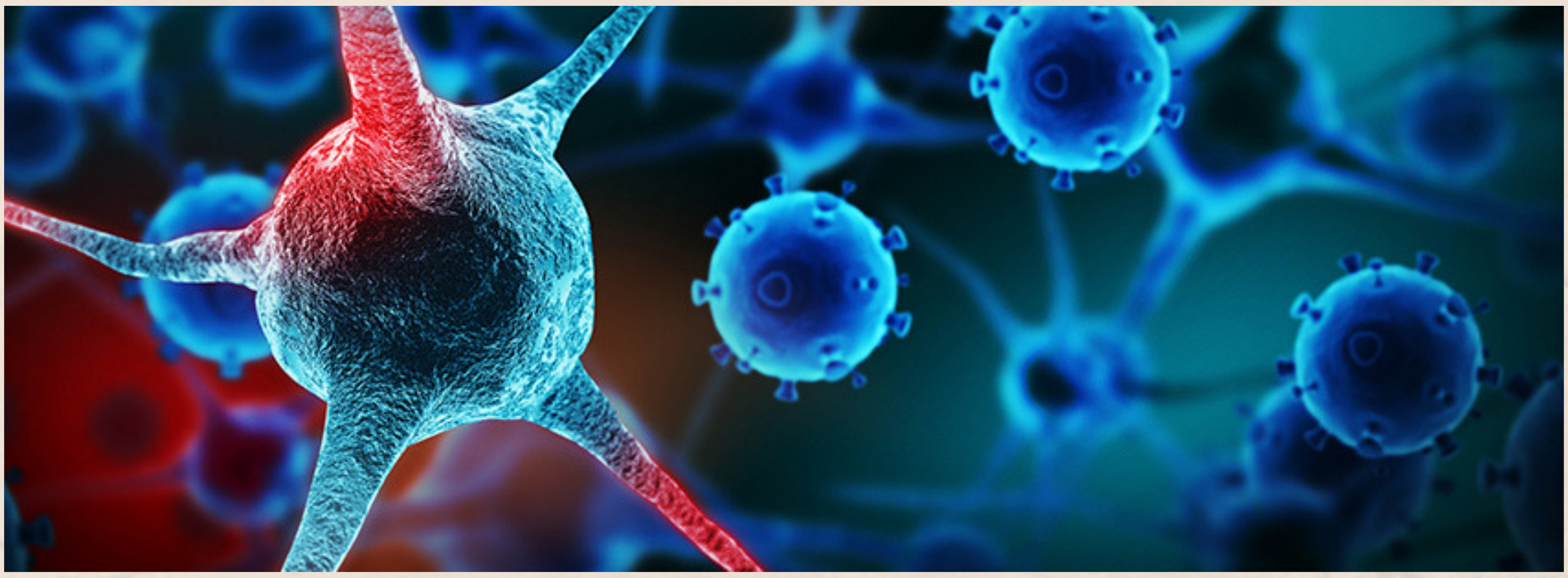
CHAPTER ONE
MOLECULAR IMAGING AND IT'S IMPACT ON CANCER



INTRODUCTION

Recent growth in medical technologies has had a huge impact on the treatment of cancer. Molecular imaging is at a turning point today with the advancement in targeted imaging agents. These agents allow cancer surgeons to not only see the location of the tumor, but also visualize small nodules, and see the activity of these nodules and processes that are advancing research. Tumors in individuals have traditionally been seen through CT scans, MRI and ultrasound. NMR imaging has advanced previous traditional techniques showing the role that the body's metabolism plays in cancer. NMR imaging does not emit radiation and can distinguish between cancerous and noncancerous tumors, unlike CT scans and traditional x-rays. Molecular imaging is an enormous turning point in cancer research because it enables doctors to see the molecular and physiological aspects of tumors in the individual. These advancements are predicted to change the way cancers are treated and provide possible noninvasive treatments and cancer cures in the future. Hence, advanced research shows that these new imaging methods will enable cancer to be detected when it is treatable. This makes a huge difference in cancer patients, as many terminal cancers are diagnosed due to the time frame they are identified.

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Many patients that have cancer growth identified early in their bodies has saved their lives in the past. Additionally, scientists indicate that new improved treatments and drugs for cancers will be discovered with these advancements.

TREATMENT

The ability to diagnose cancer at earlier stages has huge implications on cancer treatment and the welfare of the patient. Earlier research was focused on the importance of drugs to cure cancer, but detection of cancer early enough to be treated is equally important. When cancer is caught early enough it is treatable and the individual has a higher survival expectancy that enables them to live a longer life. Traditional cancer techniques have not succeeded in visualizing cancer at its earliest stage. Because they cannot be visualized at smaller levels with these traditional methods, they are often not seen until they have reached an untreatable size (around a centimeter). Molecular imaging techniques are going to have a huge impact on this area of cancer research as many advancements in imaging have been able to detect small nodules not seen by traditional methods. For example, fluorescent imaging can have a huge impact on visualization as advancements in drugs have shown specific tumor cells fluorescing when proteins are expressed drug-induced.

MOLECULAR IMAGING TECHNIQUES

CT

Computed Tomography (CT), commonly known as a CAT scan, is a traditional imaging method that integrates various x-ray points taken from diverse angles and produces a cross-section image. This image highlights the bones, tissues, and vessels inside the body. This traditional method is

used in other areas of medicine, such as lung, pancreatic and liver health, but not as frequently in cancer. This is due to new advancements in molecular imaging that have made it less accurate. In contrast to new methods, a large disadvantage is its lack of sensitivity. The CT scan is unable to make a distinction between cancerous and normal tissue. This makes it very difficult to assess the bodies reaction to a patients treatment plan. Additionally, this method exposes the patient to much higher concentrations of radiation than the typical x-ray does. However, there are several advantages to this which include high image quality and high speed.

MRI

Magnetic Resonance Imaging (MRI), also known as Nuclear Magnetic Resonance (NMR) Imaging is similar to CT scans and creates a cross-sectional image taken from different angles in the body. However, unlike traditional x-rays and CT scans, the MRI does not have radiation and instead uses a strong magnetic field and radio waves to generate the image. Although it still lacks sensitivity compared to other advanced methods, unlike the CT scans, MRI can distinguish between normal and infected tissue, which is very helpful for Doctors when staging and coming up with a treatment plan for a patient. Many times when an MRI is used to identify a mass in the brain or spinal area, contrast agents are often utilized which help identify tissues. Specifically, MRI has a stronger contrast for soft tissue and is often used for tumors in the Central Nervous System, connective tissue, muscle and the interior of bone structures.

PET

Positron Emission Tomography (PET) uses radiopharmaceuticals (radioactive drugs) which are given intravenously or orally. Using these radioactive drugs in addition to an optical scanner, comprehensive images are able to be produced as well as indicators of chemical activity. As a disadvantage, patients are exposed to radiation through this imaging technique. However, there are several advantages to this which include high sensitivity. PET can distinguish between cancerous and noncancerous tissues. This is possible due to the high metabolism that cancer cells have compared to normal cells. This allows cancer cells to show up as bright spots on the scan. PET is well established in cancer treatment today and helps doctors see the chemical activity of various organs and tissues inside the body. Specifically, solid tumors are most evident in PET scans (cervical, lymphoma, prostate, etc.) Oftentimes, PET is often paired with CT which is much more effective than CT alone. PET is useful in determining the cancers spread, reoccurrences, treatment progress, and detection.

US

Ultrasound (US) also known as ultrasonography or sonography, is an imaging technique that uses sound waves with high-frequency ranges to produce internal images of the body organs and tissues. Although this technique cannot produce images of the complete body and is limited due to the inability of waves to travel through the air (lungs, bones, etc.), ultrasonography is very helpful in cancer treatment. The ultrasound machine transmits sound waves through the body and changes the returning waves to images. This imaging technique is often used to

guide doctors during cancer surgery, and can also help identify soft tissue images that aren't visible on x-rays. Although US cannot distinguish between cancerous and non-cancerous tumors, it is able to distinguish between solid tumors and cysts. Ultrasonography also has an advantage as it does not transmit any radiation to the patient.

OPTICAL AND FGS

Optical imaging is very unique and prevents the patient from being exposed to harmful radiation by using non-ionizing radiation (visible, ultraviolet and infrared light). This technique is particularly helpful in soft tissues, where tissues can absorb or scatter light in different ways. Fluorescent-Guided surgery (FGS) is a groundbreaking technique in optical imaging today. FGS has several advantages as it has the highest sensitivity, and can detect very small nodules of cancer that aren't detected in traditional imaging methods. It is also noninvasive and the procedure can be performed quickly. FGS uses fluorescent labels to distinguish between cancerous and normal tissues. After giving a contrast agent intravenously to the cancer patient, this agent is often expressed in cancer cells and can be visualized by doctors through the fluorescent imaging system.

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