

Nuclear Medicine in Norway

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The Start

In 1947 Odvar E. Skaug got a fellowship for studies in Sweden, where at that time they had some radionuclide production. Radionuclides were made accessible to Norway, and in 1950 the first reports on the use of ^{131}I and ^{32}P in biochemical research, radioprotection and clinical medicine were presented:

OE Skaug: Some remarks on Geiger Müller equipment for biological Works. Scand J Clin Lab Invest 1950:2(2).173-5.

L Eldjarn: The metabolism of tetraethyl thiuram disulphide (Antabus, aversan) in the rat, investigated by radioactive sulphur. Scand J Clin Lab. Invest 1950 2 (3), 198 – 201).

R Bull Engelstad: Radioactive iodine for diagnostic purposes. Report of two cases. J Norw Med Ass 1950, 7.

In the course of the 1950's nuclear medicine laboratories were started in 6 hospitals in Norway. Odvar E. Skaug started 1950 at Psychiatric Clinic in Oslo, Lorentz Eldjarn in 1951 at The Norwegian Radium Hospital and in 1959 at Rikshospitalet, Herbert Palmer and Søren Chr. Sommerfelt in 1952 at Drammen Hospital, all these were medical chemists, Kåre Myhre (radiotherapist) in 1954 at Oslo Hospital Ullevål and Olav Holta (radiologist) in 1956 at Gjøvik Hospital. Through all years nuclear medicine in Norway has mainly been linked to medical chemistry. During the last decade most Nuclear Medicine Departments have been organized in Imaging Departments.

Milestones

1950. The first publications on the use of radionuclides (see above).

1952. Radionuclide production started at Institute of atomic energy (IAT), Kjeller, Norway

1958. First rectilinear scanner installed.

1966. The first $^{99\text{m}}\text{Tc}$ generator was produced at IAT

1967. Start of Nuclear Medicine at Haukeland University Hospital, Bergen

1969. First gamma camera installed.

1972. Norwegian Society of Nuclear Medicine was founded.

1974. Start of Nuclear Medicine at Tromsø University Hospital.

1974 Rikshospitalet purchased a cerebrograph for measuring regional cerebral blood flow.

1976. Medical physicist Arne Skretting developed a data program for performing SPECT on a manually moved single head gamma camera.

1978. First SPECT camera installed at Rikshospitalet.

1979. First annual Seminar in nuclear medicine and radioprotection.

1983 First nationwide quality control of nuclear medicine equipment for in vivo studies.

1984. Rikshospitalet purchased an advanced SPECT camera specially designed for examination of the head.

1987. First mobile camera installed.

1993. Kjell Rootwelt appointed to the first professorship in Nuclear Medicine

1995. Kjell Rootwelt presented the first Norwegian textbook in nuclear medicine.

1995. First dual head camera with rectangular heads installed.

1997. Nuclear medicine accepted by the health authorities as a separate medical speciality.

1998. First coincidence camera installed.

1999. First production of ^{18}F -FDG.

- 2005. First PET/CT scanner installed.
- 2006. Second PET/CT scanner installed.
- 2007. Professorship in Nuclear Medicine at the University of Bergen.
- 2008. Third PET/CT scanner installed (in Bergen).
- 2010. Fourth and fifth PET/CT scanner installed. Mobile PET cooperation in Tromsø.

The development of nuclear medicine in Norway

Radiopharmaceuticals

In 1951 the first nuclear reactor outside the superpowers was installed at *Institute of Atomic Energy* (IAE), Kjeller (since 1980 *Institute of Energy Technology* (IET)). The first radionuclides (^{24}Na , ^{32}P and ^{131}I) were produced in 1952. In the following years the number of different radionuclides and the amounts have increased rapidly. In 1957 the first pharmacist was employed. In 1963 they could deliver 28 different radionuclides in more than 50 different radioactive compounds. From 1965 iodine labeled compounds became a specialty, with 8 different ^{125}I -labeled and 21 different ^{131}I -labeled compounds.

$^{99\text{m}}\text{Tc}$ generators have been produced at Kjeller since 1966, and many $^{99\text{m}}\text{Tc}$ -labeling kits have been developed. IAE (later IET) has produced the greater part of the radionuclides used for medical purposes in Norway and a considerable part for other nordic countries.

In 1999 IET started production of ^{18}F -FDG with ^{18}F produced at a research cyclotron at the Institute of Physics, University of Oslo. This was used for performing gamma camera coincidence PET studies.

In 2005 a PET center including a new cyclotron was founded at Rikshospitalet where GE-Health is responsible for the ^{18}F -FDG production.

Imaging equipment

Handheld Geiger-Müller counters were for a few years used for measuring radioactivity, both for quantitation and for "manual" imaging. Odvar E. Skaug built his own Geiger-Müller counter in 1949 and a small series of these were sold in Sweden.

Scintillation detectors with higher sensitivity and resolution were introduced later and were used for different types of *in vivo* studies, mostly thyroid studies. A two-detector system was mainly used for renography.

The first scanner was obtained at Rikshospitalet in 1962 and the first gamma camera in 1970.

The introduction of nuclear imaging equipment from the late 1960's (rectilinear scanners, gammacameras) started a quite rapid development of nuclear Medicine in Norway

From 1980 there is 25 nuclear medicine departments, and in course of the 1970's all had got gamma cameras. In the course of the 1990's most nuclear medicine departments got dual head SPECT cameras.

In the early 1990's the work started for getting PET-scanners to Norway. The Norwegian health authorities have been reluctant to this technology and several proposals were turned down. The Norwegian Radium Hospital got a gamma camera for coincidence PET studies in 1999 and Rikshospitalet in 2000. After some years with successful activity with these and with private funding and additional money from Oslo University a PET center was started with a cyclotron at Rikshospitalet and a PET/CT scanner at the Norwegian Radium Hospital (2005) and at Rikshospitalet (2006). PET/CT scanners were installed at Haukeland Hospital in Bergen in 2008, and in 2010 at Ullevål Hospital, Oslo and by a private company (Aleris). Tromsø Hospital uses a commercial mobile PET with ^{18}F -FDG delivery from Finland.

Nuclear medicine examinations

From the start *in vitro* analyses were part of nuclear medicine, later these analyses were transferred to clinical chemistry.

The first years thyroid studies with ^{131}I (iodine uptake measurements and scintigraphic demonstration of the thyroid gland performed by handheld Geiger-Müller counters) were the dominating examinations. Static scintillation detectors took over, and later the rectilinear scanners were used for thyroid-, brain- and liver scintigraphy. Liver- and brain scintigraphy was later replaced by ultrasound and CT, respectively.

Brain studies (cerebral blood flow and scintigraphy of the basal ganglia) is performed in many nuclear medicine departments.

Kidney function studies and renography have been important through all the years, first with ^{131}I -ortho-iodohippurate, later with $^{99\text{m}}\text{Tc}$ -EDTA and now more often with $^{99\text{m}}\text{Tc}$ -MAG3.

$^{99\text{m}}\text{Tc}$ -DMSA for studies of renal cortical processes (e.g. scars, pyelonephritis, horseshoe kidneys and multiple kidneys) is also in general use.

Since the 1970's bone scintigraphy has been the most frequent nuclear medicine examination, this investigation is useful for detection of bone metastases, especially from breast and prostatic cancer, but also for bone inflammations, bone infections, bone injuries, prosthesis complications.

Myocardial scintigraphy started in the late 1970's with ^{201}Tl and later $^{99\text{m}}\text{Tc}$ -labelled hexamibi or tetrofosmine. This is still one of the most frequent nuclear medicine examinations.

Radionuclide ventriculography is in part competing with echo cardiography, this examination therefore is not accessible at all nuclear medicine units. In many cancer chemotherapy programs radionuclide ventriculography is the method of choice for monitoring heart function.

Pulmonary embolism diagnosis with perfusion and ventilation scintigraphy is done in all nuclear medicine units. The last few years multislice CT scanners have taken over this diagnostic several places.

Since the introduction of $^{99\text{m}}\text{Tc}$ -labeled compounds for parathyroid imaging this became a popular procedure and lead to increased frequency of surgical removal of hyperfunctioning parathyroid adenomas.

Sentinel node scintigraphy was introduced just before the millennium end. Sentinel node scintigraphy is now done in all hospitals where breast cancer is operated. At the Norwegian Radium Hospital the method is also used in patients with colorectal cancer and with cancer in penis and vulva.

Radionuclide therapy

Radionuclide therapy has been an important part of nuclear medicine, especially at The Norwegian Radium Hospital, which is a cancer center.

^{131}I has been used for treating hyperthyroidism and thyroid cancer since 1950. ^{131}I treatment of hyperthyroidism is still the most frequently used radionuclide therapy.

In the 1950's intravenous injections of ^{32}P -phosphate was used for treating polycythemia vera. This treatment is still in use. ^{198}Au -colloid was used for treating peritoneal metastases from ovarian cancer also since 1950's. Towards the end of the 1970's this colloid was replaced by

^{32}P -colloid, and about 1990 chemotherapy took over because this gave the same survival with less side effects.

In the 1980's ^{89}Sr was widely used for treating bone metastases. This has later partly been replaced by ^{153}Sm , and for the time being promising studies on the effect of ^{223}Ra are going on.

Since 1990 ^{131}I -MIBG has been used for treating neuroendocrine tumors. The use of radiolabeled somatostatin analogs has not become a routine procedure in Norway yet. A few patients have been treated in Sweden and in Denmark.

^{90}Y -Zevalin has been taken into use for treatment of recurrent lymphoma. This shows good results.

Nuclear Medicine organizations in Norway

1972 The Society of Nuclear Medicine (NSNM) was founded with Kjell Rootwelt as the first chairman. Since 1979 the society has arranged annual week-end meetings (Seminars in nuclear medicine and radiation protection) for education and for scientific presentations for all types of personnel working in Nuclear Medicine. These meetings have had a great impact on the nuclear medicine milieu in Norway and have been met with interest also in the other Nordic countries. Since 1992 the meetings have been associated with the Congress of the Scandinavian Society of Clinical Physiology and Nuclear Medicine every 3rd year.

In 1997 Nuclear Medicine became a medical speciality. The same year The Nuclear Medicine Speciality Committee was appointed and the year after The Norwegian Association of Nuclear Medicine was founded. These two organizations are both headed by the Norwegian Medical Association.

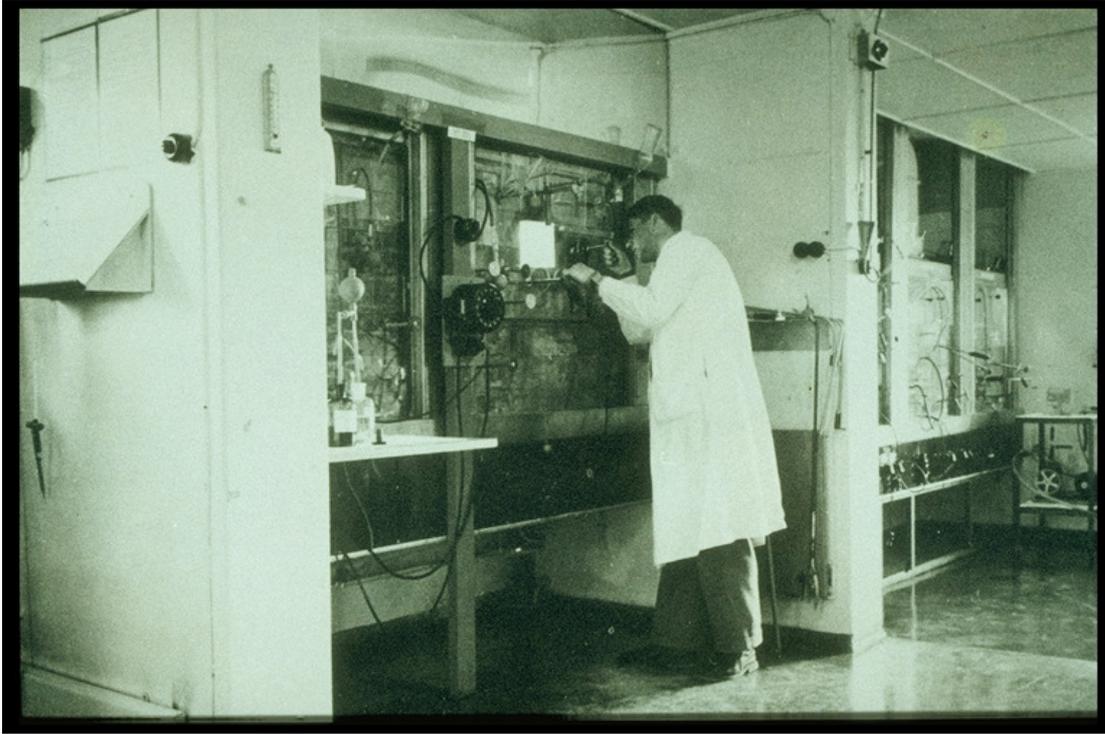
The total number of specialists in Nuclear Medicine approved by march 2011 is 88, some 60 in active work in Norway today.

The Future for Nuclear Medicine in Norway

With the addition of PET and PET/CT the future of nuclear medicine is very promising. The number of PET- and PET/CT-investigations is expected to increase, and this technology will be an important part of nuclear medicine in the future. At the same time we must further develop and keep a high quality on traditional nuclear medicine in all the departments.

The late introduction of PET and PET/CT in Norway has been an obstacle to the development of nuclear medicine in Norway. The number of Norwegian nuclear medicine specialists who have achieved qualification for work with PET and PET/CT is quite low. We must work actively to increase the number of positions for specialization.

The research in Nuclear Medicine is more active than earlier, but still lags behind the other Nordic countries.



Hotlab production of radiopharmaceuticals 1953. The producer is protected against radiation from the preparation by the help of a lead wall 10 cm thick.



Odvar E. Skaug working in his laboratory early in the 50's