

DEPARTMENT OF CLINICAL PHYSIOLOGY, NUCLEAR MEDICINE & PET

Annual Report 2010

Rigshospitalet · University of Copenhagen



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.

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Rigshospitalet



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PREFACE

For the department of Clinical Physiology, Nuclear Medicine & PET 2010 was a special year – the department was awarded the Global Excellence Prize from The Capital Region of Denmark, as one of ten centers in Copenhagen with research and patient treatment in the international excellence league. Professor Andreas Kjær received the prize as described on page 53.

Our production in terms of patient investigations rose in 2010 by 9% compared to the year previously, and we performed in total approximately 40,000 patient investigations last year. The R & D effort resulted in 98 peer review publications and 7 theses (PhD and Doctor of Medical Science). At the same time the budget was cut due to reductions for the Capital Region of Copenhagen and Rigshospitalet. So we truly had a tough year in 2010 securing that all our patients received the best and correct patient investigation without delay, while keeping capacity, infrastructure and economy for the research. We succeeded in both, and this only thanks to a very remarkable effort from all staff in the department. We would like to convey our most sincere thank you to all for making this possible. We know it has been a tough and busy year and we admire all the great work done by each and everyone - so that we could achieve the goals of the department: to deliver the best patient investigations, research of the highest international quality, give the relevant education and hopefully also be a nice place to work.

Andreas Kjær and his research team has developed their research collaboration with China further in 2010, and we now have collaboration with 3 Chinese research centers in the field of molecular imaging. The research effort from the Cluster of Molecular Imaging is highly acknowledged. In the PET Scanner Section the PET/CT 4 was exchanged with a new model, an mCT with 64 slices CT. It is used mostly for the 1,000 patients investigated annually with PET/CT for radiation therapy planning. The other 2 new modern PET/CT scanners have been very busy in 2010, as the old PET/CT from 2001 is now “end of life”. Due to the high number of patients it has been a busy year in the PET Section, and at the same time the patient investigations have been of remarkably high quality and the research very fine. We thank every one in the section sincerely.

In Nuclear Medicine the new treatment facility with ^{177}Lu Lutetium Dotatate treatment of patients with neuroendocrine tumors gave 100 treatments in 2010, and at the same time all the other nuclear medicine investigations increased, as did the research effort. The number of productions from the Cyclotron Unit was also increased compared to 2009 and the devoted team starting at 3.00 AM in the morning is thanked sincerely. In Radio Chemistry a series of new tracers were produced in 2010 for both patient studies and animal experiments, as described on page 20. At the same time a new production lab for FDG was under construction and we would like to congratulate the whole team for a diligent and hard working year 2010. Thank you!

We had time for our annual summer party in Tivoli and the winter party with carnival. As can be seen on page 11 both occasions were full of joy and fun.

Thank you to all our collaborators in the clinical departments, in other hospitals and research institutions in Denmark and internationally. We appreciate our mutual effort for strengthening patient investigations and research in the field of clinical physiology and nuclear medicine, including PET.

A warm thank you to Head of Clinical Engineering Ole Bergsten for helping us with equipment, and a big thank you to our directors at Center of Diagnostics, Rigshospitalet, Center Director, Doctor Bettina Lundgren and Leading Chief Technologist Karin Nørgaard and the whole team for good collaboration in spite of the budget cut. Our department has kept the budget now for 11 years in a row. 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, Jannik Hilsted and Helen Bernt Andersen have been helpful in many ways throughout the year.

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 and as seen on the last page of this report we have worked both and especially with the implementation of medical research in clinical practice and with basic research strengthening the possibilities for animal research in Europe. The acceptance of the new EEC directive on animal research in Fall 2010 was a great victory for us, so that we could secure animal research in this part of the world. Thank you to Doctor Stephane Berghmans, Doctor Kirsten Steinhausen and Mrs. Janet Latzel and the whole team at EMRC.



Liselotte Højgaard and Linda M. Kragh



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

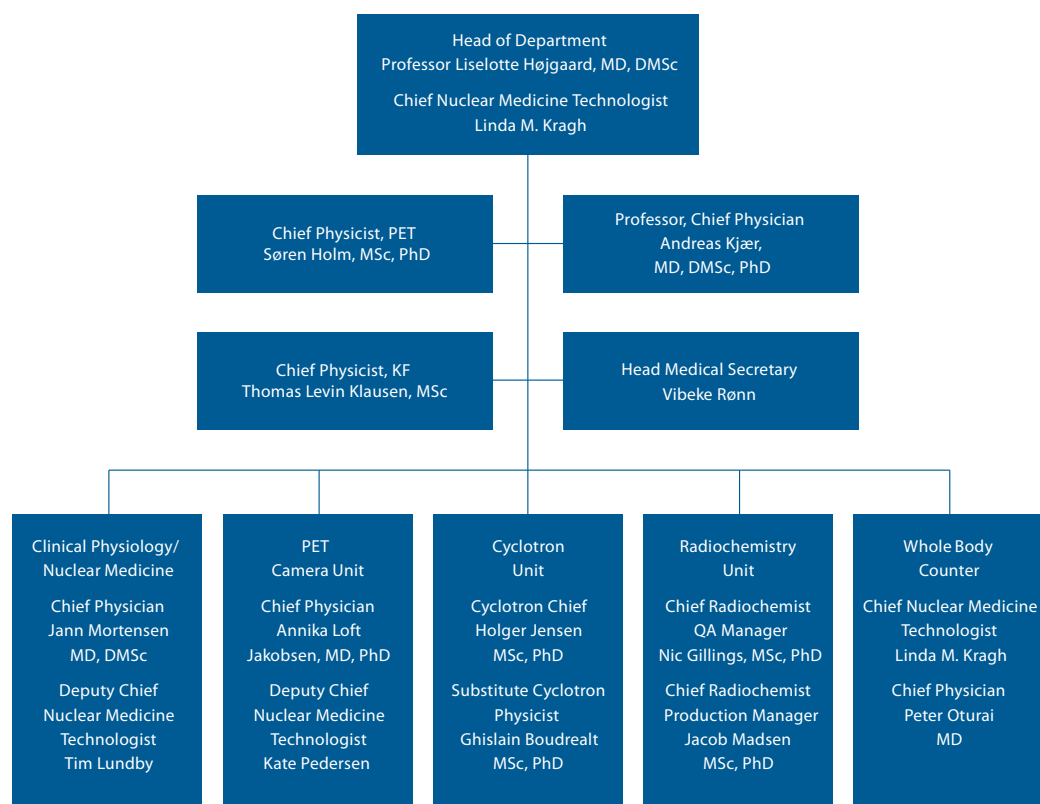
The objectives of the Department of Clinical Physiology, Nuclear Medicine & PET are:

- 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 2010 more than 250 groups and individuals visited the department.

ORGANIZATION AND STAFF



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

Physicians

Benzon, Eric von, Chief Physician. Berthelsen, Anne Kiil, MD, Chief Physician. Borgwardt, Lise, MD, PhD, Senior Registrar. Bouchelouche, Kirsten, MD, Senior Registrar. Christensen, Charlotte Birk, MD, Registrar. Costa, Junia, MD, Senior Registrar. Hansen, Tine Willum, MD, Registrar. Hasbak, Philip, MD, Chief Physician. Helmark, Ida Carøe, MD, Registrar. 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, Senior Registrar. Markova, Elena, MD, Chief Physician. Marner, Lisbeth, MD, Registrar. Mortensen, Jann, MD, DMSc, Chief Physician, Ass. Professor. Oturai, Peter, MD, Chief Physician. Özdemir, Zehra, MD, Registrar. Rønne, Frederik, MD, Registrar. Skovgaard, Dorthe, MD, PhD, Registrar. Winkler, Christine, MD, Senior Registrar.

PhD students

Andersen, Julie Bjerglund, MD, PhD Student. Binderup, Tina, MSc Human Biology, PhD Student. Erritzøe, David, MD, PhD Student, NRU Researcher. Ettrup, Anders, MSc Human Biology, PhD Student, NRU Researcher. Frøkjær, Vibe, MD, PhD Student, NRU Researcher. Græbe, Martin, MD, PhD Student. Gutte, Henrik, MD, Research Fellow, PhD Student. Hag, Anne Mette Fisker Hag, PhD Student. Haahr, Mette, MD, PhD Student, NRU Researcher. Hansen, Martin, Cand.scient, PhD Student. Hollensen, Christian, PhD Student. Jensen, Mette Munk, Human Biology, Research Fellow. Johnbeck, Camilla Bardram, MD, PhD Student. Jørgensen,



Emilie Arnth, MSc Human Biology, PhD Student. Jørgensen, Jesper Tranekær, MSc Human Biology, Research Fellow. Kalbitzer, Jan, MD, PhD Student, NRU Researcher. Knudsen, Jesper Andreas, PhD Student. Kornum, Birgitte, MSc Human Biology, PhD Student, NRU Researcher. Kristoffersen, Ulrik Sloth, MD, Research Fellow, PhD Student. Li, Fan, PhD Student. Lourcing-Andersen, Julie, MD, Research Fellow, PhD Student. Marthin, June, MD, PhD Student. Nielsen, Kristina Rue, MD, PhD Student. Olesen, Oline Vinter, PhD Student. Persson, Morten, MSc, Research Fellow. Pfeifer, Andreas, MD, Research Fellow, PhD Student. Reichkender, Michala, MD, PhD Student. Tägil, Kristina, MD, PhD Student.

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

Andersen, Flemming, MSc, PhD, Computer Scientist. Boudrealt, 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, PhD Eng, PhD. Denholt, Charlotte Lund, MSc, PhD, Chemist. Erlandsson, Maria, Chemist. Gillings, Nicolas, 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. Krag, Anders Hedenskog, Engineer. Madsen, Jacob, MSc, PhD, Chemist, Chief Production Manager. Schjøth-Eskesen, Christina, Chemist. Sibomana, Merence, IT-expert. Szabolcs, Lehel, MSc, PhD, Chemist. 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, Lasse, NMT. Hassan, Mariam, NMT. Heiberg, Therese, Cand.scient.san, NMT. Jensen, Charlotte L.K., NMT. Jensen, Martin Ravn, NMT. Jørgensen, Hanne, NMT. Jørgensen, Mette Møller, NMT. Kahveci, Zuhail, NMT. Kernchen, Ulla, Staff Nurse. Knudsen, Camilla Sloth, NMT. Kragh, Linda M., Chief NMT. Kronvall, Johanna, NMT. Lindell, Elin, NMT. Linnert, Solveig, NMT. Ljunggren, Anna, NMT. Lundby, Tim, Deputy Chief NMT. Lærke, Sonja, Technician. Magnusson, Linda, Technologist. Myschitzky, 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. Zulfovaska, Cejlan, NMT.

Medical secretaries and secretaries

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

Students

Andreassen, Nis Bo. Christensen, Anders. Christensen, Rune. Danielsen, Andreas Hjortgaard Danielsen. Dohn, Asmus Ougaard. Henriksen, Martin Romme. Ipsen, Niels Bruun. Jensen, Simon Bøgh. Kamstrup, Andreas. Kjøller, Niels-Kristian. Larsen, Thorvald Wadum. Lassen, Martin Lyngby. Matthiesen, Mads Emil. Nielsen, Anders. Øberg, Mikkil. Paamand, Rune. Petersen, Stefan Alaric. Værge, Thorkil Kowalski. Yildiran, Handan.

We have staff members from 19 different countries. Our daily languages are Danish, Swedish and English.



HIGHLIGHTS OF THE YEAR 2010

The American Ambassador Laurie S. Fulton visited the Department in April 2010 and it was a great opportunity for us to discuss research collaboration and Danish-American relations with Ambassador Fulton and her team.

The new PET/CT for planning of radiation therapy, a Siemens mCT with 64 slice CT was installed Summer 2010 and is used in collaboration with the Department of Radiation Therapy for planning of patients. We are proud to continue the close collaboration between our two departments and the new scanner has been well received by the staff from both departments.

The department was again elected: "Best Department in Denmark" in clinical physiology, nuclear medicine & PET by the Danish Journal: "Dagens Medicin" with votes from our colleagues in Denmark. We are grateful for this repeated appreciation.

Professor Andreas Kjær and his team at the Cluster for Molecular Imaging presented lectures, talks and posters at many meetings and conferences around the world, reflecting the excellent research activity carried out by the team. Our doctors, physicists, bioengineers, chemists, nuclear medicine technologists and secretaries participated in several congresses throughout the year, including those held by AMI, SNM, EANM and gave many lectures all over the world, as reflected in the illustrations.

Our Consultant, Dr. Jann Mortensen, MD, DMSc has from 2009 had responsibility for the Danish National Board of Health Accreditation of the small Department of Nuclear Medicine at the Tórshavn Hospital, Faroe Islands. We are proud of this Nordic collaboration.

At EMRC the highlight of the year was the Consensus Conference at the Council of Europe in Strasbourg October 2010 where the new Forward Look "Implementation of medical research in clinical practice" was discussed with a high level group of decision makers in medical research. NIH, Canada, Australia, New Zealand and United Kingdom graced us with their presence and made the meeting true international.

At the EMRC we had the annual meeting in Spring 2010 in Berlin, just when the Iceland volcano made flight travel on the Northern hemisphere difficult. We succeeded in spite of this to hold the meeting and DFG, Deutsche Forschungsgemeinschaft deserves a great and warm thank you for hosting us.

Twice a year we hold a party for the staff. In June 2010 we were in The Tivoli Gardens and in November we held a carnival as seen on the illustrations opposite. In spite of our serious task of attending very sick patients with the best of our professional skills, it is important that we as staff do our best to collaborate and help each other in a joyful and positive atmosphere.

Prof. Liselotte Højgaard was elected Chair of the Science Advisory Board of the EU EC Framework program FP7 Health following Sir Leszek Borysiewicz.



Global Excellence – in health 2010



Dept. Clinical Physiology, Nuclear Medicine & PET

is awarded Global Excellence – in health 2010.

The award is granted for outstanding contribution to development of world class health care services in the Capital Region of Denmark.

Global Excellence in Health is intended to promote highly qualified professional environments of international standard within health at universities and hospitals in the region.

Wibeke Storm Rasmussen

Wibeke Storm Rasmussen, Regional Council Chairman

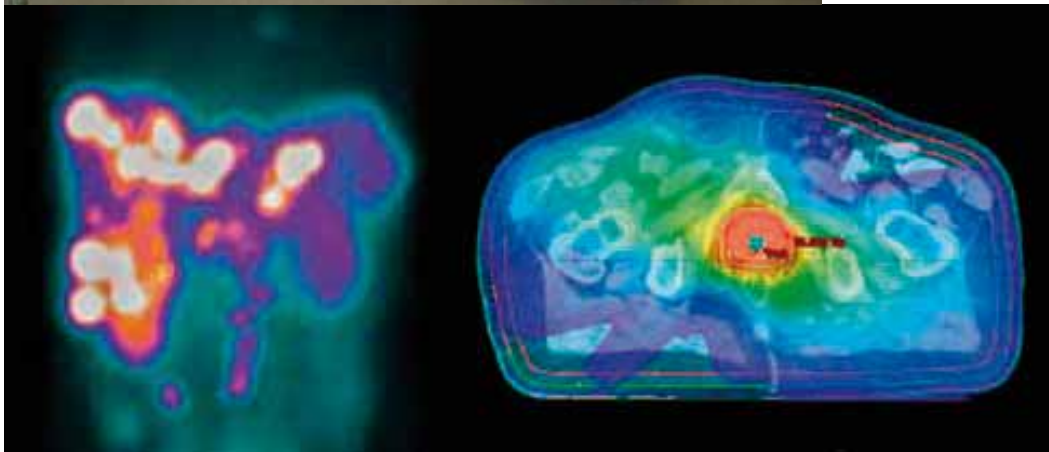
Marianne Stendell

Marianne Stendell, Chairman of the Education and Research Committee



Bedst til klinisk fysiologi





DOTATATE

^{177}Lu -DOTATATE therapy of neuroendocrine tumors: We have provided treatment with ^{177}Lu -DOTATATE in Denmark to patients with neuroendocrine tumor metastases since May 2009. Through 2009 and 2010 36 patients have been given a total of 115 treatments. In collaboration with the Department of Gastro Surgery, Rigshospitalet, and the Hevesy Laboratory at Risø DTU, where the ^{177}Lu -DOTATATE is synthesized and labelled, we treat two patients every week. ^{177}Lu -DOTATATE is administered in our dedicated facilities in the section 4114. Patients stay overnight at the surgical ward before returning to us the next day for scintigraphic imaging to visualize tumor uptake of ^{177}Lu -DOTATATE and for dosimetric calculations. We aim for a total of four ^{177}Lu -DOTATATE treatments over a period of 6 months in every patient.

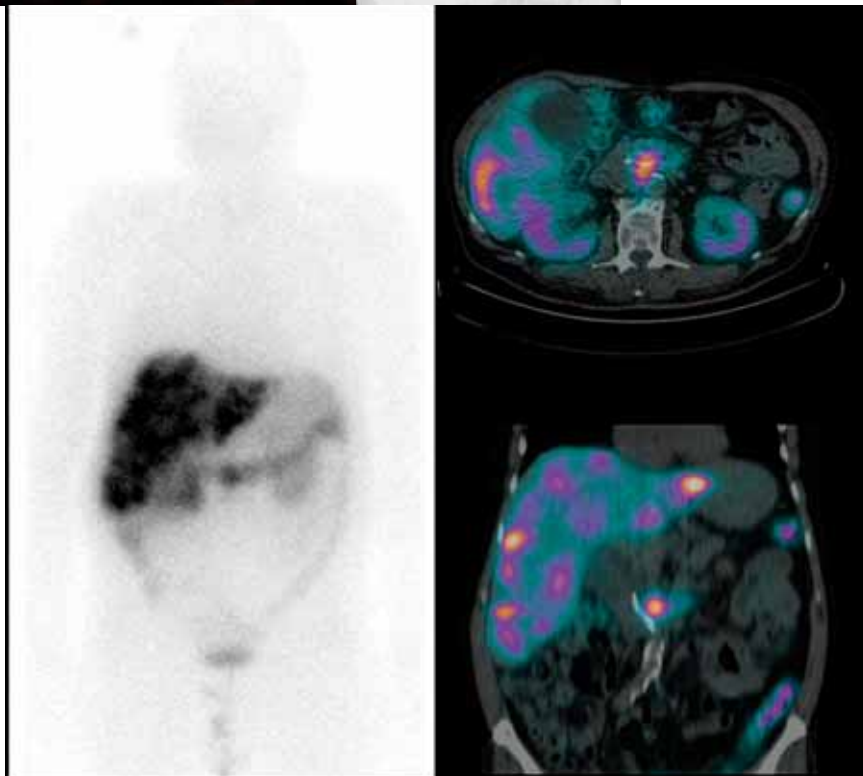
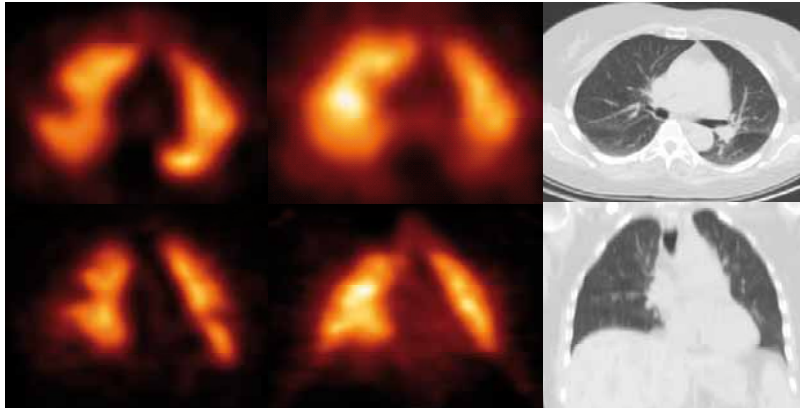
The rationale for the treatment, also called peptide receptor radio nuclide therapy, is that the radio labelled somatostatin analogue binds to neuroendocrine tumors expressing somatostatin receptors. The emitted beta-particles from the ^{177}Lu -isotope destroy the tumor cells. In addition the emission 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.

We have assessed the effects and side-effects during and after treatment. Our findings from the first evaluable 20 patients are comparable to what we expect from the literature, i.e. some measurable effect in the majority of the patients, and only few side-effects.



Jann Mortensen and Peter Oturai



NUCLEAR MEDICINE

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. We use our ultrasound scanner for thyroid patients as a supplement to thyroid scintigraphy. For lung function testing we have two Jaeger body plethysmographs. Our animal facilities are equipped with SPECT and PET and CT scanners. Weekly receptor targeted radio nuclide therapy against neuroendocrine tumors, initiated 2009, is now a routine function in department. Read more about ^{177}Lu -DOTATATE therapy on page 13.

The majority of 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 and malignant melanoma, MUGA and ^{51}Cr -EDTA clearance measurements for monitoring of chemotherapy treated patients are some examples.

The somatostatin receptor ligand ^{111}In -Octreotide imaging 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 radio aerosol 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. A major software upgrade of most gamma-camera workstations and coupling to PACS has made data flow more efficient and provides faster reports to the clinical departments.

More conferences with colleagues in both clinical and para-clinical departments have been established resulting in an optimized diagnostic patient flow. In 2010 we have had weekly and monthly conferences dealing with thyroid disease, neuroendocrine tumors, pediatric oncology, cardiology and adrenal diseases.



Jann Mortensen and Peter Oturai

PEDIATRIC NUCLEAR MEDICINE

Each year we perform 1500 pediatric nuclear medicine investigations mainly for the large pediatric clinics at the hospital. It is a special focus area for our clinic 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 clinic is a member of the Pediatric Nuclear Medicine Network, the International Telemedicine Network for Second Opinion and Exchange of Ideas. The clinic has been performing children PET scans as a focus area since 1999 and has now performed close to 1200 children PET scans. Since our introduction of PET/CT in 2001 and the second PET/CT scanner in 2003, most of the whole body studies have been performed as PET/CT though only a relevant number of high-resolution scans.

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 we developed the “Expert Task Force Visits” to help increase the level of children’s examination on a national level. On request, this year we have been visiting Department of Nuclear Medicine at Herlev Hospital, Odense Hospital and Næstved Hospital to assist them set up and develop the area of pediatric nuclear medicine. The visits have been very contributing 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. The last years the use has increased and this year 15 children have had their target for radiotherapy planned by PET/CT. More than 54 children have had their radiation therapy planned with PET/CT. This procedure seems very promising.

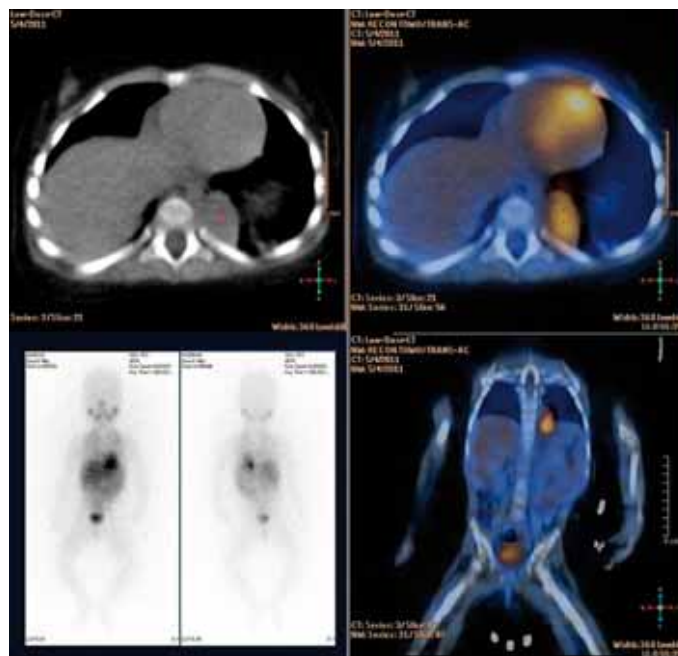
Diagnostics on the children with Hodgkin’s lymphoma follows the guidelines of the European protocol and we participate in the teleconferences in the European Pediatric Hodgkin’s Network Group to increase the level of interpretation in Europe in general. On all children, including the children with lymphoma,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

In order to continue increasing quality of our children's examinations in general, this year the Pediatric Focus Group developed certain new procedures: **The watch-keeping team:** The day before every children scan, the arrangements concerning the scans are being reassured. Has the child and its parents been informed? Has the department of anaesthesia, if necessary, been alerted, etc. This way we have decreased the number of cancellations and the degree of rework, to almost zero. **Patient Safety:** The Pediatric Focus Group has also had a represent at the national course for patient safety in the pediatric area, returning with many new ideas. **The specialist review:** To increase quality of our interpretations, all children examinations are read by our team of pediatric staff specialists at weekly reviews.

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 and PET/CT in lymphomas, sarcomas, metabolism- and perfusion PET in neonatals, diagnostic value of hepatobiliary scintigraphy and the optimal preparation of the child with suspicion of biliary atresia, ¹²³MIBG SPECT/CT and PET/CT of children with neuroblastomas in corporation with Ludwig-Maximilians-University, München etc.

Working with children is challenging, rewarding and unpredictable!

Lise Borgwardt



1-year-old girl med opsoclonus myoclonus syndrome is diagnosed with neuroblastoma in a left-sided thoracic ganglion due to SPECT/CT, with what seems to be a normal planar MIBG-scintigraphy. Opsoclonus myoclonus syndrome is a rare paraneoplastic syndrome to, the most common extracranial solid cancer in childhood, the neuroblastoma, a cancer of the sympathetic nervous system. The planar scintigraphy shows physiological uptake in the salivary glands, cor, liver, with excretion to the intestines and the urinary tract, but SPECT/CT shows a tumor hidden behind the physiological uptake of cor on the planar scintigraphy, only seen in the 3D-view of SPECT/CT.

CYCLOTRON UNIT

In 2010 we experienced, as in the previous years, an appreciable increase in the need of ^{18}F -FDG and we produced 14% more FDG as compared to in 2009. During the last 5 years we have seen in average an increase of 20% per year as seen in figure 1. In 2010 we made 561 productions of ^{18}F with our two cyclotrons (158 and 403 productions for our Scanditronix MC32 and Siemens RDS Eclipse cyclotrons respectively) corresponding to an increase of only 4,7%. The higher production capacity per production is explained by the use of the second beam line and the dual beam ($2 \times 60 \mu\text{A}$) option for the RDS Eclipse cyclotron, which was installed in 2009. For none of our other routine productions we saw a similar increase and in some cases we saw even a small reduction.

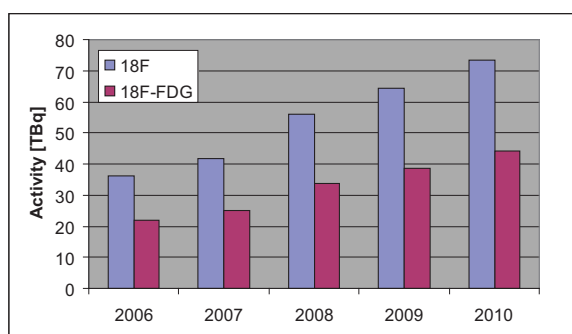


Figure 1. Produced ^{18}F and FDG activity since 2006

In total we ended up with approximately 983 successful productions or 9,5% less than in 2009. 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 only 1 cancelled production in 2010.

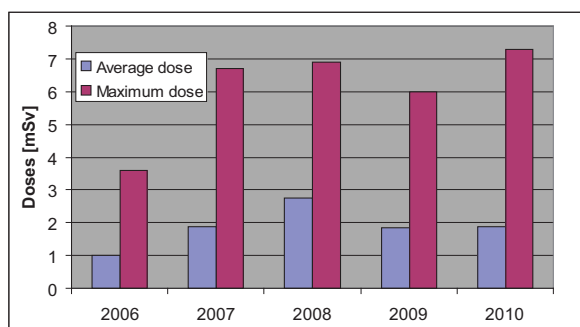


Figure 2. Average and maximum received doses for the employees in the cyclotron and radio chemistry group since 2006

Despite of the increased production, which has been doubled since 2006, we have managed to keep the doses to the employees in the cyclotron- and radio chemistry unit under control. Both the average and maximum doses for the employees scale very well with the produced activity as can be seen in figure 2.

In 2010 we signed a collaboration contract with Siemens on the development of a new ^{11}C -Carbon-dioxide target for the RDS Eclipse cyclotron with the goal of obtaining higher specific activities and target yields. The idea is to transfer some of the ideas and results obtained for the new ^{11}C -Methan target for our Scanditronix cyclotron to the RDS Eclipse cyclotron. So far we only have very preliminary results.



Holger J. Jensen



RADIO CHEMISTRY

The radio chemistry section has grown steadily over the last few years and currently consists of 4 medical laboratory technologists, 1 pharmacist (QA) and 8 radio chemists (including 1 PhD student and 1 post-doc).

Routine production

The demand for ^{18}F -FDG increased steadily in 2010. Although the demand could be met with the present facilities, a new dedicated FDG production laboratory was built and validated in 2010 and our routine FDG production will be transferred to this laboratory in early 2011. This will accommodate present and future demands and assure that our production continues to comply with national and international guidelines on good manufacturing practice. Production of krypton generators continued according to the well-established delivery schedule on Mondays, Wednesdays and Fridays.

Research production

2010 was a busy year, with regular production of a large range of radiopharmaceuticals for research use, both for humans, animals and in vitro studies (see table). The cell proliferation tracer, ^{18}F -FLT, was validated for human use towards the end of the year and an approval for human use has been granted by The Danish Medicines Agency. The neuroendocrine tumor tracer, ^{68}Ga -DOTATOC has been validated and an application for approval for human use will be submitted in early 2011. Production of the amino acid tracer ^{18}F -FET has been set up and validation for human use will follow in early 2011. ^{64}Cu -ATSM, ^{18}F -Galacto-RGD and ^{18}F -Annexin can now be produced and animal studies are ongoing with these radiopharmaceuticals.

Radiopharmaceutical development

Collaboration with The Neurobiology Research Unit, Rigshospitalet and the Department of Medicinal Chemistry at PHARMA (University of Copenhagen) under CIMBI (Center for Integrated Molecular Brain Imaging) continued in 2010. A very promising 5-HT_{2A} agonist PET tracer has been developed and the results of animal studies have been published. We are currently investigating options for funding of a toxicology study on this compound, which is necessary before approval for human use can be granted. Under the auspices of CIMBI, work is in progress on development of a 5-HT₇PET ligand. Initial results are encouraging and this work will continue in 2011. In 2010 we have secured funding for a PhD student who will work on optimizing our previously developed lead compound, ^{18}F -FALGEA, a labelled peptide for imaging the epidermal growth factor tyrosine kinase receptor (EGFR). This work will be performed in collaboration with The Department of Natural Sciences, University of Copenhagen. Another ongoing project involves efforts to label a peptide known to bind to the urokinase-type plasminogen activator receptor (uPAR). The expression of this receptor is elevated during inflammation, tissue remodelling and in many human cancers, in which it frequently indicates poor prognosis. A peptide, AE105, consisting of 9 amino acids, known to bind to uPAR, was conjugated to a chelator

such as DOTA and labelled with Cu-64 and Ga-68. A strong correlation between tumor uptake of the tracer and uPAR expression ($R^2=0.73$; $p<0.0001$) was found thus providing a strong argument for specificity of the tracer towards uPAR. These promising results have encouraged us to pursue this track in the coming years.

Radiopharmaceutical batches released for human use

	2006	2007	2008	2009	2010
^{18}F -FDG	256	268	369	433	425
$^{81\text{m}}\text{Kr}$ -Generator	694	869	885	890	882
^{18}F -Altanserin	42	36	18	14	13
^{11}C -DASB	47	49	11	21	35
^{11}C -SB207145	3	20	44	19	21
^{11}C -PIB	-	-	39	50	35
^{11}C -Flumazenil	-	1	2	3	8
^{11}C -CUMI 101	-	-	-	1	7
^{13}N -Ammonia	97	67	23	32	13
^{15}O -Water	176	62	146	248	33

Radiopharmaceutical batches produced for animal/in vitro studies

	2006	2007	2008	2009	2010
^{18}F -FLT	-	-	15	19	15
^{64}Cu -ATSM	-	10	10	15	8
^{18}F -Annexin	-	-	-	2	
^{64}Cu -DOTA-AE105	-	-	-	-	12
^{68}Ga -DOTA-AE105	-	-	-	-	20
^{68}Ga -NODAGA-RGD					5
^{18}F -Altanserin	-	-	-	-	1
^{18}F -MH.MZ	-	-	-	-	5
^{11}C -Cimbi compounds	-	-	11	11	15
^{11}C -NS analogues	-	-	2	12	2

Summary of radiopharmaceutical productions 2006-2010



Nic Gillings and Jacob Madsen



PET/CT SCANNING IN ONCOLOGY

Positron emission tomography and its usefulness in oncology are well established. With the introduction of the combined PET/CT scanners, a new world has opened with exciting possibilities.

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.

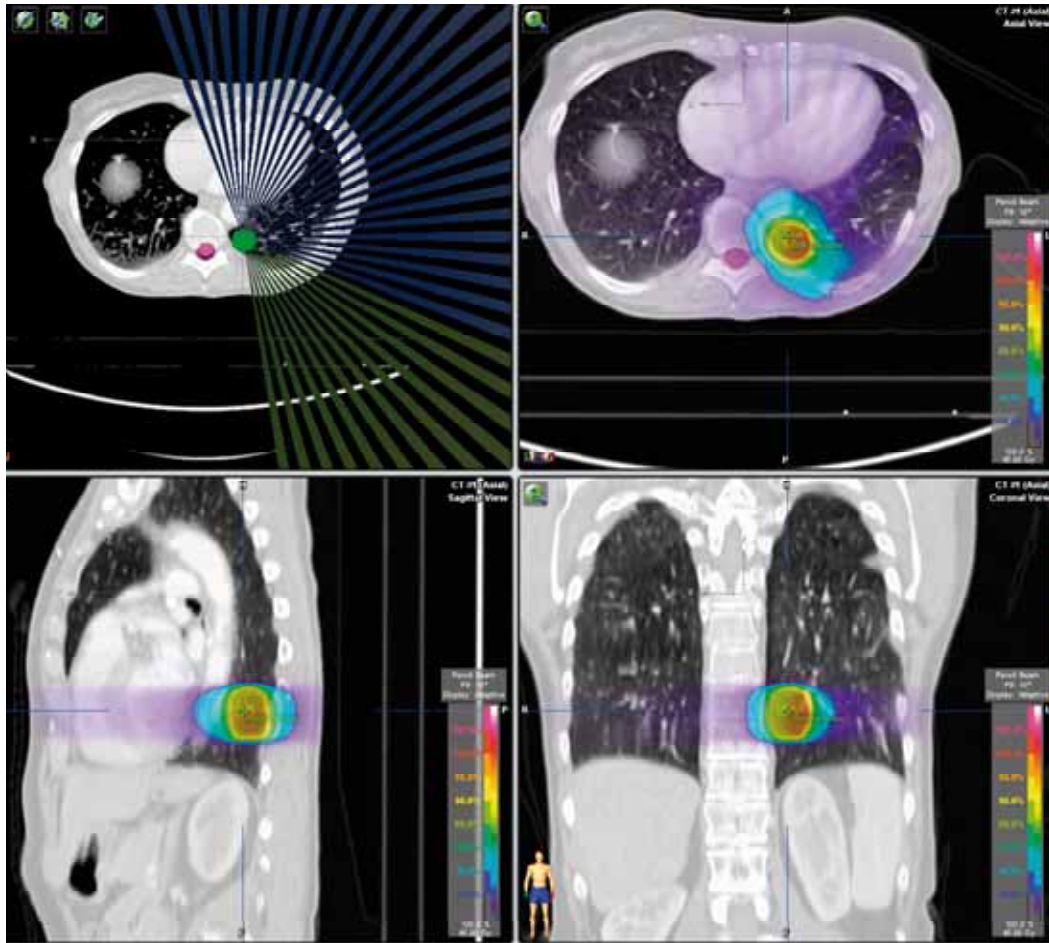
In 2010, we performed 5000 PET/CT scans and more than 90% were oncological. The indications are mainly diagnosis, staging, therapy monitoring and detection of recurrent disease in patients with a variety of malignant diagnoses. As a routine, we have included a supplementary CT of the lungs with breath hold technique to improve the diagnostic quality. Approximately 50% of our patients participate in clinical research protocols. Our main topics are gynaecology, malignant lymphoma 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 multicenter-study with Odense and Aalborg University Hospitals investigating endometrial cancer. We have 14 weekly multidisciplinary team conferences, where our PET/CT scan results are discussed.

FDG is still the main tracer in oncology, but we also use ^{18}F -Na F for bone PET scans in research protocols and plan to start ^{18}F -FLT and ^{18}F -FET studies in the coming year.

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.



Annika Loft Jakobsen and Anne Kiil Berthelsen



Dose distribution in a patient undergoing stereotactic radiation therapy for a non-small cell carcinoma

PET/CT SCANNING IN RADIATION THERAPY

Correct target definition with inclusion of macroscopic as well as microscopic disease in the target volume and sparing of as much normal tissue as possible is the main challenge in curative radiotherapy, particularly with highly conformal treatment methods. The use of PET/CT in radiotherapy planning of cancer patients has increased very rapidly since the method was introduced in 2001.

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 radiotherapy every year. Our own experience since 2002 is briefly summarized from more than 2,500 patients with various malignant diseases undergoing radiotherapy planning with PET/CT prior to the treatment. 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, and the tissue heterogeneity can then be taken into account when choosing radiation technique and energy, and only one scan is necessary. Four of 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 just finished a study showing a 19% detection rate of metastases leading to a 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.

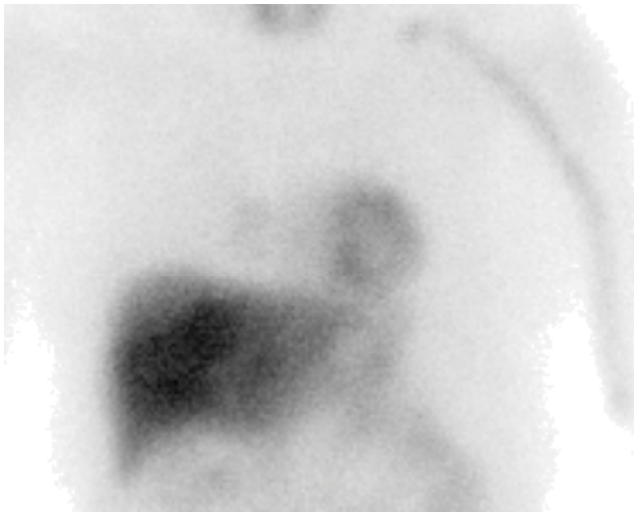
Research in this field is necessary, and we have conducted trials with nasopharyngeal- and cervical cancer and malignant lymphoma with encouraging results. PET/CT for radiotherapy planning is now used routinely for patients with cervical-, head & neck-, lung-, oesophageal-, cardia-, rectum- and anal cancer as well as malignant lymphoma and mesothelioma. We have an ongoing study using 4D-PET/CT for radiotherapy planning for lung cancer and malignant lymphoma and a study using breath hold PET in lymphoma of the mediastinum.

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



Annika Loft Jakobsen and Anne Kiil Berthelsen

A: Patient with good prognosis



B: Patient with poor prognosis



Cardiac sympathetic innervation assessed with ^{123}I -MIBG imaging can be used for risk stratification of patients with heart failure. Patients with preserved cardiac sympathetic innervation (A) show a significantly lower cumulative cardiac event rate compared with patients with severely depressed cardiac sympathetic innervation (B).

CARDIAC STUDIES

Cardiac SPECT

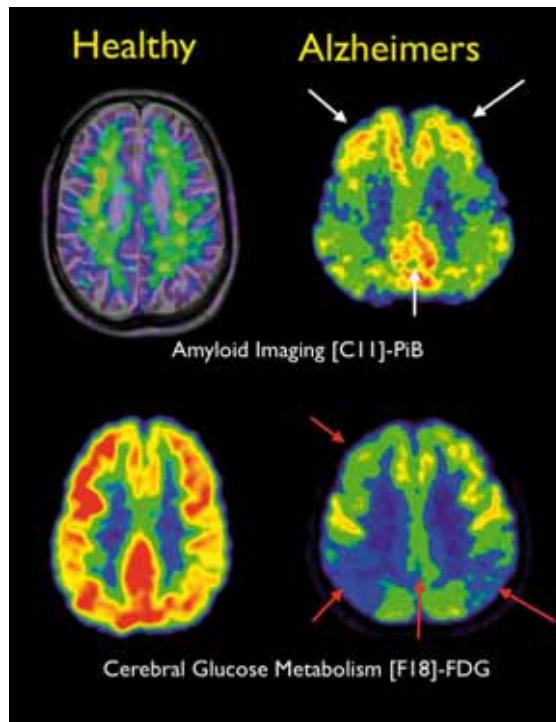
At Rigshospitalet there is a special need to provide cardiac SPECT every day, since a large proportion of our patients with ischemic heart disease need an acute or sub-acute work-up that requires quick decision making as to coronary revascularisation strategy. Patients with unstable angina or non-STEMI should be revascularised 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. Thus, we offer acute cardiac SPECT five days a week. In 2010 our gated cardiac SPECT cameraes underwent a rigorous qualification process for 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

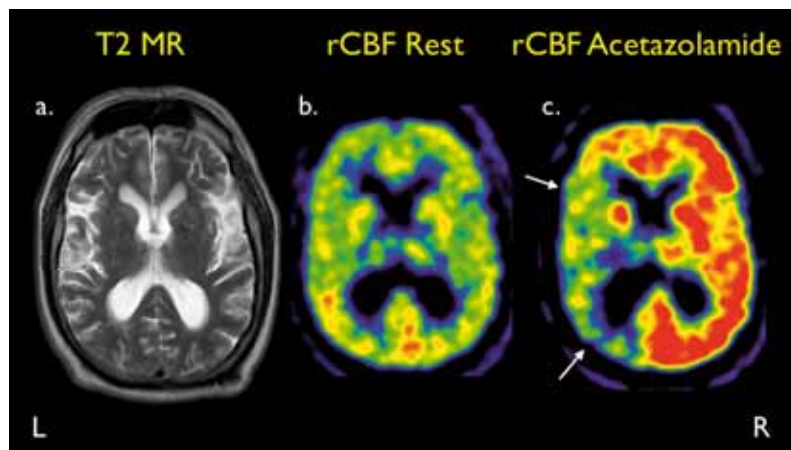
In 2010 we introduced cardiac ¹²³I-metaiodobenzylguanidine (¹²³I-MIBG). Radiotracer analogs of the sympathetic mediator norepinephrine have been investigated extensively, and are at the brink of potential widespread clinical use, especially after the presentation of the ADVANCE-HF trial. The most widely studied SPECT tracer, ¹²³I-MIBG has consistently shown a strong, independent ability to risk stratify patients with advanced congestive heart failure. Increased global cardiac uptake appears to have a high negative predictive value in terms of cardiac events, especially death and arrhythmias, and therefore may have a role in guiding therapy, particularly by helping to better select patients unresponsive to conventional medical therapies who would benefit from device therapies such as an ICD (implantable cardioverter defibrillator), CRT (cardiac resynchronization therapy), LVAD (left ventricular assist device), or cardiac transplantation.



Philip Hasbak



PET scanning in dementia. The top row shows the regional amyloid binding using ^{11}C -PiB in a healthy subject and in a patient with Alzheimer's disease. The latter shows characteristically increased uptake in the frontal and parietal cortex (white arrows) with decreased metabolic activity in some of the same areas (red arrows, lower row)



62 year old diabetic patient with occlusion of the left internal carotid and vertebral artery demonstrating a reduced hemodynamic response after vasodilation with acetazolamide in the left medial and posterior cerebral artery perfusion territories (arrows). a) T2 weighted MR; b) rCBF Rest; c) rCBF post-Acetazolamide.

PET SCANNING OF THE BRAIN

In 2010 we saw a growing clinical interest in PET and PET/CT scanning of cerebral pathophysiology. These investigations cover the range from neurooncology, neurodegenerative disease, cerebrovascular disease and epilepsy.

The neuronuclear development within this field has been dominated by the exciting new possibilities that have arisen with the advent of advanced radioligands that specifically target one of the key protein structures that accumulate in the brain in Alzheimers disease, namely A β -Amyloid. We primarily synthesize our own radioligand called Pittsburgh compound B (^{11}C -PIB), but in clinical trials we are also testing longer lived isotopes, that are more suited for routine clinical use.

This ground breaking noninvasive molecular imaging innovation allows for the first time a direct visualization of etiology of the most widespread cause of dementia. It efficiently supplements PET imaging of the cerebral glucose metabolism using ^{18}F -FDG that can evaluate the stage of the disease process and diagnose different dementia subtypes. In 2010 we have participated in several randomized controlled clinical trials of new drugs targeting Alzheimers disease, where both tracers have been used to establish a biological foundation for the treatment effects. We predict that the changing demographics and these new treatment modalities will increase the future demand of molecular brain imaging.

We have also seen an increasing interest for evaluation of the hemodynamic cerebrovascular reserve capacity. The patients have chronic cerebrovascular disease and occlusion of the cerebral vessels usually on the basis of artherosclerotic pathology. This is performed using repeated measurements of the regional cerebral blood flow (rCBF) and ^{15}O -labelled water before and after vascular dilation with acetazolamide. The investigation is used in the selection of patients for revascularizing surgery at the Charité Hospital in Berlin, a procedure that can reduce the risk of stroke in this patient category.



Ian Law

ACADEMIC ACTIVITIES

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

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

Lise Borgwardt, Senior Registrar, is a member of the Tumor Board for Pediatric Solid Tumors at Copenhagen University Hospital, Rigshospitalet, external member of the guideline group for Pediatric PET under EANM and 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.

Philip Hasbak, Chief Physician, is a member of Nucleus on the Decision of Library Subscriptions in Denmark, and a member of Nucleus for Implementing National Pathways for Life-threatening Cardiac Diseases.

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.

Søren Holm, Chief Physicist, is President of the Danish Society for Medical Physics (DSMF), a delegate for the DSMF at the European Federation of Organizations in Medical Physics (EFOMP), 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.

Professor Liselotte Højgaard, 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 the Science Advisory Board, the European Science foundation. Member, Conseil d'Administration, INSERM, L'Institut National de la Sante et de la Recherches Medicales, Frankrig. Member of the Science Advisory Board, IMI, The Innovative Medicines Initiative. Chair of of EC FP7 Science Advisory Board in Medical Research. Member of the ESS European Spallation Source, Preparatory Group, University of Copenhagen. She represents the University of Copenhagen and Rigshospitalet in the program, MSc in Medicine and Technology in cooperation with The Technical University of Denmark (DTU). Member of ATV "The Danish Academy of Technical Sciences". Member of the advisory boards: Wonderful Copenhagen, Medico-Innovation, Arvid Nilssons Foundation and Tagea Brandt.

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.

Professor Andreas Kjær, Chief Physician, is the President of the Scandinavian Society of Clinical Physiology and Nuclear Medicine (SSCPNM), a member of the Board of the Research Council at Rigshospitalet, a member of the Scientific Committee of the Danish Cancer Society, Editor-in-Chief of Open Neuroendocrinology Journal, leader of the project Molecular Imaging for Testing of New Drugs funded by the Danish National Advanced Technology Foundation, 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, 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.

Linda Kragh, Chief Nuclear Medicine Technologist, is member of Sundhedsfagligt Råd i Klinisk Fysiologi og Nuklearmedicin i Region H, the Speciality Advisory Committee (SFR) 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.

Jann Mortensen, Clinical Associate Professor, Chief Physician, is a member 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 videnskabsetiske 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 (Danish Society of Clinical Physiology and Nuclear Medicine) and representative for DSKFNM in "Dansk Medicinsk Selskab" (Danish Medical Society). 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).

Peter Oturai, Chief Physician, is responsible for the postgraduate education. He is Danish delegate, representing Danish Society for Clinical Physiology and Nuclear Medicine (DSKFNM), in the European Union of Medical Specialists (UEMS), and in the World Federation of Nuclear Medicine and Biology. 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. He is responsible for the specialist course in Endocrine Pathophysiology for nuclear medicine physicians. He is webmaster for the DSKFNM and Danske Laboratorie Læger (DLO) internet homepages.

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.

PATIENT INVESTIGATIONS 2010

CNS and peripheral nervous system

Regional cerebral blood flow, DIAMOX, ^{15}O -H ₂ O	16
Regional cerebral metabolism, ^{18}F -FDG	301
Regional cerebral metabolism, ^{18}F -Altanserlin	19
Regional cerebral receptor, stat. ^{11}C -DASB	37
Regional cerebral receptor, stat. ^{11}C -SB	24
Regional cerebral receptor, stat. ^{11}C -PIB	8
Regional cerebral receptor, ^{11}C -PIB,	54
Regional cerebral receptor, ^{18}F -PIB,	8
Regional cerebral receptor, dyn. ^{18}F -AH110690	1
Regional cerebral receptor, dyn. ^{11}C -FMZ	7
Regional cerebral receptor, stat. ^{11}C -CUMI	4
Total	479

Respiratory organs

Lung function test, whole body plethysmography	1682
Lung function test, whole body plethysmography w/reversibility	96
Lung function test, spirometry, WLHLB + WLILB	1282
Lung function test, spirometry w/reversibility	126
Lung function test, spirometry, physiological provocation	4
Lung function test, diffusionscapacity (CO)	3112
Max. inspiratorisk og eksploratorisk muskeltryk	11
Lung perfusion scintigraphy, $^{99\text{mTc}}$ -MAA	148
Lung perfusion scintigraphy, regional, $^{99\text{mTc}}$ -MAA	74
Lung perfusion scintigraphy, Spect, $^{99\text{mTc}}$ -MAA	175
Lung ventilation scintigraphy, Spect, $^{81\text{m}}\text{Kr}$ -gas	205
Lung ventilation scintigraphy, $^{81\text{m}}\text{Kr}$ -gas	136
Lung ventilation scintigraphy, regional, $^{81\text{m}}\text{Kr}$ -gas	119
Mucociliary clearance, $^{99\text{mTc}}$ -venticolloid	29
Total	7199

Heart and cardiovascular system

Isotope cardiography, first pass, $^{99\text{mTc}}$ -HSA	6
Isotope cardiography, LVEF, $^{99\text{mTc}}$ -HSA	1461
Isotope cardiography, LVEF, $^{99\text{mTc}}$ -erythrocytter	2
Isotope cardiography, LVEF + vol., $^{99\text{mTc}}$ -HSA	3
Myocardial perf. scintigr. gated, $^{99\text{mTc}}$ -MIBI, pharmacol. stress, dipy.	14
Myocardial perf. scintigr. gated, $^{99\text{mTc}}$ -MIBI, pharmacol. stress, adeno.	133
Myocardial perf. scintigr. gated, $^{99\text{mTc}}$ -MIBI, physiological stress	139
Myocardial perf. scintigr. gated, $^{99\text{mTc}}$ -MIBI, NTG	188
Myocardial perf. scintigr. gated, $^{99\text{mTc}}$ -MIBI	5
Myocardial Calcium score	125
Myocardie perf. scintigr. gated, ^{123}I -MIBG	8
PET myocardial perfusion, ^{13}N -NH ₃	12
PET myocardial perfusion, ^{13}N -NH ₃ , pharmacology. stress,	1
PET myocardial metabolism, ^{18}F -FDG	17
Exercise electrocardiography	26
Total	2140

Peripheral vessels

Isolated limb perfusion leakage monitoring, chemotherapy	12
Total	12

Gastrin intestinal tract, liver, biliary tract and pancreas

Salivary gland scintigraphy $^{99\text{mTc}}$ -pertechnetat	16
Bleeding scintigraphy (abdomen), $^{99\text{mTc}}$ -erythrocyt	3
Biliary tract scintigraphy, $^{99\text{mTc}}$ -Mebrofenin	20
Meckels diverticulum scintigraphy, $^{99\text{mTc}}$ -pertechnetat	2
Total	41

Kidneys and urinary tract

Glomerular filtration, ^{51}Cr -EDTA, several samples	190
Glomerular filtration, ^{51}Cr -EDTA, one sample	4496
Renal scintigraphy, $^{99\text{mTc}}$ -DMSA	3
Renography, $^{99\text{mTc}}$ -MAG, diuresis	29
Renography, $^{99\text{mTc}}$ -MAG 3, Dual head	2
Renography, $^{99\text{mTc}}$ -MAG 3	1801
Renography, $^{99\text{mTc}}$ -MAG 3, ACE-inhibitor	112
Renography, $^{99\text{mTc}}$ -MAG 3, Graft	8
Total	6641

Bone and joint

Bone scintigraphy, $^{99\text{mTc}}$ -HDP, regional, static	59
Bone scintigraphy, $^{99\text{mTc}}$ -HDP, whole body, static	997
Bone scintigraphy, $^{99\text{mTc}}$ -HDP, SPECT	61
Bone marrow, $^{99\text{mTc}}$ -nanocolloid	1
Bone scintigraphy, ^{18}F -flourid, whole body, static	10
Total	1128

Endocrine organs

Thyreoide scintigraphy, $^{99\text{mTc}}$ -pertechnetat	510
Parathyreoide scintigraphy, $^{99\text{mTc}}$ -MIBI, SPECT + CT	43
Tumorscintigraphy, ^{123}I -jodid	105
Adrenal marrow scintigraphy, ^{123}I -MIBG	38
Whole body scintigraphy after ^{131}I -therapy	63
Scintigraphy after ^{177}Lu -dotatate -therapy	179
Total	938

Blood and lymph system

Erythrocyt volume, $^{99\text{mTc}}$ -ery	9
Lymph scintigraphy, extremities, $^{99\text{mTc}}$ -HSA, stases	2

Sentinel node, tumor drainage, ^{99m} Tc-nanocolloid, dynamic + static	59
Sentinel node scintigr. tumor drainage, mamma c., ^{99m} Tc-nanocolloid	22
Sentinel node scintigr. tumor drainage, malign. mel., ^{99m} Tc-nanocolloid	153
Sentinel node scintigr. tumor drainage, penis c., ^{99m} Tc-nanocolloid	21
Sentinel node scintigr. tumor drainage, vulva c., ^{99m} Tc-nanocolloid	11
Peritumoral injection of ^{99m} Tc-nanocolloid for sentinel node operation	738
Spleen scintigraphy, ^{99m} Tc-erythrocyte, heated	3
Total	1018

In vitro analysis

Plasma analysis	2500
Gen expression analysis	2500
Total	5000

Other diagnostic procedures

Tumor scintigraphy, ¹¹¹ In-Octreotide	311
PET tumor scanning, ¹⁸ F-FDG	4115
PET infection scanning, ¹⁸ F-FDG	47
PET tumor scintigraphy, ⁶⁴ Cu-NET-tracer	87
White blood cell scintigraphy, ^{99m} Tc	12
White blood cell scintigraphy, ¹¹¹ In	155
Whole body, contamination measurement	45
Image fusion (PET, SPECT, MRI, CT or planar), PET and KF-section	5241
Diagnostic CT, PET	4001
Diagnostic CT, KF	169
CT-therapy scanning	699
Description of external PET and PET/CT investigations	543
Digitilization PET images	73
Extra tumor delineation	76
Description of external SPET/CT investigations	5
Supplementary/repeated imaging, PET and KF-section	1816
Investigation without specification	351
Total	17746

Radiotherapy

Treatment with ¹³¹ I, benign thyroid	88
Isotope treatment with Zevalin ⁹⁰ Yttrium	1
Isotope treatment with ¹⁷⁷ Lutetium-dotatate	75
Total	164

Total number of patient investigations	42,506
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ANIMAL STUDIES

Rats

⁶⁴ Cu-ATSM	26
¹⁸ F-FDG	56
¹¹¹ Indium-rFVIIa	6

Mice

¹⁸ F-FDG	194
¹⁸ F-FLT	202
⁶⁴ Cu-Dotatate	108
⁶⁸ Ga-AE219	100
⁶⁴ Cu-AE219	35
¹⁸ F-RGD	12
⁶⁸ Ga-RGD	10
⁶⁸ Ga-Dotatoc	48
⁶⁴ Cu-ATSM	80
¹²⁴ I-antibody	12
⁶⁴ Cu-lipoider	20
¹¹¹ In-MUC1	16
¹⁷⁷ Lu-Dotatate	76

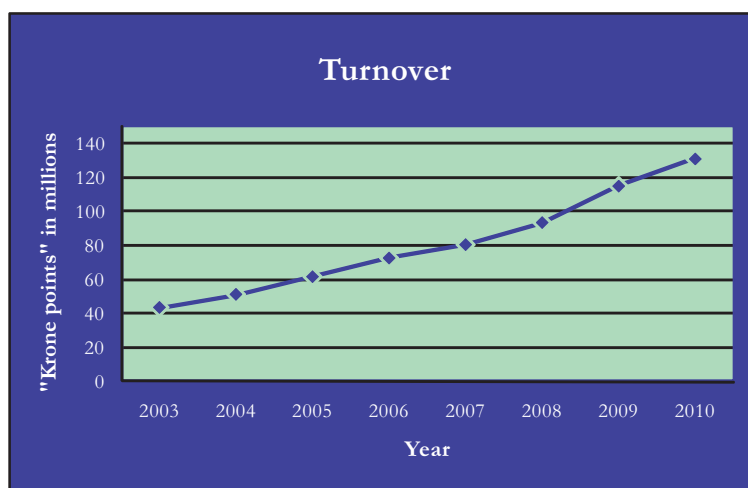
Pigs

¹¹ C PIB	14
¹¹ C-ligands	7
¹⁸ F-Altanserine	2
¹⁵ O-H ₂ O	1

Dogs

⁶⁴ Cu sarcom ATSM	4
¹⁸ F-FDG	4
Total	1033

FINANCE



The increase in activities measured in “krone points” rose from 43.5 million in 2003 to 131 million in 2010.

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

Balance 2010

Expenditure

Running costs	DKK	19.8 million
Staff	DKK	47.2 million

In total	DKK	67 million
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Receipts	DKK	22.8 million
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Net sum	DKK	44.2 million
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RESEARCH

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 currently given special attention in order to reduce time from development to use in patients. Some current areas of major research are detailed below.

New tracers

Several 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, among them targeted nanoparticles, are at present evaluated. For validation of tracers, we have molecular biology 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.

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 (IMRT, “dose-painting”) and the use of respiratory gating are also currently being evaluated.

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 is studied. In cooperation with Neurobiology Research Unit and Center 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 can non-invasively visualize atherosclerosis and predict vulnerability of atherosclerotic plaques. With this technique, several studies in different groups of patients at risk are currently undertaken.

Nuclear cardiology

With the use of PET, coronary flow regulation is studied in connection with gene therapy and pharmacological interventions in a variety of disease states. With the use of SPECT/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, 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. 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.



Andreas Kjær



CLUSTER FOR MOLECULAR IMAGING

The change in paradigm from population based therapy to individualized, tailored therapy has led to an increasing 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 diagnosis at the cellular and molecular level in living, intact organism. With PET it is possible to label biomolecules with radioactive isotopes to be used for visualization of e.g. metabolism, receptors and gene-expression. Especially within cancer biology, but not limited to this, these techniques are expected to lead to a break-through in diagnosing and treatment. Of the different methods for molecular imaging only the nuclear medicine based techniques are of a true translational nature, i.e. methods developed in animal models may directly be transferred to and used in humans.

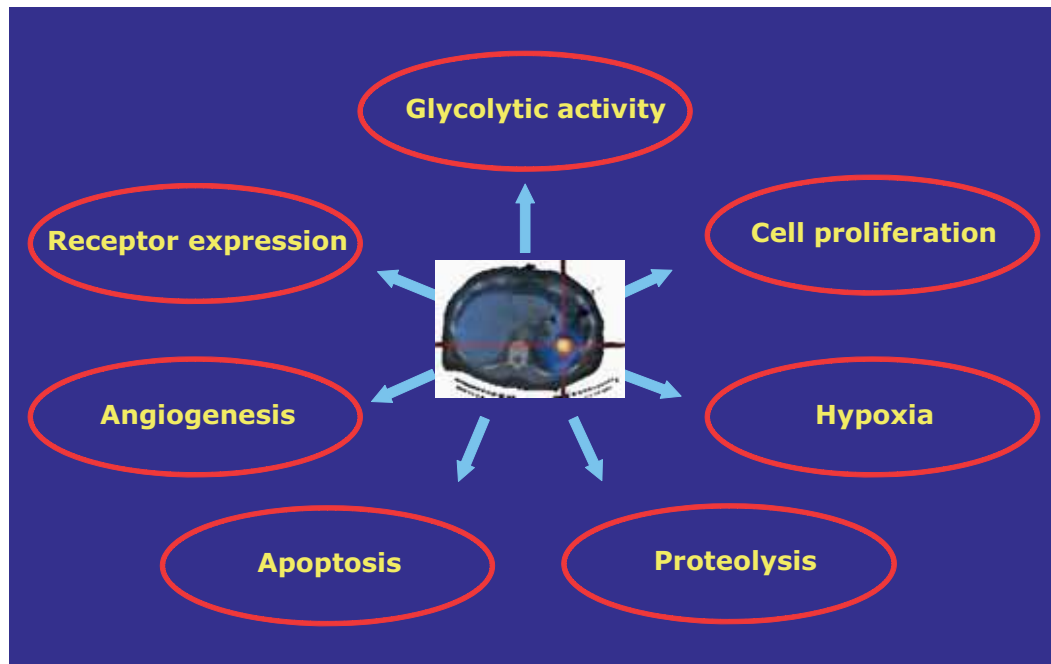
Our current molecular imaging research program is aimed at through use of molecular biology and imaging techniques in both animals and humans to develop, evaluate and use non-invasive molecular imaging for human tissue characterization. Two major applications of these tracers are anticipated: 1) planning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

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 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.



Some tissue characteristics currently targeted for imaging

Cluster for Molecular Imaging is imaging partner in the European Advanced Translational Infra-structure 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. However, several other applications are also foreseen.



Andreas Kjær

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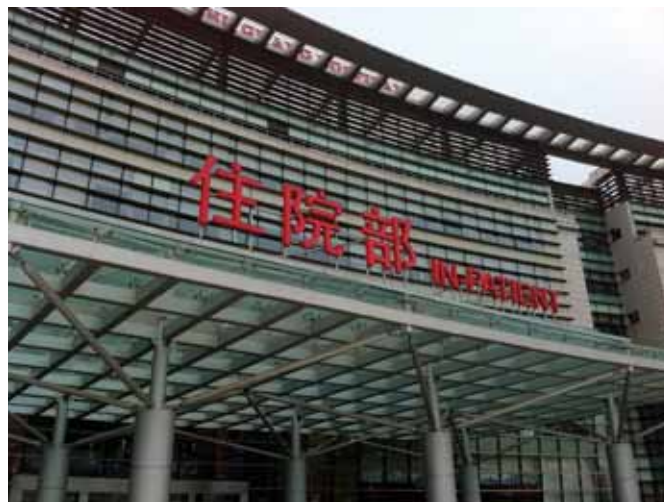
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As in previous annual reports we have listed scientific papers only and not the many abstracts and proceedings from the department.





The Seventh Scientific Meeting of the Danish-Chinese Center for Proteases and Cancer held in Fuzhou, China with participation from our department.



Shuguang University Hospital in Pudong, Shanghai



DANISH - CHINESE COLLABORATION

The Department has extensive collaboration with institutions in China. The main focus is on molecular imaging of cancer and evaluation of anti-cancer therapy, including Traditional Chinese Medicine (TCM).

Professor Andreas Kjær is partner in the Danish Chinese Center for Proteases and Cancer funded by the The National Natural Science Foundation of China and the Danish National Research Foundation. The center was established to strengthen cancer research leading to tailored therapy. Participants are in addition to Rigshospitalet, Aarhus University and Chinese researchers from the Chinese Academy of Sciences, Fuzhou and Soochow University, Suzhou. Workshops have been held in 2010 and the center has produced some promising results in PET imaging of the invasive phenotype.



Professor Andreas Kjær giving a lecture on Molecular Imaging for Tailored Cancer Therapy in Fuzhou, China.

We have continued and extended our collaboration with Shuguang University Hospital in Shanghai, a program centered around using PET for non-invasive testing of Chinese anti-cancer treatments. The program includes pre-clinical animal models as well as testing in cancer patients in China. We have now successfully tested two Chinese anti-cancer drugs. A visiting scientist from Shuguang Hospital is planned to stay at our institution as part of the collaboration. The research collaboration is supported through a grant by the Danish Ministry of Health and Prevention.

COLLABORATION WITH LANDSSYGEHUSET, FAROE ISLANDS

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

The hospital has:

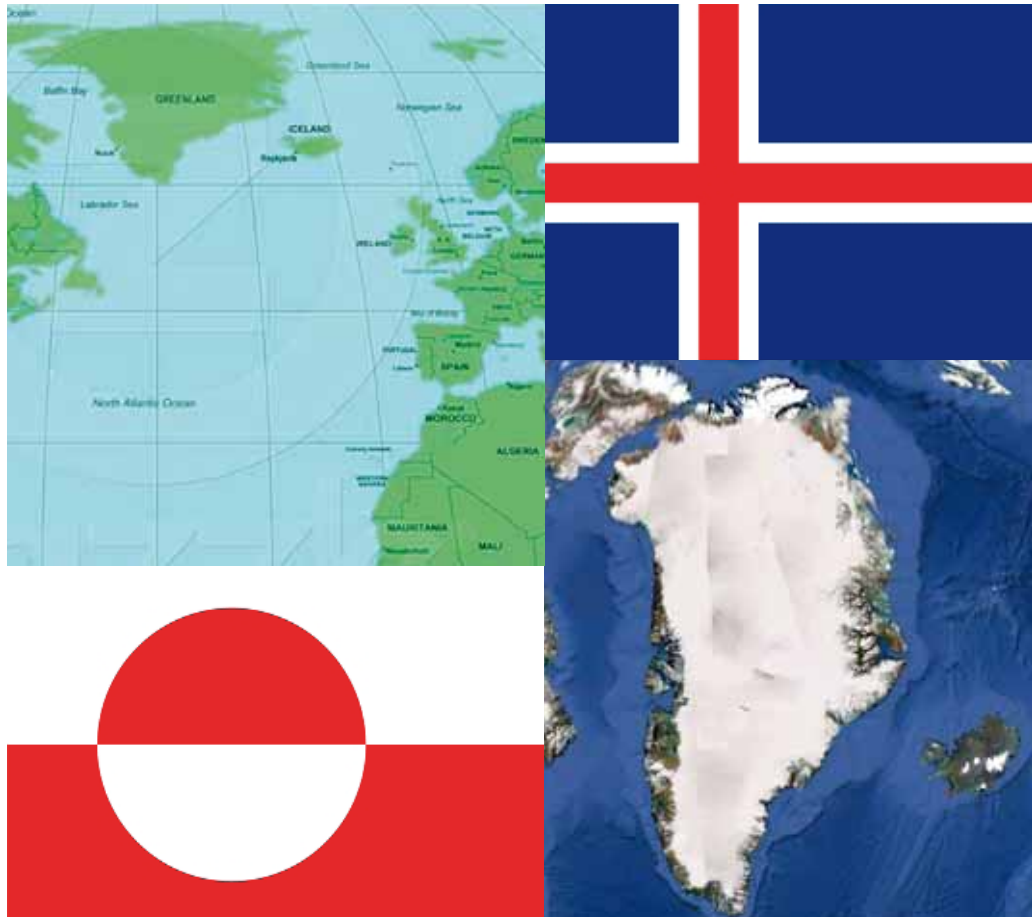
- a staff of 850 (the largest employer in Faroe Islands)
- 180 beds
- 9,000 in-patients and 35,000 out-patients annually
- 29 specialities, of which 9 consultant collaborations, including collaboration in nuclear medicine with Rigshospitalet

Department of Nuclear Medicine in Tórshavn performs annually nearly 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 lungfunction equipment. Second-opinion on specific issues 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

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



Jann Mortensen and Thomas Levin Klausen

Global Excellence – in health **2010**



Dept. Clinical Physiology, Nuclear Medicine & PET

is awarded Global Excellence – in health 2010.

The award is granted for outstanding contribution to development of world class health care services in the Capital Region of Denmark.

Global Excellence in Health is intended to promote highly qualified professional environments of international standard within health at universities and hospitals in the region.



Vibeke Storm Rasmussen, Regional Council Chairman



Marianne Stendell, Chairman of the Education and Research Committee

GRANTS, FOUNDATIONS AND AWARDS

Global Excellence Prize

Globalization makes world-class environments necessary to retain a leading position in research-based health care. To acknowledge and make these leading hospital and university environments more visible, the Regional Council launched the Global Excellence In Health award program. Following a call for applications from leading groups and departments, an international assessment panel evaluated and selected awardees to receive the prestigious prize.

Professor Andreas Kjær and his cross-disciplinary research team at the Department of Clinical Physiology, Nuclear Medicine & PET was awarded Global Excellence in Health for their research and clinical program on molecular imaging for tailored cancer therapy.

The program is focused on development of better diagnosis and treatment of cancer patients using new PET scanning methods. Currently the research is focused on neuroendocrine tumors and conducted in collaboration with several other departments at Rigshospitalet including the departments of abdominal surgery and oncology as well as the Finsen laboratory. In addition, institutes at the University of Copenhagen and the Technical University of Denmark are also part of the research collaboration.

Perspectives of the research program includes the ability for in the future to predict response to chemotherapy few hours after a test dose has been given. In addition, patients suitable for certain therapies, e.g. anti-angiogenesis treatment can be selected on basis of a PET scan demonstrating whether angiogenesis is taking place at a high level. Finally, we are developing a new PET scan that can identify the invasive phenotype of cancer. [We foresee, that the results from our research will lead to improved diagnosis and treatment for the benefit of cancer patients.](#)



Andreas Kjær

Klein Prize



Professor Liselotte Højgaard was granted the prestigious Klein Prize from the Medical Society of Copenhagen (founded 1772). The department was there to celebrate when Liselotte Højgaard received the prize in Domus Medica.

Acknowledgements

The Department wish to express our gratitude to the following public and private foundations for their generous support:

- The John and Birthe Meyer Foundation
- A.P. Møller and Hustru Chastine Mc-Kinney Møllers Foundation for General Purposes
- Novo Nordisk Foundation
- Lundbeck Foundation
- Svend Andersen Foundation
- Danish National Advanced Technology Foundation
- Danish National Research Foundation
- Danish Council for Independent Research in Medical Sciences
- Rigshospitalets Research Council
- University of Copenhagen
- Capital Region of Denmark
- Danish Ministry of Interior and Health
- Danish Cancer Society
- EU FP 7

MSc IN MEDICINE AND TECHNOLOGY

In cooperation with the Technical University of Denmark (DTU) and the University of Copenhagen (KU), the Department represented by Professor Liselotte Højgaard is involved in the MSc program in Medicine and Technology. It is a five-year bioengineering degree at bachelor and master's level. The first master graduated in 2008. Since the launch of the program in 2003 more than 200 students have applied for the 60 available places each year. You can read more about the program at www.medicin-ing.dk.



At present 4 of these bioengineers are seconded to the Department as PhD students and we have numerous students working with bachelor and master reports in collaboration with DTU, IMM (Institute for Mathematical Modelling), Professor Rasmus Larsen and DTU, Electro with Professor Jørgen Arendt Jensen and our department here at Rigshospitalet. [In 2010 the course was subject to accreditation with a positive result.](#) A warm thank you to Professor Jørgen Arendt Jensen, Associate Professor Kaj-Åge Henneberg, Reader Jens E. Wilhjelm, DTU and Associate Professor Bente Stallknecht, University of Copenhagen, for their great effort and our great collaboration both on education and research.

Liselotte Højgaard



CIMBI - CENTER FOR INTEGRATED MOLECULAR BRAIN IMAGING, UNIVERSITY OF COPENHAGEN, RIGSHOSPITALET



In cooperation with the Neurobiology Research Unit, Professor Gitte Moos Knudsen, a series of neuroreceptor ligands are being developed and used for research in neurobiology.

The focus has mainly been on the serotonergic system. In 2010 Gitte Moos Knudsen had the grant from the Lundbeck Foundation renewed for CIMBI, Center for Integrated Molecular Brain Imaging. We are proud to collaborate on the PET studies.



EDUCATION AND VISITS

The Department of Clinical Physiology, Nuclear Medicine & PET 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 radiography 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-, lung-, and endocrinology- 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.

For all staff members the department's 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. Technologists from our department and from departments all over Denmark have participated in the *CT course for Nuclear Medicine Technologists*, officially acknowledged by the National Institute of Radiation Protection. The course is arranged by the department and allows the staff to be in charge of the PET/CT and SPECT/CT scanners.

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 2010 we have had visits from England, Australia, Iceland, Italy, Sweden, Norway and Switzerland. The departments educational activities have been accredited by the *Danish National Board of Health* and by the *Accreditation of Nuclear Medicine Training Centers 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 under-graduate education of medical students. Professor Liselotte Højgaard is responsible for under- and postgraduate education for bioengineers.



Jann Mortensen and Peter Oturai

NUCLEAR MEDICINE TECHNOLOGISTS

The nuclear medicine technologist, radiographer, nurse and laboratory technician take care of different tasks depending on the section they belong to. In 2010 the number of patient investigations increased by 9%, and all staff members have exercised their power in full. The waiting lists have been kept down by extending opening hours from 16 to 19 on several days. Thank you for the great effort.

PET Scanner Section

In 2010 the number of PET/CT scans with ^{18}F -FDG PET and diagnostic CT scans, as well as PET/CT scans for therapy planning increased. It is now common practice to perform the FDG injections using an automatic FDG injector and to calculate the dose of FDG according to body weight and BMI. Following these changes we have reduced the radiation dose to the nuclear medicine technologists.

The majority of the PET/CT scans are included in scientific research protocols. Each protocol has a nuclear medicine technologist assigned who performs the examinations, the transfer of data, the image reconstruction and quality assurance.

In collaboration with CIMBI brain PET scans are performed with various tracers, and other projects like FINE (obesity and physical training in a health-promotion perspective) are also performed late afternoon and evening.

Education-wise all nuclear medicine technologists have passed a special CT training course with certification, some have passed the extended CT training course, and this year two technologists passed the radio therapy training course.

Head of the PET Scanner Section is Deputy Chief Technologist Kate Pedersen.



PET injector

KF Section

The nuclear medicine technologists produce the radiolabeled drugs and blood components used for the patient studies on gamma camera and prepare the radioactive drugs for therapy, e.g. ^{131}I -Iodine for patients with goitre and ^{177}Lu -DOTATATE for treatment of patients with neuroendocrine tumors. The nuclear medicine technologists perform all gamma camera examinations and many of the SPECT/CT examinations are now made with diagnostic quality CT scanning with oral and intravenous contrast.

In 2010 we implemented a new one-head gamma camera. It has reduced the waiting list on the large number of renographies and MUGA-studies. The use of SPECT/CT scanning has increased, as all lung perfusion and ventilation scintigraphies with the indication lung thromboses were performed with SPECT/CT following the new guidelines.

Our quality manual for all the patient examinations and procedures has been updated and implemented in an "electronic document manager". Thank you to the quality team.

The descriptions and results of examinations were until 2010 released in paper form, now we have made progress and about 90% of all studies are sent by digital media. Some of the nuclear medicine technologists have been educated to do peritumoral sentinel node injection to mamma cancer operations.

The majority of examinations are included in research protocols and normally they involve the nuclear medicine technologists. In the "CORE 320 protocol" study we measure particle sizes in a drug for pulmonary disease by a cascade impactor and a radioactive isotope and nuclear medicine technologists in cooperation with the Department of Radiology provoke and inject the patients for myocardial scintigraphy, while they are laying in the Toshiba 320 slice CT scanner.

Several technologists have participated in courses in endocrinology. The majority of the technologists has the basic, and half of the staff, the extended CT course. We have currently two technologists attending the advanced CT course and there are seven more, who are certified for i.v. injections with contrast.

Head of the KF Section is Deputy Chief Technologist Tim Lundby.



Radio Chemistry Section

In 2010 new equipment as well as several new radiopharmaceuticals have been introduced and validated in the department. After several technical challenges the synthesis of ^{68}Ga -DOTATOC finally could be produced reliably and Nuclear Medicine Technologist Louise Sørup participated in performing method and process validation of ^{68}Ga -DOTATOC.

Nuclear Medicine Technologist Tina Wikke has performed method and process validation of ^{18}F -FLT. In August we welcomed laboratory technician Sonja Lærke who has been working on a new packing system that could meet the regulations from the National Institute of Radiation for distribution and transportation of ^{18}F -FDG and $^{81\text{m}}\text{Kr}$ to our customers.

In September we received our new “Theodorico” dispensing system for ^{18}F -FDG from Comecer S.p.A. In May 2010 Chief Chemist Nic Gillings, Production Manager Jacob Madsen and Deputy Chief Technologist Anne Sørensen visited Comecer in Bologna, Italy to participate in a Factory Acceptance Test (FAT) of the dispenser. In November Louise Sørup, Jacob Madsen and Anne Sørensen performed a site acceptance test (SAT), which forms the basis for the application to the Danish Medicines Agency for permission to use the dispenser in the daily routine production. Head of the Radio Chemistry Section is Deputy Chief Technologist Anne Sørensen.

EANM congress in Vienna

Nuclear medicine technologists Karin Stahr and Elin Lindell presented their 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”.

Estro congress in Barcelona

Elisabeth Abrahamson and Marianne Federspiel were invited to speak about “How to perform a therapy PET/CT scan of lung cancer”.

Metropolitan University College, Copenhagen

Bente Dahl taught technologist students: PET/CT examinations in cancer patients. The Symposium for Technologists at the University Hospital Rigshospitalet: Camilla Knudsen, Anna Ljunggreen and Bente Dall presented the poster “A Strategy for regional analysis, using a clinical amyloid ligand ^{11}C -PIB in dementia”. Mette Frederiksen had an oral presentation: Treatment of neuroendocrine tumors with ^{177}Lu -DOTATATE in Rigshospitalet.

The department's annual summer meeting

Rebecca Mychetsky gave a dias-show about the procedures in the Cluster for Molecular Imaging and Tina Wikke gave an oral presentation on the subject: "Approval of a drug for human use".



Linda M. Kragh



PET AND PET/CT SCANNERS

The PET and Cyclotron Unit currently has one dedicated, stand-alone brain PET scanner and four combined PET/CT scanners in the hospital itself (the 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.

Brain scans to a large extent are run on the HRRT (High Resolution Research Tomograph). Originally intended - as the name indicates - mainly for research, the HRRT has 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. Technically, the HRRT has a record high number of detector crystal elements (119.808). The enormous amount of data these detectors create has always been a major challenge, but the continuous improvement in computer performance has now reached a practical level where image reconstruction times are comparable to the acquisition time. The images provide a resolution of 2-3 mm in the full field of view by standard reconstruction methods, but using improved reconstruction software (PSF-based) this can be reduced to 1.5-2 mm. Our computer scientists work actively to improve the software and provide support to the HRRT User group.

The majority of studies in the PET Section continues 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.

Our first PET/CT scanner was the GE Discovery LS, where the PET was a slightly updated version of the Advance PET scanner from 1993. The Discovery LS was installed in the autumn of 2001 as the second PET/CT in Europe. Today its 4-slice CT is considered inappropriate in most cases, and also the PET part is rapidly approaching end-of-life, technically, and a replacement is being applied for.

Our second PET/CT, installed in 2005, was a Siemens Biograph with 16 slice CT. During August of 2010 it has been substituted by a most modern Siemens mCT having 64 slice CT and the possibility 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 the one it replaced, this scanner is running in a unique well-functioning collaboration with the Department of Radiotherapy, and it is extensively used for therapy planning, for which purpose the larger opening (78 cm) is also an important design improvement.

In 2007 a third PET/CT scanner installation was made in the new extension of the Finsen building. The Siemens Biograph 40 has a CT scanner with 40 slices, and the PET axial field of view was extended (in round figures) from 15 to 20 cm. This apparently minor change increased the overall sensitivity by 78% that can be used to obtain (a combination of) lower doses, faster scans and improved images. The fourth PET/CT installation that came into routine use during the summer 2009 was a Siemens Biograph 64, identical to the previous except for the extended number of CT-slices (64 instead of 40). The two scanners share one large control room and the patient facilities. Recently a MedRad infusion cart has been achieved which reduces (finger) doses to the technologist staff. It also makes individual weight-based activity dosing feasible, and this has been utilised to optimise the combination of injected activity and scan time as a function of patient size and habitus, while reducing the average patient dose by ~25%.

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.



Søren Holm



PET 4 Scanner

EQUIPMENT

Equipment	Product	Purchase year
Gamma cameras	Philips ADAC Thyurus	2001
	Mie-Scinttron	2004
	Mediso N-TH45-D	2008
SPECT cameras	GE Millenium VG, Hawkeye, low dose CT	2001
	Philips ADAC Skylight	2002
	Mediso Nucline X-Ring-R/HR	2009
SPECT/CT cameras	Philips, Precedence 16-slice	2006
	Philips, Precedence 16-slice	2008
PET scanners	HRRT Siemens/CTI	2007
PET/CT scanners	GE Discovery LS	2001
	Siemens Biograph TrueV 40-slice CT	2007
	Siemens Biograph TrueV 64-slice CT	2009
	Siemens mCT-S (64)	2010
Lung function	Jaeger Masterscreen w/bodybox	2005
	Jaeger PFT pro w/bodybox	2007
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

The John & Birthe Meyer Foundation has donated the equipment in the PET & Cyclotron Unit.

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





EUROPEAN MEDICAL RESEARCH COUNCILS

The European Medical Research Councils (EMRC) is the membership organization 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 Organizations involved and also observers from the European Commission, The Wellcome Trust, WHO-Europe, Australia, Canada, Israel, New Zealand and USA.

In 2010 EMRC worked very hard for the revision of the EU “Animal Directive for Medical Research”. Together with members and a broad circle of organizations and researchers we have published 3 Science Policy Papers on revising the directive, emphasizing the importance of a dignified approach to research on animals for scientific purposes, at the same time without hindering research possibilities. It was a great victory, when the new EU Directive was accepted by the European Parliament Fall 2010. Thank you very much to all involved in this important endeavor for the future possibilities for animal biomedical research in Europe.

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.



We held the EMRC Annual Meeting in Strasbourg at the Council of Europe with presence from the NIH Dr. Susan Shuring, from Canada Dr. Alan Beaudet, from Australia Dr. Clive Morris, from New Zealand Dr. Robin Olds and from United Kingdom Dr. Tony Petfield. Thank you to all EMRC Core Group and plenary members and to our foreign guests for making it a very productive meeting. Following this we had the Consensus Conference for the new Forward Look on “Implementation of medical research in patient treatment”. This report will come out in spring 2011 and hopefully be a new landmarked publication in this area.

The EMRC Spring Meeting 2010 was held at DFG, Deutsche Forschungsgemeinschaft in Berlin in May, at the same time as the Iceland volcano made it difficult for travel in Europe. We would like to express a warm thank you to DFG for hosting us at this occasion and to all members for the stamina and persistence needed to make it to Berlin.

In 2010 the Science Policy Briefing on “Male Reproductive Health” was published after a huge and very fast effort from Prof. Niels Erik Skakkebaek and co-workers. Thank you for this important endeavor and for the successful international communication about the report. Hopefully it will have impact on both funding and science policy.

The Science Policy Briefing on “The use of MRI in relation to patient and staff safety” was published also in 2010 and will be important for the future use of MRI in Europe. Thank you to all contributors for the great effort.

Thank you to the EMRC Unit at ESF in Strasbourg for all the work done in 2010. It has been a tough year in many ways: the Iceland volcano, the discussions about changes at the ESF and EUROHORCS made it a special year. The dedicated work and the high productivity is acknowledged more than ever. A warm thank you to the whole unit, especially Unit Coordinator Janet Latzel, Science Officer Kirsten Steinhausen and last, but not least, Head of Unit Dr. Stephane Berghmans.



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



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Vibeke Rønn

Layout and print

Lars Søvn Dahl Pedersen
Frydenberg Tryk A/S

Fotos

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Bent Børgesen
Bo Holm
Søren Holm
Andreas Kjær
NRC Network University Research Conference

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