International Day of Radiology 2014
Interview on brain imaging
Ireland / Dr. Seamus Looby

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The ESR spoke to Dr. Seamus Looby, consultant neuroradiologist in the department of neuroradiology at Beaumont Hospital, Dublin, about the role of brain imaging in the Irish healthcare system and its future applications.

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?
Seamus Looby: There are several imaging modalities including x-ray, fluoroscopy, ultrasound, nuclear medicine, computerised axial tomography (CT) and magnetic resonance imaging (MRI). The most commonly used for imaging brain diseases are CT and MRI scans. Different types of brain diseases including vascular, trauma, neoplastic, infectious, toxic, metabolic, dementia and congenital subtypes can be characterised by CT and MRI.
Stroke is the most common brain vascular emergency requiring imaging. CT and MRI brain scanning are crucial in diagnosis and are critical in determining patient management, e.g. should the patient receive intravenous clot-busting drugs or other treatments. Other vascular disorders of the brain including haemorrhage, the cause of the haemorrhage, cerebral aneurysms and cerebral arteriovenous malformations are also diagnosed by CT and MRI brain scans.
Head and spine trauma carries a significant morbidity and prompt CT imaging is critical. CT scanning is quicker to do and easier to perform, particularly in the emergency setting. Trauma-induced haemorrhage within (intra-axial) and outside (extra-axial, epidural, subdural and subarachnoid) the brain can be promptly diagnosed by CT. Skull, facial bone and spine fractures can also be diagnosed by CT.
Brain tumours, both primary and secondary, are optimally assessed by MRI. MRI features can predict the type and grade of tumour with implications for the patient's prognosis. The location and extent of the tumour is crucial and influences the type and extent of biopsy or resection.
Infections of the brain are divided into bacterial, fungal, viral and parasitic aetiologies. Bacterial meningitis is a potentially very serious disease; it is diagnosed by cerebrospinal fluid (CSF) analysis from a lumbar puncture. The role of imaging is often to predict and diagnose complications from this disease, e.g. brain abscess or hydrocephalus. Worldwide, tuberculosis (TB) remains a very common infection and can be a mimic a tumour or other conditions on brain imaging. Many fungal and viral infections of the brain are non-specific in terms of imaging features. Lastly, prion disease, better known as Creutzfeldt–Jakob disease (CJD), has some very characteristic neuroimaging features.
Toxin exposure can cause abnormalities in all body systems, including the brain. There are an infinite number of potential toxins but it is usually exposure to an abnormal or excessive quantity, which results in clinical sequelae. An example of a brain toxin is carbon monoxide, which produces a characteristic abnormality in the basal ganglia, the deep grey matter nuclei of the brain. Some metabolic disorders will have characteristic brain imaging findings, more commonly diagnosed in children than adults.
Dementia is a diagnosis that is rapidly increasing in aging populations worldwide. Traditionally, CT and MRI scanning have been of limited use in this diagnosis. But a combination of clinical features and MRI features can help to diagnose dementia. PET-CT scanning, explained later in the interview, is a promising modality for future dementia imaging.
Finally, ultrasound, both foetal and neonatal, is usually the first imaging modality in the detection of foetal and neonatal congenital brain malformations. These are more optimally assessed by MRI.

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

SL: Brain imaging is very helpful and useful for physicians when patients present with neurological symptoms and signs. The physician will determine the differential diagnosis, the list of potential causes. Brain imaging will help narrow the differential diagnosis and often makes the diagnosis. Let's illustrate this by looking at brain imaging (CT and MRI) on three different patients. Each of these patients presented with marked weakness of the left side of their body. However, in each case the brain imaging shows there is a different cause.

Figure 1

Figure 2

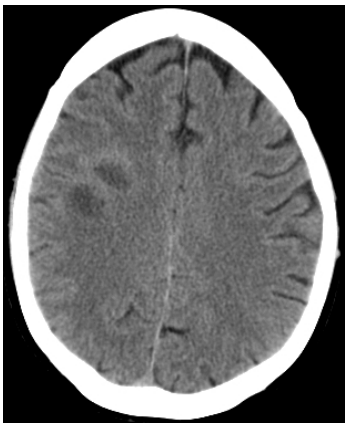

Figure 3

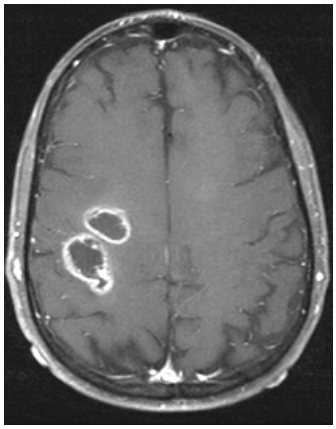

Figure 4

The patient in Figure 1 has a large haemorrhage or bleeding in the right side of the brain, which is the cause of the weakness. The patient in Figure 2 has a blood clot in the right middle cerebral artery (see red arrow), which has blocked the blood flow in this vessel, causing death of the brain cells supplied with oxygen from blood in the right side of the brain, i.e. a stroke. This is the cause of the weakness. Lastly, the patient in Figure 3 and 4 has a mass in the right side of the brain. On the MRI scan (Figure 4), it enhances with intravenous contrast indicating it is a high-grade brain tumour.
When patients present with neurological symptoms and signs, there are potential brain diseases that may cause them. Brain imaging helps in diagnosis, as management of each disease entity is different.

ESR: What kind of technology and techniques do radiologists use to image the brain? Are there any specific techniques for particular diseases?
SL: CT and MRI are the most commonly used modalities in brain imaging. CT is quick, fast and readily available in most hospitals around the world. It is of particular importance in the rapid diagnosis of stroke and in head trauma, where prompt diagnosis is necessary to improve patient outcome. However, it does carry the disadvantages of radiation exposure and does not demonstrate the brain

as optimally as MRI. MRI is the gold standard imaging modality for brain tumours and many primary brain disorders. However, it is time consuming, costly and not always readily available. Plain x-rays have a limited role, for example in the investigation of suspected non-accidental injury in paediatrics. Ultrasound is used in foetal and neonatal brain and spinal cord imaging. Positron emission tomography (PET) and PET-CT are promising as future modalities for the diagnosis of dementia.

ESR: What is the difference between a radiologist and a radiographer? Who else is involved in performing brain imaging exams?
SL: A radiographer is the person who performs the radiological test, be it the x-ray, ultrasound, CT scan or MRI scan. The patient will meet with the radiographer, who will generally explain the test to them and then perform it. A radiologist is a doctor who specialises in radiology. This is the person who looks at the x-ray, ultrasound, CT or MRI scan obtained and issues a formal report on it.

ESR: How many patients undergo brain imaging exams in your country each year?
SL: In my own hospital, we perform approximately 8,000 CT brain and spine studies a year and approximately 10,000 MRI brain and spine studies a year. The hospital is a tertiary referral centre for neurosurgery and neurology and hence has a large volume of neuroimaging.

ESR: Access to modern imaging equipment is important for brain imaging. Are hospitals in your country equipped to provide the necessary exams?
SL: In the Republic of Ireland, the country is divided into eight healthcare districts. Each district has a lead or tertiary referral hospital, with several smaller hospitals in the same district, a 'hub-and-spoke' model. Each tertiary care referral centre has two or three CT scanners and one to three MRI scanners. Each smaller hospital has one CT scanner and one MRI scanner. The equipment is modern and of a high standard in most of the centres. Like many other countries, clinical demand for neuroimaging and brain imaging continues to increase. There are significant waiting lists for outpatient MRI scans. As well as the public system outlined above, the Republic of Ireland has many private hospitals and a large number of Irish people have private health insurance. The private hospitals also have high-quality CT and MRI scanners, with minimal waiting times for scans.

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?
SL: In the emergency setting where a patient presents with a new diagnosis of stroke, brain haemorrhage or brain tumour, the patient is generally admitted through the Irish public healthcare system and will have immediate access to brain imaging. There are two hospitals in the Republic of Ireland that serve as neurosurgery centres, and most patients with brain haemorrhage and tumour will be transferred to these. Access to brain imaging for most inpatients in the Irish public healthcare system is usually quite prompt. Unfortunately, as also explained above, waiting lists for brain and spine MRI outpatient scans in particular are long, over a year in some hospitals. Many Irish people have private health insurance and can obtain MRI scanning privately.

ESR: As the global population gets older, the risk of developing neurocognitive and neurodegenerative disorders increases. How can imaging help tackle this issue?
SL: CT scanning has traditionally been of limited use in the diagnosis of neurocognitive and neurodegenerative disorders. Its main role is to out rule a reversible cause of either in an elderly patient, for example chronic subdural haemorrhage or a tumour.
MRI scanning is a little more helpful but certainly lacks specificity in diagnosis of type of dementia. The future of imaging in dementia is with PET-CT scanning, a technique that combines injection of a radionuclide, 18-fluorodeoxyglucose, to obtain a PET scan and fuses it with a CT scan. This is then a combination of functional and anatomical imaging. Newer radionuclides are in use and in development, which may be more specific in brain imaging. A lack of uptake of the radionuclide in different parts of the brain may help to diagnose and specify dementia in patients. The problem with PET-CT scanning is its cost and accessibility for what will be a large patient group.

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?
SL: Radiographers and radiologists work from the 'ALARA' principle, which stands for as low as reasonably achievable. X-rays and CT scans are obtained at the lowest dose required for diagnosis, i.e. the lowest possible radiation dose, but with the images of diagnostic quality. The radiographer and radiologist will ensure optimal use of all image dose parameters on the x-ray unit or CT scanner. Only the relevant body parts will be imaged, sparing the rest from radiation.
It is important that doctors, nurses and all health professionals receive training regarding radiation. For doctors, they have to ask: is an x-ray or CT scan really necessary for the patient? In the majority of cases it is, and prompt CT scanning, in the trauma setting for example, leads to prompt diagnosis and optimal management in many patients. In a case where a form of non-ionising imaging will answer the question, e.g. ultrasound or MRI, this will be chosen as the imaging modality. In general, the information provided by the x-ray or CT scan far outweighs the risk of radiation exposure. Patients with chronic diseases that require serial CT scanning over time are the patient group in whom radiation exposure is an issue. For most patients, the dose is so minimal that it is unlikely to ever result in an adverse effect, and the information obtained from the scan can be lifesaving.

ESR: What kind of role can imaging play in preventing and predicting brain diseases?
SL: It is a combination of radiological imaging and preventive and treatment paradigms that prevents and predicts brain disease. Stroke remains one of the most common causes of morbidity and mortality worldwide. Brain imaging can promptly diagnose stroke and the cause of the stroke. A CT angiogram study can demonstrate occlusion of a major artery to the brain, which can then be removed endovascularly, i.e. through puncturing the common femoral artery in the leg and guiding a stent retriever device through it to the occluded artery in the head. There are over 20 randomised controlled trials going on in the world currently regarding this treatment. If they show a benefit to patients receiving this treatment, then it will dramatically change the management of large vessel ischaemic infarct or stroke. The first step in this treatment paradigm is CT brain scan and CT angiography scan of the neck and head. Brain tumour management has changed and improved around the world in recent years. CT and MRI scans of the brain predict the tumour type and determine treatment plans including surgery, chemotherapy and radiotherapy. Complications are also diagnosed by brain imaging, helping clinicians with patient prognosis. Lastly, dementia remains a significant health epidemic worldwide. Treatments for it remain limited, but some subtypes, e.g. Parkinson's disease and Parkinsonism symptoms, benefit enormously from appropriate drug therapy. Neuroimaging can help exclude reversible causes of dementia and with future improvements may predict and subcategorise dementia types.

Seamus Looby *is a consultant neuroradiologist in the department of neuroradiology of Beaumont Hospital in Dublin. He did fellowships in neuroradiology at Thomas Jefferson Hospital in Philadelphia and the University of Virginia in Charlottesville, USA. He specialises in diagnostic neuroradiology, head & neck radiology, and CT-guided neuroradiological procedures. He has a diploma in medical management for doctors from the Royal College of Surgeons in Ireland.*
Dr. Looby is one of the founders of the Irish Society of Neuroradiology, which held its first ever meeting in June 2014 in Dublin. He has participated in many Irish and European radiological and neuroradiological courses and meetings. He has authored or co-authored more than 20 original papers, two book chapters, and is a reviewer for five journals.

Images: Courtesy of Dr. Looby