

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	40 and 50 years Anniversary 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	MSc in Medicine and Technology
23	Grants and foundations
24	Publications
26	Education
27	Nuclear Medicine Technologists
27	Electronic medical record
28	Other activities
30	Specialty Advisory Committee in Clinical physiology and nuclear medicine

Preface

By Liselotte Højgaard

The demography of patient study activities in the department has changed considerably as Rigshospitalet did not receive local patients for investigation after 1 January 2004 and also because an increasing number of patients in need of highly specialized treatment were referred to the department in 2004.

The increasing number and ratio of patients investigated in 2004 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 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 in these patients. The increasing number of patients given chemotherapy at Rigshospitalet have 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 every morning in patients who receive chemotherapy in the late afternoon according to the results we produce and report to the clinical departments on the same day.

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 for delivery and use at Rigshospitalet at 08:00 am in the morning. The number of new tracers being developed in the cyclotron and radiochemistry units has increased and the new production laboratories have been introduced in the daily routine. Every Tuesday night we produce ^{211}At – an alphaemitter for use in Uppsala and Gothenburg for studies on MAB (monoclonal antibody therapy) radio treatment for micrometastasis from ovarian carcinoma. Trials are also performed in collaboration with the Sloan Kettering Cancer Center in New York. We have experienced a very dramatic rise in the number of PET and PET/CT patient scans including an advanced use of PET/CT for planning of radiotherapy with IMRT (intensity modulated radiotherapy) with inverse dose planning, and we are very grateful for the positive and rewarding collaboration with the Department of Radiotherapy represented by Dr. Svend Aage Engelholm, Head of Department, 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 MR scans for co-registration with PET. The contributions of the staff have been extraordinarily high as regards patient studies, isotope production, research and development and education in 2004. In the PET and Cyclotron Unit the large donation from The John and Birthe Meyer

Foundation allowed a contract for a Siemens Biographs Hi-Rez PET/CT scanner with 16-slices CT for installation in January 2005 and a RDS Eclipse cyclotron from CTI. Including the new equipment the PET and Cyclotron Unit now has two cyclotrons, two PET/CT scanners and two PET scanners, and one NMR spectrometer along with three modernized radiochemistry laboratories, giving us facilities of a high international standard. All the equipment in the PET and Cyclotron Unit has been donated throughout the years from "The John and Birthe Meyer Foundation", to whom we are very grateful for their generous contributions. Without these contributions we would not have researched at such an advanced level. It was a very great honour for the whole department to receive the representatives of The Foundation: Mrs Birthe Meyer, Mrs Gitte Brandt, Mr Henrik Meyer and Mr Søren Drost-Nissen in the autumn 2004.

A marked increase in research and development took place in 2004, primarily within the following areas: clinical research on PET and PET/CT, development of new radioisotopes and ligands, paediatric nuclear medicine including PET, labelling of stem-cells, neuro-PET in collaboration with the Neurobiology Research Unit and other research groups in neurology. Furthermore 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



The Department of Clinical Physiology and Nuclear Medicine & PET and Cyclotron Unit had a very busy and exciting year in 2004 with an increasing number of patient investigations, in particular PET and PET/CT scans, a rising production in research and development, and an expansion in educational and external activities, all in line with the mission of Rigshospitalet.

Andreas Kjær has been appointed leader of the newly established "Cluster for Molecular Imaging" at Copenhagen University, the Faculty of Health Sciences, and he is the head of a national and international 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 actively engaged in the "AirPoLife" network.

It was a special honour for the department to participate in the Finsen Day on 24 September 2004 to mark the death of Danish Nobel Laureate Niels Finsen, 100 years ago (Niels Finsen discovered the beneficial use of light therapy in disease). The day was arranged in collaboration with the Department of Oncology and the Department of Radiotherapy, and it was a great success with an exciting scientific programme, delivered by a distinguished international scientific faculty with more than 400 participants including distinguished guests from the Niels Finsen family.

Our department staff has participated in many national and international meetings and congresses as invited lecture. They have given oral presentations, presented abstracts and posters and functioned as chairmen. International research groups have visited the department in 2004 and

we have received very 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 now 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 2004, the four departments were audited. 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 2004, we participated in the "Report on use of Clinical Physiology and Nuclear Medicine in H:S" concerning diagnostic strategies. The annual meeting of the four departments concentrated on this issue. In 2004 we prepared for the second Joint Commission of Accreditation Evaluation to take place in January 2005. Our Chief Nuclear Medicine Technologist, Linda M. Kragh was appointed leader of the quality committee and she was responsible for patient safety and accreditation in the

department. All annual standard operating procedures were updated and implemented in the quality handbook in the autumn of 2004.

The department participated in the programme, MSc in Medicine and Technology. In September 2004, the second year of the programme, 220 students applied and 66 students were accepted. An average score of 9.1 was acquired for admission to the study. Liselotte Højgaard was appointed Professor in Medicine and Technology on 1 March 2004 by the Health Science Faculty, the University of Copenhagen and in May 2004 Professor Jørgen Arendt Jensen, the Technical University of Denmark, and Liselotte Højgaard received the prize "Medicoprisen 2004" from "Medicoindustrien" (the trade organisation for the medical device industry in Denmark). 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 Liselotte Højgaard was appointed member of the "Danish Council for Research Policy" in 2004 and of "Arbejdsgruppen for Forskningsinfrastruktur" (AFI), a working group for research infrastructure in Denmark, as well as the "European Strategy Forum on Research Infrastructures" (ESFRI Medical) with the contributions aimed at achieving better conditions for research and development in medicine.

A very warm thanks to all staff members and all external collaborators for a very big contribution in 2004!



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 2004 more than 65 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:

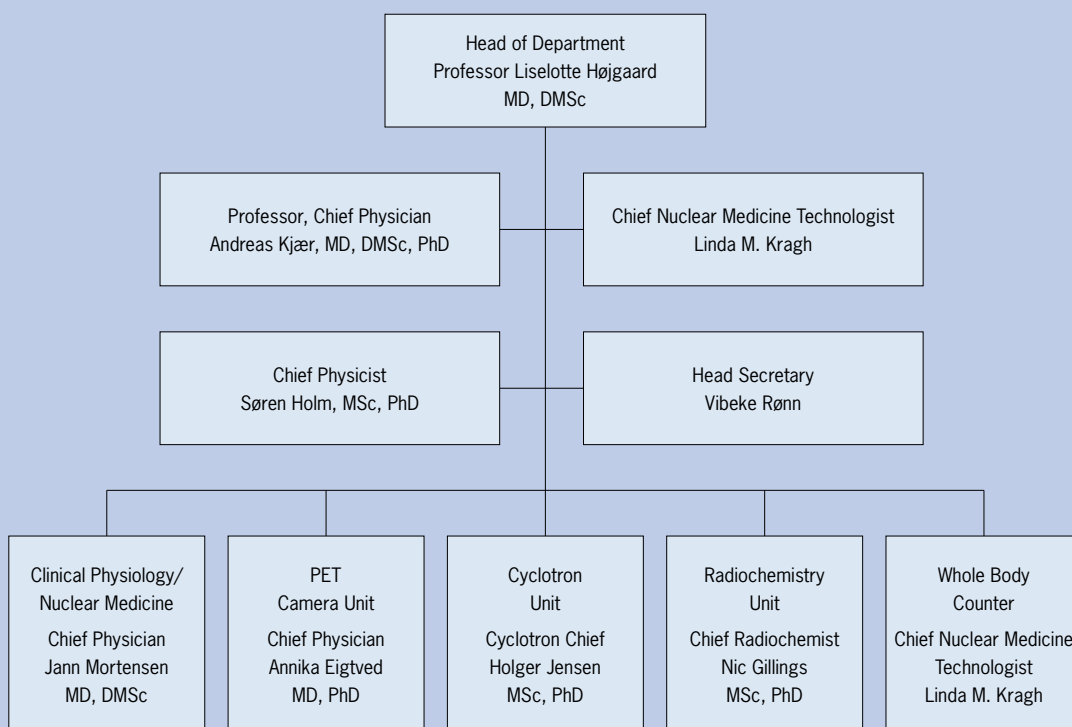
General objectives:

- To be in the lead within highly specialized diagnostic treatment and nursing
- To carry out research and development at an advanced international level
- To educate staff in the health services at a 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 is:

- To carry out clinical patient investigations in clinical physiology, 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
- 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

- Anne Kiihl Berthelsen, MD, Chief Physician
- Thora Buhl, MD, Staff Physician
- Birgitte Klee Burton, MD, Registrar
- Henrik Gutte, MD, Registrar
- Annika Loft Jakobsen, MD, PhD, Chief Physician
- Birger Hesse, MD, DMSc, Chief Physician
- Liselotte Højgaard, MD, DMSc, Head of Department, Professor
- Andreas Kjær, MD, DMSc, PhD, Professor
- Ian Law, MD, PhD, Senior Registrar
- Jens Marving, MD, Staff Physician
- Jann Mortensen, MD, DMSc, Chief Physician
- Lea Niemann, MD, Registrar

PhD students

- Lise Borgwardt, MD, PhD, Registrar, Clinical Assistant
- Barbara Malene Fischer, MD, Registrar, Clinical Assistant
- Martin Hutchings, MD, Registrar, Clinical Assistant
- Minna W. Pedersen, MSc, Research Assistant
- Trine Stavngaard, MD, Clinical Assistant
- Kåre Søndergaard, MSc, Chemist
- Kristina Tagil, MD, Clinical Assistant

Physicists, chemists

- Ghislain Boudrealt, MSc, PhD, Physicist
- Nicolas Gillings, MSc, PhD, Chief Radiochemist
- Charlotte Lund Hansen, MSc, Chemist
- Søren Holm, MSc, PhD, Chief Physicist
- Holger J. Jensen, MSc, PhD, Cyclotron Chief Physicist
- Thomas Levin Klausen, MSc, Physicist
- Jacob Madsen, MSc, PhD, Chemist
- Szabolcs Lehel, MSc, PhD, Chemist

Engineers, technicians, computer scientists

- Flemming Andersen, MSc, PhD, Computer Scientist
- Jan Damgaard Christensen, Engineer Assistant
- Andreas Dähnhardt, Computer Scientist
- Lasse Hauerberg, Research Technician
- Ole Jensen, Engineer Assistant
- Per Hovalt Jensen, MSc, Civil Engineer

Nuclear Medicine Technologists, radiographers and charge nurses

- Elisabeth Abrahamsson, Radiographer
- Lone Agerskov, NM Technologist
- Pia Christensen, NM Technologist
- Annette Cortsen, NM Technologist
- Brita Dondera, NM Technologist
- Sakeena Elkington, NM Technologist
- Marianne Federspiel, NM Technologist
- Sven Gudmundsson, NM Technologist
- Birgitte Hanel, DMSc, NM Technologist
- Therese Heiberg, NM Technologist
- Anita Holm, NM Technologist
- Lene Høybye, NM Technologist
- Hanne Jørgensen, NM Technologist

- Ulla Kernchen, Charge Nurse
- Linda M. Kragh, Chief NM Technologist
- Ramiz Kurt, NM Technologist
- Helle Jung Larsen, NM Technologist
- Lis Larsen, Department NM Technologist
- Lone Hougaard Larsen, NM Technologist
- Jann Lohse, Teacher NM Technologist
- Tim Lundby, NM Technologist
- Dina Lykke, NM Technologist
- Rebecca Myschetzky, NM Technologist
- Mette Bøhm Nielsen, NM Technologist
- Kate Pedersen, Department NM Technologist
- Maria H. Pejtersen, NM Technologist
- Lutjeta Ramadani, NM Technologist
- Susanne Svalling, NM Technologist
- Tina Sonne Svendsen, NM Technologist
- Anne Sørensen, NM Technologist
- Rikke Sørensen, NM Technologist

Secretaries

- Anne-Marie Damborg, Quality Coordinator
- Ulla Forstrøm, Assistant Secretary
- Joan Marquardsen, Medical Secretary
- Mette Myltoft, Medical Secretary
- Gitte Runge, Medical Secretary
- Vibeke Rønn, Head Secretary
- Gudrun Semitoje, Medical Secretary
- Lizzie Skarn, Medical Secretary
- Birgit Smidt Sneftrup, Medical Secretary

Students

- Maria Christiansen, Student
- Christian Rønn Hansen, Student
- Jesper Jørgensen, Student
- Lea Allingham Nielsen, Student
- Rasmus Pinholt, Student
- Helge Thisgaard, Student
- Rasmus Toft-Petersen, 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.

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 2004, we started preparing for the 2nd accreditation to take place in January 2005.

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





40 and 50 years Anniversary 2005



Head of Department: Troels Munkner, Niels Rossing and Svend Sølvsten Sørensen.

1955 In 1955 the Isotope Laboratory at Rigshospitalet opened as a division under the Department of Radiology and on 23 March 1955 the first nuclear medicine patient investigation was performed. Dr. Svend Krogh Dahlgaard was in charge as registrar and 71 patients were investigated, all with ^{131}I .

In 1956 Dr. Boye Nielsen initiated patient studies with ^{51}Cr -EDTA and Dr. Knud Olsen performed patient studies with ^{24}Na . On 1 September 1957 Dr. Troels Munkner was appointed Chief Physician for the Isotope Laboratory and in December 1959 Dr. Svend Sølvsten Sørensen was appointed as Registrar at the Isotope Laboratory.

1965 On the 1 April 1965 the Department of Nuclear Medicine was established as an independent department headed by Dr. Troels Munkner and on 1 August 1973 Dr. Svend Sølvsten Sørensen was appointed Chief Physician.

The Isotope laboratory was sited in the basement below the old Department of Radiology, in buildings, which no longer exists. After the Department of Radiology was moved to the new Rigshospitalet's new central wing in September 1970, the Department of Nuclear Medicine extended the facilities to comprise rooms at the other side of Blegdamsvej, where the medical company Ferrosan had left for a new factory outside of Copenhagen. When the new south wing opened in 1978, the Department of Nuclear Medicine acquired

a fine new department on the first floor of entrance 4, where the present department is still located.

1974 The Finsen Institute established the Department of Clinical Physiology on 1 March 1974 and Dr. Niels Rossing was appointed Head of Department.

1981 The Finsen Institute opened the new Department of Clinical Physiology in the old building of the Finsen Laboratory. In 1981, the Finsen Institute and Rigshospitalet were formally merged. After the merger all chief physicians at both hospitals were formally employed by both institutions.

1985 On the 1 April 1985 Dr. Niels Rossing was appointed Head of Department for the new merged Department of Clinical Physiology and Nuclear Medicine, Rigshospitalet. In the beginning only Niels Rossing worked physically both at Rigshospitalet and the Finsen Institute. In 1988-1990, the rest of the staff from the Finsen Institute was moved to Rigshospitalet. Niels Rossing was on leave from 1 June 1988 to 1994, when he returned as Director for the Center of Diagnostic Imaging.

1988 From 1988 to 2000 Dr. Svend Sølvsten Sørensen was Head of Department. At the Finsen Institute lung function tests were performed by the

Department of Clinical Physiology. At Rigshospitalet lung function tests were performed by the Department of Cardiology and at first Professor Johan George was in charge succeeded by Dr. Alf Wennevold and Dr. Jørgen Videbæk. In 1991 the Lung Function Unit on ward 2011 was included in The Department of Clinical Physiology and Nuclear Medicine. The Whole Body Counter at Rigshospitalet was installed in 1977-78 and is still in use for research studies in collaboration with The Royal Veterinary and Agricultural University, Denmark (KVL).

1992 The PET and Cyclotron Unit opened with the Scanditronix MC32 Cyclotron in 1992, a PET scanner GE 4096 in 1993, an Advance PET scanner in 1995, and a PET/CT scanner in December 2001. The cyclotron was run by Mikael Jensen, Nuclear Physicist, now at the Hevesy Laboratory at Risø, and Professor at The Royal Veterinary and Agricultural University, Denmark. From 2001 Holger Jensen, Nuclear Physicist became the new Cyclotron Chief. Peter Larsen, MSc, PhD initiated the Radiochemistry Unit and his student Lars Martiny, MSc, PhD took over in 1997. In 2001 Nic Gillings, MSc, PhD was appointed Chief Radio Chemist and Jacob Madsen, MSc, PhD in Radio Chemistry was appointed Head of Production in 2004. Søren Holm, MSc, PhD was appointed Physicist in 1991, where he was in charge of the PET cameras and radiation

physics. From 2002 he was given the responsibility to coordinate the radiation safety at Rigshospitalet and he was appointed Chief Physicist at the Department of Clinical Physiology and Nuclear Medicine & PET and Cyclotron Unit. In 1990 Linda M. Kragh was appointed Chief Nuclear Medicine Technologist.

2005 Liselotte Højgaard, MS, DMSc was appointed Chief Physician in 1998 and 1 March 2000 she was appointed Head of the Department for Clinical Physiology and Nuclear Medicine & PET and Cyclotron Unit, when Dr. Svend Sølvsten Sørensen retired. A new Siemens Biograph Hi-Rez PET/CT scanner with 16-slices CT will be opened

in April 2005 together with the second cyclotron, a RDS Eclipse cyclotron from CTI. During the last 50 years the department has grown from the initial 71 patient investigations the first year to well around 15,000 patient investigations annually, including 3,000 clinical PET scans and 1,200 paediatric patients.



Nuclear medicine



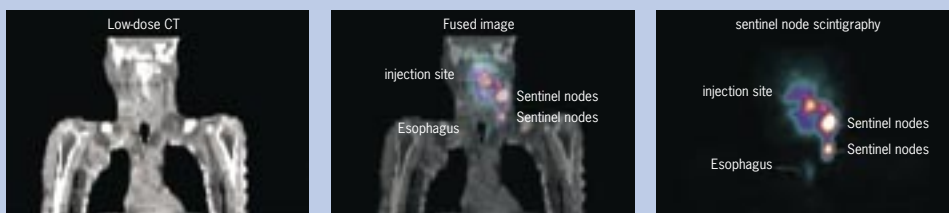
By Birger Hesse and Jann Mortensen

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 patient investigations consist of the diagnosis and control of cancer patients.

Research studies in myocardial perfusion imaging include continuous quality improvement comprising the evaluation of cardiac function and compensation for technical artifacts including attenuation-scatter. Tomographic blood pool scanning is compared with planar "MUGA" scanning for the left ventricle and first pass imaging for the right ventricle. As regards endocrine nuclear medicine, we use the somatostatin receptor ligand ^{111}In Octreotide for analogue imaging with SPECT/CT leading to new, extensive diagnostic information.

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.

There has been a large increase in the numbers of radioisotope leakage monitoring procedures during isolated limb perfusion with melphalan for recurrent malignant melanoma and in 2004, our treatment of soft tissue sarcomas with melphalan plus $\text{TNF}\alpha\text{-1a}$ was accredited. The use of sentinel node imaging technique increases rapidly, leading to optimized surgery of breast cancer, melanoma, head and neck & gynaecological cancers.



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 close collaboration with the Children's Hospital of Michigan, USA. We participate in Rigshospitalets Children's Programme and have developed new exciting leaflets aimed at patients about our investigations and dedicated to children and their parents. The leaflets are written in a direct and understandable language and they are 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. In 2004, the department participated in the Open Hospital Day for children, where we had the great pleasure of a huge and very interested crowd of visitors.

Lise Borgwardt defended her PhD thesis in 2004: "PET with MRI co-registration and image fusion in children with CNS tumors" – with the first prospective studies on the diagnostic use of PET and MRI scanning in brain tumors in children.



Cyclotron unit



By Holger J. Jensen

The year of 2004 was marked by two major activities in the Cyclotron Unit: An increased production of ^{18}F for FDG and the installation of our new cyclotron. In 2003 our production laboratories were rebuilt and a new ^{18}F target from IBA, with a production capacity four times higher than previously, was installed in order to cover the increased demand for FDG among our customers. This year the production was increased considerably and a total of 599 productions were performed. Out of these 64% were carried out for our PET activities (^{18}F , ^{13}N , ^{11}C and ^{15}O), 25% for our Rb/Kr- generators, 7% for ^{211}At , and the remaining 4% were for $^{111\text{m}}\text{Cd}$, ^{64}Cu and test irradiations of satellite components. Only one production had to be cancelled this year.

In 2003, it was decided to buy an additional cyclotron, which should 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. In May 2004, a contract was signed with Siemens for delivery of a RDS Eclipse cyclotron from CTI. In November 2004, the cyclotron was delivered and it will be installed and tested in January 2005.

Our collaboration with research groups in Gothenburg and Upssala, Sweden, on the development of a new treatment of micrometastases by means of nuclide therapy using the alpha emitter ^{211}At peaked last year by the permission to start the first human trials in 2005. In 2004, physics student from the Niels Bohr Institute carried out the experimental work in connection with his master's thesis in our group. The purpose of the project was to investigate a new way of producing the PET isotope $^{110\text{m}}\text{In}$.



Radiochemistry



By Nic Gillings and Jacob Madsen

Routine Production

The year 2004 was a busy year for the radiochemistry section. The newly built laboratory facilities are now fully operational. The FDG production has increased steadily and FDG is produced routinely four days a week for use “in-house” and for distribution to our customers. To meet the increasing demands, the amount of radioactivity for each production has also increased significantly. After some initial teething problems our fully automated dispenser system is now running reliably and allows for dispensing of FDG in glass vials without radiation dose to the operator. Labels and packing lists are printed automatically after dispensing allowing for a more streamlined process with a reduced possibility of errors. On 1 September our on-line FDG ordering system (TracerSHOP) was launched. This is designed to simplify the ordering proce-

cedure for our customers and to enable them to follow the status of each order. In 2004, we produced 248 batches of FDG and sent approximately 325 vials to external customers.

The production of krypton generators continued according to the well-established delivery schedule on Mondays, Wednesdays and Fridays. From 1 May we started delivery of krypton generators to Holbæk Hospital twice a week, giving a total production for 2004 of approximately 800 generators.

Research Production

Production of the serotonin_{5HT}2A receptor ligand, [¹⁸F]altanserin, for use in research projects by the Neurobiology Research Unit continued as previously with production every Wednesday and every second Monday. A new PET tracer for investigation of serotonin reuptake sites in the brain,

[¹¹C]DASB was validated and an application for approval for human administration was sent to the “Danish Medicines Agency” in November 2004. It is expected that we can begin to produce [¹¹C]DASB from the start of March 2005. Several other new compounds will be validated for human use in 2005, both for oncology and neurobiology research.

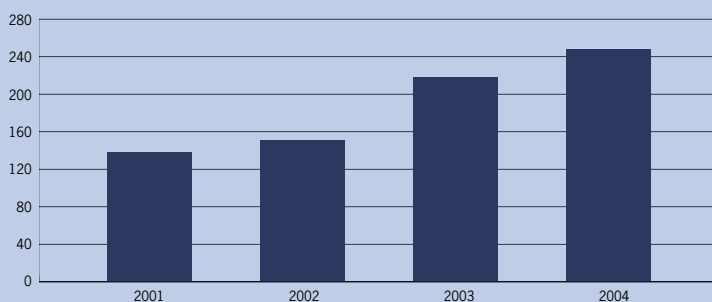
Oncology Research and Development

Charlotte Lund Hansen, MSc received a PhD stipendium from “Kræftens Bekæmpelse” (The Danish National Cancer Foundation) in the summer 2004. She will start the project on development of labelled peptides for imaging the epidermal growth factor tyrosine kinase receptor in January 2005. This project will be carried out in collaboration with the Department of Radiation Biology at Rigshospitalet and the Chemistry Department at the “Royal Veterinary and Agricultural University in Denmark” (KVL).

Neurobiology Research and Development

PhD Student Kaare Søndergård has been hard at work at “The Danish University of Pharmaceutical Sciences” synthesising new candidate dopamine D₂ agonist ligands, which can be labelled for use in PET studies of the brain in collaboration with the Neurobiology Research Unit. The labelling of the first of these ligands was achieved at the end of 2004 and will be tested in animal models in the beginning of 2005. Several other candidates have been tested in vitro and one candidate in particular is very promising and will be labelled with carbon-11 and tested also in the beginning of 2005.

FDG PRODUCTIONS DURING THE LAST FOUR YEARS



PET and PET/CT scanners



By Søren Holm

The PET and Cyclotron Unit has two PET scanners and two PET/CT scanners. The oldest PET scanner is a GE4096 from 1991. The image field of view is only 10 cm, which is acceptable for heart imaging studies, but for whole body scans it is time-consuming. In 2004 it was our “back-up scanner” and in January 2005 it will be moved to the Panum Institute, where it will be a part of “The Cluster for Molecular Imaging”, headed by Professor Andreas Kjær. The GE Advance PET Scanner from 1993 was a new generation with 3D scanning and higher sensitivity. The field of view is 15 cm, sufficient for the whole brain, and whole body scans can be performed with 6-8 images. In the Advance PET scanner we carry out all the heart and brain scans, including the receptor scans from the Neurobiology Research Unit, and also a substantial number of whole body FDG scans.

Our first PET/CT scanner is a GE Discovery LS, a combined PET and CT scanner, where the PET is identical with the Advance scanner. This PET/CT scanner was installed in the autumn of 2001. The CT is used for both diagnostic quality CT and for attenuation correction of the PET images. A PET/CT on the Discovery will only take half the time of a PET scanner on the Advance scanner, which is of benefit to the individual patient and to the capacity of the department. We have a very large and increasing number of patients referred for PET and PET/CT scans, and in spite of a very high activity it has been a struggle to keep the waiting list low. Just a few years ago, PET scanning was looked upon as research, 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.

In 2004, we strengthened our collaboration with the Department of Clinical Radiotherapy, where our young physicist Thomas Levin Klausen worked on respiratory gating of PET/CT for radiation therapy. With the help of Varian and GE, we have established a method where respiratory gating can increase the sharpness and quality of the PET images: Usually the acquisition of PET images lasts several minutes, much longer than anyone can hold their breath. Consequently, moving objects like lung tumors, which move along with the respiration will result in “blurry” and “flickering” images. To resolve this problem we have an RPM-camera; a real position management camera following the

movements from a little reflex box, placed on the chest of the patient. The information from the RPM camera is transferred to the PET scanner, and instead of one long PET image, the scanner will be gated to make ten images, each in different phases of the respiratory circle. This can improve both the diagnostic accuracy of the PET/CT scan and improve the use of PET/CT for radiation therapy, as it will give a more precise delineation of the region of interest for therapy. The first acquisitions have been made, but as it is very laborious and time-consuming, there is a long way before it becomes a routine investigation. Troels Jørgensen, who is a student of physics, has carried out the computer simulations and phantom studies for his project in physics at the “Niels Bohr Institute”.

The image shows the PET/CT scanner with the gating equipment as it looked at the first respiratory gated acquisition in 2004. The image was also displayed in the Danish newspaper “Jyllands-Posten” in connection with an article explaining the method and the perspectives. 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, especially designed also to facilitate studies in children. 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. This scanner is acquired in close collaboration with the Department of Radiotherapy, and is installed in January 2005.

PET/CT and radiotherapy



By Annika Loft Jakobsen and Anne Kill Berthelsen

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.

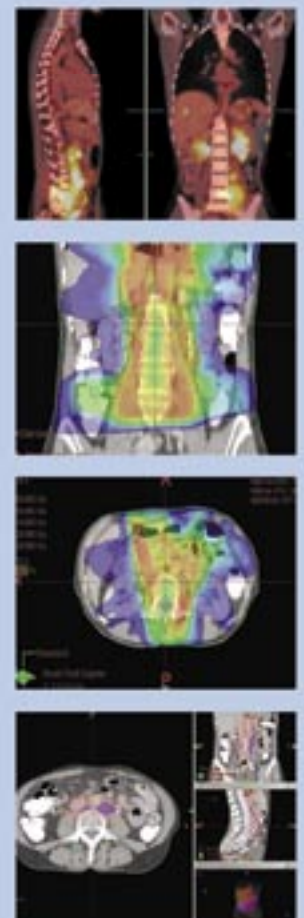
We have two dedicated PET scanners, a GE Advance and a GE 4096. Our PET/CT scanner, a GE Discovery LS was installed in December 2001, and a new Siemens Biograph Hi-Rez PET/CT scanner with 16-slice CT will be installed in January 2005.

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. 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.

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.

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.

Working with PET/CT every day, we are convinced of the usefulness of PET/CT in clinical work as well as in clinical research. However, the introduction of any kind of new modality requires clinical trials to verify the usefulness of the method. In prospective controlled trials we investigate the clinical diagnostic value of PET/CT for malignant lymphoma, colorectal, cervical, ovarian and lung cancer at present.



Patient investigations

CNS and peripheral nervous system

Regional cerebral bloodflow, physiological, O-15-H2O	3
Regional cerebral metabolism, F-18 FDG	94
Regional cerebral metabolism, F-18 Altanserin	56
Total	153

Respiratory organs

Lung function test, whole body plethysmography	1054
Lung function test, whole body plethysmography w/reversibility	71
Lung function test, spirometry w/reversibility	70
Lung function test, spirometry w/pharmacol. provocation	6
Lung function test, spirometry physiological provocation	1
Lung function test, diffusionscapacity (CO)	1893
Max inspiratory and expiratory muscle pressure	44
Lung perfusion scintigraphy, Tc-99m-MAA	284
Lung perfusion scintigraphy, regional, Tc-99m-MAA	62
Lung perfusion scintigraphy, Spect, Tc-99m-MAA	10
Lung ventilation scintigraphy, ind. Spect 16, Kr-81m	83
Lung ventilation scintigraphy, Tc-99m-DTPA	1
Lung ventilation scintigraphy, regional, Kr-81m	54
Mucociliary clearance, Tc-99m-nanokolloid	29
Total	3862

Heart and cardiovascular system

Isotope cardiography, Tc-99m	66
Cardiography, SPECT, LVEF+vol., Tc-99m, scientific invest.	26
Isotope cardiography, LVEF, Tc-99m-HAS	675
Isotope cardiography, LVEF + vol., Tc-99m-HSA	73
Myocardial perfusion scintigr., Tc-99m-MIBI, pharmacol. stress, dipy.	1
Myocardial perfusion scintigr., Tc-99m-MIBI, pharmacol. stress, dobut.	1
Myocardial perfusion scintigr., Tc-99m-MIBI, pharmacol. stress, adeno.	4
Myocardial perfusion scintigr., gated, Tc-99m-MIBI, pharmacol. stress, dipy.	26
Myocardial perfusion scintigr., gated, Tc-99m-MIBI, pharmacol. stress, dobut.	4
Myocardial perfusion scintigr., gated, Tc-99m-MIBI, pharmacol. stress, adeno.	71
Myocardial perfusion scintigr., gated, Tc-99m-MIBI, physiological stress	53
Myocardial perfusion scintigr., Tc-99m-MIBI, physiological stress	2
Myocardial perfusion scintigr., gated, Tc-99m-MIBI, NTG	156
PET Myocardial perfusion, N-13-NH3	24
Myocardial perfusion, N-NH3, pharmacol. stress, dipy.	21
PET myocardial metabolism, F-18 FDG	3
Exercise electrocardiography	58
Total	1264

Peripheral vessels

Isolated limb perfusion leakage monitoring, chemotherapy	16
Total	16

Gastrin intestinal tract, including liver, biliary tract and pancreas

Salivary gland scintigraphy, Tc-99m	4
Bleeding scintigraphy (abdomen), Tc-99m-erythrocyt	4
Bleeding scintigraphy (adomen), Tc-99m-human serumalb.	3
Biliary tract scintigraphy, Tc-99m	16
Meckels diverticulum scintigraphy, Tc-99m	2
Schillings test I	7
Total	36

Kidneys and urinary tract

Glomerular filtration, Cr-51-EDTA, several samples	254
Glomerular filtration, Cr-51-EDTA, one sample	2971
Renal scintigraphy, Tc-99m-DMSA	13
Renography, Tc-99m-MAG3, diureses	41
Renography, Tc-99m-MAG3, ph	1556
Renography, Tc-99m-MAG3, ACE-inhibitor	113
Total	4948

Bone and joint

Bone scintigraphy, 3-phase	2
Bone scintigraphy, regional, static	67
Bone scintigraphy, whole body, static	753
Bone scintigraphy, SPECT	68
Total	890

Endocrine organs

Thyreoid scintigraphy, Tc-99m	420
Thyreoid scintigraphy, I-131-jodid, residual tissue and up-take	35
Parathyreoid scintigraphy, Tc-99m-MIBI, SPECT + CT	52
Adrenal marrow scintigraphy, I-123-MIBG	27
Whole body scintigraphy after I-131-therapy	53
Total	587

Blood and lymph system

Erythrocyt volume, Tc-99m	14
Erythrocyt volume, Cr-51	6
Plasma volume, I-125	27
Lymph scintigraphy, extremities, Tc-99m	2
Sentinal node, tumor drainage, Tc-99m	13
Sentinal node scintigraphy, tumor drainage, mamma c., Tc-99m	185
Sentinal node scintigraphy, tumor drainage, malignant mel., Tc-99m	96
Sentinal node scintigraphy, tumor drainage, penile c, Tc-99m	7
Sentinal node scintigraphy, tumor drainage, vulva c., Tc-99m	6
Peritumoral injection of Tc-99m-nanocoll	46
Spleen scintigraphy, w/Tc-99m-erythrocyte, heated	2
Total	404



Other diagnostic procedures

Aprotinin scintigraphy, Tc-99m	19
Tumor scintigraphy, I-131-jodid	3
Tumor scintigraphy, In-111-Octreotide	117
PET tumor scanning, F-18 FDG	1909
PET infection scanning, F-18 FDG	20
White blood cell scintigraphy, In-111	121
Whole body counting, K-40	32
Whole body counting, contamination measurements	3
Image fusion (PET, SPECT, MRI, CT or planar), PET-section	1201
Image fusion (PET, SPECT, MRI, CT og planar), KF-section	96
Diagnostic CT	1174
Fixation tools for radiotherapy	16
CT-therapy scanning	44
Total	4755

Radiotherapy

Treatment with I-131, benign	72
Zevalin 90-Yttrium	178
Total	250

In vitro analysis

Plasma thyreoglobulin	932
Total	932

Total number of patient investigations **18,097**

Finance

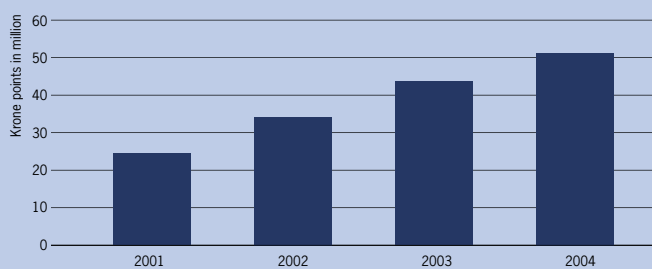
BALANCE 2004

Expenditure

Running costs	DKK 7.0 million
Staff	DKK 24.6 million
In total	DKK 31.6 million

Receipts	DKK 12.3 million
Net sum	DKK 19.3 million

TURNOVER DURING THE LAST FOUR YEARS



The increase in activities measured in "krone points" rose from 24.4 million in 2001 to 51.2 in 2004. "Krone points": price for each patient investigation multiplied with the number of investigations, summarized for alle patient studies performed during the year.

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 we are strengthening the experimental animal facilities in order to focus on 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 diagnose 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. Subsequently, we plan to perform a series of experiments with the use of these labelled stem cells.

Neuro PET: In cooperation with the Neurobiology Research Unit a series of neuroreceptor ligands are developed and used for neuroresearch. So far, the focus has mainly been on the serotonergic system. Furthermore, we cooperate with other research groups, studying neuronal activation and brain tumours.

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. 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 function test: 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 ligand 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.

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 the planning of the new programme, MSc in Medicine and Technology, which was implemented on 1 September 2003, as a five year bachelor and master education.

In 2003, 219 students applied and 66 students were accepted. In 2004 220 students applied and an average score of 9.1 was required for admission to the study in 2004. The education is 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

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

- *Jann Mortensen*, Chief physician received a travel grant amounting to DKK 9,717 from "Dansk Lungeforening" (the Danish Lung Association) to participate in the EANM congress 2004.
- *Trine Stavngaard*, Physician, Clinical Assistant received DKK 70,000 from "Dansk Lungeforening" (the Danish Lung Association) for a project on "MR scanning of the lungs with hyperpolarized helium at patients with alpha-1-antitrypsin deficiency".
- *Annika Loft Jakobsen*, Chief Physician received DKK 5,000 from Rigshospitalets foundation for oncological purposes to participate in a course held by the "International Cancer Imaging Society" (ICIS), the 4th Annual Teaching Course in Italy, October 2004.
- *Martin Hutchings*, Registrar and Professor Liselotte Højgaard received DKK 50,000 kr. from the foundation "Savværksejer Jeppe Juhl og Hustru Ovita Juhl's Mindelegat" for a research programme on "PET & children – lymphoma"
- *Professor Liselotte Højgaard* received the prize "Medicoprisen 2004" from "Medicoindustrien" (the trade organisation for the medical device industry in Denmark) for her involvement in the new programme MSc in medicine and technology. She received the prize together with Professor Jørgen Arendt Jensen, the Technical University of Denmark.
- *Andreas Kjær*, Chief Physician received DKK 7.2 million from the foundation "A.P. Møller og Hustru Chastine Mc-Kinney Møllers Fond til almene Formaal" for a mini-PET/CT scanner.

Professor Liselotte Højgaard, Head of Department received the Danish prize "Medicoprisen 2004" from "Medicoindustrien" (the trade organisation for the medical device industry in Denmark).



Publications

PhD thesis

Adams KH. The in vivo brain distribution of serotonin 5-HT_{2A} receptors in healthy subjects and in patients with obsessive-compulsive disorder: A positron emission study with [18F]-altanserin. (PhD thesis). 2004:1-86. Copenhagen University, The Medical Faculty.

Borgwardt L. PET with MRI co-registration and image fusion in children with CNS-tumors (PhD thesis). 2004:1-79. Copenhagen University, The Medical Faculty.

Scheuer KH. Assessment of cerebral involvement in SPG4 linked hereditary spastic paraplegia (PhD thesis). 2004:1-70. Copenhagen University, The Medical Faculty.

Scientific publications

Adams KH, Pinborg LH, Svarer C, Hasselbalch SG, Holm S, Haugbol S et al. A database of [F-18]-altanserin binding to 5-HT_{2A} receptors in normal volunteers: normative data and relationship to physiological and demographic variables. *Neuroimage* 2004; 21(3):1105-13.

Bach-Gansmo T, Bogsrud TV, Aas M, Fischer BM. Positron emission tomography (PET) ved lungekræft. *Tidsskr Nor Lægeforen* 2004;124:1088-9.

Balslev D, Christensen LO, Lee JH, Law I, Paulson OB, Miall RC. Enhanced accuracy in novel mirror drawing after repetitive transcranial magnetic stimulation-induced proprioceptive deafferentation. *J Neurosci* 2004; 24(43):9698-702.

Bischof Delaloye A, Hojgaard L, Knuuti J. Peter Ell: portrait of an editor. *Eur J Nucl Med Mol Imaging* 2004;31:3-4.

Bode S, Dreyer T, Greisen G. Gastric emptying and small intestinal transit time in preterm infants: a scintigraphic method. *J Pediatr Gastroenterol Nutr* 2004; 39(4): 378-82.

Chakera AH, Drzewiecki KT, Eigtved A, Juhl BR. Sentinel node biopsy for melanoma: a study of 241 patients. *Melanoma Res* 2004; 14(6):521-6.

Chakera AH, Law I, Friis E, Ingvar C, Hesse B. Bilateral axillary sentinel nodes from breast carcinoma. *Clin Nucl Med* 2004; 29(12):840.

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* 2004;31:450.

Dirksen A, Mortensen J. Billeddiagnostik af lunger. *Medicinsk Kompendium* 16. udgave, bind 1. Nyt Nordisk Forlag Arnold Busck. 2004;38:1306-10.

Fischer BM, Mortensen J, Dirksen A, Eigtved A, Hojgaard L. Positron emission tomography of incidentally detected small pulmonary nodules. *Nucl Med Commun* 2004; 25(1):3-9.

Fischer BM, Mortensen J. Lungecancer – skal man bruge positronemissionstomografi? *Ugeskr Laeger* 2004; 166:2537-41.

Freiberg J, Hove JD, Kofoed KF, Fritz-Hansen T, Holm S, Larsson HB et al. Absolute quantitation of left ventricular wall and cavity parameters using ECG-gated PET. *J Nucl Cardiol* 2004; 11(1):38-46.

Gerlach C, Law I, Paulson OB. Structural similarity and category-specificity: a refined account. *Neuropsychologia* 2004; 42(11): 1543-53.

Grinder-Pedersen L, Bukhave K, Jensen M, Hojgaard L, Hansen M. Calcium from milk or calcium-fortified foods does not inhibit nonheme-iron absorption from a whole diet consumed over a 4-d period. *Amer Jour Clin Nutr* 2004; 80(2):404-9.

Hartoft-Nielsen ML, Rasmussen AK, Friis E, Blichert-Toft M, Buhl T, Hesse B et al. Unsuccessful radioiodine treatment of a non-toxic goiter: A case report. *Basic Clin Pharmacol Toxicol* 2004; 95(2):72-5.

Hesse B, Meyer C, Nielsen FS, Sato A, Hove JD, Holm S et al. Myocardial perfusion in type 2 diabetes with left ventricular hypertrophy: normalisation by acute angiotensin-converting enzyme inhibition. *Eur Jour Nucl Med Mol Imaging* 2004; 31(3):362-8.

Hove JD, Iida H, Kofoed KF, Freiberg J, Holm S, Kelbaek H. Left atrial versus left ventricular input function for quantification of the myocardial blood flow with nitrogen-13 ammonia and positron emission tomography. *Eur Jour Nucl Med Mol Imaging* 2004; 31(1):71-6.

Humphreys GW, Kyllingsbaek S, Watson DG, Olivers CNL, Law I, Paulson OB. Parieto-occipital areas involved in efficient filtering in search time course analysis of visual marking using behavioural and functional imaging procedures. *Q J Exp Psychol A* 2004; 57(4):610-35.

Husted SE, Christiansen T, Hassager C, Mortensen J, Jensen KS, Nielsen HK et al. Lungeemboli. Klaringsrapport 2004.

Hutchings M, Eigtved AI, Specht L. FDG-PET in the clinical management of Hodgkin lymphoma. *Crit Rev Oncol Hematol* 2004; 52(1):19-32.



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

Højgaard L. Lung cancer - should the PET be used? *Ugeskr Laeger* 2004; 166:2536.
Højgaard L. Should PET scanning be used in lung cancer? *Tidsskr Nor Laegeforen* 2004;124:1074.

Kehlet H, Højgaard L. Det sengeløse hospital - en realistisk mulighed. *Ugeskr Laeger* 2004; 166:4706-7.

Kjær A, Appel J, Hildebrandt P, Petersen CL. Basal and exercise-induced neuroendocrine activation in patients with heart failure and in normal subjects. *Eur J Heart Fail* 2004; 6(1):29-39.

Kjær A, Lebech AM, Eigtved A, Højgaard L. Fever of unknown origin: prospective comparison of diagnostic value of F-18-FDG PET and In-111-granulocyte scintigraphy. *Eur J Nucl Med Mol Imaging* 2004; 31(5): 622-6.

Kjær A, Lebech AM, Eigtved A, Højgaard L. Reply. *Eur J Nucl Med Mol Imaging* 2004; 31(9):1344.

Knudsen GM, Rostrup E, Hasselbalch SG. Quantitative PET for assessment of cerebral blood flow and glucose consumption under varying physiological conditions. *Int Congress Series* 2004;(1265):189-200.

Lebech AM, Gerstoft J, Hesse B, Petersen CL, Kjær A. Right and left ventricular cardiac function in a developed world population with human immunodeficiency virus studied with radionuclide ventriculography. *Am Heart J* 2004; 147(3):482-8.

Lindhardt TB, Gadsboll N, Kelbaek H, Saunamaki K, Madsen JK, Clemmensen P et al. Pharmacological modulation of the ATP sensitive potassium channels during repeated coronary occlusions: no effect on myocardial ischaemia or function. *Heart* 2004; 90(4):425-30.

Liptrot M, Adams KH, Martiny L, Pinborg LH, Lonsdale MN, Olsen NV et al. Cluster analysis in kinetic modelling of the brain: a noninvasive alternative to arterial sampling. *Neuroimage* 2004; 21(2):483-93.

Lou HC, Luber B, Crupain M, Keenan JP, Nowak M, Kjær TW et al. Parietal cortex and representation of the mental self. *Proc Natl Acad Sci U S A.* 2004;101:6827-32.

Madsen J, Elfving B, Andersen K, Martiny L, Knudsen GM. Gas phase production of [C11]methyl iodide-d-3. Synthesis and biological evaluation of S-[N-methyl-C11]-citalopram and deuterated analogues. *J Label Compd Radiopharm* 2004; 47: 335-48.

Mortensen J, Fischer BM. PET udredning af lungekræft. *Respiratory review* 2004.

Mortensen J, Dirksen A. Lungefunktionsundersøgelse. *Medicinsk Kompendium* 16. udgave, bind 1. Nyt Nordisk Forlag Arnold Busck. 2004;38:1298-306.

Nielsen JE, Johnsen B, Koefoed P, Scheuer KH, Grønbech-Jensen M, Law I et al. Hereditary spastic paraplegia with cerebellar ataxia: a complex phenotype associated with a new SPC4 gene mutation. *Eur J Neurol* 2004; 11:817-24.

Nøttrup T, Fischer BMB, Elberling C, Skuladottir H, Pappot H. Lungekræft - en teknologisk udfordring I. Diagnostik og stadietildeling. *Ugeskr Laeger* 2004; 166:4241-3.

Olsen MH, Wachtell K, Meyer C, Hove JD, Palmieri V, Dige-Petersen H et al. Association between vascular dysfunction and reduced myocardial flow reserve in patients with hypertension: a LIFE substudy. *J Hum Hypertens* 2004; 18(6):445-52.

Oturai PS, Mortensen J, Enevoldsen H, Eigtved A, Backer V, Olesen KP et al. Gamma-Camera F-18-FDG PET in diagnosis and staging of patients presenting with suspected lung cancer and comparison with dedicated PET. *J Nucl Med* 2004; 45(8):1351-7.

Pappot H, Fischer BM, Elberling C, Skuladottir H, Nøttrup T. Lungekræft - en teknologisk udfordring II. Nye behandlingstiltag. *Ugeskr Laeger* 2004; 166: 4243-5.

Pinborg LH, Adams KH, Svarer C, Holm S, Hasselbalch SG, Haugbol S et al. Quantification of 5-HT_{2A} receptors in the human brain using [18F]altanserin-PET and the bolus/infusion approach. *J Cereb Blood Flow Metab* 2004; 23:985-6.

Pinborg LH, Adams KH, Yndgaard T, Hasselbalch SG, Holm S, Kristiansen H et al. [F-18]altanserin binding to human 5HT_{2A} receptors is unaltered after citalopram and pindolol challenge. *J Cereb Blood Flow Metab* 2004; 24(9):1037-45.

Vansteenkiste J, Fischer BM, Dooms C, Mortensen J. Positron-emission tomography in prognostic and therapeutic assessment of lung cancer: systematic review. *Lancet Oncol* 2004; 5(9):531-40.

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 Associate Professor Jann Mortensen. In human biology, clinical physiology and nuclear medicine, and in theoretical physiology by Professor Andreas Kjær and in 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 technolo-

gists. As regards post graduate 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, symposias, meetings, congresses and workshops. The department's educational activities are very comprehensive and comprise 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 scanners also for the CT part, including the low-dose CT for the Hawkeye gamma camera. Their CT competence is officially acknowledged by the Danish National Agency for Radiation Protection.

The inspectors on the specialist education in clinical physiology and nuclear medicine from the Danish National Board of Health visited the department officially in 2003. The report published in 2004 displayed a very positive evaluation. Assistant Professor Jann Mortensen, Chief Physician is responsible for the education in the department.

Nuclear Medicine Technologists



By Linda M. Kragh

In our Department of Clinical Physiology and Nuclear Medicine & PET and Cyclotron Unit we have employed our nuclear medicine technologists with an education in clinical chemistry throughout the years. In the 1970ies and 1980ies, the majority of the clinical tasks carried out by the technologists at our department, were to set-up RIA-analyses, which led to the natural conclusion that the staff members should also handle the gamma cameras. The education was primarily a practical education and the theoretical part of the education was given by our nuclear medicine physicians. In 1996, a new technologist programme (3½ years) including nuclear medicine and clinical physiology was initiated. The first student graduated in July 1999.

The structure of the training was classified into seven modules and during the last module the students carried out a theoretical and practical four weeks' project resulting in a report and an oral examination. In 2001, the education became more international with the introduction of the European Credit Transfer System (210 ECTS points):

The theoretical part of the education (school) lasts two years and the student obtains a maximum of 135 ECTS points. The practical part of the education lasts 18 months and the student obtains a maximum of 75 ECTS points. Finally, the students will graduate as "Bachelors of Medical Laboratory Technology".

The new education of nuclear medicine technologists (in Danish "Bioanalytiker")

has improved the theoretical and practical skills in nuclear medicine considerably.

The present nuclear medicine technologists at the department consist of a very good and dynamic mixture of people with the former education and the present one. 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 now officially acknowledged by the Danish National Agency for Radiation Protection.

Electronic medical record

By Linda M. Kragh

We are heading towards the Electronic Medical Record – called EPJ. At present, the referrals and bookings are electronic as well as the medical report. In 1996, we changed from manual booking to an electronic booking system – called RIS. The staff of the department quickly accepted the new technology and it further provided us with a mail system for all employees. Thereby we could introduce modern communication technologies in the daily work. In 2003 and 2004, we introduced electronic referral to the clinic and the medical reports were electronically available to the referring physicians and clinics. In the near future, we expect our images to be available to all the clinical departments through the PACS system – our diagnostic imaging archiving system.

Other activities



Professor Liselotte Højgaard, Head of Department, is the chairman of "Sundhedsfagligt Råd i Klinisk fysiologi og nuklearmedicin" in H:S, the Specialty Advisory Committee (SFR) in Clinical Physiology and Nuclear Medicine. She is the chairman of "Begrebsrådet" in H:S, (the council on use of medical language) and a member of "Det Nationale Begrebsråd" (the national council on use of medical language). She is a member of "Det nationale råd for lægers videreuddannelse" (the National Council for Medical Education), as well as the "Danish Council for Research Policy". Furthermore, she is a member of "Arbejdsgruppen for Forskningsinfrastruktur" (AFI), a working group for research infrastructure in Denmark and a member of the steering group for biological and medical sciences, the "European Strategy Forum on Research Infrastructures" (ESFRI Medical). She is chair of the "Medical Museion" (the former Museum of the History of Medicine in Copenhagen). Liselotte Højgaard represented The University of Copenhagen in connection with the establishment of the new programme, MSc in Medicine and Technology in cooperation with The Technical University of Denmark (DTU). 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. Furthermore, he is a member of "Forskningsrådet" at Rigshospitalet (The Research Council) and a member of "Sundhedsfagligt Råd i Klinisk fysiologi og nuklearmedicin" in H:S, the Specialty Advisory Committee (SFR) in Clinical Physiology and Nuclear Medicine.

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 "Rygestop udvalget" (the "Stop smoking" committee at Rigshospitalet and a steering member of the "Dansk Lunge Cancer Gruppe" (the Danish Lung Cancer Group) and member of the subcommittees "Dansk Diagnostisk Lunge Cancer Gruppe" (the Danish Diagnostic Lung Cancer Group) and the Danish Steering Committee for Screening of Lung Cancer. He is 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 internal medicine.

Annika Loft Jakobsen, Chief Physician is a member of the "European Organisation for Research and Treatment of Cancer" (EORTC), the Functional Imaging Group.

Birger Hesse, Chief Physician is a member of the "European Council of Nuclear Cardiology" (ECNC) and chairman of the working party for the "European Procedu-

ral Guidelines on Nuclear Cardiology". He was a member of the "Scientific Committee for the EANM congress in Helsinki 2004" and chair for "Medicinsk bibliotek" at Rigshospitalet (the Medical Library) and "Biblioteksgruppen" in H:S (Library group).

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 Physiology 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).

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").

Lise Borgwardt, Registrar is responsible for the "Telemedicine Children's Programme" carried out in cooperation with the Children's Hospital of Michigan.

Birgitte Hanel, Nuclear Medicine Technologist has been Vice President for "Laboratoriemedicinsk Selskab for Bioanalytikere" (LSB), the Society of Medical Laboratory Technologists, since October 2004.



Specialty Advisory Committee in Clinical Physiology and Nuclear Medicine

The four departments of Clinical Physiology and Nuclear Medicine at Bispebjerg Hospital, Frederiksberg Hospital, Hvidovre Hospital and Rigshospitalet cooperate in "Sundhedsfagligt Råd" (SFR) for Clinical Physiology and Nuclear Medicine, 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. We have produced a central quality handbook for use in all four departments for clinical physiology and nuclear medicine. Besides we coordinate patient information, information posters on patient investigations, and we conduct mutual audits on all departments every spring. SFR has estab-

lished a common standard on how to perform the basic investigations in clinical physiology and nuclear medicine: 1) lung function test, 2) lung scintigraphy, 3) bicycle test/working electrocardiography, 4) distal systolic blood pressure on lower extremities, 5) skin perfusion scintigraphy, 6) GFR clearance, 7) renography, 8) bone scintigraphy, 9) thyroidea scintigraphy, 10) measurement of activity quantity for children.

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 would be inappropriate.

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.

Homepage

www.hosp.dk/HSSR/kliniskFysiologiogNuklearmedicin.nsf



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



Editors:

Liselotte Højgaard
 Andreas Kjær
 Gitte Runge

Layout:

Bjørn & List A/S

Fotos:

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

Issues:

1.000

Copyright:

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



H:S – The Copenhagen Hospital Corporation

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, and has at present 1,500 beds, a staff of 7,000 and a budget approximately ½ billion Euros. The research production is approximately 1,000 publications annually.