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Medical Fusion Imaging: Paving the Way for Better Diagnosis of Tumours

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Medical imaging involves creating images of the human body to assist medical practitioners in effective clinical diagnosis. A number of imaging techniques have been developed over time that not only help in anatomical diagnosis, but also assist in functional diagnosis. The imaging scenario has continuously evolved from x-ray film and cassettes to using computers and digital techniques. The aim of such reinventions in imaging techniques is to provide excellent patient care, without compromising on accuracy of diagnosis. As technology evolved, for accurate diagnosis different imaging modalities were being used one after another. The clinicians obtained physiological and anatomical information on separate machines. These images were viewed together after using special registry software to superimpose images from each of the participating modalities. Recently, there has been an improved need to utilise different modalities together for effective diagnosis, and this has promoted a novel hybrid technology called fusion imaging.

Fusion imaging is a combination of two independent imaging modalities, where one depicts an organ's functional aspects, while the other modality aims at indicating the anatomy of the organ. The combination of modalities provides a level of diagnostic superiority that allows clinicians to achieve unparalleled accuracy in diagnosis. The most advanced hybrid fusion imaging equipment is capable of performing examinations of two different modalities simultaneously. The resultant image data is merged automatically, forming a composite image. Fusion imaging, by bringing together the molecular function and anatomic form on a common scale, helps in understanding the human body with a very high level of precision. The first commercial hybrid fusion imaging machine in 1995 was a combination of Computed Tomography (CT) with Single Photon Emission Computed Tomography (SPECT). This CT-SPECT hybrid was later followed by a more ad vanced combination where Positron Emission Tomography (PET) is combined with CT imaging.

Advancing technology drives the need for better ways to acquire clinical information by non-invasive means. Medical decision making is now being supported by a wide choice of imaging technologies. Conventional cross-sectional imaging techniques like CT have important roles to play in non-invasive diagnosis. CT scans are highly efficientin anatomical diagnosis. However, CT can be incapable of non-clinical malignancies that have a potential to metastasize and become difficult to treat. Nuclear medicine procedures like PET and SPECT are the best known techniques that identify the metabolic function of an organ. These techniques are excellent indicators of tumours and malignancies, but the exact location of the tumour may go undetected. When combined with a CT system, the tumour detected by the PET can belocated on the anatomical representation from the CT image. By integrating different, but complementary working principles, imaging technology can be used to provide highly efficient non-invasive diagnosis of tumours. The potential of these technologies to enable effective treatment planning for radiation therapy drives the demand for such hybrid imaging machines. A PET-CT scan offers a precise reference point for radiation therapy by indicating the functional attributes of the tumour and indicating where to target the radiation. This ensures that the tumour receives maximum radiation.

PET-CT Fusion Imaging

PET-CT fusion imaging combines PET with 16 slice CT modality. PET is an excellent indicator of tumours, while CT forms the anatomical base in the fusion image. PET, as a nuclear medicine procedure, is performed by injecting 15-fluorodeoxyglucose (FDG) intravenously. The glucose in FDG is taken up by the tumour cells that seek high levels of sugar in comparison to the other cells. As a result of this sugar seeking behaviour, large amounts of FDG are absorbed into the malignant tumours, hence making the smallest of tumours visible in the scan. Through PET alone physicians can effectively identify potential tumours, with an uncertainty about the exact location, while CT provides the anatomical details. PET-CT fusion imaging merges the best of the two worlds. PET-CT not only can identify cancers, it also plays an important role in radiation therapy by monitoring how tumours respond to chemotherapy treatment. The major advantages of PET-CT are:

• The ability to correct attenuation of PET using CT image as co-efficients.

• This enables analysing all PET derived biochemical information on a common single morphological volume.

The limits of PET-CT are:

• In some clinical cases, PET-CT fusion imaging may not meet the adequate requirements for diagnosis.

• With time PET-CT hybrid may become very routine, with increasing demands for new research targets for fusion imaging.

Drivers of Fusion Imaging

• Cost cutting in healthcare institutions across the globe calls for excellent management strategies that are cost-effective.

Fusion imaging is a cost-effective approach whereby the cost of two different imaging technologies can be reduced by combining both technologies into one.

• Earlier, software registrations were used to fuse images from two individual modalities. Though this added clinical value as it was a well-developed approach, with advancement in technology, a need developed for a far more innovative hybrid that could perform what the software does, in a single machine automatically at a lesser cost.

• An increasing demand for effective treatment of various cancers using non-invasive means encourages research to develop more variants of hybrid fusion imaging technologies.

• Advancements in computation power provide flexibility for real time image fusion using independent imaging technologies combined into a single hybrid, in a cost effective and affordable manner. In an attempt to streamline workflow, hybrids play a crucial role as the patient is needed just once for performing diagnostic analysis.

Limitations of Fusion Imaging

• Fusion of images from two incompatible modalities is possible using software registration, but a hybrid system for these modalities is not feasible.

• In an individual CT examination, an average of four to five patients is scanned every hour. But in a hybrid system fusion scan, an average of 12-15 scans can be performed in a day. Therefore this makes the process of scanning more elaborate.

• Operating personnel are expected to have advanced qualifications in order to understand the regulations of operating hybrid equipment.

• In hybrid hardware integration, the technology of the constituents of the fusion may lag behind individual modalities, due to development required in terms of research, time and money. Though there is high emphasis on information sought rather than the technology used, with extended research and new biomarkers being developed all the time, strategies that are applied today may be outdated in a few years' time.

Conclusion

The most important criteria of fusion imaging are obtaining best image quality while delivering minimum radiation dose. Hybrid fusion systems form the core of fusion imaging and hold the key for advancements in the future. There is much research that is looking into different types of multimodality fusion, and the hybrid technology still has a long way to evolve. The PET-CT technology has been competent in tumour non-invasive examination, and the difficulties that were posed initially have been successfully overcome. But emerging fusion technologies involving magnetic resonance (MR) and ultrasound, like PET-MR, having shown promise during research, still have a long way to go before being applied for full scale diagnosis. The main aim for developing fusion imaging technologies was to provide high quality patient care. In order to ensure that the patient gets the best service, emphasis has to be on training the personnel to perform the fusion imaging procedures. In spite of the continuing debate regarding the efficiency of hybrid fusion imaging like PET-CT, it has been observed that healthcare institutions are adopting the technology rapidly, hence showing explosive growth. The promising performance of fusion imaging in effectively identifying tumours and targeting radiation for various malignant cancers, including but not restricted to hepatic cell carcinoma, pulmonary nodules, colorectal cancer, melanomas and lymphomas, is expected to encourage more research to develop a number of advanced hybrid modalities for fusion imaging.

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