

DEPARTMENT OF CLINICAL PHYSIOLOGY AND NUCLEAR MEDICINE & PET AND CYCLOTRON UNIT

Department of Clinical Physiology and
Nuclear Medicine & PET and Cyclotron Unit, KF 4011,
Rigshospitalet, Copenhagen University Hospital,
Blegdamsvej 9, DK-2100 Copenhagen Ø, Denmark.
Telephone: +45 3545 4011
Fax no: +45 3545 4015
KF@rh.dk
www.kf.rh.dk

PET & Cyclotron Unit, division 3982,
Rigshospitalet, Copenhagen University Hospital,
Blegdamsvej 9, DK-2100 Copenhagen Ø, Denmark.
Telephone: +45 3545 3919
Fax no: +45 3545 3898
PET@rh.dk
www.pet.rh.dk



Contents

4	Preface
6	Mission and Objectives
8	Organisation and Staff
10	Equipment
10	Accreditation
12	Highlight of the year 2005
14	Nuclear medicine
15	Paediatric investigations
16	Cyclotron unit
17	Radiochemistry
18	PET and PET/CT scanners
19	PET/CT and Radiotherapy
20	Patient investigations
21	Finance
22	Research
23	From molecule to diagnosis
24	Publications
26	Education
27	Nuclear Medicine Technologists
28	Other activities
29	MSc in Medicine and Technology
29	Grants and foundations
30	The future of Clinical Physiology and Nuclear Medicine in the New Region

Preface

By Liselotte Højgaard

The highlight of 2005 was the opening of the new advanced Siemens Biograph Hi-Rez PET/CT scanner donated by The John & Birthe Meyer Foundation. Ms. Birthe Meyer, Ms. Gitte Meyer Brandt, Mr. Henrik Meyer and Director Søren Drost-Nissen from The John & Birthe Meyer Foundation participated in the opening. We had a very nice day at the opening symposium with international participants: Professor Thomas Beyer, Essen, Professor Bengt Långström, Uppsala, Professor Søren Bentzen, Madison and Professor Janet Eary, Seattle.

All the equipment in the PET and Cyclotron Unit has been donated throughout the years from The John & Birthe Meyer Foundation, to whom we are very grateful for their generous contributions.

The increasing numbers of patients investigated in 2005 were primarily cancer patients with complicated cases. As regards sentinel node investigations, we have extended the indications to comprise head and neck cancer. The number of patients referred to octreotid scintigraphies has been augmented with the gamma camera scintigraphies performed as SPECT and low dose CT for a more precise tumor localisation. For parathyroid scintigraphies, the routine is also to carry out SPECT with CT to optimize the useability of the studies for minimal invasive surgery procedures. The increasing number of patients given chemotherapy at Rigshospitalet has resulted

in an increase in the number of patients investigated daily by renal clearance studies to monitor renal function. We now perform more than 20 clearance studies daily, and the opening hours have been extended to comprise late afternoon and evening every Tuesday.

In The PET and Cyclotron Unit the production of FDG has increased and we now deliver FDG daily to our own PET and PET/CT scans and to Bispebjerg Hospital, Herlev Hospital, Glostrup Hospital, Hillerød Hospital, Lund University Hospital and also The Sahlgrenska Hospital in Gothenburg. The Cyclotron starts at 04:00 am in the morning and the FDG is ready at 08:00 am. The number of new tracers being developed in the cyclotron and radiochemistry unit has increased and the new production laboratories have been introduced in the daily routine. Every Tuesday night we produce ^{211}At – an alphaemitter for studies with monoclonal antibody radio treatment for micrometastasis from ovarian carcinoma for use in Gothenburg in trials performed in collaboration with the Sloan Kettering Cancer Center in New York.

We have experienced a rise in the number of PET and PET/CT patient scans including PET/CT for planning of radiotherapy with IMRT (intensity modulated radiotherapy). We are very grateful for the positive and rewarding collaboration with The Department of Radiotherapy represented by Dr. Svend Aage Engelholm, Head of Depart-

ment, Håkon Nyström, Chief Physicist and Kirsten Amsinck, Leading Staff Nurse. Also many thanks to The Department of Radiology for a fruitful collaboration on the CT and MRI scans for co-registration with PET. In 2005 the research and development was further developed and now comprises more than 50 peer review publications annually. The focus areas are primarily clinical research on PET and PET/CT, development of new radioisotopes and ligands, pediatric nuclear medicine including PET, labelling of stem-cells, neuro-PET in collaboration with The Neurobiology Research Unit. Research in nuclear cardiology and neuroendocrinology, lung function investigations and treatment with radionuclides, as well as research in the Whole Body Counter in collaboration with "The Royal Veterinary and Agricultural University in Denmark" (KVL).

Professor Andreas Kjær was appointed leader of the newly established "Cluster for Molecular Imaging" at Copenhagen University, the Faculty of Health Sciences, where he is leader of a group of researchers with interest in molecular imaging, gene expression imaging and pathophysiology. Andreas Kjær has established a molecular imaging facility at the Panum Institute with gamma camera, SPECT, PET/CT and other advanced imaging modalities for research in small animals. The department also participates in several European EU founded networks and integrated projects, where Associate Professor Jann Mortensen is ac-



2005 was a busy, exciting and positive year with an increasing number of patient investigations, in particular PET and PET/CT scans, also for radiotherapy planning – and a rising production in research and development.

tively engaged in the “AirPoLife” network. Our department staff has participated in many national and international meetings and congresses as invited lectures. They have given oral presentations, presented abstracts and posters and functioned as chairmen. Many international research groups have visited the department in 2005 and we have received frequent visits from Denmark and the other Nordic countries. We have participated in the Danish education for specialists in clinical physiology and nuclear medicine with several courses. Furthermore, we have held international courses and our nuclear medicine technologists and doctors have participated in the department’s own dedicated CT course. This allows our staff to run the PET/CT scanners; also for the CT part – and their CT competence is officially acknowledged by the Danish National Agency for Radiation Protection.

The four Departments of Clinical Physiology and Nuclear Medicine in the H:S hospitals in Copenhagen collaborated closely under the auspices of the “Specialty Advisory Committee in Clinical Physiology and Nuclear Medicine (SFR)”. In the spring of 2005, the four departments were audited again with focus on medical equipment and quality assessment and development. To utilize the expertise available in the four departments, we cooperate closely on patient investigations as well as research and development and the education of all staff groups. In the autumn of 2005, we partici-

pated in the “Report on use of Clinical Physiology and Nuclear Medicine in the new Region Hovedstaden” in collaboration with the other 7 departments in the Copenhagen and Northern Zealand region. In 2005 we had the second Joint Commission of Accreditation Evaluation and again the evaluaters visited our department. Their report was very positive. Our Chief Nuclear Medicine Technologist, Linda M. Kragh is head of the quality committee and responsible for patient safety and accreditation in the department. All standard operating procedures are updated and implemented in the revised quality handbook, autumn 2005.

The department participated in the education: “MSc in Medicine and Technology”. In September 2005, the third year of the programme, we again had more than 200 students applying for the 60 student slots. Linda M. Kragh, Chief Nuclear Medicine Technologist and Søren Holm, Chief Physicist were committee members of the “Danish Society for Clinical Physiology and Nuclear Medicine” (DSKFNM), and Kate Pedersen was committee member of the “European Society of Nuclear Medicine and Molecular Imaging Technologist Section”. Liselotte Højgaard was member of the “Danish Council for Research Policy” and finished the report from the Strategic Research Council, “Arbejdsgruppen for Forskningsinfrastruktur” (AFI), and was appointed chair of the “ESFRI Expert Group in Clinical and Translational Medical

Research”. In December 2005 Liselotte Højgaard received the Niels A. Lassen award 2006. At the annual meeting of the Danish Society for Clinical Physiology and Nuclear Medicine, Birger Hesse, MD, DMSc, consultant at the department received the “Prize of honour” of the society. In December 2005 Professor Andreas Kjær was informed that he was to receive the August Krogh Prize for 2006 at the annual meeting of the “Danish Medical Society”.

The contributions of the staff have been very high in 2005 for patient studies, isotope production, research & development and education, both in the PET and Cyclotron Unit and Clinical Physiology and Nuclear Medicine.

A very warm thank you to all staff members and all external collaborators for the contributions in 2005 – for the sake of better patient care and progress in research & development.



The staff has participated in a number of congresses, symposias, meetings and workshops with invited lectures, oral presentations, abstracts and posters. We have a comprehensive programme for all staff members at the department, and frequent visits from Danish and international research groups. In 2005 more than 80 groups visited the department.



Mission and Objectives

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

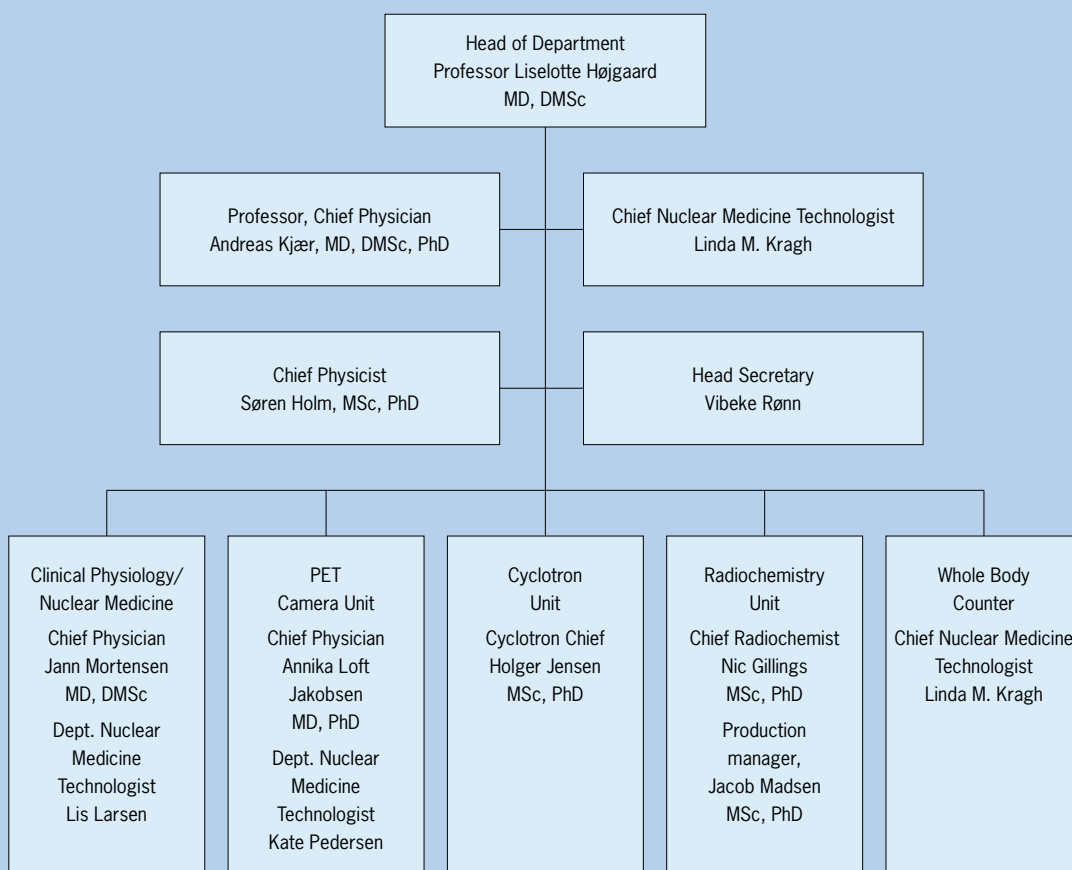
General objectives:

- To be in the lead within highly specialized diagnostics treatment and nursing
- To carry out research and development at an advanced international level
- To educate staff in the health services on an highly specialized level
- To contribute with professional advice and exchange of knowledge and expertise with the surrounding world
- To be characterized by openness and human respect

The objectives of The Department of Clinical Physiology and Nuclear Medicine & PET and Cyclotron Unit are:

- To carry out clinical patient investigations in clinical physiology and nuclear medicine, including PET – at the most advanced international level and dedicated to patients in need of highly specialized treatment.
- To conduct research and development in nuclear medicine, including PET and clinical physiology at a high international level
- To develop and test new radioactive isotopes and to produce radioactive isotopes and medicinal products for clinical purposes and research
- To participate in education and the spreading of knowledge in a national and international setting within the expert fields of the clinic
- To develop diagnostic strategies for clinical patient investigations in collaboration with clinicians in accordance with the principles of evidence-based medicine
- To be an attractive and positive place of work with emphasis on teamwork, competence and a positive atmosphere

Organisation and Staff



The Department of Clinical Physiology and Nuclear Medicine & PET and Cyclotron Unit is part of the Diagnostic Center, headed by Mogens Sandbjerg Hansen, Director, MD, DMSc and Karin Nørregaard, Vicedirector.



Physicians

- Berthelsen, Anne Kiil, MD, Chief Physician
- Buhl, Thora, MD, Staff Physician
- Christensen, Charlotte, MD, Registrar
- Doetsch, Anne-Marie, MD, Senior Registrar
- Graff, Jesper, MD, Staff Physician
- Gutte, Henrik, MD, Registrar
- Jakobsen, Annika Loft, MD, PhD, Chief Physician
- Hesse, Birger, MD, DMSc, Chief Physician
- Hoving, Peter, MD, DMSc, Registrar
- Højgaard, Liselotte, MD, DMSc, Head of Department, Professor
- Høyer, Alice Outzen, Consultant
- Kjær, Andreas, MD, DMSc, PhD, MBA, Chief Physician, Professor
- Kupers, Ron, MD, Associate Professor
- Law, Ian, MD, PhD, Staff Physician
- Lyttkens, Kerstin, MD, Chief Physician
- Marving, Jens, MD, Staff Physician
- Mortensen, Jann, MD, DMSc, Chief Physician
- Niemann, Lea, MD, Registrar
- Ormstrup, Tina, MD, Staff Physician
- Pedersen, Anne-Birgitte, MD, Senior Registrar

PhD students

- Binderup, Tina, Human Biologist
- Borgwardt, Lise, MD, PhD, Registrar, Clinical Assistant
- Chakera, Anette H., MD, PhD Student
- Fischer, Barbara Malene, MD, Registrar, Clinical Assistant
- Hansen, Charlotte Lund, MSc, Chemist
- Hutchings, Martin, MD, Registrar, Clinical Assistant
- Jørgensen, Emilie Arnth, Human Biologist
- Kristoffersen, Ulrik Sloth, MD, Clinical Assistant
- Pedersen, Dorthe, MD, PhD Student
- Pedersen, Minna W., MSc, Research Assistant
- Stavngaard, Trine, MD, PhD, Clinical Assistant
- Søndergaard, Kåre, MSc, PhD Student, Chemist
- Tagil, Kristina, MD, Clinical Assistant
- Vogelsang, Thomas Wiis, MSc, Research Assistant

Physicists, chemists

- Andersen, Peter Andreas, MSc, Physicist
- Boudreal, Gislain, MSc, PhD, Cyclotron Physicist
- Gillings, Nicolas, MSc, PhD, Chief Radio Chemist
- Holm, Søren, MSc, PhD, Chief Physicist
- Jensen, Holger J., MSc, PhD, Cyclotron Chief Physicist
- Klausen, Thomas Levin, MSc, Physicist
- Madsen, Jacob, MSc, PhD, Production Manager, Chemist
- Szabolcs, Lehel, MSc, PhD, Chemist

Engineers, technicians, computer scientists

- Andersen, Flemming, MSc, PhD, Computer Scientist
- Christensen, Jan Damgaard, Engineer Assistant
- Dähnhardt, Andreas, Computer Scientist
- Jensen, Ole, Engineer Assistant
- Jensen, Per Hovalt, Civil Engineer
- Kuhlmann, Per, Cyclotron Technician
- Steffensen, Anders H., Engineer Assistant

Nuclear Medicine Technologists, radiographers and nurses

- Abrahamsson, Elisabeth, Radiographer
- Bøhm, Mette, NM Technologist
- Christensen, Pia, NM Technologist
- Cortsen, Annette, NM Technologist
- Dondera, Brita, NM Technologist
- Elkington, Sakeena, NM Technologist
- Federspiel, Marianne, NM Technologist
- Frommelt, Louise B., NM Technologist
- Gudmundsson, Sven, NM Technologist
- Hanel, Birgitte, DMSc, NM Technologist
- Heiberg, Therese, NM Technologist
- Holm, Anita, NM Technologist
- Hovgaard, Beinta, NM Technologist
- Lene Høybye, NM Technologist
- Jensen, Laila Nyboe, NM Technologist
- Jensen, Martin Ravn, NM Technologist
- Jørgensen, Hanne, NM Technologist
- Jørgensen, Marianne, NM Technologist
- Jørgensen, Mette Møller, NM Technologist
- Kernchen, Ulla, Staff Nurse
- Kragh, Linda M., Chief NM Technologist

- Korfitsen, Julie, NM Technologist
- Kurt, Ramiz, NM Technologist, NMT Teacher
- Larsen, Helle Jung, NM Technologist
- Lis Larsen, Department NM Technologist
- Larsen, Lone Hougaard, NM Technologist
- Linnet, Solveig, NM Technologist
- Lohse, Jann, Teacher NM Technologist
- Lundby, Tim, NM Technologist
- Myschetzky, Rebecca, NM Technologist
- Nielsen, Majbritt Lykke, NM Technologist
- Nielsen, Merete Søndersø, NM Technologist
- Nilausen, Mia, NM Technologist
- Pedersen, Kate, Department NM Technologist
- Pejtersen, Maria H., NM Technologist
- Ramadani, Lutjeta, NM Technologist
- Svalling, Susanne, NM Technologist
- Sørensen, Anne, NM Technologist
- Velgaard, Susanne, NM Technologist

Secretaries

- Damborg, Anne-Marie, Quality Co-ordinator
- Forstrøm, Ulla, Assistant Secretary
- Jensen, Camilla, Medical Secretary
- Marquardsen, Joan, Medical Secretary
- Myltoft, Mette, Medical Secretary
- Runge, Gitte, Medical Secretary
- Rønn, Vibeke, Head Secretary
- Semitoje, Gudrun, Medical Secretary
- Skarn, Lizzie, Medical Secretary

Students, assistants

- Boota, Sobia Aniki Aslam, Assistant
- Christiansen, Maria, Assistant
- Gudmundsson, Marie L., Assistant
- Jørgensen, Jesper, Student
- Naert, Arne, Student
- Nielsen, Lea Allingham, Student
- Nielsen, Carsten Haagen, Student
- Pappens, Meike, Student
- Pinholt, Rasmus, Student
- Thisgaard, Helge, MSc, Student
- Toft-Petersen, Rasmus, Student

Equipment



The Department of Clinical Physiology and Nuclear Medicine, i.e. the divisions 4011, 4012 and 4112, is placed in the south wing of Rigshospitalet on the first floor. The Department is in possession of eight gamma cameras and two lung function equipments. The PET and Cyclotron Unit, division 3982, which is placed in the Finsen Building, is in possession of two PET/CT scanners, two PET scanners, two cyclotrons and an NMR spectrometer. Furthermore, three new radiochemistry laboratories are at our disposal and we have office and laboratory facilities in PET, division 3992.

The John and Birthe Meyer Foundation has donated all the equipment in the PET and Cyclotron Unit. The department has a Whole Body Counter with two chambers in the basement under the south wing, division 4191, which was renovated in 2002.

A new Siemens Biograph Hi-Rez PET/CT scanner with 16-slices CT was opened in April 2005 together with the second cyclotron, a RDS Eclipse cyclotron from CTI.

Accreditation

The Joint Commission International, an international American accreditation board, performed a successful accreditation in the spring of 2002 of all the H:S hospitals including Rigshospitalet. In January 2005 the 2nd accreditation took place, also with success.

We have worked on standards and politics, standard operation procedures, our quality handbook, patient informations and documentation. It has been an extensive task, and it has contributed to a positive improvement of the quality for the department.





Highlight of the year 2005



Opening of the PET/CT scanner donated by "The John & Birthe Meyer Foundation", April 8th 2005. With the presence of Birthe Meyer, Birgitte Meyer Brandt, Henrik Meyer and Søren Drost-Nissen. Mona Heiberg, Chair of the Board of H:S, Helle Ulrichsen, CEO of H:S and Jørgen Jørgensen, CEO Rigshospitalet.





Nuclear medicine



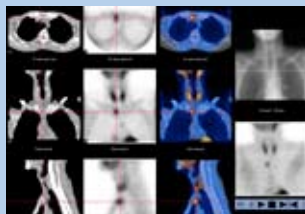
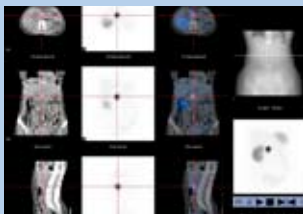
By Birger Hesse and Jann Mortensen

The Department of Clinical Physiology and Nuclear Medicine has six gamma cameras for routine clinical imaging and human research studies: There are three 2-headed gamma cameras, including one camera with a low-dose CT-scanner, and three 1-headed cameras, plus two small mobile cameras for experimental animals. Furthermore, there are two Jaeger body plethysmographs used for lung function testing. The majority of our examinations are related to the diagnosis and monitoring of cancer patients.

Research studies in nuclear cardiology have been performed with myocardial perfusion imaging in the evaluation of the effect of stem cells and gene therapy in severe coronary disease. Right and left ventricular function has been studied in HIV patients. The department has been much involved in the recently published European guidelines of myocardial perfusion imaging.

The somatostatin receptor ligand ^{111}In Octreotide for analogue imaging has become an important part of endocrine nuclear medicine together with parathyroid imaging with Tc-99m sestamibi with SPECT/low dose CT, which both have lead to new, important diagnostic information before surgery and during follow-up. ^{111}In Octreotide imaging is increasingly used for the evaluation of possible radionuclide therapy of inoperable patients with neuroendocrine tumours.

Lung physiology is studied in children and adults. The most frequent indications are control after chemotherapy, transplantation or preoperative evaluation. Improved lung scintigraphy using combined perfusion and $^{81\text{m}}\text{Kr}$ ventilation SPECT has been applied to detect pulmonary embolism and early detection of chronic obstructive lung disease. Radioaerosol mucociliary clearance studies are performed to detect primary ciliary dyskinesia. Radioisotope leakage monitoring procedures during isolated limb perfusion with melphalan for recurrent malignant melanoma is successfully used and a long-term clinical follow-up is underway. The use of the sentinel node imaging technique increases rapidly, leading to optimized surgery of breast cancer, melanoma, and other cancers. A Nordic postgraduate seminar on the sentinel node technique and perspectives was organized in 2005.



Paediatric investigations



The department performs around 1,200 paediatric nuclear medicine investigations every year, including approximately 100 PET scans. The PET scans are performed in tele medicine collaboration with “The Children’s Hospital of Michigan”, USA and “The Hospital for Sick Children”, Great Ormond St., London. We participate in Rigshospitalets Children’s Programme and have a dedicated programme for children and their parents, with special leaflets for children written in a direct and understandable language and illustrated with the wonderful drawings of little Rigo, by illustrator Carl Quist Møller.

The children leaflets are also available in English. New procedures for all investigations and procedures in relation to paediatric investigations have been implemented. If possible, we avoid sedation and anaesthesia. Instead we show cartoons and films to the children during the investigations in gamma cameras and PET scanners. The children listen to stories, they play with dolls and we give them small “bribery gifts”, including fizzy drinks and candy.



Cyclotron unit



By Holger J. Jensen

The year of 2005 was marked by the successful installation and operation of our new cyclotron from CTI – having the first beam on target the 17. January 2005. The additional cyclotron is going to serve as a back-up for our Scanditronix cyclotron, and in this way guarantee a daily and reliable supply of FDG to all our customers. The RDS Eclipse cyclotron is a single particle and single energy accelerator optimized for producing the standard PET isotopes ^{18}F , ^{13}N , ^{11}C and ^{15}O . The cyclotron accelerates negative hydrogen atoms to energies of 11 MeV and can produce beam currents of 150-200 μA . It is designed for dual beam line irradiations, with four possible target positions at each beam line and at present equipped with one beam line and two ^{18}F targets and a ^{11}C -target. Each target can produce between 140 and 200 GBq in a 2 hour irradiation.

In 2005 the total number of irradiations increased by 21% relative to 2004. The increase was mainly due to the fact that we now produce FDG for our customers five days per week and that our research program on ^{11}C labelled radio-pharmaceuticals has increased. The success rate this year was 98.6%. The small decrease relative to the record last year (99.8) was due to target problems. Consequently we have invested in an additional ^{18}F target this year.

Our collaboration with research groups in Gothenburg and Upssala, Sweden, on the development of a new treatment of micrometastases by means of radionuclide therapy using the alpha emitter ^{211}At peaked last year by the first human trials which turned out to be very successful.



Radiochemistry



By Nic Gillings and Jacob Madsen

Routine Production

In 2005 the radiopharmaceutical production has increased steadily and [^{18}F]FDG is now produced routinely five days a week for use in-house and for distribution to our customers. At present one [^{18}F]FDG production each day is sufficient, although a second daily production can be envisaged in the near future to meet growing demand. Of the 235 batches of [^{18}F]FDG produced in 2005 the average batch size was 65 GBq at end of synthesis (Figure 1). Production of krypton generators continued according to the well-established delivery schedule on Mondays, Wednesdays and Fridays, amounting to production of approximately 800 generators in 2005.

Research Production

Production of labelled neuroreceptor ligands for use in research projects by the Neurobiology Research Unit at Rigshospitalet increased in 2005. At present both [^{18}F]altanserin and [^{11}C]DASB are produced every second Monday and every Tuesday and Wednesday. In 2005 the 5-HT $_4$ antagonist [^{11}C]SB207145 was

approved for human use by the Danish Medicines Agency and regular production of this will commence early in 2006. This project is a collaboration with the pharmaceutical company Glaxo Smithkline in the UK who conducted a GMP audit of our production facility in 2005. Other routinely produced tracers for research include [^{13}N]ammonia for cardiac blood flow measurement and [^{15}O]water for cerebral blood flow measurement.

Oncology Research and Development

In 2005 Charlotte Lund Hansen continued her PhD project on development of labelled peptides for imaging the epidermal growth factor tyrosine kinase receptor. This project is conducted in collaboration with The Department of Radiation Biology at Rigshospitalet and The Chemistry Department at the Royal Veterinary and Agricultural University in Denmark (KVL). Contact has been made to the PET research group in Orsay, Paris and Charlotte will spend 6 months in their laboratories working on peptide labelling from September 2006.

Production of the promising hypoxia tracer [^{64}Cu]ATSM is currently being set up and validated. The new Hevesy Laboratory at

Risø National Laboratory supplies copper-64. An application for human use will be sent to The Danish Medicines Agency in 2006.

Neurobiology Research and Development

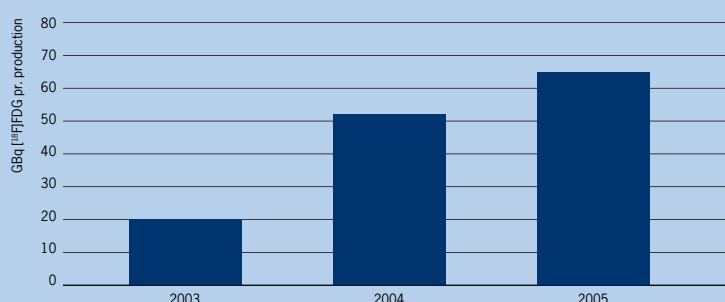
Kaare Søndergård submitted his PhD thesis entitled "Synthesis binding studies and PET studies of 2-substituted apomorphines" at the end of 2005. This was successfully defended on 26th January 2006. Kaare's project was part of a very fruitful collaboration between this department, the Neurobiology Research Unit and the Department of Medicinal Chemistry at the Danish University of Pharmaceutical Sciences (as a part of Copenhagen Brain Research Centre). In 2005 this collaboration was strengthened by the award of a five year "Research Centre Grant" to create the Centre for Integrated Molecular Biology Imaging (CIMBI), headed by Professor Gitte Moos Knudsen. In 2006 a three-year post-doc position and a PhD position will be filled as part of this centre. The particular focus for the research will be the development of 5-HT $_1\text{A}$ agonist ligands for PET studies. This will include both medicinal chemistry of radiochemistry research.

Pain Research and Development

In 2005 senior researcher Ron Kupers moved to Rigshospitalet and will be conducting pain research using PET imaging together with Professor Henrik Kehlet from the Section for Surgical Pathophysiology at Rigshospitalet. The research will focus on furthering the understanding of chronic post-operative pain processes. For this project the synthesis of two carbon-11 labelled neuroreceptor ligands will be set up and validated in 2006, and we expect to be able to start scanning patients in autumn 2006.

[^{18}F]FDG PRODUCTION 2003-2005

Average batch sizes of [^{18}F]FDG



PET and PET/CT scanners



By Søren Holm

The PET and Cyclotron Unit is now running two PET scanners and two PET/CT scanners.

Our first PET/CT scanner is a GE Discovery LS, a combined PET and CT scanner, where the PET is identical to the Advance scanner. This PET/CT scanner was installed in the autumn of 2001 as the second in Europe; today there are several hundreds from different vendors. The CT is used for both diagnostic quality CT and for attenuation correction of the PET images. A PET/CT scan on the Discovery will only take half the time of a PET scan on the Advance scanner, which is of benefit to the individual patient and to the capacity of the department. We have a large and still increasing number of patients referred for PET and PET/CT scans. Just a few years ago, PET scanning was looked upon primarily as a research tool, the number of patients was small and we had plenty of time for research and experimentation.

Today all the scanners are used from early morning till late afternoon for patient studies.

The collaboration with the Department of Radiotherapy has been further strengthened during 2005.

In the summer of 2003, the department received a generous donation from "The John and Birthe Meyer Foundation" for a new improved PET/CT scanner. After a thorough examination of available equipment in the market, we have chosen to buy a Siemens Biograph Hi-Rez PET/CT scanner with a 16-slice CT this time. The scanner was installed in the beginning of 2005 and the inauguration was celebrated on the 8th of April 2005. The Biograph is located in the Finsen Building near the other scanners and is run in a close collaboration with the Department of Radiotherapy. One major advantage, among others, of the Biograph is that the patient opening in this new generation of scanners has been widened to 70 cm (vs. 60 cm before). This

is particularly important for patients that are being prepared for therapy, because it ensures that there is enough room for the necessary "fixation" devices that are used to guarantee that the position of the patient is known and can be transferred to the linear accelerators with great precision.

The work on respiratory gating has been continued, and we are now able to make, almost on a routine basis, gated CT-scans in preparation for gated radiotherapy. The gating of PET is still being improved, the major problems being the much longer duration of the study and the limitations in statistics.



PET/CT and Radiotherapy



By Annika Loft Jakobsen and Anne Kill Berthelsen

With the introduction of the combined PET/CT scanners, a new world has opened with exciting possibilities for oncology.

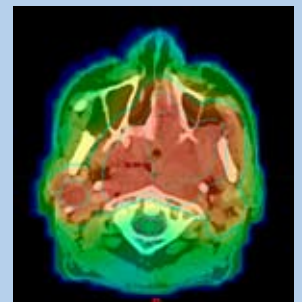
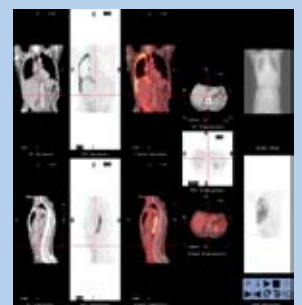
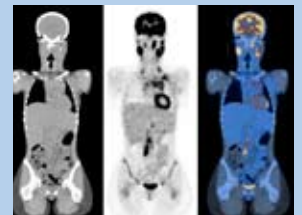
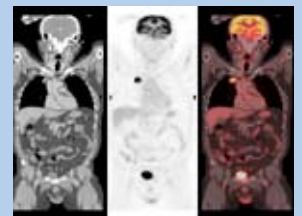
We have one dedicated PET scanner, a GE Advance and two PET/CT scanners, a GE Discovery LS installed in December 2001, and a Siemens Biograph Hi-Rez PET/CT scanner with 16-slice CT installed in January 2005.

We perform the CT scans as high quality diagnostic scans using oral and intravenous contrast media. When reading the scans, we describe the PET and the CT scans separately before reading the fused images and giving 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 the PET result can help depicting the small tumours that could easily have been overlooked even by a trained radiologist's eye. The combined PET/CT conclusion is superior to both scan results alone and the patient is spared from the extra CT examination.

We cooperate closely with The Department of Radiotherapy on the use of PET/CT in connection with the treatment planning of cancer. The advantages are numerous: the anatomical localisation and the metabolic activity of the tumour are defined, and the tissue heterogeneity can then be taken into account when choosing radiation technique and energy, and only one scan is necessary. Research in this field is necessary, and we conduct trials with nasopharyngeal and cervical cancer, mesothelioma and lymphoma.

Respiratory movements are a challenge for radiotherapy, since the tumour as well as surrounding normal tissues move. Traditionally, the radiation fields are enlarged in order to ensure that the tumour is constantly inside the target area. This means that more normal tissue is radiated upon concordantly. The respiratory movements also seem to blur the PET/CT images and hereby decrease the signal from small tumours. Lung metastases are often quite small, less than 5 mm in diameter, which makes them difficult to identify on a PET scan. We are investigating the usefulness of respiratory gating in two different settings, one on each scanner.

The introduction of new modalities require clinical trials to verify the usefulness of the method. We investigate the clinical diagnostic value of PET/CT for cervical, ovarian and lung cancer in prospective controlled trials at present.



Patient investigations

CNS and peripheral nervous system

Regional cerebral bloodflow, physiological, O-15-H2O	174
Regional cerebral metabolism, F-18 FDG	90
Regional cerebral metabolism, F-18 Altanserin	44
Regional cerebral metabolism, dyn, F-18 FDG	1
Regional cerebral receptor, stat., C-11-DASB	17
Total	326

Respiratory organs

Lung function test, whole body plethysmography	1.390
Lung function test, whole body plethysmography w/reversibility	98
Lung function test, spirometry w/reversibility	17
Lung function test, spirometry physiological provocation	1
Lung function test, diffusionscapacity (CO)	2.188
Lung function test, peak flow w/reversibility	1
Max inspiratory and expiratory muscle pressure	7
Lung perfusion scintigraphy, Tc-99m-MAA	278
Lung perfusion scintigraphy, regional, Tc-99m-MAA	69
Lung ventilation scintigraphy, Kr-81m	304
Lung ventilation scintigraphy, Tc-99m-DTPA	1
Lung ventilation scintigraphy, regional, Kr-81m	82
Pulmonale DTPA clearance	121
Mucociliary clearance, Tc-99m-venticolloid	33
Ciliary test	89
Total	4.679

Heart and cardiovascular system

Isotope cardiography, first pass, Tc-99m, HSA	79
Isotope cardiography, first pass, Tc-99m, ery	14
Isotope cardiography, SPECT, LVEF+vol., Tc-99m, scientific invest.	3
Isotope cardiography, LVEF, Tc-99m-ery	91
Isotope cardiography, LVEF, Tc-99m-HSA	573
Isotope cardiography, LVEF + vol, Tc-99m-ery	16
Isotope cardiography, LVEF + vol., Tc-99m-HSA	115
Myocardial perfusion scintigr., Tc-99m-MIBI, pharmacol. stress, adeno.	3
Myocardial perfusion scintigr., gated, Tc-99m-MIBI, pharmacol. stress, dipy.	26
Myocardial perfusion scintigr., gated, Tc-99m-MIBI, pharmacol. stress, dobut.	3
Myocardial perfusion scintigr., gated, Tc-99m-MIBI, pharmacol. stress, adeno.	100
Myocardial perfusion scintigr., gated, Tc-99m-MIBI, physiological stress	67
Myocardial perfusion scintigr., Tc-99m-MIBI, physiological stress	1
Myocardial perfusion scintigr., Tc-99m-MIBI, NTG	5
Myocardial perfusion scintigr., gated, Tc-99m-MIBI, NTG	145
Myocardial perfusion scintigr., gated, Tc-99m, MIBI	7
PET Myocardial perfusion, N-13-NH3	20
PET Myocardial perfusion, N-NH3, pharmacol. stress, dipy.	17
PET myocardial perfusion, N-13-NH3, cold press, phys. stress	3

PET myocardial metabolism, F-18 FDG	3
EKG	1
Exercise electrocardiography	21
Total	1.313

Peripheral vessels

Isolated limb perfusion leakage monitoring, chemotherapy	20
Total	20

Gastrin intestinal tract, including liver, biliary tract and pancreas

Salivary gland scintigraphy, Tc-99m	5
Bleeding scintigraphy (abdomen), Tc-99m-erythrocyt	3
Bleeding scintigraphy (abdomen), Tc-99m-human serumalb.	1
Biliary scintigraphy, Tc-99m-Mebrofenin w/cream stim.	1
Biliary tract scintigraphy, Tc-99m-Mebrofenin	15
Meckels diverticulum scintigraphy, Tc-99m	3
Schillings test I	8
Total	36

Kidneys and urinary tract

Glomerular filtration, Cr-51-EDTA, several samples	219
Glomerular filtration, Cr-51-EDTA, one sample	3.145
Renal scintigraphy, Tc-99m-DMSA	7
Renography, Tc-99m-MAG3, diureses	34
Renography, Tc-99m-MAG3, Dual head	1
Renography, Tc-99m-MAG3, ph	1.485
Renography, Tc-99m-MAG3, graft	6
Renography, Tc-99m-MAG3, ACE-inhibitor	105
Total	5.002

Bone and joint

Bone scintigraphy, Tc-99m-HDP, regional, static	141
Bone scintigraphy, Tc-99m-HDP, whole body, static	818
Bone scintigraphy, Tc-99m-HDP, SPECT	33
Total	992

Endocrine organs

Thyreoid scintigraphy, Tc-99m	426
Thyreoid scintigraphy, I-123 jodid	4
Thyreoid scintigraphy, I-131-jodid, residual tissue and up-take	14
Thyreoid scintigraphy, I-123 jodid, residual tissue and up-take	10
Parathyreoid scintigraphy, Tc-99m-MIBI, SPECT + CT	65
Adrenal marrow scintigraphy, I-123-MIBG	32
Whole body scintigraphy after I-131-therapy	50
Total	601

Finance

Blood and lymph system

Erythrocyt volume, Tc-99m-ery	19
Plasma volume, I-125, S-albumin	19
Lymph scintigraphy, extremities, Tc-99m-nanocolloid, stases	2
Sentinal node, tumor drainage, Tc-99m-nanocolloid	33
Sentinal node scintigr., tumor drainage, mamma c., Tc-99m-nanocolloid	271
Sentinal node scintigr., tumor drainage, malign. mel., Tc-99m-nanocolloid	121
Sentinal node scintigr., tumor drainage, penile c, Tc-99m-nanocolloid	4
Sentinal node scintigr., tumor drainage, vulva c., Tc-99m-nanocolloid	8
Peritumoral injection of Tc-99m-nanocolloid	45
Spleen scintigraphy, w/Tc-99m-erythrocyte, heated	4
Total	526

In vitro analysis

Plasma thyreoglobulin	860
Total	860

Other diagnostic procedures

Aprotinin scintigraphy, Tc-99m	38
Tumorscintigraphy, I-123-jodid	1
Tumor scintigraphy, In-111-Octreotide	140
PET tumor scanning, F-18 FDG	2.274
PET infection scanning, F-18 FDG	34
White blood cell scintigraphy, In-111	114
Whole body counting, K-40	5
Whole body counting, Ca-47, in meal	41
Whole body counting, Fe-59m in meal	54
Image fusion (PET, SPECT, MRI, CT or planar), PET and KF-section	1.831
Diagnostic CT	1.548
Fixation tools for radiotherapy	2
CT-therapy scanning	157
Supplementary/repetition imaging KF and PET section	652
Total	6.891

Radiotherapy

Treatment with I-131, benign thyreoid	64
Zevalin 90-Ytrium	2
Total	66

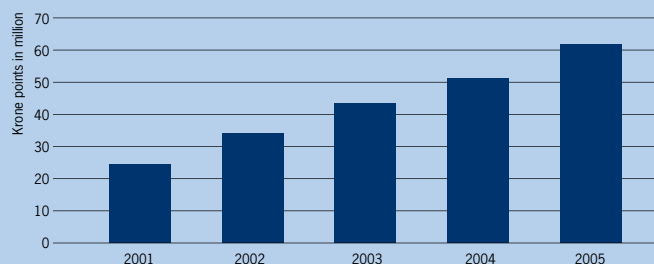
Total number of patient investigations **21.312**

BALANCE 2005

Expenditure

Running costs	DKK 8.4 million
Staff	DKK 26.4 million
In total	DKK 34.8 million

TURNOVER DURING THE LAST FIVE YEARS



Research



By Andreas Kjær

Our research focuses on development of new tracers for PET and nuclear medicine, clinical evaluation of new diagnostic methods as well as the use of methods from clinical physiology and nuclear medicine to study pathophysiology. At present, special attention is given to translational research in the area of molecular imaging.

We conduct extensive research based on the principles behind molecular imaging. Major research areas at present:

Clinical PET & PET/CT: A series of prospective protocols evaluate the diagnostic and prognostic value of PET and PET/CT in different cancer forms in children and adults. Furthermore, the use of PET/CT for the planning of radiation therapy (IMRT) and the use of respiratory gating are evaluated.

Development of new tracers: A series of projects about the development of new, specific tracers for the diagnosis of different cancer types are set up. These projects, which are carried out in collaboration with other departments and laboratories, are dependent on expertise in molecular biology, chemistry, radiochemistry, cancer biology and imaging. In collaboration with a pharmaceutical company, a new method for diagnosing bleeding has been patented.

Paediatric nuclear medicine investigations: The department conducts many paediatric investigations. Especially within oncology, several research protocols with the use of PET and SPECT are carried out in cooperation with clinical departments.

Labelling of stem cells: In cooperation with stem cells researchers from cardiology, we are involved in the labelling of stem cells in order to be able to follow the cells in vivo with nuclear medicine techniques. A series of experiments with the use of these labelled stem cells are planned.

Neuro PET: In cooperation with the Neurobiology Research Unit, Professor Gitte Moos Knudsen and Professor Olaf B. Poulson, a series of neuroreceptor ligands are developed and used for research and developed in neurobiology. The focus has mainly been on the serotonergic system. In 2005 Professor Gitte Moos Knudsen received a grant from the Lundbeck Foundation and established CIMBI; "Center for Integrated Molecular Brain Imaging", where we are proud to collaborate on the PET studies.

Nuclear cardiology and neuroendocrinology: 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 ischemic heart diseases is studied in selected groups of patients. The connection between neuroendocrine activation, isotope cardiography and MRI variables is evaluated and used for research in different patient groups and under various interventions.

Lung studies: Research especially focusing on mucociliar clearance and evaluation of the use of hyperpolarized helium MRI is conducted. The latter is evaluated together with lung function tests, lung scintigraphy and CT.

Animal experiments studying deposit characteristics and lung transplanted patients are other examples of current lung research.

Radionuclide treatment: Localized radiation therapy using specific ligands binding to certain cancer forms are currently being developed. The department takes part in the research within this area through tests of new ligands and production of certain isotopes. Currently targeted cancer forms are certain types of lymphoma, neuroendocrine tumours as well as ovarian cancer.

Whole Body Counting: Together with external partners, whole body counting is used for exact measurements of body composition in a series of studies. Furthermore, absorption of certain minerals from the gastrointestinal tract is evaluated. The department conducts research in collaboration with several national and international research partners.

From molecule to diagnosis



By Birger Hesse

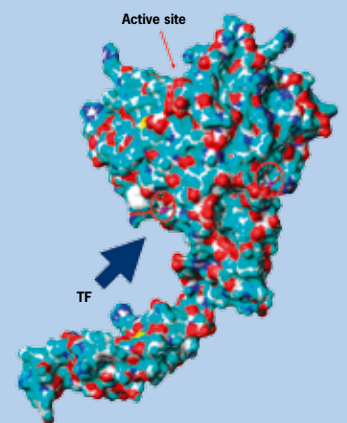
Detection of a lesion causing acute gastrointestinal (GI) bleeding

The many diagnostic tools available for finding the source of an acute GI bleeding, sometimes life-threatening, include endoscopy, X-ray, angiography, bleeding scintigraphy etc, sometimes even laparoscopy. Still in several patients the exact diagnosis is not obtained, and bleeding continues.

A radiolabelled tracer, suited for gamma camera imaging, with high affinity and specificity for a bleeding lesion, could be a non-invasive and very sensitive, diagnostic method for the localization of the bleeding site. In collaboration with NovoNordisk we succeeded in producing such a tracer, ^{99m}Tc -labelled rFVIIa (coagulation factor VII in its activated form), and tested it in rabbits with rectal bleeding.

Radioactive labelling of coagulation factor seven (rFVIIa) with ^{99m}Tc :

The rFVIIa protein is shown as van der Waals surface colored (oxygen: red, nitrogen: blue, carbon: white, and hydrogen: turquoise) and the probes are shown as stick models (technetium: purple). The active site and the tissue factor binding region have been indicated. Two candidate interaction sites have been expanded, both at crevices on the protein surface.



Cimbi

Center for integrated molecular brain imaging
University of Copenhagen, Rigshospitalet

In cooperation with the Neurobiology Research Unit, Professor Gitte Moos Knudsen and Professor Olaf B. Poulson, a series of neuroreceptor ligands are developed and used for research and developed in neurobiology. The focus has mainly been on the serotonergic system. In 2005 Professor Gitte Moos Knudsen received a grant from the Lundbeck Foundation and established CIMBI; "Center for Integrated Molecular Brain Imaging", where we are proud to collaborate on the PET studies.

Professor Gitte Moos Knudsen



Publications

As in previous annual reports we have chosen only to list scientific papers, and not the many abstracts and proceedings etc. from the department.

PhD thesis

Stavngaard, T. New imaging techniques in COPD (ph.d.-afhandling). Hvidovre: Eget forlag; 2005:1-62. Forsvaret den 26/10 2005 ved Københavns Universitet, Det Sundhedsvidenskabelige Fakultet.

Scientific publications

Adams KH, Hansen ES, Pinborg LH, Hasselbalch SG, Svarer C, Holm S, et al. Patients with obsessive-compulsive disorder have increased 5-HT_{2A} receptor binding in the caudate nuclei. *Int J Neuropsychopharmacol* 2005;8(3):391-401.

Ahmed SB, Hovind P, Parving HH, Rossing P, Price DA, Laffel LM, et al. Oral contraceptives, angiotensin-dependent renal vasoconstriction, and risk of diabetic nephropathy. *Diabetes Care* 2005;28(8):1988-94.

Andersen F, Watanabe H, Bjarkam C, Danielsen EH, Cumming P. Pig brain stereotaxic standard space: mapping of cerebral blood flow normative values and effect of MPTP-lesioning. *Brain Res Bull* 2005;66(1):17-29.

Bach KM, Hels O, Morberg C, Marving J, Bugel S, Tetens I. Pork meat increases iron absorption from a 5-day fully controlled diet when compared to a vegetarian diet with similar vitamin C and phytic acid content. *Br J Nutr* 2005;94(1):78-83.

Balslev D, Nielsen FA, Paulson OB, Law I. Right temporoparietal cortex activation during visuo-proprioceptive conflict. *Cereb Cortex* 2005;15(2):166-9.

Berthelsen AK, Holm S, Loft A, Klausen TL, Andersen F, Hojgaard L. PET/CT with intravenous contrast can be used for PET attenuation correction in cancer patients. *Eur J Nucl Med Mol Imaging* 2005;32(10):1167-75.

Bjarkam CR, Larsen M, Watanabe H, Röhl L, Simonsen CZ, Pedersen M, et al. A porcine model of subthalamic high-frequency deep brain stimulation in Parkinson's disease. In: Willow MJ, ed. *Parkinson's disease: New Research*. 1st ed. New York: Nova Science Publishers; 2005: kap. 5.

Borgwardt L, Hojgaard L, Carstensen H, Laursen H, Nowak M, Thomsen C, et al. Increased fluorine-18

2-fluoro-2-deoxy-D-glucose (FDG) uptake in childhood CNS tumors is correlated with malignancy grade: a study with FDG positron emission tomography/magnetic resonance imaging coregistration and image fusion. *J Clin Oncol* 2005;23(13):3030-7.

Buhl T, Stentzer K, Hede A, Kjaer A, Hesse B. Bone infection in patients suspected of complicating osteomyelitis: the diagnostic value of dual isotope bone-granulocyte scintigraphy. *Clin Physiol Funct Imaging* 2005;25(1):20-6.

Chakera AH, Friis E, Hesse U, Al Suliman N, Zerahn B, Hesse B. Factors of importance for scintigraphic non-visualisation of sentinel nodes in breast cancer. *Eur J Nucl Med Mol Imaging* 2005;32(3):286-93.

Daugaard G, Lassen U, Bie P, Pedersen EB, Jensen KT, Abildgaard U, et al. Natriuretic peptides in the monitoring of anthracycline induced reduction in left ventricular ejection fraction. *Eur J Heart Fail* 2005;7(1):87-93.

Engelmann MD, Niemann L, Kanstrup IL, Skagen K, Godtfredsen J. Natriuretic peptide response to dynamic exercise in patients with atrial fibrillation. *Int J Cardiol* 2005;105(1):31-9.

Fields PA, Mikhael G, Hutchings M, van der Walt J, Nunan T, Schey SA. The prognostic value of interim positron emission tomography scans combined with immunohistochemical data in diffuse large B-cell lymphoma. *Haematologica* 2005;90(12):1711-3.

Gutte H, Hojgaard L, Kjaer A. Early clinical experience and impact of 18F-FDG PET. *Nucl Med Commun* 2005;26(11):989-94.

Gutte H, Højgaard L. Generalized decreased osseous uptake on bone scintigraphy in hepatorenal syndrome. *Clin Nucl Med* 2005;30:834.

Gyongyosi M, Khorsand A, Zamini S, Sperker W, Strehlow C, Kastrup J, et al. NOGA-guided analysis of regional myocardial perfusion abnormalities treated with intramyocardial injections of plasmid encoding vascular endothelial growth factor A-165 in patients with chronic myocardial ischemia: subanalysis of the EUROINJECT-ONE multicenter double-blind randomized study. *Circulation* 2005;112(9 Suppl):1157-1165.

Hesse B, Tagil K, Cuocolo A, Anagnostopoulos C, Bardies M, Bax J, et al. EANM/ESC procedural guidelines for myocardial perfusion imaging in

nuclear cardiology. *Eur J Nucl Med Mol Imaging* 2005;32(7):855-97.

Højgaard L. Det nye forskningsrådssystem i Danmark og Europa. *Ugeskr Læger* 2005;167(46):4362-6.

Hovind P, Hansen TK, Tarnow L, Thiel S, Steffensen R, Flyvbjerg A, et al. Mannose-binding lectin as a predictor of microalbuminuria in type 1 diabetes: an inception cohort study. *Diabetes* 2005;54(5):1523-7.

Hovind P, Tarnow L, Rossing P, Jensen BR, Graae M, Torp I, et al. Risikofaktorer for udvikling af mikro- og makroalbuminuri ved type 1-diabetes: et incidenskohortestudie – en sekundærpublikation. *Ugeskr Læger* 2005;167(1):57-60.

Hoyer M, Roed H, Sengelov L, Traberg A, Ohlhuis L, Pedersen J, et al. Phase-II study on stereotactic radiotherapy of locally advanced pancreatic carcinoma. *Radiother Oncol* 2005;76(1):48-53.

Hutchings M, Loft A, Hansen MT, Pedersen LM, Buhl T, Jurlander J, et al. FDG-PET after two cycles of chemotherapy predicts treatment failure and progression-free survival in Hodgkin Lymphoma. *Blood* 2005;107(1):52-9.

Hutchings M, Mikhael NG, Fields PA, Nunan T, Timothy AR. Prognostic value of interim FDG-PET after two or three cycles of chemotherapy in Hodgkin lymphoma. *Ann Oncol* 2005;16(7):1160-8.

Juul K, Tybjoerg-Hansen A, Mortensen J, Lange P, Vestbo J, Nordestgaard BG. Factor V leiden homozygosity, dyspnea, and reduced pulmonary function. *Arch Intern Med* 2005;165(17):2032-6.

Kalliokoski KK, Langberg H, Ryberg AK, Scheede-Bergdahl C, Doessing S, Kjaer A, et al. The effect of dynamic knee-extension exercise on patellar tendon and quadriceps femoris muscle glucose uptake in humans studied by positron emission tomography. *J Appl Physiol* 2005;99(3):1189-92.

Kastrup J, Jorgensen E, Ruck A, Tagil K, Glogar D, Ruzyllo W, et al. Direct intramyocardial plasmid vascular endothelial growth factor-A165 gene therapy in patients with stable severe angina pectoris A randomized double-blind placebo-controlled study: the Euroinject One trial. *J Am Coll Cardiol* 2005;45(7):982-8.

Kjaer A, Hildebrandt P, Appel J, Petersen CL. Neurohormones as markers of right- and left-sided cardiac

dimensions and function in patients with untreated chronic heart failure. *Int J Cardiol* 2005;99(2):301-6.

Kjaer A, Meyer C, Wachtell K, Olsen MH, Ibsen H, Opie L, et al. Positron emission tomographic evaluation of regulation of myocardial perfusion in physiological (elite athletes) and pathological (systemic hypertension) left ventricular hypertrophy. *Am J Cardiol* 2005;96(12):1692-8.

Kjaer A, Lebech AM, Hesse B, Petersen CL. Right-sided cardiac function in healthy volunteers measured by first-pass radionuclide ventriculography and gated blood-pool SPECT: comparison with cine MRI. *Clin Physiol Funct Imaging* 2005;25(6):344-9.

Klausen TL, Chakera AH, Friis E, Rank F, Hesse B, Holm S. Radiation doses to staff involved in sentinel node operations for breast cancer. *Clin Physiol Funct Imaging* 2005;25(4):196-202.

Kristiansen H, Elfving B, Plenge P, Pinborg LH, Gillings N, Knudsen GM. Binding characteristics of the 5-HT_{2A} receptor antagonists altanserin and MDL 100907. *Synapse* 2005;58(4):249-57.

Larsen A, Kyllingsbaek S, Law I, Bundesen C. Activation in the MT-complex during visual perception of apparent motion and temporal succession. *Neuropsychologia* 2005;43(7):1060-71.

Pedersen MW, Pedersen N, Ottesen LH, Poulsen HS. Differential response to gefitinib of cells expressing normal EGFR and the mutant EGFRvIII. *Br J Cancer* 2005;93:915-23.

Pedersen MW, Pedersen N, Damstrup L, Villingshoj M, Sonder SU, Rieneck K, Bovin IF, Spang-Thomsen M, Poulsen HS. Analysis of the epidermal growth factor receptor specific transcriptome: effect of receptor expression level and an activating mutation. *J Cell Biochem* 2005;96:412-27.

Mikhael NG, Hutchings M, Fields PA, O'Doherty MJ, Timothy AR. FDG-PET after two to three cycles of chemotherapy predicts progression-free and overall survival in high-grade non-Hodgkin lymphoma. *Ann Oncol* 2005;16(9):1514-23.

Mortensen J. Billedidiagnostik ved lungeemboli. *Ugeskr Læger* 2005;167(41):3863.

Nielsen SS, Rehling M, Hesse B, Mortensen J. Dipyridamol infusion ved kronisk obstruktiv lunge-sidelse. *Ugeskr Læger* 2005;167(32):2918-9.

Niemann LL, Hesse B, Jensen KE. Månedens billede: insufficiensfraktur. *Ugeskr Læger* 2005;167(25-31):2792.

Nowak M, Holm S, Biering-Sorensen F, Secher NH, Friberg L. "Central command" and insular activation during attempted foot lifting in paraplegic humans. *Hum Brain Mapp* 2005;25(2):259-65.

Nygaard E, Kofoed KF, Freiberg J, Holm S, Aldershvile J, Eliassen K, et al. Effects of high thoracic epidural analgesia on myocardial blood flow in patients with ischemic heart disease. *Circulation* 2005;111(17):2165-70.

Petersen CL, Kjaer A. Impact of medical treatment on lung diffusion capacity in elderly patients with heart failure. Baseline characteristics and 1-year follow up after medical treatment. *Int J Cardiol* 2005;98(3):453-7.

Petersen CL, Kjaer A. Magnetisk resonansundersøgelse af hjertet. *Ugeskr Læger* 2005;167:1386.

Poulsen AN, Klausen TL, Pedersen PS, Willumsen NJ, Frederiksen O. Regulation of ion transport via apical purinergic receptors in intact rabbit airway epithelium. *Pflugers Arch* 2005;450(4):227-35.

Ptito M, Kupers R. Cross-modal plasticity in early blindness. *J Integr Neurosci* 2005;4(4):479-88.

Rossing K, Christensen PK, Hovind P, Parving HH. Remission of nephrotic-range albuminuria reduces risk of end-stage renal disease and improves survival in type 2 diabetic patients. *Diabetologia* 2005;48(11):2241-7.

Rostrup E, Knudsen GM, Law I, Holm S, Larsson HB, Paulson OB. The relationship between cerebral blood flow and volume in humans. *Neuroimage* 2005;24(1):1-11.

Scheuer KH, Nielsen JE, Krabbe K, Simonsen C, Koefoed P, Sorensen SA, et al. Reduced regional cerebral blood flow in SPG4-linked hereditary spastic paraplegia. *J Neurol Sci* 2005;235(1-2):23-32.

Schreiber WG, Morbach AE, Stavngaard T, Gast KK, Herweling A, Sogaard LV, et al. Assessment of lung microstructure with magnetic resonance imaging of hyperpolarized Helium-3. *Respir Physiol Neurobiol* 2005;148(1-2):23-42.

Stavngaard T, Mortensen J. Assessment of ventilation inhomogeneity with Krypton SPECT and planar imaging. *Clin Physiol Funct Imaging* 2005;25(2):106-12.

Stavngaard T, Sogaard LV, Mortensen J, Hanson LG, Schmiedeskamp J, Berthelsen AK, et al. Hyperpolarized ³He MRI and ⁸¹mKr SPECT in chronic obstructive pulmonary disease. *Eur J Nucl Med Mol Imaging* 2005;32(4):448-57.

Stavngaard T, Mortensen J, Dirksen A. Emphysema /alpha-1 antitrypsin deficiency. In: van Beek EJR, Lenfant C, Lipson DA, eds. *Functional Lung Imaging. Lung biology in health and disease*. Boca Raton, Florida: CRC Press, Taylor & Francis Group; 2005:453-78.

Svarer C, Madsen K, Hasselbalch SG, Pinborg LH, Haugbol S, Frokjaer VG, et al. MR-based automatic delineation of volumes of interest in human brain PET images using probability maps. *Neuroimage* 2005;24(4):969-79.

Søndergaard K, Kristensen JL, Gillings N, Begtrup M. Synthesis of (R)-(-)-2-Fluoronorapomorphine – A Precursor for the Synthesis of (R)-(-)-2-Fluoro-N-[11-C]propyl-norapomorphine for Evaluation as a Dopamine D2 Agonist Ligand for PET Investigations. *Eur J Org Chem* 2005;4428-33.

Søndergaard K, Kristensen JL, Palmer M, Gillings N, Knudsen GM, Roth BL, et al. Synthesis and binding studies of 2-aryl-norapomorphines. *Org Biomol Chem* 2005;3(22):4077-81.

Tetens I, Larsen TM, Kristensen MB, Hels O, Jensen M, Morberg CM, et al. The importance of dietary composition for efficacy of iron absorption measured in a whole diet that includes rye bread fortified with ferrous fumarate: a radioisotope study in young women. *Br J Nutr* 2005;94(5):720-6.

Wang Y, Tagil K, Ripa RS, Nilsson JC, Carstensen S, Jorgensen E, et al. Effect of mobilization of bone marrow stem cells by granulocyte colony stimulating factor on clinical symptoms, left ventricular perfusion and function in patients with severe chronic ischemic heart disease. *Int J Cardiol* 2005;100(3):477-83.

Wiese L, Nielsen X, Andresen K, Kjaer A, David K. 16S rDNA sequencing revealed *Citrobacter freundii* as the cause of liver abscess after banding of rectal haemorrhoids. *J Infect* 2005;50(2):163-4.

Education



By Jann Mortensen

The Department of Clinical Physiology and Nuclear Medicine & PET and Cyclotron Unit participates in the pre-graduate medical education at the Health Faculty of the University of Copenhagen within the following fields: *clinical physiology and nuclear medicine* by Assistant Professor Jann Mortensen, *human biology, clinical physiology and nuclear medicine*, and in *theoretical physiology* by Professor Andreas Kjær and human biology and medical engineering by Professor Liselotte Højgaard. The department participates in the OSVAL I and II programmes for medical students and the education of nuclear medicine technologists. As regards postgraduate education, the department participates in the specialist education of doctors in clinical physiology and

nuclear medicine in Denmark. The staff members attend numerous courses for both doctors and other academics in Denmark. Furthermore, the staff participates in international courses, symposiums, meetings, congresses and workshops. The department's educational activities are very comprehensive and include all staff members. The Nuclear Medicine Technologists have participated in our special dedicated CT courses, which include 80 lectures and tutorials and is completed with an examination. This allows our staff to be in charge of the PET/CT and SPECT/CT scanners also for the CT part. Their CT competence is officially acknowledged by the Danish National Agency for Radiation Protection.

The Department of Clinical Physiology and Nuclear Medicine & PET and Cyclotron Unit

performs extensive training to staff from other Nuclear Medicine and Radiological Departments in Denmark and the Nordic countries via study visits to our facilities of physicians and nuclear medicine technologists for periods of weeks up to 6 months. In addition, our staff travel to foreign hospitals: Nuclear Technologist Therese Heiberg and Chief Physician Jann Mortensen have implemented a new gamma camera at the Department of Nuclear Medicine at the Queen Alexandrines Hospital in the Faroe Islands. Chief Physician Jann Mortensen and Chief Physician Esbern Friis from the Department of Surgery, Rigshospitalet implemented sentinel node scintigraphy and biopsy in the Faroe Islands.

Jann Mortensen is responsible for the education in the department.



Nuclear Medicine Technologists



By Linda M. Kragh

The Department of Clinical Physiology and Nuclear Medicine & PET and Cyclotron Unit employ 30 Nuclear Medicine Technologists, a staff nurse and a radiographer. The Nuclear Medicine Technologists run the daily patient investigations in nuclear medicine and PET, and they also participate in the research and development projects. They have co-responsibility for the projects and are involved in both data management, quality assurance and patient- and animal studies. The research participants results in oral presentations and posters at both Danish and international meetings and symposia. In 2005 four posters from the nuclear medicine technologist group at the department were visible at the European Association of Nuclear Medicine Congress

in Istanbul, and also this year one of the posters acquired an award. The nuclear medicine technologists are very frequently asked to give courses and lectures both in Denmark and Scandinavia and at the PET/CT courses in Vienna. Our nuclear medicine technologists have been in Münster in Germany and in Baltimore, US to learn more about PET/CT and SPECT/CT before use of new equipment in our department, and chief nuclear medicine technologist Linda M. Kragh and department nuclear medicine technologist Kate Pedersen were visiting the M.D. Andersons Cancer hospital in Texas with the aim of improving our organisation and patient investigations.*

The nuclear medicine technologists in the department are a very dynamic, competent and responsible group with a very impor-

tant role for the continuous development of the clinic. In 2005 4 nuclear medicine technologists participated in our own dedicated CT course, officially acknowledged by the "Danish National Agency for Radiation Protection".

Nuclear Technologist Therese Heiberg and Chief Physician Jann Mortensen have implemented a new gamma camera at the Department of Nuclear Medicine at the Queen Alexandrines Hospital in the Faroe Islands. Therese Heiberg task was to teach the staff at the department to use the new gamma camera.

**The two Department Nuclear Medicine Technologists Kate Pedersen and Lis Larsen are attending the Management Course at Righospitalet.*



Other activities



Professor Liselotte Højgaard, Head of Department, is the chair of “Sundhedsfagligt Råd i Klinisk fysiologi og nuklearmedicin” in H:S, the Specialty Advisory Committee (SFR) in Clinical Physiology and Nuclear Medicine. She is chair of “Begrebsrådet” in H:S, (the council on use of medical language) and member of “Det Nationale Begrebsråd” (the national council on use of medical language). She is member of the “Danish Council for Research Policy”, and member of “Arbejdsgruppen for Forskningsinfrastruktur” (AFI), a working group for research infrastructure in Denmark. Member of the Steering Group for Biological and Medical Sciences, the “European Strategy Forum on Research Infrastructures” and chair of the ESFRI Expert Group on Clinical and Translational Medical Research. She is chair of the “Medical Museion”. She is a member of “Forskningsudvalget” in H:S” (the Research Committee) and the “European Organisation for Research and Treatment of Cancer” (EORTC), the Functional Imaging Group.

Linda M. Kragh, Chief Nuclear Medicine Technologist, is a member of “Sundhedsfagligt Råd i Klinisk fysiologi og nuklearmedicin” in H:S, the Specialty Advisory Committee (SFR) in Clinical Physiology and Nuclear Medicine”, she is a member of “Uddannelsesrådet for Bioanalytikeruddannelsen i Storkøbenhavn” in H:S (the speciality council for the education of laboratory technologists) and a member of the “Danish Society for Clinical Physiology and Nuclear Medicine”.

Professor, Andreas Kjær, Chief Physician is the Danish delegate in the “Scandinavian Society of Clinical Physiology and Nuclear Medicine” (SSCPNM). He is a member of the board of “Selskabet for Teoretisk og Anvendt Terapi” (the Society of Theoretical and Applied Therapy) and he is responsible for the course in heart pathophysiology for nuclear medicine physicians. Member of “Forskningsrådet” at Rigshospitalet (The Research Council) and a member of “Sundhedsfagligt

Råd i Klinisk fysiologi og nuklearmedicin” in H:S. He is head of Cluster for Molecular Imaging at the Faculty of Health Sciences, University of Copenhagen.

Assistant Professor Jann Mortensen, Chief Physician is a member of “Sundhedsfagligt Råd i Onkologi” in H:S, the Specialty Advisory Committee (SFR) for Oncology. He is a member of the steering committee of “Dansk Lunge Cancer Gruppe” and member of the subcommittees “Dansk Diagnostik Lunge Cancer Gruppe” and the Danish Steering Committee for Screening of Lung Cancer. He is also a member of the supplementary training committee of the “Danish Society for Clinical Physiology and Nuclear Medicine” and a substitute for the board of the “Danish Society for Clinical Physiology and Nuclear Medicine” and he is responsible for the specialist course in “Clinical respiratory physiology” for nuclear medicine physicians and interal medicine.

Annika Loft Jakobsen, Chief Physician is a member of the “European Organisation for Research and Treatment of Cancer” (EORTC), the Functional Imaging Group and “The British Institute of Radiology”.

Birger Hesse, Chief Physician is a member of the “European Council of Nuclear Cardiology” (ECNC) and he is chair for “Medicinsk bibliotek” at Rigshospitalet (the Medical Library) and “Biblioteksgruppen” in H:S (Library group). Member of the “Cardiovascular Committee, EANM” and chair of “Sektorudvalg for diagnostiske specialer, DANAK”. Head of “Corelab for myocardialscintigraphy”.

Anne Kiil Berthelsen, Chief Physician is a member of “British Institute of Radiology”.

Søren Holm, Chief Physicist is a member of “Sundhedsfagligt Råd i Klinisk fysiologi og nuklearmedicin” in H:S, the Specialty Advisory Committee (SFR) in Clinical physio-

logy and nuclear medicine and a member of the board of the “Danish Society for Clinical Physiology and Nuclear Medicine”. He is the delegate of the “Danish Society for Medical Physics” for the “European Federation of Organizations in Medical Physics” (EFOMP).

Jesper Graff, Staff Physician is chair for kursusudvalget in the “Danish Society of Clinical Physiology and Nuclear Medicine” and representative in “Vurderings- og Ansættelsesudvalget” in Clinical Physiology and Nuclear Medicine under the Danish Society of Clinical Physiology and Nuclear Medicine. He is also member of the board of “Young doctors in Clinical Physiology and Nuclear Medicine”.

Ian Law, Senior Registrar/Physician is a member of the board in the “Medical Society of Copenhagen” and a member of the “Research Council” at Rigshospitalet.

Nic Gillings, Chief Radio Chemist is a member of the management committee of the EU COST Action B12 programme: “Radiotracers for in vivo assessment of biological function”.

Lis Larsen, Department Nuclear Medicine Technologist is a member of the supplementary training committee of the “Danish Society for Clinical physiology and nuclear medicine”, and member of “Udviklingsgruppen for Klinisk fysiologi og nuklearmedicin under Danske Bioanalytikere” (Developing Group for Clinical Physiology and Nuclear Medicine under “The Danish Association of Biomedical Laboratory Technologists”). She is also attending the Management Course at Rigshospitalet.

Kate Pedersen, Nuclear Medicine Technologist is a member of the Technologist Committee under EANM and a member of “Udvalget for Ledende og Afdelingsbioanalytikere i Region Hovedstaden under Dbio”. She is also attending the Management Course at Rigshospitalet.

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 has been involved in planning of the new programme, MSc in Medicine and Technology, which was implemented on 1 September 2003, as a five years bachelor and master education. In 2003, 219 students applied and 66 students were accepted. Also in 2004 and 2005 more than 200 students applied. The education is co-sponsored by the medical industry. Radiometer A/S has donated DKK 5 million for a research professorship. Besides, Radiometer A/S, Novo Nordisk and Coloplast have donated equipment for the education amounting to approximately DKK 2 million. You can read more about the education on: www.medicin-ing.dk. The first bachelors will graduate in 2006.

MSc in Medicine and Technology

“At the cross-road between medicine and technology the health care sector is facing very complex problems today, which can only be solved in teams of doctors, engineers, physicists, nuclear medicine technologists, nurses, radiographers, computer scientists and chemists. The programme Medicine and Technology supplies the student with broad health-related knowledge together with classical technical engineering expertise. The Medicine and Technology engineers will be able to fulfil positions in hospitals, in research institutions and in the medical industry in general”.



Grants and foundations

- *Charlotte Lund Hansen*, Physicist received a PhD scholarship from the Danish Cancer Institute of DKK 1,35 mio.
- *Birger Hesse*, Chief Physician received the “Prize of honour” 2005 from the “Danish Society for Clinical Physiology and Nuclear Medicine” and a grant from Novo Nordisk for science.
- *Peter Hovind*, Physician received a research grant from “Diabetesforeningen” (The Danish Diabetes Society) of 40.000 DKK. From “Aase & Ejnar Danielsens Foundation” he received 100.000 DKK for a project concerning “Risk factors for macrovascular disease and neuropathy at patients with type 1 diabetes”.
- *Liselotte Højgaard*, Professor received the “Niels A. Lassen Prize” 2005.



The future of Clinical Physiology and Nuclear Medicine in the New Region

The four departments of Clinical Physiology and Nuclear Medicine at Bispebjerg Hospital, Frederiksberg Hospital, Hvidovre Hospital and Rigshospitalet cooperate in "Sundhedsfagligt Råd for Clinical Physiology and Nuclear Medicine" (SFR), a specialty advisory committee, which is our professional council in clinical physiology and nuclear medicine. In SFR we coordinate the implementation of new laws, rules and regulations issued by the Danish authorities, and we have produced a central quality handbook for use in all four departments. We coordinate patient informations, information posters on patient investigations, and we conduct mutual audit in all departments every spring. SFR has established a common standard on how to perform the basic investigations in clinical physiology and nuclear medicine. An update will be published in 2006.

In 2003, a consultancy (PLS Rambøll) drew up a report about the future of our medical speciality, clinical physiology and nuclear medicine in H:S. The conclusion was that the departments were efficient and well run. The present organisation of clinical physiology and nuclear medicine and diagnostic radiology in separate clinics were preferable and a merger between the four departments in H:S was not recommended.

In 2005 a Report on the future development of Clinical Physiology and Nuclear Medicine in the new coming "Region Hovedstaden" (The Copenhagen and Northern Zealand Region) was made for the politicians and leaders in the New Region. The report was written by the leaders from the present 8 departments of Clinical Physiology and Nuclear Medicine in the Hospitals in the region with Ole Faber, MD., DMSc.,

Medical Director Copenhagen County as editor and chair. The report concluded that our speciality is very active in research & development, and is a field with rapid growth and expansion.

Members of SFR

Bispebjerg Hospital: Lars Friberg, Birte Hjort Jensen. **Frederiksberg Hospital:** Claus Leth Pedersen, Hanne Petersen.

Hvidovre Hospital: Jens H. Henriksen, Ingelise Siegumfeldt, Stefan Fuglsang.

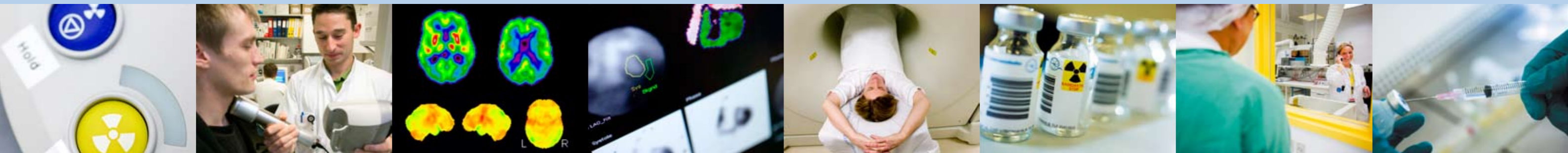
Rigshospitalet: Liselotte Højgaard (chair), Andreas Kjær, Søren Holm, Linda M. Kragh and secretary Gitte Runge.

Home page

www.hosp.dk/HSSR/kliniskFysiologiogNuklearmedicin.nsf



Specialty Advisory Committee: Frederiksberg Hospital, Rigshospitalet, Bispebjerg Hospital and Hvidovre Hospital.



Editors:

Liselotte Højgaard
Gitte Runge

Layout:

Bjørn & List A/S

Fotos:

Lars Bahl
Steen Brogaard
(Thierry Wieleman)
(Per Rasmussen)

Issues:

1.000

Copyright:

Department of Clinical Physiology and Nuclear Medicine
& PET and Cyclotron Unit, KF 4011, Rigshospitalet,
Copenhagen University Hospital, Blegdamsvej 9,
DK-2100 Copenhagen Ø, Denmark.

Contact:

Professor Liselotte Højgaard
E-mail: lottepet@rh.dk
Phone: +45 3545 4215 / 1792



H:S – The Copenhagen Hospital Corporation

H:S The Copenhagen Hospital Corporation is a public organisation established in 1995, that owns and operates six hospitals in the centre of the Copenhagen metropolitan area. The overall strategy for H:S is to improve quality of health services and at the same time to improve the efficiency by reducing the total costs. H:S services the population of 560.000 in urban Copenhagen and Frederiksberg municipality. Furthermore, Rigshospitalet, in particular, offers specialised services to the eastern region of Denmark and to the whole country.



Rigshospitalet, Copenhagen University Hospital

Rigshospitalet, Copenhagen University Hospital, was founded in 1757. At present it has 1500 beds, 17.000 employees and a budget of approximately ½ billion euros. The research production is more than 1000 publications per year, including approximately 50 higher academic degrees (PhD and doctoral of medical science).