ROHINI COLLEGE OF ENGINEERING AND TECHNOLOGY
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**DEPARTMENT OF BIOMEDICAL ENGINEERING**

**VII Semester**

**OBT357 BIOTECHNOLOGY IN HEALTH CARE**

**UNIT- 4 OUT PATIENT & IN-PATIENT SERVICES**

**4.1. Radiotherapy, Nuclear medicine**

## OUT-PATIENT & IN-PATIENT SERVICES

- **Out-Patient Services (OPD):**

  Patients visit the hospital/clinic for consultation, diagnosis, or treatment but do not stay overnight.

  **Examples:**

- ✓ Doctor consultations (e.g., general practitioner, specialists like cardiologists or dermatologists).
- ✓ Diagnostic tests (e.g., X-rays, blood tests, MRIs, ultrasounds).
- ✓ Minor procedures (e.g., mole removal, dental work, cataract surgery).
- ✓ Physical therapy, counseling, or rehabilitation sessions.
- ✓ Vaccinations, health screenings, or wellness checkups.

- **Advantages**:

- ✓ Cost-effective (generally less expensive than inpatient care).
- ✓ Convenient for non-emergency conditions, allowing patients to maintain daily routines.
- ✓ Shorter wait times for appointments and procedures in many cases.

❖ **In-Patient Services (IPD):**

Patients are admitted to the hospital and stay for one or more days for treatment, monitoring, or surgery.

**Examples:**

- ✓ Major surgeries (e.g., heart surgery, joint replacement).
- ✓ Treatment for severe conditions (e.g., stroke, heart attack, severe infections).
- ✓ Maternity care (e.g., childbirth, cesarean sections).
- ✓ Intensive care unit (ICU) services for critical conditions.
- ✓ Inpatient rehabilitation (e.g., post-stroke recovery, severe trauma).
- ✓ Psychiatric care requiring observation or stabilization.

❖ **Advantages**:

- ✓ 24/7 medical supervision and access to advanced equipment.
- ✓ Comprehensive care for complex or life-threatening conditions.
- ✓ Multidisciplinary teams (doctors, nurses, specialists) available.

### 4.1.2 Radiotherapy

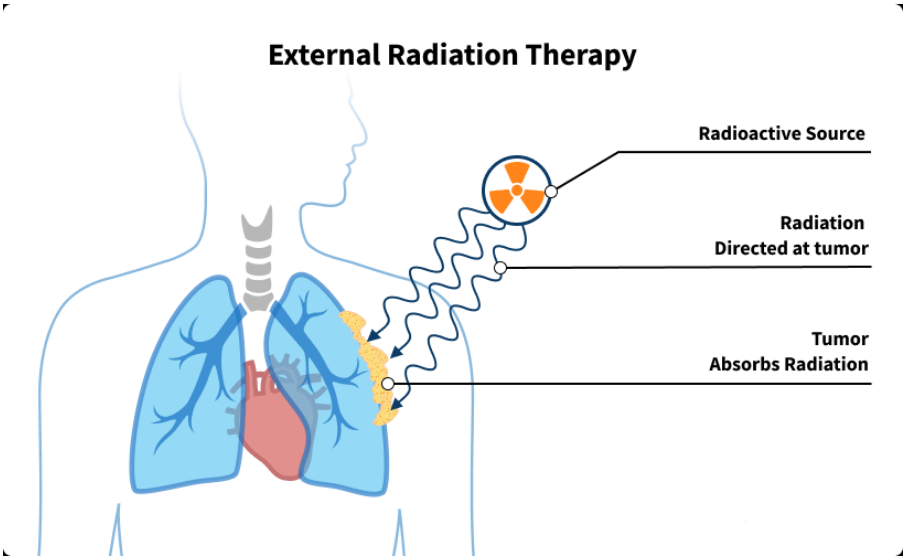
Radiotherapy, also known as radiation therapy, is a medical treatment that uses high-energy radiation, such as X-rays, gamma rays, or charged particles, to target and destroy cancer cells or shrink tumors. It works by damaging the DNA of cancer cells, which prevents them from growing and dividing. Radiotherapy is often used as part of cancer treatment, either alone or in combination with surgery, chemotherapy, or immunotherapy.

#### 4.1.2.1 Outpatient Radiotherapy:

❖ **Description**: Most radiotherapy is delivered on an outpatient basis, where patients visit a treatment center for sessions and return home afterward. Treatments are typically scheduled daily (Monday–Friday) over several weeks.

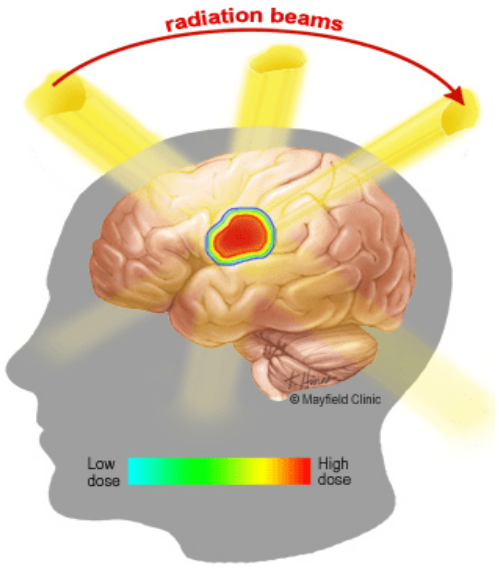
**Examples**:

1. **External Beam Radiation Therapy (EBRT):** Patients receive precise radiation doses from a machine (e.g., linear accelerator). Common for cancers like breast or lung cancer.




   - A **radioactive source** (shown as an orange symbol with radiating lines) emits radiation.
   - The radiation is **directed at the tumor**, represented by yellow shading on the patient's chest, likely indicating a lung or chest wall tumor.
   - The tumor **absorbs the radiation**, which is intended to damage or destroy cancer cells while minimizing harm to surrounding healthy tissues.
   - **Outpatient:** External radiation therapy, as depicted, is typically an outpatient procedure. Patients receive daily sessions (e.g., 10–30 minutes) using machines like linear accelerators, returning home afterward. This aligns with the non-invasive, targeted nature shown in the image.

2. **Stereotactic Radiosurgery (SRS)/Stereotactic Body Radiotherapy (SBRT):** High-dose, focused radiation delivered in fewer sessions (1–5) for brain tumors, liver cancer, or lung metastases.

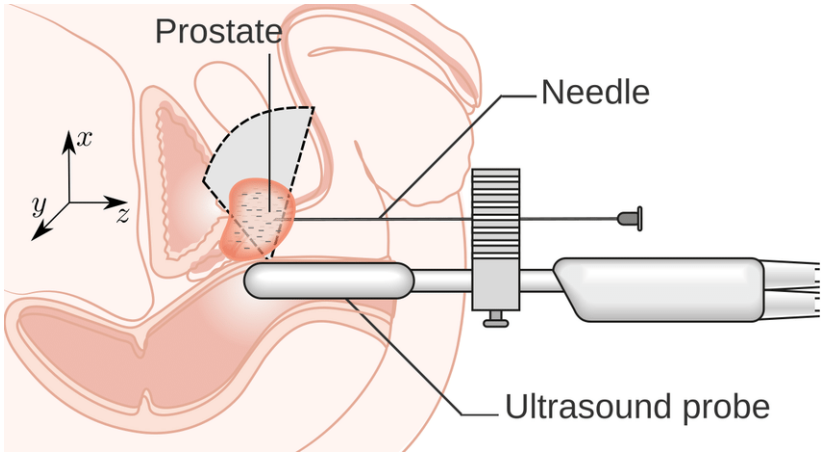



- Multiple **radiation beams** (shown as yellow arrows) converge from different angles onto a specific target within the brain.
- The beams focus on a central area, indicated by a red core surrounded by color gradients (green to yellow), representing varying radiation doses.
- The color scale at the bottom (green for low dose, red for high dose) shows the intensity, with the highest concentration at the tumor or lesion site.
- **Outpatient:** This technique, often delivered in 1–5 sessions using equipment like the Gamma Knife or Cyber Knife, is typically outpatient. Patients receive treatment and go home the same day, aligning with the precision and minimal recovery time implied by the image.

3. **Brachytherapy (Outpatient)**: For certain cancers (e.g., prostate or cervical), radioactive sources are placed temporarily near the tumor and removed after treatment.

    - A **needle** is inserted into the prostate gland, guided by an **ultrasound probe**.
    - The ultrasound probe, inserted into the rectum, provides real-time imaging to target a specific area within the prostate, shown with a shaded region indicating the treatment zone.

- The coordinate axes (x, y, z) suggest a three-dimensional mapping or targeting system, ensuring precise placement of the needle.



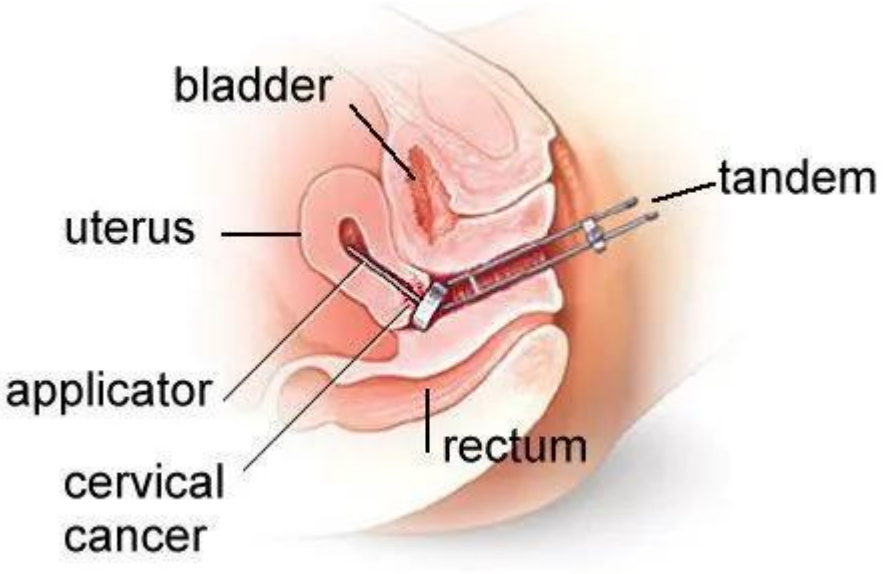

- **Outpatient:** Prostate brachytherapy, particularly low-dose rate (LDR) techniques where radioactive seeds are permanently implanted, is often an outpatient procedure. Patients receive the treatment under local or general anesthesia and go home the same day, aligning with the minimally invasive approach shown.

### 4.1.2.2 Inpatient Radiotherapy

- **Description**: Inpatient radiotherapy is less common but required for complex cases where patients need close monitoring, have severe symptoms, or undergo specialized procedures.

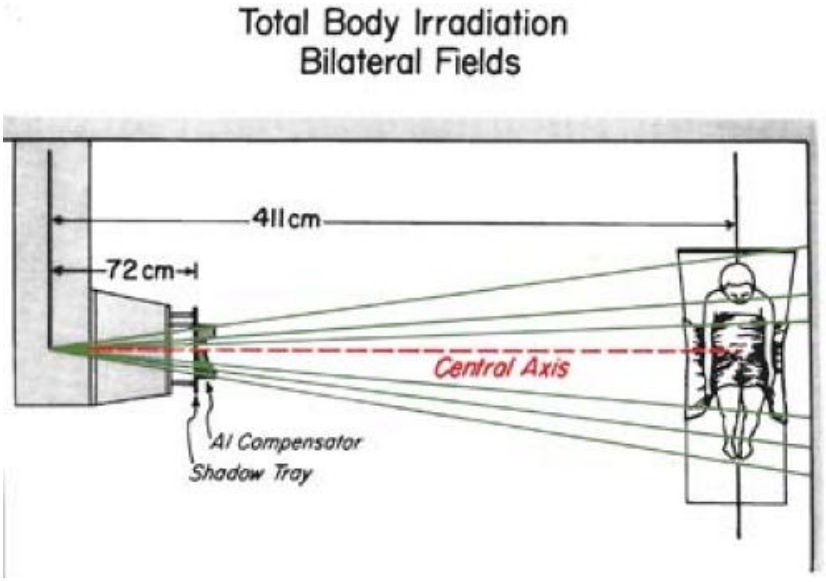
- **Examples**:

1. **Brachytherapy (Inpatient)**: For some cancers (e.g., gynecologic), radioactive implants are placed for days, requiring hospital stays for safety and monitoring.




- An **applicator** and **tandem** (a combination of devices) are inserted into the vaginal cavity and uterus to deliver radiation directly to the cervical cancer site.
- The applicator is positioned near the **cervical cancer** area, with the tandem extending into the uterus, ensuring targeted radiation delivery.
- The surrounding anatomical structures (bladder, uterus, rectum) are shown to indicate the proximity and need for precise placement to minimize damage to healthy tissues.
- Inpatient: HDR brachytherapy for cervical cancer often requires a short hospital stay (1–2 days) for treatment delivery and monitoring, especially when the applicator is left in place for several hours or when multiple sessions are needed. The image suggests an inpatient context due to the complexity of device placement.

2. **Total Body Irradiation (TBI):** Used in preparation for bone marrow transplants, often requiring hospitalization due to high doses and side effects.
    - Radiation is delivered from a source on one side of the patient, passing through the body to the opposite side, using **bilateral fields** (two opposing beams).
    - The **central axis** (marked in red) represents the primary path of the radiation beam through the patient's body.




- ❖ An **Al compensator shadow tray** is used to adjust and distribute the radiation dose evenly across the body, compensating for variations in tissue thickness.
- ❖ **Inpatient:** TBI is almost exclusively an inpatient procedure. It is typically administered as part of a conditioning regimen before a bone marrow or stem cell transplant, requiring hospitalization for monitoring due to high radiation doses and potential side effects (e.g., nausea, immune suppression).

3. **Pediatric Cases**: Children may need inpatient care for sedation during radiotherapy sessions or to manage complications.

### 4.1.3 Nuclear Medicine:

Nuclear medicine is a specialized branch of medical imaging and therapy that uses small amounts of radioactive materials, called radiopharmaceuticals, to diagnose and treat various diseases.

❒ **Principle**:

- ❖ Radioactive tracers are introduced into the body (by injection, inhalation, or swallowing).

- These tracers emit gamma rays or positrons, which can be detected by special cameras.
- The images show both the **structure** and **function** of organs.

❒ **Diagnostic Applications**:

- **PET (Positron Emission Tomography) Scan** – detects cancers, brain disorders, heart problems.
- **SPECT (Single Photon Emission Computed Tomography)** – evaluates blood flow to heart, brain, or bones.
- **Bone Scans** – detect fractures, infections, or tumors.
- **Thyroid Scans** – assess thyroid function.

❒ **Therapeutic Applications**:

- **Radioiodine therapy (I-131)** – treats thyroid cancer and hyperthyroidism.
- **Radiolabeled antibodies or peptides** – target certain cancers.
- **Radionuclide therapy** – used in bone pain from metastases.

**Outpatient vs. Inpatient:**

- **Outpatient**: Common for diagnostic scans and low-dose therapies (e.g., thyroid treatment), offering convenience and lower costs.
- **Inpatient**: Required for high-dose therapies (e.g., advanced cancer treatments) to manage radiation exposure and side effects like nausea or fatigue.

1. **Radioiodine therapy (I-131):**
   - Radioiodine (I-131) therapy is a nuclear medicine treatment primarily used for hyperthyroidism (e.g., Graves' disease, toxic nodular goiter) and differentiated thyroid cancer (e.g., papillary or follicular carcinoma).
   - It involves administering radioactive iodine (I-131), which is absorbed by thyroid cells to destroy overactive or cancerous tissue through localized beta radiation.
   - Inpatient I-131 therapy is typically required for higher doses, particularly for thyroid cancer, to manage radiation safety and minimize exposure to

others. Below is a detailed overview of inpatient I-131 therapy services based on current standards and practices.

- **Hyperthyroidism**: Reduces thyroid activity by destroying overactive thyroid tissue. Doses typically range from 100–600 MBq (2.7–16.2 mCi).
- **Thyroid Cancer**: Ablates residual thyroid tissue post-thyroidectomy or treats metastatic disease. Doses are higher, often 1.75–7.4 GBq (47–200 mCi).
- Higher doses (usually >1.1 GBq or 30 mCi) require hospitalization to comply with radiation safety regulations, as patients emit radiation that could pose a risk to others. The International Atomic Energy Agency (IAEA) recommends inpatient care until residual activity falls below 1100 MBq.

## 2. Radiolabeled antibodies or peptides:

- Radiolabeled antibodies and peptides are used in nuclear medicine for diagnostic imaging and targeted therapy, primarily in oncology, but also in fields like rheumatology, cardiology, and neurology.
- Unlike high-dose radioiodine (I-131) therapy, which often requires inpatient care due to radiation safety concerns, radiolabelled antibodies and peptides are frequently administered in outpatient settings, especially for diagnostic purposes or lower-dose therapeutic applications

| Aspect | Inpatient | Outpatient |
|---|---|---|
| **Indications** | High-dose therapies (e.g., 7.4 GBq 177Lu-DOTATATE), long half-life radionuclides (e.g., 177Lu, 90Y), slow-clearing antibodies. | Low-dose diagnostics (e.g., 68Ga, 99mTc), low-dose therapies, rapid-clearing peptides. |
| **Dose Range** | Therapeutic: 1–7.4 GBq; higher radiation output. | Diagnostic: 185–370 MBq; therapeutic: <1.1 GBq or rapid clearance. |

| Aspect | Inpatient | Outpatient |
|---|---|---|
| **Hospital Stay** | 2–5 days, in shielded isolation room. | Same-day discharge after 1–4 hours observation. |
| **Radiation Safety** | Strict isolation, no/limited visitors, lead-lined rooms. | Minimal precautions (1–3 days), no isolation required post-discharge. |
| **Radionuclides** | 177Lu, 90Y, 225Ac (longer half-lives, higher energy). | 68Ga, 99mTc, 111In (shorter half-lives, lower energy). |
| **Patient Restrictions** | Avoid contact for 3–14 days, strict hygiene, travel card for 1–3 months. | Avoid contact for 1–3 days, basic hygiene, travel card for 1–3 months. |
| **Facility Requirements** | Lead-lined rooms, medical physicist monitoring, specialized nursing. | Shielded injection room, access to PET/SPECT, trained nuclear medicine staff. |
| **Side Effects** | Higher risk of bone marrow suppression, nephrotoxicity with therapeutic doses. | Milder (e.g., nausea, fatigue), lower nephrotoxicity risk. |
| **Examples** | 177Lu-DOTATATE (PRRT), 90Y-ibritumomab tiuxetan (RIT). | 68Ga-DOTATOC (PET), 111In-octreotide (SPECT), low-dose 177Lu-PSMA. |

3. **Radionuclide therapy:**

Radionuclides emit beta particles (e.g., 177Lu, 90Y, 131I) or alpha particles (e.g., 225Ac, 223Ra) to damage DNA in targeted cells, leading to cell death. Gamma emissions may also allow imaging to monitor uptake.

**Comparison of Inpatient vs. Outpatient Radionuclide Therapy:**

| Aspect | Inpatient | Outpatient |
|---|---|---|
| **Indications** | High-dose therapies (e.g., I-131 >1.1 GBq, 177Lu-DOTATATE 7.4 GBq), long half-life radionuclides, slow-clearing agents. | Low-dose therapies (e.g., I-131 <1.1 GBq, 223Ra), short half-life radionuclides, rapid-clearing peptides. |
| **Dose Range** | Therapeutic: 1–7.4 GBq; higher radiation output. | Therapeutic: <1.1 GBq or rapid clearance; diagnostic: 185–370 MBq. |
| **Hospital Stay** | 2–5 days in shielded isolation room. | Same-day discharge after 1–4 hours observation. |
| **Radiation Safety** | Strict isolation, no/limited visitors, lead-lined rooms. | Minimal precautions (1–3 days), no isolation post-discharge. |
| **Radionuclides** | 131I, 177Lu, 90Y, 225Ac (longer half-lives, higher energy). | 68Ga, 99mTc, 223Ra (shorter half-lives, lower external radiation). |
| **Patient Restrictions** | Avoid contact for 3–14 days, strict hygiene, travel card for 1–3 months. | Avoid contact for 1–3 days, basic hygiene, travel card for 1–3 months. |
| **Facility Requirements** | Lead-lined rooms, medical physicist monitoring, specialized nursing. | Shielded injection room, access to imaging (PET/SPECT), trained staff. |
| **Side Effects** | Higher risk of bone marrow suppression, nephrotoxicity, hypothyroidism. | Milder (e.g., nausea, fatigue), lower toxicity risk. |
| **Examples** | I-131 (thyroid cancer), 177Lu-DOTATATE (PRRT), 90Y-Zevalin (RIT). | I-131 (hyperthyroidism), 223Ra (bone metastases), low-dose 177Lu-PSMA. |