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Advancements in Noninvasive Imaging Techniques for Cellular and Molecular Disease Understanding

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Commentary

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DESCRIPTION

Noninvasive imaging methods have demonstrated significant potential in aiding the comprehension of diseases at the cellular and molecular levels. As defined by the Society of Nuclear Medicine, molecular imaging refers to the capacity to observe, characterize, and comprehend cellular and molecular processes in humans and other living organisms. The substances that facilitate this capability are known as molecular imaging agents. Molecular imaging encompasses a field of imaging that furnishes both anatomical and functional insights.

In a literal sense, molecular imaging agents present the images of molecules. Imaging is used to determine the characteristics of the tumor so that a treatment strategy can be developed that will optimize the patient's prognosis. Imaging is a powerful tool for real-time treatment monitoring and can also be used for early tumor detection, visualizing the tumor's margin and assessing whether it has spread to other parts of the body. Imaging modalities comprise a variety of techniques that make use of different characteristics, such as the anatomical, physiological, and molecular characteristics of tumors.

In order to determine the best course of action, imaging modalities have recently been combined to provide as much information as possible about the tumor. Clinicians can plan the best course of treatment for a patient based on the type, characteristics, location, stage, and grade of the tumor in order to achieve the best possible result. Additionally, imaging can be used to track the effectiveness of treatment to determine whether the tumor is shrinking. If the tumor's characteristics change while the patient is receiving treatment, a clinician can adjust the patient's treatment plan. In order to stop the tumor from growing back after treatment, the patient must be monitored for the rest of their life.

Many different molecular imaging techniques have been used, either alone or in combination, with other techniques like Magnetic Resonance Imaging (MRI), fluorescence-based optical imaging, ultrasound imaging, and newly developed modalities like photoacoustic imaging and optical coherence tomography. These techniques range from radionuclide-based Positron Emission Tomography (PET) and Single-Photon Emission Computerized Tomography (SPECT) and ionizing radiation-based Computerized Tomography (CT) and X-rays.

Numerous cancers have already benefited greatly from the use of imaging systems in screening, diagnosis, and staging. Among these, Magnetic Resonance Imaging (MRI) has gained popularity as a tumor detection tool due to its high sift tissue contrast, depth penetration, and spatial resolution. The majority of MRIs rely on the use of contrast-enhancing substances like gadolinium. However, more recent research has shown that tumor contrast can be enhanced by using nanoparticles like regular Iron Oxide Nanoparticles (IONPs) and Super Paramagnetic Iron Oxide Nanoparticles (SPIOs). Using such nanoparticles has the benefit of enabling the delivery of additional agents, such as DNA, chemotherapeutic drugs, or other imaging agents.

The delivery of MRI agents has also been aided by photosensitizers. It has been discovered that porphyrin-based photosensitizers are great options for delivering MRI contrast agents to tumor.

Another imaging technique that has proven to be highly successful in the clinic is CT. In the clinic, its main uses are for tumor detection, monitoring, and screening. Most CT scans use radionuclides based on iodine. The primary drawback of CT is that it generates contrast by using X-rays, which puts patients at risk of developing tumors due to prolonged exposure to this kind of radiation. However, current research in the field demonstrates that low-dose CT has improved tumor early detection while also lowering the risk of secondary tumors.