

Gamma Camera

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Medical Imaging

Medical imaging is a multidisciplinary field of science and Engineering that addresses the gathering, transfer, storage, Processing, display, perception, and use of information in Medicine. It overlaps many other disciplines such as electrical Engineering, computer and information sciences, medical Physics, and perceptual physiology and psychology.(1)Medical imaging or diagnostic radiology is a type of technology that is used to produce images of the internal organs of the body for the purpose of accurate diagnosis of some different diseases, such as: detecting bone fractures, or locating solid objects such as: shrapnel and bullets in the body, and thanks to these rays it became possible Diagnosing many diseases with high accuracy, and the uses of X-rays are not limited to detecting diseases of the body only, but are also used in the treatment of cancerous tumors (11).

The history of medical imaging dates back to the year 1895 AD. At that time, the dangers of radiation in general were not known, whether to patients, technicians, or doctors. This is why many of those who worked with radiation suffered from different types of skin, bone, and thyroid cancers, and this risk was realized in our current time, as all workers are monitored. Radiology from specialized authorities that are keen on the safety of patients, auditors, and workers on an ongoing basis, and there are many types of radiation, the simplest of which is X-rays, which have been

developed into several technologies, and their uses are not limited to the medical field only, but are used in many other sciences and industries (11)(2) .

In this chapter, we review some simple concepts about radiology, as well as a brief overview of the history of radiology, and how it was discovered, because it is very important to realize the magnitude of the changes that occurred in diagnostic radiology since its discovery to the changes that occurred in diagnostic radiology since its discovery to the present time, which in turn affected our perceptions of radiology and its danger to the human body.

Types of medical imaging

Computed Tomography (CT):

became clinically available in the Early 1970s, and is The first medical imaging modality made Possible by the computer. CT images are Produced by passing x-rays through the body at a large number of angles, by rotating The x-ray tube around the body. A detector array, opposite the x-ray source, collects The transmission projection data.(1)CT scan, commonly called a CT scan, can create a detailed Picture of the inside of the body using X-rays and computers. They are different from X-rays because they produce a cross-Sectional image of the body, similar to an MRI, which makes Them better at looking at soft tissues and more subtle parts of The image that X-rays may not pick up (11) .

Uses

They can be used to image bones, internal organs, and blood vessels. The upper body is examined, such as the brain, neck, spine, chest, and sinuses (11) .

Device principle:

As shown in the image below, the patient lies on his back on a board. This plate passes into the scanner, which goes around the section of your body that is currently in the scanner. The patient needs to lie down so that the scan can get a clear picture. Usually, the radiologist operating the machine will stand in another room to avoid radiation, but can communicate with the patient via an intercom. The scan can take anywhere from 10 to 20 minutes, but the results are available once the computer analyzes the scans (2).



Figure 1.1 CT scan

The advantages of CT scans Positives:

1. CT scans are fairly short - they only take about 10 to 20 minutes. The results are very fast compared to some other types of scanning.
2. CT scans are painless, as they are non-invasive.

Negatives:

As with a lot of scans, your body is exposed to some radiation. The more a patient's body is examined, the more radiation it will be exposed to. However, they are designed to reduce radiation exposure. There is a possibility of an allergic reaction to the dye used (2).

Magnetic resonance imaging (MRI): is a tomographic imaging modality, and competes with x-Ray CT in many Clinical applications. The acquisition of the highest quality Images using MRI requires Tens of minutes, whereas a CT scan Of the entire head requires seconds. Thus, for Patients where Motion cannot be controlled (pediatric patients) or in anatomical Areas where involuntary patient motion occurs (the beating Heart and churning intestines), CT is often used instead of MRI. Also, because of the large magnetic field used In MRI, Only specialized electronic monitoring equipment can be used While the Patient is being scanned. Thus, for most trauma, CT Is preferred. MRI should not Be performed on patients who Have cardiac pacemakers or internal ferromagnetic Objects such as surgical aneurysm clips, metal plate or rod Implants, or metal shards Near critical anatomy such as the Eye.(12)An MRI scan, otherwise known as an MRI scan, is a detailed cross-sectional image of a part of the body. It's similar to a CT scan, but with a higher quality, so it's easier to see differences in tissue .

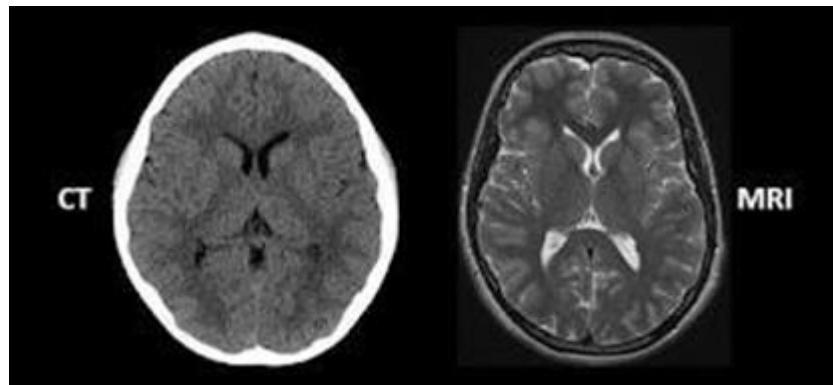


Figure 1.2 CT and MRI examinations

Uses

MRI can be used to obtain images of the brain, spinal cord, bones, heart, blood vessels, and various internal organs.(3)

Device principle

Unlike a CT scanner, an MRI scans the whole body. The patient is pushed into a thin tube, about 24 inches in diameter, and powerful magnets and radio waves are used to create detailed images. Similarly, back to the CT scanner, the radiographer will stand in another room to view the results and communicate via an intercom, but the MRI is much louder than the CT scanner. It can take anywhere from 15 to 90 minutes. (3)

The advantages of MRI Positives: MRI scans are painless and safe, because magnetic fields and radio waves have no known negative effect on the patient. It does not involve any x-ray exposure, so it can be used by pregnant women and children if needed.(3)

Negatives:

MRIs surround a lot of the body, so make people with claustrophobia uncomfortable. And Metal cannot get inside an MRI scanner, so people with certain implants such as pacemakers cannot use them.(3)

PET scan

A PET scan can create a 3-D image of the inside of the body. It can be combined with CT and MRI scans to create a clearer picture to show what is going on. It can also focus on specific parts of the body, and show how well a body part is working.

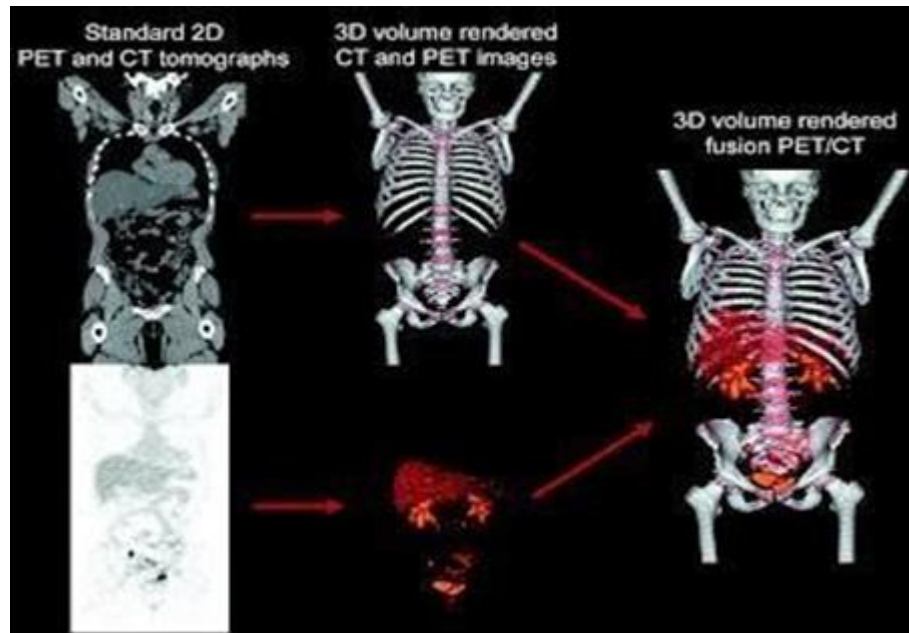


Figure 1.3 shows how PET and CT scan can be combined

Uses:

They are used to detect the progression of cancer, and can be used to obtain high-resolution images of the brain. (4)(3). They are most commonly used in people who have already been diagnosed with cancer, as they can clearly show how far the cancer has spread or is responding to treatments such as chemotherapy. It is also used in planning surgery, such as brain or heart operations. Dementia can also be diagnosed using a PET scan, as it can show if the normal function of the brain has been altered.(4)

Device principle

A radioactive radiator, usually fluorodeoxyglucose (FDG), is injected into your arm, and this emits radiation. A PET scanner can detect this radiation when it collects in certain parts of the body. If there is an area where FDG does not accumulate, there is a certain body function that is not working there. Cancer cells use glucose at a faster rate than normal, thus by examining the concentration of FDG, cancer can be identified and tracked in the body. A PET scanner looks similar to an MRI machine. The scan takes about 30 minutes.(4)

The advantages of PET scan

Radioactive glucose is used for glucose, so the body processes it in a similar way. The scan only takes about 30 minutes. A PET scan can detect cell-level metabolic changes occurring in an organ or tissue, which

CT or MRI cannot.(4)

Negatives

A PET scan exposes you to radiation, which can lead to cancer. However, the amount is very small. Half-life of a radioactive tracer. Patients should avoid people who should not be exposed to radiation, such as pregnant women, for a few hours after the scan. (4)

Ultrasound imaging

Ultrasound uses high-frequency waves to show the inside of a part of the body. It is also known as ultrasound. (5) Ultrasound is reflected strongly by interfaces, such as the Surfaces and internal Structures of abdominal organs. Because Ultrasound is thought to be less harmful Than ionizing radiation To a growing fetus, ultrasound imaging is preferred in obstetRical patients . An interface Between tissue and air is highly echoic, and Thus, very little Sound can penetrate from tissue into an air-filled cavity. Therefore, Ultrasound imaging has less utility in the thorax Where the air in the lungs presents a Barrier that the sound Beam cannot penetrate. Similarly, an interface between tissue And bone is also highly echoic, thus making brain imaging, for Example, impracti-Cal in most cases. Because each ultrasound Image represents a tomographic slice, Multiple images spaced a known distance apart represent a Volume of tissue, and With specialized algorithms, anatomy can Be reconstructed with volume rendering Methods .

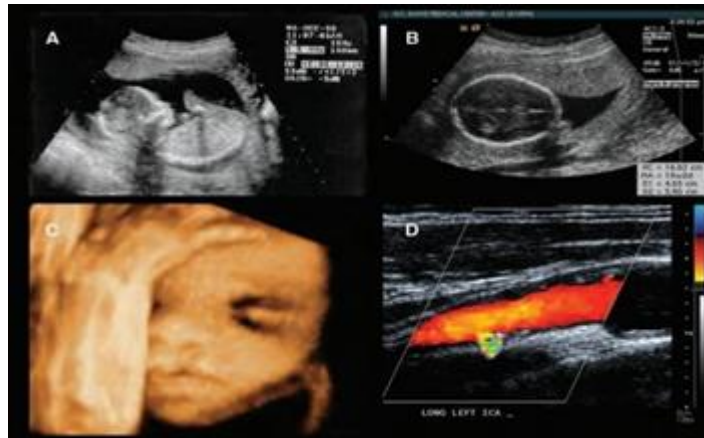


Figure 1.4 Ultrasound imaging

Uses:

Ultrasounds can produce images of unborn babies in real time.



Figure 1.5 Real-time Ultrasound image

Its common uses

The most common use is to monitor unborn children, but they are also used in diagnosis and during certain procedures to guide surgeons.(5)

Device principle

The device contains a probe that emits high-frequency sound waves. They bounce off different parts of the body, creating echoes, and when they bounce back to the probe, they can also be detected. This can create a live image on another scanner. The examination can last from 15 to 45 minutes. It can be performed externally, internally, or laparoscopically.(5)

The advantages of Ultrasound imaging

Usually there are no after effects of an ultrasound scan. This means that normal activity can be resumed immediately afterwards. Results appear in real time, so there is no need to wait.(5)

Negatives

Some probe covers contain latex, which can be a problem if the patient is allergic to latex. Endoscopic ultrasound can cause a sore throat, bloating, or in extreme cases, internal bleeding.(5)

X-ray imaging

X-rays are a very common procedure used to obtain images of the inside of the body. Radiation is used in the x-ray portion of the electromagnetic spectrum.(5)

Uses

They are used to produce pictures of the bones, usually to see if and where there are breaks. It is also used by dentists and orthodontists to look at teeth. Bone tumors can also be seen on x-rays.(5)

Its common uses

They can be used to guide surgeons as they work. It can also be used to detect broken bones and to plan the best course of treatment.(5) .

Device principle

X-rays, a type of electromagnetic radiation invisible to humans, pass through the body. Energy is absorbed by different parts of the body at different rates, and a detector on the other side of the person will see how much is absorbed, and will be able to generate an image from this. More dense parts of the body, such as bones, appear white, as few X-rays can pass. Sometimes a contrast agent is given to the patient in order to see the soft tissues more easily on the image. X-rays are very fast, and the whole process should only take a few minutes.(5)

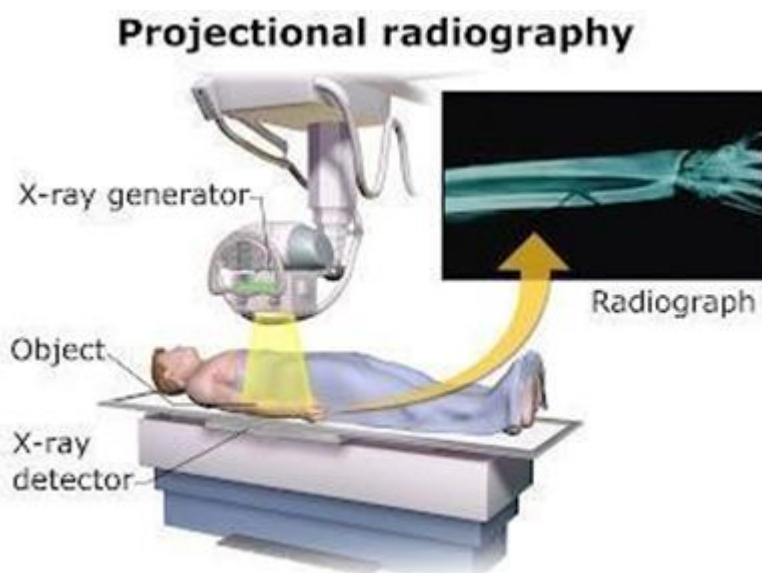


Figure 1.6 X-ray imaging

The advantages X-ray imaging:

Positives

The device does not surround the whole body, so it will not cause anxiety in people with claustrophobia. The procedure takes only a few minutes.(5)

Negatives

Some contrast agents may cause unwanted side effects. X-rays expose the patient to unwanted radiation, which can lead to cancer, but the amount of radiation emitted is small.(5)

Gamma rays

Gamma rays are electromagnetic rays that were discovered in 1900 by the French scientist Villard. It is denoted by γ , which is the most energetic of x-rays; Its energies are estimated between 1 million electron volts and 14 million electron volts, while the energy of X-rays is between 50 kilo electron volts and about 500 kilo electron volts. Gamma rays are a product of nuclear reactions that often occur in space, in nuclear reactions and nuclear reactors, and are also produced from radioactive elements such as uranium and other radioactive isotopes, plutonium and polonium. Therefore, international treaties prohibit nuclear explosions. They propagate in vacuum and air at a speed equal to the speed of light. They are electromagnetic waves, not particles. It has high energies and a great ability to penetrate materials more than X-rays and ultraviolet rays, and its waves are very short, and its wavelengths range from 0.05 angstroms to 0.005 angstroms. Gamma rays have a very harmful effect on living cells, and had it not been for the presence of the atmosphere around the earth that absorbs and scatters these rays of high wave frequency and great energy, life would have ceased on the surface of the earth. Because gamma rays have a superior ability to run out and penetrate objects. Its ability to destroy living cells is due to the fact that it is ionizing radiation, that is, it causes ionization of matter, and ionization of living matter means damage that may lead to cell death (5). Gamma rays are among the most dangerous radiations in the electromagnetic field, as they have the highest energy due to their high frequency and thus short wavelengths. As for its uses, it is used in the medical and industrial fields, but in very small quantities, as the doses of radiation that are given to the patient are calculated with great accuracy so that they destroy cancerous cells, and as for healthy body cells, they regain their health after a period of convalescence and can follow the course of vital processes in the body.



Figure 2.1 gamma rays

In medical treatment, it is often used to kill cancer cells. In the industrial field, it is used to photograph oil pipelines to see the quality of pipes and the integrity of welding, in addition to killing germs in canned food and sterilizing grains. Since it is a product of nuclear reactions, it is undoubtedly used in reactors and nuclear bombs .

As we know, the danger of the thing lies in its strength, and the intense exposure to sunlight, which therefore produces gamma rays, but its percentage in the sun's rays is very low, and the risk of exposure to the sun's radiation lies in the high-frequency ultraviolet rays, which may lead to direct skin cancer .

Physicists and those working in the fields of gamma rays take care to protect themselves from exposure to these rays. They use those rays and the materials that they emit from behind a 1-cm-thick barrier of lead.

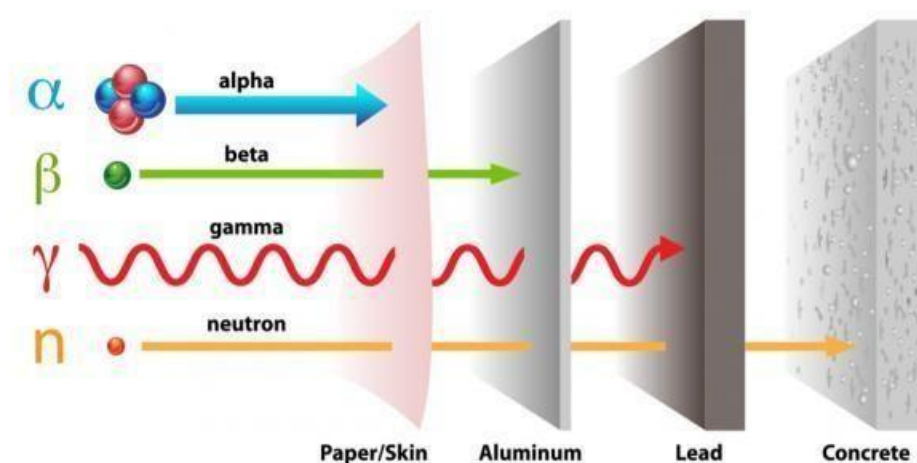


Figure 2.2 Comparison of the penetrating ability of alpha, beta and gamma rays

Gamma rays were discovered by the French scientist Paul Villard in the year 1900. These rays have the shortest wavelength in the electromagnetic spectrum and have the highest energy, because they are produced from nuclear collisions as well as from radioactive elements. As is the case in the production of X-rays, the electrons were accelerated in a high voltage difference. Here, the nuclei are accelerated with very high energy using accelerators such as the cyclotron and the synchrotron.(5)

In nature, gamma rays are produced from the sun as a result of nuclear reactions, and the energy of gamma rays reaches one million electron volts. Celestial galaxies and stars scattered in space are sources of Xrays. Astronomers are working on studying these rays with observatories dedicated to this purpose in order to understand the secrets of this universe. Also, radioactive elements such as uranium, plutonium and polonium constantly produce gamma rays . Gamma rays travel astronomical distances in space and absorb these rays only when they collide with the Earth's atmosphere. Thus, the atmosphere protects living creatures from these destructive rays. In the illustration, the effect of the Earth's atmosphere on the electromagnetic spectrum is shown. We note that only visible rays pass through the atmosphere, while shorter wavelengths are prevented from reaching the Earth's surface, because they are absorbed by the ozone layer in the atmosphere (5).

The use of gamma rays in photography

Gamma imaging or SPECT in nuclear medicine for the detection and diagnosis of tumors. imaging by gamma rays. The advantage of this method is to give it stereo images. This information is formed by photographing sections of the patient, and the resulting image can be rotated after combining the images of the sections or slides with the computer to show the image from different sides on the computer screen. (6)

The method requires the patient to inject a radioactive isotope called a radionuclide into a circulating vein (such as a gallium III solution). One of the properties of gallium is that it is concentrated in certain types of bodily tissues. It is also possible to select isotopes of other substances concentrated in the kidneys, lungs, or others that are under diagnosis. And by imaging the gamma rays emanating from the member in which the radioactive substance was concentrated, pictures of clips can be taken.

Gamma Camera

It is an imaging device used in the field of medicine, mostly in nuclear medicine, to photograph gamma rays emanating from radioactive compounds in the body.

It is a device consisting of one or more detectors installed between the place where the patient is placed and connected to a control system to operate the device and store images (7).



Figure 2.3 The parts that make up the gamma camera

The parts that make up the gamma camera

1- The collimator

In short, it is like a filter that filters a torrent of rays so that it only passes rays that are almost parallel to each other, as shown in this picture .

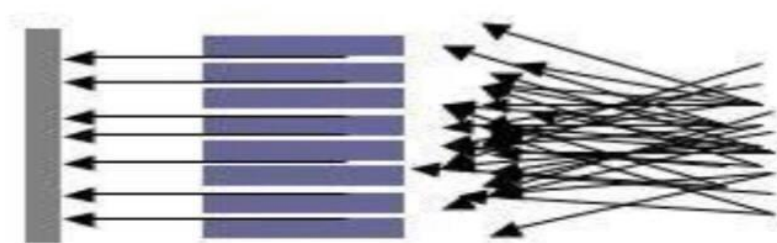


Figure 2.4 the work of collimator

The image is captured on one side of the parallel rays that have been filtered, but if the device is used without a collimator, it will photograph the desired part from all sides according to the rays coming from each side, and therefore it will not produce a clear or accurate image.(8)

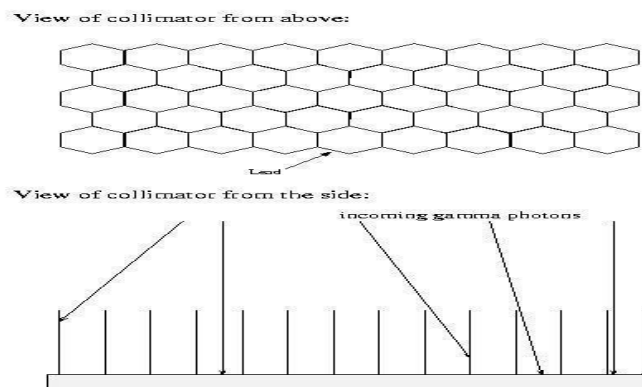


Figure 2.5 viewing the collimator from above and from the side

2 – Scintillation Detector flashing detector:

This detector is usually a detector for gamma photons, and the detector usually used in gamma cameras consists of [NaI(Tl)]. This compound is used due to its quality and the strength of its effectiveness in capturing or detecting gamma radiation emitted from the radioactive compound, and this detector interacts with photons of gamma rays according to the photoelectric theory or Compton's theory with iodine ions in the crystal (from which the detector is made). This interaction causes the release of electrons, which in turn interact with the crystal to produce light in a process known as scintillation, flashing, or sparking (9).

3- Photomultiplier Tubes

From the flash detector, we do not receive either a small amount of light, and therefore Photomultiplier Tubes, which are tubes connected to the back of the crystal, and at the front of the Photomultiplier, there is what is called a photocathode, which, if stimulated by photons of light, releases electrons.

Photomultiplier is a machine that detects and magnifies the electrons produced by the photocathode, for every 7-10 photons directed at the photocathode only one electron is generated, and this electron from the cathode is focused on the dynode that stores this electron and re-releases many electrons usually from 6 to 10 and these electrons The new one is focused on the dynode and the process is repeated again and again in multiple dynodes, and at the base of the Photomultiplier Tube there is an anode that in turn attracts this large group of electrons and converts them into an electrical pulse. (9)

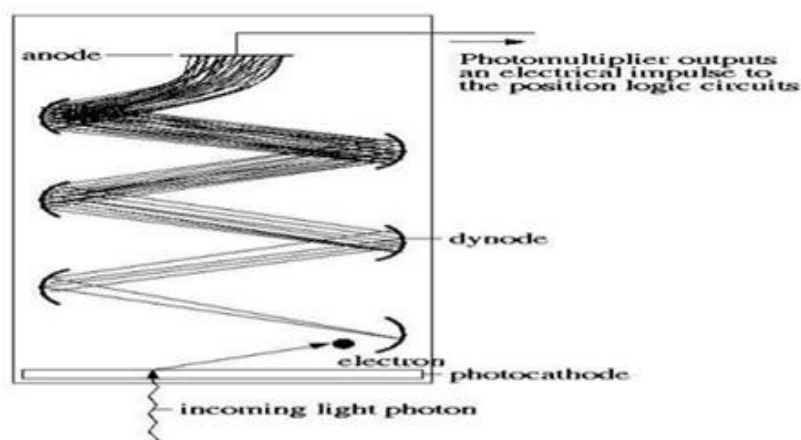


Figure 2.6 photomultiplier tubes

Each gamma camera has a set of these tubes that are arranged in a specific geometric shape, and the typical camera contains many 37 to 91 tubes.

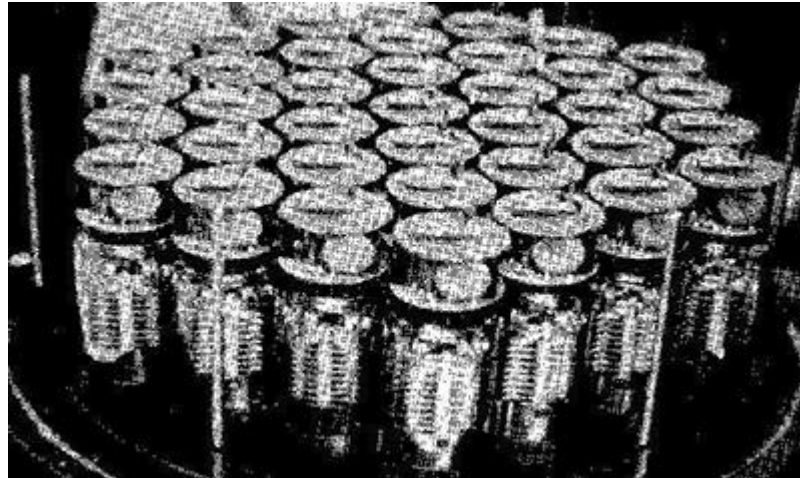


Figure 2.7 gamma camera tubes

4- position circuitry

Logically, I mean, the position must be subordinate to the photomultiplier tubes mentioned above, so that they receive electrical pulses from the tubes to the SMC, which is the Summing Matrix Circuit or pulse assembly template. This allows the circuit position to determine each flash that occurred on the detector crystal.(10)

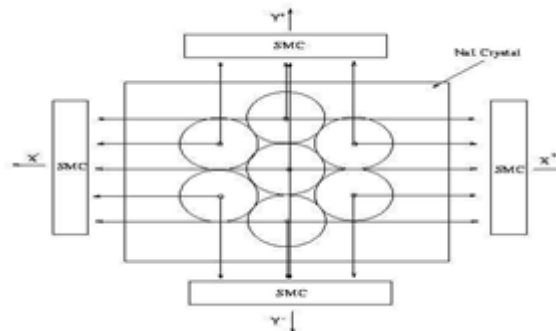


Figure 2.8 position circuitry

5- data analysis computer

In the end, all these signals are transferred to the computer, and then certain programs are used to produce the image in a three-dimensional form, either gray or colored, depending on the available program, and then it is simplified and analyzed to be stored on disks .

2-3-2 use it

Scintigraphy is used to study the distribution of doses of some drugs in the human body, as well as in medical imaging to photograph and analyze images of human body organs or the distribution of radioactive isotopes that are given in some cases to patients for the purpose of conducting medical examinations and diagnosis. Radioisotopes in the patient radiate gamma rays and are photographed outside the body with a gamma-ray camera.(11)

Table (2-1) Gamma emitters

Radionuclide	Half-life	Photon Energy (keV)
Technetium-99m	6h	140
Fluorine-18	110min	2×511
Thallium-201	73h	135,167
Iodine-131	8.04d	364
Strontium-87m	2.8h	388

Methods:

Technetium-99

Technetium-99m is used in 90% of radionuclide imaging, as it fulfils most of the above criteria .With its gamma energy of 140 keV , it is easily collimated and easily absorbed in a fairly thin crystal, thus giving good spatial resolution. With its short half-life (6 h) and pure gamma emission, a reasonably large activity can be administered, reducing noise in the image. It is supplied from a generator shielded with lead. this contains an exchange column of alumina beads on which have been absorbed a compound of the parent ^{99}Mo (which can be produced in a reactor and has a 67 h half-life).

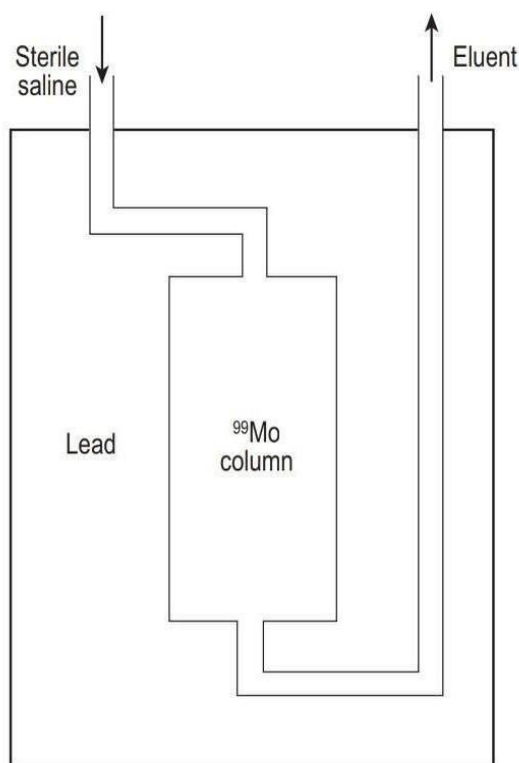


Figure 3.1 A Techetium-99 generator

Uses of technetium-99m Sodium pertechnetate-99m

is used for imaging the tissues, which take it up on account of its similarity to iodide and chloride ions: the thyroid (by which it is trapped but not fully metabolized), the gastric mucosa (localization of Meckel's diverticulum) and the salivary glands. Blocked from the thyroid by administration of potassium perchlorate, it can be used for cerebral blood flow and testicular imaging and, mixed with bran porridge, for gastric-emptying studies.

Preparations before examination:

The patient has the food for the food for at least 6 hours before the schedule. The ideal level of blood glucose is the FBS2200mg / dl. The patient is free in drinking water at that time. I am one of the 1-2 liters of water in the time of wage for the pre-examination and 250-500cc during the break period after the injection of radioactive materials and before examining the medical examination. Avoid performing any heavy work in the home or at least 6 hours at least (48 hours) preferred before the time of examination. It is recommended not chewed by 24 hours of photography. Wear warm and comfortable clothes in cold seasons. Your outfit must not contain metal bodies (including nozzles). Diet: Consumer foods are aligned in protein, low-sugar and narrow for 24 hours before scanning. Drink alcohol, cigarettes, tea and coffee is prohibited before 12 hours of examination. Sugar consumption with tea or coffee can not be consumed within 24 hours before taking pictures. The consumer drinks and industrial juices containing high levels of sugar are also prohibited. Proof of uses synthetic and desserts is also prohibited. Do not eat bread, rice, pasta, alphere, potatoes, legumes and nuts for 24 hours before scanning. Chicken, fish, meat, eggs, butter, dairy products and salaries are safe and there is no problem of eating. Other drugs are addressed in particular by the dysfunction of diabetes. List of drugs used and previous images including radiation, cutting radiation, magnetic rural, vibration or nuclear medicine including the previous BET / CT before submitting before the examination. The bladder must be incorporated before the examination is followed by the follow-up.

Difficultie patients who control the blood sugar are only by diet: precision according to the above list. Patients who do not depend on insulin: If the time is set for you 12 before 12, the fishing of the food starts from 12 midnight, avoid breakfast or diabetes. If your time is selected after your session, use diabetes as usual, and then stacking for food for 6 hours until the specified time. Patients who depend on insulin: to be better to ask your appointment before 12 noon. After eating and take insulin, you should stay in the lying position for 4 hours until the specified time. Take insulin with you. If the time after 12:00, breakfast was as required as regular on the following regions. Use your insulin as normally. The period of insulin consumption and the time of the radioactive period of 4 hours of drugs: Damruhey, Bamma Baidi, a medical, and the use of all medicines used in accordance with the current procedure before and after the examination. Special treatments before checking, if necessary alprazolam oral from 0.5 mg at the time of the radiation injury for head and neck patients, indoor fear, overworking Mall 20 mg Propranolol or 10 mg Diazepam half an hour before injection radioactive materials to suppress the removal of the FDG by fat bone. By surveying to check the collision of the colon in colon, you must stop metalfor to 2-3 days. The conditions surrounded by the exposed avoid exposure to cold or cold air for anomis before the examination. Stop all air conditioners using the day of the examination. Avoid opening the windows of the car when going to the center and use the car heating in the cold days. Be sure to wear warm clothes and hats while accessing the PET / CT center during the cold days of the year, wear long sleeves and pants in the warm seasons .

After the completion of the examination, the patient is transferred to a special room for patients to drink water for a period not exceeding one hour and then the patient is discharged after the success of the examination is confirmed, he is informed of the date of the result of the examination.

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