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EDITORIAL

Dual-modality imaging

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We are now entering an exciting time in the development of medical imaging technology. As elegantly described by Townsend and Cherry in this issue of "European Radiology" [1], the hardware is now available to acquire combined CT and positron emission tomography (PET) scans in a single sitting and there are continuing advances in the development of combined MRI and PET systems. There is little doubt in the minds of most nuclear medicine and radiology specialists that the fusion of images between separate modalities can be of considerable help in guiding patient management in numerous circumstances. This is particularly true when functional images [e.g. PET or single photon emission CT (SPECT)] can be fused with anatomical images (e.g. CT or MRI) so that the strengths of the individual modalities can be exploited and the limitations minimised.

However, numerous questions remain to be answered. It is clear that fused images are not required for all imaging studies and it will be necessary to attempt to identify those clinical areas where dual-modality imaging is most effective in influencing patient management and outcome. This is particularly true in the current situation of limited health care resources and in the interests of limiting the radiation burden to the patients to the minimum that is required for diagnosis.

The next question is to decide what type of image fusion is required for a particular clinical situation. For example, in many cases it may be sufficient to interpret functional and anatomical images side by side on the same viewing box or workstation without the need for more formal registration or acquisition of a combined scan. Software algorithms continue to improve so that retrospective image registration is more robust. This is especially so in the brain, but even in the rest of the body where some limitations in the accuracy of registration still exist, they may prove adequate for many situations. In addition, this would be the most suitable method for comparing sequential studies from a single modality whether it is anatomical or functional; however, the work involved in retrospective image registration should not be underestimated. Even if there is prospective optimisation of each modality's scan acquisition to facilitate subsequent registration, it can be a time-consuming and labour-intensive procedure that may limit the routine use of this technique in some institutions.

A combined functional/anatomical scanner would potentially facilitate the seamless production of fused images and probably currently offers the most accurate superimposition of functional and anatomical data. This might be especially advantageous when accurate localisation is required to plan or guide surgery in areas where vital structures neighbour disease or in anatomically complex regions such as the head and neck or abdomen and pelvis. It might also improve accuracy of transcutaneous biopsies by not only identifying the site of disease in relation to surrounding structures, but also by reducing sampling error by guiding biopsies to the viable regions of heterogeneous tumour masses. Image fusion may be particularly important in the post-operative or post-therapy setting where anatomy may be distorted or where fibrous scar tissue exists. There are nu-

merous normal variants of ^{18}FDG uptake that may mimic malignancy and accurate fusion of anatomical and functional images may also help prevent potential pitfalls and misdiagnosis in these situations [2, 3]. Another area of importance for dual-modality scanners is in planning radiotherapy where efficacy could be potentially improved and toxicity minimised when compared with the current practice of using CT images alone [4].

By including top-of-the-range equipment for each modality in a combined scanner, it might be possible to use such a machine as a single-modality device (e.g. CT alone or PET alone) in those departments where the requirements for fusion imaging are not enough to employ the combined scanner full-time. Many patients currently undergo both anatomical and functional scanning as a routine, without necessarily fusing images, and so the device might aid efficiency and reduce waiting times, notwithstanding any additional diagnostic benefits resulting from fusion images. In the interests of limiting radiation exposure it would be important to coordinate an individual patient's imaging investigations so that a normal diagnostic CT scan would not be performed on a single-modality scanner in addition to a combined PET/CT scan, the latter being purely for image fusion purposes. It might also prove difficult to resist the temptation to acquire dual-modality studies simply because of the availability of a combined scanner. Without taking some of these factors into account, smaller departments may not be able to justify the need for a combined modality scanner and it is likely that these devices will be initially limited to larger departments. This may well be where separate CT and PET facilities already exist and where the image fusion workload is predicted to be high.

Other manufacturers have combined SPECT (or coincidence PET) with lesser performance X-ray-tube-based CT systems, with the advantage of lower capital cost but lower-resolution anatomical information. There continues to be some disagreement as to whether combined systems should compromise on either of the imaging modalities, but there seems to be a trend for manufacturers to develop combined scanners with performance towards the top end of the range for each modality.

Other areas that will require thought, if such systems are to be utilised efficiently, are in the training of technical personnel to operate combined scanners and the training of imaging clinicians able to interpret both modalities, or at least, an increase in effective liaison between radiologists and nuclear medicine specialists.

Townsend and Cherry describe some of the technological difficulties in the different methods of fusing images [1], how many of these have been overcome and how the introduction of combined scanners may be a further improvement in this technology. They also give an insight into what is expected in the future from this developing field. The currently or imminently commercially available CT/PET scanners offer high-resolution anatomical image fusion with good-quality PET scans. There is the additional benefit of providing low-noise attenuation correction with the prospect of improved PET scan quality and quantitative accuracy. The extra radiation dose would probably not be justified if the CT scan were only used for attenuation correction purposes, however. Although combined scanners are likely to improve the accuracy of image fusion, some inaccuracies still exist, for example, related to respiratory chest movement differences between fast CT and slow PET acquisitions. As the two scans are not acquired simultaneously, the risk of patient movement between scans will also remain.

Nevertheless, image fusion is an exciting area where there is the potential to positively influence patient management, particularly in the field of oncology. The availability of combined scanners is a significant further step towards this goal and this should be taken as an opportunity to further integrate radiology and nuclear medicine for the benefit of patients. However, the planning, organisation and provision of clinical image fusion technology is not trivial and the priority should now be to scientifically investigate in which types of clinical indication there will be a significant benefit over and above current practices.

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