

International Day of Radiology 2014
Interview on brain imaging
Hungary / Dr. Péter Barsi



**INTERNATIONAL
DAY OF
RADIOLOGY**
AN INITIATIVE OF THE ESR, ACR AND RSNA

The ESR spoke with by Dr. Péter Barsi, consultant neuroradiologist at Semmelweis University in Pécs, Hungary, about how Hungarian radiologists interact with patients and how imaging helps in neurological care.

European Society of Radiology: Imaging is known for its ability to detect and diagnose diseases. What kind of brain diseases can imaging help to detect and diagnose?

Péter Barsi: Neuroimaging, which is the specific field of medical imaging dealing with diseases of the skull, brain and spine, helps in the diagnosis of all kind of brain diseases: abnormalities of brain development, the effects of hereditary and metabolic diseases involving the brain, viral and bacterial infections, stroke, degenerative brain disorders like Alzheimer's disease, multiple sclerosis (MS) and other inflammatory brain processes, and tumours of the brain and its covering.

ESR: How useful is imaging in brain disease management? Does it improve the understanding of disease or improve patient prognosis?

PB: Imaging has become an indispensable tool in both the understanding of brain diseases and in patient management. In the field of abnormalities of brain development, Prof. A.J. Barkovich and his co-workers published a classification model in 1996, and revised it in 2001 and again in 2012, based on the tremendous amount of data provided by magnetic resonance imaging (MRI) studies. A properly performed MRI examination can determine if a brain lesion is an abscess caused by bacterial infection, a tumour, or a very active MS lesion. These lesions are similar on basic images, but need completely different therapy, thus their differentiation without surgical intervention (brain biopsy) is of utmost importance. In ischaemic stroke (brain damage caused by severe narrowing or occlusion of the artery providing the circulation to the given brain region), there is a short time window, the first three to six hours, when intravenous, intra-arterial thrombolysis (administration of a drug into the general circulation through a vein or directly into the occluded artery through a fine catheter that resolves the blood clot occluding the artery) and thrombectomy (a procedure where a neuroradiologist extracts the blood clot from the artery with a special device driven into place by a catheter) can be performed, with the purpose of salvaging significant regions of the brain. An urgent computed tomography (CT) or MRI examination shows the brain damage, differentiates ischaemia from bleeding (the aforementioned therapies must not be used in bleeding), shows the site of the arterial occlusion, and it can also tell if there is brain tissue with decreased circulation but still alive and rescuable; the so-called penumbra.

If we use all the capabilities of MRI, we can identify the exact extent and location of a brain tumour, we can tell if it is benign or malignant, and also, we can provide important information to the neurosurgeon for the planning of the operation. Based on that information, she/he will be able to remove all or most of the tumour while not destroying important brain regions and white matter tracts, and the patient gets the best chance of recovering without serious neurological deficit.

ESR: What kind of technology and techniques do radiologists use to image the brain? Are there any specific techniques for particular diseases?

PB: The three most important tools are CT, MRI and digital subtraction angiography.

CT is widely available and provides the necessary information for therapy in urgent cases like trauma and stroke. It provides high resolution images of the bone structures that are very important, for example in frequent diseases involving the middle and inner ear or the paranasal sinuses. CT angiography using iodinated contrast material delivered through a vein can precisely depict the large arteries of the neck region and the arteries and veins inside the skull. CT perfusion is a method for

analysing the circulation of normal and damaged brain tissue, as well as the circulation of lesion-like tumours by following the passage of the intravenously administered contrast material through the vasculature and the brain itself; an important tool in stroke for example. It is important to note, however, that CT uses ionising radiation that means harm to the human body.

MRI is the best imaging method for all kinds of brain abnormalities, without known biological hazards in most cases. Unfortunately, it has its limitations. It is more expensive and thus much less widespread and available than CT, and has additional problems. As it uses a strong magnetic field, special safety precautions are necessary. For example, patients with aneurysm clips (a small device used to close bulges of the arterial wall and prevent bleeding caused by their rupture) of the old type, made from steel, or those with non-MRI compatible pacemakers cannot be examined with MRI. Other medical equipment cannot be taken into the scanner room either if they are not MRI-compatible, making the examination of patients with a serious medical condition much more expensive or impossible. People with claustrophobia (the fear of enclosed spaces) may find the scanner with its narrow tunnel intolerable, though anti-anxiety drugs and open MRI scanners can help.

Nevertheless, an MRI study of the brain provides the most detailed and exact information on brain disease today. The images show fine anatomical detail. The assessment of information provided by different sequences (measurements with different parameters) helps to differentiate the lesion's histological nature. MR angiography can show normal and sick arteries and veins in high detail, even without an intravenous injection of contrast material. MR perfusion analyses brain circulation in a way similar to CT perfusion, but it can be performed without contrast material (the so-called arterial spin labelling – ASL – technique). Diffusion-weighted imaging (DWI) shows brain ischaemia very early and is powerful for differential diagnostics (distinction of lesion of different pathological nature). Its more advanced form, diffusion tensor imaging (DTI) with tractography is the first tool in history that shows white matter tracts (bundles of offshoots of neuron cells) in the living human brain, a very important achievement in surgical planning. MR spectroscopy, the root technique of modern medical MRI, provides information on the biochemical composition of brain tissue; another important tool in differential diagnostics. Finally, functional MRI shows the brain regions actively working while the patient is performing a certain task (movement, speech, memory and even emotions), thus connecting brain anatomy to function. All these methods are developing quickly, giving increasingly precise and reliable information.

Single-photon emission tomography (SPECT) and positron emission tomography (PET), the latter combined with CT or MRI today, are methods used by radiologists or professionals in nuclear medicine. The methods gather information on brain circulation and metabolism. Their most important role is the detection and differentiation of tumours in neuro-oncology.

ESR: What is the difference between a radiologist and a radiographer? Who else is involved in performing brain imaging exams?

PB: The radiologist is a medical doctor specialised in medical imaging, directing and evaluating diagnostic imaging studies, performing and evaluating interventional radiological (therapeutic) procedures. The radiographer is a secondary school or college graduate specially trained in the field of medical imaging, performing imaging studies under the direction of the radiologist or helping her/him in interventional procedures. As mentioned above, specialists in nuclear medicine are medical doctors performing SPECT and PET examinations. In research, specifically in the field of functional MRI, neurologists, psychiatrists, psychologists and biologists actively participate in the execution and evaluation of imaging studies. Neurosurgeons use imaging data in surgical planning and neuronavigation (a procedure where three-dimensional imaging data are the basis of a virtual space where the movement of special neurosurgical tools can be followed in the brain in real time during the operation – just like GPS in everyday road traffic).

ESR: How many patients undergo brain imaging exams in your country each year?

PB: In 2012, approximately 276,000 brain CT and 84,000 brain MRI examinations were performed. These numbers may appear to be enormous, but are well below the average number in OECD

countries if we compare them to the Hungarian population. The difference is smaller when the difference in the number of CT and MR scanners is compared to other OECD countries; so far this has been solved by overworking the existing scanners and personnel.

ESR: Access to modern imaging equipment is important for brain imaging. Are hospitals in your country equipped to provide the necessary exams?

PB: In Hungary, there are 94 CT scanners distributed relatively widely around the country. Each university and county hospital, most of the larger hospitals in Budapest, and a number of smaller hospitals in the countryside have at least one scanner. Private centres also provide CT examinations. Unfortunately, there are far fewer MRI scanners than necessary in our country, and their number is currently 44. There are even county hospitals without a scanner. These numbers are even worse if we compare them to the average number for a million inhabitants in the OECD countries as mentioned earlier. Hungary does not reach a third of the OECD average in CT and a quarter of that average in MRI. The situation is even more serious in the field of urgent examinations and for children requiring anaesthesia. We should also mention that a proportion of the MR scanners use a low magnetic field strength (0.3–0.5 Tesla), which is not really suitable for neuroradiological examinations.

ESR: In many countries there are waiting lists for MRI exams. How long can patients typically expect to wait for an exam in your country?

PB: The low number of MRI scanners in our country results in significant waiting lists. Patients currently have to wait at least two to three months for a standard government-paid MRI examination and much longer for special examinations. The waiting time can vary significantly in different regions of the country. Private MRI examinations can be done much faster, even in one to two days, but are rather expensive compared to the average income in Hungary.

ESR: As the global population gets older, the risk of developing neurocognitive and neurodegenerative disorders increases. How can imaging help tackle this issue?

PB: As the therapeutic possibilities are currently rather few and not very effective in these disorders, research for new drugs is very intensive in the field. Neuroimaging has the tools to diagnose the disorders in their advanced phase and follow their progression, thus it can help in the evaluation drug effectiveness and possible side effects. The goal of intensive neuroradiological research is to find biomarkers (imaging signs, measurement values) indicating the early phase of these disorders, when the routine MRI examination is usually negative or non-specific. These possible biomarkers are very important as the sooner the diagnosis is made and the potentially effective therapy is introduced, the better the chance for the patient to stop or at least slow down the progression of the disease and remain in complete or long-lasting good health.

ESR: Some imaging techniques, like x-ray and CT, use ionising radiation. What risk does this radiation pose to the patient and what kind of safety measures are in place to protect the patient?

PB: The smallest amount of ionising radiation means a hazard for the human body. High exposure can damage the cells and tissues, but even lower exposure can cause cancer, specifically damaging sensitive organs like the lens of the eye or the genetic material of reproductive cells, impacting the next generation. Radiation exposure is even more dangerous for children, as it will have a much longer lifetime to exert its harmful effects. While we are planning an examination using ionising radiation, we always have to consider this danger and the potential benefit of information provided by the examination.

One way to protect patients is to use MRI instead of CT as much as possible, because to our recent knowledge MRI is not harmful to the human body, except in some special cases as mentioned earlier. The other way is to decrease radiation exposure to the lowest possible level, while ensuring that the examination provides satisfactory diagnostic information. The manufacturers are very actively exploring these possibilities and implementing tools in their equipment.

ESR: What kind of role can imaging play in preventing and predicting brain diseases?

PB: The most important role of imaging in this context is in hereditary diseases. If imaging and clinical data reveal a hereditary metabolic brain disease in a baby or child, examination of her/his close relatives can help to clarify the path of inheritance, which in turn can help in genetic counselling; to give advice to parents on the odds that their next child will have the same disease.

Another example: In families that have many individuals with intracranial aneurysm, screening brain MRI with MR angiography helps to detect those family members who have aneurysms without clinical signs. If the aneurysm has a morphology indicating the danger of its future rupture, a preventive interventional procedure may be performed.

ESR: In general, patients don't see the radiologist. A patient will discuss the image with the neurologist, neurosurgeon or oncologist. When they ask a question, they're often told: "I'm not a radiologist". Why don't radiologists discuss the image with the patient first?

PB: Traditionally, radiologists talked to their patients if they needed further information to understand the imaging results, and discussed their final results with them. This is the case in interventional neuroradiology where diagnostics and therapy are done at the same time. The low number of CT and predominantly MRI scanners means that both the scanner and the personnel are overworked, with strict time schedules. Today, a good number of these examinations are reported through teleradiology, which means that the radiologist is not present during the examination but working from another hospital, city or even country or continent; thus direct contact with the patient is not possible. An additional problem is that the radiologist gets substantially differing amounts of information on the patient's medical state, depending on the working situation. She/he may receive the complete information in a hospital department through the information system, but has to rely on the referral written by the clinician from an outpatient clinic or ordered through teleradiology. In a few cases, a minimal amount of clinical information is enough to give a reliable final opinion on the imaging study. In most cases, however, complete clinical information is necessary as a certain disease may be very variable on the images of different patients, and different diseases can have very similar imaging signs. In the latter case, the radiologist can report on possibilities and probabilities, but not a final diagnosis. It is also important to note that the decision on further diagnostic steps and therapy is made by the patient and the clinician; the radiologist is not authorised to make such a decision. Nevertheless, if the patient is interested in the result of her/his examination and wants to discuss that with the reporting radiologist, she/he can find a way to do this in most cases. If requested, radiologists are happy to do that.

ESR: How expensive are radiological examinations to the health service and is there a risk that some of these examinations could be blocked by health technology assessment agencies deeming them to be not cost-effective? If so, how can patients help to ensure that these examinations are made available?

PB: Medical imaging, especially neuroimaging, is a very expensive field of medicine. Our equipment is high-tech and continuously developing, therefore it has to be upgraded and replaced regularly if the institute wants to provide up-to-date service to its patients. This development means rapidly increasing amounts of digital information has to be stored in huge secure servers for a long time. New techniques and their evaluation are also rather time-consuming, which means that fewer examinations per day can be performed and more radiologists are required for the task. The personnel are highly educated and mostly specialised.

Nevertheless, we should realise that the faster and more accurate the imaging diagnosis is, the better the chance for the patient to receive appropriate therapy and recover fast, and the cheaper the whole process will be. In neuroradiology, a properly performed brain MRI can detect most diseases in one step (we discussed the problems of urgent cases earlier), thus the best way is to perform an MRI scan instead of x-ray, CT or other examinations. The problem is the low scanner availability, the long examination time (not only in Hungary but in most European countries) and the high cost.

Patients can help to convince the government to increase the level of neuroradiological services through patients associations, representatives in local councils and in the government, and through the media. The final results will depend on the economic state and resources of smaller or larger communities.