Introduction to radiotherapy

Presented by:
Atefeh Mahmoudi

PhD Candidate in Medical Physics
Iran university of Medical Sciences

Introduction

Radiation therapy is the precise delivery of high-energy x-rays or other forms of radiation to treat disease, especially cancer.

This is also called **radiation oncology**.

Radiotherapy alone

In combination with surgery,
Either preoperatively or postoperatively

In combination with systemic chemotherapy
Before,
During,
Subsequent to the course of radiotherapy

Introduction

Absorbed dose

A measure of the energy deposited in a medium by ionizing radiation. It is equal to the energy deposited per unit mass of a medium

$$D\ (Gy) = 1\ J.\ kg^{-1}$$

1 rad = 0.01 Gy = 0.01 J/kg

Radiotherapy consult

6 main questions must be answered by radiation oncologist:

* What is the **indication** for the radiotherapy?
* What is the **goal** of radiotherapy?

* What is the planned treatment **volume**?
* What is the planned treatment **technique**?
* What is the planned treatment tumor **dose** and **fractionation**?
* What is the radiation **tolerance** of the surrounding normal tissue / Organs at risk?

Indication of the radiotherapy

The *indication* for radiation therapy is that body of data that can be brought to bear showing that radiation therapy would be efficacious for the patient's condition.

Such data might exist in the form of retrospective single-institution reviews of the specific malignancy, which provide evidence favoring the role of radiotherapy.

Phase I and II studies demonstrating safety and possible efficacy could be invoked to justify a course of radiation therapy.

For many physicians, the gold standard, however, is a prospective, randomized, phase III trial that demonstrates the value of radiation therapy.

Goal of radiotherapy

* Curative (radical)
* Palliative
* Prophylactic

- relieve bone pain
- treat pressure on the spinal cord (spinal cord compression)
- shrink a tumor to relieve pressure or a blockage
- treat symptoms of cancer in the brain
- treat symptoms of cancer in the lungs
- control an ulcerating cancer and reduce bleeding

Volume

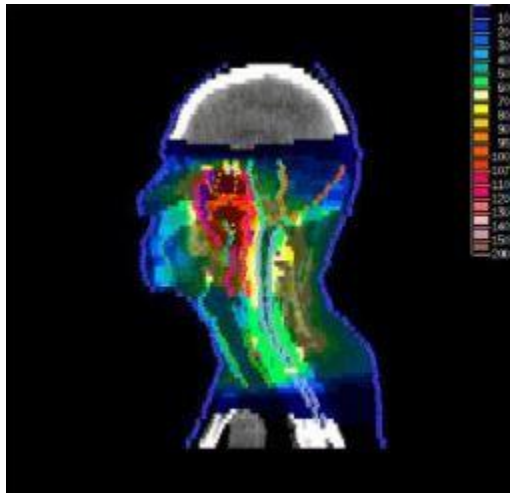
Volumes that needs to be irradiated for achieving desired curative or palliative goal.

* Visualized or palpable tumor mass?
* Mass and surrounding lymphatics?
* Microscopic disease spread?

Example, medulloblastoma

Surgery alone, almost all patients relapse both locally and by leptomeningeal dissemination via CSF

Thus RT volume for patients with intermediate /high risk disease will be the entire craniospinal axis



Technique

.

Teletherapy
(external RT)

Cobalt 60 unit
Linear accelerators
Gamm knife
Cyber knife
Proton therapy
Heavy ion therapy-Carbon therapy
RT fields:
Parallel opposed fields
Four fields
Multiple fields
IMRT, SRS, SRT, SBRT

Brachytherapy

Radioactive implant

* Interstitial brachytherapy (soft tissue sarcoma)
* Intracavitary * brachytherapy (cervical)
Mold therapy (skin)

Dose/Fractionation

- **The correct number of RT fractions per day**
- **Correct dose per fraction**
- **Proposed total dose of RT**
- **Dose rate (RT given per minute)**
  HDR VS LDR

Decisions concerning dose will, in part, be driven by decisions concerning treatment volume and technique.

Normal Tissue Tolerance

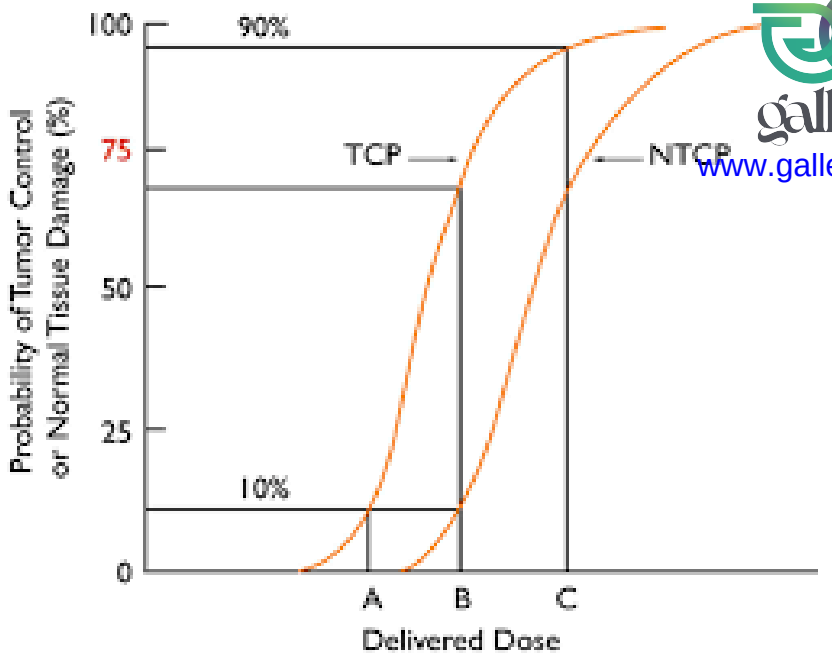
Finally, the radiation oncologist must consider normal tissue *tolerance*.

In general terms, the probability of acute and late effects of radiation is a function of dose.

Ultimately, the prescription of a dose requires the radiation oncologist to engage in a balancing act between a sufficient dose of radiation to achieve the desired treatment goal and not giving so much dose as to engender an unacceptable risk of side effect.

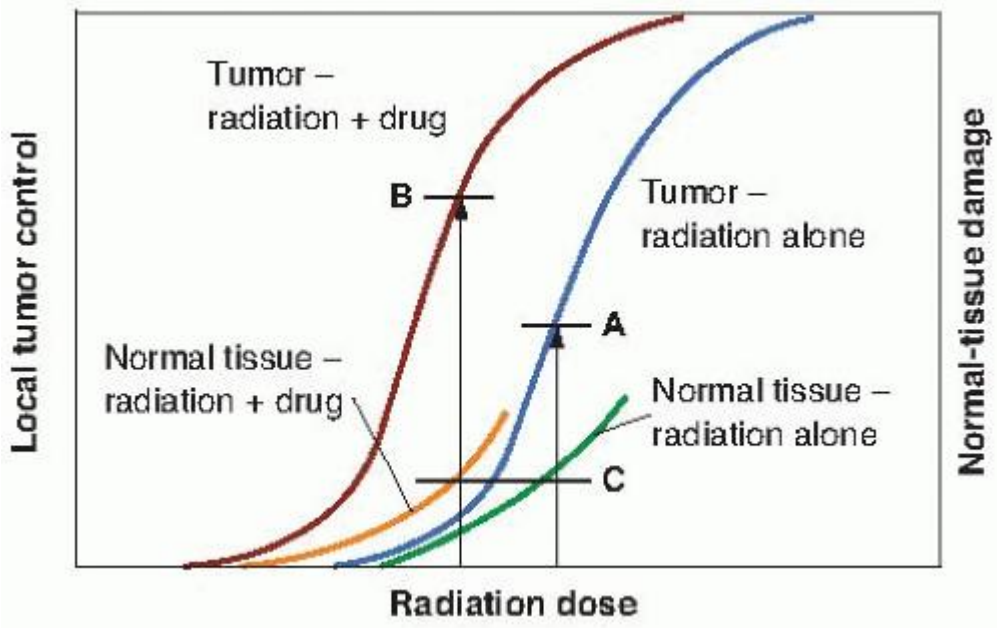
Therapeutic Ratio (TCP & NTCP)

$$\text{Therapeutic Ratio} = \frac{\text{probability of tumor control}}{\text{probability of normal tissue damage}}$$



How to increase therapeutic ratio?

* Time factor, hyperfractionation
* To add a drug or radiosensitizer



Preparation for radiotherapy

Prescription

Dose/fraction, total dose, number of fractions, intervals, overall time

Simulation

Patient positioning on conventional or CT simulator

Treatment plan

Developing the treatment plan by a medical physicist

Treatment delivery

Radiation dose delivery

Immobilization

Quite simply, the process of immobilization involves limiting or eliminating target movement for the time period of imaging or treatment.

The aim of immobilization in radiotherapy is to secure the patient in the same position at each treatment fraction. This is required in order to deliver the planned radiation doses accurately.

Immobilization devices for radiation oncology should have the following general properties:

(1) reproducible and comfortable for the patient,

(2) ease of use and setup,

(3) easy in making and cleaning,

(4) maintaining the rigidity and shape throughout the course of treatment for patient-specific devices, and

(5) indexing to the treatment table.

Immobilization devices

www.galleny.com

- Masks and headrests are used for treatment to the brain, head & neck, and upper spine areas

Molds, Vac-Lok Bags, and Casts

Immobilization devices

www.galleny.com

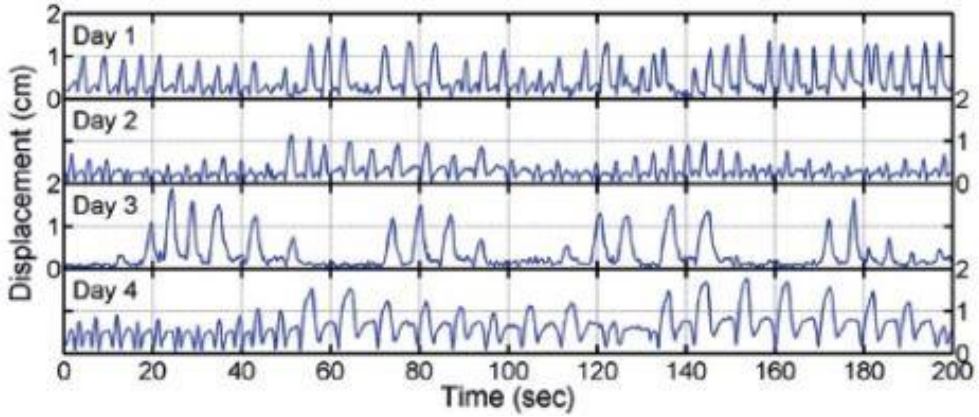
Breast board
There are two types of breast boards, one where you lie on your back (supine breast board) and one where you lie on your stomach (prone breast board)

Knee and Foot Locks
are used to keep you still if you are getting radiation to the pelvic area

Belly boards
are often used if the pelvic area is being treated and your small bowel is too close to the treatment area

Technology to manage organ motion

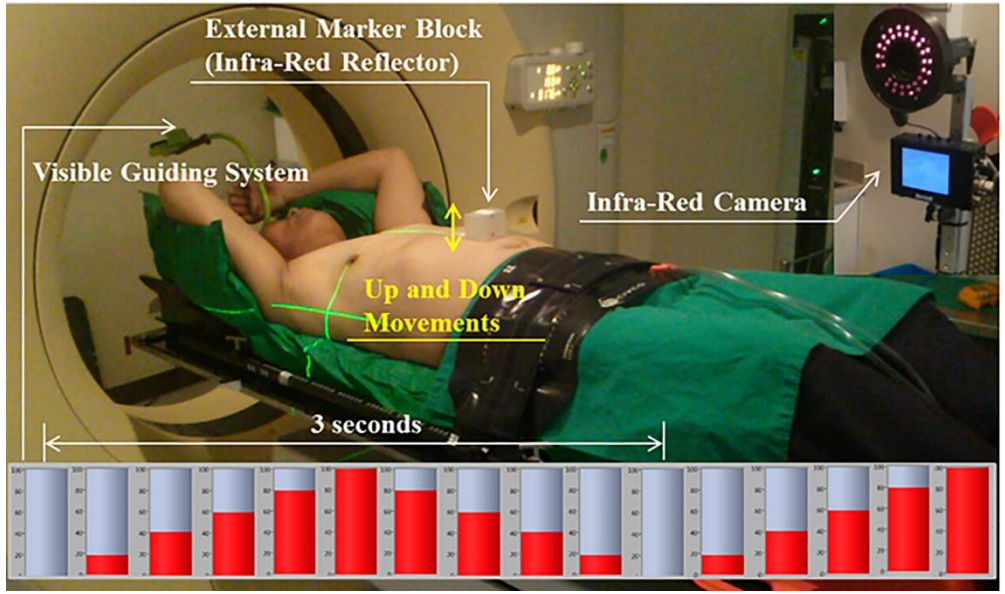
* Larger margins



* gating (turning on and off) the treatment beam

Gating is a system that tracks a patient's normal respiratory cycle with an infrared camera and chest/abdomen marker.

The most significant concern with external gating is the relationship between the external marker position and the tumor location.



Technology to manage organ motion

* Active breathing control (ABC)

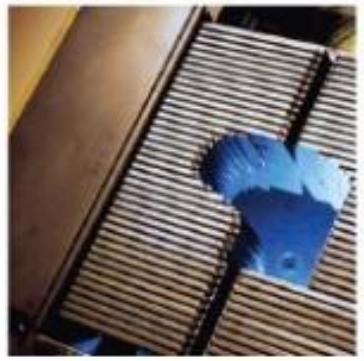
* Tumor tracking

  In this process, an estimate of the target's trajectory is used to adjust the couch, linear accelerator orientation, or field aperture.

Robotic linac head
CyberKnife
Synchrony, Accuray
Clinical 2004

Gimbaled linac
Vero/Mitsubishi
Clinical 2011

MLC adaptation
Clinical 2013
Smallest
Lightest
6 DoF
Deformation



Robotic couch
Clinical ?

Technology to manage organ motion

* 4D CT scan

Multiple scans are obtained for each location (oversampling) whereby the organ motion is captured at different sampled phases of the respiratory cycle.

At the end of the scan a very large set of 3D images is produced corresponding to each of the phases in which the breathing cycle was sampled.