

# SVENSK FÖRENING FÖR NUKLEARMEDICIN

SWEDISH SOCIETY OF NUCLEAR MEDICINE

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## The Beginnings of Nuclear Medicine in Sweden (when; how)

In Sweden nuclear medicine started in the beginning of the 1940's, when Erik Lindgren treated 5 patients with leukaemia and one with polycytemia vera using  $^{24}\text{Na}$  and  $^{32}\text{P}$ . The radionuclides were produced by Professor Manne Siegbahn using the cyclotron in the Research Institute for Experimental Physics.

Already during WWII professor Jan Waldenström visited USA and professor Robley D Evans and got an introduction to tracer techniques. Later his colleague Bengt Skanse was sent to Boston and started research with radioactive iodine. His thesis "Radioactive iodine in the diagnosis of thyroid disease" was published 1949. Bengt Skanse is the pioneer of nuclear medicine diagnosis in Sweden. During the 1950's isotope laboratories were started in Malmö, Stockholm, Göteborg, Lund and Umeå and the use of scintigraphs was introduced, both for thyroid scanning and whole body scanning.

## National Milestones of Nuclear Medicine (people; equipment; events; first studies)

1944 Erik Lindgren: Versuche mit Radioaktiven Isotopen bei Leukämibehandlung. Acta Radiol. 25, 614

1949 Bengt Skanse: Radioactive iodine in the diagnosis of thyroid disease.. Acta Med Scand Suppl. 235

1951 Licence issued for use of radionuclides at Malmö General Hospital

1953 Sven Johansson & Bengt Skanse A photographic method of determining the distribution of radioactive material in vivo. Acta Radiol. 39, 317.

1954 A scintigraph for thyroid imaging was constructed by Agnar Egmark

1956 A whole body scanner was constructed by Lars Jonsson and Inger Ragnhult

1961 Erik Berne and Sven-Erik Lindell presented a method for gated acquisition of a first-pass study.

1961 National regulations on the use of radioactive isotopes were issued.

1963 Production of radioisotopes was started at the research reactor in Studsvik

1967 First gamma camera in Sweden was installed in Lund,

1969 Swedish Society of Nuclear Medicine was founded.

1977 A commercial SPECT system was developed by Stig A. Larsson and Anders Israelsson in cooperation with Nuclear Diagnostics.

1979 A method of whole body scanning with moving table and dual head camera was introduced by K-J. Vikterlöf

1980 Recommendations on quality control of gamma cameras were issued by Swedish Society for Radiation Physics.

1981 First PET-camera produced and installed in Uppsala

1982 National regulations on the use of radiopharmaceuticals were issued.

1996 Medical specialisation in nuclear medicine was introduced.

2003 A national PET-group was started for promoting PET and PET/CT in the country

2004 First PET/CT investigation was performed in Uppsala (Imanet)

2006 A new medical speciality: 'Image and functional medicine', where nuclear medicine is sub-speciality, was introduced,

## **The Establishment of the Swedish Society of Nuclear Medicine**

The rapid introduction and development of nuclear medicine in Swedish hospitals during 1960's created a need for education and a national forum for presenting and discussing scientific matters as well as promoting nuclear medicine. National meetings were started in 1963 and the Swedish Society of Nuclear Medicine was finally founded in Nov 28 1969. The members of the board represented different specialities with interests in nuclear medicine and this is still the case. The society became a section of the Swedish Medical Society in 1970. In 2001 Swedish Society of Nuclear Medicine and Swedish Nuclear Medicine Union were joined. The present chairman of the society is Peter Gjertsson and the number of members is about 320 persons and 8 companies.

## **The Development of Nuclear Medicine in Sweden**

### *Radiopharmaceuticals*

The company AB Atomenergi had two research reactors and started to produce radionuclides for medical use in January 1963. Due to the limited number of radionuclides produced and to the increased use of radionuclides produced in cyclotrons the production ended in 1982. Since then all radiopharmaceuticals except for those used in PET, are imported from abroad.

### *Imaging equipment*

In the late 1950's the Swedish company NUKAB made a rectilinear scanner which was sold all over the world. Inger Ragnhult and Lars Jonsson constructed the first whole-body scintigraph in 1956. The equipment was then further developed by the company LKB. These types of imaging devices were the standard instrumentation in Swedish hospitals until the introduction of the gammacamera.

The physicists Agne Larsson and John Svedberg made significant contributions in collimator design and pulse arithmetic in the further development of the Anger-camera .

As mentioned above, Stig A. Larsson and Anders Israelsson in cooperation with the company Nuclear Diagnostics (now Hermes Medical) made the first commercial SPECT system, which was further developed and sold by General Electric as 400T.

The Swedish company Scanditronix successfully developed a PET-camera during 1980's. The company's PET-business was acquired by GE in 1996.

The use of computer in nuclear medicine was early introduced in Sweden. Already in 1960 the physicist Erik Berne gave a talk on the use of computer analysis in nuclear medicine. He later designed a computer system for use both with scanners and gammacameras, The software was based on a PDP-computer which later became the Gamma11-system, which in the 1980's was further developed by Hermes Medical. This company is still one of the leading companies in nuclear medicine application software.

### *Nuclear medicine methods*

As mentioned above, the first radionuclide therapies in Sweden were performed in early 1940's. Iodine therapies were introduced in late 1940's and scientific work to improve the method was done in Stockholm and Malmö. It is still the most common radionuclide therapy method in Sweden.

Arvid Carlsson (Nobel Prize 2000) and his students Bertil Lindquist and Göran Bauer made pioneering work in bone metabolism using  $^{45}\text{Ca}$ . Arvid Carlsson's thesis in this area was published 1951. Göran Bauer and B Wendeberg used  $^{85}\text{Sr}$  already in 1959 in their studies of bone destruction. Inge Gynning, Per Langeland and Sture Lindberg continued with  $^{85}\text{Sr}$  and external measurements on patients with bone metastases from breast cancer. With the introduction of  $^{99\text{m}}\text{Tc}$  and diphosphonates in the 1970's, bone scintigraphy became the most frequent nuclear medicine examination in Sweden.

The first bone marrow scintigraphy in the world with colloidal  $^{198}\text{Au}$  was done at Radiumhemmet in Stockholm by Lars-Gunnar Larsson and co-workers (1956). Also the lymph drainage from the breast to axillary and parasternal lymph nodes was studied.  $^{198}\text{Au}$  was replaced by  $^{99\text{m}}\text{Tc}$  colloid, which was extensively studied in early 1980's by S-E Strand and co-workers in Lund. The use of colloids is now very frequent in the sentinel node technique applied to patients with breast cancer and malignant melanoma.

Kidney function using  $^{131}\text{I}$  ortho-iodohippurate was studied by Gösta Magnusson in Stockholm in his thesis 1962. Bertil Nosslin in Malmö made theoretical calculations of clearance estimations with single injection technique and without urine collection. This method was further developed in Denmark using  $^{51}\text{Cr}$ -EDTA and is still in quite frequent use. Today more than 90% of kidney function studies are performed with  $^{99\text{m}}\text{Tc}$ -MAG3.

Research on the diagnosis of pulmonary embolism with perfusion and ventilation scintigraphy using  $^{99\text{m}}\text{Tc}$ - macroaggregated serum albumin and aerosols of carbon particles has been performed by several people in Sweden; Alf Holmgren in Stockholm, Sven Erik Lindell, Måns Arborelius and Per Wollmer in Malmö. Marika Bajc and co-workers in Lund has now introduced V/P SPECT as a method for diagnosis of pulmonary embolism and also written a guideline for the method in EANM.

David Ingvar in Lund together with his Danish colleague Nils Lassen developed a method to measure the regional cerebral bloodflow using radioactive noble gases. The method has long been used as a gold standard but is now replaced by PET-methods.

Examinations of the heart have a long tradition in Sweden. It started with first-pass studies. Erik Berne and Sven-Erik Lindell in Malmö used ECG to trig the collection of data already in 1961. Software for analysis of gated equilibrium studies were developed in Stockholm and Uddevalla. Early studies of myocardial bloodflow were performed in Lund using  $^{86}\text{Rb}$  and  $^{131}\text{Cs}$  (Håkan Westling and Sven-Eric Svensson). After the introduction of  $^{201}\text{Tl}$  which made the break-through of the method, and after the introduction of  $^{99\text{m}}\text{Tc}$ - substances myocardial scintigraphy is together with bone scintigraphy the most common nuclear medicine examination in Sweden.

### **Nuclear Medicine in Sweden Today**

Nuclear medicine is practised in 34 hospitals in Sweden. In the beginning of 2009 there were 126 registered specialists including 33 women. About 80 full time medical physicists are working in the field, together with radiopharmacists and technologists. There are close to 100 gamma cameras in Sweden and about 140 work stations. PET/CT equipment are installed in Uppsala with two systems, Stockholm, Linköping, Lund, Malmö, Göteborg, Örebro and Umeå. Cyclotrons for isotope production are found in Uppsala, Stockholm, Lund and Umeå.

In 2008 about 84000 examinations using  $^{99m}\text{Tc}$  were performed together with about 7000 PET examinations using  $^{15}\text{O}$ ,  $^{11}\text{C}$  and  $^{18}\text{F}$ . In 2009 more than 2800 therapies were done. About 65% was treatment of benign thyroid diseases. Other therapies are performed with  $^{153}\text{Sm}$ ,  $^{32}\text{P}$ , and  $^{90}\text{Y}$ , and nearly 300 with  $^{177}\text{Lu}$ -octreotate for treatment of neuroendocrine tumors. In total, about 106000 nuclear medicine examinations and radionuclide therapies are performed in Sweden today giving a frequency of 11.8 per 1000 people.

National courses in nuclear medicine are regularly arranged by different departments in cooperation with the national society. Together with EANM courses and congresses these gives continuous education and training for the different personal categories.

### **The Future for Nuclear Medicine in Sweden**

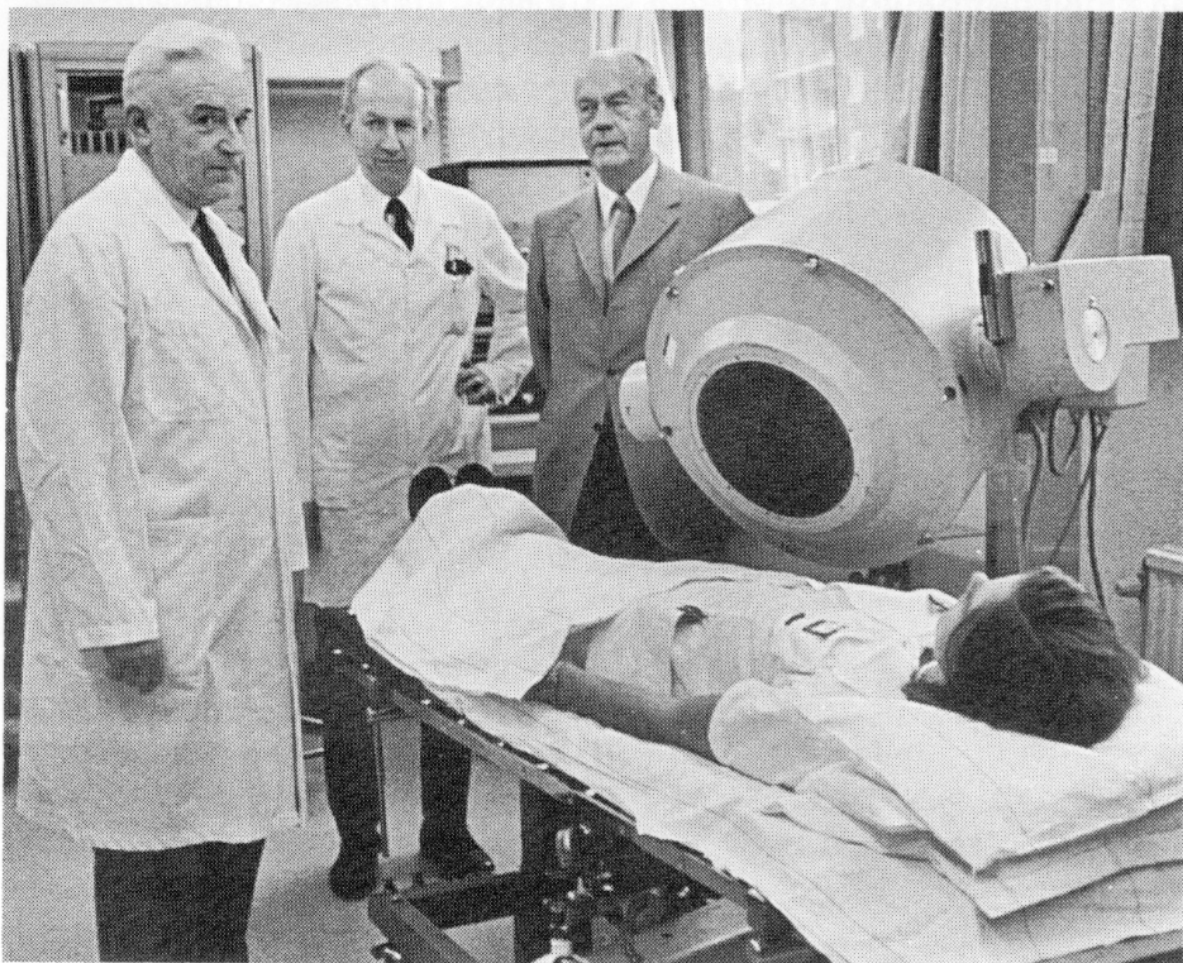
Based on a long tradition nuclear medicine is now a well established diagnostic and therapeutic tool in Swedish health care. The standard of the equipment is up-to-date and a programme for continuing replacement is working. For instance, conventional gamma cameras are now replaced by SPECT/CT:s. The growing demand of PET/CT is challenging in a country with large distances and a fairly low population density, especially regarding production and distribution of the short-lived radiopharmaceuticals and still keeping the economy under control. The research activities in the country are fairly intensive and is of high standard. Together with well educated personnel, this will secure the future of the speciality.

*Sven-Åke Starck & Sten Carlsson*

Courtesy of Swedish Society for Radiation Physics (image archive)



The first scintillation camera with collimator developed by Sven Johansson and Bengt Skanse. A photographic film was placed directly on the sodium-iodide crystal.



The first scintillation camera in the Nordic countries. From left, Martin Lindgren, Kurt Lidén and representative from John and Augusta Persson foundation.