Interventional Cardiology

Interventional radiology – current practice and future developments

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Can you tell us a little bit about your background & what first drew you to the field of cardiovascular imaging & vascular interventional radiology?

I graduated from Edinburgh Medical School (University of Edinburgh, Edinburgh, UK) in 1982 and went on to train in medicine and cardiology. I then become a research fellow at the Non-Invasive Unit at Killingbeck Hospital Leeds (Leeds, UK) and was involved in the development of cardiac Doppler ultrasound, which was central to my thesis into diastolic filling patterns of the left ventricle. Back in 1988, we were also the first unit in the UK to introduce a transesophageal echo service, which was a very exciting development for cardiac imaging. At that time, there was immense development in the imaging of cardiac structures and, at the same time, rapid development in cardiac intervention. My interest in cardiovascular imaging and intervention continued to grow and after completing my research I undertook 5 years of training in radiology at Bristol Royal Infirmary (UK). After that, I spent a further year's fellowship at Green Lane Hospital in Auckland (New Zealand), which was the major cardiovascular center for the South Pacific. I took up my consultant post in 1995 and have specialized in cardiovascular imaging and intervention, becoming increasingly involved in the management of aortic and peripheral vascular disease.

What imaging modalities are available to radiologists & how do they differ?

A wide range of imaging modalities including planar imaging, computed tomography (CT), MRI, ultrasound and newer techniques such as PET are available. They are utilized in a variety of combinations, depending on the information required and the nature and complexity of the interventional procedure which is being planned. Imaging approaches vary between centers and often reflect local expertise. In most vascular patients, initial assessment is undertaken by duplex ultrasound, avoiding the need for ionizing radiation. Increasingly, patients also undergo pre-interventional assessment using magnetic resonance angiography, which is of particular value in planning interventions in the aorta and iliac vessels. Multi-detector row CT is the mainstay for the planning of endovascular abdominal and thoracic aneurysm repair and in follow-up after stent–graft deployment. Catheter angiography is now largely reserved for interventional procedures, but there are still occasions when

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this remains the most appropriate diagnostic modality. Additionally, angiography allows us to proceed immediately to intervention, which can be critical in emergency situations such as uncontrolled hemorrhage. When I started out as an interventional radiologist, most patients would have a diagnostic angiogram, but that's very rare these days as we can now get the information via noninvasive methods in all but a few cases, which has been an important step in reducing overall radiation burden. Obviously, the less x-rays used, the better it is for both the patient and angiography room staff, and so another important potential application of these newer imaging techniques is to develop interventional radiology (IR) procedures performed without fluoroscopy. Already there are a significant number of interventional procedures that can be performed under ultrasound control, and a great deal of work has already gone into developing the equipment and techniques required for guidance using MRI.

There are many various catheters & devices that an interventional radiologist might use during a procedure. How do radiologists determine what equipment is most appropriate & most effective for each procedure?

Anyone who goes through radiological training will be largely based in a central unit that has its own particular caseload and case mix. While training to perform a wide range of procedures, be those either angiographic or in solid organs, trainees will learn all about the different types and applications of angiographic and therapeutic catheters and why certain shapes or designs might or might not be appropriate in a given situation. Each doctor will have a background in general training related to the application of devices, from different types of catheters and guidewires, moving on to different types of balloons and stents or the materials needed for embolization procedures. There is a large bank of shared knowledge and then a lot of it comes down to personal preference. An interventional radiologist that has many years of experience will have a basic kit of several catheters that they commonly use and will keep other things in reserve for more difficult or unexpected situations. There is not a prescription that says you must always use 'this catheter' to do 'this procedure' but there is a lot of experience that directs us as to when to use certain devices and at the same time, specialists will have their own chosen devices that they prefer over others.

When it comes down to issues such as choosing one stent over another, there is some science in it as some devices will work better in certain anatomical areas and in the presence of certain types of lesions, but a lot of this is not terribly well supported by good randomized data. Devices are carefully developed and tested, but often the clinical research behind them is not thorough enough to be conclusive. Partly, this is owing to the speed with which interventional devices are being developed and brought to the market. Before one product has been thoroughly evaluated, a newer generation or alternative is already available and we move on. However, despite the lack of randomized data, there is a substantial evidence base from cohort and observational studies that supports the enhanced outcomes that we can achieve by using these modern interventional devices.

How do physicians determine which patients should undergo interventional procedures & whether a patient is suitable or not?

If you look back over the last 30 or 40 years, the use of imaging and the use of image-guided intervention has completely changed the way that medicine is practiced; it is probably the most fundamental event that has happened during my time as a doctor. Increasingly, patients who are sicker and sicker are being referred for these noninvasive procedures. To a large extent the conventional disciplines, such as open vascular, aortic or cardiac surgery, have been altered fundamentally as more and more patients can be treated by these techniques. I think in many instances, this has become the starting point rather than the alternative; if somebody needs an intervention, they are going to have a noninvasive image-guided interventional procedure as opposed to conventional surgery. This makes perfect sense in terms of a number of factors including patient acceptability, reduced mortality, faster return to normal life and important cost savings. However, there are still some groups of patients who, for various reasons, are better treated using conventional surgical procedures. For instance, very long occlusions of the femoral and below-knee arteries may have a superior long-term patency if treated using surgical bypass and this is likely to be important in younger patients who have a higher life expectancy. However, as technology develops, an ever greater proportion of these lesions can be treated using a catheter-based approach by balloons and stents and endografts. The whole situation is very dynamic but we all expect a progressive shift to minimally invasive procedures for all but a minority. But we must not forget that there is still a definite balance between conventional surgery and intervention, and proper selection of patients by means of multidisciplinary meetings is essential to ensure the right treatment for the right patient; self-referral by the inves-

tigating physician should never happen. It is also important that, as interventionists, we do not lose sight of the wide range of pharmacological and other therapies that are available and under development. For instance, in some cases, a program of supervised exercise may yield equivalent long-term results to angioplasty for the patient with claudication.

In your opinion, how has interventional radiology shaped the medical field over the last 50 years?

I think it has changed medicine out of all recognition. In 1964, by introducing the concept that a diagnostic catheter could be modified to deliver treatment, Dotter effectively invented IR as we know it. When I was a junior doctor, back in the 1980s, we simply could not do most of the procedures we have now; they just weren't there. You could not take a patient that was facing amputation and perform thrombolysis, angioplasty, stenting or whichever other procedure was needed to save their limb or life, yet this is something that is now a matter of routine. I can remember the early clinical trials of systemic thrombolysis for myocardial infarction; my cardiological colleagues now undertake immediate percutaneous intervention in such patients on a scale that would have been unimaginable 30 years ago. We can treat symptomatic carotid disease, mesenteric and renal arterial disease in the same way. In more recent times, interventional techniques have come to the fore in the management of catastrophic gastrointestinal and obstetric bleeding and in the management of polytrauma. Clearly, developments in imaging have been key to this; we previously could not image patients in the way that we now can. Small and early lesions can be detected and accurately characterized and then, instead of major invasive surgery, we can manage these lesions using an array of microinvasive procedures. Earlier and less invasive treatment for malignancy represents an important change in the way we will continue to develop and practice medicine in the coming years.

What have been the most prominent advances? Has there been a single procedure that you think has had the most impact?

Of course there are important interventional radiological procedures for every part of the body and every system, arguably with the exception of the skin. If you look back over the development of IR year on year, you can pick out significant advances that have not only increased the scope of our work, but have improved outcomes and offered better patient safety. However, if I were to single out a development that I personally think has been revolutionary, it would be the endovascular treatment of abdominal and thoracic aortic aneurysms. When I was a fellow in Auckland in 1994, I remember reading reports of Parodi's first experimental cases of endovascular aortic repair. Across the globe we now routinely undertake aortic repair replacement of the aorta by using minimal surgical or even percutaneous access. While that is still a major procedure, it has completely changed the way that we look at dealing with a major life-threatening condition. The need for major surgery in literally millions of patients has been removed by the progressive development of image-guided procedures.

How significant a health risk does routinely working with radiation pose for radiologists?

The effects of absorbed radiation and radiation protection is a vast and complicated subject in itself, but there are important aspects of this topic that everyone working with ionizing radiation must be familiar with. The history of radiology cites many of the early radiologists who did succumb to the effects of radiation; they developed cancers and other problems as a result. Again, within living memory, radiologists used to look directly into the x-ray beam when performing fluoroscopic studies. Modern digital radiological equipment with advanced beam filtration, pulsed fluoroscopy and image intensification has dramatically reduced doses to patient and operator. Nevertheless, minimizing radiation exposure to staff is of paramount importance. No recent studies have demonstrated a clear link between the development of malignancy or other causes of mortality in interventional radiologists or radiographic staff but adherence to careful technique and radiation protection measures is essential in reducing cumulative dose for workers. It has been suggested that a typical interventional cardiologist may have a cumulative lifetime attributable risk of one cancer per 100 exposed subjects. One important concern that has been highlighted is dose to the eye and recent revisions in European law will significantly reduce the acceptable recorded dose for workers and may lead to restrictions in the amount of activity some operators are able to undertake. The simple message to everyone involved in fluoroscopically guided procedures is that all reasonable steps must be taken to minimize cumulative lifetime dose and if these precautions are followed then risks are minimized. However, personal dosimetry remains an essential part of our daily work – modern real-time telemetric dosimetry may prove particularly valuable in helping angiography laboratory staff to adopt better practice with regard to radiation protection.

What is your opinion on the recent ESC position document on appropriate & justified use of radiation in cardiovascular imaging?

I suspect that when it comes to an awareness of the doses and risks to patients associated with cardiac imaging, many cardiologists are, as the authors state, imperfectly aware of the potential effects of the imaging studies they request or supervise. The paper clearly and succinctly reiterates the long established ALARA principle (as low as reasonably achievable) for imaging studies that utilize ionizing radiation. We know that medically administered ionizing radiation now makes up the greatest part of the radiation burden on society as a whole. The substantial increase in coronary CT has raised justifiable concerns regarding radiation exposure but with technological improvements and prospective gating, this burden can be significantly reduced. Nevertheless, overuse of CT in young patients should remain a concern across both radiological and cardiological communities. I would recommend that all readers refer to this paper [1].

In your opinion, what are currently the most important research areas in interventional radiology?

There is certainly a great deal going on but it is worth picking up on a small number of potentially very important developments. Restenosis after intervention remains the Achilles' heel of endovascular treatment in all anatomic territories, but is a particular challenge in the infra-inguinal arteries. The introduction of drug-eluting devices has already yielded some promising data with regard to improved primary patency although, as yet, this has not definitely translated into better clinical outcomes. A cost–effective adjunct to conventional angioplasty with clearly demonstrable improvement in long-term outcomes would be of great benefit in the population of claudicants and critical limb ischemia, many of whom require repeat procedures to maintain vessel patency. The use of renal sympathetic denervation for the treatment of resistant hypertension is currently big news. Surgical sympathectomy was attempted years ago and this catheter-based therapy could offer important health benefits to many millions. At present, uncertainty over the efficacy (but not the safety) of this procedure has been raised following the Simplicity trial and we await presentation of its results to determine where we go next with this procedure. Certainly it would be unusual to abandon any treatment on the basis of one randomized study alone, and further carefully controlled studies of this technology will be vital.

Looking further into the future, it is likely that simulation and robotics will play an increasing role in interventional therapies. In fact this technology is already available, but real challenges are still to be overcome with regard to the effects of respiration, movement and cardiac pulsation. Eventually, it will be possible to use the datasets derived from CT, MRI or angiographic studies to guide interventional procedures either remotely or using automated systems. One can imagine that for procedures such as selective internal radiotherapy or transarterial chemoembolization, robotics could have a significant advantage in reducing operator risk.

Can you explain a little bit more about your own current research interests?

The northeast of England, where my hospital is based, has a very high incidence of advanced atherosclerotic disease. We treat a great number of patients with diabetes and frequently encounter patients with severe ischemia of the lower limbs. We are very interested in how to best treat those patients and looking at strategies to improve the long-term outcomes of intervention and reduce rates of amputation. We have a particular interest in the use of thrombolysis in the management of native vessel and graft occlusion, and for the treatment of massive pulmonary embolus. Like many other centers we are involved in the evaluation of renal sympathetic denervation and we are also in the early stages of a study looking into the use of drug-eluting balloons in patients with dialysis access problems. The unit also has a significant experience in the investigation and management of acute aortic syndromes and we have recently published treatment algorithms for the management of patients with penetrating atherosclerotic ulcers of the aorta.

You previously held the position of Head of Training for radiology in East Yorkshire. Can you tell us a bit about the training that interventional radiologists undertake and what some of the most difficult aspects are?

The approach to training in IR has improved in leaps and bounds over the past few years. Importantly, IR became a subspecialty in 2010 with the requirement that trainees undertake 6 years of training to become accredited. Trainees can elect to follow higher training in vascular or nonvascular intervention and this is carefully mapped to a separate IR training curriculum. I think that one of the biggest challenges we still face relates to the selection of suitable IR trainees. Some doctors seem to be innately better suited to interventional work than others but, as yet, we have no reliable methods of identifying these individuals through established interview and selection processes. Perhaps in time some form of validated practical assessment or simulator-based task will be developed to help with this. In any

case, I have observed that trainees can develop competencies at quite different rates, and so a faltering start to interventional work does not necessarily predict a poor training outcome. At the outset, most doctors find the whole prospect of interventional work rather difficult as it is a completely new concept, almost like learning to drive a car, which involves skills both in observation and manipulation of objects in three dimensions. So training is a long process and one which requires a significant investment of time and energy on both sides. Our juniors are taken through a basic spectrum of procedures that involve both vascular and nonvascular interventions and build these skills up gradually over a period of many months. There will inevitably be mistakes along the way, but a good trainer makes all the difference to the junior's progress.

By necessity, training for intervention involves risk and for this reason the greater use of simulation may prove invaluable in developing the skill sets needed to operate on live patients. From fairly humble beginnings, virtual reality simulators have developed to a fairly high degree of sophistication and 'reality'. Before the trainee undertakes a new procedure on a live patient, they have the opportunity to rehearse the basic steps 20 or 30 times on the simulator. As CT and angiographic datasets can be loaded into some simulators, the level of simulation comes closer to real life and can be used to plan interventions for individual patients. The next step in the development of this technology will involve 'virtual immersion', whereby mechanical simulation and an enhanced virtual environment can be coupled to rehearse complex scenarios. Our local university, the University of Hull (Hull, UK), has developed such a facility and a trip to the Hull Immersive Visualization Environment, or the HIVE, as it is known, is quite mind blowing.

Of course, time spent as an interventional trainee is really just the beginning of a lifelong learning process. It takes years of experience to become competent in interventional procedures and even after 10, 20 or 30 years in post, we all still encounter situations that are new and difficult. One of the challenges, and also one of the most enjoyable aspects about being an interventional radiologist, is that you are never really completely 'there' – there's always something to learn.

How would you like to see the field progress in the next 5–10 years?

I think we need to continue to develop interventional radiology (IR) as a clinical specialty, by which I mean interventional radiologists should be closely involved in the day-to-day management of patients by taking part in ward rounds and holding outpatient clinics; and many radiologists are already doing that.

As president of the British Society of Interventional Radiologists, I have been closely involved in curriculum development for the next generation of interventional trainees. This new IR training curriculum was approved by the General Medical Council at the beginning of 2014 and represents a significant advance for subspecialty training. IR sits in a slightly strange position as many patients (and quite a lot of doctors) still do not really know what we can offer. But IR now occupies a pivotal role in the treatment of patients referred by many other services and the clinical aspects of the service continue to grow. So we will continue to look at ways of taking the specialty forwards to make it more clinically based. This will not only help to further improve the patient experience, but offer the substantial time and cost efficiencies that are increasingly important in modern healthcare.

We know from surveys that have been conducted by the NHS in England and by the British Society of Interventional Radiologists that there are still not enough interventional radiologists in post. It has been calculated that at least 200 more interventional radiologists are needed to provide 24/7 out-of-hours cover for England. If you live in certain parts of the UK, and are, for example, a young woman who suffers postpartum bleeding, the on-call IR team can perform a life-saving embolization procedure. But elsewhere such services may not be available and that's because of a lack of properly trained interventional radiologists. This is not an acceptable long-term situation. There is no doubt that the number of consultant interventional radiologists has to increase and this is currently under discussion between the Royal College of Radiologists and Health Education England.

Do you think there are ways to attract more junior doctors to specialize in interventional radiology?

I think a big part of the problem is that a lot of people don't quite understand what IR has to offer; that applies both to the general public and to doctors who work both in the primary care setting and in hospitals. Radiology still isn't very well represented in the curricula of our medical schools, but this has steadily improved and opportunities for senior medical students to spend time in IR are offered in an increasing number of departments. The BSIR ran a very successful study day this year at our annual scientific meeting, where medical students came along and were able to listen to talks about IR, attend the scientific presentations, get into close contact with interventional radiologists and find out more about the career path. I think these undergraduate opportunities and the increased dissemination of information about IR are key to attracting people into the specialty.

What else does the future hold for interventional radiology?

IR has become a very wide specialty and it continues to grow with further opportunities for subspecialization. Whereas I perform mainly vascular interventions, other interventionalists subspecialize in the treatment of renal and bone tumors or use their expertise in the management of hepatobiliary conditions. Pediatric intervention and neurointervention exist as further subspecialist disciplines which, while beyond the scope of our discussion, have had an enormous effect on patient care. We can expect further expansion for IR as the detection and need for treatment of early cancers develops. The population is aging and the effects of an increased incidence of diabetes and obesity will impact further on IR services. Finally, greater recognition of the role of IR in service delivery by managers and commissioners will be an important driver to develop interventional services as an alternative to conventional surgery.

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Financial & competing interests disclosure

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No writing assistance was utilized in the production of this manuscript.

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1 Picano E, Vañó E, Rehani MM *et al*. The appropriate and justified use of medical radiation in cardiovascular imaging: a position document of the ESC Associations of Cardiovascular Imaging, Percutaneous Cardiovascular Interventions and Electrophysiology. *Eur. Heart J.* doi:10.1093/eurheartj/eht394 (2014) (Epub ahead of print).