

A Review on Application of Radioisotopes in Cancer Therapy

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Abstract: Radioisotope therapy is a procedure where liquid radiation, such as Lutathera, along with amino acids to protect the kidneys, are administered through an infusion. The liquid radiation targets cancerous cells while causing minimal damage to surrounding healthy cells. Radiopharmaceutical are radioactive isotopes which are used to diagnose or work as a cancer therapy. Radioactive isotopes have unstable nucleus that decays or emit excess radiation or energy until the nucleus becomes stable. To date, researchers have discovered radioactive substances that can target various cancer like thyroid cancer, lymphoma, ovarian cancer, brain cancer or cancer which widespread to the bones. In the thyroid cancer the cause is unknown or poorly understood but may involve the genetic and environmental factors.

Keywords: Radioisotope therapy

I. INTRODUCTION

Radioisotope therapy is a procedure where liquid radiation, such as Lutathera, along with amino acids to protect the kidneys, are administered through an infusion. The liquid radiation targets cancerous cells while causing minimal damage to surrounding healthy cells. Radiopharmaceutical are radioactive isotopes which are used to diagnose or work as a cancer therapy. Radioactive isotopes have unstable nucleus that decays or emit excess radiation or energy until the nucleus becomes stable. To date, researchers have discovered radioactive substances that can target various cancer like thyroid cancer, lymphoma, ovarian cancer, brain cancer or cancer which widespread to the bones. In the thyroid cancer the cause is unknown or poorly understood but may involve the genetic and environmental factors.

To treat the thyroid cancer patients undergo the medication, surgery and radiation therapy to kill the cancerous cell which left after the surgery. Radioactive substances administered in the different form such as orally [in form of pill], IV and interstitial [inserted into the cavity]. A radiopharmaceutical is a drug made up of radioactive substances i.e. radionuclide's. Sometimes it bound with the mAb which attaches to the cancerous cell. Examples of radioactive substances are Cobalt- 60, Iodine, Bismuth, Radium.

Radioisotopes, also known as radionuclides, are radioactive atoms used in cancer treatment to deliver radiation directly to cancer cells.

- **Radioisotope therapy:** A treatment that uses liquid radiation, such as Lutathera, to target cancer cells. The liquid is administered through an infusion along with amino acids to protect the kidneys.
- **Diagnostic:** Doctors use isotopes to visualize the location and contours of a tumor.
- **Theragnostic:** A combination of diagnostic and therapeutic uses.

Radioisotopes can be given as a drink, capsule, or injection into a vein. There are different types of radioisotopes, and each type may treat a different type of cancer. Radioisotopes therapy, also known as targeted radionuclide therapy, uses a radioactive drug that seek out and destroy cancer cell while minimizing damage to neighboring healthy cell. Radioisotope therapy can be used to treat several different kinds of cancer, including thyroid cancer, bile duct cancer, liver cancer, bone metastases, and neuroblastoma. Depending on which type of cancer is present, different radioactive isotopes will be used.

ADVANTAGES OF RADIOACTIVE ISOTOPES IN CANCER

- Give accurate result, if proper metabolic time and technique applied.
- Wide ranges of stable isotopes are available for cancer therapy.
- Immune reactions are highly specific and sensitivity when patient is treated over conventional.
- Easier and cheaper to dispose of lower dose
- More reliable, easily administration and isolation procedure required.
- It can treat certain thyroid cancer and some cases of graves disease
- Radium-223 is effective at treating bone tumor when prostates cancer spreads to your bone.
- Radioisotopes therapy with lutathera is able to target and kill these cancer cell .

DISADVANTAGES

- Toxicity: Radioisotopes can cause harm to healthy cells and tissues, leading to side effects such as fatigue, nausea, and bone marrow suppression.
- Limited accessibility: Radioisotope-based cancer treatments are not widely available, particularly in developing countries, due to high costs and limited infrastructure.
- Cost: Radioisotope-based cancer treatments can be expensive, making them inaccessible to many patients.
- Radiation exposure: Patients and medical staff may be exposed to radiation during treatment and handling of radioisotopes.
- Limited tumor specificity: Radioisotopes may not specifically target cancer cells, leading to damage to healthy tissues.
- Resistance and relapse: Cancer cells may develop resistance to radioisotope-based treatments, leading to relapse.
- Short half-life: Some radioisotopes have a short half-life, requiring frequent administrations.
- Immunosuppression: Radioisotope-based treatments can weaken the immune system, making patients more susceptible to infections.
- Secondary cancers: Long-term exposure to radioisotopes may increase the risk of secondary cancers.
- Disposal challenges: Radioisotopes require specialized disposal procedures to prevent environmental contamination

II. LITERATURE REVIEW

Dhiman Kapil et al 2019, Radiopharmaceutical basically deals with the application of radioactive nuclides as a therapeutic agent in different diseases treatment and somewhere also as sterilising agent. The therapeutic action depends on the radiation potential of nuclides which is utilised to terminate the cancerous cell by either implanting nuclides close to the tumour or by selective delivery of nuclides to the malignant cells using immunobiology.

Sharma jyoti et al 2019, Radionuclides are outlined to be more lethal towards malignant cells in comparison to normal cells, and this stimulated the researchers to use radionuclides in cancer treatment. Teletherapy one of the method for treating deep settled tumours is through the application of a direct powerful narrow beam of gamma rays [γ], emitted by an artificial isotope, into the tumour. Cobalt-60 is most commonly used isotope for teletherapy. In “Brachytherapy” compact source of radiation is implanted for treatment of superficial tumours.

Dejene Tolossa Debela et al 2021, Cancer is a global health problem responsible for one in six deaths worldwide. Treating cancer has been a highly complex process. Conventional treatment approaches, such as surgery, chemotherapy, and radiotherapy, have been in use, while significant advances are being made in recent times, including stem cell therapy, targeted therapy, ablation therapy, nanoparticles, natural antioxidants, radionics, chemodynamic therapy, sonodynamic therapy, and ferroptosis-based therapy.

Kumar Damit et al 2019, The recent advancement in drug delivery stimulated the focus toward the application of monoclonal antibodies (mAb's) for selective targeting of the malignant cells. Previously the mAb's used were derived from mouse which is recently seen to form HAMA (Human Anti-Mouse Antibody) Genetically engineered and

humanised mAb's appear to be one of the most promising strategies to avoid HAMA formation. This review include the detailed study and the recent application of radioisotopes like ^{90}Y , ^{212}Bi , ^{213}Bi , ^{123}I & ^{124}I in treatment of cancer through radio immunotherapy

Johanna L. Wickemeyer et al 2020, Radioisotope therapy uses the natural decay process of the radioactive material to emit radioactive rays. Commonly used in head and neck cancer is Iodine-131 for the treatment of thyroid cancer. The use of this therapy poses a theoretic risk to the CI. Radioisotope therapy is similar to gamma rays and proton beams, and radioisotopes have the potential to destroy the atomic grid of semiconductors in a CI.

III. AIM

A Review on Application of Radioisotopes in cancer Therapy

OBJECTIVE:-

The objective of radioisotope therapy in cancer treatment is to deliver a high dose of radiation to cancer Cells while minimizing damage to healthy cells.

- To understand the role of radioisotopes in cancer diagnosis and treatment.
- To review the different types of radioisotopes used in cancer management.
- To discuss the advantages and limitations of radioisotope-based cancer therapies.
- To explore the future directions and potential applications of radioisotopes in cancer care.

IV. PLAN OF WORK

A Review on Applications of Radioisotopes in Cancer Therapy

Introduction

- Background: Brief overview of cancer therapy and the role of radioisotopes
- Objective: To review the applications of radioisotopes in cancer therapy
- Scope: Types of radioisotopes, delivery methods, and cancer types treated

Types of Radioisotopes Used in Cancer Therapy

- Alpha-particle emitters (e.g., Ra-223, Ac-225)
- Beta-particle emitters (e.g., I-131, Y-90)
- Gamma-ray emitters (e.g., Ir-192, Cs-137)

Delivery Methods for Radioisotopes in Cancer Therapy

- Brachytherapy: Direct implantation of radioisotopes into tumors
- Radiopharmaceuticals: Systemic administration of radioisotopes attached to targeting molecules

Applications of Radioisotopes in Cancer Therapy

- Prostate cancer: Ra-223, I-131, Y-90
- Thyroid cancer: I-131
- Breast cancer: I-131, Y-90
- Leukemia: I-131, Y-90
- Lymphoma: I-131, Y-90

Advantages of Radioisotopes in Cancer Therapy

- Advantages: Targeted therapy, improved efficacy, reduced side effects

Future Directions and Emerging Trends

- Alpha-particle therapy: Development of new alpha-particle emitting radioisotopes
- Nanoparticle-based radiotherapy: Use of nanoparticles to deliver radioisotopes to tumors

- Combination therapy: Use of radioisotopes in combination with other cancer therapies

References

- List of sources cited in the review, formatted according to the chosen citation style.
- This plan of work provides a comprehensive outline for a review on the applications of radioisotopes in Cancer therapy.

V. MACHINE PROFILE

The most common machine used for radiotherapy is a linear accelerator (LINAC), which is a large machine that uses electricity to generate high-energy x-rays or electrons to treat cancer:

Appearance

The LINAC looks like a large x-ray machine or CT scanner. It's often kept in a separate room and may have an imaging device attached.

Treatment

During treatment, you lie on a couch while the treatment head moves around you to deliver the radiation. You usually receive treatment once a day for five days in a row.

Side effects

Radiation therapy can injure healthy cells near the cancer cells, which can cause side effects. The side effects depend on the part of the body being treated and vary in degree from person to person

Other types of radiotherapy

Other types of radiotherapy include Cyber Knife or Robotic Radiosurgery, which uses a frameless robotic system to deliver a high dose of radiation to cancer cells.

A radiotherapy machine, often known as a linear accelerator (linac), is a piece of medical equipment utilised to deliver high-energy radiation. This radiation is used typically in the treatment of cancer to destroy cancer cells while minimising damage to the surrounding healthy tissue. Radiation therapy can be given inside or outside of your body. The most common kind is external beam radiation therapy. This treatment uses a large machine called a linear accelerator.

Highenergy beams are aimed from the machine to a precise point on your body.

New machine

Halcyon™ Radiation Therapy System is the latest and most advanced system that has transformed radiation therapy by providing sophisticated, highly targeted cancer treatment with precision and accuracy. It delivers high quality care by optimizing 3D conformal, intensity- modulated radiation therapy (IMRT), image-guided radiotherapy (IGRT) and RapidArc radiotherapy treatments.



TYPES OF RADIATION THERAPY

There are two main types of radiation therapy :

External beam radiation therapy (EBRT) and internal radiation therapy. Both types work by destroying a cancer cell's DNA. Without DNA instructions telling them to grow and multiply, cancer cells die and tumors shrink.

External beam radiation therapy (EBRT)

Arc-based radiotherapy- is a form of IMRT. It directs energy beams of varying intensity in a rotational arc- like pattern. This method delivers radiation faster than traditional IMRT. Volumetric modulated arc therapy (VMAT) and tomotherapy are two forms of arc-based radiotherapy.

Image-guided radiotherapy (IGRT) - is a form of EBRT in which the radiation machine obtains a low-dose X-ray or mini CT scan before each treatment. This image helps align the treatment site, resulting in more precise radiation delivery.

Particle therapy- uses radiation therapy that consists of protons instead of photons (X-rays). For certain people, protons can deliver the same radiation dose to the tumor and reduce radiation dose to healthy tissues. Stereotactic radiosurgery- such as Gamma Knife surgery, uses high doses of focused radiation to destroy small brain tumors with surgical precision. Unlike surgery, it doesn't require cutting.

Typically, this treatment takes one to five days.

Stereotactic body radiation therapy (SBRT)- uses high doses of focused radiation to destroy tumors outside of your brain. Like stereotactic radiosurgery, it eliminates tumors with surgical precision but without actual surgery.

Intraoperative radiation (IORT)- delivers radiation during surgery. After a tumor has been removed surgically, IORT destroys any remaining cancer cells that aren't safe to surgically remove.

Internal radiation therap

Brachytherapy implants a solid radioactive source, or "seed," inside or beside a tumor. The source releases radiation to a small area to kill cancer cells. Some implants release low doses for longer periods (weeks). Others may release high doses for shorter periods (minutes).

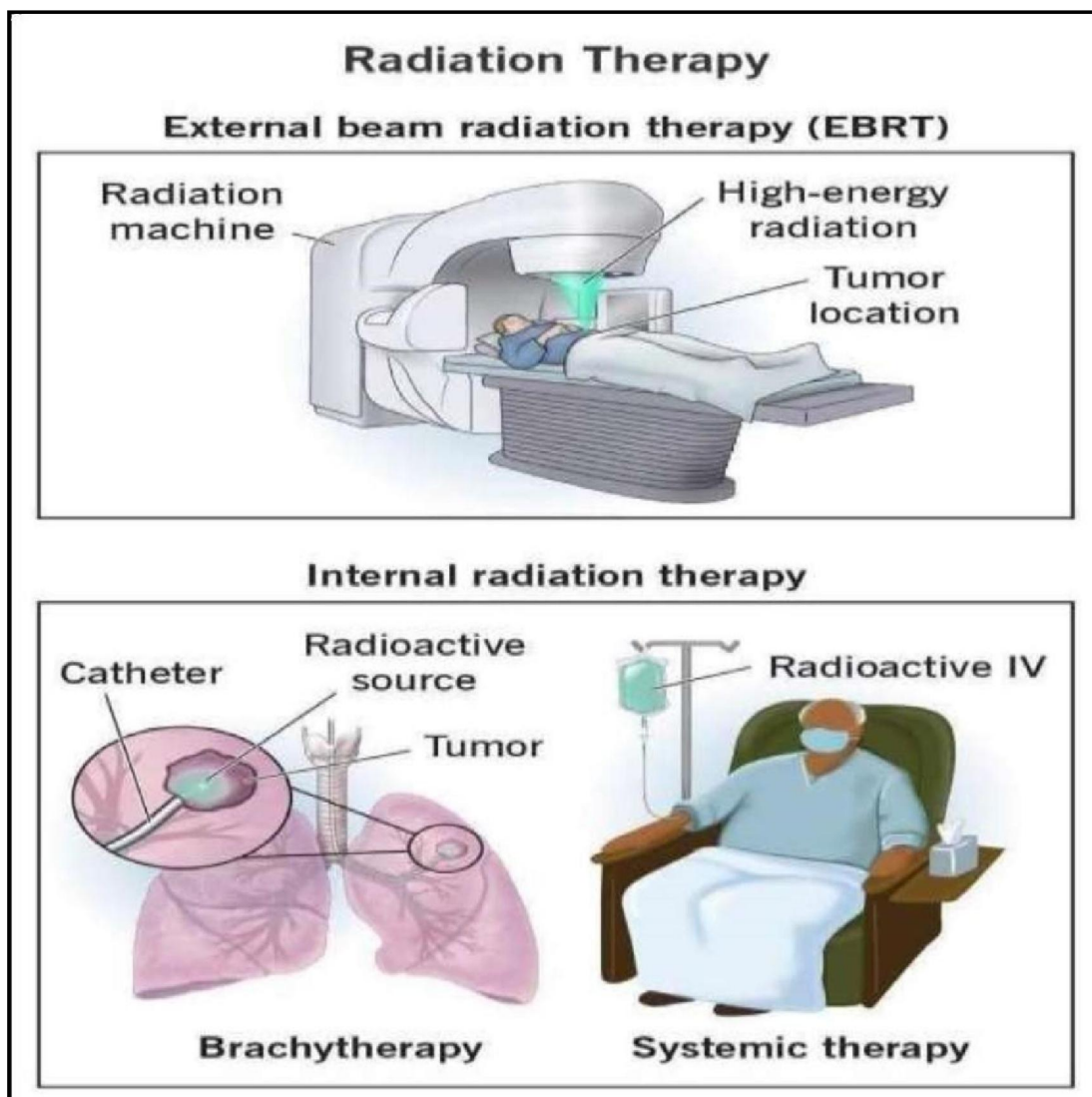
Some implants used in brachytherapy are temporary. Others stay in your body forever. Eventually, they stop releasing radiation.

Systemic therapy Sends liquid radioactive material through your blood to find and destroy cancer cells. Some forms are swallowed. For others, you'll receive an injection through a vein

(IV). Treatments include radionuclide therapy (radioimmunotherapy). With radioimmunotherapy, a radioactive protein recognizes specific cancer cells, attaches to them and then releases radiation to kill them.

Internal radiation therapy

- Eye cancer
- Breast cancer
- Gyenacology cancer
- Bladde cancer
- Skin cancer



APPLICATION OF MEDICINES

| Radioactive Isotopes | Application in Medicine |
|----------------------|--|
| Cobalt-60 | Radiation therapy to prevent cancer |
| Iodine-131 | Locate brain tumours ,liver and thyroid activity |
| Carbon-14 | Study metabolism change for patient with diabetes |
| Carbon-11 | Tagged onto glucose to monitor organ during PET scan |
| Sodium-24 | Study blood circulation |
| Thallium-201 | Determine damage in heart tissue ,detection of tumours |
| Technetium-99 | Locate brain tumour and damage heart cell ,radiotracer in medical diagnostics (imaging of organ and blood flow |

WAVELENGTH OF RADIOACTIVE ISOTOPES

| | |
|------------|---------------------------------------|
| Cobalt 60 | 1.17-1.33 Mev (Million electron volt) |
| Iodine 131 | 364 Kev (Kelo electron volt) |
| Carbon 14 | 156 Kev |
| Carbon 11 | 960 Kev |
| Sodium 24 | 1.39 Mev |
| Gamma rays | 0.01 -10 Pm (Pico meter) |

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