Rigshospitalet

Department of Clinical Physiology, Nuclear Medicine & PET

Annual Report 2017

PET

— 25 —

years anniversary

June, 21st 1992-2017

The most grateful thank you to the John and Birthe Meyer Foundation

1991	Scanditronix 32 MeV,
1991	GE4096 PET Scanner
1993	NMR Spectrometer
1993	PET Advance Scanner
2001	PET/CT Scanner
2005	PET/CT Scanner
2005	Cyclotron 2
2007	HRRT Scanner
2009	Radiochemistry Synthesizer
2011	PET/MR Scanner
2017	PET/CT Scanner

Rigshospitalet · University of Copenhagen

Rigshospitalet
King Frederik V founded Rigshospitalet in 1757. Today it has app. 1,400 beds and 12,000 employees. Research at Rigshospitalet is published in more than 2,000 peer review papers per year, including higher academic theses (PhD and Doctor of Medical Science). Rigshospitalet is part of The Capital Region of Denmark and is a Copenhagen University Hospital.

Glostrup Hospital
Glostrup Hospital were established in 1958, and 1st of January 2015 Rigshospitalet, Blegdamsvej and Glostrup Hospital were unified as Rigshospitalet.

University of Copenhagen
The University of Copenhagen was founded in 1479. The Faculty of Health and Medical Sciences has 10,000 students, including medicine and bioengineering in collaboration with The Technical University of Denmark, DTU. The University of Copenhagen is member of IARU, the International Alliance of Research Universities and LERU, League of the European Research Universities. www.ku.dk

REGION Rigshospitalet DTU UNIVERSITY OF COPENHAGEN

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Preface

2017 was a special year. Rigshospitalet had implemented the new EPIC (electronic patient record) in December 2016, and the first half year of 2017 was an uphill struggle both for the clinicians and for us in the Department of Clinical Physiology, Nuclear Medicine & PET. In the end of 2017 the production and patient flow was up on normal level again, and the last months of the year have been very busy.

In 2017 we had a special happy occasion, as we celebrated the 25 years anniversary of the first PET Center in Denmark here at Rigshospitalet. PET was established by a large donation from the John and Birthe Meyer Foundation in 1991 with Cyclotron, Radiochemistry facility and PET scanner. It was opened in 1992 by Chair of the Board Birthe Meyer, Board Member Gitte Meyer Brandt, Henrik Meyer and Director of the foundation Søren Drost-Nissen. Here in 2017 we celebrated the 25 years anniversary on the 21th of June 2017, and again the Meyer Foundation graced us with their presence; Birthe Meyer, Gitte Meyer Brandt and Søren Drost-Nissen. It was a wonderful and very happy day, and we celebrated with a symposium and festive reception. The day was special as the Foundation graced us with a donation for a new digital PET/CT scanner. We are immensely grateful for the confidence and support throughout the last 25 years. It has been a privilege for us, and we are deeply grateful. Without the support from The John and Birthe Meyer Foundation we had not been able to achieve our results for patient treatment, research and education. So from all of us in the department: A big thank you to the foundation.

2017 was in other aspects a very tough year. In April 2017 a large water damage over the SPECT/CT scanner in KF 4011 flooded the whole department. The scanner was totally destroyed, and floors and walls all over the department had to be renovated and exchanged throughout the next 6 months. Believe it or not, the same type of accident happened 2 weeks after with a water hose leaking in the Department of Radiology on the 2nd floor, and it flooded the whole unit KF 4114, where water was leaking out of the cealing and the walls. Renovation also in this section was ongoing for the same 6 month period. So the whole KF Section was in a state of emergency, as patients had to be taken care of in spite of the catastrophes. We would like to say a warm thank you to everyone in the KF Section and in the other parts of the department; as help was provided from everyone to try to alleviate the situation. In spite of the uphill battle we succeeded in taking care of the patients almost without creating a waiting list. We owe everyone the greatest, warmest and most respectful thank you.

Our long term Head of the KF Section, Consultant Jann Mortensen was appointed professor the 1th of April 2017 and therefore he stepped down as section leader to take up the position as professor. A warm thank you to Jann Mortensen for leadership of the section in 14 years. Consultant Lotte Hahn Enevoldsen was appointed new section leader from the 1th of April 2017. It was a huge challenge to take over the new position in this state of emergency due to the water damage and crisis situation. A warm thank you to Lotte Hahn Enevoldsen for handling it so professionally and with great enthusiasm and good spirit together with Staff Technologist Birgit Krindel Beyer. We are grateful for your effort and all the work spent to secure that the section was guided successfully through these difficult waters.

In summer we performed a rebuilding of the Cyclotron Section with new chimney and new facilities for ventilation and cleaning of the outlet from our production. It was a big project with new renovation and building.

Thank you very much to the Service Center in the hospital for helping us with the project and a special warm thank you to Cyclotron Chief Holger Jensen for handling the project so professionally. Unfortunately the builders who took care of the practical work had forgotten to remember, that sometimes it rains very heavily in Denmark in summer. We had water damage in the Cyclotron facilities and Radiochemistry labs due to flooding of the digits around the buildings. It was renovated in some weeks due to a helpful effort from everyone.

In the fall of 2017 a drain of the patient toilet in the waiting area for PET leaked, and for the next 4 month this area was under renovation. When water started to leak in the small tunnel between the Finsen 1 and Finsen 2 buildings in PET, we all started to cry, as it was the 5th time with water damage in the year 2017. Now it all seems to be renovated, and we will hopefully not experience anything like this ever again.

In spite of the tremendously difficult year the annual electronic surveyance of staff satisfaction showed to our surprise, that on average the whole staff of approximately 250 employees is happy and satisfied working in our department. We would like to express our greatest admiration and respect to everyone, as it has been a true challenge to work here in 2017.

The research in 2017 was performed succesfully in spite of the challenges, and the new uPAR and RGD trials in patients with “first-in-man trials” with new radiopharmaceuticals were carried out.

In 2017 we published 149 publications, 5 PhD and DMSc theses, 2 patents, as in the previous years in collaboration with international partners in Europe, US and China.

We would like to convey a warm thank you to everyone in the department for the great effort.

Thank you to our directors at the Center of Diagnostics, Rigshospitalet, Center Director Bettina Lundgren and Vice Director Lene Ørnstrup and their team for important, positive and helpful collaboration. Thank you to Department of Radiology, Head of Department Ilse Vejborg and Chief Radiographer Johnny Madelung. We appreciate the positive collaboration very much.
Thank you to all staff, collaborators and international colleagues for making this possible.

Our aim is to deliver the best patient treatment and the best research and education.

Linda M. Kragh
Chief Technologist

Liselotte Højgaard
Professor, Head of Department

Mission and objectives

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

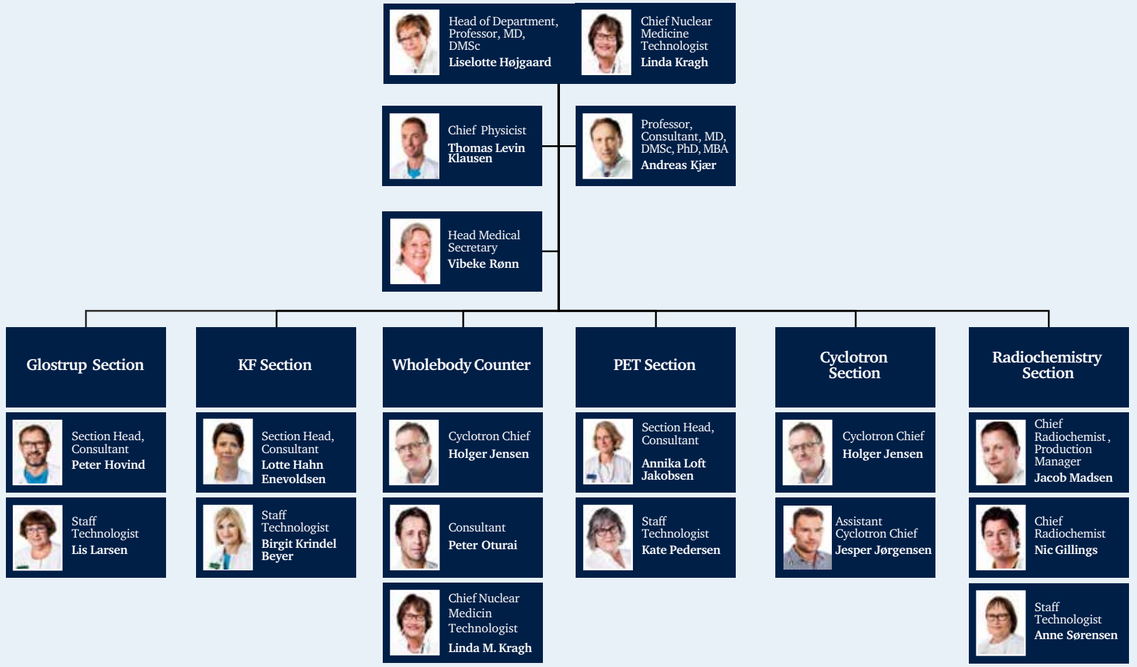
- to provide optimal clinical physiology and nuclear medicine for patient investigations and patient treatment with radiopharmaceuticals
- to carry out research at the highest international level in clinical physiology and nuclear medicine with special emphasis on molecular imaging, isotopes and radiopharmaceuticals
- to deliver undergraduate and postgraduate education for all relevant professionals nationally and internationally
- to provide a good patient experience with emphasis on quality and patient security and ensure wellbeing of patients, relatives and staff.

We aim high – we strive to be one of the five best departments in our field worldwide before 2020.

Organisation and staff 2017

Abrahamsen, Nynne Hejdemann, Technologist.
Abrahamsson, Elisabeth, Radiographer.
Aggergaard, Amalie, Student.
Agner, Elissaveta Castella, Radiographer.
Ahmadi, Amir, Radiographer.
Albers, Mia C. Hjorth, Teaching Technologist.
Albrecht-Beste, Elisabeth, MD, Consultant.
Allerslev, Kathrine Bøwig, Radiographer.
Alslev, Louise, MD, Staff Specialist.
Al-Tai, Reya Tarik Hamid, Technologist.
Amtoft, Annemarie Gjelstrup, MD, Consultant.
Anderberg, Lasse, Research Fellow.
Andersen, Flemming Littrup, MSc, PhD, Computer Scientist.
Andersen, Jane, Technologist.
Andersen, Julie Bjerglund, MD, PhD, Registrar.
Andersen, Kim Francis, MD, Consultant.
Andersen, Ulrik Bjørn, MD, Consultant.
André, Cecilie Dura, Student.
Anthony, Erwin Jørry, Cyclotron Technician.
Asmar, Ali, MD, Registrar.
Awwal, Zara Amalie Krog, Radiographer.
Azizi, Nadia, Radiographer.
Barløse, Mads Christian Johannes, MD, Registrar.
Bashir, Asma, Clinical Assistant.
Bay, Emma Therese, Student.
Bendtzon, Camilla Kuhre Vildrik, Medical Secretary.
Bentsen, Simon, MD, PhD Student.
Benzon, Eric von, MD, Consultant.
Berthelsen, Anne Kiil, MD, Consultant.
Beyer, Birgit Krindel, Staff Technologist.
Binderup, Tina, MSc Human Biology, PhD, Postdoc.
Birch, Kirsten Junker, Technologist.
Bisgaard, Sissel, MSc Med.Tech., Research Assistant.
Bjørling, Nina Louise, Medical Secretary.
Bobruk, Daniel Abdulla, Student.
Boldt, Tina Louise, Student.
Borgwardt, Lise, MD, PhD, Consultant.
Brakti, Inna, Student.
Brandt, Patrick Krøll, Student.
Brandt-Larsen, Malene, MSc, PhD, Chemist.
Brittain, Jane Maestri, MD, Senior Registrar.
Brun, Frederik Jager, Student.
Børresen, Betina, DVM, PhD student.
Bærentsen, Christian Ørtoft, Student.
Bærentzen, Anne-Sophie Sparresø, Student.
Calvo, Oriol Puig, PhD Student.
Cappelen, Katrine Louise, Engineer.
Carlsen, Esben Andreas, MD, PhD Student.
Chehri, Sarah, Scholarship.
Choudry, Aisha Bilal, Student.
Christensen, Anders, MD, PhD Student.
Christensen, Camilla, Chemist.
Christensen, Camilla, Technologist, Clinical Tutor.
Christensen, Esben, MSc Bio.Med., PhD student.
Christensen, Jan Damgaard, Cyclotron Technician.
Christensen, Line-Marie Neumann, Student.
Christensen, Thomas Emil, MD, PhD Student.
Christensen, Tine Nøhr, MD, PhD Student.
Clausen, Malene Martini, MD, PhD, Postdoc.
Clausen, Anne Skovsbo, DVM, PhD Student.
Clemmensen, Andreas Ettrup, MSc Med.Tech., PhD Student.
Cortsen, Annette, Technologist.
Cramer, Stig Præstekjær, MD, PhD, Postdoc.
Cucchi, Francesca, MD, Registrar.
Dahan, Daniel, Cyclotron Technician.
Dall, Bente, Technologist.
Dalgaard, Maya Ottilia, Student.
Dalsgaard, Birthe Hunnerup, Technologist.
Damgaard, Jeannette, Radiographer.
Damm, Kristina, Secretary.
de Nijs, Robin Vedel, Medical Physicist, MSc, PDEng, PhD.
Dejanovic, Danijela, MD, Staff Specialist.
Denholt, Charlotte Lund, MSc, PhD, Chemist.
Do, Manh Tan, Student.
Dunbar, Douglas, Technologist.
Dähnhardt, Andreas, System Administrator.
Døssing, Kristina Benedikte Vangsted, MSc Biology, PhD Student.
Edem, Patricia Edim, MSc Chem., PhD, Postdoc.
Eldirdiri, Abubakr, MSc Tech., Research Assistant.
Elkington, Sakeena, Technologist.
Pollmann, Sofie Ellebæk, MSc Biotech., PhD Student.
Ellegaard, Andreas Høyby, Student.
Enevoldsen, Lotte Hahn, MD, Consultant.
Eschen, Christian, Student.
Federspiel, Marianne, Technologist.
Fischer, Barbara Malene, MD, DMSc, PhD, Consultant.
Fliedner, Frederikke Petrine, MSc Biotech., PhD Student.
Foldager, Annette, Teaching Technologist.
Folkmann, Nanna Freja, Secretary.
Fosbøl, Marie Øbro, MD, PhD Student.
Frederiksen, Mette Helene Borggreen, Quality Coordinator.
Fredskil, Niels Ungermann, Student.
Frost, Nadia, Student.
Frydendahl, Christina Schjøth, MSc Chem, PhD, Postdoc.
Gelle, Liibaan Mohamed, Technologist.
Ghotbi, Adam Ali, MD, PhD Student.
Gillings, Nic, MSc, PhD, Chief Radiochemist.
Ginsborg, Lone Agervold, Medical Secretary.
Grunwald, Nicolas Konrad Voigt, Student.
Gudmundsdóttir, Edda Rós, Technologist.

Department of Clinical Physiology, Nuclear Medicine & PET



Organisation and Staff 2017

Gutt, Lars Emil, Student.
Haddock, Bryan Thomas, Chief Physicist.
Hag, Anne Mette Fisker, MSc Human Biology, PhD, Postdoc, Research Coordinator.
Handreck, Emilia Trolle, Student.
Hanel, Birgitte, Technologist.
Hansen, Adam Espe, Physicist.
Hansen, Anders Elias, DVM, PhD, Postdoc.
Hansen, Anja Vallin, Technologist, Clinical Instructor.
Hansen, Camilla Josephine Teglgaard, Technologist.
Hansen, Caroline Lind Hansen, Technologist.
Hansen, Casper, Student.
Hansen, Christian, Student.
Hansen, Helena, Student.
Hansen, Joachim Pries, Student.
Hansen, Matilde Bro, Student.
Hansen, Michele Zaugg, Student.
Hansen, Ole Michael Raun, Technologist.
Hansen, Sofie Lindskov, Physicist.
Hasbak, Philip, MD, DMSc, Consultant.
Hassan, Mariam, Technologist.
Haarbye, Martin Christian, Technologist.
Henriksen, Frederikke Hurup, Medical Secretary.
Henriksen, Otto Mølby, MD, PhD, Consultant.
Hercman, Alexandra Regina Nowacka, Technologist.
Hindsholm, Amalie Monberg.
Hokland, Sigbjørn Christian, Student.
Holm, Stine, Technologist.
Holm, Søren, MSc, PhD, Senior Physicist.
Holten, Victoria, Student.
Holtz, Simon Herken, MSc Molecular Biology, QA Academic.
Hovind, Peter, MD, DMSc, Consultant.
Hübbe, Mie Linder, MSc Human Biology, PhD Student.
Hurry, Preetee Kapisha, MD, Senior Registrar.
Høgh, Julie, Student.
Højgaard, Liselotte, MD, DMSc, Professor, Head of Department.
Iljazovska, Cejlan Zulfovska, Technologist.
Jakobsen, Annika Loft, MD, PhD, Consultant.
Jakobsen, Josefine Amalie Loft, Student.
Jakobsen, Mette Høy, Human Biology, PhD Student.
Jensen, Berit, Technologist.
Jensen, Holger, MSc, PhD, Chief Cyclotron Physicist.
Jensen, Julie Milbak, Student.
Jensen, Kim Ryder, Technologist.
Jensen, Mads Radmer, Registrar.
Jensen, Martin Juul Ravn, Technologist, Clinical Tutor.
Jensen, Mette Munk, MSc Human Biology, PhD, Postdoc.
Jensen, Michael Lundemann, Engineer.
Jensen, Vibeke, Technologist.
Jeppesen, Troels Elmer, MSc Chem, PhD Student.
Johannesen, Helle Hjorth, MD, Consultant.
Johannesson, Rasmus Skov, Student.
Juel, Merri Ingrid Rothaus, Technologist.
Juhl, Karina, MSc Human Biology, PhD Student.
Juul, Mark Uhrskov, MSc Med.Tech., Research Assistant.
Jørgensen, David, Student.
Jørgensen, Henriette Schjørring, MSc Mol.Bio.Med., Research Assistant.
Jørgensen, Jennifer Solgaard, MSc Engineer BioTech., PhD Student.
Jørgensen, Jesper, MSc, Cyclotron Physicist.
Jørgensen, Jesper Tranekjær, MSc Hum. Biology, PhD, Postdoc.
Jørgensen, Mads Wissenberg, Registrar.
Jørgensen, Mette Møller, Technologist.
Jæhger, Ditte Elisabeth, MSc Human Biology, PhD Student.
Kaijer, Michelle Westergaard, Technologist, PA Professor Andreas Kjær.
Karnov, Kirstine, MD, PhD Student.
Keller, Sune Høgild, MSc, PhD, Computer Scientist.
Khare, Harshvardhan Ajay, Student.
Kjems, Ida, Service Assistant.
Kjær, Andreas, MD, DMSc, PhD, MBA, Consultant, Professor.
Kjær, Kristian Skov, Student.
Klausen, Thomas Levin, MSc, Chief Physicist.
Klavsen, Mads Fjelbro, Engineer.
Knigge, Pauline Natalie Seindal, Student.
Knudsen, Camilla Sloth, Technologist.
Knudsen, Lisbet Lomholdt, Consultant.
Korsholm, Kirsten, MD, Senior Registrar.
Kragh, Linda M., Chief Technologist.
Krarup, Marie Manon Krebs, Student.
Kristensen, Anna Warncke, Student.
Kristensen, Lotte Kellemann, MSc Human Biology, PhD Student
Ladefoged, Claes Nøhr, Computer Scientist, PhD Student.
Langer, Jonathan Andreas Wang, Student.
Larsen, Bjarke Follin, MSc Ind.Med., PhD Student.
Larsen, Lis, Staff Technologist.
Larsen, Lena Tina, Animal Technologist.
Larsen, Mads Rud, Student.
Larsen, Mette Fabiansen, Medical Secretary.
Larsen, Trine Bjørnbo, MSc Pharm Tech, PhD Student.
Larsson, Henrik Bo Wiberg, MD, DMSc, Consultant, Professor.
Law, Ian, MD, PhD, Consultant, Professor.
Lehel, Szabolcs, MSc Chemistry, PhD., Chemist.
Lejre, Daniel, Student.
Lind, Camilla Louise Nordvig, Technologist.
Lindberg, Ulrich, MSc Med.Tech, PhD., Engineer.
Lindell, Elin, Technologist, Clinical Tutor.
Linnet, Simone, Student.
Linnet, Solveig, Technologist.
Ljunggren, Anna, Technologist.
Ludvig, Helle, Technologist.
Lundberg, Helena Inez Sofia, MD, Registrar.
Lundsgaard, Christoffer Cramer, Student.
Lykkegaard, Magnus Rønne, Student.
Lænkholm, Isak Trap, Student.
Lærke, Sonja Pedersen, Lab Technician.
Löfgren, Johan, MD, Consultant.
Madsen, Jacob, MSc, PhD, Chemist, Chief Production Manager.
Madsen, Karine, MD, Registrar.
Magnusson, Linda Helena Margaretha, Technologist.
Marner, Lisbeth, MD, DMSc, PhD, Staff Specialist.
Martín, Marina Simón, MSc Mol.Bio.Med., Research Assistant
Mehlsen, Anne-Birgitte, MD, Consultant.
Mikkelsen, Henny, Technologist.
Mikkelsen, Mathias, Student.
Mohebbi, Ali, Student.
Mollerup, Birgit Lilian, Technologist.
Morsing, Anni, MD, Consultant, PhD, DMSc.
Mortensen, Jann, MD, DMSc, Consultant, Professor.
Mottelson, Mathis Nygaard, Student.
Munch, Mette, Lab Technician.
Myschetzky, Rebecca Sue Main, Technologist.
Mølvig, Bjørn Hübschmann, Student.
Nielsen, Anders Bo, Student.
Nielsen, Carsten Haagen, MSc Med.Tech., PhD, Postdoc.
Nielsen, Cora Schaumann, Technologist.
Nielsen, Kasper With, Animal Technologist.
Nielsen, Kirstine Terese, Student.
Nielsen, Mariane, Service Assistant.
Nielsen, Susanne Weile, Technologist.
Nielsen, Tina Vikmann, Medical Secretary.
Nyrnberg, David Enslev, Student.
Nørgaard, Martin, Engineer.
Nørregaard, Kamilla, MSc Physicist, PhD, Postdoc.
Nørst, Tim Niclas, Technologist.
Olesen, Oline Vinter, MSc Engineer, PhD.
Olin, Anders. Student.
Olsen, Ingrid Marie Holst, MD, PhD, Postdoc.
Olsen, Paw Winther, Engineer.
Oturai, Peter, MD, Consultant.
Oxbøl, Jytte, Technologist, Lab. Manager.
Pedersen, Kate, Staff Technologist.
Pedersen, Kirsten Foldberg, Radiographer.
Pedersen, Sune Folke, MSc Human Biology, PhD, Postdoc.
Pejtersen, Maria, Technologist.
Petersen, Ida Nymann, MSc, Chemist, PhD, Postdoc.
Petersen, Lars Ringgaard, MSc Bio.Med., PhD Student
Petersen, Lotte Pia, Service Assistant.
Petersen, Rikke Juelsgaard, Scholarship.
Philipsen, Frederik Ersø, Student.
Poulsen, Constance Eline Grandjean, MSc Pharm., Research Assistant
Poulsen, Jákup Martin, Radiographer.
Poulsen, Sidsel Højklint, Student.
Raghava, Jayachandra Mitta, MSc Biology, Postdoc.
Rasmussen, Gregers Brünnich Damgaard, MD, PhD Student.
Rasmussen,Thomas, MD, PhD, Postdoc.
Ravnborg, Nanna, Student.
Reichkendler, Michala, MD, Staff Specialist.
Ripa, Rasmus Sejersten, MD, DMSc, Staff Specialist.
Risør, Louise Madeleine, MD, PhD Student.
Rostrup, Egill, MD, DMSc, Consultant.
Rusborg, Rebecca Borum, Student.
Rønbirk, Lilian, Medical Secretary.
Rønn, Vibeke, Head Medical Secretary, PA Professor Liselotte Højgaard.
Sadikovic, Edin, Student.
Salihu, Armend, Technologist.
Sammour, Razan Abu, Technologist.
Saxtoft, Eunice, Technologist, Technologist, Clinical Tutor.
Schulze, Christina, Technologist.
Segur, Liva, Student.
Semitoje, Gudrun, Medical Secretary.
Setterberg, Victoria, Technologist.
Simonsen, Helle Juhl, Technologist.
Skovgaard, Dorthe Charlotte, MD, PhD, Postdoc.
Slipsager, Jakob Mølkjær, Student.
Sommer, Niyan, Technologist.
Stahlfest, Marianne, Medical Secretary.
Stahr, Karin, Technologist.
Stavnsbjerg, Camilla, MSc Mol.Bio.Med., PhD student.
Strandberg, Sandra, Student.
Suetta, Charlotte Arneboe, MD, PhD, Consultant, Ass. Professor.
Sunde, Christine Høj, Technologist.
Svalling, Susanne, Technologist.
Svane, Peter Frederiksen, Clinical Assistant.
Svendsen, Nini Hvidtfeldt, Technologist.
Sørensen, Anne, Staff Technologist.
Sørensen, Jette Bitten, Service Assistant
Sørensen, Louise Sørup Lendorf, Technologist.
Sørensen, Mathias Munkholm, MD, Registrar.
Saaie, Hanan Rahim, Technologist.
Tayyab, Mahvish, Technologist.
Teksen, Alime Sema, Student.
Toft, Cecilie Grønkær, Student.
Tolstrup, Britt Maria Jæger, Radiographer.
Tornvig, Cecilie Maja, Technologist.
Uzer, Sefika, Technologist.
Vestergaard, Mark Bitsch, Postdoc. PhD Student.
Vignisdottir, Lilja Dögg, Radiographer.
Vilmar-Knudsen, Hanne, Medical Secretary.
Vu, Katja Cat Trang, Student.
Wehn, Pernille, Technologist.
Weihrauch, Per, Cyclotron Technician.
Wikke, Tina, Technologist.
Witt, Mette Neiegaard, MSc Human Biology, PhD Student.
Wittekind, Anne-Mette Nielsen, QA Pharmacist.
Wittrup, Charlotte, Student.
Yesefi, Leila, Technologist.
Aagaard, Christina Byrne Faurholt, MD, PhD Student.

Highlights 2017

The PET 25 years anniversary was celebrated on the 21th of June 2017, where the board of The John and Birthe Meyer Foundation, Birthe Meyer, Gitte Meyer Brandt and Director Søren Drost-Nissen graced us with their presence. It was a highlight of the many years and a wonderful occasion.

Head of Department, Professor Liselotte Højgaard was graced with a Knighthood of the 1st grade by Her Majesty the Queen on the 13th of November 2017.

In 2017 Professor Andreas Kjær as project leader received the prestigious Grand Solutions grant from Innovation Fund Denmark for the project Fluoguide. The project aims at developing molecular optical imaging for guiding cancer surgeons to ensure more gentle surgery with better outcome. The project is a multipartner, private-public collaboration.

Jann Mortensen was inaugurated as professor on the 25th of August 2017. We are proud of his achievements.

Consultant and Head of the Nuclear Medicine Paediatric Section was awarded by the American Society of Nuclear Medicine with the Butterfly Award as a recognition of her international work to reduce doses to paediatric patients.

Head of Department, Professor Liselotte Højgaard published the book: "How do we obtain the best health care system in the world?" as input to the debate about the current status of the hospitals in Denmark. The book was sold out, and the first edition has been reported in the medias and all the big Danish newspapers. A debate has been ongoing since. We hope it will strengthen patient treatment, research and education in the Danish hospitals.

At the annual education day in November 2017, the theme for the evening was the 1970'ies.

Medical secretaries

In the department we have highly competent medical secretaries important for referral of patients, organisation of the flow of patients through the department, writing the reports and sending them to the clinical departments. They do a dedicated effort, and we have no waiting lists for patients or reports. The medical secretaries master the complicated booking and secure that the waiting lists, the patient control examinations and research scans can be done in spite of a high work load. A dedicated thank you to Tina Vikmann Nielsen, Gudrun Semitoje, Hanne Vilmar-Knudsen, Lilian Rønbirk, Lone Agervold Ginsborg, Marianne Stahlfest, Mette Fabiansen Larsen, Kristina Damm, Nina Bjørling, Frederikke Hurup Henriksen, Camilla Kuhre Vildrik Bendtzon and Nanna Folkmann.

Our Head Medical Secretary Vibeke Rønn is assistant to the management of the department and also a great help in the daily work, when needed.

We would like to say a warm thank you to everyone for the high quality and performance.

KF Section

Section Head, Consultant Lotte Hahn Enevoldsen

The KF Section offers a variety of nuclear medicine and clinical physiological examinations of both routine patients and also for many research investigations in a broad spectrum of disciplines. In addition to nuclear medicine diagnostics the section also comprises radionuclide therapy of patients with neuroendocrine tumors (^{177}Lu-Dotatate), patients with castration resistant prostate cancer and symptomatic bone metastases (^{223}Ra) and patients with benign thyroid diseases (^{131}I-Iodine).

We participate in various weekly and monthly multidisciplinary team conferences discussing neuroendocrine tumors, thyroid diseases, adrenal diseases, cardiac diseases, lung diseases, and paediatric oncology with our clinical colleagues.

In April 2017 an extensive water damage due to a ruptured pipe over one of the SPECT/CT scanners in KF 4011 and 2 weeks later another large water damage due to a leaking water pipe resulted in that the section was flooded. As a consequence several examination rooms and offices were closed and most of the section had to be totally renovated. Fortunately, at the end of 2017 a new SPECT/CT scanner was successfully installed and the renovation of the section was completed.

Water damages

2017 was in other aspects a very tough year. In April 2017 a large water damage over the SPECT/CT scanner in KF 4011 flooded the whole department. The scanner was totally destroyed, and floors and walls all over the department had to be renovated and exchanged throughout the next 6 months. Believe it or not, the same type of accident happened 2 weeks after with a water hose leaking in the Department of Radiology on the 2nd floor, and it flooded the whole unit KF 4114, where water was leaking out of cealing and the walls. Renovation also in this section was ongoing for the same 6 month period. So the whole KF Section was in a state of emergency, as patients had to be taken care of in spite of the catastrophes. In summer we had water damage in the Cyclotron facilities and Radiochemistry labs due to flooding of the digits around the buildings. It was renovated in some weeks due to a helpful effort from everyone.

In the fall of 2017 a drain of the patient toilet in the waiting area for PET leaked, and for the next 4 month this area was under renovation. When water started to leak in the small tunnel between the Finsen 1 and Finsen 2 buildings in PET, we all started to cry, as it was the 5th time with water damage in the year 2017. Now it all seems to be renovated, and we will hopefully not experience anything like this ever again.

Inauguration of new professor

Professor Jann Mortensen gave his Inaugural Lecture the 25th of August 2017 as clinical professor at the University of Copenhagen, Department of Clinical Medicine and Department of Clinical Physiology, Nuclear Medicine and PET. Jann Mortensen had been section leader Nuclear Medicine and consultant at the department for long. It was with great happiness that we all celebrated our new professor. There are now 5 professors at the Department of Clinical Physiology and Nuclear Medicine.

Jann Mortensen's special area is lung physiology and pathophysiology, functional and diagnostic imaging of lung diseases and also theranostics, including radium for prostate cancer.

Congratulations to Jann Mortensen with the new professorship from all of us in the Department of Clinical Physiology, Nuclear Medicine & PET.

Glostrup Section

Section Head, Consultant Peter Hovind

The Glostrup Section examine patients hospitalized at the Glostrup location of Rigshospitalet as well as patients from the Glostrup outpatient clinics and patients from general practice in the surrounding area. A tradition of combining classical clinical physiology with modern nuclear medicine methods is currently developing into more and more sophisticated methods.

After a quick and successful implementation of the PET/CT technique in the section with the first PET/CT scanner installed late in 2016, we have now a more complete armamentarium of examinations offered to the patients at the Glostrup section of the department. In collaboration with the experienced staff in the PET Section our Siemens Biograph mCT is used to examine patients from both Glostrup and the PET Section. Wholebody scans are predominately performed three days a week with the remaining two days to perform dedicated brain scans. The latter examinations used in patients with dementia and other cerebral disorders are increasing rapidly in numbers.

Parallel to the possibility and use of the PET/CT technique, we continue to perform routine nuclear medicine imaging with our three dedicated gamma SPECT/CT scanners and two single head gamma cameras. The newly replaced NephroCam for kidney examinations is a work horse taking care of examinations for the follow-up on kidney function and for possible kidney diseases in patients with spinal cord injury. In addition, we perform many different types of planar and SPECT/CT examinations. This includes DAT scanning which visualize dopamine transport receptor binding in the brain for diagnosing Parkinson's disease and other neurological diseases involving dopamine transport receptors. Bone scintigraphy for rheumatologic diseases and evaluation of surgery performed in the spine with various prostheses are performed in patients from the large clinic at Glostrup evaluating patients with these diseases.

Using the tilt test examination under standardized situations with our two Task Force tilt test monitors, we examine patients with episodes of falling, syncope episodes or unexplained dizziness. Other physiological examinations offered are blood pressure measurements on the extremities, where blood pressure in the lower limbs can be evaluated in patients with claudication or ulcers, as well as measurement of systemic blood pressure over 24 hours for detection and evaluation of hypertension in adults and children. We assist in diagnosing secondary hypertension with Captopril renography, Doppler ultrasound of renal arteries and analysis of urinary steroid metabolism, where patients are received from the Capital Region and Region of Sealand.

Diagnostic ultrasound is also used together with thyroid scintigraphy in patients with disease in the thyroid. In patients with stroke, we examine the arteries to the brain for plaques and eventual stenoses of the vessels.

For measuring of lung function, we have a Jaeger body pletysmograph where patients with COPD, asthma and preoperative lung testing are performed. We participated as a part of a large multicenter study collecting a Danish reference material which has been completed.

We have three DXA-scanners, two Lunar Prodigy scanners and one Lunar iDXA scanner. After establishing a Danish reference material consisting of 1,500 healthy controls for muscle mass in collaboration with the Copenhagen City Heart study using the Lunar iDXA scanner, this up-to-date scanner is now used for the measurement of bone mineral density in patients with or suspected for osteoporosis. In patients treated for epilepsy – even at a younger age – there is a risk of bone loss. In these patients we evaluate BMD as well as whole body composition with our DXA scanners.

Functional imaging using Magnetic Resonance Imaging (MRI) is performed in collaboration with the Department of Radiology. The research areas are within functional imaging and brain physiology, measurement of perfusion, cardiac functional imaging, normal ageing of the brain as well as other applications of advanced MRI methods in clinical practice and research.

We frequently have multidisciplinary conferences dealing with cerebral disorders, thyroid diseases, secondary hypertension, geriatric patients and general medical cases with collaborating units and departments in the section.

Paediatric Nuclear Medicine

Consultant Lise Borgwardt

In 2017 we performed more than 3,000 paediatric nuclear medicine investigations. It is a special focus area for our clinic to perform children investigations at the highest level of excellence, and at the same time make it a positive experience for both the child and its parents.

This year we visited Stanford, Lucile Packard Children's Hospital, in order to exchange experiences on PET/MR and collaborate on the development on the modality for children. Our experience is that PET/MR can solve clinical diagnostic dilemmas and PET/MR is indeed a technique that can be used robustly in clinical practice. We find the combination of regional PET/MR and WB PET/CT on the same tracer injection especially useful, since we get the hybrid scan information with high soft tissue discrimination from PET/MR and the good hybrid staging scan with the highest diagnostic value of the lung parenchyma from PET/CT and all in an acceptable timeframe. Also our clinicians are very impressed by this combination of modalities.

Research in paediatric nuclear medicine and PET is necessary, as we have an increasing amount of medical doctors, PhD students and technologists involved in the field, and we conduct research protocols in children with PET/MRI in order to develop this interesting area, but also methods for evaluating regional liver function in children.
In 2017 we continued participating in randomized clinical trials for experimental immunotherapy for children with cancer as a part of the Nordic Center for these treatments.

Also this year the winner of the architect competition for the new National Children's Hospital in Copenhagen was announced. The project is very visionary and contains a large Diagnostic Unit where Paediatric Nuclear Medicine, among other diagnostic specialities, will be located. The new children's hospital will be ready in 2023.

We have a children unit integrated in our department with a children-friendly PET/128 Slice CT, SPECT/CT, EDTA Clearance and renography rooms. PET/MR scans are performed in the PET Section. In each scannerroom in the children's section, high quality projectors are showing films at the ceiling to secure and entertain the child during the scan. In the waiting area the children have the opportunity to watch the animated decorations, use apps or watch films at the tablets giving when entering the section or play in the toy corner. We offer 20 specially produced films and audio essays: "20 stories for the children of Rigshospitalet", both films for projection on the ceiling and audios essays to listen to while walking around looking at the wall decoration during tracer uptake period, that make our children have less sedation and feel entertained and secure while visiting our department.

The Glostrup Section is specialized in detection and evaluation of hypertension in children with equipment for measurement of systemic blood pressure over 24 hours and assist in the assessment for secondary hypertension in children with Doppler ultrasound of renal arteries.

The multidisciplinary paediatric haematology and oncology conferences are presented as a web-based nuclear medical platform combined with videoconference including districts outside the capital. Our collaborators are very pleased with the possibilities and the advantages in the diagnostic evaluation of the children.

This year we started our National Interest Group for Paediatric Medicine, DAPNM, Danish Association of Paediatric Nuclear Medicine. The first meeting was held during the yearly meeting of DSKFNM, Danish Society of Clinical Physiology and Nuclear Medicine, and the interest was great with more than 50 participants.

The work in the Paediatric Committee, EANM this year has been very interesting and inspiring, and we are looking forward to next year's work as Vice Chair in the committee.

Cardiac ^{82}Rb PET/CT

Consultant Philip Hasbak

Rigshospitalet was the first hospital in Scandinavia and one of the first in Europe to diagnose ischemic heart disease using cardiac ^{82}Rb PET/CT. At Rigshospitalet there is a special need to provide cardiac PET every day, since a large proportion of our patients with ischemic heart disease need an acute or sub-acute work-up that requires quick decision making as to coronary revascularization strategy. Patients with unstable angina or non-STEMI should be re-vascularized with percutaneous coronary intervention (PCI) within 3 days after admission or with coronary artery bypass graft surgery (CABG) within 5-7 days according to the Danish National Board of Health. Non-invasive assessment of myocardial function is an important domain of cardiac ^{82}Rb PET. Traditionally, cardiac PET images have been visually interpreted, using uptake as a measure of function. This approach, however, takes only a fraction of the full PET information into account. The application of tracer kinetic modelling to dynamically measured data is able to extract objective measures of perfusion and/or metabolism, depending on the tracer. While such true cardiac quantification has been troublesome and time-consuming in the past, our new cardiac tools now makes this state-of-the-art technology readily available. Further, we offer CT coronary angiography (CTCA) which is useful for planning many invasive cardiac procedures, particularly complex PCI procedures including chronic total occlusions (CTOs) and bifurcation stenting.

Cardiac and renal ^{123}I-MIBG scintigraphy

In 2010 we introduced cardiac ^{123}I-metaiodobenzylguanidine (^{123}I-MIBG). Radiotracer analogues of the sympathetic mediator norepinephrine have been investigated extensively, and are at the brink of potential widespread clinical use, especially after the presentation of the ADVANCE-HF trial. The most widely studied SPECT tracer, ^{123}I-MIBG has consistently shown a strong, independent ability to risk stratify patients with advanced congestive heart failure. Recently we have evaluated ^{123}I-MIBG as an estimate of renal sympathetic nervous activity.

Research-wise we have a close and good cooperation with various clinical departments.

Education 2017

Consultant Peter Oturai, Consultant Peter Hovind and Professor Jan Mortensen

Seven educational positions for young physicians training to become specialists in clinical physiology and nuclear medicine are held by the facilities In the KF, PET and Glostrup Sections. Other roles in the specialist education of physicians are related to the dedicated courses in oncology-, cardiology-, lung-, and endocrinology- pathophysiology, molecular imaging as well as more basic courses in methodology (MRI and kinetics), all held at our department and arranged by our professors and consultants. Furthermore, we contribute to the specialist education of physicians from other specialities such as urology, nephrology, radiology, oncology, haematology, pulmonology and thoracic surgery. A high number of PhD students are associated with the research activities in the department.

Regarding undergraduate education, nuclear medicine technologist students and radiographer students receive part of their education at the department. The department contributes to the activities of the Faculty of Health Sciences at the University of Copenhagen for medical students, human biology students and medicine & technology students in collaboration with DTU in various subjects, e.g. physiology, nuclear medicine and medical technology.

Colleagues and students from Denmark and abroad have visited the department for educational and research purposes for periods ranging from weeks to months.

The department delivers training programmes to staff from other nuclear medicine and radiological departments in Denmark and the Nordic countries.

The department's educational activities have been accredited by the the Accreditation of Nuclear Medicine Training Centres Committee of the Section of Nuclear Medicine of the European Union of Medical Specialists (UEMS) and The Danish Health Authorities.

Consultant Peter Oturai and Consultant Peter Hovind are responsible for the postgraduate education of physicians in the department. Professor Jann Mortensen and Professor Henrik Larsson are responsible for the undergraduate education of medical students in the department. Professor Liselotte Højgaard is responsible for under- and postgraduate education for bioengineers.

Nuclear medicine technologists, radiographers and lab technicians

Staff Technologists Kate Pedersen, Birgit Krindel Beyer, Anne Sørensen and Lis Larsen

The nuclear medicine technologists, radiographers and lab technicians have had a busy and exiting year 2017. The demand for our patient investigations have been rising, the number of research protocols have increased and we have had several serious water damages simultaneously with the preparation for our new ICT booking system. We have no waiting list in our sections in spite of the increasing number of patient investigations, and because of that we have had extended opening hours in the afternoon and evening almost every week. Thank you to each and everyone who have contributed and made this extra effort for our patients.

This demands good leadership, good colleagues and that everyone have a high level of knowledge and competences, and this is continuously developed by participation in relevant post graduate education and courses. We have a strong focus on continuous education with CT courses, advanced CT courses, courses about isotopes and radioactivity, MRI courses, the international lung function "driver license" and a MRI 7 tesla "driver license". Apart from this we participate in the annual meeting of the Danish Society for Clinical Physiology and Nuclear Medicine, both the annual and bi-annual meetings, the national meeting for radiochemistry and other relevant meetings with groups sharing common knowledge. All staff members are active and take responsibility for their own theoretical and practical postgraduate education. From our group we have presented posters at EANM, DSKFNM annual meeting and ESMRBMB, and it is a great delight to participate in national and international exchanging knowledge.

All sections have introduced a new planning system for the daily staff allocation to scanners etc. In Danish it is called "Alt i plan" and the new software and planning system has optimized the daily work and overall allocation of staff for both nuclear medicine technologists, radiographers, lab technicians and the group and team leaders. For the individual staff member it has given the possibility for a better overview of tasks and duties every day, and it is easier to find the right person to ask, as the new system can identify who is doing what.

The production from the Radiochemistry Section is a prerequisite for PET scans, and it is important that the PET tracer is produced in the right amount and at the right time. Simultaneously with a high daily production, Technologist Tina

Nuclear medicine technologists, radiographers and lab technicians

Wikke and Lab Technician Sonja Pedersen Lærke have developed a new first-in-man tracer ^{68}Ga-OPS202 for the diagnosis of neuroendocrine tumors and as part of a multicenter phase II study.

To be sure that all 100 projects in the PET Section is performed in accordance with the protocols, we have acquired new iPads, where projects and protocols are registered in a continuously updated program developed and tendered by Nuclear Medicine Technologist Eunice Saxtoft.

We celebrated the 25 years anniversary of the PET Section in June 2017 and in prolongation of this we gave a course in December with a two day PET course for the nuclear medicine technologists, radiographers and nurses from the whole of Denmark. It was planned by the Clinical Tutors Nuclear Medicine Technologists Elin Lindell and Eunice Saxtoft. It was a great success with 40 participants from the whole country and with the different backgrounds among the participants we had a great opportunity for exchanging knowledge about PET and how to do the daily routine. We received a very positive feedback on the course, and several of the participants have asked for a repetition.

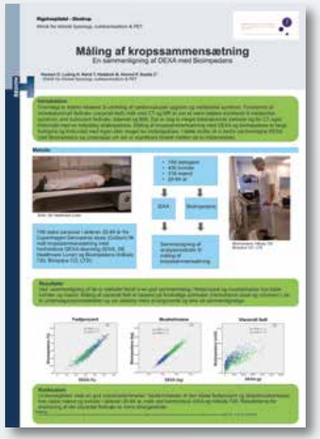
In the KF Section a theme afternoon in May 2017 included the whole group, plus physicians, medical secretaries, physicists, engineers etc. lead by our new Section Head, Consultant Lotte Hahn Enevoldsen and Staff Technologist Birgit Krindel Beyer. It was an occasion with group work and with the aim of improving the work environment. The emphasis was on trust, respectfulness, openness and helpful attitude towards one another. The KF Section has a very broad range of nuclear medicine and clinical physiology examinations, including a large amount of paediatric investigations performed under the leadership of the Paediatric Team KF.

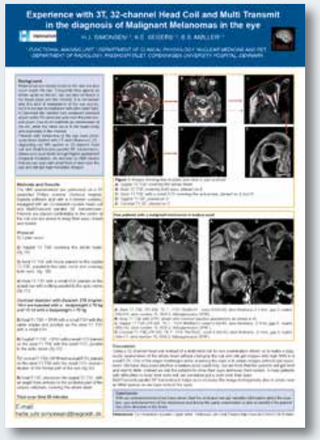
Spring 2017 had some wet surprises for us, as two of our main sections were flooded by water from the ceiling due to a crush of the water hoses. It meant that from May to December 2017 a very huge reconstruction had to be performed in the whole department with movement of patient investigation rooms and offices. We have had craftsmen of all kinds to repair the damages, and a new scanner had to be implemented as replacement for the SPECT/CT scanner, which was flooded by the water. It is extremely well done with the high number of patient investigations and in spite of the relocation due to the water catastrophe. At the same time the clinical quality research and team spirit has been high. Thank you to Staff Technologist Birgit Krindel Beyer and the whole team of nuclear medicine technologists and radiographers for a tremendously impressive effort. A lucky side effect has been a nice and tidy new section.

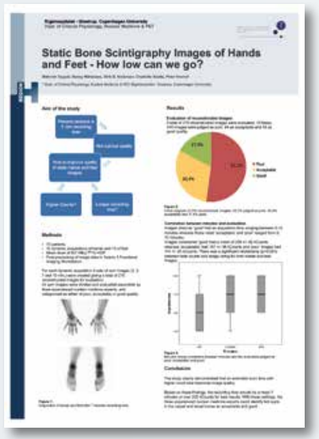
In the Glostrup Section the new PET/CT scanner from winter 2016 is now up and running full steam. The collaboration with the PET Section is well functioning for all staff members, and we have a close collaboration booking patients. Nuclear Medicine Technologist Helle Juhl Simonsen working specially with the MRI scanner and research was honored by an honorary title in the international MR collaboration: “Awarded as Fellow of the Society for MR Radiographers and Technologists" for significant and substantial contributions to the mission of the SMRT (International Society for MR Technologists).

We have had a high number of students in the department in 2017, and they have all been very satisfied with their period in our department. In spite of the challenges with a busy year and the water damages, and therefor very tight physical conditions, the students have been very satisfied with their practical period. From fall 2017 the education for technologists has been changed into a semester structure, and in the future the study for radiographers and technologists have been parted into semesters, which means that the individual student is with us for a longer period, which is very positive. For the technologists the practical period will be equal to that of the radiographers and they can learn a lot about clinical physiology and nuclear medicine. At the graduation at Metropol one of our bachelor groups were honored with the invitation to proceed with a reporting of their project as paper or poster. The project was concerning isotope cardiography (MUGA) made in 50 patients comparing 300 MBq ^{99m}Tc-HSA and 600 MBq ^{99m}Tc-HSA. If patients had normal cardiac rhythm the dose could be halved. That is of course very important for future patients and further investigations is ongoing.

In 2017 we said goodbye to radiographer Elisabeth Abrahamsson and Nuclear Medicine Technologist Solveig Linnet who went on retirement. Thank you very much to both of you for a tremendous effort for our department throughout many years.







PET Section

Consultants Anne Kiil Berthelsen and Annika Loft Jakobsen

In oncology and as well as in infectious and inflammatory diseases the use of FDG PET/CT is increasing tremendously around the world – and it is still an exciting and interesting challenge to develop the clinical set-up in our everyday work with more than 12,000 PET/CT scans every year. In treatment of oncological as well as inflammatory diseases personalized medicine plays an increasing role and PET/CT takes a natural part in this new paradigm, including testing of new tracers and investigating the clinical indications for these, as well as being part of the development of modern radiotherapy planning. PET/CT also plays an important role in multidisciplinary team conferences and tumor boards.

With clinical research imbedded in our everyday work, we have had the opportunity to take part in many clinical trials with results that now are implemented in our clinical routine, e.g. deep inspiration breathhold PET/CT for radiotherapy planning of malignant lymphoma and the use of PET/CT for gynaecological cancers.

25 years anniversary for PET at Rigshospitalet

In 2017 we had a special happy occasion, as we celebrated the 25 years anniversary of the PET Center at Rigshospitalet. PET was established by a large donation from The John and Birthe Meyer Foundation in 1991 with Cyclotron, Radiochemistry and a PET scanner. It was opened in 1992 by the Chair of the Board Birthe Meyer, Board Member Gitte Meyer Brandt and Director of the foundation Søren Drost-Nissen.

Here in 2017 we celebrated the 25 year anniversary on the 21th of June 2017, and again the Meyer Foundation graced us with their presence; Birthe Meyer, Gitte Meyer Brandt and Søren Drost-Nissen. It was a wonderful day, celebrated with a symposium and festive reception. The day was a special occasion, as the John and Birthe Meyer Foundation graced us with a donation for a new digital PET/CT scanner.

We are immensely grateful for the confidence and support throughout the last 25 years. It has been a privilege for us, and we are deeply grateful. Without the support from The John and Birthe Meyer Foundation we had not been able to achieve our results for patient treatment, research and education. So from all of us in the department: A big thank you to the foundation

25 years anniversary for PET at Rigshospitalet

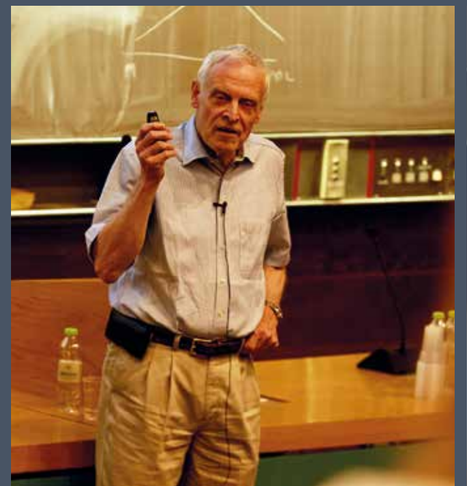
Leader of the PET Section, Consultant Annika Loft Jakobsen, together with our Leader of Radiology, Consultant Anne Kiil Berthelsen, and the whole team of nuclear medicine physicians and radiologists have together with the nuclear medicine technologists, headed by Staff Technologist Kate Pedersen, developed clinical PET to the highest clinical state of the art quality worldwide. We can say that without bragging. We perform at the moment 15,000 PET scans per year, including a large research program. In total we have published >1,000 peer review publications about PET in oncology, cardiology, neurobiology and various other areas. We have been part of the international development of PET/CT for diagnosis, staging, treatment, evaluation, prognosis, relapse and treatment planning with radiotherapy. We are proud of our clinical service to patients to secure, that every patient is given the best treatment according to guide lines and evidence based medicine.

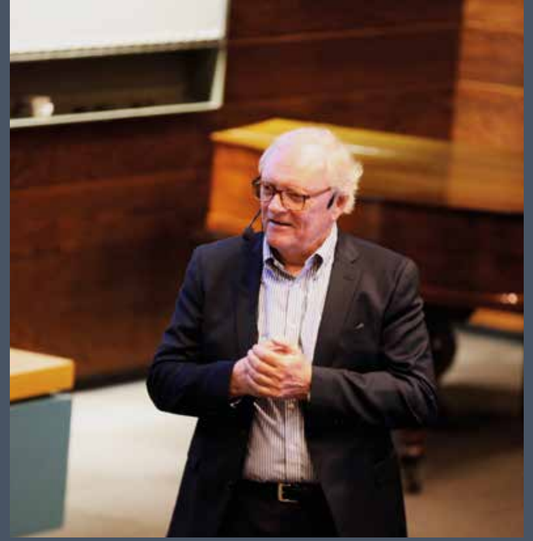
We have introduced PET/MRI as clinical one-stop-shop investigation for dementia and brain tumor patients, a great service to patients and a major step forward, initiated by our Professor Ian Law and his team.

Along with the celebration of the 25 years anniversary, the 21th of June 2017, The John and Birthe Meyer Foundation graced us with a donation to a new digital PET/CT Scanner. We look very much forward to this new major step forward.

Professor Andreas Kjær, Leading Professor in the department and Head of Cluster for Molecular Imaging is responsible for the research in our department. Andreas Kjær initiated the PET/MRI hyperpolarized MRI Spectroscopy as hyperPET, a term launched also internationally by him.

And as well known internationally we were the first to dare to describe, that the PET/MRI scanner we acquired in December 2011 was not able to come up with a correct attenuation correction for the brain scans. To make a long story short; we are extremely proud that our PhD Student Claes Nøhr Ladefoged has solved the problem in collaboration with a big international group of researchers and the problem is now fixed.





THANK YOU TO THE JOHN AND BIRTHE MEYER FOUNDATION. THANK YOU TO THE STAFF OF THE PET- , CYCLOTRON- AND RADIOCHEMISTRY SECTIONS FOR A TREMENDOUS EFFORT.

From 1991 the big M.Sc. Scanditronix cyclotron has been our most important piece of equipment in the department. We start the cyclotron at 03.30 in the morning, so that the tracers are ready for patients in the morning and for sending out of house to assure that the other hospitals can also start running patients early. We acquired cyclotron no. 2, the CTI cyclotron, in 2005.

The team running the cyclotrons is highly acknowledged for the excellent effort from all staff members. Cyclotron Chief Holger Jensen and Deputy Jesper Jørgensen: We owe you a big thank you for providing an up time of 99.9 % and a very high production. At the same time you are flexible and helpful towards radiochemistry and the clinical sections; for that we would like to say thank you.

The Radiochemistry Section opened 25 years ago and has now developed into an international academic section with many PhD students and thesis coming out from the department, new “first-in-man” tracers several times every year and a large research program, also in collaboration with the University of Copenhagen. Nic Gillings, our Chief Radiochemist and QP and Jacob Madsen, our Head Radiochemist and production responsible are thanked greatly together with Staff Technologist Anne Sørensen and the whole team. At present the production from the Radiochemistry Section is very high, innovative, original and state of the art. Last year approximately 1,300 productions were provided.

Throughout the 25 years we have developed the area of PET, PET/CT and PET/MRI in collaboration with The John and Birthe Meyer Foundation. In 1991 we acquired a Scanditronix 32 MEV Cyclotron and a radiochemistry facility and a GE 4096 PET scanner.

From the Foundation we have in the years obtained:

1991	Scanditronix 32 MeV,
1991	GE4096 PET Scanner
1993	NMR Spectrometer
1993	PET Advance Scanner
2001	PET/CT Scanner
2005	PET/CT Scanner
2005	Cyclotron 2
2007	HRRT Scanner
2009	Radiochemistry Synthesizer
2011	PET/MR Scanner
2017	PET/CT Scanner

Neuro PET

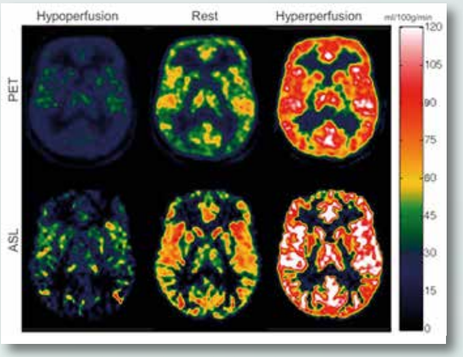


Figure 1. Examples of simultaneously obtained ^{15}O-H_2O PET (top row) and arterial spin labelling MRI (lower row) cerebral blood flow measurements from a healthy volunteer during hyperventilation (left), in rest (middle) and after acetazolamide (right). All measurements were obtained from the same volunteer on the same session. Data presented at Brain and Brain PET 2017 in Berlin, 2017 (courtesy of PhD student O. Puig).

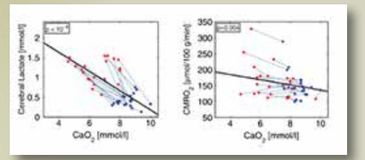
Professor Ian Law and Consultant Otto Mølby Henriksen

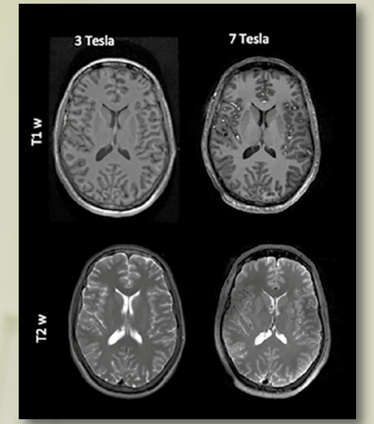
The overall goal of the Neuro PET Group is to continuously improve use of PET and hybrid imaging in routine clinical brain imaging and to further explore hybrid imaging of the brain physiology in both the diseased and the healthy brain.

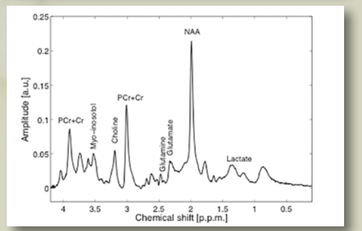
The Siemens hybrid PET/MR scanner allowing a comprehensive structural and functional evaluation of brain pathologies within a single imaging session has been implemented into clinical routine investigations for dementia and brain tumors. The ability to perform simultaneous PET and MRI measurements also make hybrid PET/MR system ideal for validation of quantitative physiological MRI techniques. Using ^{15}O-H_2O as reference we have investigated the accuracy of non-invasive regional and global cerebral blood flow measurements (Figure 1) and are currently exploring how these techniques may be applied clinically, either replacing or as an adjunct to gold standard PET methods.

The glucose analog [F18] Flouro-deoxy-glucose (FDG) PET showing the functional integrity of the brain is the backbone of clinical imaging of dementia. Our non-FDG radiotracers have had a relative increase in the overall production. They consist of the amino acid analogue [F18] Flouro-Ethyl-Tyrosine (FET), the somatostatin II receptor ligand [Ga68]-DOTATOC and [C11]-PiB. FET has an established role in the management of brain tumors, and is increasingly been evaluated in a multiparametric approach using PET/MR. For radiotherapy planning and the evaluation of recurrent meningioma we are employing [Ga68]-DOTATOC using our high resolution research tomograph (HRRT) PET scanner, as the growth pattern of meningioma, and the small margins of the stereotactic radiation therapy used make a 2 mm resolution desirable. [C11]-PiB amyloid binds to amyloid plaques, a pathological hallmark for Alzheimers disease, and is used to support the diagnosis.

Collaborating with international and clinical research partners, a number of clinical and basic science projects explore the use of the most recent development in radiopharmaceuticals and MR imaging.







MR of the brain

Professor Henrik Larsson

◂ *Figure 1. Left figure shows an increase of lactate from a situation of normoxia (blue points) to a situation with hypoxia (red points) as indicated by a decrease in arterial oxygen concentration (CaO_2). Right figure shows the corresponding changes in $CMRO_2$ form a situation with normoxia to hypoxia. As seen lactate increases despite maintained oxygen consumption. By courtesy of Mark B Vestergaard, Ulrich Lindberg and Henrik BW Larsson.*

◂ *Figure 2. Conventional T1 weighted (MPRAGE) and T2 weighted (Turbo-spin echoe) images of the same healthy subjects obtained with our Philips 3 Tesla scanner in the Glostrup Section and the 7 Tesla Philips scanner at Hvidovre Hospital. By courtesy of Ulrich Lindberg, Mark B Vestergaard, Helle Simonsen, Henrik BW Larsson (FIUNIT Rigshospitalet Glostrup) and Olaf Paulson, Nizar Hamrouni, Giske Opheim (NRU, Rigshospitalet).*

◂ *Figure 3. A proton magnetic resonance spectrum from a 1 ml brain tissue in the occipital area, obtained at the 7 Tesla Philips MR scanner at Hvidovre Hospital. Excellent spectral resolution is obtained at this high field strength e.g. allowing separation of glutamate and glutamine. By courtesy of Ulrich Lindberg, Mark B Vestergaard, Olaf Paulson and Henrik BW Larsson.*

Magnetic Resonance Imaging can give information about the brain's glycolysis and oxygen consumption, initial 7 Tesla MRI experience.

Lactate and its role in the brain is a topic of increasing interest, both from a physiologic but also a clinical point of view. It has recently become clear that lactate is both produced and consumed in aerobic condition and serves as a link between glycolytic and oxidative metabolism in the brain. Lactate seems to have many functions and may even act as a signalling molecule in the brain through hydroxycarboxylic acid receptor, a receptor found in neurons of hippocampus, neocortex and cerebellum. Lactate has a diurnal cycle, increasing during daytime and being cleared during sleep; this finding could suggest a link to the brain clearance system: the glymphatic system, a term introduced by Maiken Nedergaard and colleagues, and could have wide implication in neurodegenerative diseases, especially Alzheimer's dementia. With Magnetic Resonance Imaging (MRI) and Spectroscopy (MRS) it is possible to study lactate in the brain non-invasively. In May 2017 Mark Vestergaard defended his thesis: "Energy Metabolism of the Hypoxic Brain in Healthy Humans and Free divers". In this project we investigated the brain lactate concentration during resting condition and during a hypoxic challenge, using MRI and MRS. In addition, a method was developed allowing us to measure the brain's total oxygen consumption ($CMRO_2$) with a 10 second time resolution, both during rest and during a hypoxic challenge consisting of inhalation of 10% oxygen and 90 % nitrogen. $CMRO_2$ can be estimated from a measurement of the total delivery of blood to the brain, combined with arterial oxygen saturation (pulsoxymetri) and blood haemoglobin (blood sample). In addition, the oxygen saturation from the venous blood leaving the brain is needed and is obtained from MRI phase information from the sagittal sinus. This setup was applied both in young and elderly healthy volunteers and in patients suffering from sleep apnoea. A remarkable finding was a 180 % increase in lactate in young healthy subjects during a hypoxic challenge, in spite of a slightly increase of $CMRO_2$, see figure 1. Lactate increase was also seen in the elder subjects, but now a concurrent drop of $CMRO_2$ was seen. Most striking was the finding of a lack of lactate increase in patients with sleep apnoea during hypoxia, and a decrease in $CMRO_2$ similar to the observation in healthy elderly. The results corroborate with the idea, that the ability to produce brain lactate is a sign of brain health, and we speculate that induced lactate can be developed as a biomarker of an active well functional glucolytic pathway signalling brain health. This idea will be investigated in future studies in common brain diseases.

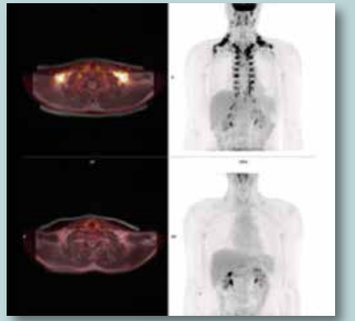
In 2017 we started MRI studies on the 7 Tesla MR scanner at Hvidovre Hospital, which constitute a national core facility. Our group and collaboration with the Neurobiology Research Unit have launched a number of projects within epilepsy and brain tumors and in other brain diseases. Examples of T1 and T2 weighted images at 3 and 7 Tesla are shown in figure 2. In addition we have started including proton spectroscopy in our projects. An example is seen in figure 3, and one can appreciate the high spectral resolution allowing discrimination of among others, brain glutamate and glutamine.

PET/MR

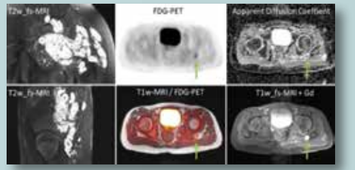
Physicist Adam Espe Hansen and Consultant Johan Löfgren

PET/MRI offers a unique simultaneous combination of molecular imaging with anatomic and functional MRI. These capabilities are being exploited in clinical, translational and basic research, as well as for clinical examinations. The types of PET/MRI examinations performed at the department range from clinical dementia exams including static ^{18}F-FDG PET and anatomic MRI with a duration of 20 minutes to dynamic PET with kinetic modeling and physiologic MRI measurements which may last 1-2 hours. In 2017 the number of examinations performed was 756, out of which approximately 40 % were clinical. The demand for PET/MRI is steadily growing and expanded opening hours is currently under consideration.

Clinical PET/MRI is undertaken primarily of patients with dementia and Alzheimer's disease, patients with brain tumors examined with ^{18}F-FET PET and paediatric patients. Here, the simultaneous PET and MRI acquisition reduces the overall scan time and provides all indicated imaging within one session. Such a 'one-stop-shop' examination provides a valuable logistic advantage for patients and relatives as well as for the diagnostic reading and minimizes PET/MRI misalignment. To further expand the clinical use of PET/MRI, a large number of ongoing clinical research studies explore the utilization of PET and MRI in a synergistic fashion to improve patient management. Indications investigated include lung cancer, head and neck cancer, prostate cancer, sarcoma, neuro-oncology, paediatric oncology and vascular brain diseases. Finally, a number of clinical and pre-clinical research studies examine the utilization of combined PET and MRI to characterize the biology of disease.



^{18}F-FDG PET/MRI from a project investigating cold induced activation of brown adipose tissue (BAT). Upper row shows a patient with metabolic activated brown adipose tissue. Lower row shows same patient without activation. (project PI: S Søberg)



Example of a paediatric PET/MRI examination. Images show a patient (male, 11 years) with a large, heterogeneous pelvic lesion compatible with plexiform neurofibromatosis. PET/MRI was undertaken prior to ultrasound guided biopsy to identify the foci with highest probability of malignancy from both ^{18}F-FDG PET and diffusion-weighted MRI (green arrows). Biopsy proved the lesions to be benign and thus outruled malign transformation with a high diagnostic confidence. (Diagnostic workup L Borgwardt, HH Johannesen)

PET and PET hybrid systems

Senior Physicist Søren Holm and Chief Physicist Thomas Levin Klausen

In 2017 the department was blessed with a donation from The John and Birthe Meyer Foundation for a new digital PET/CT system to be installed in 2018. By the end of 2017 the department has a total of 8 PET systems; 1 dedicated, stand-alone brain PET system, 6 combined whole-body PET/CT systems and 1 integrated PET/MR system.
Brain research continues on the PET-only HRRT (High Resolution Research Tomograph) in close collaboration with the Neurobiology Research Unit (NRU), but the system also works as a unique clinical instrument.

The 6 PET/CTs in the department are all Siemens systems. 2 are Biograph TrueV, 1 with 40 and 1 with 64 slice CT, acquired in 2007 and 2009. The other 4 (from 2010, 2011, 2014 and 2016) are mCTs, 3 with 64 slice CT and 1 with 128 slices, all of them with time-of-flight and overall with very similar specifications, which provides an important flexibility in patient scheduling.

The majority of the studies in the PET Section continue to be FDG whole-body scans for cancer diagnosis, staging, planning and follow-up, but in recent years a significant number of FET, FLT, ^{11}C-PiB, and ^{68}Ga-Dotatoc examinations have been added. All these scans are routinely performed with the use of combined PET and CT, and most CT scans are performed as full diagnostic quality CT including contrast enhancement. One of the mCTs is run in a unique well-functioning collaboration with the Department of Radiotherapy, and it is extensively used for therapy planning, for which purpose its large opening (78 cm) is an important design improvement over the previous generation of systems.

The 128 slice PET/CT is installed in the KF Section. This system mainly performs paediatric PET scans and scans with ^{82}Rb (heart perfusion), ^{68}Ga-Dotatoc (neuroendocrine tumors) and ^{18}F- NaF, replacing some bone scintigraphy or SPECT/CT.

The fully integrated PET/MR system (Siemens mMR) was among the first in the world to become operational in early 2012. Previous attempts to combine the two modalities were either limited in use (brain "insert" only) or not fully integrated (two separate gantries). In the mMR, a new amplifier principle in the PET detectors made them insensitive to the magnetic field, and small enough to allow the PET system's detector ring to be placed inside the 3-tesla MR-magnet between the gradient coils and the RF transmitter. This made it possible to perform truly simultaneous measurements of PET or MR. The combined system offers better soft tissue differentiation than PET/CT, but also has the potential of reducing radiation exposure, which is particularly important in examination of children. The physics group has been working on the issues of attenuation correction and artefact suppression in order to support the clinical research protocols. In particular for quantitative results in brain scanning, the lack of direct attenuation measurements was a challenge, and we have been addressing these issues in collaborations with Siemens (Erlangen and Knoxville), University of Leuven, and the institute of Computer Science at Copenhagen University, resulting in a correction method which is clinical feasible and with high precision.

Recently the PET/MR installation was complemented with an MR hyperpolarizer (GE SPINlab), allowing the production of ^{13}C-labelled pyruvate, and we hope for an approval for human use in 2018.

At the Cluster for Molecular Imaging at Panum, the Faculty of Health Sciences, University of Copenhagen, we also operate research scanners for small animal PET. We have an "old" PET system (Focus 120) from 2006 and a fully integrated PET/CT system (Inveon) from 2016.

Equipment 2017

Equipment	Product	Purchase year
Gamma cameras	Mediso Nucline X-Ring	2003
	Mie-Scintron	2004
	Mediso TH45	2007
	Mediso N-TH45-D	2008
	DDD SoloMobile	2012
	DDD NephroCam System	2016
SPECT-cameras	Mediso Nucline X-Ring-R/HR	2009
	Symbia Evon	2017
SPECT/CT cameras	GE Infinia Hawkeye	2004
	Siemens SymbiaT2	2006
	Philips, Precedence 16-slice CT	2008
	GE Discovery 670	2010
	Siemens Symbia 16-slice CT	2011
	Siemens Symbia Intevo Bold 16 slice CT	2017
PET scanner	HRRT Siemens/CTI	2007
PET/CT scanner	Siemens Biograph TrueV 40-slice CT	2007
	Siemens Biograph TrueV 64-slice CT	2009
	Siemens mCT-S (64)	2010
	Siemens mCT-S (64)	2011
	Siemens mCT-S (128)	2013
	Siemens mCT-S (64)	2016

Equipment	Product	Purchase year
PET/MR scanner	Siemens mMR	2011
	GE SPINlab MR Hyperpolarizer	2014
Lung function	Jaeger Masterscreen w/bodybox	2005
	Jæger Masterscreen w/bodybox	2007
	Jaeger PFT pro w/bodybox	2007/13
DXA scanner	GE Lunar Prodigy	2004
	GE Lunar Prodigy	2005
	GE Lunar Prodigy	2011
	GE Lunar iDXA	2014
Whole body counter	WBC w/NaI counting chamber	1977
	WBC w/plast counting chamber	1978
Cyclotrons	Scanditronix 32 MeV	1991
	RDS Eclipse cyclotron, CTI	2005
At Cluster for Molecular Imaging, Panum	Provivo/ ADAC mobile gamma camera	1990
	Siemens Micro-PET Focus 120	2006
	Phosphor Imager Perkin Elmer cyclone	2007
	Bruker preclinical MRI PharmaScan 7T	2013
	Siemens preclinical PET/CT Inveon	2013
	PX Inc. preclinical RT X-RAD 320	2013
	Mediso nanoScan SPECT/CT	2015

Cyclotron Section

Assistent Cyclotron Chief Jesper Jørgensen and Cyclotron Chief Holger Jensen

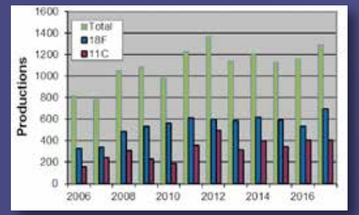


Figure 1. Development in total number of productions, ^{18}F and ^{11}C productions since 2006

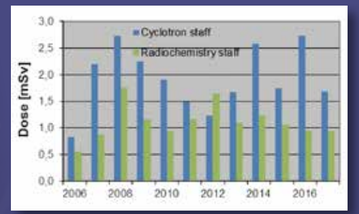


Figure 2. Average received doses per year for employees in the Cyclotron- and Radiochemistry Section since 2006

During the last years we have experienced a relative stable number of productions at our two cyclotrons of approximately 1,220±90 productions per year, see Figure 1. In 2017 we had in total 1,296 successful productions (607 and 689 for our Scanditronix MC32 and Siemens RDS Eclipse cyclotrons respectively). As in the previous years we also managed to keep the average radiation dose to the employees in the Cyclotron- and Radiochemistry Section at a low level, see Figure 2.

Examples of ongoing and/or finished upgrade projects for our Scanditronix MC32 cyclotron:

The upgrade of the original Siemens Simatic S5 and CP521 based control system with a new S7 and IGSS based SCADA system described in previous annual reports was finalized this year. The final replacement of all I/O boards (for the more than 1,000 digital and analog signals) was done with great success January 2017 by our external company Taangberg Pro Consult, see Figure 3. The work was done during an extended weekend and in this way we minimized the number of cancelled productions to only 2 Rb/Kr-generator productions.

Figure 3. I/O boards in the SCADA system

Cyclotron Section

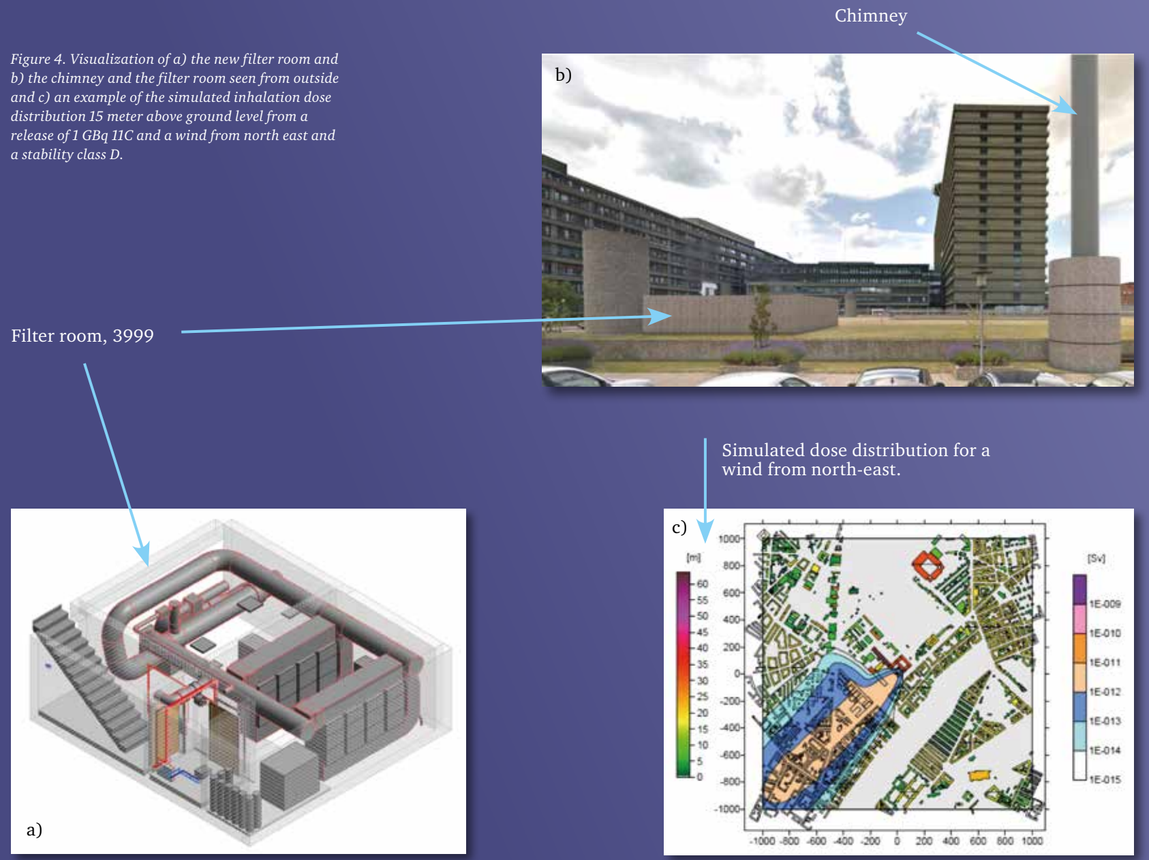
The new helium cooling system for the beam-line-2 project was validated this year and the control system was integrated into the existing cyclotron SCADA system. The helium cooling system is designed for 8 targets in total and will be used for future targets planned to be build and mounted at the coming new beamline-2 system. The work on the new beamline-2 is planned to 2018.

The beam line 2 target room was rebuilt this year. Power, ventilation, compressed air supply and water cooling was rebuilt. A new additional "service" floor was constructed under the roof at a height of 2.2 m. All future support equipment for the bending magnet and the targets will be installed at the service-floor. In this way we will gain more space around the very radioactive targets and we will be able to reduce the radiation dose to the employees when they do service at the equipment.

The project, described in previous annual reports, for building a new chimney for release of radioactive gases produced in our radiopharmacy production was finished this year. Figure 4a and 4b shows the chimney and the filter room. The authorities (SIS) require the chimney designed/built, so no one in the general public will receive a radiation dose more than 100 μSv/y from our activities (or approximately 40 times lower than the average background dose in Denmark). To guarantee this we have made an extensive risk analysis together with the wind energy section at Risø for various chimney locations and heights. For each combination of position and height both the external- and the inhalation dose distributions were simulated for combinations of 16 wind directions, 6 classes of wind stabilities and 10 different heights over ground level. An example of the calculated inhalation dose distribution for 20 m chimney and measured at a height of 15 m above ground level is shown at figure 4c. The example is for a wind from north-east and a Pasquill-Gifford wind stability class D.

With the new chimney the release has been moved to a safe distance from the new building "Nordfløjen", that was the main cause for building the new chimney, and our annual radioactive gas release limit has been increased to 10 TBq/year.

Figure 4. Visualization of a) the new filter room and b) the chimney and the filter room seen from outside and c) an example of the simulated inhalation dose distribution 15 meter above ground level from a release of 1 GBq 11C and a wind from north east and a stability class D.



Radiochemistry Section

Chief Radiochemist Nic Gillings and Chief Radiochemist, Production Manager Jacob Madsen

Highlights

- [^{18}F]FE-PE2I, a PET ligand for imaging patients with Parkinson's Disease was approved for human use.
- [^{68}Ga]Ga-PSMA-HBED-CC, a PET tracer for imaging prostate cancer patients was approved for human.

Production for clinical and research PET investigations in humans

Production of [^{18}F]FDG and krypton-81m generators along with [^{18}F]FET, [^{18}F]FLT, [^{68}Ga]Ga-DOTATOC, [^{11}C]PIB and [^{15}O]water continued on a similar level compared to previous years. Two new radiopharmaceuticals were approved for routine clinical use in 2017: a dopamine transporter ligand, [^{18}F]FE-PE2I, which is used for studying patients with Parkinson's Disease, and [^{68}Ga]Ga-PSMA-HBED-CC, an established tracer for prostate cancer imaging. From October 2017, [^{68}Ga]Ga-DOTATOC production was performed using a new marketed radiolabelling kit (Somakit TOC). We continued to produce the uPAR imaging agent, [^{68}Ga]Ga-NOTA-AE105, for a number of phase II clinical trials in 2017 and phase II clinical trials with our in-house developed angiogenesis tracer, [^{68}Ga]Ga-NODAGA-E[c(RGDyK)]$_2$, were also started. 14 different radiopharmaceuticals were produced for human use in 2017 (see figure) and compared to 2016, the total number of batches produced increased by 9.8 % to 1,181 in total.

Production of neuroreceptor PET ligands for human use, for various research projects conducted by the Neurobiology Research Unit at Rigshospitalet, continued at a similar level compared to previous years.

Radiopharmaceutical development

Oncology
The production of [^{18}F]ASIS (active site-inhibited factor VIIa) for human use is currently being validated and a clinical trial application will be submitted early 2018. Several other tracers targeting biological processes related to cancer are available for preclinical investigations.

Neurobiology
Our collaboration with the Neurobiology Research Unit, Rigshospitalet and the Department of Drug Design and Pharmacology, Faculty of Health and Medical Sciences, University of Copenhagen continued as in previous years. This work mainly focuses on development and evaluation of new PET ligands for the serotonin system.

Radiochemistry Section

Radiopharmaceutical	Batches Produced	Usage/Target
[^{18}F]FDG	332	Oncology/glucose metabolism
[^{68}Ga]Ga-DOTATOC	241	Neuroendocrine tumours/somatostatin receptors
Krypton-81m generator	145	Lung ventilation
[^{68}Ga]Ga-NOTA-AE105	107	Oncology/uPAR imaging
[^{11}C]PIB	99	Alzheimer's Disease/β-amyloid plaques
[^{18}F]FET	69	Oncology/amino acid transport
[^{18}F]FLT	45	Oncology/cell proliferation tracer
[^{11}C]SB207145	45	Brain Research/5-HT4 receptors
[^{15}O]Water	18	Cerebral blood flow
[^{11}C]Cimbi-36	29	Brain Research/5-HT2A receptors
[^{11}C]AZ10419369	26	Brain Research/5-HT1B receptors
[^{68}Ga]Ga-NODAGA-E[c(RGDyK)]$_2$	11	Oncology/angiogenesis imaging
[^{18}F]FE-PE2I	9	Neurology/dopamine transporter ligand
[^{68}Ga]Ga-PSMA-HBED-CC	5	Oncology/prostate specific membrane antigen ligand
Total	**1,181**	

◂ *Radiopharmaceuticals produced for human use in 2017*

Radiopharmaceutical research and PhD projects

- Ida Nymann Petersen successfully defended her PhD thesis in March 2017 on the developments of fluorine-18 labelled 5-HT2a agonist radioligands and is now employed as a postdoc, working on the development of pretargeting imaging agents.
- Patricia Edem (postdoc) continued her work on development of chelator based labelling of pretargeting imaging agents.
- Vladimir Shalgunov started as a postdoc in November 2017 and will work on the establishment of methods for direct labelling of tetrazines with fluorine-18.
- Troels Elmer Jeppesen continued his PhD project searching for new protein radiolabelling strategies. In particular the project is focused on radiolabelling of chemically modified derivatives of ASIS (active site-inhibited factor VIIa) using fluorine-18 and copper-64.
- Elina Nyberg L'Estrade continued her PhD project on combinatorial-like fluorine-18 labelling approaches for the development of 5-HT$_7$ selective ligands.
- Johanna Steen continued her PhD project focussed on carbon-11 and fluorine-18 labelled click agents for pretargeted imaging.

Education in radiopharmaceutical chemistry

The teaching program in radiopharmaceutical chemistry led by Associate Professor Matthias Herth, which was initiated in 2016 at the Faculty of Health and Medical Sciences, University of Copenhagen, continued in a similar format in 2017, with several members of the Radiochemistry Section involved in lecturing and practical exercises. There were four master students who successfully defended their theses on radiopharmaceutical chemistry in 2017.

Academic and other activities

Andreas Kjær, Professor, Consultant, ERC advanced grantee, is member of the Oncology Committee of the European Association of Nuclear Medicine (EANM), member of the advisory board of the European Neuroendocrine Tumor Society (ENETS), national representative of the European Society for Molecular Imaging (ESMI), board member of the Cancer Research Foundation at University of Copenhagen, advisory board member of the Avatar Cancer Program, CPMC (Sutter Health), San Francisco. Past President of the Scandinavian Society of Clinical Physiology and Nuclear Medicine (SSCPNM) and member of the Scientific Committee of the Danish Cancer Society. Editor-in-Chief of Diagnostics (Basel). Editorial board member of Journal of Nuclear Medicine (JNM) and European Journal of Nuclear Medicine & Molecular Imaging (EJNMMI). Leader of projects for development of theranostics for aggressive cancer and for project of hyperPET, funded by the Innovation Fund Denmark. Coordinator of an H2020 project on click-chemistry for PET. Head of the Cluster for Molecular Imaging and Director of the PhD Program for Medical & Molecular Imaging at the Faculty of Health and Medical Sciences, University of Copenhagen. Co-chair of the Lundbeck Foundation Clinical Research Fellowship Program (US-DK). Member of the Academy of Technical Sciences (ATV).

Anne Kiil Berthelsen, Consultant, is member of the International Lymphoma Radiation Oncology Group, Steering Committee (ILROG), European Organisation for Research and Treatment of Cancer Lymphoma Group (EORTC), the Danish Society of Radiology, the Danish and the Nordic Society of Gynaecological Oncology, British Institute of Radiology (BIR), Billeddiagnostisk Udvalg Ukendt Primærtumor (DAHANCA), National PET/CT Group, the Danish Society of Clinical Oncology, the Danish Society of Magnetic Imaging, Diagnostic Imaging Group under Danish Lymphoma Group, ERS European Society of Radiology and Sundhedsstyrelsens Udvalg for Kræft.

Anne-Mette N. Wittekind, MSc. Pharm, Deputy Qualified Person, is member of Dansk Standard.

Annika Loft Jakobsen, Consultant, MD,Ph.D., is involved in a various number of clinical research protocols, teaching at national and international courses pre- and postgraduate for medical doctors, technologists, radiographers and nurses and is invited speaker at national and international meetings and congresses. She is supervisor for several PhD students and responsible for the specialist course in oncology for nuclear medicine physicians. She is member of the European Organisation for Research and Treatment of Cancer (EORTC). Member of the Oncology Committee of the European Association of Nuclear Medicine (EANM), member of BIR, Danish Society of Oncological Radiology and Danish Society of Clinical Physiology and Nuclear Medicine. Member of Regional Working Groups for implementation of clinical guidelines for: colorectal liver metastases, lymphoma, malignant melanoma, cancer of unknown primary, and suspicion of severe disease. Member of National Working Groups for lymphoma (Chair of the Diagnostic Imaging Group under Danish Lymphoma Group (DLG)) and pharyngeal/laryngeal cancer. Member of the National PET/CT Group. Board member of DGCG (Danish Gynecological Cancer Group) and DCCG (Danish Colorectal Cancer Group).

Elisabeth Albrecht-Beste, Clinical Associate Professor, Consultant, member of Danish Society of Radiology, chair of post-graduate radiology courses in Denmark, chair of post-graduate education committee of Danish Society of Radiology, chair of the Regional Advisory Board in postgraduate education in radiology and member of the Danish Society of Oncoradiology.

Helle Hjorth Johannesen, Consultant, is member of Danish Society of Radiology, member of Danish Society of Oncoradiology, member of Danish Society of Medical Magnetic Resonans Imaging and Danish Society for Good Clinical Practice.

Helle Juhl Simonsen, Research MR Technologist, Biomedical Laboratory Scientist, is board member and treasurer in the International Society for Magnetic Resonance in Medicine (ISMRM)/Nordic Chapter. Member of the Local Chapters Committee, Awards and Nominations Committee and Abstract Committee in International Society for Magnetic Resonance in Medicine (ISMRM)/Section for MR Technologist (SMRT), awarded as Fellow of SMRT ((f)SMRT). Member of the Members and Services Committee in European Society for Magnetic Resonance in Medicine and Biology (ESMEMB). Board member of the Danish Society for Magnetic Resonance, member and service responsible.

Henrik B.W. Larsson, MD, DMSc , Consultant, Head of Functional Imaging Unit. Professor in Clinical and Comparative Physiology, Institute of Clinical Medicine, the Faculty of Health and Medical Science, University of Copenhagen, Denmark, Professor in Medical Magnetic Resonance Imaging, Norwegian University of Science and Technology, Norway, Responsible for specialist course in tracer kinetic theory, math and statistic for nuclear medicine physicians. Responsible for specialist course in functional imaging (MRI, PET-MRI, UL) for nuclear medicine physicians, Management Board of EU COST Action (BM1103): "Arterial Spin Labelling in Dementia", Steering committee of the 7 Tesla project, Copenhagen, Denmark.

Ian Law, Professor, Consultant, is Chair of the Neuroimaging Comittee, European Association of Nuclear Medicine (EANM), Member of the "PET Response Assessment in Neurooncology (RANO) working group" under the European Association of Nuclear Medicine (EANM), European Association of Neurooncology (EANO), and Society of Neurooncology (SNO). Member of the Danish Neurooncology group (DNOG). Member of the working group for "Clinical Guidelines for the Treatment of Brain Metastases", Danish Neurosurgical Society (DNKS), responsible for the specialist training course in the central nervous system for nuclear medicine physicians.

Jann Mortensen, Professor, Consultant, is member of "Den Regionale Videnskabsetiske Komité F for Hovedstaden" (Regional Ethics Committee). He is responsible for the specialist course in "Clinical Respiratory Physiology" for Nuclear Medicine physicians and Respiratory Physicians, he is the responsible physician for Nuclear Medicine in the Faroe Islands, member of the steering committee of "Dansk Lungecancer Gruppe" (Danish Lung Cancer Group), the subcommittees for "Dansk Diagnostisk Lungecancer Gruppe" (Danish Diagnostic Lung Cancer Group) and "Lungecancer Screeningsgruppen" (Screening of Lung Cancer Group), member of the steering committee and the quality subcommittee for creating Danish reference values for lung function and member of the steering committee of the Danish ESDL spirometry course.

Johan Löfgren, Consultant, teaches at specialist courses for oncologists and is member of the Diagnostic Imaging Group under Danish Lymphoma Group. He is involved in clinical research protocols with special focus on PET/MRI and is an invited speaker at national and international meetings and congresses.

Kim Francis Andersen, Consultant, is member of the Board of Danish Sarcoma Group (DSG). He is involved in various clinical research protocols. He teaches at specialist courses for medical doctors and is supervisor for students at the Medicine and Technology program (Biomedical Engineering), Technical University of Denmark (DTU).

Linda Kragh, Chief Technologist, is member of Sundhedsfagligt Råd i Klinisk Fysiologi og Nuklearmedicin i Region H, SFR, (the Speciality Advisory Committee in Clinicial Physiology and Nuclear Medicine in the Capital Region), member of the DRG Committee of DSKFNM, member of Uddannelsesforum for Bioanalytikeruddannelsen i Region H, (the Speciality Council for the Education of Technologists in the Capital Region) and member of Uddannelsesudvalget på Radiografuddannelsen at Metropol (the Speciality Council for the Education of Radiographers at Metropol).

Lise Borgwardt, Consultant, Chief of Paediatric Nuclear Medicine at Rigshospitalet. Vice Chair of the Paediatric Committee under EANM, Scientific Committee member of the EANM, member of the Paediatric Imaging Harmonization Group EANM/SNM, member of the Tumourboard for Paediatric Solid Tumours at Rigshospitalet, Chair of Danish Association of Paediatric Nuclear Medicine, Chair of the Paediatric Focus Group at the Department of Clinical Physiology, Nuclear Medicine and PET and member of the Process Group for the development of the Children's Hospital at Rigshospitalet. Involved in clinical research protocols, supervisor for PhD students, teaching at national and international courses pre- and postgraduate for medical doctors, and invited speaker at national and international meetings and congresses.

Academic and other activities

Liselotte Højgaard, Professor, Head of Department. Chairman of the Board of the Danish National Research Foundation. Member of the Board, Konsistoriet, the Karolinska Institutet and member of the Board, Die Robert Bosch Stiftung, Germany. She represents the University of Copenhagen, Rigshospitalet in the Medicine and Technology Bioengineer Program, the Technical University of Denmark (DTU), where she is also adj. professor. Elected member of the Royal Danish Academy of Sciences and Letters, member of ATV, (the Danish Academy of Technical Sciences), member of the Olav Thon Foundation, Science Advisory Board, member of the Board of the Crown Prince Frederik and Crown Princess Mary's Foundation and member of the Board of Arvid Nilssons Foundation and Tagea Brandt's prize.

Louise Alslev, Staff Specialist, is responsible for the planning of educational visits for physicians at the PET Section. Responsible for the specialist course in oncology for nuclear medicine physicians. She teaches at a PhD course at the Faculty of Health and Medical Sciences, University of Copenhagen and at the Bachelor´s Degree Program in Radiography at the Metropolitan University College. Employee representative for the junior doctors at the Centre of Diagnostic Investigation, Rigshospitalet. Member of Yngre Læge-rådet (Counsel of Junior Doctors) at Rigshospitalet.

Malene Fischer, Associate Professor of Research, Consultant, is supervisor for several PhD, master and bachelor students and involved in both pre- and postgraduate teaching. Course Director of "Klinisk Medikoteknik " (Introduction to Clinical use of Medical Technology) at the Medicine and Technology Bioengineer Program, member of the European Association of Nuclear Medicine (EANM), the Danish Society of Clinical Physiology and Nuclear Medicine (DSKFNM) and the Danish Society of Clinical Oncology. Affiliated to the Centre of Excellence for Personalized Medicine of Infectious Complications in Immune Deficiency (PERSIMUNE). Elected member of the Board of the Association of Consultants in Denmark. Member of the ESMIT (European School of Multimodal Imaging and Therapy) Level 3 working group. Member of the HYBRID Network; a collaboration for research and training of young researchers in the field of hybrid imaging, funded as a Marie Sklodowska-Curie Innovative Training Network under EU Horizon 2020.

Maria Helene Pejtersen, Nuclear Medicine Technologist, is member of the Symposiagroup for Technologists at Rigshospitalet.

Nic Gillings, MPhil, PhD, Chief Radiochemist, Qualified Person (QP) is vice chair of the EANM Radiopharmacy Committee, member of the Society of Radiopharmaceutical Sciences and member of the Royal Society of Chemistry. He also acts as coordinator for the joint supplier audit program for all manufacturers of PET radiopharmaceuticals in Denmark and Southern Sweden.

Otto Mølby Henriksen, Consultant, PhD, is member of the DRG Committee in Danish Society for Clinical Physiology and Nuclear Medicine (DSKFNM) and member of the Danish Epilepsy Surgery Team. He is co-supervisor of two PhD students, and teaches at PhD courses as well as pregraduate courses for medicine and technology bioengineers.

Peter Hovind, Consultant, is President of the Danish Society of Clinical Physiology and Nuclear Medicine. Member of the Board of the Danish Endocrine Society (DES) and the Niels A. Lassen Foundation. He is co-editor for the Danish Medical Journal in the medical imaging section. He is involved in both clinical research protocols and teaching, and is responsible for the postgraduate education in the Glostrup Section.

Peter Oturai, Consultant, is responsible for the postgraduate education of physicians in the department. Danish delegate, representing Danish Society for Clinical Physiology and Nuclear Medicine (DSKFNM), in the European Union of Medical Specialists (UEMS) and deputy delegate in the European Association of Nuclear Medicine (EANM). He is member of the Danish Thyroid Cancer Guideline Group (DATHYRCA), member of the Doctors CPNM Training Committee and member of the CME and Educational Committee – both affiliated to DSKFNM. He is responsible for the specialist course in Endocrine Pathophysiology for CPNM physicians in Denmark.

Rasmus Sejersten Ripa, Staff Specialist, is supervisor for several PhD students. Member of the Danish Health Authority's Committee for Heart Disease. Board member of the Society for Theoretical and Applied Therapy and member of American Society of Nuclear Cardiology.

Robin de Nijs, MSc, PDEng, PhD, Specialist Medical Physicist, is member of EANM's Network of Excellence for Brain Imaging, member of the Danish Society for Medical Physics and lecturer at EFOMP's School for Medical Physics Experts and Copenhagen University.

Sune Høgild Keller, Computer Scientist PhD, is involved in various clinical and preclinical research protocols PET/CT, PET/MR and neuro-PET (HRRT). He teaches at a variety of courses for medical doctors, PhD students, technologists and MSc students. He is supervisor for students at the Medicine and Technology Program (Biomedical Engineering), Technical University of Denmark (DTU) and co-supervises PhD students in biomedical engineering and computer science.

Søren Holm, Senior Physicist, is member of the EANM Physics Committee and the EANM Radiation Protection committee, and has represented EANM in meetings with IAEA and HERCA (Heads of European Radiation Competent Authorities). Delegate for DSMF to the European and International organisations for Medical Physics (EFOMP and IOMP), assessor for EFOMP's Examination Board (EBB) , board member of the Nordic Society for Radiation Protection (NSFS), member of one IAEA advisory group concerned with QA/QC and image artefacts affecting SPECT/CT and another IAEA advisory group regarding staffing in medical physics, member of Sundhedsfagligt Råd i Klinisk Fysiologi og Nuklearmedicin in the Capital Region, (the Specialty Advisory Committee (SFR) in Clinical Physiology and Nuclear Medicine) and external lecturer at University of Copenhagen.

Thomas Levin Klausen, Chief Physicist, MSc, Specialist Medical Physicist, is Chair of Danish Society for Medical Physics Educational Council, member of the Danish Society for Medical Physics (DSMF) and the Danish Society of Clinical Physiology and Nuclear Medicine (DSKFNM). Responsible Physicist for Nuclear Medicine at the Faroe Islands.

Ulrik B. Andersen, Consultant, is co-supervisor for PhD students in the department. Member of European Society of Hypertension and acknowledged hypertension specialist by this society. Responsible for the specialist course in cardiovascular circulation for nuclear medicine physicians in Denmark. Member of the Danish Society of Clinical Physiology and Nuclear medicine, Danish Society of Cardiology and Danish Society of Diagnostic Ultrasound.

Studies 2017

CNS and peripheral nervous system	
Regional cerebral blood flow, DIAMOX, ^{15}O-H_2O	12
Regional cerebral blood flow, ^{15}O-H_2O	1
Regional cerebral metabolism, ^{18}F-FDG	1,277
Regional cerebral receptor, ^{11}C-PIB	175
Regional cerebral receptor, ^{18}F-FET	310
Regional cerebral blood flow, ^{99m}Tc-HMPAO, pharm.prov.	18
Regional cerebral blood flow, ^{99m}Tc-HMPAO	23
Regional Dopamine Transporter (DAT) receptor imaging, ^{123}I-FP-CIT	292
Regional cerebral receptor, ^{11}C different tracers (NRU)	96
Regional cerebral receptor, ^{18}F-Florbetapir	7
Regional cerebral receptor, ^{18}F-FLT	42
Regional cerebral receptor, ^{68}Ga-Dotatoc	37
CT-scanning of cerebrum	152
MR-scanning of cerebrum	399
MR-scanning of hippocampus (MR-HCV)	144
Total	**2,985**

Respiratory organs	
Lung function test, whole body plethysmography	2,162
Lung function test, whole body plethysmography w/reversibility	46
Lung function test, spirometry,	1,998
Lung function test, spirometry w/reversibility	255
Lung function test, diffusion capacity (CO)	3,808
Lung function test, spirometry with phys.prov.	1
Max. insp. abd exspir. muscle pressure	1
Lung perfusion scintigraphy, ^{99m}Tc-MAA	8
Lung perfusion scintigraphy, regional, ^{99m}Tc-MAA	16
Lung perfusion scintigraphy, SPECT, ^{99m}Tc-MAA	381
Lung ventilation scintigraphy, ^{81m}Kr-gas	9
Lung ventilation scintigraphy, regional, ^{81m}Kr-gas	154
Lung ventilation scintigraphy, SPECT, ^{81m}Kr-gas	315
Lung ventilation scintigraphy, SPECT ^{99m}Tc-Technegas	73
Mucociliary clearance, ^{99m}Tc-Venticolloid	4
CT thorax PET/CT breathhold	21
PET thorax PET/CT breathhold	9
Total	**9,261**

Heart and cardiovascular system	
Isotope cardiography, LVEF, ^{99m}Tc-HSA	1,424
Myocardial perf. scintigr. gated, ^{99m}Tc-MIBI, pharmacol. stress, adeno.	253
Myocardial perf. scintigr. gated, ^{99m}Tc-MIBI,	211
Myocardial ^{123}I- MIBG, sympaticus activity	46
Myocardial calcium score	552
Tilt table test	189
Analysis of heart rate variability	192
PET myocardial metabolism, ^{18}F-FDG	104
PET myocardial perfusion, ^{82}Rb, rest	687
PET myocardial perfusion, ^{82}Rb, pharmacological stress, adeno	645
CT cardiac (angiography)	13
Total	**4,316**

Peripheral vessels	
Systolic blood pressure, fingers	5
Systolic blood pressure, ancle and toes	434
Systolic blood pressure, ancle-brachial index after treadmill	87
24 hours blood pressure measurement	224
Doppler ultrasound of abdominal vessels	293
Isolated limb perfusion leakage monitoring, ^{99m}Tc-erythrocyt	5
Total	**1,048**

Gastrin intestinal tract, liver, biliary tract and pancreas	
Salivary gland scintigraphy ^{99m}Tc-Pertechnetat	11
Biliary tract scintigraphy, ^{99m}Tc-Mebrofenin	119
Bleeding scintigraphy (abdomen) ^{99m}Tc-erytrocytter	**1**
Bleeding scintigraphy (abdomen) ^{99m}Tc-HSA	**1**
Doppler ultrasound of splanchnic blood flow	**315**
Meckels diverticle scintigraphy	**1**
Ultrasound retroperitoneum, incl. aorta og binyrer	**3**
Total	**451**

Kidneys and urinary tract	
Glomerular filtration, ^{51}Cr-EDTA, several samples	92
Glomerular filtration, ^{51}Cr-EDTA, one sample	2,733
Renal scintigraphy, ^{99m}Tc-DMSA	9
Renography, ^{99m}Tc-MAG , diuresis	68
Renography, ^{99m}Tc-MAG 3, graft	7
Renography, ^{99m}Tc-MAG 3, ACE-inhibitor	28
Renography, ^{99m}Tc-MAG 3	2,125
Renography, ^{99m}Tc-MAG 3, dual head	4
Renography, ^{99m}Tc-DTPA	**25**
Renography, ^{99m}Tc-DTPA, ACE-inhibitor	**115**
Doppler ultrasound of renal blood flow	**316**
Ultrasound kidneys	**272**
MR kidneys	6
Total	**5,800**

Bone and joint	
Bone scintigraphy, ^{99m}Tc-HDP, regional, static	63
Bone scintigraphy, ^{99m}Tc-HDP, 2 phased	23
Bone scintigraphy, ^{99m}Tc-HDP, whole body, static	988
Bone scintigraphy, ^{99m}Tc-HDP, SPECT	634
Osteodens. dual X-ray absorptiometri (DXA), columna lumb.	4,774
Osteodens. dual X-ray absorptiometri (DXA), lat.spine	373
Osteodens. dual X-ray absorptiometri (DXA), radius	184
Osteodensitometri, dual X-ray absorptiometri collum fem.	9,328
DXA, body composition	636
MR scanning columna cervicalis	48
MR scanning columna thoracalis	17
MR scanning columna lumbalis	4
MR scanning femur	32
Total	**17,104**

Endocrine organs	
Thyroid scintigraphy, ^{99m}Tc-Pertechnetat	1,114
Thyroid scintigraphy, ^{123}I-Iodide	63
Thyroid, ultrasound	1,147
Thyroid scintigraphy, ^{99m}Tc-Pertechnetat, SPECT	2
Thyroid, fine needle aspiration biopsy	43
Iodine uptake test, ^{131}I-Iodide	4
Parathyroid scintigraphy, ^{99m}Tc-Stamisis	64
Tumorscintigraphy, ^{123}I-Iodide	3
Adrenal marrow scintigraphy, ^{123}I-MIBG	32
Scintigraphy after ^{177}Lu- Dotatate therapy	112
Synacthen test	39
Total	**2,623**

Blood and lymph system	
Erythrocyt volume, ^{99m}Tc-erythrocytter	40
Plasma volume, ^{125}I-HSA	40
Lymph scintigraphy, extremities, ^{99m}Tc-HSA, leakage	2
Sentinel node scintigr. tumor drainage, ^{99m}Tc-Nanocolloid	46
Sentinel node scintigr. tumor drainage, c. mammae, ^{99m}Tc-Nanocolloid	32
Sentinel node scintigr. tumor drainage, mel. malign., ^{99m}Tc-Nanocolloid	134
Sentinel node scintigr. tumor drainage, c. penis, ^{99m}Tc-Nanocolloid	28
Sentinel node scintigr. tumor drainage, c. vulvae, ^{99m}Tc-Nanocolloid	44
Sentinel node scintigr. tumor drainage, head/neck, ^{99m}Tc-Nanocolloid	99
Peritumoral injection of ^{99m}Tc-Nanocolloid for sentinel node	612
Spleen scintigraphy, ^{99m}Tc-erythrocyte, heated	3
Total	**1,080**

Other diagnostic procedures	
Aprotinin scintigraphy, ^{99m}Tc-Aprotinin	1
PET tumor scanning, ^{18}F-FDG	5,615
PET scanning, ^{18}F-FDG	165
PET infection scanning, ^{18}F-FDG	282
PET tumor scanning, ^{68}Ga-Dotatoc	702
PET tumor scanning, ^{68}Ga-PSMA	1
White blood cell scintigraphy, ^{99m}Tc-white blood cell	16

White blood cell scintigraphy, ^{99m}Tc-white blood cell, SPECT	12
Whole body, contamination measurement	151
Image fusion (PET, SPECT, MRI, CT or planar)	11,400
CT head/neck SPECT/CT	307
CT wb SPET/CT	318
CT thorax SPECT/CT	414
CT pelvis SPECT/CT	76
CT abdomen SPECT/CT	222
CT lower and upper extremities SPECT/CT	17
CT wb PET/CT	7,278
CT wb PET/CT	8,278
MR wb PET/MR	95
CT lover extremities PET/CT	29
Second opinions external	1,213
Extra tumor delineation	194
Other investigations	407
Supplementary/repeated imaging	2,719
Total	**39,912**

Radiotherapy	
Treatment with ^{131}I, benign thyroid	103
Isotope treatment with ^{177}Lu-Dotatate	105
Isotope treatment with ^{223}Ra-Dichlorid	299
Total	**507**

In vitro analyses	
Affinity studies	3,589
Flow cytometry analyses	46,596
Gene expression analyses	6,058
Immunohistochemistry	1,119
Plasma and protein analyses	9,154
Total	**66,516**

Animal studies

Mice	
^{11}C-Tetrazine	8
^{18}F-FDG	751
^{18}F-FET	14
^{18}F-FLT	113
^{18}F-Tetrazine	150
^{64}Cu-AU-NP1	80
^{64}Cu-Liposome	474
^{64}Cu-Herceptin	20
^{68}Ga-Tetrazine	32
^{89}Zr-Anti-CD4	54
^{89}Zr-Anti-CD8	162
^{89}Zr-Anti-PD-L1	206
^{89}Zr-Heceptin	80
^{90}Y-Gel	40
^{90}Y-Ionophore	8
^{111}In-Tetrazine	95
^{124}I-Liposome	144
^{177}Lu-Ionophore	8
Optical imaging, bioluminescence	63
MR-scans	1,540
MR-scans DWI	56
MR Hyperpol scans, ^{13}C pyruvate	16
MR Hyperpol scans, ^{13}C fumarate	20
MR scan with contrast	63
Radiotherapy, externally	4,239
Radiotherapy (α and β emitters)	561
CT-scans	51
CT-scans for image fusion	1,951

Rats	
^{64}Cu-liposomes	48
^{68}Ga- RGD	16
^{82}Rubidium	210
^{99m}Tc SPECT	119
Optical imaging, bioluminescence	92
MR-scans	100
MR-scans with contrast	300
CT-scans for image fusion	491

Dogs	
HyperPET (xx/^{13}C-pyruvate)	7

Rabbits	
^{18}F-Apopep	1
^{18}F-FDG	45
^{18}F-NaF	21
^{64}Cu-DOTATATE	21
^{64}Cu-RGD	21
^{68}Ga-RGD	4
CT-scans for image fusion	113

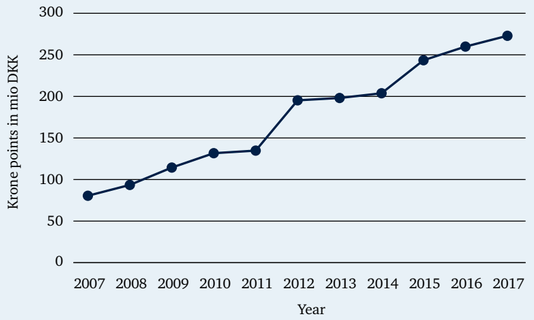
Pigs	
HyperPET (^{18}F-FDG/^{13}C-pyruvate)	2
MR-scans	60

Total	**12,670**

Total number of studies **164,273**

Finance

Turnover



The increase in activities measured in krone point* rose from 80,5 mio DKK in 2007 to 272,3 mio DKK in 2017.

* Krone point: Price for each patient investigation multiplied with number of investigations, summarized for all patient studies performed during the year.

Balance 2017

Expenditure (DKK mio)	93
Receipts	16

Publications

Theses

Hasbak P. Doctoral thesis. CGRP receptors and peptide pharmacology in the cardiovascular system: Impact of hypoxia. Defended on the 22th of February 2017, University of Copenhagen.

Børresen B. PhD thesis. The enhanced permeability and retention effect: Challenges of limited therapeutic success and the accelerated blood clearance phenomenon. Defended on the 8th of December 2017. University of Copenhagen.

Christensen A. PhD thesis. Optical-guided surgery and nucleotide-based imaging modalities in head and neck cancer. Defended on the 22nd of June 2017. University of Copenhagen.

Jensen P. PhD thesis. Translocator protein imaging with ^{123}I-Clinde SPECT - Method development and clinical research. Defended on the 15th of September 2017. University of Copenhagen.

Eldirdiri A. PhD thesis. Early detection of response to treatment in cancer by Hyperpolarized Metabolic MR. Defended on 30th of June 2017. Technical University of Denmark.

Patents

Kjær A (with co-inventors). Quantitative PET imaging of tissue factor expression using ^{18}F-labled active site inhibited factor VII. WO-2017121436A1. July 20, 2017.

Kjær A (with co-inventors). uPAR targeting peptide for use in peroperative optical imaging of invasive cancer. US-20170304468A1. October 26, 2017.

Publications

Ahlström MG, Kjær A, Gerstoft J, Obel N. Agreement between Estimated and Measured Renal Function in an Everyday Clinical Outpatient Setting of Human Immunodeficiency Virus-Infected Individuals. Nephron 2017; 136 (4):318-327.

Amin FM, Hougaard A, Cramer SP, Christensen CE, Wolfram F, Larsson HBW, Ashina M. Intact blood-brain barrier during spontaneous attacks of migraine without aura: a 3T DCE-MRI study. Eur J Neurol 2017; 24 (9):1116-1124.

Andersson Z, Thisted E, Andersen UB. Renal Branch Artery Stenosis: A Diagnostic Challenge? A Case Report With Review of the Literature. Urology 2017; 100:218-220.

Arngrim N, Hougaard A, Ahmadi K, Vestergaard MB, Schytz HW, Amin FM, Larsson HBW, Olesen J, Hoffmann MB, Ashina M. Heterogenous migraine aura symptoms correlate with visual cortex functional magnetic resonance imaging responses. Ann Neurol 2017; 82 (6):925-939.

Asferg CL, Andersen UB, Linneberg A, Hedley PL, Christiansen M, Goetze JP, Jeppesen JL. Serum proatrial natriuretic peptide does not increase with higher systolic blood pressure in obese men. Heart 2017; 103 (2):154-158.

Aznar MC, Girinsky T, Berthelsen AK, Aleman B, Beijert M, Hutchings M, Lievens Y, Meijnders P, Meidahl PP, Schut D, Maraldo MW, van der Maazen R, Specht L. Interobserver delineation uncertainty in involved-node radiation therapy (INRT) for early-stage Hodgkin lymphoma: on behalf of the Radiotherapy Committee of the EORTC lymphoma group. Acta Oncol 2017; 56 (4):608-613.

Bandak M, Jørgensen N, Juul A, Lauritsen J, Kreiberg M, Oturai PS, Helge JW, Daugaard G. A randomized double-blind study of testosterone replacement therapy or placebo in testicular cancer survivors with mild Leydig cell insufficiency (Einstein-intervention). B M C Cancer 2017; 17 (1):461.

Bandak M, Jørgensen N, Juul A, Lauritsen J, Oturai PS, Mortensen J, Hojman P, Helge JW, Daugaard G. Leydig cell dysfunction, systemic inflammation and metabolic syndrome in long-term testicular cancer survivors. Eur J Cancer 2017; 84:9-17.

Bandak M, Jørgensen N, Juul A, Lauritsen J, Kier MGG, Mortensen MS, Oturai PS, Mortensen J, Hojman P, Helge JW, Daugaard G. Reproductive hormones and metabolic syndrome in 24 testicular cancer survivors and their biological brothers. Andrology 2017; 5 (4):718-724.

Beliveau V, Ganz M, Feng L, Ozenne B, Højgaard L, Fisher PM, Svarer C, Greve DN, Knudsen GM. A High-Resolution In Vivo Atlas of the Human Brain's Serotonin System. J Neurosci 2017; 37 (1):120-128.

Bernsdorf M, Loft Jakobsen A, Berthelsen AK, Specht L, Kjems J, Gothelf A, Kristensen C, Friborg J. OC-008: Incidence of malignant disease outside the head and neck region in head and neck cancer. Radiother Oncol 2017:7-8.

Binderup T, Johnbeck CB, Loft A, Berthelsen AK, Federspiel B. FDG-PET is superior to WHO Grading in predicting overall survival of patients with neuroendocrine tumors: A prospective study of 172 patients. Neuroendocrinology 2017; (105):164.

Bjerre J, Kyhl K, Gustafsson F, Kelbaek H, Engstrøm T, Olsen PS, Hasbak P, Vejlstrup N, Madsen PL. Longitudinal shortening of sub-epicardial myo-cytes in severe ischaemic cardiomyopathy: insights from gadolinium contrast cardiac magnetic resonance imaging. ESC Heart Fail 2017; 4 (4): 670-674.

Bozkurt MF, Virgolini I, Balogova S, Beheshti M, Rubello D, Decristoforo C, Ambrosini V, Kjær A, Delgado-Bolton R, Kunikowska J, Oyen WJG, Chiti A, Giammarile F, Fanti S. Guideline for PET/CT imaging of neuroendocrine neoplasms with Ga-DOTA-conjugated somatostatin receptor targeting peptides andF-DOPA. Eur J Nucl Med Mol Imaging 2017; 44 (9):1588-1601.

Bozkurt MF, Virgolini I, Balogova S, Beheshti M, Rubello D, Decristoforo C, Ambrosini V, Kjær A, Delgado-Bolton R, Kunikowska J, Oyen WJG, Chiti A, Giammarile F, Sundin A, Fanti S. Erratum to: Guideline for PET/CT imaging of neuroendocrine neoplasms with Ga-DOTA-conjugated somatostatin receptor targeting peptides and F-DOPA. Eur J Nucl Med Mol Imaging 2017; 44 (12):2150-2151.

Bremholm L, Andersen UB, Hornum M, Hilsted L, Veedfald S, Hartmann B, Holst JJ. Acute effects of glucagon-like peptide-1, GLP-19-36 amide, and exenatide on mesenteric blood flow, cardiovascular parameters, and biomarkers in healthy volunteers. Physiol Rep 2017; 5 (4):e13102.

Brittain JM, Nymark T, Hildebrandt MG, Hovgaard D, Andersen KF. Stewart-Treves Syndrome on the Lower Extremity Associated to Idiopathic Chronic Lymphedema Visualized on FDG PET/CT. Clin Nucl Med 2017; 42 (12):e519-e522.

Bäck TA, Chouin N, Lindegren S, Kahu H, Jensen H, Albertsson P, Palm S. Cure of human ovarian carcinoma solid xenografts by fractionated [211At] alpha-radioimmunotherapy: Influence of tumor absorbed dose and effect on long-term survival. J Nucl Med 2017; 58 (4):598-604.

Celicanin M, Blaabjerg M, Maersk-Moller C, Beniczky S, Marner L, Thomsen C, Bach FW, Kondziella D, Andersen H, Somnier F, Illes Z, Pinborg LH. Autoimmune encephalitis associated with voltage-gated potassium channels-complex and leucine-rich glioma-inactivated 1 antibodies – a national cohort study. Eur J Neurol 2017; 24 (8):999-1005.

Christensen TE, Bang LE, Holmvang L, Skovgaard DC, Oturai DB, Søholm H, Thomsen JH, Andersson HB, Ghotbi AA, Ihlemann N, Kjær A, Hasbak P. The Authors Reply. JACC Cardiovasc Imaging 2017; 10 (1):94-95.

Christensen TE, Bang LE, Holmvang L, Skovgaard DC, Oturai DB, Søholm H, Thomsen JH, Andersson HB, Ghotbi AA, Ihlemann N, Kjær A, Hasbak P. The Authors Reply. JACC Cardiovasc Imaging 2017; 10 (1):96-97.

Christensen RH, von Scholten BJ, Hansen CS, Heywood SE, Rosenmeier JB, Andersen UB, Hovind P, Peinhard H, Parving HH, Pedersen BK, Jørgensen ME, Jacobsen PK, Rossing P. Epicardial, pericardial and total cardiac fat and cardiovascular disease in type 2 diabetic patients with elevated urinary albumin excretion rate. Eur J Prev Cardiol 2017; 24 (14):1517-1524.

Christensen A, Juhl K, Persson M, Charabi BW, Mortensen J, Kiss K, lelkaitis G, Rubek N, von Buchwald C, Kjær A. uPAR-targeted optical near-infrared (NIR) fluorescence imaging and PET for image-guided surgery in head and neck cancer: proof-of-concept in orthotopic xenograft model. Oncotarget 2017; 8:15407-15419.

Christensen A, Kiss K, Lelkaitis G, Juhl K, Persson M, Charabi BW, Mortensen J, Forman JL, Sørensen AL, Jensen DH, Kjær A, von Buchwald C. Urokinase-type plasminogen activator receptor (uPAR), tissue factor (TF) and epidermal growth factor receptor (EGFR): tumor expression patterns and prognostic value in oral cancer. BMC Cancer 2017; 17 (1):572.

Clemmensen AE, Ghotbi AA, Bodholdt RP, Hag AMF, Hasbak P, Ripa RS, Kjær A. Perfusion imaging using rubidium-82 (^{82}Rb) PET in rats with myocardial infarction: First small animal cardiac (82)Rb-PET. J Nucl Cardiol 2017; 24 (2):750-752.

da Cunha-Bang S, Hjordt LV, Perfalk E, Beliveau V, Bock C, Lehel S, Thomsen C, Sestoft D, Svarer C, Knudsen GM. Serotonin 1B Receptor Binding Is Associated With Trait Anger and Level of Psychopathy in Violent Offenders. Biol Psychiatry 2017; 82 (4):267-274.

da Cunha-Bang S, Hjordt LV, Dam VH, Stenbæk DS, Sestoft D, Knudsen GM. Anterior cingulate serotonin 1B receptor binding is associated with emotional response inhibition. J Psychiatr Res 2017; 92:199-204.

Dejanović D, Loft A. ^{18}F-FDG PET/CT findings following repeated intramuscular injections of "Site Enhancement Oil" in the Upper Extremities. Clin Nucl Med 2017; 42 (10):e436-e437.

Dickson JC, Tossici-Bolt L, Sera T, Booij J, Ziebell M, Morbelli S, Assenbaum-Nan S, Borght TV, Pagani M, Kapucu OL, Hesse S, Van Laere K, Darcourt J, Varrone A, Tatsch K. The impact of reconstruction and scanner characterisation on the diagnostic capability of a normal database for [123I]FP-CIT SPECT imaging. EJNMMI Res 2017; 7 (1):10.

Dreier JP, Fabricius M, Ayata C, Sakowitz OW, William Shuttleworth C, Dohmen C et al. Recording, analysis, and interpretation of spreading depolarizations in neurointensive care: Review and recommendations of the COSBID research group. J Cereb Blood Flow Metab 2017; 37 (5):1595-1625.

Edgar FG, Hansen HD, Leth-Petersen S, Ettrup A, Kristensen JL, Knudsen GM, Herth MM. Synthesis, radiofluorination, and preliminary evaluation of the potential 5-HT2A receptor agonists [18F]Cimbi-92 and [18F]Cimbi-150. J Labelled Comp Radiopharm 2017; 60 (12):586-591.

Publications

Ekberg C, Jensen H, Mezyk SP, Mincher BJ, Skarnemark G. Extraction of ^{211}At from nitric acid solutions into various organic solvents for use as an β-source for radiation chemistry studies. J Radioanal Chem 2017; 314:235-239.

Eldirdiri A, Clemmensen A, Bowen S, Kjær A, Ardenkjær-Larsen JH. Simultaneous imaging of hyperpolarized [1,4-(13) C2]fumarate, [1-(13) C] pyruvate and ^{18}F-FDG in a rat model of necrosis in a clinical PET/MR scanner. NMR Biomed 2017; 30 (12): 1-9:e3803.

Elmelund M, Klarskov N, Bagi P, Oturai PS, Biering-Sørensen F. Renal deterioration after spinal cord injury is associated with length of detrusor contractions during cystometry-A study with a median of 41 years follow-up. Neurourol Urodyn 2017; 36 (6):1607-1615.

Enevoldsen LH, Heaf J, Højgaard L, Zerahn B, Hasbak P. Increased technetium-99 m hydroxy diphosphonate soft tissue uptake on bone scintigraphy in chronic kidney disease patients with secondary hyperparathyroidism: correlation with hyperphosphataemia. Clin Physiol Funct Imaging 2017; 37 (2):131-136.

Feng L, Jensen P, Thomsen G, Dyssegaard A, Svarer C, Knudsen LV, Møller K, Thomsen C, Mikkelsen JD, Guilloteau D, Knudsen GM, Pinborg LH. The variability of translocator protein signal in brain and blood of genotyped healthy humans using in vivo ^{123}I-CLINDE SPECT imaging - a test-retest study. J Nucl Med 2017; 58 (6):989-995.

Fisher PM, Ozenne B, Svarer C, Adamsen D, Lehel S, Baaré WFC, Jensen PS, Knudsen GM. BDNF val-66met association with serotonin transporter binding in healthy humans. Transl Psychiatry 2017; 7 (2):e1029.

Foged MT, Lindberg U, Vakamudi K, Larsson HBW, Pinborg LH, Kjær TW, Fabricius M, Svarer C, Ozenne B, Thomsen C, Beniczky S, Paulson OB, Posse S. Safety and EEG data quality of concurrent high-density EEG and high-speed fMRI at 3 Tesla. PLoS One 2017; 12 (5):e0178409.

Fosbøl M, Reving S, Petersen EH, Rossing P, Lajer M, Zerahn B. Three-phase bone scintigraphy for diagnosis of Charcot neuropathic osteoarthropathy in the diabetic foot - does quantitative data improve diagnostic value? Clin Physiol Funct Imaging 2017; 37 (1):30-36.

Galldiks N, Albert NL, Sommerauer M, Grosu AL, Ganswindt U, Law I, Preusser M, Le Rhun E, Vogelbaum MA, Zadeh G, Dhermain F, Weller M, Langen KJ, Tonn JC. PET imaging in patients with meningioma-report of the RANO/PET Group. Neuro Oncol 2017; 19 (12):1576-1587.

Galldiks N, Law I, Pope WB, Arbizu J, Langen K-J. The use of amino acid PET and conventional MRI for monitoring of brain tumor therapy. Neuroimage Clin 2017; 13:386-394.

Ganz M, Feng L, Hansen HD, Beliveau V, Svarer C, Knudsen GM, Greve DN. Cerebellar heterogeneity and its impact on PET data quantification of 5-HT receptor radioligands. J Cereb Blood Flow Metab 2017; 37 (9):3243-3252.

Ganz M, Kondermann D, Andrulis J, Knudsen GM, Maier-Hein L. Crowdsourcing for error detection in cortical surface delineations. Int J Comput Assist Radiol Surg 2017; 12 (1): 161-166.

Girard R, Fam MD, Zeineddine HA, Tan H, Mikati AG, Shi C, Jesselson M, Shenkar R, Wu M, Cao Y,Hobson N, Larsson HB, Christoforidis GA, Awad IA. Vascular permeability and iron deposition biomarkers in longitudinal follow-up of cerebral cavernous malformations. J Neurosurg 2017; 127 (1):102-110.

Ghotbi AA, Clemmensen A, Kyhl K, Follin B, Hasbak P, Engstrøm T, Ripa RS, Kjær A. Rubidium-82 PET imaging is feasible in a rat myocardial infarction model. J Nucl Cardiol 2017; 124:1172-12.

Guldbrandsen KF, Hendel HW, Langer SW, Fischer BM. Nuclear Molecular Imaging Strategies in Immune Checkpoint Inhibitor Therapy. Diagnostics 2017; 7 (2):23.

Guo S, Vollesen AL, Hansen YB, Frandsen E, Andersen MR, Amin FM, Fahrenkrug J, Olesen J, Ashina M. Part II: Biochemical changes after pituitary adenylate cyclase-activating polypeptide-38 infusion in migraine patients. Cephalalgia. 2017; 37 (2):136-147.

Gutte Borgwardt H, Mortensen J, Mørk ML, Kristoffersen US, Jensen CV, Petersen CL, von der Recke P, Kjær A. Non-ECG-gated CT pulmonary angiography and the prediction of right ventricular dysfunction in patients suspected of pulmonary embolism. Clin Physiol Funct Imaging 2017; 37 (6):575-581.

Haddock B, Holm S, Poulsen JM, Enevoldsen LH, Larsson HBW, Kjær A, Suetta C. Assessment of muscle function using hybrid PET/MRI: comparison of ^{18}F-FDG PET and T2-weighted MRI for quantifying muscle activation in human subjects. Eur J Nucl Med Mol Imaging 2017; 44 (4):704-711.

Harder-Lauridsen NM, Nielsen ST, Porsdam Mann S, Lyngbæk MP, Benatti FB, Langkilde AR, Law I, Wedell-Neergaard AS, Thomsen C, Moller K, Karstoft K, Pedersen BK, Krogh-Madsen R. The effect of alternate-day caloric restriction on the metabolic consequences of eight days bed rest in healthy lean men: a randomized trial. J Appl Physiol 2017; 122 (2):230-241.

Hasholt L, Ballegaard M, Bundgaard H, Christiansen M, Law I, Lund AM, Norremolle A, Krogh Rasmussen A, Ravn K, Tumer Z, Wibrand F, Feldt-Rasmussen U. The D313Y variant in the GLA gene – no evidence of a pathogenic role in Fabry disease. Scand J Clin Lab Invest 2017; 77 (8):617-621.

Henriksen OM, Hansen NL, Osler M, Mortensen EL, Hallam DM, Pedersen ET, Chappell M, Lauritzen MJ, Rostrup E.Sub-Clinical Cognitive Decline and Resting Cerebral Blood Flow in Middle Aged Men. PLoS One 2017; 12 (1):e0169912.

Holm S, Mawlawi O, Beyer T. PET/CT. In: Dahlbom M (ed). Physics of PET and SPECT imaging. CRC press, 2017, 339-368. ISBN 9781466560130.

Holm S. Radiation protection measurement equipment. Chapter 12 in: EANM Technologist Guide 2017. EANM Wien. ISBN: 978-3-902785-13-8

Hougaard A, Amin FM, Christensen CE, Younis S, Wolfram F, Cramer SP, Larsson HBW, Ashina M. Increased brainstem perfusion, but no blood-brain barrier disruption, during attacks of migraine with aura. J Neurol 2017; 140 (6):1633-1642.

Hougaard A, Amin FM, Larsson HBW, Rostrup E, Ashina M. Increased intrinsic brain connectivity between pons and somatosensory cortex during attacks of migraine with aura. Hum Brain Mapp 2017; 38 (5):2635-2642.

Hvid LG, Brocca L, Ørtenblad N, Suetta C, Aagaard P, Kjær M, Bottinelli R, Pellegrino MA. Myosin content of single muscle fibers following short-term disuse and active recovery in young and old healthy men. Exp Gerontol 2017; 87 (Pt A):100-107.

Højgaard L, Löwenberg B, Selby P, Lawler M, Banks I, Law K et al. The European Cancer Patient's Bill of Rights, update and implementation. ESMO Open 2017; 1 (6):e000127.

Højgaard L. Hvordan får vi verdens bedste sundhedsvæsen? Informations Forlag. 2017. ISBN: 978-87-7514-5768.

Håkansson K, Rasmussen JH, Rasmussen GB, Friborg J, Gerds TA, Fischer BM, Andersen FL, Bentzen SM, Specht L, Vogelius IR. A failure-type specific risk prediction tool for selection of head-and-neck cancer patients for experimental treatments. Oral Oncol 2017; 74:77-82.

Haarmark C, Andersen KF, Madsen C, Zerahn B. Coronary artery calcium score and N-terminal pro-B-type natriuretic peptide as potential gatekeepers for myocardial perfusion imaging. Clin Physiol Funct Imaging 2017; 37 (6):710-716.

Ishøy PL, Knop FK, Broberg BV, Bak N, Andersen UB, Jørgensen NR, Holst JJ, Glenthøj BY, Ebdrup BH. Effect of GLP-1 Receptor Agonist Treatment on Body weight in Obese Antipsychotic-treated Patients with Schizophrenia: a Randomized, Placebo-controlled Trial Byline. Diabetes Obes Metab 2017; 19 (2):162-171.

Johansson J, Keller S, Tuisku J, Teräs M. Performance of an image-based motion compensation algorithm for the hrrt: A striatum-phantom study with true motion. IEEE NSS/MIC Conf Rec. 2016, ISBN: 978-1-5090-1642-6.

Jensen NL, Pedersen HS, Vestergaard M, Mercer SW, Glümer C, Prior A. The impact of socioeconomic status and multimorbidity on mortality: A population-based cohort study. Clin Epidemol 2017; 9:279-289.

Jensen CH, Hansen HD, Bay T, Vogensen SB, Lehel S, Thiesen L, Bundgaard C, Clausen RP, Knudsen GM, Herth MM, Wellendorph P, Frølund B. Radiosynthesis and Evaluation of [11C]3-Hydroxycyclopent-1-enecarboxylic Acid as Potential PET Ligand for the High-Affinity β-Hydroxybutyric Acid Binding Sites. ACS Chem Neurosci 2017; 8 (1):22-27.

Jensen AI, Binderup T, Ek PK, Grandjean CE, Rasmussen PH, Kjær AK, Andresen TL. PET imaging with copper-64 as a tool for real-time in vivo investigations of the necessity for cross-linking of polymeric micelles in nanomedicine. J Labelled Comp Radiopharm 2017; 60 (8):366-374.

Johnbeck CB, Knigge U, Loft A, Berthelsen AK, Mortensen J, Oturai P, Langer S, Elema D, Kjær A. Head-to-head comparison of 64Cu-DOTATATE and ^{68}Ga-DOTATOC PET/CT: a prospective study of 59 patients with neuroendocrine tumors. J Nucl Med 2017; 58 (3):451-457.

Jürgens TP, Barloese M, May A, Láinez JM, Schoenen J, Gaul C, Goodman AM, Caparso A, Jensen RH. Long-term effectiveness of sphenopalatine ganglion stimulation for cluster headache. Cephalalgia 2017; 37 (5):423-434.

Jørgensen LM, Weikop P, Villadsen J, Visnapuu T, Ettrup A, Hansen HD, Baandrup AO, Andersen FL, Bjarkam CR, Thomsen C, Jespersen B, Knudsen GM. Cerebral 5-HT release correlates with [11C] Cimbi36 PET measures of 5-HT2A receptor occupancy in the pig brain. J Cereb Blood Flow Metab 2017; 37 (2):425-436.

Keizman D, Fosbøl MØ, Reichegger H, Peer A, Rosenbaum E, Desax MC, Neiman V, Petersen PM, Mueller J, Cathomas R, Gottfried M, Dresler H, Sarid D, Mermershtain W, Rouvinov K, Mortensen J, Gillessen S, Daugaard G, Omlin A.. Imaging response during therapy with radium-223 for castration-resistant prostate cancer with bone metastases-analysis of an international multicenter database. Prostate Cancer Prostatic Dis 2017; 20 (3):289-293.

Keller SH, L'Estrade EN, Dall B, Palner M, Herth M. Quantification accuracy of a new HRRT high throughput rat hotel using transmission-based attenuation correction: A phantom study. IEEE NSS/MIC Conf Rec. 2016, ISBN978-1-5090-1642-6.

Kragholm K, Wissenberg M, Mortensen RN, Hansen SM, Malta Hansen C, Thorsteinsson K, Rajan S, Lippert F, Folke F, Gislason G, Køber L, Fonager K, Jensen SE, Gerds TA, Torp-Pedersen C, Rasmussen BS. Bystander Efforts and 1-Year Outcomes in Out-of-Hospital Cardiac Arrest. N Engl J Med 2017; 376 (18):1737-1747.

Krakauer K, Ebdrup BH, Glenthøj BY, Raghava JM, Nordholm D, Randers L, Rostrup E, Nordentoft M. Patterns of white matter microstructure in individuals at ultra-high-risk for psychosis: associations to

Publications

level of functioning and clinical symptoms. Psychol Med 2017; 47 (15):2689-2707.

Krustrup P, Skoradal M-B, Randers MB, Weihe P, Uth J, Mortensen J, Mohr M. Broad-spectrum health improvements with one year of soccer training in inactive mildly hypertensive middle-aged women. Scand J Med Sci Sports 2017; 27 (12):1893-1901.

Kyhl K, Lønborg J, Hartmann B, Kissow H, Poulsen SS, Ali HE, Kjær A, Dela F, Engstrøm T, Treiman M. Lack of effect of prolonged treatment with liraglutide on cardiac remodeling in rats after acute myocardial infarction. Peptides 2017; 93:1-12.

Ladefoged CN, Law I, Anazodo U, St K, Izquierdo-garcia D, Catana C, Burgos N, Cardoso MJ, Ourselin S, Hutton B, Mérida I, Costes N, Hammers A, Benoit D, Holm S, Juttukonda M, An H, Cabello J, Lukas M, Nekolla S, Ziegler S, Fenchel M, Jakoby B, Casey ME, Benzinger T, Højgaard L, Hansen AE, Andersen FL. A multi-centre evaluation of eleven clinically feasible brain PET/MRI attenuation correction techniques using a large cohort of patients. Neuroimage 2017; 147:346-359.

Ladefoged CN, Andersen FL, Kjær A, Højgaard L, Law I. Resolute PET/MRI Attenuation Correction for O-(2-F-fluoroethyl)-L-tyrosine (FET) in Brain Tumor Patients with Metal Implants. Front Neurosci 2017; 11:453.

Langhans L, Tvedskov TF, Klausen TL, Jensen MB, Talman ML, Vejborg I, Benian C, Roslind A, Hermansen J, Oturai PS, Bentzon N, Kroman N. Radioactive Seed Localization or Wire-guided Localization of Nonpalpable Invasive and In Situ Breast Cancer: A Randomized, Multicenter, Open-label Trial. Ann Surg 2017; 266 (1):29-35.

Larsen JR, Vedtofte L, Jakobsen MSL, Jespersen HR, Jakobsen MI, Svensson CK, Koyuncu K, Schjerning O, Oturai PS, Kjær A, Nielsen J, Holst JJ, Ekstrøm CT, Correll CU, Vilsbøll T, Fink-Jensen A. Effect of Liraglutide Treatment on Prediabetes and Overweight or Obesity in Clozapine- or Olanzapine-Treated Patients With Schizophrenia Spectrum Disorder: A Randomized Clinical Trial. Arch Gen Psychiatry 2017; 74 (7):719-728.

Larsson HBW, Vestergaard MB, Lindberg U, Iversen HK, Cramer SP. Brain capillary transit time heterogeneity in healthy volunteers measured by dynamic contrast-enhanced T1 -weighted perfusion MRI. JMRI 2017; 45 (6):1809-1820.

Lassen ML, Muzik O, Beyer T, Hacker M, Ladefoged CN, Gonzalez JC, Wadsak W, Rausch I, Langer O, Bauer M. Reproducibility of quantitative brain imaging using a PET-only and a combined PET/MR system. Front Neurosci 2017; 11:396.

Lauridsen TK, Iversen KK, Ihlemann N, Hasbak P, Loft A, Berthelsen AK, Dahl A, Dejanovic D, Albrecht-Beste E, Mortensen J, Kjær A, Bundgaard H, Bruun NE. Clinical utility of ^{18}F-FDG positron emission tomography/computed tomography scan vs. ^{99m}Tc-HMPAO white blood cell single-photon emission computed tomography in extra-cardiac work-up of infective endocarditis. Int J Cardiovasc Imaging 2017; 33 (5):751-760.

Lebech AM, Gaardsting A, Loft A, Graff J, Markova E, Bertelsen AK, Madsen JL, Andersen KF, Benzon EV, Helms M, Mathiesen LR, David KP, Kronborg G, Kjær A. Whole body ^{18}F-FDG PET/CT is superior to CT as first line diagnostic imaging in patients referred with serious non-specific symptoms or signs of cancer: a randomized prospective study of 200 patients. J Nucl Med 2017; 58 (7):1058-1064.

Lehnert P, Møller CH, Mortensen J, Kjærgaard J, Olsen PS, Carlsen J. Surgical embolectomy compared to thrombolysis in acute pulmonary embolism: morbidity and mortality. Eur J Cardiothorac Surg 2017; 51 (2):354-361.

Lindberg U, Witting N, Jørgensen SL, Vissing J, Rostrup E, Larsson HB, Kruuse C. Effects of Sildenafil on Cerebrovascular Reactivity in Patients with Becker Muscular Dystrophy. Neurotherapeutics 2017; 14 (1):182-190.

Lindquist SG, Møller LB, Dali CI, Marner L, Kamstees EJ, Nielsen JE, Hjermind LE. A Novel TTBK2 De Novo Mutation in a Danish Family with Early-Onset Spinocerebellar Ataxia. Cerebellum 2017; 16 (1):268-71.

Loft M, Sun Y, Liu C, Camilla C, Huang D, Kjær A, Cheng Z. Improved positron emission tomography imaging of glioblastoma cancer using novel Ga-labeled peptides targeting the urokinase-type plasminogen activator receptor (uPAR). Amino Acids 2017; 49 (6):1089-1100.

Lohse Z, Bytoft B, Knorr S, Clausen TD, Beck Jensen R, Beck-Nielsen H, Hermann AP, Oturai P, Frystyk J, Damm P, Gravholt CH, Højlund K, Jensen DM. Abnormal levels of adipokines in adolescent offspring of women with type 1 diabetes - Results from the EPICOM study. Metabolism 2017; 72:47-56.

Lund N, Barloese M, Petersen A, Haddock B, Jensen R. Chronobiology differs between men and women with cluster headache, clinical phenotype does not. Neurology 2017; 88 (11):1069-1076.

Lundemann M, Costa JC, Law I, Engelholm SA, Muhic A, Poulsen HS, Munck af Rosenschold P. Patterns of failure for patients with glioblastoma following O-(2-[(18)F]fluoroethyl)-L-tyrosine PET- and MRI-guided radiotherapy. Radiother Oncol 2017; 122 (3):380-386.

Löfgren J, Loft A, Barbosa de Lima VA, Østerlind K, von Benzon E, Højgaard L. Clinical importance of re-interpretation of PET/CT scanning in patients referred to a tertiary care medical centre. Clin Physiol Funct Imaging 2017; 37 (2):143-147.

Löfgren J, Mortensen J, Rasmussen SH, Madsen C, Loft A, Hansen AE, Oturai P, Jensen KE, Mørk ML, Reichkendler M, Højgaard L, Fischer BM. A Prospective Study Comparing ^{99m}Tc-Hydroxy-ethylene-Diphosphonate Planar Bone Scintigraphy and Whole-Body SPECT/CT with ^{18}F-Fluoride PET/CT and ^{18}F-Fluoride PET/MRI for Diagnosing Bone Metastases. J Nucl Med 2017; 58 (11):1778-1785.

Madsen K, Hesby S, Poulsen I, Fuglsang S, Graff J, Larsen KB, Kammersgaard LP, Law I, Siebner H. Comparison of Analytical Methods of Brain [18F] FDG-PET after Severe Traumatic Brain Injury. J Neurosci Methods 2017; 176-181.

Mandrup CM, Egelund J, Nyberg M, Lundberg Slingsby MH, Andersen CB, Løgstrup S, Bangsbo J, Suetta C, Stallknecht B, Hellsten Y. Effects of high-intensity training on cardiovascular risk factors in premenopausal and postmenopausal women. Am J Obstet Gynecol 2017; 216 (4):384.

Marner L, Henriksen OM, Lundemann M, Larsen VA, Law I. Clinical PET/MRI in neurooncology: opportunities and challenges from a single-institution perspective. Clin Transl Imaging 2017; 5 (2):135-149.

Merchán A, Navarro SV, Klein AB, Aznar S, Campa L, Suñol C, Moreno M, Flores P. Tryptophan depletion affects compulsive behaviour in rats: strain dependent effects and associated neuromechanisms. Psychopharmacology 2017; 234 (8):1223-1236.

Michelsen MM, Mygind ND, Pena A, Olsen RH, Christensen TE, Ghotbi AA, Hasbak P, Kjær A, Gustafsson I, Hansen PR, Hansen HS, Høst N, Kastrup J, Prescott E. Transthoracic Doppler echocardiography compared with positron emission tomography for assessment of coronary microvascular dysfunction: The iPOWER study. Int J Cardiol 2017; 228:435-443.

Mogensen MB, Loft A, Aznar M, Axelsen T, Vainer B, Osterlind K, Kjær A. FLT-PET for early response evaluation of colorectal cancer patients with liver metastases: a prospective study. EJNMMI Research 2017; 7 (1):1-56.

Munkholm M, Madsen F, Hanel B, Mortensen J. Spirometri – anvendelighed og kvalitetssikring. Best Practice. 2017; Jan.

Møller S, Munck af Rosenschöld P, Costa J, Law I, Poulsen HS, Engelholm SA, Engelholm S. Toxicity and efficacy of re-irradiation of high-grade glioma in a phase I dose- and volume escalation trial. Radiother Oncol 2017; 125 (2):223-227.

Nepper-Christensen L, Lønborg J, Ahtarovski KA, Høfsten DE, Kyhl K, Ghotbi AA, Schoos MM, Göransson C, Nertelsen L, Køber L, Helqvist S, Pedersen F, Saünamaki K, Jørgensen E, Kelbæk H, Holmvang L, Vejlstrup N, Engstrøm T. Left Ventricular Hypertrophy Is Associated With Increased Infarct Size and Decreased Myocardial Salvage in Patients With ST-Segment Elevation Myocardial Infarction Undergoing Primary Percutaneous Coronary Intervention. J Am Heart Assoc 2017; 6 (1): e004823.

Nielsen J, Gejl KD, Hey-Mogensen M, Holmberg HC, Suetta C, Krustrup P, Elemans CPH, Ørtenblad N. Plasticity in mitochondrial cristae density allows metabolic capacity modulation in human skeletal muscle. J Physiol 2017; 595 (9):2839–2847.

Nielsen JL, Frandsen U, Prokhorova T, Bech RD, Nygaard T, Suetta C, Aagaard P. Delayed Effect of Blood Flow-restricted Resistance Training on Rapid Force Capacity. Med Sci Sports Exerc 2017; 49 (6):1157-1167.

Nielsen JL, Aagaard P, Prokhorova TA, Nygaard T, Bech RD, Suetta C, Frandsen U. Blood flow restricted training leads to myocellular macrophage infiltration and upregulation of heat shock proteins, but no apparent muscle damage. J Physiol 2017; 595 (14):4857-4873.

Norregaard K, Jørgensen JT, Simón M, Melander F, Kristensen LK, Bendix PM, Andresen TL, Oddershede LB, Kjær A. ^{18}F-FDG PET/CT-based early treatment response evaluation of nanoparticle-assisted photothermal cancer therapy. PLoS One 2017; 12 (5):e0177997.

Norregaard K, Metzler R, Ritter CM, Berg-Sørensen K, Oddershede LB. Manipulation and Motion of Organelles and Single Molecules in Living Cells. Chem NZ 2017; 117 (5):4342-4375.

Nørbak-Emig H, Pinborg LH, Raghava JM, Svarer C, Baaré WFC, Allerup P, Friberg L, Rostrup E, Glenthøj B, Ebdrup BH. Extrastriatal dopamine D2/3 receptors and cortical grey matter volumes in antipsychotic-naïve schizophrenia patients before and after initial antipsychotic treatment. World J Biol Psychiatry 2017; 18 (7):539-549.

Nørgaard M, Ganz M, Svarer C, Fisher PM, Churchill NW, Beliveau V, Grady C, Strother SC, Knudsen GM. Brain Networks Implicated in Seasonal Affective Disorder: A Neuroimaging PET Study of the Serotonin Transporter. Front Neurosci 2017; 11:614.

Pauls MMH, Clarke N, Trippier S, Betteridge S, Howe FA, Khan U, Kruuse C, Madigan JB, Moynihan B, Pereira AC, Rolfe D, Rostrup E, Haig CE, Barrick TR, Isaacs JD, Hainsworth AH. Perfusion by Arterial Spin labelling following Single dose Taladafil In Small vessel disease (PASTIS): Study protocol for a randomised controlled trial. Trials 2017; 18 (1):229-236.

Perfalk E, Cunha-Bang SD, Holst KK, Keller S, Svarer C, Knudsen GM, Frokjær VG. Testosterone levels in healthy men correlate negatively with serotonin 4 receptor binding. Psychoneuroendocrinol 2017; 81:22-28.

Petersen IN, Kristensen JL, Herth MM. Nucleophilic ^{18}F-labeling of spirocyclic iodonium ylide or boronic pinacol ester precursors: Advantages and disadvantages. European J Org Chem 2017; 453-458.

Petersen IN, Hansen HD, Madsen J, Villadsen J, Jensen AA, Lehel S, Gillings N, Herth MM, Knudsen GM, Kristensen JL. ^{18}F-labelling of electron rich iodonium ylides: application to the radiosynthesis of potential 5-HT2A receptor PET ligands. Chemistry 2017; 15(20):4351-4358.

Poulsen SH, Urup T, Grunnet K, Christensen IJ, Larsen VA, Jensen ML, af Rosenschöld PM, Poulsen

Publications

HS, Law I. The prognostic value of FET PET at radiotherapy planning in newly diagnosed glioblastoma. Eur J Nucl Med Mol Imaging 2017; 44 (3):373-381.

Pourhassan H, Clergeaud G, Hansen AE, Østrem RG, Fliedner FP, Melander F, Nielsen OL, O'Sullivan CK, Kjær A, Andresen TL. Revisiting the use of sPLA-sensitive liposomes in cancer therapy. J Control Release 2017; 261:163-173.

Qayyum AA, Kühl JT, Kjær A, Hasbak P, Kofoed KF, Kastrup J. Semi-quantitative myocardial perfusion measured by computed tomography in patients with refractory angina: a head-to-head comparison with quantitative rubidium-82 positron emission tomography as reference. Clin Physiol Funct Imaging 2017; 37 (5):481-488.

Qayyum AA, Qayyum F, Larsson HB, Kjær A, Hasbak P, Vejlstrup NG, Kastrup J. Comparison of rest and adenosine stress quantitative and semi-quantitative myocardial perfusion using magnetic resonance in patients with ischemic heart disease. Clinical MRI 2017; 41:149-156.

Rafiq S, Johansson PI, Kofoed KF, Lund JT, Olsen PS, Bentsen S, Steinbrüchel DA. Thrombelastographic hypercoagulability and antiplatelet therapy after coronary artery bypass surgery (TEG-CABG trial): a randomized controlled trial. Platelets 2017; 28 (8):786-793.

Rahbek S, Gutte H, Johannesen HH, Koch J, Jensen LK, Dich-Jorgensen K, Jensen H, Hansen A, Kjær A. Hyperpolarized ^{13}C-MRSI and PET (hyperPET) in an osteomyelitis pig model: a pilot study. IEEE Transactions on Nuclear Science 2017; 1:2469-7303.

Rahbek S, Gutte H, Johannesen HH, Koch J, Jensen LK, Dich-Jorgensen K, Jensen H, Hansen AE, Kjær A. Hyperpolarized ^{13}C-MRSI and PET (hyperPET) in an Osteomyelitis Pig Model: a Pilot Study. IEEE Trans Radiat Plasma Med Sci 2017; 1 (2):164-167.

Rasmussen LJH, Schultz M, Gaardsting A, Ladelund S, Garred P, Iversen K, Eugen-Olsen J, Helms M, David KP, Kjær A, Lebech AM, Kronborg G. Inflammatory biomarkers and cancer: CRP and uPAR as markers of incident cancer in patients with serious nonspecific symptoms and signs of cancer. Int J Cancer 2017; 141 (1):191-199.

Rasmussen JH, Nørgaard M, Hansen AE, Vogelius IR, Aznar MC, Johannesen HH, Costa J, Engberg AM, Kjær A, Specht L, Fischer BM. Feasibility of Multiparametric Imaging with PET/MR in Head and Neck Squamous Cell Carcinoma. J Nucl Med 2017; 58 (1):69-74.

Rasmussen GB, Vogelius IR, Mathias T, Rasmussen JH, Zhang Y, Fischer BM, Therkildsen MH, Specht L, Bentzen SM. Immunohistochemical and molecular imaging biomarker signature for the prediction of failure site after chemoradiation for head and neck squamous cell carcinoma. Acta Oncol 2017; 56 (11):1562-1570.

Rausch I, Rischka L, Ladefoged CN, Furtner J, Fenchel M, Hahn A, Lanzenberger R, Mayerhoefer ME, Traub-Weidinger T, Beyer T. PET/MRI for Oncologic Brain Imaging: A Comparison of Standard MR-Based Attenuation Corrections with a Model-Based Approach for the Siemens mMR PET/MR System. J Nucl Med 2017; 58(9):1519-1525.

Sari H, Erlandsson K, Law I, Larsson HB, Ourselin S, Arridge S, Atkinson D, Hutton BF. Estimation of an image derived input function with MR-defined carotid arteries in FDG-PET human studies using a novel partial volume correction method. J Cereb Blood Flow 2017; 37 (4):1398-1409.

Schmidt KK, Grønhøj C, Jensen DH, Wessel I, Charabi BW, Specht L, Kjær A, von Buchwald C. Increasing incidence and survival in oral cancer: a nationwide Danish study from 1980 to 2014. Acta Oncol 2017; 56 (9):1204-1209.

Severin GW, Kristensen LK, Nielsen CH, Fonslet J, Jensen AI, Frellsen AF, Jensen KM, Elema DR, Maecke H, Kjær A, Johnston K. Neodymium-140 DOTA-LM3: Evaluation of a Generator for PET with a Non-Internalizing Vector. Front Med 2017; 4:98.

Skibsted AP, Cunha-Bang S, Carré JM, Hansen AE, Beliveau V, Knudsen GM, Fisher PM. Aggression-related brain function assessed with the Point Subtraction Aggression Paradigm in fMRI. Aggressive Behav 2017; 43 (6):601-610.

Skovgaard D, Persson M, Brandt-Larsen M, Christensen C, Madsen J, Klausen TL, Holm S, Andersen FL, Loft A, Berthelsen AK, Pappot H, Brasso K, Kroman N, Hoejgaard L, Kjær A. Safety, dosimetry and tumor detection ability of ^{68}Ga-NOTA-AE105 - a novel radioligand for uPAR PET imaging: first-in-humans study. J Nucl Med 2017; 58 (3):379-386.

Skovgaard D, Svensson RB, Scheijen J, Eliasson P, Mogensen P, Hag AMF, Kjær M, Schalkwijk CG, Schjerling P, Magnusson SP, Couppé C. An advanced glycation endproduct (AGE)-rich diet promotes accumulation of AGEs in Achilles tendon. Physiol Rep 2017; 5 (6).

Specht L, Berthelsen AK. Radiation Therapy in Hematologic Malignancies. I Diffuse Large B-Cell Lymphoma. Springer Verlag 2017: 29.

Stéen EJL, Nyberg N, Lehel S, Lykke Andersen V, Di Pilato P, Knudsen GM, Kristensen JL, Herth MM. Development of a simple proton nuclear magnetic resonance-based procedure to estimate the approximate distribution coefficient at physiological pH (logD7.4): Evaluation and comparison to existing practices. Bioorg Med Chem Lett 2017; 27 (2):319-322.

Stenbæk DS, Fisher PM, Ozenne B, Andersen E, Hjordt LV, McMahon B, Hasselbalch SG, Frokjær VG, Knudsen GM. Brain serotonin 4 receptor binding is inversely associated with verbal memory recall. Brain Behav 2017; 7 (4):e00674.

Stenbæk DS, Dam VH, Fisher PM, Hansen N, Hjordt LV, Frøkjær VG. No evidence for a role of the serotonin 4 receptor in five-factor personality traits: A positron emission tomography brain study. PLoS One 2017; 12 (9):e0184403.

Suetta C. Plasticity and function of human skeletal muscle in relation to disuse and rehabilitation: Influence of ageing and surgery. Dan Med Bull 2017; 64 (8).

Sundin A, Arnold R, Baudin E, Cwikla JB, Eriksson B, Fanti S, Fazio N, Giammarile F, Hicks RJ, Kjær A, Krenning E, Kwekkeboom D, Lombard-Bohas C, O´Connoer JM, O´Toole D, Rockall A, Wiedemann B, Valle JW, Vullierme MP; all other Antibes Consensus Conference participants. ENETS Consensus Guidelines for the Standards of Care in Neuroendocrine Tumors: Radiological, Nuclear Medicine & Hybrid Imaging. Neuroendocrinology 2017; 105 (3):212-244.

Svenstrup K, Nielsen TT, Aidt F, Rostgaard N, Duno M, Wibrand F, Vinther-Jensen T, Law I, Vissing J, Roos P, Hjermind LE, Nielsen JE. SCA28: Novel Mutation in the AFG3L2 Proteolytic Domain Causes a Mild Cerebellar Syndrome with Selective Type-1 Muscle Fiber Atrophy. Cerebellum 2017; 16 (1):62-67.

Tossici-Bolt L, Dickson JC, Sera T, Booij J, Asenbaun-Nan S, Bagnara MC, Borght TV, Jonsson C, de Nijs R, Hesse S, Koulibaly PM, Akdemir UO, Koole M, Tatsch K, Varrone A. [123I]FP-CIT ENC-DAT normal database: the impact of the reconstruction and quantification methods. EJNMMI Physics 2017; 4 (1) 8.

Tuominen L, Miettunen J, Cannon DM, Drevets WC, Frokjær VG, Hirvonen J, Ichise M, Jensen PS, Keltikangas-Järvinen L, Klaver JM, Knudsen GM, Takano A, Suhara T, Hietala J. Neuroticism associates with cerebral in vivo serotonin transporter binding differently in males and females. Int J Neuropsychopharmacol 2017; 20 (12):963-970.

Vensby PH, Schmidt G, Kjær A, Fischer BM. The value of FDG PET/CT for follow-up of patients with melanoma: a retrospective analysis. Am J Nucl Med Mol Imaging 2017; 7 (6):255-262.

Vestergaard MB, Lindberg U, Aachmann-Andersen NJ, Lisbjerg K, Christensen SJ, Rasmussen P, Olsen NV, Law I, Larsson HB, Henriksen OM. Comparison of global cerebral blood flow measured by phase-contrast mapping MRI with ^{15}O-H_2O positron emission tomography. J Magn Res Imaging 2017:692-699.

von Scholten BJ, Persson F, Svane MS, Hansen TW, Madsbad S, Rossing P. Effect of large weight reductions on measured and estimated kidney function. BMC Nephrology 2017; 18 (1):52.

von Scholten BJ, Persson F, Rosenlund S, Hovind P, Faber J, Hansen TW, Rossing P. The effect of liraglutide on renal function: A randomized clinical trial. Diabetes Obes Metab 2017; 19 (2):239-247.

Wahlstrøm KL, Novovic S, Ersbøll AK, Hasbak P, Jørgensen LN, Berner Hansen M. Serotonin, calcitonin and calcitonin gene-related peptide in acute pancreatitis. Scand J Gastroenterol 2017; 52 (10):1140-1147.

Wareham NE, Lundgren JD, Da Cunha-Bang C, Gustafsson F, Iversen M, Johannesen HH, Kjær A, Rasmussen A, Sengeløv H, Sørensen SS, Fischer BM. The clinical utility of FDG PET/CT among solid organ transplant recipients suspected of malignancy or infection. Eur J Nucl Med Mol Imaging 2017; 44 (3):421-431.

Yang KC, Stepanov V, Martinsson S, Ettrup A, Takano A, Knudsen GM, Halldin C, Farde L, Finnema SJ. Fenfluramine Reduces [11C]Cimbi-36 Binding to the 5-HT2A Receptor in the Nonhuman Primate Brain. Int J Neuropsychopharmacol 2017; 20 (9):683-691.

Younis S, Hougaard A, Vestergaard MB, Larsson HBW, Ashina M. Migraine and magnetic resonance spectroscopy: a systematic review. Curr Opin Neurol 2017; 30 (3):246-262.

Ørbæk M, Hasbak P, Sejersten Ripa R, Kjær A, Lebech A-M, Knudsen A. Comparison of the Peripheral Reactive Hyperemia Index with Myocardial Perfusion Reserve by (82)Rb PET/CT in HIV-Infected Patients. Diagnostics 2017; 7 (2):31.

Østrem RG, Parhamifar L, Pourhassan H, Clergeaud G, Nielsen OL, Kjær A, Hansen AE, Andresen TL. Secretory phospholipase A2 responsive liposomes exhibit a potent anti-neoplastic effect in vitro, but induce unforeseen severe toxicity in vivo. J Control Release 2017; 262:212-221.

Aarup A, Nielsen CH, Bisgaard LS, Bot I, El-Ali HH, Kjær A, Nielsen LB, Pedersen TX. Uremia does not affect neointima formation in mice. Sci Rep 2017; 7 (1):6496.

Cluster for Molecular Imaging

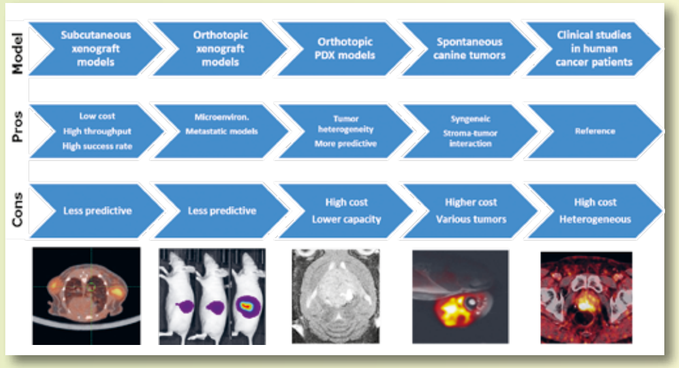
Professor Andreas Kjær

The paradigm of precision medicine, i.e. tailoring therapy to the disease characteristics of each patient, has led to a need for diagnosing at the molecular level. Traditional molecular biology methods need tissue sampling for in vitro analysis. In contrast, molecular imaging allows for non-invasive studies at the molecular level at a whole-body level in the intact organism. Compared to tissue sampling, image based techniques circumvent sampling error, i.e. the non-representativeness of a biopsy with regard to the disease due to heterogeneity. Due to the unsurpassed sensitivity of PET, the use of PET ligands for molecular imaging for precision medicines is most promising. Characteristics that can be imaged include such tissue characteristics as angiogenesis, cell proliferation and cancer aggressiveness. We expect such PET ligands for individual phenotyping and tissue characterization to become game-changing within an array of diseases, e.g. cancer and cardiovascular diseases. In addition to imaging, successful ligands may be developed into radionuclide therapies if they are labeled with alpha or beta-emitting isotopes. The imaging companion may predict the distribution of the therapeutic ligand and such imaging-therapy pairs are known as theranostics.

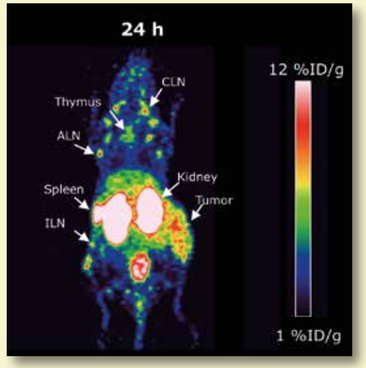
Currently, our molecular imaging and theranostics research program is aimed at development, evaluation and application of molecular imaging/therapeutic ligands. Key application areas include, but are not limited to: 1) individual therapy planning (companion diagnostics), 2) therapy monitoring and early detection of non-responders, 3) drug development, and 4) radionuclide therapy (theranostics). Disease wise our translational research is in tracer development for non-invasive tissue characterization is for the use in cancer, cardiovascular disease, infection/inflammation, metabolic disease (brown adipose tissue) and new targeted radionuclide therapies for cancer.

Development of new molecular imaging tracers for PET is a complex process that involves many steps from definition of target to final use of the tracer in patients. The major steps involved in PET tracer development and translation into patients are shown in figure 1.

Figure 1. The major steps involved in PET tracer development: after identification of an unmet clinical need, selection of the key-process involved in the pathophysiology of the disease and a relevant molecular target is identified. Thereafter, a specific ligand is developed and labeled with a suitable radionuclide for imaging (or therapy). Target validation (specificity) is then initially evaluated in vitro followed by testing in vivo in relevant animal models where also the biodistribution is studied for calculation of radiation dosimetry. From animals used in vivo, tissue is excised, which then undergo ex vivo investigations, e.g. to confirm target binding and expression. Successful, lead candidates are then rigorously tested for possible toxicity according to European guidelines and biological and radiochemical data and procedures form the basis for the Investigational Medicinal Product Dossier (IMPD), which is part of the application for human use. Following approval by the health authorities, a first-in-humans phase I clinical trial may then be initiated. If successful, phase II studies of clinical utility are then pursued. This may be followed by commercialization to reach clinical use on a broader basis. Imaging ligands may also be used as a starting point for new targeted therapies, in particular radionuclide based therapies.



▲
Figure 2. Comparison of the different in vivo models used by us in the development and testing of new PET tracers and targeted radionuclide therapies for cancer



▶
Figure 3. Specific imaging of CD8+ cells using a novel PET tracer developed by us. Note the high uptake in lymph nodes (CLN, ALN, ILN), thymus and spleen. Also high uptake in an immunogenic tumor. High activity in kidneys represents excretion (Kellerman L, Nielsen CH, et al. AACR 2018)

By establishment in 2003 of Cluster for Molecular Imaging at the Faculty of Health and Medical Sciences, University of Copenhagen, a specialized facility at the Panum Institute for molecular imaging in animals with PET, SPECT, CT, MRI and optical imaging was established. This is a key component of our translational capabilities since it allows us to test novel tracers and radionuclide therapies in animal models as basis for selection and translation into clinical use. Accordingly, we currently have a broad pipeline of PET tracers and radionuclide therapies in pre-clinical testing. We expect several of these candidates to be taken into clinical trials and become available for human use over the next years. We continuously have a strong focus on use and development of more predictive animal models for PET tracer and radionuclide therapy development. This includes use of orthotopically implanted human xenograft tumors as well as metastatic cancer models using human cancer cell lines. Increasingly, we use patient-derived tumors (PDX) for orthotopic implantation (PDOX) to even better mimic the conditions in cancer patients regarding the tumor microenvironment, which is of great importance for tumorigenesis.

Over more than a decade, we have refined our translational platform for development of new PET tracers. Regarding cancer, the platform includes early use of promising PET tracers in companion dogs with spontaneous tumors scheduled for cancer therapy. This allows for testing in "full-size" as well as evaluation of tumor-stroma interaction due to the syngeneic tumor environment. In this way, we bridge between xenograft models and first-in-human studies. This bridging is unique and has attracted international attention. The comparative advantage and pros and cons of the different cancer models are shown in figure 2.

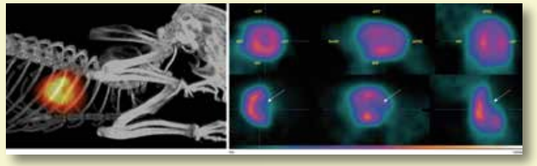


Figure 4. As the first, we succesfully applied ^{82}Rb-myocardial perfusion imaging in rats. Left: ^{82}Rb-PET/CT in a rat. Right, upper panel: baseline ^{82}Rb-imaging, lower panel: follow-up after left anterior descending artery ligation for induction of myocardial infarction. Please note the clear lateral perfusion defect seen on the PET imaging following induction of myocardial infarction. Late gadolinium enhancement MRI (not shown) confirmed the myocardial infarction to be located in the hypoperfused area. (Clemmensen A, Ghotbi A, et al. J Nucl Cardiol 2017)

Figure 5. How robot-assisted optical guided surgery using our uPAR targeting probe ICG-glu-glu-AE105 works. An orthotopically implanted human pancreatic xenograft tumor was resected using a clinical surgical robot equipped with near-infrared vision. Image to the left in white light where it can be difficult to identify the exact borders of the tumor in the pancreas model. Image to the right with near-infrared vision activated clearly lights up the uPAR positive tumor, helping the surgeon to obtain negative margins and a better outcome. (Christensen A, Juhl K, et al. Oncotarget 2017)

Recently, a breakthrough in cancer therapy has been achieved with immunotherapies that support the immune system to fight cancers. This success of immunotherapies has prompted us to establish numerous models of syngeneic cancers as well as initiate work with humanized (with regard to the immune system) animal models. Only by using such models, is it possible to study the interaction between cancer and the immune system as well as immunotherapies. The goal is to help unfolding the immense potential of immunotherapies that are currently hampered by low response rates. For this purpose, we are developing imaging ligands that can track the immune response, e.g. cytotoxic T-cells (CD8) (Figure 3).

Within the cardiovascular area, we have introduced and further developed animal models of cardiovascular diseases including models of atherosclerosis, myocardial infarction and heart failure. In this focus, we use mice, rats, minipigs and rabbits. Many of the models include complicated surgical procedures. We apply various PET tracers for the study of cardiovascular disease and were recently the first ever to successfully apply ^{82}Rb-PET for myocardial perfusion in rats (Figure 4).

With the increasing focus on radionuclide therapies, Cluster for Molecular Imaging has recently added SPECT/CT capabilities to our existing PET/MRI/MRS capabilities. SPECT/CT will in particular be used to visualize ^{177}Lu-labeled radionuclide therapy ligands to investigate biodistribution and binding to tumors. In addition, we have obtained approval for animal experiments using alpha-emitting therapy, which is more effective due to the high linear energy transfer (LET). Also, preclinical studies in the field of hyperpolarized ^{13}C-MRS and PET (hyperPET) are performed in collaboration with DTU. Finally, optical imaging has gained translational potential as it can be used intraoperatively for delineation of tumors and in particular when robotic surgery is performed (Figure 5).

Some tissue characteristics currently targeted for imaging:

- Cancer specific receptors (numerous projects, e.g. SST, HER2, Tissue Factor, EGFRvIII)
- Glycolytic activity (PET and hyperpolarized MRSI)
- Cell proliferation
- Amino acid transport
- Angiogenesis
- Hypoxia
- Apoptosis
- Necrosis
- Invasive cancer phenotype
- Atherosclerotic plaque vulnerability
- Immune-response
- Myocardial perfusion

Research

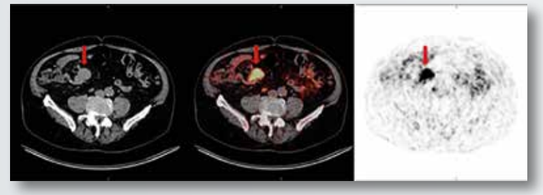


Figure showing PET imaging of angiogenesis using our new tracer ^{68}Ga-NODAGA-RGD$_2$ PET tracer in a patient with a neuroendocrine tumor (NET). Note the high uptake in the primary tumor (arrow), (Clausen MM, Skovgaard D et al. 2017). We foresee angiogenesis PET to be used for the selection of patients suitable for receiving antiangiogenesis therapies

Professor Andreas Kjær

A continuous focus on research and development is a key activity of our department. We have over the years build, and continuously strengthened, a comprehensive research program aimed at developing innovative solutions to solve unmet clinical needs. We constantly adjust our research program to be clinically relevant and timely. Our research program is build on strong in-house competencies as well as strategic collaborations with leading international and national research groups with complementary capabilities and expertise. The focus of our research program is development of new tracers for PET, PET/MRI hybrid imaging, radionuclide therapies (theranostics), clinical evaluation of new diagnostic methods, and the use of methods from clinical physiology and nuclear medicine to study pathophysiology. Translational research in molecular imaging is given special attention in order to accelerate translation of new tracers into clinical use in patients. Current major research areas, seeking to fulfill unmet patients needs, are briefly described below.

New tracers

Numerous projects aimed at development of new PET and SPECT tracers for non-invasive specific tissue characterization, phenotyping, are currently undertaken. These novel tracers will be used for diagnosing, staging, risk stratification, and therapy planning and monitoring. Tracers developed at our department, and taken first-in-humans by us, include ^{64}Cu-DOTATATE, ^{64}Cu-DOTA-AE105, ^{68}Ga-NOTA-AE105, and ^{68}Ga-NODAGA-RGD$_2$. Once taken successfully first-in-humans, we investigate in phase II clinical trials the utility of the tracers in a clinical setting to establish where they may be of particular value. Accordingly, ^{68}Ga-NOTA-AE105, which is a marker of cancer aggressiveness and metastatic potential (the invasive phenotype), is currently being tested in 7 phase II protocols in different cancer types. Likewise, ^{68}Ga-NODAGA-RGD$_2$, an angiogenesis PET tracer, has entered Phase II clinical trials.

As part of our research program, we developed a comprehensive platform for validation of new tracers, including cell laboratory, molecular biology (proteomics and genomics), histology and biomarker laboratory. We currently have several other promising new PET tracers in our developmental pipeline and expect a continuous translation of the most promising of these into clinical use over the coming years.

PET/MRI

Being one of the first departments to have a hybrid PET/MRI scanner installed, we continuously have expanded our research program on PET/MRI with focus on the added value of combining molecular imaging with PET and multiparametric MRI. A large number of clinical trials is currently undertaken for this purpose. In addition, we develop new protocols for PET/MRI. The goal is to improve tissue characterization and response monitoring ability in cancer treatment, paediatric studies, brain studies

and atherosclerotic plaque characterization. Focus of MRI includes the use of diffusion weighted images (DWI)/apparent diffusion coefficient (ADC) and magnetic resonance spectroscopy (MRS). With access to matching preclinical PET and MRI, we are capable of working translational when developing and evaluating new methods. As an example, the use of PET/MRI for radiation therapy planning and response monitoring is being evaluated both preclinically and clinically. Also, the added value of multiparametric imaging combining information from both PET and MRI is currently studied.

Hyperpolarized ^{13}C-MRSI combined with PET - hyperPET

Our department was the first to install a dynamic nuclear polarized (DNP) for hyperpolarization of ^{13}C-labeled compounds next to a PET/MRI scanner. We have used this combined set-up for development of and research in the combination of hyperpolarized ^{13}C-MRS and PET, a combination we named hyperPET. We have so far studied the use of hyperPET for tissue characterization in cancer, cardiovascular disease and inflammation/infection. Using ^{13}C-pyruvate, we have continued our studies of the Warburg effect and compared it to glucose utilization and thereby FDG uptake. As a next step, we now combine ^{13}C-pyruvate with non-FDG PET tracers as well as study non-pyruvate ^{13}C-compounds. Based on our results obtained so far, hyperPET may be superior in cancer phenotyping and response monitoring and has the potential for clinical use.

Clinical PET/CT in oncology

Numerous prospective clinical protocols are ongoing aimed at evaluation of the diagnostic and prognostic value of PET/CT using various tracers, including the ones developed in-house. The studies are performed in various types of cancer and both in children and in adults. Head-to-head comparison of new PET tracers and established imaging methods is also an area of interest. The use of PET/CT for the planning of radiation therapy ("dose-painting") and the use of respiratory gating are also currently being evaluated. Many of these studies also include PET/MRI to study the added value compared to PET/CT.

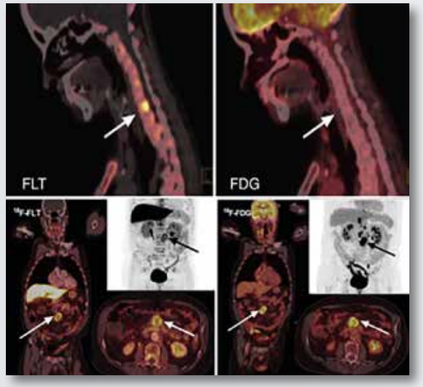


Figure showing head-to-head comparison of ^{18}F-FLT and ^{18}F-FDG in neuroendocrine tumor (NET) patients. Upper panel: Bone metastasis (arrows) from small intestinal NET seen on ^{18}F-FLT, but not on ^{18}F-FDG PET. Lower panel: Primary NET (arrows) seen on both ^{18}F-FLT and ^{18}F-FDG, but additional foci only seen on ^{18}F-FDG (from Bardram C et al. J Nucl Med 2017)

Paediatric nuclear medicine investigations

The department undertakes many paediatric investigations and is involved in an array of prospective protocols in paediatric patients. These research protocols, using of PET and SPECT, are carried out in cooperation with clinical departments, particularly within oncology and function of the hepato-biliary system. Also targeted radionuclide therapy for cancer in children is currently an area of intense interest. Finally, the use of PET/MRI in children to save radiation dose is also being investigated.

Neuro PET

Studies on brain tumors are currently undertaken using PET/MR, PET/CT and HRRT PET. Brain tumors are in particular studied with the amino acid tracer FET but also with several of our novel in-house developed tracers, e.g. uPAR-targeting ligands. Studies of brain perfusion using PET or DCE-CT are also performed. In addition, attention is given to imaging of dementia using various new tracers. In cooperation with Neurobiology Research Unit and Centre for Integrated Molecular Brain Imaging, neuroreceptor ligands have been developed and used for research in neurobiology. The focus has mainly been on the serotonergic system.

Functional MR

With focus on the brain, studies of functional MR are undertaken in close collaboration with clinical departments including neurology and psychiatry. A particular area of interest is development of new methods and clinical application of new functional and molecular MR methods. Methods are aimed at obtaining information on tissue physiology, organ perfusion, and molecular biology.

Atherosclerosis

With the ability to non-invasively visualize atherosclerosis and predict vulnerability of atherosclerotic plaques using PET/MRI and PET/CT, several translational and clinical studies are performed. In particular, the quantification of low-grade vascular inflammation, seen as part of the atherosclerotic process, has been in focus. These methods are currently used for evaluation of effects of pharmacological therapies, e.g. GLP-1 analogues. In addition, patient groups at risk are studied and special focus is on the value of new specific PET tracers, e.g. for the study of macrophage activation. The ambition is to develop an image-based

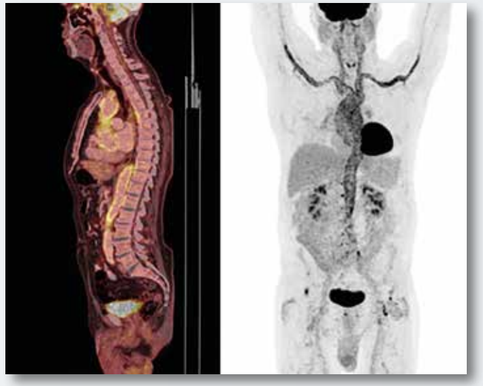


Figure showing a case from a randomized prospective study of 200 patients referred with serious nonspecific symptoms or signs of cancer. The study showed that ^{18}F-FDG PET/CT should be considered first-line imaging rather than CT only. The case shown was a 77 year old male where PET/CT as initial imaging modality showed increased ^{18}F-FDG in vessel walls and the patient was diagnosed with large vessel vasculitis with subsequent good response to prednisolone (from Lebech AM, et al. J Nucl Med 2017)

algorithm for identification of patients at risk that will benefit from surgery. We were the first to publish data showing advantage of PET/MRI over PET/CT for carotid artery imaging and we continue to refine and develop vascular imaging using PET/MRI with novel PET tracers.

Nuclear cardiology

Taking advantage of our ability to measure absolute myocardial perfusion and myocardial flow reserve by ^{82}Rb PET, we study the regulation of these parameters in various cardiovascular diseases and the predictive value of the measures, e.g. final infarct size. Also the influence of interventions including stem cell therapy, gene therapy and pharmacological treatment is studied using ^{82}Rb PET. With the use of ^{123}I-MIBG, the cardiac sympathetic innervation and activity may be measured. With the use of SPECT/CT or PET/CT, the development of ischaemic heart diseases is studied in selected groups of patients, e.g. HIV, CMV infected and hepatitis patients. On basis of this, screening algorithms for detection of ischaemic heart disease are evaluated. Some of the studies are combined with PET tracers characterizing other aspects of the myocardium, e.g. its viability and regeneration.

Lung studies

A large number of studies using lung function testing and lung scintigraphy in different patient groups, e.g. lung transplantation and endobronchial stenting for emphysema, are performed. Accordingly, we recently demonstrated the value of combined use of SPECT/CT for diagnosing pulmonary embolism. The value of biomarkers in combination with imaging is also studied. In addition, evaluation of the different ventilation tracers for assessment of ventilation inhomogeneity, is undertaken. Research is also being conducted into mucociliary clearance, a method pioneered at the department, of the nose and lungs. Finally, the department is participating in a large study colleting data for a lung function test reference database.

Studies of muscle function

With the use of methods from clinical physiology and nuclear medicine as well as molecular analyses, muscle function, bone density, and body composition are studied. The current focus is on the effect of exercise, immobilization and ageing. In addition, data are collected on the same parameters from a population-based study. These data will serve as a reference database and elucidate markers to predict aging-related diseases.

Inflammation, infection and rejection

Presently, several studies with focus on non-invasive imaging of inflammation and infection are undertaken at the department. Also studies on the best way to visualize and evaluate rejection reactions are performed. In some studies, the added value of MR-derived parameters of PET/MR is studied. Our department is a partner in the PERSIMUNE program, personalized medicine of infection complications in immune deficiency. Currently, special attention is given to development of new PET ligands for specific imaging of the immune response, e.g. CD8 imaging. These tracers will also be applicable within immune oncology, where they can serve to better understanding of the mechanisms behind immune response during tumorigenesis and as a tool to select patients eligible for specific immunotherapies.

Radionuclide therapy and theranostics

Increased attention is given to development and use of targeted radionuclide therapy using both beta- or alpha-emitting specific ligands targeting relevant cancer characteristics. The department takes part in research within this area by testing new ligands and producing relevant therapeutic isotopes. In particular, we in-house develop new theranostics based on promising imaging ligands, which are then labeled with beta or alpha emitting radionuclides. Cancers that are currently being targeted clinically include neuroendocrine tumors, prostate cancer, and ovarian cancer. Treatment with radionuclides will in part be based on imaging using new tracers for molecular profiling or the same ligand as the therapy (theranostics) for better outcome and fewer side effects. The concept of a tracer that visualizes the target prior to starting therapy is also known as companion diagnostics.

Image guided surgery

Optical imaging ligands are increasingly used for guiding cancer surgery. Together with clinical departments, we develop our most promising PET ligands targeting cancer specific targets into near-infrared optical probes. These probes will be used for intraoperative delineation of cancer to ensure negative margins while leaving normal tissue intact. This will potentially lead to better patient outcome, including survival and quality of life. The technology will be used in pair with preoperative PET imaging of the same target. Optical imaging will be particularly promising in concert with the use of surgical robots that come with build-in optical capabilities.

Whole body counting

In a series of collaborative studies, we apply whole body counting for precise measurements of body composition. Moreover, studies on the absorption of certain minerals from the gastrointestinal tract are undertaken.

Collaboration with Landssygehuset, Faroe Islands

Professor Jann Mortensen and Chief Physicist Thomas Levin Klausen

The Faroe Islands population of 50,000 is served by 2 smaller hospitals in Klaksvík and Tvøroyri and the larger National Hospital of the Faroe Islands, Landssjúkrahúsið in Tórshavn. The 3 hospitals have recently been merged into one hospital system with joint leadership.

The national hospital has a staff of 850 and 180 beds. The 8,000 in-patients and 60,000 out-patients annually are taken care of by 29 specialities, of which 9 are via consultant collaborations, including collaboration in clinical physiology and nuclear medicine with our department at Rigshospitalet.

The responsible physician and phycisist for Nuclear Medicine in Tórshavn is Professor , Consultant, Jann Mortensen and Chief Physicist Thomas Levin Klausen.

Second opinion on scintigraphies and lung function measurements is provided via a direct telemedicine connection.

In 2017 the Department of Clinical Physiology and Nuclear Medicine in Tórshavn performed nearly 500 scintigraphies of lungs, bones, thyroid, kidneys and renographies on the department´s 2-headed Sky-light camera. Around 500 lung function tests were performed with the Jaeger whole body plethysmo-graph and nearly 650 routine and research DXA studies were performed with The Norland DXA 840 scanner. This equals a 40 % increase in the annual numbers of studies compared to 2016.

Neurobiology Research Unit

We appreciate the excellent collaboration with Professor Gitte Moos Knudsen, Head of the Neurobiology Research Unit (NRU) at Rigshospitalet, University of Copenhagen and also Director of the Lundbeck Foundation's Center for Integrated Molecular Brain Imaging (CIMBI) and Innovation Fund Denmark Center for Experimental Medicine NeuroPharmacology (NeuroPharm). The research focus of NRU is neurobiology, physiology and pathophysiology, molecular imaging and neuroreceptor ligands with focus on the serotonergic system.

nru.dk | cimbi.dk | neuropharm.eu

MSc in Medicine and Technology

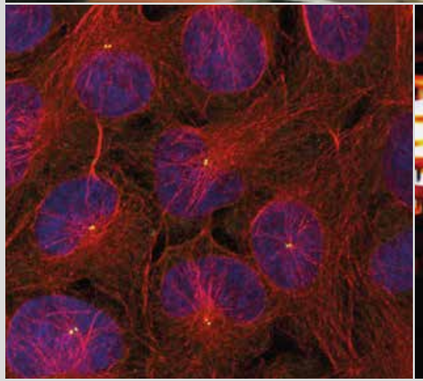
UNIVERSITY OF COPENHAGEN

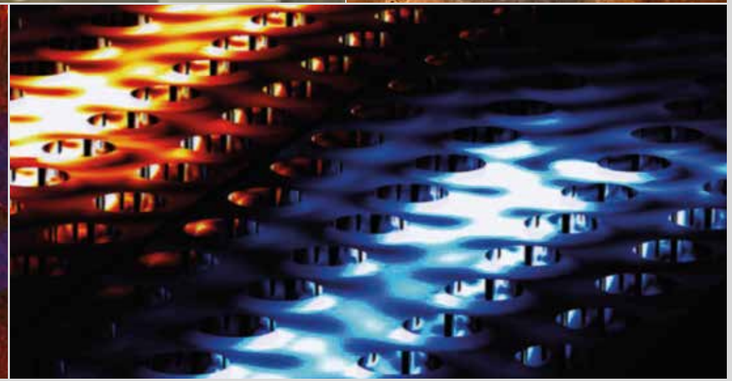
DTU

In cooperation with the Technical University of Denmark (DTU) and the University of Copenhagen (KU), the department represented by Professor Liselotte Højgaard is involved in the MSc program in Medicine and Technology. It is a five year bioengineering degree at bachelor and master level. The first masters graduated in 2008. You can read more about the program at www.medicin-ing.dk.

At present several of these bioengineers are seconded to the department as PhD students, and we have numerous students working with bachelor and master reports in collaboration with DTU.

Photos: DTU Elektro





Danish National Research Foundation

Danmarks Grundforskningsfond
Danish National Research Foundation

Professor Liselotte Højgaard
Chairman of the Board of the Danish National Research Foundation

The Danish National Research Foundation (DNRF) is an independent organisation established by the Danish Parliament in 1991 with the objective to promote and stimulate basic research at the highest international level at the frontiers of all scientific fields. The foundation could celebrate the first successful 25 years November 2016. The Center of Excellence (CoE) program is the main funding mechanism together with the Niels Bohr professorships. Since 1991 the Foundation has commited itself to support Danish Research with more than 6 billion DKK (= 800 mio €).

The Center of Excellence is the primary funding mechanism and the foundation's flagship. A center grant is large and flexible, and a center may have a lifetime up to 10 years. Only top researchers with the most ambitious ideas will be awarded a CoE through fierce competition involving a two-staging application process. The objective of the CoE program is to strengthen Danish research by providing the best possible working conditions and organisational setup for selected top researchers. Centers may be established within or across all fields of research. A total of 110 Centers of Excellence have been established so far.

In 2013 DNRF was evaluated by an international panel leader by Dr Wilhelm Krull, Secretary General of Die Volkswagen Stiftung. The outcome was very positive and showed that the DNRF's Centers of Excellence are on level with the very best researchers in the world. The outcome was very positive, and a continuation of DNRF was recommended to the Danish Parliament and Government. The Danish Parliament gave the foundation 3 bio DKK on the State Budget for 2015 to secure the foundation to 2036.

Professor Liselotte Højgaard is chairman of the Board of the Danish National Research Foundation.

The board members at the end of 2017: Professor Liselotte Højgaard, Professor Eero Vuorio, Professor, Dr. Bart De Moor, Professor Christina Moberg, Professor Morten Overgaard Ravn, Professor Minik Rosing, Professor Jesper Ryberg and Professor Anne Scott Sørensen.

Professor Søren-Peter Olesen is director of DNRF and Steen Marcus is vice director. A warm thank you to all staff members and directors for an excellent collaboration.

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