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Focus on Interventional Radiology Equipment: Technology Drives Clinical Practice

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Interventional radiology (IR) refers to a wide range of minimally invasive procedures in which radiology equipment is used to guide interventions, such as stenting, biopsy, embolisation, and ablation.While guidance can be achieved with various radiologic modalities, including fluoroscopy, ultrasound, computed tomography, and magnetic resonance, the term interventional radiology usually refers to the use of x-ray fluoroscopy-based equipment. In recent years a number of technological developments have increased the usefulness of IR.This article will review the improvements in IR equipment and the possibilities for the future.

Flat Panel Technology

For many years, image intensifiers mounted on a Carm have provided useful service and this technology can be considered mature. However, image intensifiers are not only bulky but are also susceptible to image distortion and have limited dynamic range. Flat panel detectors offer a number of advantages.

Electronic flat panel detectors were first developed to provide digital radiography without the need to transport image cassettes between the patient and the image plate reader, as is necessary with computed radiography. Cutting out the transport step means that images are available within about ten seconds of an exposure, so efficiency is greatly improved. The next development was to modify the radiographic detectors for fluoroscopic use. To achieve this modification two significant differences needed to be addressed: fluoroscopy uses much lower x-ray dose rates and image read times of up to 60 frames per second are necessary.

Adoption of Flat Panel Technology

The first commercial flat panel detector was introduced in the late 1990's by Marconi (previously known as Picker, now part of Philips) as an add-on to the Mx8000 CT system. The FACTS (Fluoro-Assist Computed Tomography) was designed to help CTguided interventional procedures by allowing greater access to the patient than is possible with CT. However, the concept never gained wide clinical acceptance. In 2000, GE Healthcare introduced a cardiology interventional system, the Innova 2000. This was truly the first fluoroscopy flat panel to gain widespread acceptance for an interventional application. Cardiology was chosen first since a relatively small detector is sufficient. Cardiologists quickly recognised the advantages of the flat panel, for example, the lack of distortion and even image quality. What is more, the flat panels are physically smaller, so they are less obtrusive. So, despite the higher cost (about $200,000 or more), flat panel-based cardiology systems quickly replaced image intensifier based systems. Technical issues, in particular the detector size issue and the higher cost, meant that general radiology interventional systems were not yet available. However, as the detectors improved it was inevitable that image intensifier based interventional radiology would become obsolete.

Reduced Radiation Dose

At the same time the greater computer power becoming widely available enabled manufacturers to improve capabilities. Some developments were made that significantly reduced radiation exposure. For example, last image hold, virtual collimators, and fluoroscopy storage all help reduce the amount of fluoroscopy time and, therefore, the radiation dose.

Image Processing Presents More Information

All fluoroscopy images are two-dimensional. Anatomy, however, is three-dimensional. In applications in which more 3D information is essential, the traditional approach was to use a biplane system. The resulting two orthogonal views help neuroradiologists and paediatric cardiologists gain an accurate understanding of vasculature. The other solution is to use CT. CT fluoroscopy is widely used, particularly for biopsies. However, the limited coverage (present day CT systems have a maximum of 4 cm), the high doses to the operator, and the limited access to the patient, mean that CT fluoroscopy is limited. Also, judging by the very limited adoption of the FACTS system mentioned above, neither is a combined CT and fluoroscopy system a practical solution.

3D Angiography

However, this increased computer power enabled the development of rotational angiography. The idea is that the C-arm can rotate 180 ∞ around the patient while capturing multiple images. The images can then be backprojected, in much the same way as in CT, to produce a 3D depiction of the anatomy. Angiography was the first application of this, since it is inherently high contrast, on account of the contrast media, allowing the use of low x-ray doses. The earliest implementations were limited due to the five minutes needed for reconstruction. As more computing power was added and the algorithms improved, this delay has been significantly reduced, so that a few seconds is all that is required.

The 3D angiography technique has now been extended to produce more CT-like image performance: in other words, better soft tissue contrast. The idea is that CTlike images can be acquired during an interventional procedure without having to take the patient to a CT scanner midprocedure. The images, while of insufficient quality for diagnosis, are good enough to guide therapeutic applications. In fact, while interventional CT images don’t have the same contrast resolution found in diagnostic CT, the spatial resolution is better.

Flat Panels Become Necessary for IR

While these applications are theoretically possible with image intensifier-based equipment, the wider dynamic range, high uniformity, and distortion-free image quality mean that flat panel systems are necessary. So, flat panel detectors can now be found on interventional radiology systems from all major manufacturers. More recently, healthcare facilities have a greater variety of biplane flat panel systems to choose from. So, the use of image intensifiers is shrinking. It is mainly due to cost considerations that the radiographic/fluoroscopic systems used in diagnostic applications are still equipped with image intensifiers.

What About the future?

Minimally invasive procedures are becoming increasingly important. Flat panel technology will improve, allowing further dose savings and higher resolution imaging. The present limitations on frame rate will be improved. But the area with the most benefit to patients will be the addition of more robotic technology and other automated guidance techniques. For example, one technique that already exists is magnetic guidance of catheters in cardiology. Such a technique would be impossible with an image intensifier on account of the magnetic fields. But with 3D data sets it is possible to guide a catheter through the tortuous vasculature with far greater precision and, therefore, safety.

Another example is the addition of an xray imager on an MR system. MR cannot provide real-time images and makes it extremely difficult to access the patient. But MR does provide soft tissue contrast that is simply unobtainable with x-ray-based imaging. So, combining the two modalities promises significant advantages.

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