

# Effectiveness of early cancer detection method: Magnetic resonance imaging and X-ray technique

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**Abstract.** Cancer is a major problem plaguing human society today. With the research and development of nano-drug delivery technology and new non-surgical treatment methods, many types of early cancers can be cured or effectively controlled. However, the current treatment methods for advanced cancer are still limited, and efficient early cancer identification is crucial for enhancing patients' prognosis and survival rates. Magnetic resonance imaging (MRI) and X-ray technologies are currently the mainstream and generally applicable means of early cancer detection. However, there is a lack of unified comparison and interpretation for their respective applicable cancer detection types. Herein, the paper first provides a comprehensive comparison and explanation of the working principles of the two technologies, as well as their advantages and disadvantages. Further, this article introduces the application of MRI and X-ray technology in the early detection of different common cancer types, including lung, breast, and brain cancers. The paper found that MRI is crucial in the early detection of brain cancer, and X-ray is a common method for lung cancer screening. With further advances in technology, cancer-related deaths can be further curbed.

**Keywords:** early cancer detection method, magnetic resonance imaging, X-ray technique.

## 1. Introduction

Cancers are one of the leading causes of death globally. Annually, over 9.5 million people die from cancer-related deaths, and this number is expected to rise to 16.4 million by 2040 due to increased factors such as air pollution, pesticides, and unhealthy lifestyle choices, including processed foods, alcohol consumption, etc. [1]. Cancer occurs with oncogenes that develop into cancerous cells which divide uncontrollably. These cancer cells sometimes clump together to form harmful tumours known as malignant tumours, which take nutrients and space from healthy functioning cells, and this causes the healthy cells to be unable to convert energy to function and sustain the body for life. It is estimated that over 19 million individuals were diagnosed with cancer in 2020 [2]. By 2040, it is expected that the number of new diagnoses annually will be 29.5 million. Men are 19% more likely to develop cancer than women. Furthermore, 1 in 8 men who are diagnosed die due to cancer, and 1 in 11 diagnosed women die due to cancer [3]. Early development of cancer is a crucial stage for patients because the mortality rate can be greatly decreased during this period if diagnosed and treatment is initiated because the earlier the diagnosis, the easier to prevent the metastasizing and growth of cancer.

Currently, most cancer diagnosis tests can be placed under two categories. Imaging or biochemical. Imaging and biochemical diagnostic tests are invaluable advancements because doctors can diagnose

cancer without needing to wait for symptoms to develop. Once cancer reaches the stage where symptoms would develop, this would be more difficult to treat, and thus treatment might be less successful if left to this stage. This can prevent the regression of the tumour since the mutated can be limited to a confined area of the body. Biochemical examples of cancer diagnosis tests include biopsy, sputum cytology, urinalysis, complete blood count testing, etc. The biochemical diagnosis examines a sample from the body, for example, the blood, mucus, or urine, at a microscopic level, searching for its biomarker, usually mutated cells or abnormal fragments of DNA. The second type of cancer diagnosis test is imaging. Examples of imaging diagnostics are: X-rays, CT scans, MRIs, Ultrasounds, PET scans, etc. Imaging tools can detect anomalies and physical abnormalities, such as density, electronegativity, and other irregular body properties. Two main diagnostic tests that dominate the imaging field are X-rays and MRIs. This paper compares the effectiveness of MRI and X-rays for detecting early signs of brain, lung, and breast cancer. MRI was first used on a human subject in 1977. In 1980, it became commercially available to the public and is now widely used for examining the interior of the body and for cancer diagnosis. X-rays were utilised much earlier than MRI, first used by clinics in 1986 in the United States of America [4]. X-rays were initially used to examine the skeletal system and organs.

## 2. Magnetic Resonance Imaging (Mri) for early cancer detection

### 2.1. Introduction of MRI

MRI (magnetic resonance imaging) machines are large tubular technology capable of creating strong magnetic fields. The MRI creates images of the internal body. The protons in human's body all spin which creates a tiny amount of magnetic charge. The MRI machine produces a strong magnetic field, which allows all the protons to align parallel to it. Then the MRI technician introduces a radiofrequency that forces the proton to re-align to either 90 or 180 degrees. When the radiofrequency is turned off, the protons re-align with the magnetic field. As they return to their original position, they release electromagnetic energy, which the MRI can detect. The faster they realign; the more energy is released. Thus, the technology allows differentiation between tissues by how fast their protons re-align.

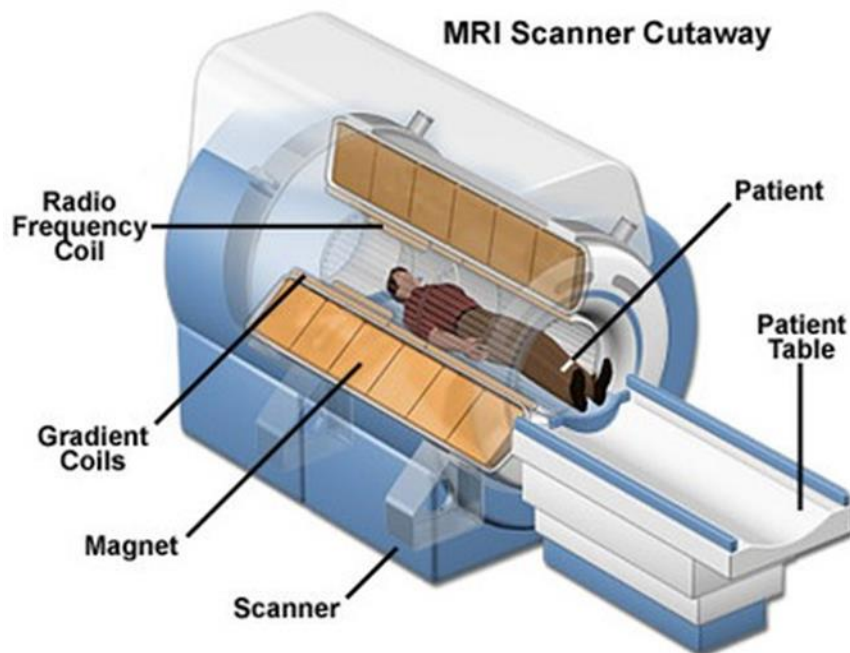


Figure 1. MRI machine diagram.

## 2.2. *Advantages and disadvantages of MRI*

The advantage of MRI is that it is able to produce detailed images without the use of ionising radiation like the X-ray. This reduces the risk of cancer, which makes it safe for pregnant women and children. Another advantage is that it is a non-invasive process meaning that medical instruments do not need to be inserted into the body. This lessens the possibility of infections from cuts in the skin where the instruments are inserted from.

Although the MRI does not expose patients to radiation, the strong magnetic field can stimulate the nerves and cause a twitching sensation which some may find uncomfortable. The MRI can also cause the medical instruments to malfunction because of their high radiofrequency; this can fail the medical instrument to perform its intended tasks. The strong magnetic field can disrupt medical instruments implanted in the body and cause it to heat up, leading to burns on surrounding tissues. This is because most medical instruments are made of conductive material (able to transmit heat and electricity), so when introduced to a high electromagnetic field, that results in more concentrated electrical currents. This allows energy to be transmitted through the insulator, which results in excess heating [5]. Lastly, the presence of the medical instruments themselves can decrease the resolution of MRI images, so images may be uninformative or misleading and can lead to a misdiagnosis and inappropriate treatment. Because MRI detects physical properties of tumors they miss biochemical biomarkers such as DNA or cells, which other chemical biosensors could detect. Because of this, it limits the MRI's abi

## 3. **X-ray technique for early cancer detection**

### 3.1. *Introduction of X-ray techniques*

How an X-ray works are, firstly, the patient is positioned between an X-ray source and an x-ray detector. A small amount of ionising radiation is fired through the X-ray source, and as it passes through the patient's body, the tissues absorb the radiation based on radiology density which is how dense (based on the atomic number) the material is. X-rays use a small dosage of specific radiation called ionising radiation. Ionising radiation has sufficient energy to ionise atoms, which allows the X-ray detector to differentiate where the tissue has absorbed energy.

The radiation then reaches the detector, which translates the information into shades of grey, thus creating the image. Defining characteristics of X-ray: i) Frequency range: 30 Petahertz to 30 exahertz ( i.e.  $3 \times 10^{16}$  to  $3 \times 10^{19}$  ); ii.) Wavelength range: 0.01 to 10 nanometers; iii.) Energy range: 100 eV to 100 KeV; iv.) Energy-type electromagnetic radiation [6].

### 3.2. *Advantages and disadvantages*

The advantages of X-rays like MRIs are non-invasive procedures and do not require any samples from the patients. X-rays are faster, cheaper and more accessible compared to MRIs and have been used by most medical professionals. X-ray results also process quickly. Results can take one or two days to process, while MRIs take up to one or two weeks for images to finish processing. In emergency cases, commonly in ERs, X-rays are preferable because of how fast they are, where images are produced in minutes or hours. The advantage of using imaging technology is that it is not invasive, because X-rays rely on ionising radiation to produce images. Exposure to this radiation to patients can increase the possibility of radiation-induced cancer. The electromagnetic energy from the radiation is strong enough to break molecular bonds in the DNA base and lead to mutations. The probability of a formed oncogene is increased from the radiation. This leaves a mutational signature on the genome [7]. X-rays, like other imaging diagnostic tools, can only detect tumours or other physical symptoms of cancer, which means the earliest stages of cancer are often missed because cancer starts as mutated DNA which is too microscopic to be detected by X-rays or MRI.

## 4. **Application of Mri and X-ray in cancer diagnosis**

MRI has both a high sensitivity rate (93%) and a specificity rate (97%). The sensitivity rate refers to the number of true positives (the number of people who do have cancer that will test positive for that cancer),

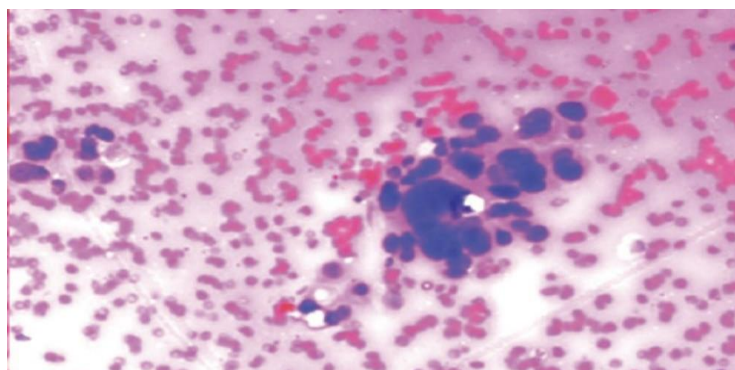
and vice-versa the specificity test refers to the number of negatives [8]. Overall, MRIs have a high accuracy rate of 95%. MRI employs different types of scans for different diagnostic tests. MRI specialises in brain cancer and breast cancer diagnostic screening, but it is not that commonly used with lung cancer. All MRI screening uses the standard MRI machine but utilises different processes. Breast cancer is screened with a breast scan, where the MRI takes multiple images of the breast, which can take around half an hour. But for brain cancer, a more advanced process is used. Gadolinium-enhanced MRI is an enhanced type of MRI scanning used specifically in neurology. Gadolinium is a heavy metal injected into the body to enhance the resolution of the images. Gadolinium creates perturbation or disturbance specifically to protons of water atoms creating a strong contrast hence why it is referred to as a contrast media. Despite a high sensitivity rate of 89% to 100% Gadolinium-enhanced MRI, a specificity rate varies from 46% to 88% [8].

There are many forms of X-ray with different radiation levels for imaging different body parts. The type of x-ray used for breast cancer is called a mammogram. The mammogram machine uses two plates to compress and spread the breast tissue, which allows for high-resolution images that require less radiation. Previously mammography was printed on sheets; however, digital mammograms are much more commonly used in recent times, where the images are translated digitally and can be viewed or saved on a computer. The sensitivity of digital mammography is around 97%. However, specificity is much lower at around 64%. The overall accuracy rate of breast cancer detection is 89%. For Lung cancer detection, CT scanning is commonly used for lung cancer. The sensitivity rate of CT scanning for lung cancer detection is 88.9%, and the specificity rate is around 96% [9].

#### 4.1. Lung cancer

Lung cancer is when abnormal cells in the lung multiply, forming benign, malignant cells which can metastasize and can spread throughout various parts of the body. In the USA, 1 in 17 Americans has lung cancer, accounting for 21% of all cancer-related deaths. Smoking is the leading cause of lung cancer. Around 80% to 90% of Lung cancer deaths are related to smoking. Other Causes of lung cancer include secondhand smoke, air pollution, and a family history of Lung cancer. Apart from imaging, methods for lung cancer detection include biopsy and sputum cytology.

A biopsy is extracting a tissue sample from the lungs and examining it under the microscope to detect mutated cells. Sputum cytology works similarly where sputum (mucus) samples are taken and examined under a microscope: Sputum Cytology and Biopsies examine lung cancer symptoms at a much more microscopic level than imaging. However, Sputum cytology and biopsy are less commonly used compared to imaging. Sputum cytology has an overall 40% false-negative rate. 71% of tumours located centrally in the lungs are detected, but the tumours located in the periphery of the lungs are detected less than 50% of the time [10]. Though biopsies have a high diagnostic accuracy rate (83% to 97%), they also have a high complication rate of 22% to 51% [10]. Complication rates mean that medical problems arise because of the biopsy procedure.



**Figure 2.** Sputum cytology sample of present lung cancer.

#### 4.2. Breast cancer

Breast cancer is one of the most common cancers in women, and though rare, men can also be diagnosed with breast cancer. In 2022, 1 in every 8 women was diagnosed with breast cancer, though mortality rates are just over 1%. The lobule of the breast are glands that produce milk, and ducts connect the lobule to the nipple. The abnormal growth of the lining of the lobule and ducts leads to breast cancer. Breast cancer is hereditary cancer, meaning they are inherited from parent to offspring. Mutations of genes BRCA2 (located in chromosome 17), BRCA1 (located in chromosome 13) and CHEK2, if inherited, can develop into breast cancer. Other correlations are age, with the average age of diagnosis being 62. There is also a correlation that women who started their menstrual cycle before 12 are more likely to develop breast cancer [11].

Sometimes biopsies can be performed on the breast tissue to determine if there is cancer, but usually, women with a history of breast cancer or those concerned with breast cancer undergo mastectomy. The much more common practice of mastectomy is removing breast tissue before breast cancer can develop. Removing the breast cells eliminates the possibility of them mutating. Despite that, it is impossible to remove all the breast cells. Although the risk of breast cancer is reduced by 90%, the possibility is still present [11].

#### 4.3. Brain cancer

Brain cancer is the result of malignant tumours in the brain or spinal cord. The probability of the development of brain cancer is very small, less than 1%. However, glioblastoma is the most common brain malignancy (49.1% of all brain tumors), with a survival rate of only 6.8%. Most patients die within 12. There currently are no definitive causes of brain cancer or the development of primary brain tumours (cancerous cells starting in the brain). In fact, secondary brain tumors are far more common than primary brain tumours. Secondary brain cancer is abnormal cells originating from other parts of

The body eventually spreads to the brain. Because of our limited knowledge of brain cancer, the causes of brain cancer are still uncertain. Some causes of brain cancer may be exposed to radiation, inheritance, and old age. Treatment or surgery is extremely difficult because of the brain blood barrier, a natural layer outside the brain that defends it from toxic substances. Chemotherapy, a common treatment that uses strong drugs such as melphalan, busulfan, capecitabine, 5-fluorouracil, etc., to kill cancerous cells, is less effective because of the brain blood barrier.

### 5. Conclusion

To conclude, both MRI and X-ray are vital diagnostic tools that save lives. They both have different properties, making them better suited for detecting specific cancers. MRI, with high resolution for soft tissue, is one of the most common diagnostic tools for brain cancer detection. In contrast, X-rays (CT scans) are still the recommended screening test for lung cancer detection. As new advances are made with MRI and X-rays, the ability to accurately diagnose early signs of cancer could combat the crisis of rising cancer-related deaths.

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