

Chapter 21

History of the Swedish Society of Neuroradiology and Swedish Neuroradiology 1990–2024



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Neuroradiology in Sweden during 1990–2024, and thus the national society’s agenda, is marked by the main methods developed and used in modern diagnostics and intervention: CT, MRI, and angiography. However, the history of the speciality and the society is based on technical developments of a far more historic character. Thus, a brief retrospection is needed to set the stage for the events that followed.

The formation of the Swedish Society of Neuroradiology (SSNR) in 1971 was preceded by many decades where Swedish neuroradiology was characterized by a pioneering spirit that already struck a chord far beyond the country’s borders. Only 1 year after the discovery of X-rays in 1895, Thor Stenbeck used the technique to localize a bullet in the brain of a patient, who later was successfully operated on [1]. In the 1930–1940s, the Serafimer Hospital in Stockholm became a research and teaching centre for neuroradiology well known far outside Sweden. Also referred to as the “Stockholm School of Neuroradiology,” Stockholm was visited by many international guest researchers and colleagues. The same applied to other academic institutions in Sweden, where former colleagues from Stockholm established their centres: Ingmar Wickbom moved to Gothenburg, and Sten Cronquist to Lund [2, 3].

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Refinements in the use of X-rays in neuroradiology were not least achieved by Erik L.R. Lysholm, who showed technical aptitude and was a driving force in the technological development of radiology and neuroradiology—e.g. “the Lysholm grid” and “the Lysholm skull table” [4, 5]. Angiography also quickly found its place in Swedish neuroradiology. The Sven-Ivar Seldinger technique [6] and Torsten Almén’s work with non-ionic contrast agents [7] are two Swedish pioneering achievements that were especially important for the breakthrough of angiography and interventional neuroradiology.

Computed Tomography was introduced in Sweden in 1973, the first CT scanner in mainland Europe and the third in the world outside of the United Kingdom [2] was placed at the Karolinska Hospital in Stockholm, only 2 years after the first patient was examined with the technique. Notably, this gave rise to the first publications on CT cisternography, CT angiography, dynamic CT, and stereotactic CT. This pioneering installation sparked national collaborations on CT techniques and was soon followed by installations at other major academic hospitals in Sweden. Magnetic resonance imaging began its victory streak in Swedish neuroradiology during the early 1980s, with in-house manufactured installations, early clinical systems, and a paper in Swedish on “Medical applications of nuclear spin resonance—NMR” published in 1982 [8].

The Swedish Society of Neuroradiology, SSNR (Svensk Förening för Neuroradiologi, SFNR)

The idea to form a Swedish Society of Neuroradiology (SSNR) was born in 1969 when the European Society was formed. SSNR was established in 1971, one year prior to the formation of the Nordic Society of Neuroradiology, with Erik Lindgren as president, Torgny Greitz as vice-president, and Bengt Liliequist as secretary.

SSNR has always focused on the scientific development of neuroradiology as a speciality, and on education for members and health professionals working within or close to neuroradiology. To support educational and scientific goals of the society, SSNR has promoted appointments of professorships within the field. Currently, six of the seven Universities with medical faculties have, or have had, appointed professorships in neuroradiology. Current active full professors in neuroradiology and/or interventional neuroradiology are Johan Wikström, Uppsala, Staffan Holmin, Stockholm, Pia Maly Sundgren, Lund, and Isabella Björkman-Burtscher, Gothenburg. Presidents of SSNR during the last 20 years were Elna-Marie Larsson, Lars Gustafsson, Anders Lilja, Birgitta Ramgren, Tommy Andersson, Birgitta Leiram, Johan Wikström, Roger Siemund, and the current president Ida Blystad.

Early members of the board strongly promoted the establishment of neuroradiology as a medical speciality in Sweden. The history of neuroradiology in Sweden and the SSNR from 1990 and onwards is greatly influenced by the fact that

neuroradiology was established as a medical subspeciality by the Swedish National Board of Health and Welfare in 1991.

On the request of the National Board of Health and Welfare, the society has outlined and revised the training curricula for the speciality in collaboration with the Swedish Society of Radiology and adhering to the European training curriculum for radiology and for subspecialisation. From the beginning of the millennium, SSNR has, for more than a decade, awarded grants for participation in the European Course of Neuroradiology (ECNR) to support young neuroradiologists in their ambition to certify internationally. Today employers endorse the participation in the ECNR series for neuroradiologists in training and the courses as well as the European Diploma in Neuroradiology (EDiNR) are part of the recommended education of young neuroradiologists. The society has further awarded travel grants to meetings such as ESNR, Symposium Neuroradiologicum, ASNR, and ISMRM.

Funding for research and visits abroad is also facilitated by The Erik Lysholm Foundation (Stiftelsen för Medicinsk Bildering till Erik Lysholms Minne), founded in 1995 and since managed by SSNR.

The society has, during the last decades, increased its international partnerships and SSNR is today affiliated with the Swedish Society of Radiology (SFMR) and the Swedish Society of Medicine (SLS), a member organization of the World Federation of Neuroradiological Societies (WFNRS), a member society of the World Federation of Interventional and Therapeutic Neuroradiology (WFITN), and an institutional member of the European Society of Neuroradiology (ESNR). Further, SSNR has representation in the European Union of Medical Specialists (UEMS) Section of Radiology, Division of Neuroradiology with two delegates.

According to the statutes, SSNR is open to all who work in and/or have an interest in neuroradiology. Its purpose is to represent the speciality's scientific interests, to promote the development of neuroradiology by organizing meetings with scientific lectures and discussions, to conduct and support education in the field, and to constitute a referral body for the Swedish Medical Society and other national health care and governmental bodies.

For more than four decades, educational courses have been arranged or endorsed by the society covering basic and advanced diagnostic neuroradiology, spine imaging, head and neck imaging, paediatric neuroradiology, interventional radiology, and MR physics. A much-appreciated concept was courses held, for example, on Cyprus and Mallorca, gathering neuroradiologists and clinicians such as neurologists and neurosurgeons as members of the teaching faculty, that discussed and taught course participants not only imaging findings but also the relevance of radiological examinations, how they are performed, how they are read, and how they are reacted upon. These courses were also exceptional as they invited different professions to participate—radiologists, neuroradiologists, clinicians, radiographers, and physicists. The exchange of knowledge at these meetings has also been driving the development of clinical neuroradiology in Sweden. Due to economic and sustainability requirements, these courses are today held in Sweden with the driving aim of gathering a multidisciplinary faculty for a few days.

In addition to these educational efforts, the SSNR arranges annual meetings with scientific and educational programmes that reflect both contemporary aspects of neuroradiology and honour national and international achievements in the field.

SFNR honorary lecturers and former Torgny Greitz lecturers between 1991 and 2024 are:

1991: Professor Makthar Gado, Bethesda, USA; 1992: cancelled; 1993: Professor Pierre Lasjaunias, Paris, France; 1994: Professor Ian Isherwood, Manchester, UK; 1995: Professor Danielle Balériaux, Bruxelles, Belgium; 1996: Professor Derek C. Harwood-Nash, Toronto, Canada; 1997: Assoc. Professor Sten Cronqvist, Lund, Sweden; 1998: Professor Ivan Moseley, London, UK; 1999: Professor Guiseppe Scotti, Milan, Italy; 2000: Professor Ingar Skalpe, Oslo, Norway; 2001: Professor A. James Barkovich, USA; 2002: Professor Carsten Gyldensted, Århus, Denmark; 2003: Professor Isabelle Berry, Toulouse, France; 2004: Professor Michael Sage, Australia; 2005: Professor Anne Osborn, Utah, USA; 2006: Professor Luc Picard, Nancy, France; 2007: Tomas Hindmarsh, Stockholm, Sweden; 2008: Pål Svendsen, Gothenburg, Sweden; 2009: Dan Greitz, Stockholm, Sweden; 2010: Professor Rüdiger von Kummer, Dresden, Germany; 2011: Professor Raili Raininko, Uppsala, Sweden; 2012: Professor Daniela Prayer, Vienna, Austria; 2013: Professor Karel Terbrugge, Toronto, Canada; 2014: Professor Sven Ekholm, Rochester, USA and Gothenburg Sweden; 2015: Professor Sven Haller, Geneva, Switzerland; 2016: Professor Tommy Andersson, Stockholm, Sweden; 2017: Professor Ric Harnsberger, Utah, USA; 2018: Professor Elna-Marie Larsson, Uppsala, Sweden; 2019: Professor Pia Maly Sundgren, Lund, Sweden; 2020 and 2021: cancelled; 2022: Assoc. Professor Michael Söderman, Stockholm Sweden; 2023: Professor Meike Vernooji, Rotterdam, The Netherlands; 2024: Assoc. Professor Birgitta Ramgren, Lund, Sweden.

The international perspective of the Society and its members is further reflected by the huge number of contributions to the field that individual members from Sweden have achieved during these decades. It is impossible to list all. Neuroradiologists and radiographers in Sweden and members of SSNR have served amongst other achievements as presidents of ESNR, ESMRMB, ISMRM, ISMRT, UEMS division of neuroradiology, and WFITN. Not least the relation to ISMRM and ESMRMB shows the close relationship between neuroradiology and physics and technology in Sweden, which is also evident by the fact that neuroradiological departments in Sweden always closely collaborate with medical radiation physicists both regarding CT and MR. Frequently, MR physicists are either employed by or directly affiliated with the radiology/neuroradiology department. Further, at several university departments, neuroradiologists nowadays also build bridges to nuclear medicine and cover reading also of SPECT and PET-CT/MR. A further fruitful symbiosis in clinical practice is the many multidisciplinary conferences neuroradiologists in Sweden participate in, building bridges between different specialities and ensuring a focus on the patient's actual needs.

There is a strong national collaboration in Swedish neuroradiology. Employers of SSNR board members represent all Swedish University Hospitals and thus the whole country. Further, the board includes clinical and academic neuroradiologists

with an interest in diagnostic and interventional neuroradiology, head and neck radiology, and nuclear medicine, the latter mainly among head and neck radiologists.

The broad national representation of the board and its diversity in areas of interest allows SSNR to address national questions of interest and anchor decisions broadly within national health care. For example, a current focus of the society is to publish national recommendations on neuroradiological MRI protocols and reporting templates for main diseases and patient groups. Members of the society publish white papers and guidelines and are involved in the development of national care programmes and national clinical guidelines that include diagnostic and/or interventional neuroradiology.

SSNR has 231 members (45 retired) per October 2024, including 15 honorary members. According to statistics from the Swedish National Board of Health and Welfare (Table 21.1), the number of certified neuroradiologists employed within healthcare has increased from 46 in 1995 to 145 in 2022. However, the number of colleagues working at private departments or smaller public hospitals (no data available) who are not specialized specifically in neuroradiology has also increased. The latter potentially means that specialist competence is not necessarily used adequately.

Sweden has a population of 10.5 million inhabitants on a land area of 450,000 km² and a length from north to south of 1550 km. In 2018, Sweden had approximately 225 MRI scanners installed at approximately 90 sites (numbers are based on communication with vendors; according to OECD Data Explorer [data-explorer.oecd.org] 14.9 scanners per million) and according to OECD, 19 CT scanners per million inhabitants. For radiology at large, these produced approximately 1,501,000 CT scans and 548,000 MR examinations in 2018, compared to 651,000 CT scans and 268,000 MR examinations in 2005. This is an increase of approximately 130% for CT and 100% for MR over 13 years and these numbers have continued to increase since [9]. For neuroradiology, there is a continuous shift from CT to MRI. This is heavily noticeable in the clinical workflow and implies a huge challenge due to the limited number of neuroradiologists. Further, the number of neuro-interventionists among neuroradiologists has increased and today 26 interventionists perform approximately 4000 interventions per year at seven neuro-interventional centres.

Table 21.1 Statistics on neuroradiologists working in health care in Sweden 1995–2022

	Neuroradiologists ^a (n, %) employed:		
Year	In public healthcare	In private healthcare	Total
2022	123 (85%)	22 (15%)	145
2012	97 (84%)	18 (16%)	115
2002	61 (88%)	8 (12%)	69
1995	46	No data available	46

^aIncluding neurointerventionists; data collected from the statistical database of the Swedish National Board of Health and Welfare

The national health care development has also contributed to an increased availability of advanced radiological imaging modalities available for diagnostic and interventional radiology and thus neuroradiology, including amongst others two 7 Tesla MR installations (Lund and Stockholm) allowing both clinical imaging and research; four PET-MR installations (Umeå, Uppsala, Stockholm, and Gothenburg); intra-operative MR systems; several installations with high performance gradient MR systems; multinuclear MR systems; and 14 photon-counting CT scanners (including one system in pre-authorization trials) in addition to a modern CT-scanner infrastructure with multiple dual energy scanners.

Current Swedish neuroradiological research spans a wide range of topics (Fig. 21.1). On the neuro-interventional side, this includes the participation in multiple randomized controlled trials, the introduction of AI software tools in stroke diagnosis, and the development of an inverted Seldinger technique, referred to as an “extroducer,” for intraparenchymal access and localized treatments and biopsies. On the diagnostic side, Sweden continues its pioneering work in CT diagnostics, leveraging its considerable fleet of photon-counting CT scanners. This includes optimized cerebral CT angiographies with spatial resolution non-invasively matching that of conventional angiography. Notably, usage of dual-source high-pitch photon-counting CT has also expanded the boundaries of neuroradiology when the heart can be imaged without ECG gating at the primary CT examination for stroke

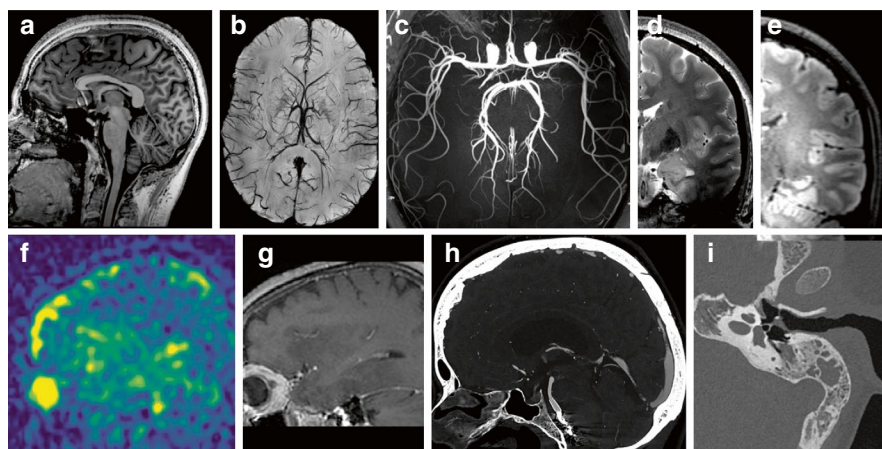


Fig. 21.1 Swedish neuroradiological research spans a wide range of topics and implementation of new technologies is one of the fundamental driving forces. Sweden has, for example, two 7 Tesla MR installations despite its population of only ten million inhabitants—T1-weighted (a) and SWI (b) 7 Tesla MR scans from Stockholm and TOF angiogram (c) and T2-weighted (d) and FLAIR scans (e) from Lund. Sodium MR imaging is implemented for clinical trials in Gothenburg (f)—illustrating ^{23}Na MRI in a low-grade glioma, g—corresponding contrast-enhanced T1-weighted imaging), and the currently 14 PCCT installations are used for both routine outpatient and emergency care (h—PCCT cerebral angiography in a patient with coiling due to a giant vertebral aneurysm and a flow diverter with patent lumen; i—pre-surgical planning temporal bone scan of a cholesteatoma)

calls. Another example of strong national collaborations, in conjunction with the unique opportunities of Swedish quality registers, is where photon-counting CT of the brain will be acquired at multiple sites as part of the national nationwide, population-based Swedish Cardiopulmonary bioimage study (SCAPIS). Notable research within MRI includes the clinical optimization of PET-MR for neuroradiology, clinical implementation of 7 Tesla MRI, and advanced motion-correction allowing for high-quality imaging even in small children without sedation. Future aspirations include diversifying clinical use of CT and MRI also to the bedside of paediatric and adult patients. This work will likely change our way of providing neuro-intensive care, with more informed and targeted decisions. Several centres focus on the development of advanced diffusion imaging techniques in the central nervous system and in peripheral nerves. Other development areas include metabolic MRI, where efforts into leveraging GlucoCEST for non-ionizing quantification of the brain glucose metabolism are ongoing in both Lund and Stockholm. Also, APTw imaging is evaluated in several studies, including multicentre studies. Clinical sodium MR research in brain diseases is further ongoing in brain tumour and epilepsy cohorts in Gothenburg.

Sweden is widely known for its many and comprehensive quality registers. For example, the Swedish Neuro registry has excellent coverage and is the foundation of a vast amount of research studies. The tight integration with standardized neuro-radiological reporting, for example, in neuroinflammatory and neurodegenerative disorders, has been the basis for several post-authorization studies. This has, for example, been used in proving the efficacy of anti-CD20 therapy for multiple sclerosis, which is now considered an essential drug by the WHO. Nationwide registries for neurointerventional procedures are a further example of close collaboration within the nation. Sweden is also a nation of early adopters of new IT tools. This has been reflected in the early implementation of digital PACS systems in the 1990s and hospitals can today share images nationwide. Swedish neuroradiologists also pioneer the efforts in introducing brain volumetrics, AI decision support tools, and quantitative MRI in clinical practice.

In conclusion, the Swedish Society of Neuroradiology (SSNR) has played a pivotal role in shaping the landscape of modern neuroradiology, not just in Sweden but also globally. From pioneering advancements in diagnostic techniques like CT and MRI to fostering a spirit of international collaboration and education, SSNR's contributions have been profound. The society has consistently pushed the boundaries of neuroradiological practice, ensuring that Sweden remains at the forefront of innovation in both diagnostics and intervention. As we look to the future, SSNR's commitment to research, training, and multidisciplinary collaboration will continue to shape the field, making it not only a leader in technology but also a beacon of clinical excellence. The legacy of the SSNR is a testament to the power of vision, dedication, and collaboration in advancing medical science. On behalf of the board of SSNR, the authors would like to express their gratitude to everybody contributing to this legacy (Fig. 21.2).

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