ESNR—the next 50 years

Johan Van Goethem^{1,2}

Published online: 10 November 2018
© Springer-Verlag GmbH Germany, part of Springer Nature 2018

How it all began

Exactly 50 years ago, in 1969, under the initiative of Auguste Wackenheim, Jean Paul Braun, and Ziedses des Plantes, the European Society of Neuroradiology was founded with 68 members, the majority of whom were radiologists. Today, as ESNR lights its 50th candle, we have over 2000 individual members and more than 4500 members in total.

The first 50 years

Over the past 50 years, neuroradiology has experienced a revolution. Our speciality is driven by innovation and groundbreaking discoveries, many of which have received prestigious awards such as the Nobel Prize, making their way into routine clinical practice. It was a mere 10 years after founding the ESNR, in 1979, that Englishman Sir Godfrey Newbold Hounsfield and South African/American Allan McLeod Cormack shared the Nobel Prize for Physiology or Medicine for the development of computed tomography. More than 20 years later, in 2003, the Nobel Prize was awarded jointly to Englishman Sir Peter Mansfield and American Paul Lauterbur for their discoveries concerning magnetic resonance imaging, amid some controversy because many people felt that Raymond Damadian, a medical doctor, who in 1977 made the first MR images as a volunteer, should at the very least have been co-awarded the Nobel Prize.

The next 50 years

End of X-rays and CT

Although the discovery of X-rays in 1895 by German Wilhelm Röntgen was the very reason radiology came into existence, all X-ray imaging techniques are essentially doomed. However promising the technologies were at first and despite the fact that they remain the cornerstone of neuroradiologic imaging, X-rays and CT will soon but disappear due to the harmful biological effects of X-rays, which have been known from the outset. Two years after Röntgen's discovery, in 1897, reports of the terrible effects of exposure to X-rays began to appear. Since then, engineers designing X-ray or CT machines and radiologists using them have tried, and succeeded, in reducing the radiation dose to as low as possible. On modern CT machines, radiation doses are now so low that diagnostic imaging quality begins to suffer. Previously, when installing a new CT, we were very happy about the new features and the much improved image quality. Yet, after installing the newest and most expensive CT scanner a year ago, I was very disappointed that image quality had significantly deteriorated compared to images provided by our older scanner; however, the radiation dose was almost halved! Since physical constraints dictate a minimal dose to acquire usable images, the dose will never be zero; as such, it is only a matter of time before CT disappears. For most indications, CT can and will be replaced by MR, especially as it becomes less expensive and more widely available.

Strange new MR techniques

MR itself has seen an accelerated evolution from a purely anatomic to a mixed anatomic-functional imaging technique. For instance, brain edema makes itself visible not only as mass effect but also as water content changes. MRI can even show if the water content has changed inside or outside brain cells or spinal cord (DWI). Bone edema, on the other hand, does not

✉ Johan Van Goethem
johan.vangoethem@uantwerpen.be

¹ Professor of Medical Imaging and Neuro-Imaging, Antwerp University, Antwerp, Belgium

² Department of Radiology, University Hospital Antwerp, Wilrijkstraat 10, 2650 Edegem, Belgium

change anything anatomically, and bone edema is key to evaluate low back pain. Although spectral CT also claims to visualize bone edema (in essence, water in the bone), it is an area where MRI clearly shines. Thus, a steadily increasing number of important functional, physiological, or metabolic parameters are being measured by MRI in daily practice.

Many more new “probes” are on the way from the research lab to clinical practice.

Chemical exchange saturation transfer (CEST) imaging is a technique to probe molecules at concentrations that are too low to influence either normal MR signal or MR spectroscopy. It works by saturating these molecules and transferring this saturation to the water pool by exchanging protons. By allowing a continuous buildup of this effect on the water pool, the water signal change can be detected. One application of this scheme is amide proton transfer imaging. Because pH influences this proton exchange effect, it can be used to probe brain pH in stroke patients. It can also be used in brain tumor imaging to demonstrate the increased cellular content of proteins and peptides. Another use of CEST is dynamic glucose enhanced (DGE) imaging, which looks at glucose uptake in brain tumors delivering complementary information to gadolinium uptake.

Research on MRI contrast agents has gained new attention as well, especially after gadolinium chelates face increased scrutiny due to potential safety concerns. New gadolinium-based contrast agents are fabricated in large molecules that shield the gadolinium from water making it temporary MRI invisible. These contrast agents probe for enzymes or molecules that can open up the macrostructure, reactivating its contrast effect on MRI. Other gadolinium-based agents contain peptides that bind specifically, for example, to β -amyloid. New research has devised ways to allow these molecules to pass the blood-brain barrier so that one day we might use these new agents for evaluating Alzheimer’s disease. Iron as a contrast agent is not new but was believed to be too toxic and impractical until nanoparticles were constructed as nanomatsyoshkas (like Russian dolls) or nanoshells shielding the toxic iron from its surroundings. However, these are all niche techniques.

Engineers and physicists have been looking at ways to increase field strength in order to gain better image quality. The downsides are enormous costs and safety issues related to high field imaging. A major step forward would be ultra-low field (ULF) MRI. ULF MRI suffers from many challenges associated with low signal and long acquisition times. Nevertheless, many proof-of-concept demonstrations of ULF MRI at field strengths of only a few mT to μ T have been made. These are usually based upon pre-polarization methods and superconducting quantum interference device (SQUID) sensors. Imagine MRI using just the earth’s magnetic field! No safety issues, no incompatibility with patient monitoring and support and no costs related to a high field magnet. Would not that be a giant step forward?

Inventing the future

In 1963, Dennis Gabor, a Hungarian-British electrical engineer and physicist, stated: “the future cannot be predicted, but futures can be invented.” He subsequently invented holography, for which he received the Nobel Prize in Physics in 1971. What will be the new neuroradiologic imaging technique of the future? Both X-rays and NMR were used in science decades before someone modified them for medical imaging.

Theoretical physicists are fairly certain; they have figured out all the elementary particles of the universe. Of these particles, only photons, one of the four force carrying particles, is used in X-rays, CT, and MRI. So perhaps future-imaging techniques will be based on some of the other elementary particles (or forces).

Albert Einstein published the general theory of relativity, describing gravitation and predicting gravitational waves, in 1915. The graviton, not yet discovered, is the force-carrying particle associated with relativity. In 2002, the US Laser Interferometer Gravitational-Wave Observatory (LIGO) began looking for these gravitational waves and in 2007; the Virgo interferometer in Europe joined the search. In LIGO and Virgo, a laser shines in two perpendicular tubes of 3- to 4-km length with a mirror at the end. If one of these tubes is shortened or lengthened by a gravitational wave, the two returning beams are out of sync. These immense machines can detect a change in length of less than a 1/10,000th the diameter of a proton, which is like measuring the distance from Earth to the nearest star with an accuracy narrower than the width of a human hair. Perhaps one day, we will be able to detect gravitational changes induced by a human body and construct an image of the brain or spine without the use of any particles.

The neutrino, also an elementary particle, was first hypothesized by Wolfgang Pauli in 1930. In 1956, Frederick Reines’ group detected the neutrino, for which he received the 1995 Nobel Prize in physics. The neutrino is a whimsical particle that minimally interacts with anything else and typically passes through normal matter unimpeded and undetected. In fact, more than 1,000,000,000,000,000 neutrinos have passed through your body while you have been reading this text. Most neutrinos come from the sun—although we can also produce them in particle accelerators. Some neutrinos also come out of space and these are known as cosmic neutrinos. In the last century, Belgian physicist Francis Halzen designed a cosmic neutrino detector. It took more than 5 years to build the detector and was an extraordinary engineering achievement. IceCube, in fact, is an enormous cube of ice more than a kilometer deep under the Antarctic surface. Deep within this cubic kilometer of clear ice are more than 5,000 detectors looking for neutrinos. Although neutrinos usually do not interact with other matter, occasionally one hits a proton in this cubic kilometer of ice. This interaction produces another particle, a muon or an electron that has sufficient energy to move

faster than the speed of light in ice. This gives rise to what we know as Cherenkov radiation, a blue glow detected by IceCube. In July 2018, IceCube, for the first time, pinpointed the origin of cosmic neutrinos to a supermassive black hole in a galaxy far far away. Will neutrino imaging one day be part of our medical imaging spectrum? It sounds impossible today, but that is true for many of techniques in common usage now. These advancing frontiers of science are what keep our field of neuroimaging alive and buzzing and make possible many new discoveries around the corner that we will embrace as our own.

Will we be replaced by computers?

Artificial intelligence (AI) is surely a buzzword in neuroradiology today. Let me clarify first that many of the software programs available for neuroradiologists today are not AI. AI assumes at least some form of self-learning software, machine learning, or deep learning, whatever you want to call it. Software that measures brain volumes or multiple sclerosis lesion loads are not AI; they are just sophisticated computer programs. The ability to modify algorithms and to learn from mistakes is key to AI. Usually, these machines learn from data, typically MR or CT images, and telling the machine what an expert neuroradiologist viewed on the images. In other words, we do not specifically tell the machine what to look for; instead, it has to find out for itself, provided we give the machine sufficient normal datasets too! After feeding the machine sufficient data, one can try to give it an unknown dataset and ask what it thinks. One would do this until happy with the accu-

racy and voila, you have created an AI program for your specific neuroradiologic problem. AI works best if you ask it a very specific question. It also assumes your original datasets were interpreted correctly. If the problem or task you ask AI is more ambiguous, the results are less reliable. Self-driving cars are a typical example. Driving on a motorway, all cars in the same direction and with clearly defined lanes works fine most of the time. But, self-driving cars in a congested city center where many unexpected things might happen are not yet viable. AI that helps a clinician to determine the type of brain tumor will be available sooner than AI that will provide more accurate reports than experts in degenerative spine disease. In the end, AI will aid neuroradiologists by helping them to make more accurate reports, but rest assured, replacing neuroradiologists will not occur over the next few decades.

The future of neuroradiology is exciting and bright. Have a happy 2019!

Johan Van Goethem
President, ESNR

Compliance with ethical standards

Funding No funding was received for this study.

Conflict of interest The author declares that he has no conflict of interest.

Ethical approval NA

Informed consent NA