumors it has been implemented with of routine diagnostic use of ^{18}F -FET (O-(2- ^{18}F -Fluorethyl)-L-Thyrosin), an amino acid analogue for better delineation of brain tumors than hitherto used tracers. Approximately 50 patients every month are investigated by FET, and the scans are used for radiation therapy planning. A major part of PET/CT scans are included in research protocols, and all projects have a nuclear medicine technologist as anchor person, responsible for the practical procedures and data management, booking, examinations, patient care, quality insurance etc.

Our close collaboration with CIMBI, Professor Gitte Moos Knudsen, involves brain scanning three days a week as research in neurobiology. Our nuclear medicine technologists are part of the scanning procedure to ensure the highest technical quality. The brain scans are started in the morning and often continued till late afternoon and evening.

Radiochemistry Section

We produce at present eleven tracers for human use in our PET section. The CIMBI Neurobiology Research Unit is a busy research collaborator, and in our Radiochemistry Section nuclear medicine technologists are present from six in the morning until four o'clock in the afternoon. Our technologists have been important for the development of both ^{18}F -FET for brain scanning and for ^{18}F -FLT to cell proliferation studies. This year we initiated the rebuilding and renewal of the Quality Control Laboratory, which will be finished in 2012.



The year was busy with many extroverted activities for the nuclear medicine technologists:

Congresses

» *Society of Nuclear Med (SNM) San Antonio, USA June 2011*

Kate Pedersen attended to update her knowledge of PET / MR.

Anne Sørensen attended to update her knowledge with new fields of radiochemistry.

She also visited the company "Proportional Technologies Inc". in Houston to look at the preparation and Quality Control of ATSM to 64 Cu-ATSM.

» *EANM congress in Birmingham October 2011*

Susanne Svalling, Poster: "Whole Body Doses 2001-2010 to technologists working in a large PET and PET / CT department" and Karin Stahr, Poster: "The impact of Nova StatSensor® Creatinine Point-of-Care Monitoring System on the number of i.v. contrast enhanced CT scanning procedures performed in a clinical PET / CT unit". Tina Wikke, Louise Sørup Sørensen and Sonja Pedersen Lærke attended to update their knowledge of ¹⁸F-FET, ¹⁸F-FLT and ⁶⁸Ga-labeling. In addition, they participated in some sessions on PET / MR.

» *Nordic Medicines Laboratory (NML) Congress in Copenhagen September 2011*

Linda Kragh, planning.

Mette Frederiksen and Kate Pedersen, lecture: "Comparison of the two methods, from a medical laboratory perspective (bone scintigraphy with ^{99m}Tc-HDP versus bone scan with a ¹⁸F- NaF", Solveig Linnet, lecture: "Preparation and logistics at the children's nuclear medicine studies" and Elisabeth Abrahamsson & Marianne Federspiel, lecture: "PET / CT for diagnosis and treatment response of lymphoma in children".

Karin Stahr, poster: "The impact of Nova StatSensor® Creatinine Point-of-Care Monitoring System on the number of i.v. contrast enhanced CT scanning procedures performed in a clinical PET / CT unit".

Symposium

» *The Symposium for Technologists at the University Hospital Rigshospitalet, Maj 2011*

Linda Kragh, lecture: "Global Excellence, technologists in an active research department".

Susanne Svalling, poster: "Radiation dose to technologists, working with PET and PET / CT scanners".

Education

» *Metropolitan University College, Copenhagen:*

Nuclear Medicine Technologist Teacher Mia Alberts and Nuclear Medicine Technologist Lasse Hansen have graduated a supervisor course (six weeks).

Nuclear Medicine Technologist Christina Bojesen have graduated a diploma course in nuclear medicine and clinical physiology.

Deputy Chief Technologist Tim Lundby has arranged a day about infectious diseases, DIC.

Deputy Chief Technologist Tim Lundby has graduated a master degree, in "Quality and leadership".

Deputy Chief Technologist Anne Sørensen has started a leadership course.

The majority of the technologists have participated in different relevant courses in 2011.



PET and PET hybrid scanners



Søren Holm

The PET and Cyclotron Unit now has 1 dedicated, stand-alone brain PET scanner, 4 combined PET/CT scanners and 1 PET/MR scanner in the hospital itself (Finsen building). We are also involved in the experimental work with PET and CT at Cluster for Molecular Imaging at the Faculty of Health Sciences at the University of Copenhagen.

In the Cluster for Molecular Imaging, we support the old GE 4096 PET scanner (suitable for larger animals, e.g. pigs), and research scanners for PET and CT of small animals. The PET is a Focus 120 with resolution well below 2 mm, and the CT is a microCAT II, with an ultimate 15 μ resolution

In the hospital, brain research continues on the HRRT (High Resolution Research Tomograph). Originally intended - as the name indicates - mainly for research, the HRRT has however also become a clinically useful instrument. Designed in cooperation by several research groups in Europe and USA, and built by CTI in Knoxville, Tennessee (now owned by Siemens) the HRRT project has a more than 10 year long history that finally resulted in the building of one series of 18 instruments; the Copenhagen installation is among the last of these, but nevertheless at the front in application. Our computer scientists work actively to improve the software and in this respect provide support to the HRRT User group worldwide.

Although several interesting tracers have come into routine use during 2011, the major-

ity of studies in the PET department continue to be FDG whole-body scans for cancer diagnosis, staging, planning and follow-up. These scans are routinely performed with the use of combined PET and CT. In this combination, the CT scan is used both as a full diagnostic quality CT (including contrast media) and for attenuation correction of the PET images. With the last achievement in 2011, we now have 4 highly modern scanners with rather similar specifications, which provide an important flexibility in patient scheduling.

This year, our first PET/CT scanner (the GE Discovery LS from 2001) was replaced by a new Siemens mCT with 64 slice CT, which is identical to the scanner installed in 2010. Both have the potential of performing Time-of-Flight PET. This feature improves image quality, in particular in larger patients, or patients that have to be scanned with “arms down”. Like previously, one scanner is run in a unique well-functioning collaboration with the Department of Radiotherapy, and it is extensively used for therapy planning, for which purpose its large opening (78 cm) is an important design improvement.

The remaining 2 PET/CT scanners are Siemens Biographs, one with 40 and one with 64 slice CT, acquired in 2007 and 2009. These are installed in the new part of the Finsen building, sharing patient preparation facilities and with one common, large control room.



The most important (and most expensive) new piece of equipment in 2011 is the fully integrated PET /MR scanner, a Siemens mMR which is among the first in the world to become operational. Previous attempts to combine the two modalities have either been limited in use (brain “insert” only) or not fully integrated (two separate gantries). In the mMR, a new amplifier principle in the PET detectors make them insensitive to the magnetic field, and small enough to allow the PET scanner’s detector ring to be placed inside the 3-tesla MR-magnet between the gradient coils and the RF transmitter. The receiver coils have been redesigned to minimize absorption of the PET-photons. This makes it possible to perform truly simultaneous measurements with little or no compromise in the quality of either PET or MR. The combined scanner is anticipated to improve the diagnostic power (in particular soft tissue differentiation) but also has the potential of reducing radiation exposure, which is particularly important in childrens examination. A large number of clinical research protocols are being launched to explore this new area and provide evidence for the method.



Equipment 2011

Equipment	Product	Purchase year
Gamma cameras	Philips ADAC Thyrus	2001
	Mie-Scinttron	2004
	Mediso N-TH45-D	2008
SPECT cameras	Philips ADAC Skylight	2002
	Mediso Nucline X-Ring-R/HR	2009
SPECT/CT cameras	Philips, Precedence 16-slice CT	2006
	Philips, Precedence 16-slice CT	2008
	Siemens Symbia 16-slice CT	2011
PET scanners	HRRT Siemens/CTI	2007
PET/CT scanners	Siemens Biograph TrueV 40-slice CT	2007
	Siemens Biograph TrueV 64-slice CT	2009
	Siemens mCT-S (64)	2010
	Siemens mCT-S (64)	2011
PET/MR scanner	Siemens mMR	2011
Lung function	Jaeger Masterscreen w/bodybox	2005
	Jaeger PFT pro w/bodybox	2007
DXA scanner	GE Lunar Prodigy	2011
Whole body counter	WBC w/Nal counting chamber	1977
	WBC w/plast counting chamber	1978
Cyclotrons	Scanditronix 32 MeV	1991
	RDS Eclipse cyclotron, CTI	2005
Cluster for Molecular Imaging	Provivo/ ADAC mobile gamma camera	1990
	PET scanner GE 4096	1991
	SPECT Mediso Nucline X-Ring/R	2004
	Siemens Micro-PET Focus 120	2006
	Micro-CT Siemens Micro-CAT II	2006
	Phosphor Imager Perkin Elmer cyclone	2007

European Medical Research Councils



Professor Liselotte Højgaard

The European Medical Research Councils (EMRC) is the membership organisation of all the European medical research councils – for the EU member states as well as other European countries. The Chair of the Committee for the European Medical Research Councils is Professor Liselotte Højgaard from Rigshospitalet, University of Copenhagen, Denmark. The Standing Committee is composed of delegates with a high scientific profile in biomedical sciences nominated by their ESF Member Organisations involved and also observers from the European Commission, The Wellcome Trust, WHO-Europe, Australia, Canada, Israel, New Zealand and USA. From Spring 2010 Liselotte Højgaard was appointed Chair of The European Commission Science Advisory Board for Frame Work Program 7 in Health. This has secured coordination between the national funders and the Frame Work Program. A warm thank you to Dr. Ruxandra Draghia-Akli and her team for a very fine collaboration.

In 2011 EMRC launched the important Forward Look: “Implementation of Medical Research in Clinical Practice” about how to transfer the research results in biomedicine into every day practice in health care throughout the world. The Forward Look was launched at a great event in Berlin May 2011 and was quoted broadly in the press internationally. All the press quotes can be seen on the homepage of EMRC/ESF and the key messages from the Forward Look were communicated in articles in English, German and French. Working groups have been established to secure the true implementation of all the recommendations from the Forward Look in health care in Europe in the coming years.

In 2011 the EMRC White Paper II: “A Stronger Biomedical Research for a better European Future” was finalized and launched September 2011, giving a status report on the current situation for biomedical research in Europe with recommendations for how

to strengthen biomedical research from basic over translational to clinical research; prevention, epidemiology and health care. This publication can be used as reference document for the years to come.

The animal directive on the protection of animals used for scientific purposes was accepted in the European Parliament end of 2010 and our position paper to secure translation into national laws of the EU member states were launched February 2011 so that all countries secure the proper use of the new directive. It was a great victory for all the organisations working together that we accomplished to secure a new directive emphasizing the importance of a dignified approach to research on animals for scientific purposes, and at the same time without hindering research possibilities.

The Forward Look “Gene Environment Interaction in Chronic Diseases”, also called GENESIS, was launched in November 2011. We are proud that Allergy and Clinical Immunology, JACI, published an article about the key messages of the Forward Look in their November issue. For this Forward Look, as for all the other publications, the dissemination to the biomedical community is as important as the work itself.

In Fall 2011 EMRC held its 40 years jubilee in Strasbourg and a special publication about all work done hitherto by EMRC is available on the ESF/EMRC website: www.esf.org.

A warm thank you to the EMRC Unit at ESF in Strasbourg for all the work done in 2011. It has been a tough year due to the changes in ESF. A warm thank you to the whole unit, specially Unit Coordinator Janet Latzel, Science Officer Kirsten Steinhausen and last, but not least, Head of Unit Dr Stephane Berghmans. A warm thank you to the Core Group and Planary Group of EMRC making it worth the effort.

EMRC Publications 2011



Stress and Mental Health (EuroSTRESS)
EUROCORES Final Report
December 2011

EMRC Newsletter No. 19
December 2011



Gene-environment interaction in chronic disease: a European Science Foundation Forward Look. Preface.

Kristiansen LV, Röllinghoff M, Berghmans S, Højgaard L.J Allergy Clin Immunol. 2011 Dec;128(6 Suppl):S25-6. PMID: 22118217, Journal article – Journal of Allergy and Clinical Immunology (JACI), December 2011



Frontline health care can be improved by bringing research into the clinic.

Steinhausen K, Berghmans S, Højgaard L. Br J Hosp Med (Lond). 2011 Nov;72(11):606-7. PMID: 22082999, Journal article – British Journal of Hospital Medicine, November 2011



Die ESF Fordert eine engere Verknüpfung von klinischer Praxis und Forschung

Steinhausen K, Berghmans S, Højgaard L. Bulletin SAMW 3/11 on Forward Look - Implementation of Medical Research in Clinical Practice

Bulletin – Schweizerische Akademie der Medizinischen Wissenschaften (SAMW)
ISSN: 1662-6028, November 2011



Health Research Classification Systems: Current Approaches and Future Recommendations

ESF Science Policy Briefing No. 43
November 2011



Gene-Environment Interaction in Chronic Disease (GENESIS)

Forward Look Report
ISBN: 978-2-918428-48-0
November 2011



A Stronger Biomedical Research for a Better European Future

EMRC White Paper II
ISBN: 978-2-918428-35-0
September 2011



Ecological and Evolutionary Functional Genomics (EuroEEFG)

EUROCORES Program
September 2011



Functional Genomic Variation in the Epilepsies (EuroEPINOMICS)

EUROCORES Program
September 2011



European biobanks and sample repositories – relevance to Personalised Medicine

Position paper
May 2011



Implementation of Medical Research in Clinical Practice (FLIP)

Forward Look Report
ISBN: 978-2-918428-36-7
May 2011



European Myosotis Network (EuMyoNet)

Research Networking Program
May 2011



EMRC Newsletter No. 18
May 2011



ESF-EMRC Position on the Directive on the Protection of Animals used for Scientific Purposes

Position paper
February 2011



European Network for Gastrointestinal Health Research (ENGHR)

EUROCORES Program
February 2011

Professor Liselotte Højgaard is member of Conseil d'Administration de l'INSERM, L'Institut National de la Santé et de la Recherches Médicale, France.

Accreditation

Rigshospitalet and our department have been accredited succesfully by:

- » Center of Excellence by the European Neuroendocrine Tumour Society
- » Certified by SIS, National Institute of Radiation Protection, The Danish National Board of Health
- » Danish Medicines Agency
- » The Danish National Board of Health, MD Specialist education
- » EURATOM, The European Atomic Energy Community
- » Joint Commission International, the International American accreditation board
- » Section of Nuclear Medicine of the European Union of Medical Specialists (UEMS)s
"Accreditation of Nuclear Medicine Training Centers Committee", MD Specialist Education.
- » European Association of Nuclear Medicine.
- » The Specialty Advisory Committee (SFR) in Clinical Physiology and Nuclear Medicine



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