International Day of Radiology 2014
Interview on brain imaging
United Kingdom / Dr. Stavros Stivaros

Dr. Stavros Stivaros, head of paediatric neuroradiology at the Royal Manchester Children's Hospital, and a National Institute for Health Research (NIHR) clinician-scientist at the University of Manchester, spoke to the ESR about multidisciplinary patient care, the technology used in brain imaging, and the safety measures in place in the UK.

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

Stavros Stivaros: Imaging can help to diagnose a whole plethora of diseases within the brain at all stages of life, from before birth right through to post-mortem imaging. The type of abnormalities that can be detected before birth include congenital brain abnormalities caused by abnormal development, including brain abnormalities caused by genetic diseases, as well as acquired causes such as infections.

After birth, the types of abnormality that imaging can detect include infections, brain tumours, abnormalities relating to the causes of epilepsy or seizures, abnormalities of the blood vessels feeding blood to the brain including strokes (bleeding in the brain), hydrocephalus (water on the brain), and immune-mediated diseases where the brain is affected by the body's own immune system. In addition imaging has a major role in the identification, assessment and treatment planning relating to brain injury due to trauma. This is particularly important in children as it also includes brain injuries suffered by children due to abuse.

This is by no means an exhaustive list, but gives us an insight into the broad range of pathologies and illnesses where brain imaging plays a pivotal role in both diagnosis and management.

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

SS: Imaging is often vital in the management of diseases of the brain, an example of which is brain tumours. Firstly, imaging is pivotal in the initial diagnosis of the tumour, not only to identify the presence of the tumour in the first place, but also to help determine what type of tumour is present. As imaging becomes more sophisticated our ability to define the type of tumour is becoming more and more accurate. This helps doctors to plan treatment from an earlier stage, as well as better direct the treating clinicians as to likely outcomes, enabling them to advise patients more accurately and at an earlier stage about the course of their disease management.

Imaging enables diseases to be identified at sites distant to the original tumour, which is vital for treatment planning, as well as providing prognostic information to patients. In addition it is the mainstay for identifying whether surgery has been successful at completely or partially removing a tumour.

Once other treatment, such as x-ray therapy or chemotherapy, has started imaging is again of the utmost importance in following the course of the disease; it can give information on whether the disease is responding to treatment and how good that response is. This means that if there is little response from one therapy, that can be identified early using imaging so that the treating clinician can change to a different treatment regime.

In addition, imaging can help to identify complications from therapy such as infection or bleeding, and help differentiate between such complications and disease progression. This is very important with regards to changing treatment if necessary, or adding in an alternate therapy.

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

SS: There are four main techniques used to image the brain, ultrasound, x-ray-based imaging in the form of a computed tomography (CT) scan, magnetic resonance imaging (MRI) and nuclear medicine-based techniques, such as positron emission tomography (PET).

Some techniques are age dependant, for example small babies benefit from ultrasound scans of the brain as their skull bones are not fused so the ultrasound is able to 'see' into the brain substance. In an adult, where the skull bones are fused, ultrasound is not possible.

Often, however, imaging diseases is a combination of techniques. For example, a patient who presents with seizures may initially have a CT scan to look for an acute brain injury or a mass. If this is negative, an MRI scan may be performed to look more closely at the structure of the brain. In some cases, a PET scan is then undertaken to look for areas of the brain that are not functioning normally and identify a region that may benefit from being surgically resected to cure the epilepsy. A neuroradiologist needs to be able to interpret these techniques and advise his clinical colleagues on which techniques are best suited to a particular clinical problem or question.

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

SS: A radiologist is a qualified medical doctor who subspecialises in the field of radiology. To become a radiologist in the UK, one first needs to be accepted onto a recognised radiology training scheme, which lasts between five to six years. During this training time, one has to then pass a series of examinations set by the Royal College of Radiologists UK. These include written examinations on the physics and techniques of radiology and imaging machines, such as magnetic resonance imaging scanners; anatomy; and imaging specific to particular body regions and illness types such as brain and spine imaging or paediatrics (there are six modules in this part of the exam).

Once these modules have been passed, trainee radiologists are then invited to London, where they have written exams testing their ability on complex imaging cases, as well as assessment of their ability to accurately and efficiently report plain x-rays from say an accident & emergency department. Finally, they have a one-to-one examination with four separate examiners, who present scans and x-ray images to the trainees and ask them to make a diagnosis and, importantly, test their knowledge on what should happen next with regards to patient management.

All radiologists are able to report a brain scan. However, because of the complexity of brain imaging techniques and also the disease processes seen in the brain, more and more brain CT and MRI scans are being reported by radiologists who have had specific training in brain imaging interpretation. They are called neuroradiologists, and they spend over 70% of their working time just reporting brain imaging. In some diseases (for example brain aneurysms), treatment involves minimally invasive brain surgery, and this is also provided by neuroradiologists. Their job title is termed an interventional neuroradiologist.

A radiographer is not a medically qualified practitioner, but has undertaken a degree course and training in how to perform medical imaging, for example, how to control a CT or MRI scanner or how to take a plain x-ray image. They are highly skilled in the knowledge of anatomy, physics and have to have excellent computer skills. Some radiographers take their training further and learn to interpret and report specific imaging techniques. For example, a sonographer is skilled at performing an ultrasound scan and interpreting the result. Or a reporting radiographer can interpret and report x-ray images from an emergency department.

Specific to brain imaging, the majority of the imaging is obtained by a radiographer and in the vast majority of cases reported by a radiologist. The exception to this may be in ultrasound of the brains of small babies just after birth, where sonographers do sometimes also report the scans they have undertaken.

It is important to note that the process of performing a brain scan also involves many other healthcare professionals in an imaging department. This includes nursing staff, radiography helpers, clerical staff and in many instances professionals from other departments such as anaesthetics. Brain imaging, just like all imaging in the UK, is a true multidisciplinary process.

ESR: How many patients undergo brain imaging exams in your country each year?
SS: This is very difficult to determine and no centralised figures exist to give an answer to this question. However, one can say that in the United Kingdom all patients have access to the full range of brain imaging examinations required for any patient care scenario through the National Health Service (NHS).

ESR: Access to modern imaging equipment is important for brain imaging. Are hospitals in your country equipped to provide the necessary exams?
SS: Most certainly yes! Within the NHS the full range of brain imaging can be performed for all patients. A patient may have to travel to their region's neuroscience unit for a very specialised exam such as a PET brain scan, but all patients have free access to such imaging if it is clinically indicated in their case.

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?
SS: This depends entirely on the clinical context. For example, a patient being admitted as an emergency into a hospital with a suspected stroke or major trauma will have a CT scan, under the NHS, performed and reported in under an hour. In cases where a patient has been admitted to hospital with an undiagnosed brain abnormality, where the clinical team think that an in-patient brain scan is necessary, this is often performed and, importantly, reported by the radiologist within forty-eight hours in most centres. In cases where patients are being referred for a scan as an outpatient with a suspected malignancy, then they will be scanned and reported within two weeks. For less urgent imaging, the wait depends on the degree of urgency and the complexity of imaging being requested, but is of the order of weeks rather than months.

ESR: As the global population gets older, the risk of developing neurocognitive and neurodegenerative disorders increases. How can imaging help tackle this issue?
SS: Imaging can help in such diseases by identifying diagnoses which can be treated, such as deposits overlying the brain that can be drained, or water on the brain which responds to shunt drainage. Imaging can also be of benefit by helping to identify the cause of the neurocognitive decline, for example vascular disease or dementia due to brain volume loss in specific areas of the brain. As our clinical colleagues develop more treatments for the causes of such disorders imaging will be vital for the validation of such treatments, as well as for monitoring their performance.

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?
SS: Whilst it is true that CT, which uses x-rays, increases a patient's risk of developing a later tissue or blood cancer, it is always important to remember that treating clinicians, radiologists and radiographers will always weigh up this risk against the benefits of having the imaging test in the first place. If possible, alternate imaging such as an MRI scan may be used, or the interval between scans will be extended as much as possible to minimise the number of CT scans being undertaken. In all instances the primary goal of the radiology/radiography team is to undertake the scan whilst keeping the dose of radiation to the patient 'as low as reasonably achievable' often abbreviated to ALARA. This means that the methodology of the technique itself is optimised to reduce the radiation dose to the patient, as well as using radiation shielding to prevent a radiation dose to other parts of the body.

It must be reiterated, however, that these scans are only ever performed when clinically necessary and that the concept of ALARA is not only good practice but a regulatory requirement within the UK.

ESR: What kind of role can imaging play in preventing and predicting brain diseases?
SS: One of the biggest advances that has been made by imaging in preventing brain disease over the last 10–20 years is in the treatment of cerebral aneurysms. Imaging has revolutionised this treatment by affording patients the opportunity to have their aneurysms treated by an interventional neuroradiologist using minimally invasive keyhole surgical techniques. This is undertaken to prevent the aneurysm rupturing and to prevent a catastrophic brain haemorrhage. Imaging plays a vital role in the diagnosis of the aneurysm, the treatment of the aneurysm, where x-rays are used in real time to image the minimally invasive surgery being performed by the interventional neuroradiologist, and then in the follow-up to survey the treated aneurysm.

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?
SS: In the UK, all patient management is by way of a multidisciplinary approach, where imaging, neurosurgery, neurology, oncology, etc. come together to discuss each and every patient on a regular basis. This meeting is referred to as a multidisciplinary team meeting or MDT. A treatment plan is then drawn up based on the discussion of these different experts' opinions. However, it is vital that a patient has a point of contact with their primary treating physician such that they are receiving the opinion of the MDT as a whole. In most instances, the treating clinician will not be a radiologist per se, but in the UK they will have discussed the images with one. In some instances, radiologists do attend clinics to help with image interpretation for patients and in cases such as neurovascular abnormalities (such as aneurysms) where the treating clinician is a radiologist; they will discuss the imaging with the patient in the first place.

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?
SS: The Royal College of Radiologists provides guidelines on the use of imaging services, including brain imaging within the NHS. It also fully supports screening programmes such as those for breast and bowel cancers, where the effectiveness of imaging has been proven. Specifically with regards to brain imaging, screening does exist in, for example, foetal anomaly scans at 20 weeks of pregnancy. However, there is no evidence to support 'routine screening' for other brain conditions across the general population. In most cases, the main obstacle with regards to the provision of a screening service would not be the imaging test itself, but the provision of the manpower to perform the test and provide the reports.
In the UK, all neuro-imaging examinations are available on the basis of clinical need. The National Institute for Clinical Excellence reviews imaging tests to ensure that they are recommended for use if evidence exists to demonstrate their benefit. With regards to screening it is vital that one considers the benefits of screening against the potential negatives, including the major problem of false positives. Some scans may pick up changes, which are thought to possibly be an abnormality when in fact they are nothing to worry about. This becomes more of a problem as imaging becomes more and more able to detect subtle changes in the brain. Investigation of these changes means that a patient may need to have further tests or re-scans to further assess the brain and may be given the worrying news that an abnormality exists (with the associated stress that ensues) when in fact there is nothing to worry about. I would always recommend discussion with your general practitioner, physician or surgeon, who will be able to further discuss your case with a neuroradiologist and recommend if you require a scan, what that scan should be, and finally help you deal with the scan findings in an appropriate and controlled manner.

Stavros Stivaros *is head of paediatric neuroradiology at the Royal Manchester Children's Hospital, one of the largest specialist children's hospitals in Europe. He is also a National Institute for Health Research (NIHR) clinician-scientist at the University of Manchester.*

He specialises in paediatric neuroradiology with a special interest in imaging hydrocephalus and the imaging of blood flow and cerebrospinal fluid throughout the head and spine.

He is a fellow of the Royal College of Radiologists (RCR) of London and is the current British Society of Neuroradiologists du Boulay Professor of Neuroradiology. He was one of the first Medical Research Council/RCR clinical research fellows and is currently one of the first NIHR Clinical Scientists in Imaging. He is a regular reviewer for international radiology journals and frequently provides evidence and reports to the Courts on issues related to brain imaging in children.