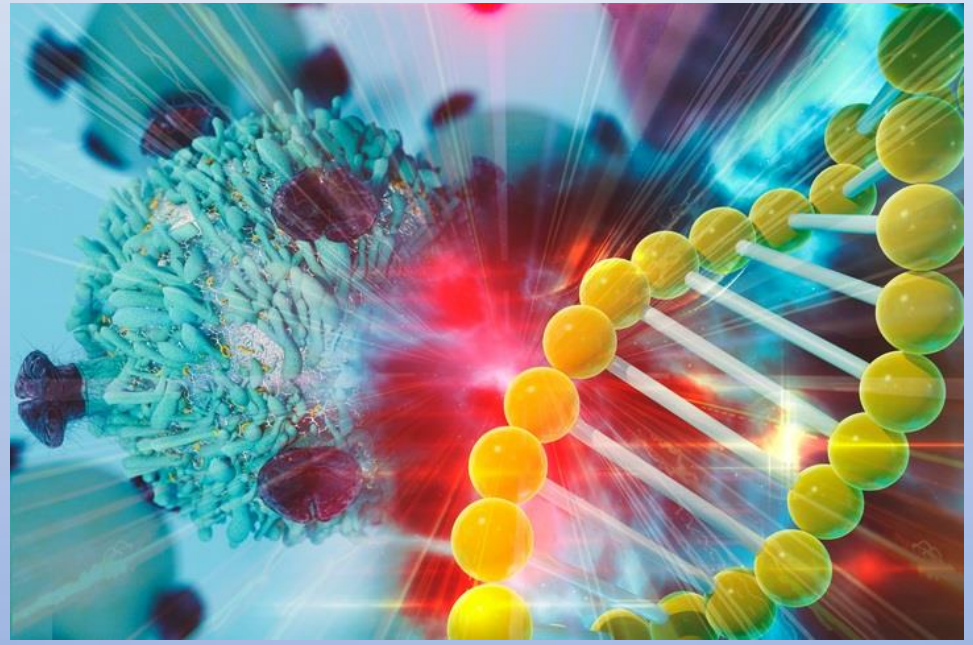
Complications of Radiation Therapy



Gregg Goldin, MD

BRRH Grand Rounds

2/26/19

BOCA RATON
REGIONAL HOSPITAL

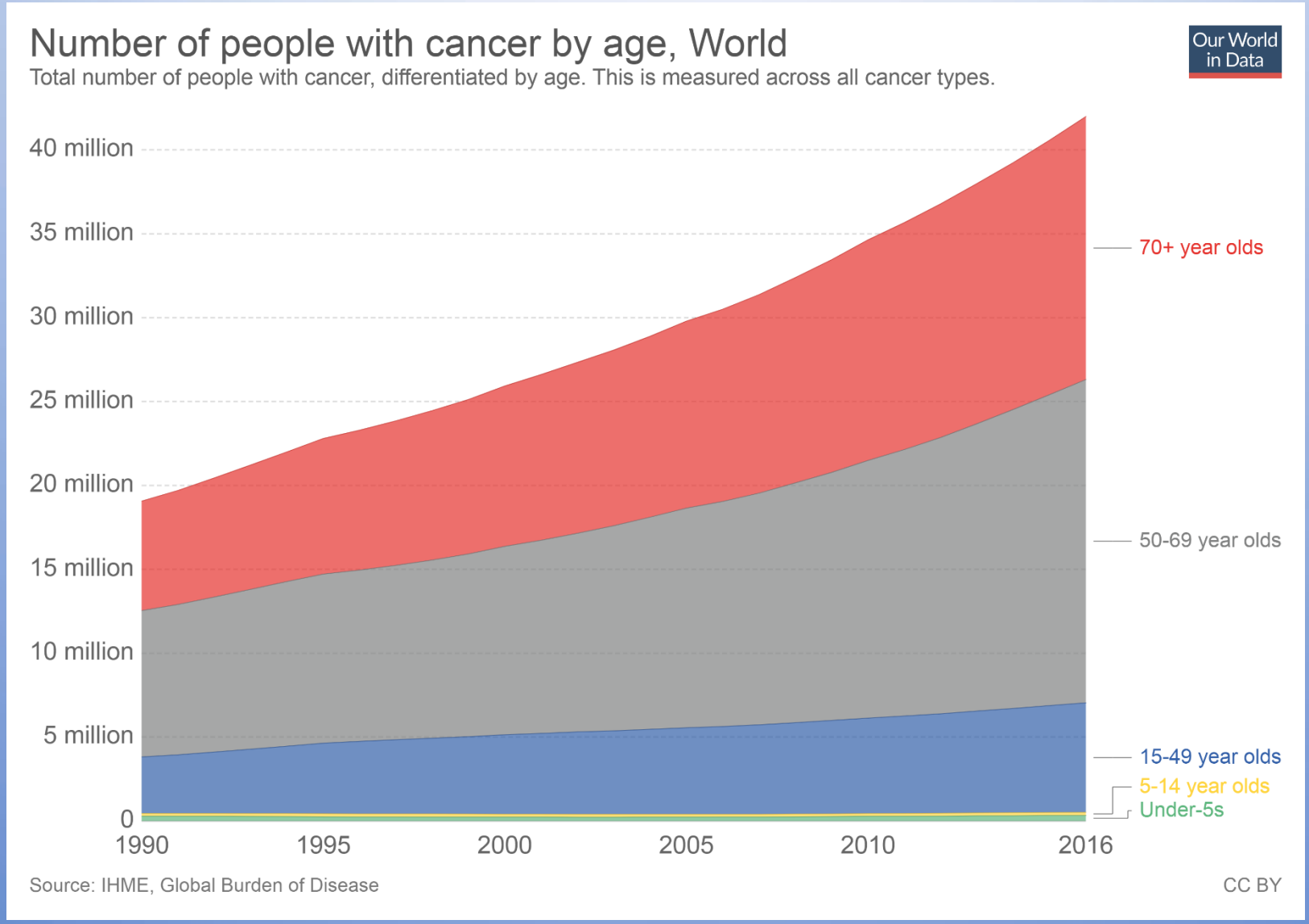
- I have no financial disclosures relevant to this presentation


(There aren’t any)

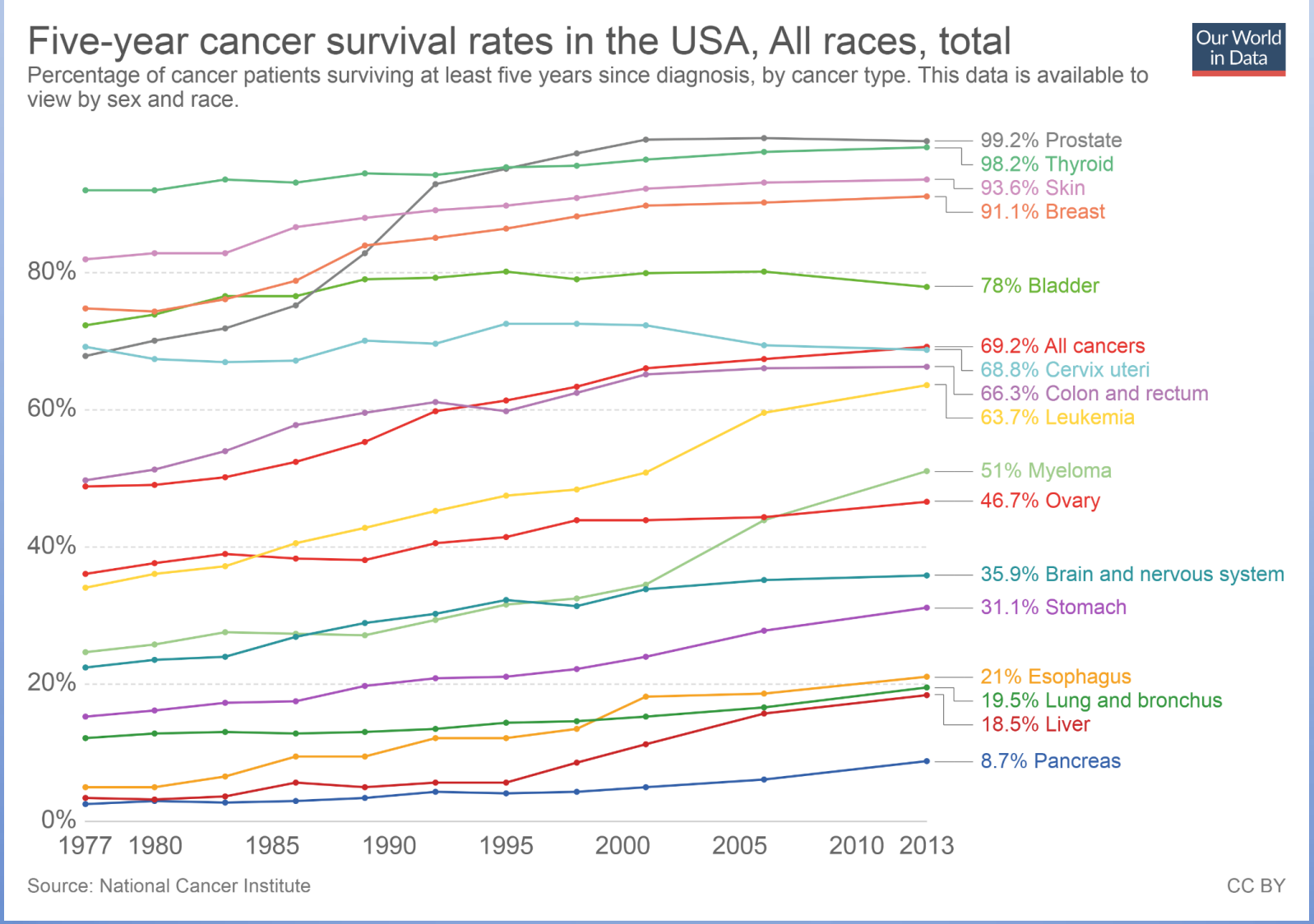
Many Cancer Treatments are Aggressive

- In general, to accomplish the goals of treatment we usually need to accept at least some toxicity
- Cancer is complex and requires a multidisciplinary approach (we all care for cancer patients)
  - The burden for patient and family is not only physical, but also psychosocial and financial in nature
- Seems to be general confusion about the expected side effects of a radiation treatment.
  - Many patients have comorbid issues not related to radiation; being able to differentiate between expected and non-expected side effects will allow us all to better care for our patients.

There will be more cancer survivors in the future…



Cancer Therapies and Early Detection Rates are Improving…



Objectives

- Learn basic physical, chemical, and biological principles of radiation oncology
- Learn some of the various mechanisms of radiation delivery
- Review radiation plans to understand the expected complications from some of the more common radiation treatments
  - Side effects and complications depend on total radiation dose, treatment volume, and exposed normal tissues in the near vicinity

Case Presentation

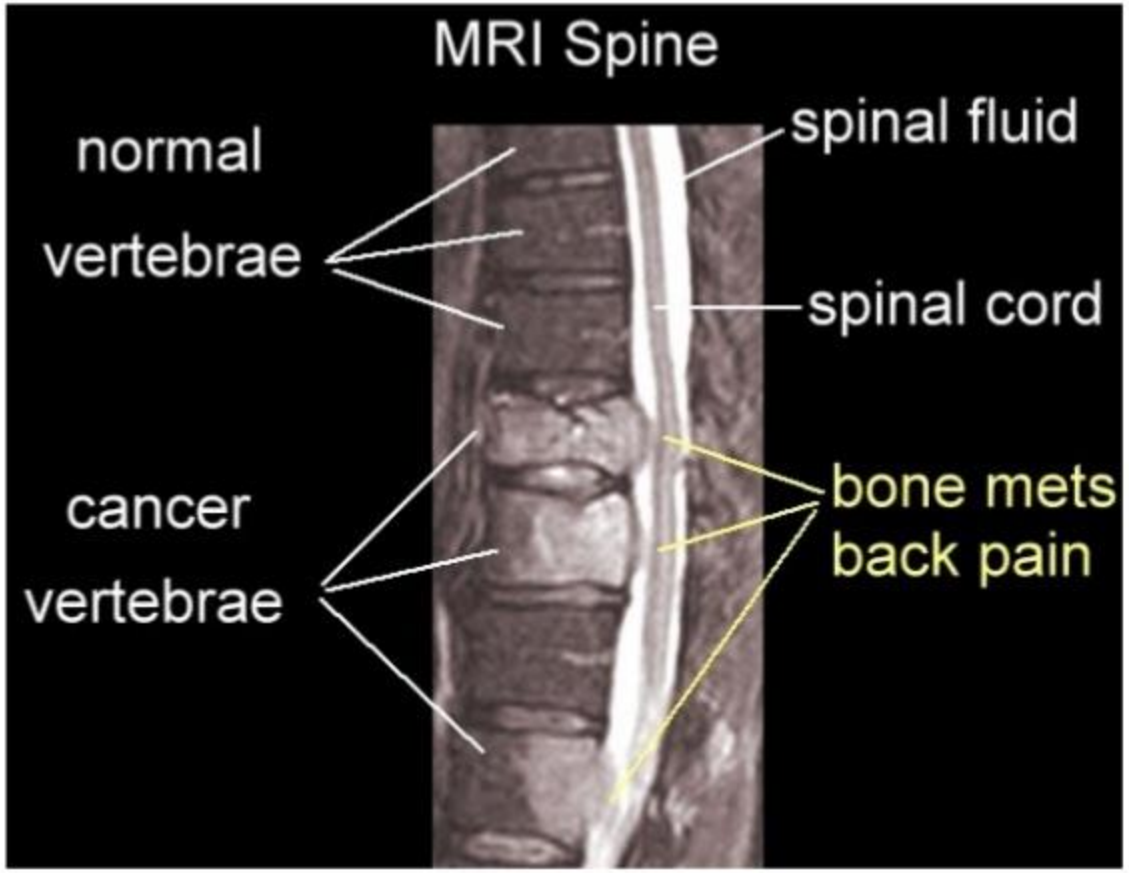
62 y/o M presents with new 3 month h/o back pain and Progressive lower extremity weakness/numbness

- History
  - No prior h/o cancer, otherwise was very healthy and fully functional
  - When did the pain begin?
    - 6 months ago
  - When last walking independently?
    - 3 days ago, walking with walker
  - Fever or weight loss?
    - 20 lbs in 3 months
  - Bowel/bladder symptoms?
    - Increased urinary retention and constipation

- Physical exam
  - KPS?
    - 70
  - Raise legs against gravity?
    - 2/5 bilat.
  - Hands sensation compared with feet sensation?
    - Worse in feet
  - Reflexes (ankle, knee, elbow, wrist)?
    - Hyper-reflexia in lower joints

PSA is 1200 ng/mL

MRI Spine: Epidural Spinal Cord Compression

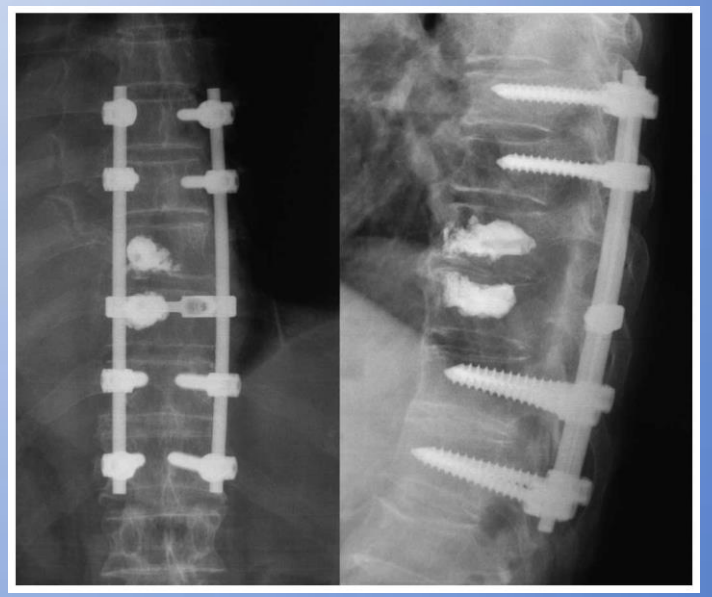


- Imaging findings

  Compression of dural sac and its contents (spinal cord) by an extradural tumor mass involving 3 mid-thoracic vertebral levels

Management

- Steroids
  - Reduce edema
  - If clinical suspicion is high, should be administered even before radiographic diagnosis
- Surgery
  - Indicated especially in young/fit patients when there is spinal instability or bony retropulsion causing the cord compression (radiation will not pull bone off nerve), as well as radioresistant tumors
  - Surgical Decompression/Stabilization
- Radiotherapy
  - indicated after surgery or in lieu of surgery
- Androgen Deprivation Therapy after staging w/u
  - to treat systemic disease as the diagnosis most likely prostate cancer based on PSA



Introduction

- Radiation has been an effective tool for treating cancer for more than 100 years
- More than 60 percent of patients diagnosed with cancer will receive radiation therapy as part of their treatment
- Radiation oncologists are cancer specialists who manage the care of cancer patients with radiation for either cure or palliation

Patient being treated with modern radiation therapy equipment.

Brief History of Radiation Therapy

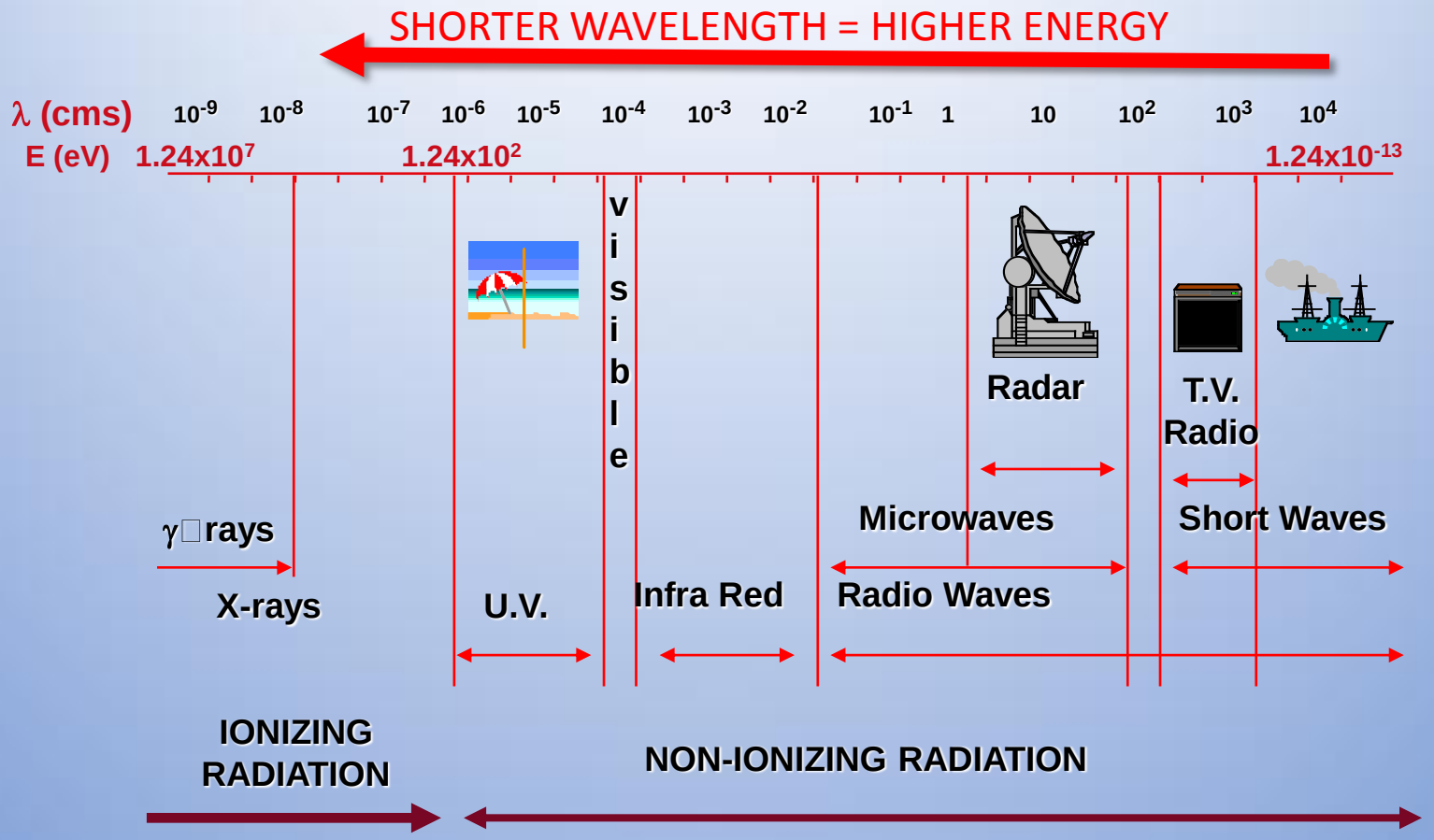
- The first patient was treated with radiation therapy in 1896, just two months after the discovery of the X-ray.
- Rapid technology advances began in the early 1950s, with the invention of the linear accelerator.
- Planning and treatment delivery advances have enabled radiation therapy to be more effective and precise, while decreasing the severity of side effects.

The linear accelerator is still used today to deliver external beam radiation therapy.

What is Radiation?

- Radiation is classified into two main categories:
  - Non-ionizing radiation
  - Ionizing radiation

ELECTROMAGNETIC RADIATIONS



Photon E = $h\nu$ (energy = Planck's const x frequency)

= hc/λ (c = speed of light, λ = wave length)

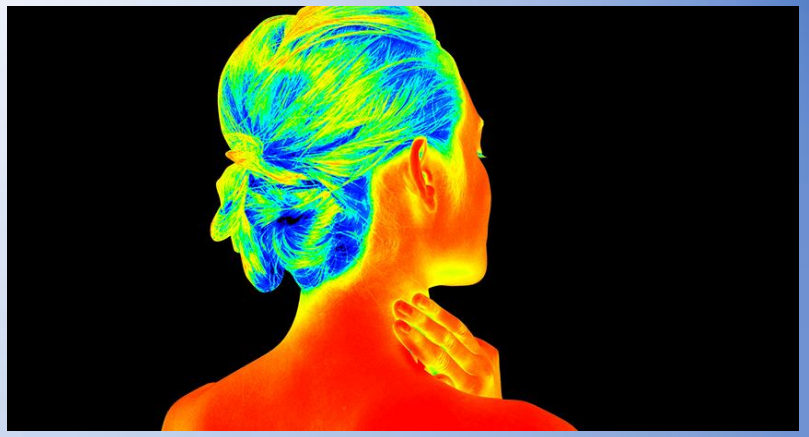
ENERGY IS INVERSELY PROPORTION TO WAVELENGTH

Non-ionizing radiation

visible light,

microwaves, and infrared

particle or wave that has enough kinetic energy to raise the thermal energy of an outer shell electron and cause excitation with emission of low energy electromagnetic radiation (detected as heat or infrared)

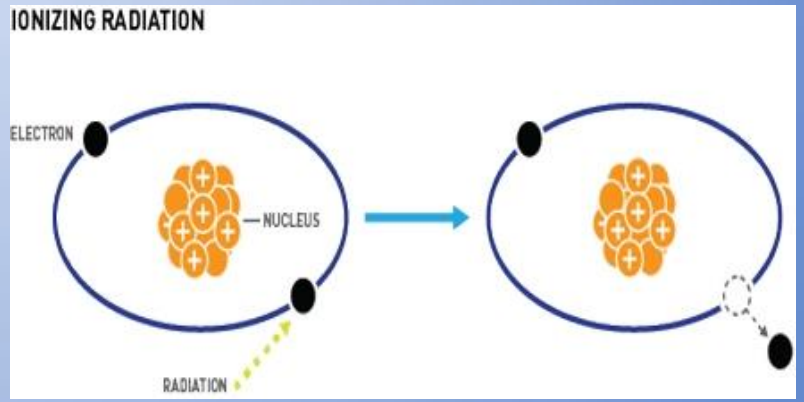


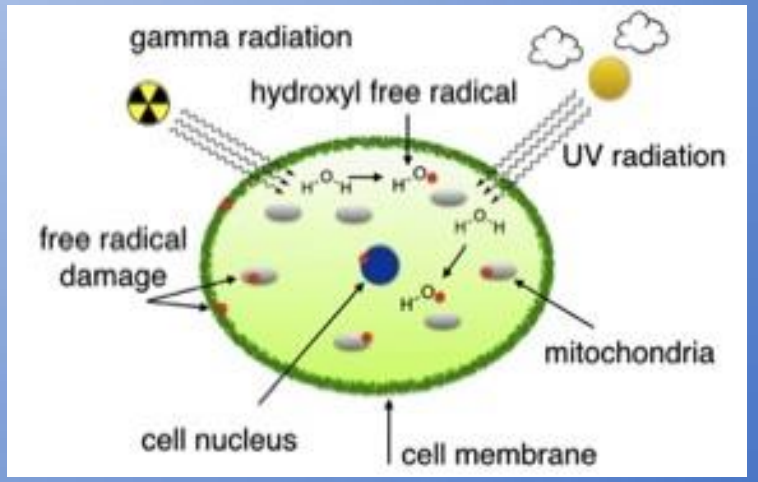
Ionizing radiation

Ionizing radiation has enough kinetic energy to detach at least one electron from an atom or molecule, creating ions…

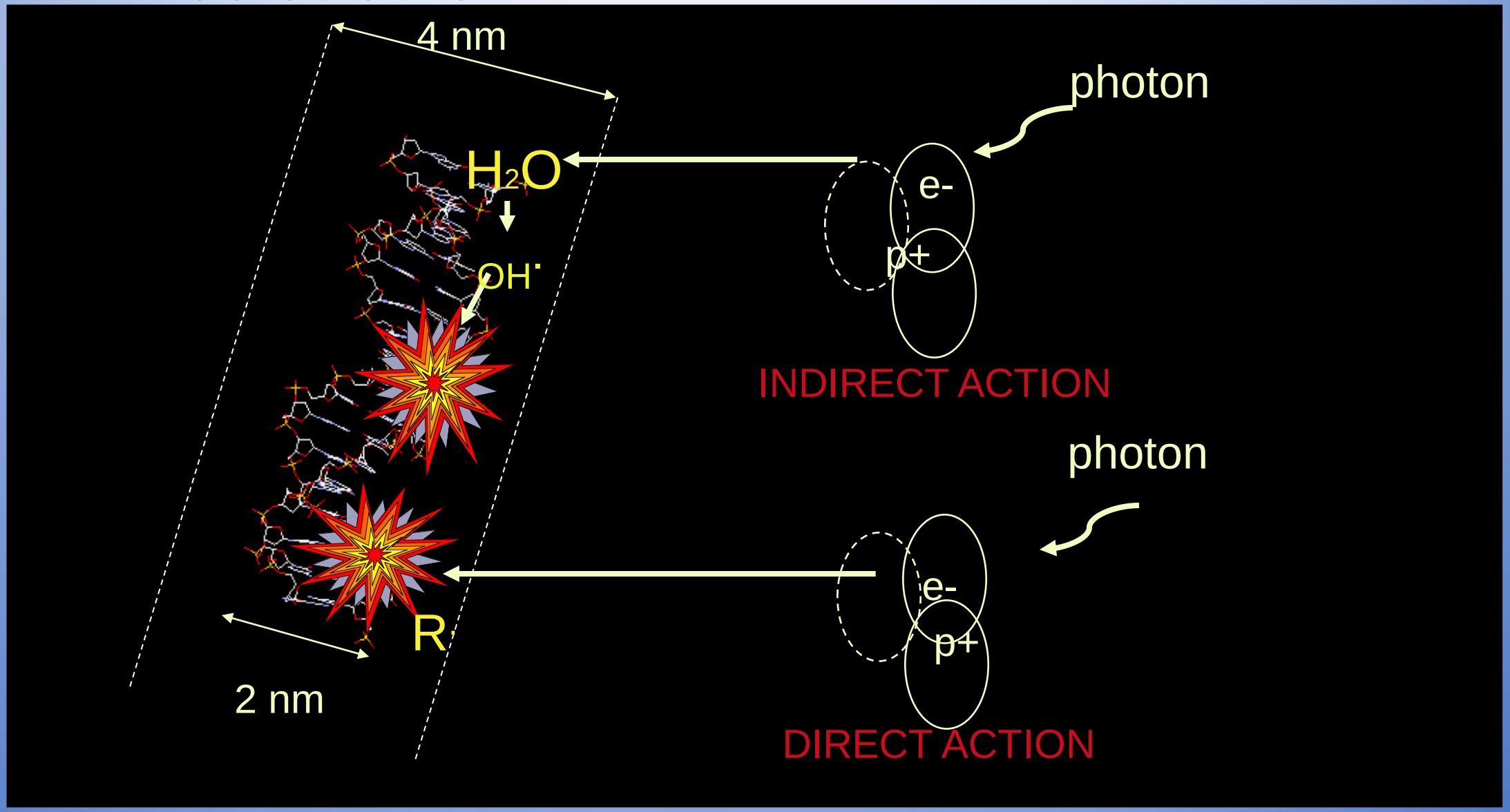
…in nature, ions are very unstable and free radicals typically result in a domino effect of utter molecular destruction

The main pertinent target in biological systems is the DNA within the cell nucleus, where irreparable damage results in cell apoptosis… leading to tumor destruction and tissue injury





Direct and Indirect Action of Ionizing Radiation on DNA



Oxygen Matters for Indirect Radiation

- Binds H radicals forming hydrogen peroxide

  $H\cdot + O_2 \longrightarrow HO_2\cdot\ (+HO_2\cdot) \longrightarrow H_2O_2\ (+O_2)$

- Binds electrons to give superoxide

  $e^- + O_2 \longrightarrow O_2^-\ + (H_2O) \longrightarrow HO_2\cdot + OH^-$

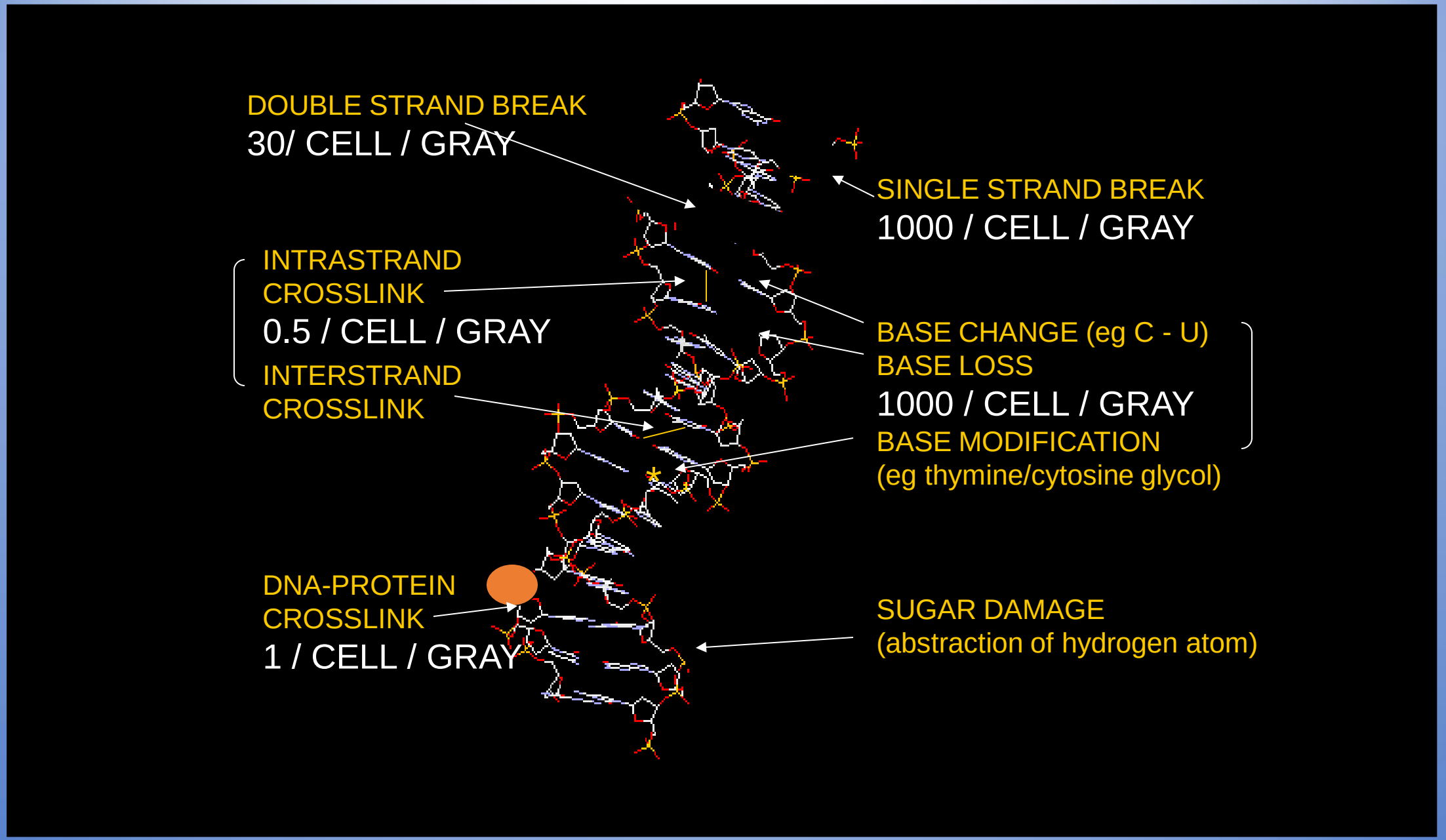
- Binds organic radicals to form peroxides

  $R\cdot + O_2 \longrightarrow RO_2\cdot$ (radical peroxide)

  $RO_2\cdot + R'H \longrightarrow ROOH + R'$ (hydroperoxide)

  $RO_2\cdot + R'\cdot \longrightarrow ROOR'$ (peroxide)

Oxygen <u>"fixes"</u> the radical lesions in DNA in a form that can not be easily chemically repaired and therefore is a very powerful radiosensitizer.


DOUBLE STRAND BREAK
30/ CELL / GRAY
SINGLE STRAND BREAK
1000 / CELL / GRAY
INTRASTRAND
CROSSLINK
0.5 / CELL / GRAY
INTERSTRAND
CROSSLINK
BASE CHANGE (eg C - U)
BASE LOSS
1000 / CELL / GRAY
BASE MODIFICATION
(eg thymine/cytosine glycol)
DNA-PROTEIN
CROSSLINK
1 / CELL / GRAY
SUGAR DAMAGE
(abstraction of hydrogen atom)

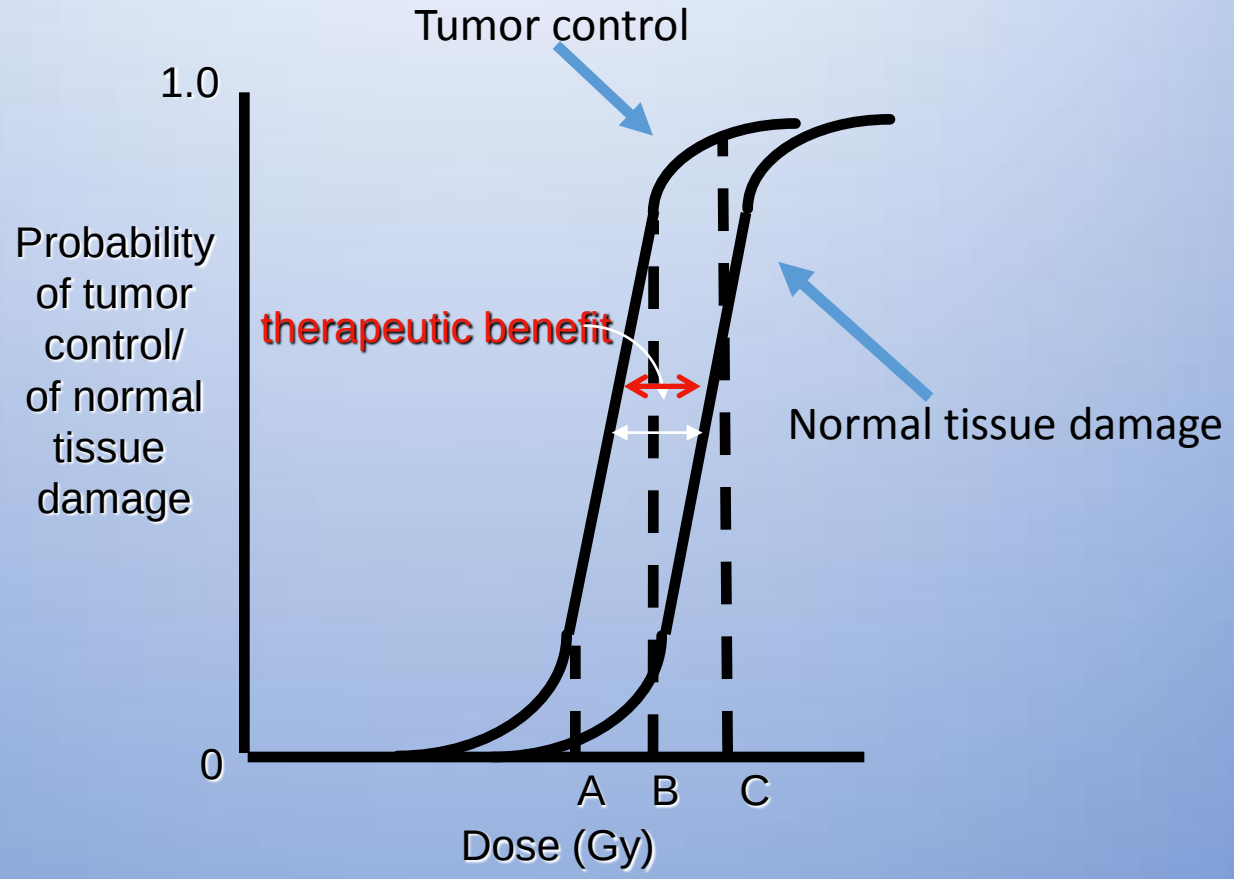
What Is the Biologic Basis for Radiation Therapy?

- Radiation therapy works by damaging the DNA of cells and destroys their ability to reproduce

- Both normal and cancer cells can be affected by radiation, but cancer cells have generally impaired ability to repair this damage, leading to cell death

- All tissues have a tolerance level, or maximum dose, beyond which irreparable damage may occur

The Aim is to Increase Therapeutic Benefit!



Normal tissue complication dose-response curves are steep!

Latency

Different tissues take different times to express damage (latency). This depends on their turnover time.

On this basis, normal tissues can be divided into

- ACUTE/TRANSIENT (clinic effects start 10-14 days after initiation of therapy and start to resolve slowly 10-14 days after radiation is completed)
  - Gut
  - Skin
  - Bone Marrow
  - Mucosa

- LATE (clinic side effects start > 6 weeks after initiation of therapy, may be transient or permanent)
  - Brain
  - Spinal Cord
  - Kidney
  - Lung
  - Bladder

- Short term side effects – results from destruction of some (but not all) stem cells in the compartment of rapidly dividing epithelial tissues (skin, gut, oral mucosa, bone marrow, sclera, hair follicle, and anus/rectum).
- The result is inflammation and sloughing of the epithelial tissue. The stem cells regenerate at the end of treatment (latency period of 2 weeks) and the tissue typically heals well
    - Dermatitis
    - Mucositis
    - Enteritis
    - Proctitis
    - Cystitis
    - alopecia
    - marrow suppression
    - Otitis
    - conjunctivitis
- Also, local inflammation results in leaky vessels, leading to edema, hyperemia, warmth, and occasional pain flare

Late Effects

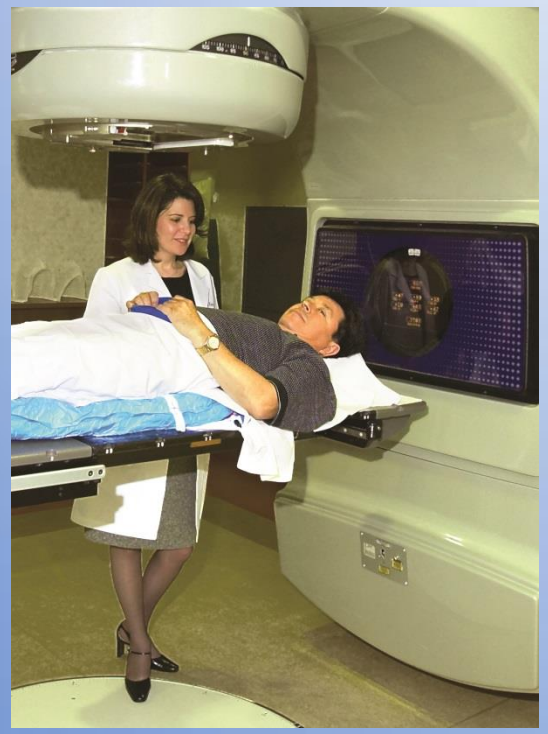
- Long term effects can include fibrosis and end-organ damage. There are well-described cascades of cytokines which directly injury parenchymal cells and indirectly lead to necrosis/fibrosis by causing subendothelial damange in blood vessels, eventually leading to radiation induced arteriosclerosis.

- Nearly all patients will experience some level of fatigue during and after radiation is delivered due to the pro-inflammatory cytokine cascade. Level of fatigue varies per size of the radiation field volume, individual sensitivity, activity level, and nutritional status.

CLASSIFICATION OF ORGANS AT RISK

- Classified as :
  - ✓ Serial – whole organ is a continuous unit and damage at one point will cause complete damage of the organ (spinal cord, digestive system). So even point dose is significant
  - ✓ Parallel – organ consists of several functional units and if one part is damaged, the rest of the organ makes up for the loss (lung, bladder). Dose delivered to a given volume or average/mean dose is considered

Clinical Uses for Radiation Therapy



External beam radiation treatments are usually scheduled five days a week and continue for one to ten weeks

- Therapeutic radiation serves two major functions
  - To cure cancer
    - Destroy tumors that have not spread
    - Kill residual microscopic disease left after surgery or chemotherapy
    - Aid in organ preservation (breast, anal, certain head/neck, extremity sarcoma)
  - To reduce or palliate symptoms
    - Shrink tumors affecting quality of life, e.g., a lung tumor causing shortness of breath
    - Alleviate pain or neurologic symptoms by reducing the size of a tumor

Radiation Therapy Basics

- The delivery of external beam radiation treatments is painless and usually scheduled five days a week for one to ten weeks
- The effects of radiation therapy are cumulative with most significant side effects occurring near the end of the treatment course.
  - Side effects usually resolve over the course of a few weeks

Example of erythroderma after several weeks of radiotherapy with moist desquamation

Source: sarahscancerjourney.blogspot.com

Common Radiation Side Effects

Unlike the systemic side effects from chemotherapy, radiation therapy usually only impacts the area that received radiation

Side effects during the treatment vary depending on site of the treatment and affect the tissues in radiation field:

- Breast – swelling, skin redness
- Abdomen – nausea, vomiting, diarrhea
- Chest – cough, shortness of breath, esophogeal irritation
- Head and neck – taste alterations, dry mouth, mucositis, skin redness
- Brain – hair loss, scalp redness
- Pelvis – diarrhea, cramping, urinary frequency, vaginal irritation
- Prostate – impotence, urinary symptoms, diarrhea
- Fatigue is often seen when large areas are irradiated

Modern radiation therapy techniques have decreased these side effects significantly

The Treatment Process

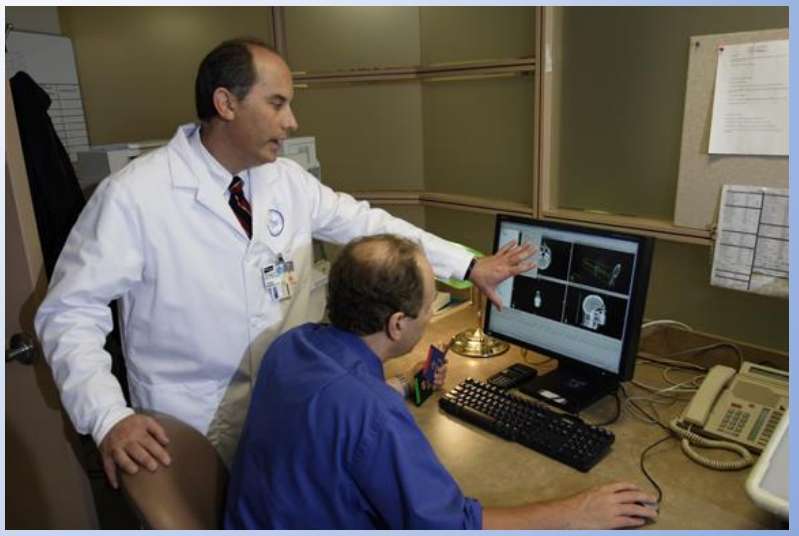
- Referral
- Consultation
- Simulation
- Treatment Planning
- Quality Assurance

Simulation

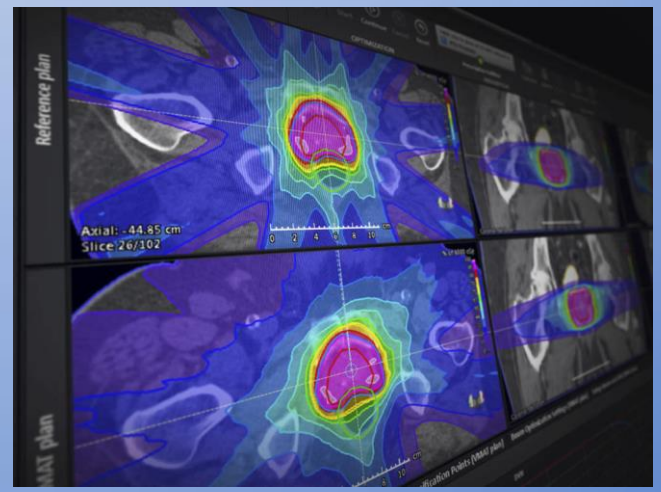
- Patient is set up in treatment position on a dedicated CT scanner
  - Immobilization devices may be created to assure patient comfort and daily reproducibility
  - Reference marks or “tattoos” may be placed on patient
- CT simulation images are often fused with PET or MRI scans for treatment planning

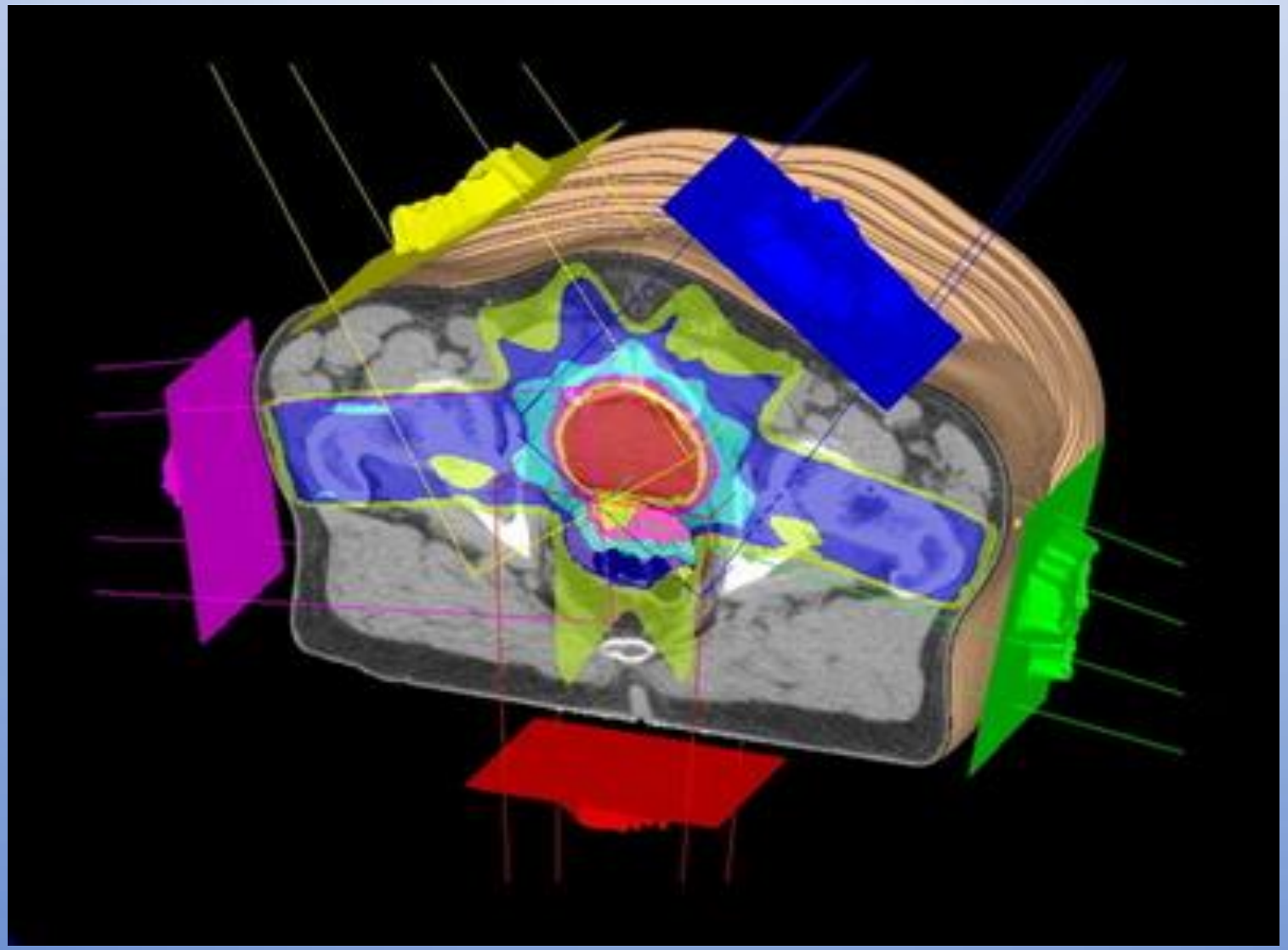
Treatment Planning

- Physician outlines the target and organs at risk
  - Sophisticated software is used to carefully derive an appropriate treatment plan
    - Computerized algorithms enable the treatment plan to spare as much healthy tissue as possible
  - Medical physicist checks the chart and dose calculations
  - Radiation oncologist reviews and approves final plan



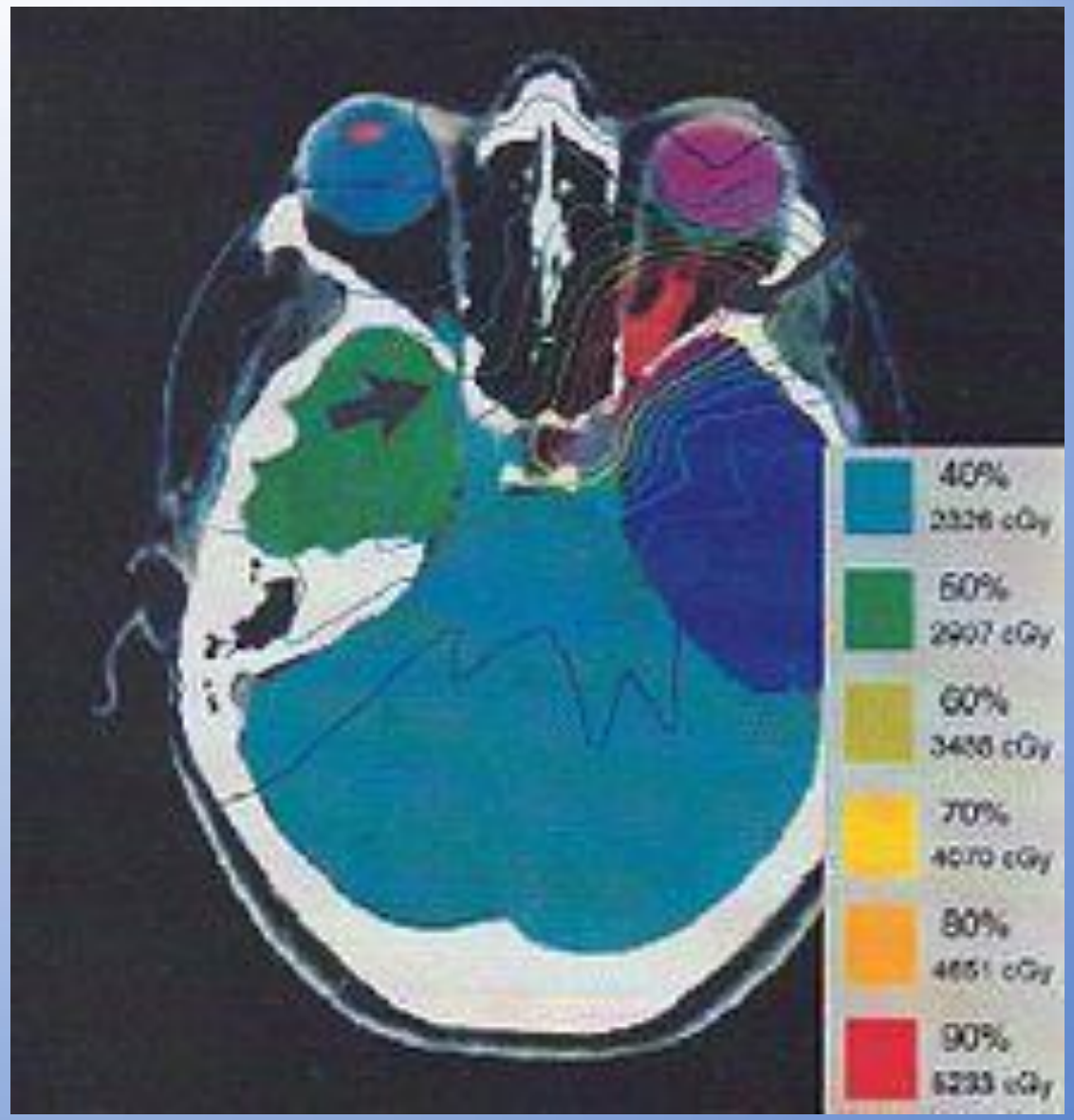
Radiation oncologists work with medical physicists and dosimetrists to create the optimal treatment plan for each individualized patient






Wedge ID: EDW (25 deg)

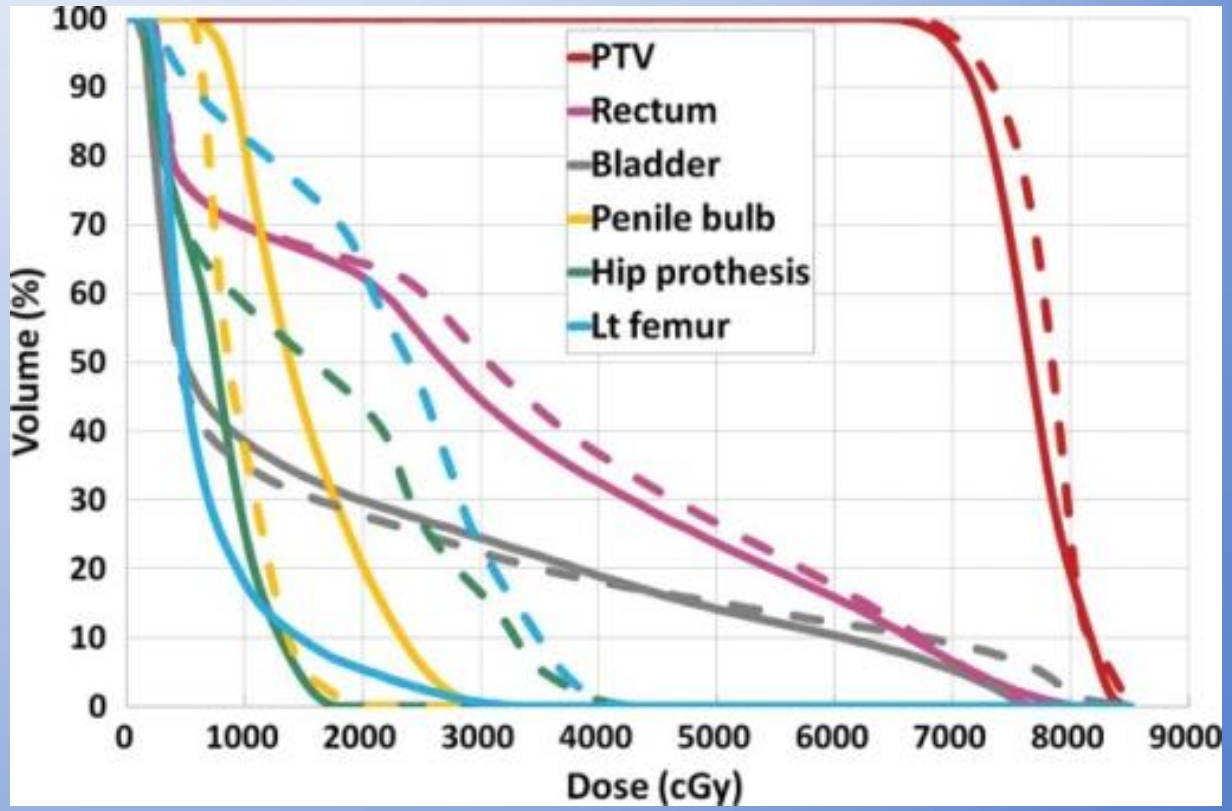
Left Optic Nerve Sheath Meningioma



- Isodose lines

Dose Volume Histogram

- Plots dose delivered to volume of tissue exposed
- Need to meet guidelines at various doses for different tissues
  - Guidelines based on decades of collective experience
- Allows for comparison between different radiation plans (see dotted and solid lines)



Prostate radiation plan

Safety and Quality Assurance

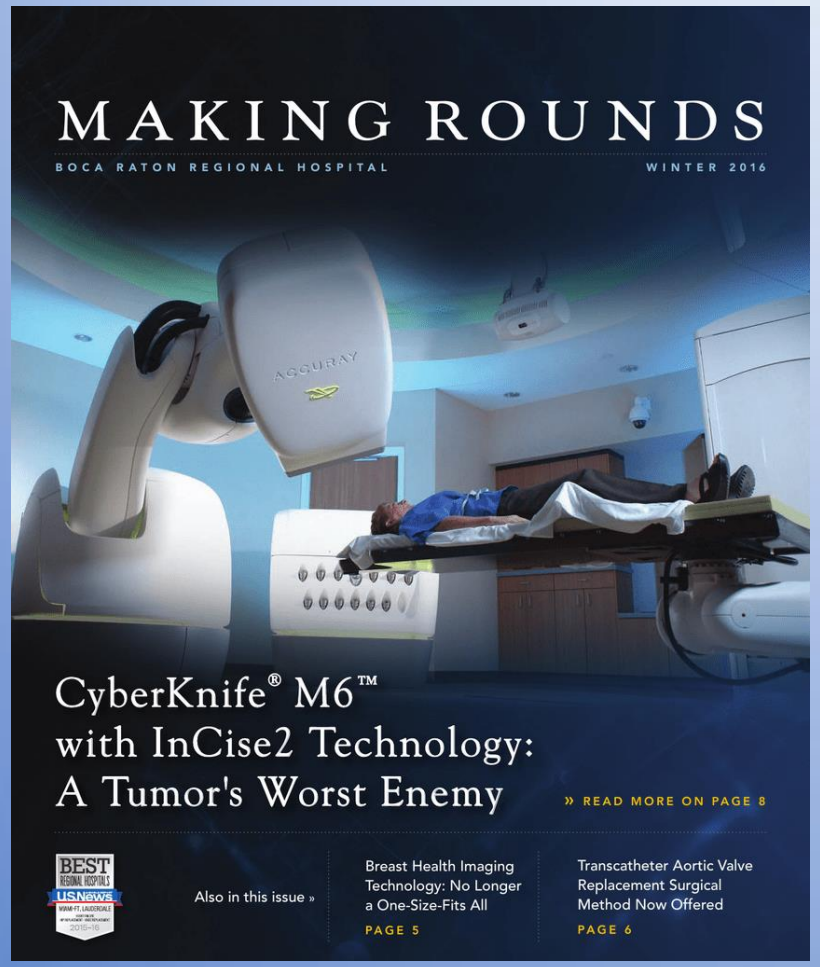
- Each radiation therapy treatment plan goes through many safety checks
  - The medical physicist checks the calibration of the linear accelerator on a regular basis to assure the correct dose is being delivered
  - The radiation oncologist, along with the dosimetrist and medical physicist go through a rigorous multi-step QA process to be sure the plan can be safely delivered
  - QA checks are done by the radiation therapist daily to ensure that each patient is receiving the treatment that was prescribed for them

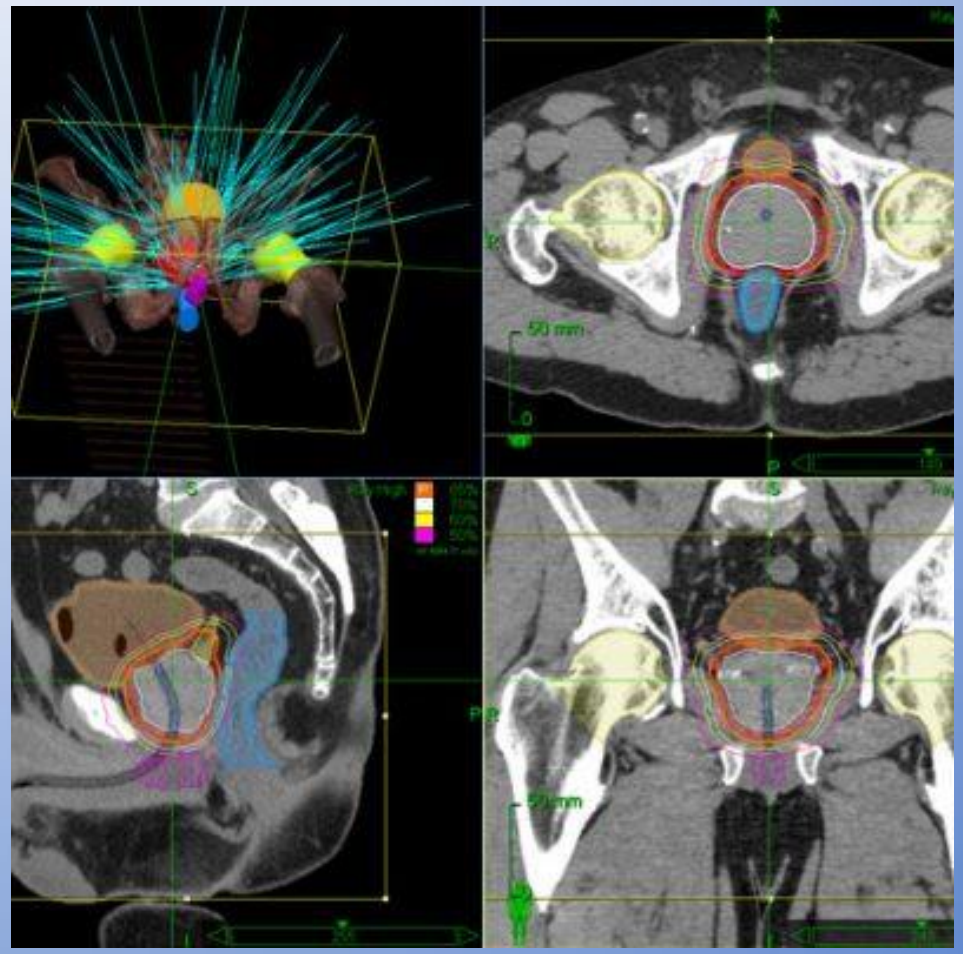
Delivery of Radiation Therapy

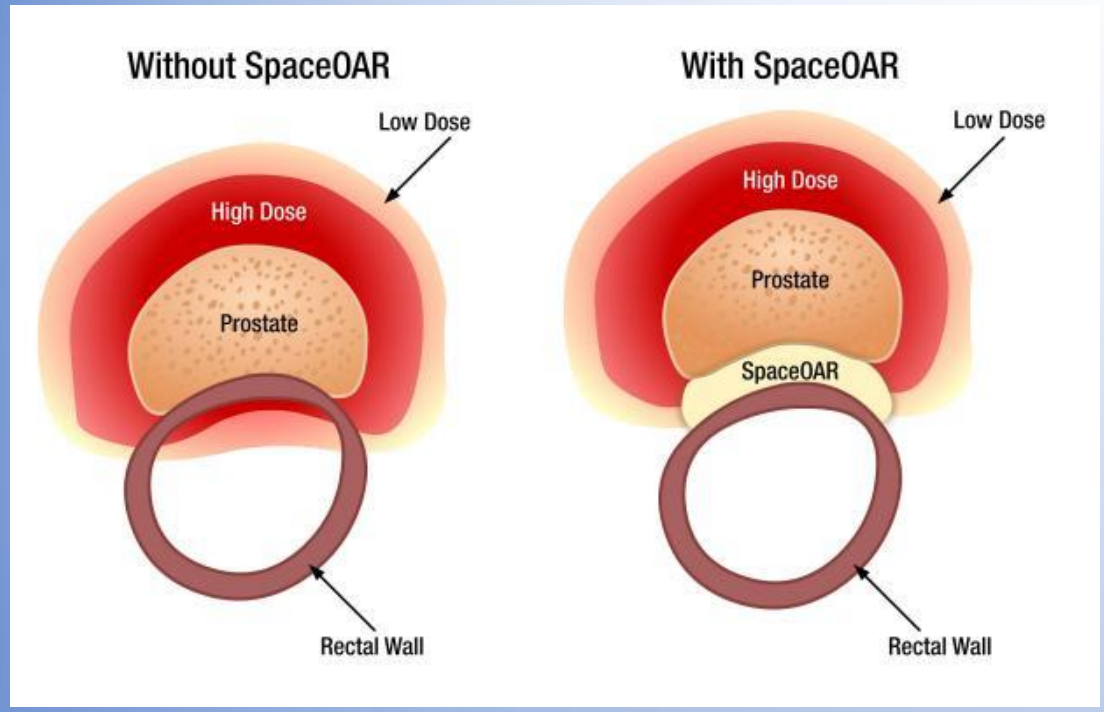
The type of treatment used will depend on the location, size and type of cancer.

- *External beam* radiation therapy typically delivers radiation using a linear accelerator
- Internal radiation therapy, called *brachytherapy*, involves placing radioactive sources into or near the tumor
- The modern unit of radiation is the *Gray (Gy)*, traditionally called the *rad*
  - 1Gy = 100 centigray (cGy)
  - 1cGy = 1 rad

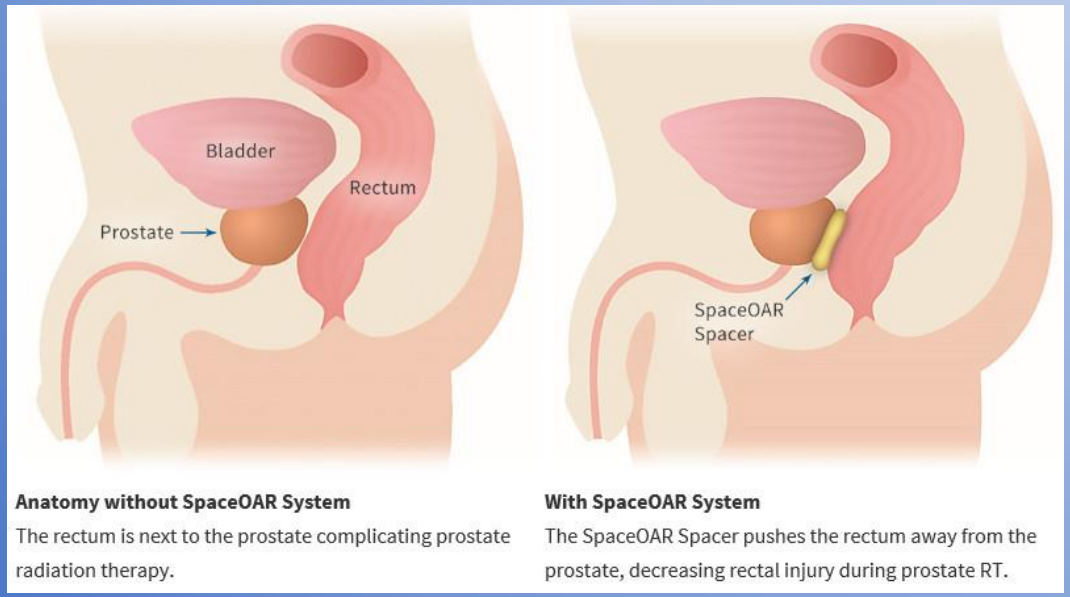
Cyberknife Prostate SBRT – for low and favorable intermediate risk prostate ca.





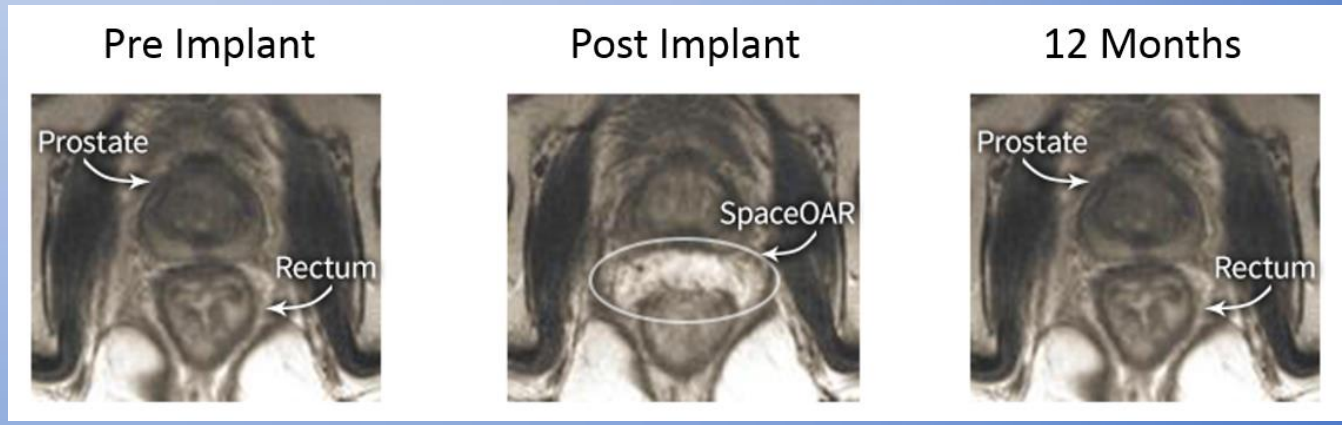


Space OAR®

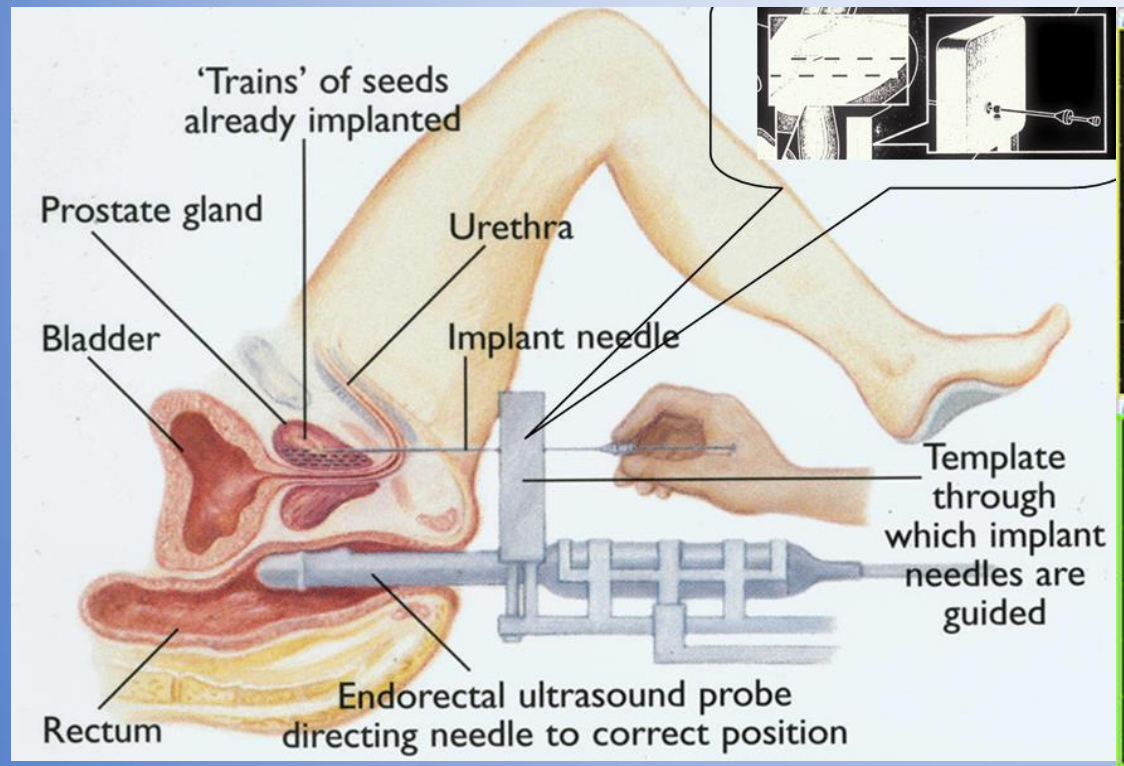


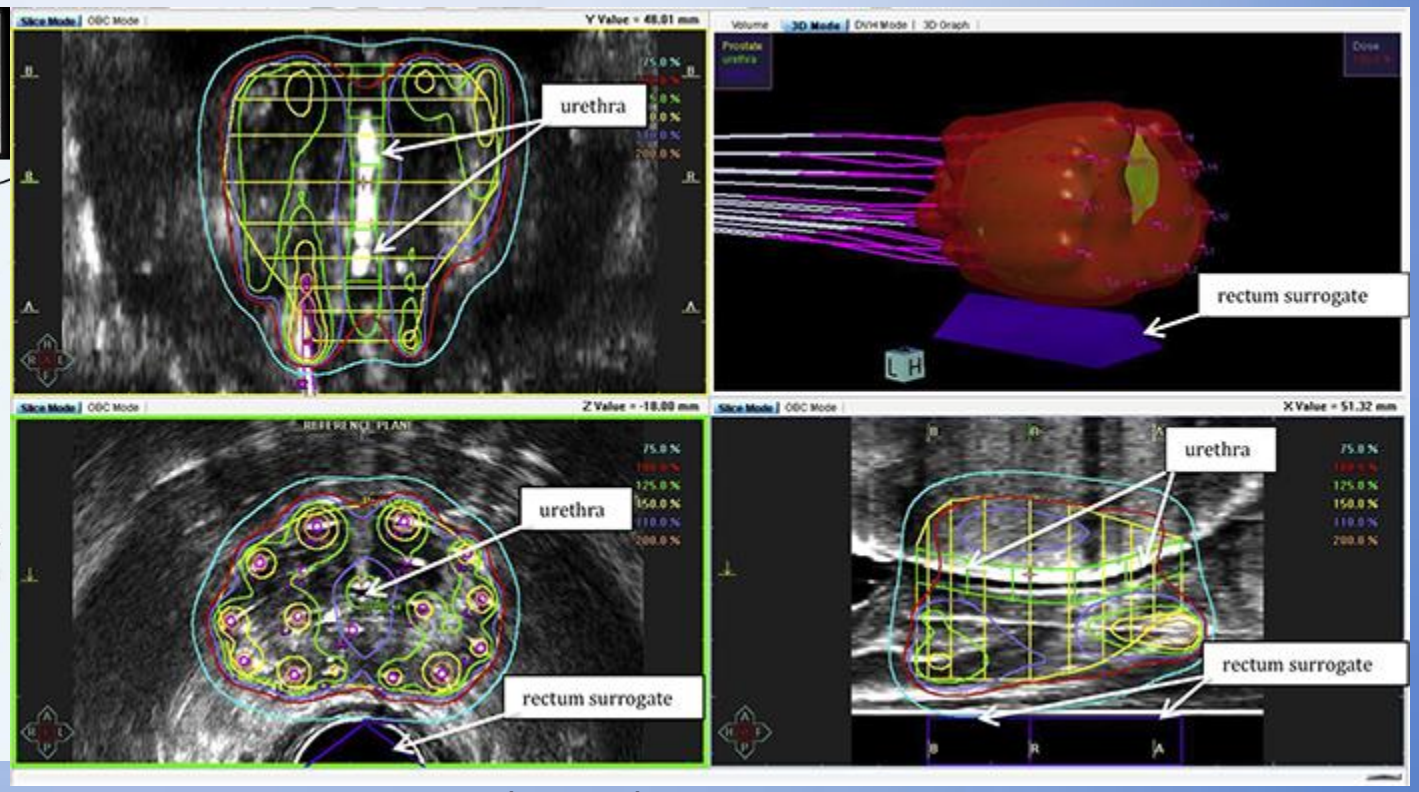
Anatomy without SpaceOAR System
The rectum is next to the prostate complicating prostate radiation therapy.

With SpaceOAR System
The SpaceOAR Spacer pushes the rectum away from the prostate, decreasing rectal injury during prostate RT.



Prostate seed implant





Low Dose Rate (LDR)

"aka permanent seed implant"

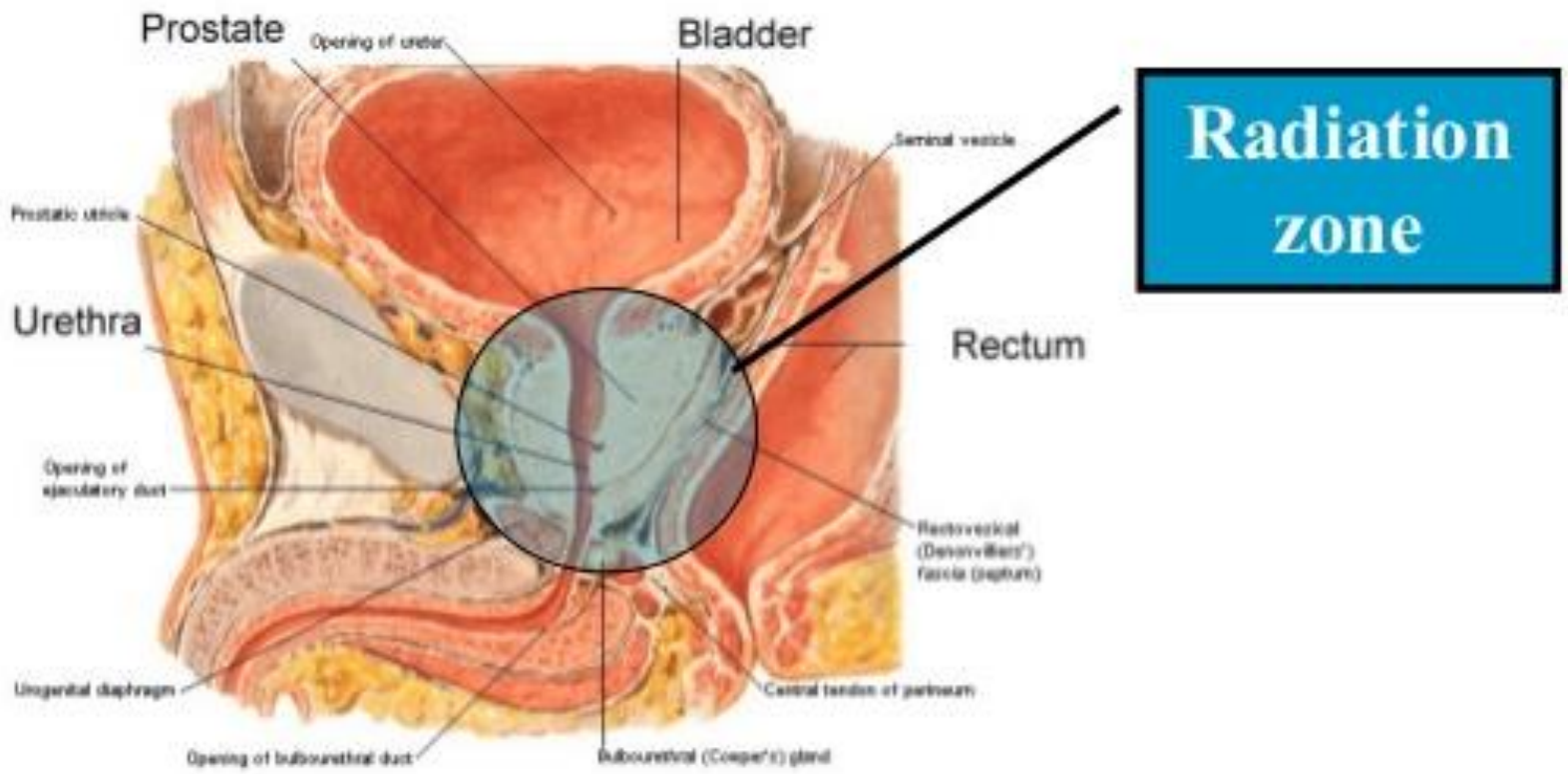
High Dose Rate (HDR)

2-4 treatments

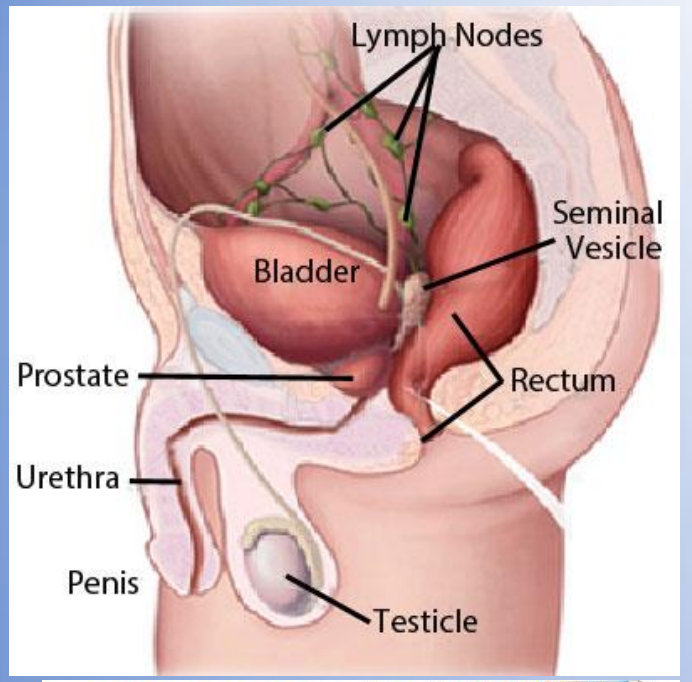
a single Highly active Iridium seed moves through hollow catheters

to specified points within the gland

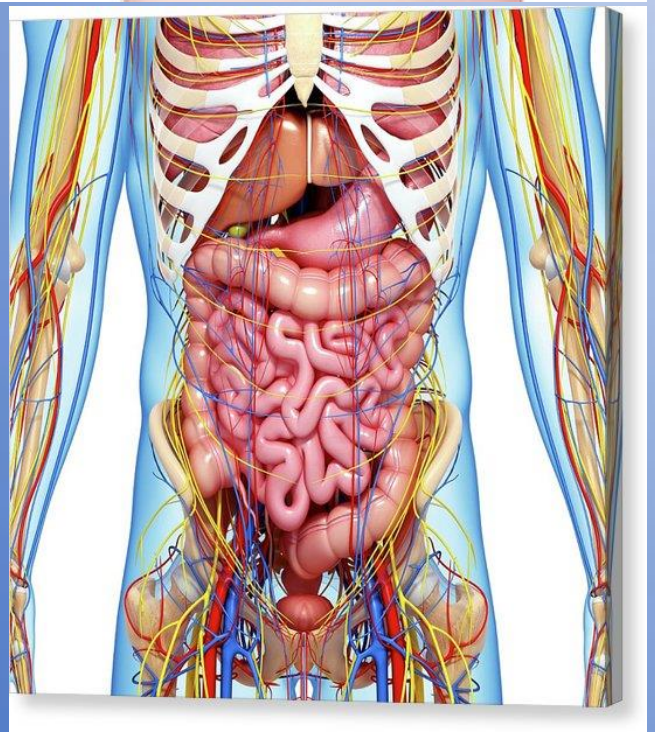
Side Effects of Prostate Radiation

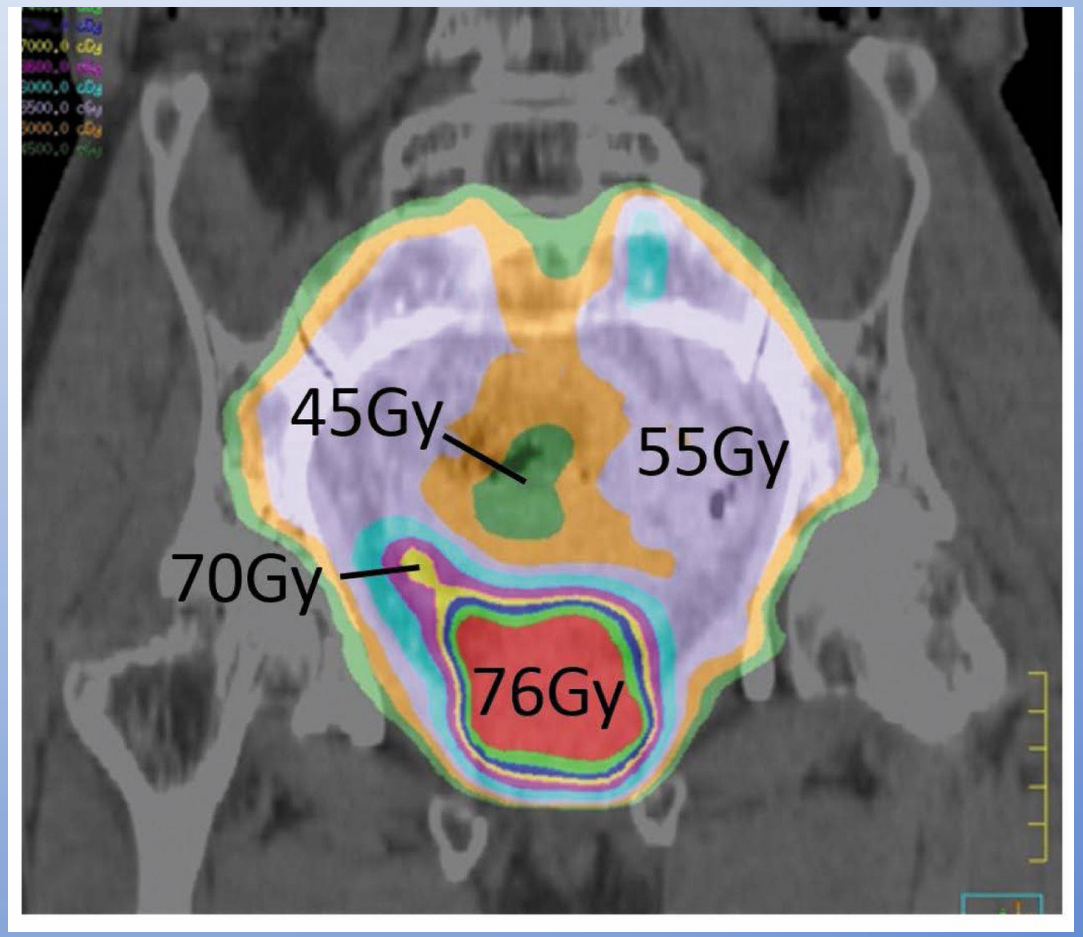


The <u>structures</u> that will get "hit" by radiation and have inflammation or irritation: bladder, urethra and rectum

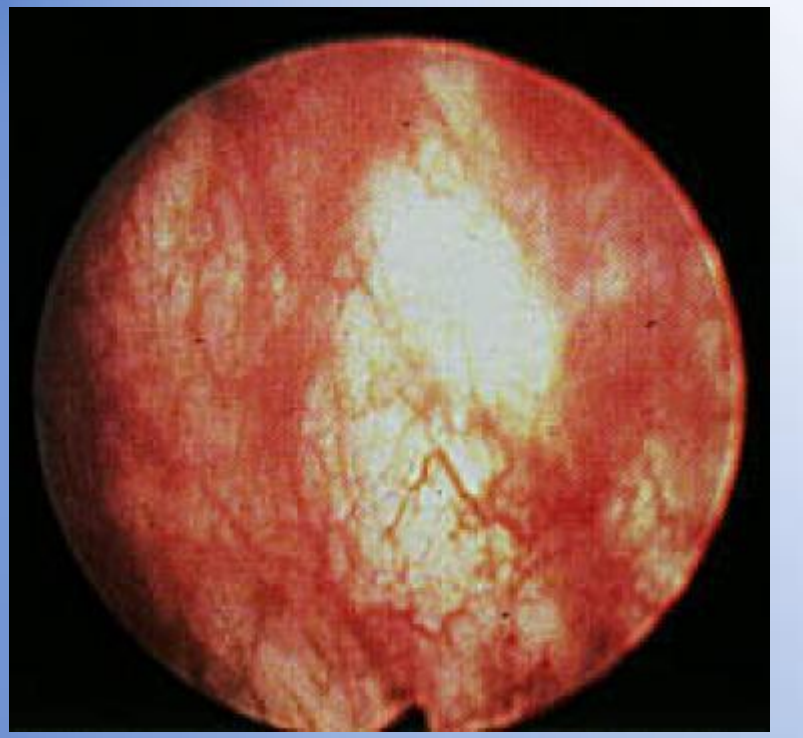


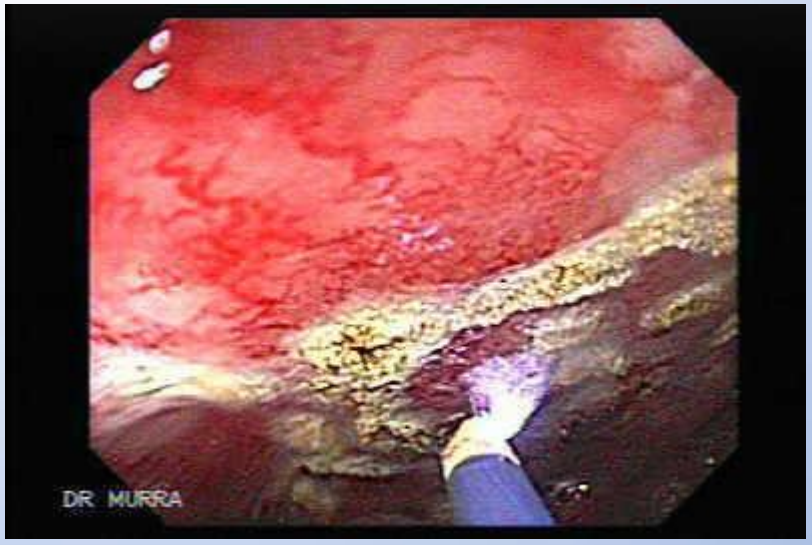
Pelvic Nodal RT increases bowel exposure – risk for SBO and permanent low grade bowel changes

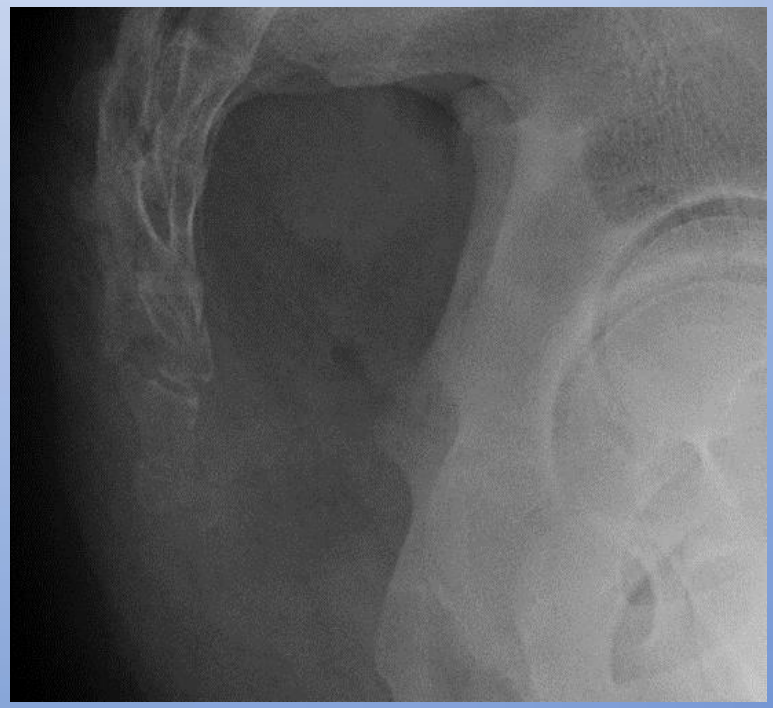


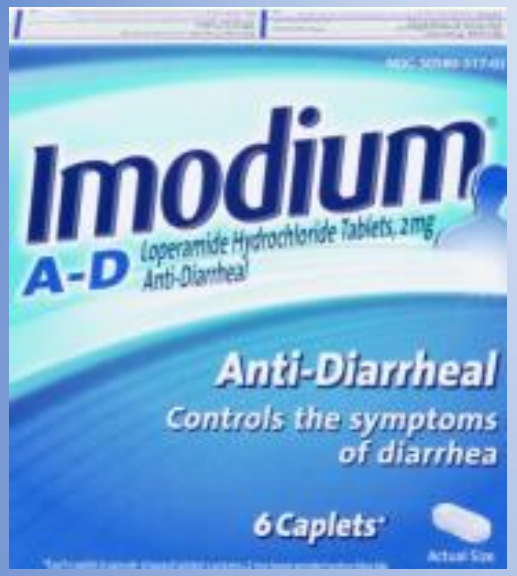


- Rectum – loose/frequent stools, burning, urgency, bleeding, ulceration
- Bladder/urethra – dysuria, frequency, nocturia, hesitancy, 10-20% chance of permanent low grade urinary changes, bladder outlet obstruction, bleeding/ulceration
- Large and Small Bowel – enteritis, 10-20% chance of permanent low grade bowel changes, bowel obstruction,
- Pelvic Bones – fractures difficult to heal
- Sexual Nerves – erectile dysfunction
- Prostate and seminal vesicles – dry ejaculate




DR MURRA



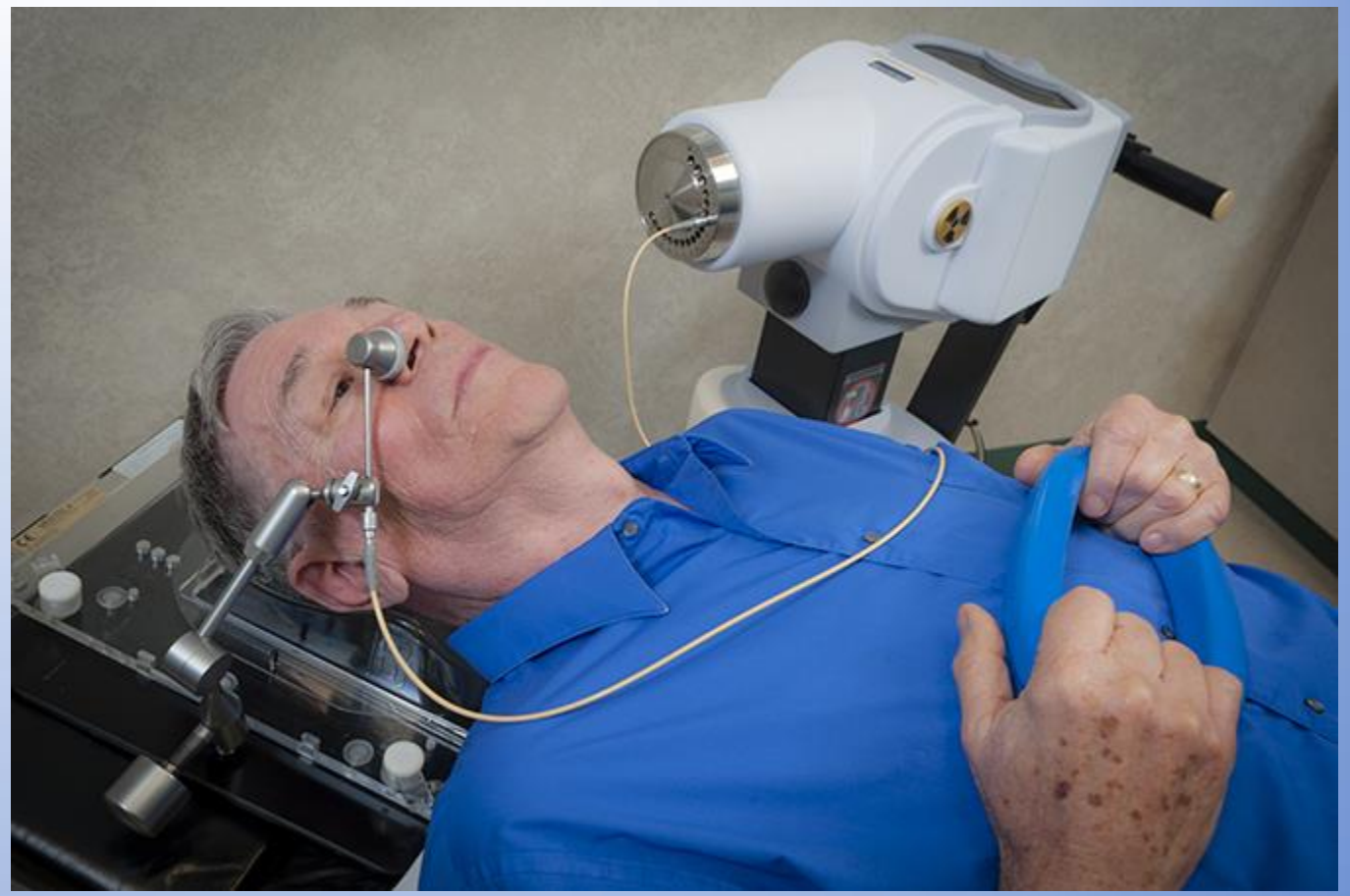

Imodium
A-D
Loperamide Hydrochloride Tablets, 2 mg
Anti-Diarrheal
Anti-Diarrheal
Controls the symptoms of diarrhea
6 Caplets

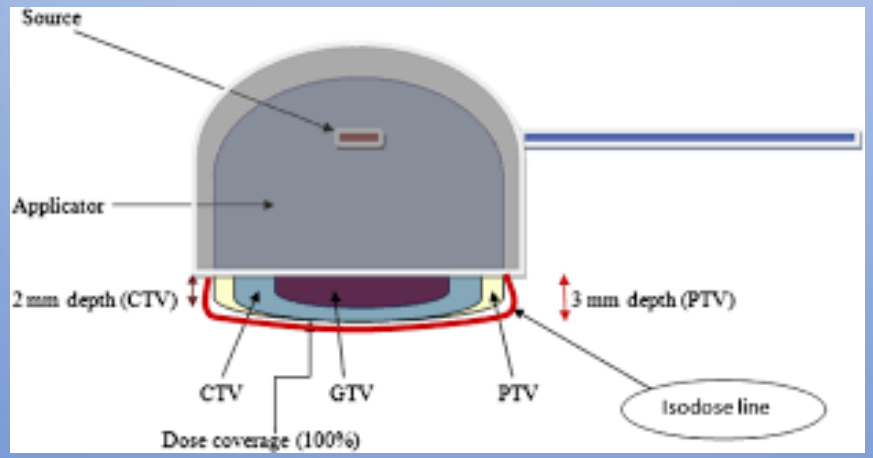

Advil
Ibuprofen Tablets, 200 mg
Pain Reliever/Fever Reducer (NSAID)
100 Coated Gel Caplets*
*Capsule-Shaped Gelatin-Coated Tablets
Gel Caplets

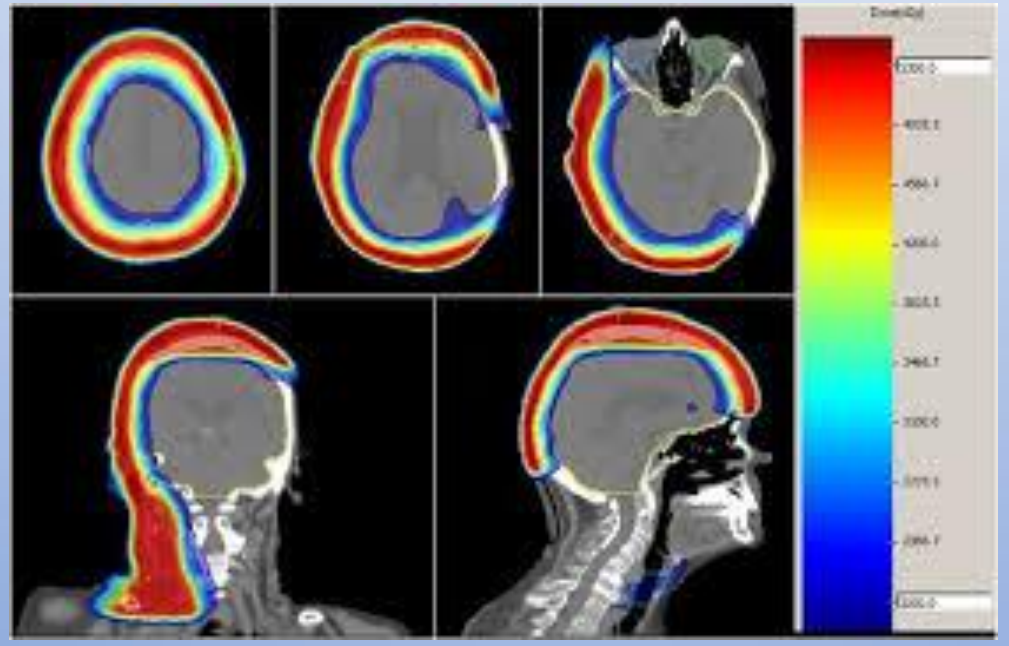

NEW LOOK!
RELIEF That's Fast
AZO
Urinary Pain Relief
MAXIMUM STRENGTH
#1 MOST TRUSTED BRAND
MORE ACTIVE INGREDIENT RELIEVES PAIN, BURNING & URGENCY
TARGETS THE SOURCE OF PAIN
24 TABLETS
97.5mg Phenazopyridine Hydrochloride


Flomax
Generic Tamsulosin
0.4mg
90 60 30
Ditropan 5 mg
Oxybutyninum 5 mg
sanofi aventis

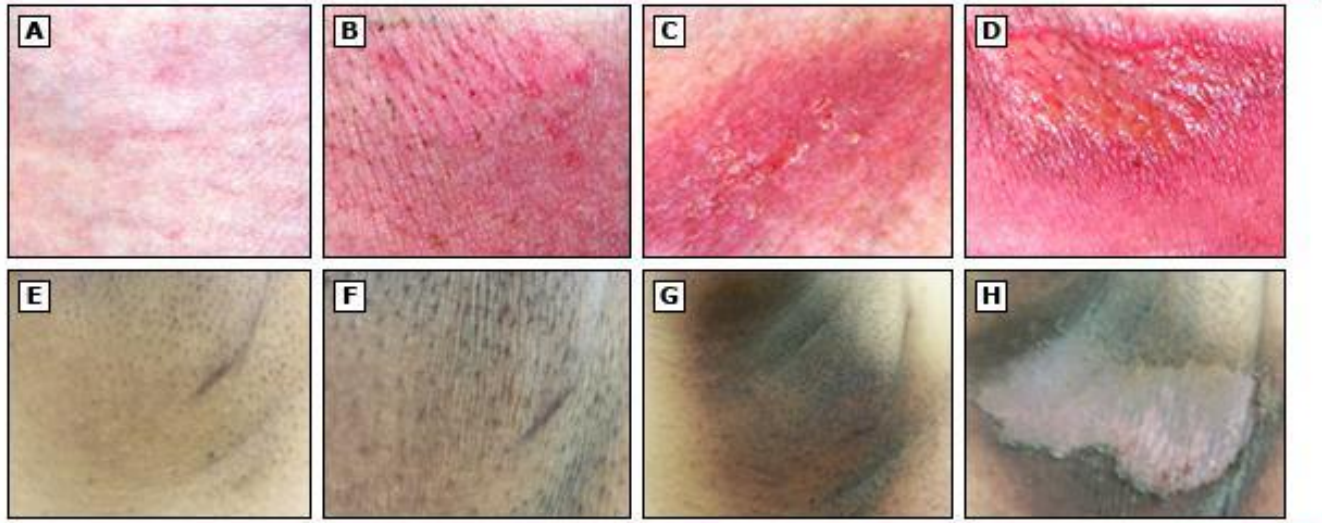
Skin




Source
Applicator
2 mm depth (CTV)
3 mm depth (PTV)
CTV
GTV
PTV
Isodose line
Dose coverage (100%)



Progression of radiation dermatitis



The images show radiation dermatitis at four different stages of severity in fair skin (A-D) and darkly-pigmented skin (E-H). Radiation dermatitis ranges from faint erythema and hyperpigmentation (A, E) to definite erythema and hyperpigmentation with dry fine desquamation (B, F) to early moist desquamation, and patchy crusting (C, G) to moist desquamation, superficial ulceration, and peeling in sheets (D, H).

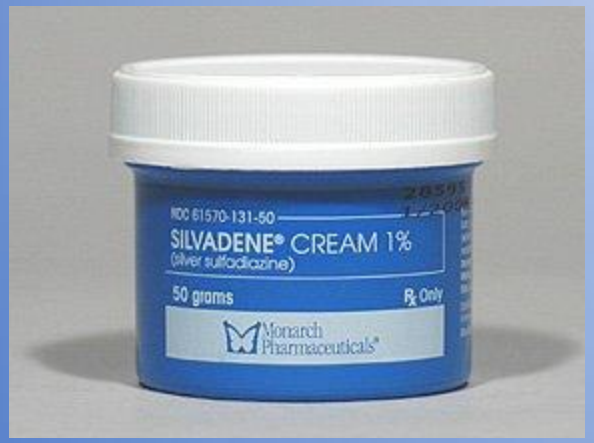
- dryness, itching, burning, blistering, peeling, infection

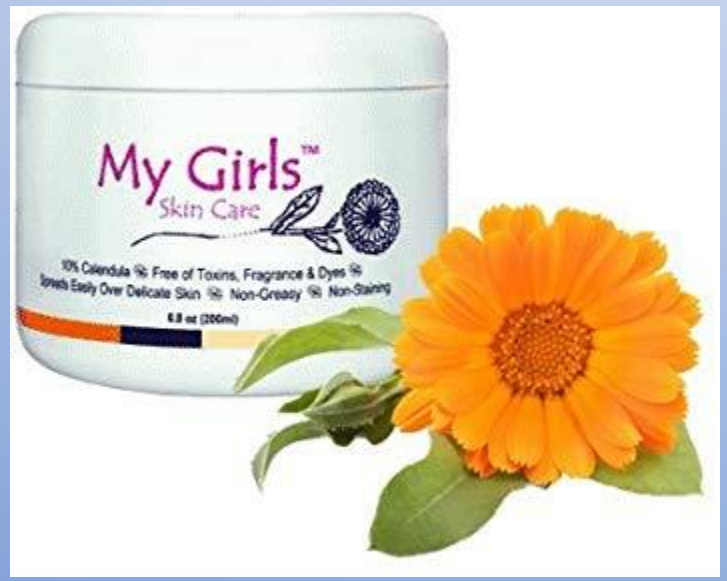
- Delayed Healing:
  - Areas on the extremities prone to edema
  - Poor wound healing (smokers, diabetics)
  - infection
  - Persistent tumor

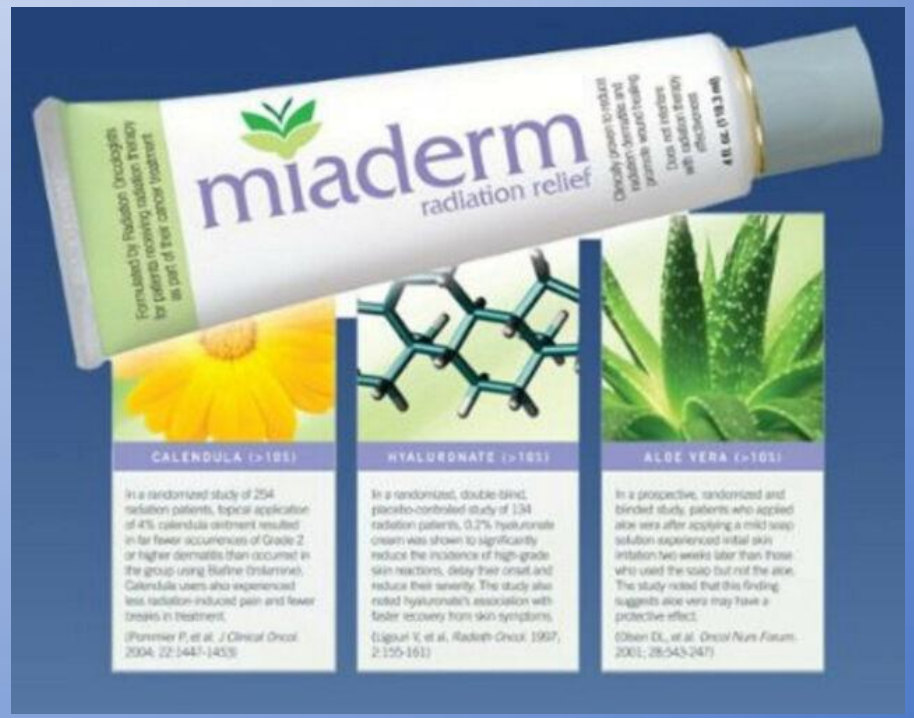

Aquaphor
HEALING OINTMENT
#1
Advanced
Therapy
For dry, cracked or irritated skin
Clinically proven to restore
smooth, healthy skin
NET WT 1.75 OZ. 50g


Compare to the active ingredient in Cortizone-10®*
MAXIMUM STRENGTH
Hydrocortisone 1%
Cream
Antipruritic (Anti-Itch)
Itch and Rash Relief
With Aloe
Itch and Rash Relief
MAXIMUM STRENGTH
Hydrocortisone 1%
Cream
Antipruritic (Anti-Itch)
NET WT 1 oz (28.4 g)

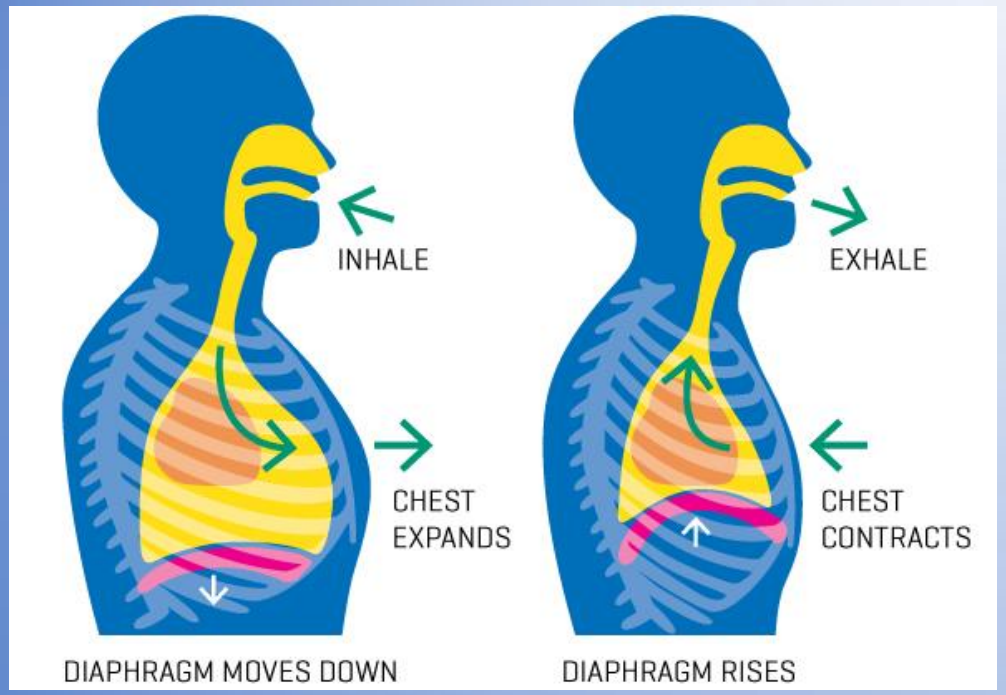

PERRIGO
Mometasone Furoate Cream USP, 0.1%
For Dermatologic Use Only. Not for Ophthalmic Use.
Rx Only
PERRIGO
Mometasone Furoate Cream USP, 0.1%
For Dermatologic Use Only. Not for Ophthalmic Use.
15 g
Rx Only

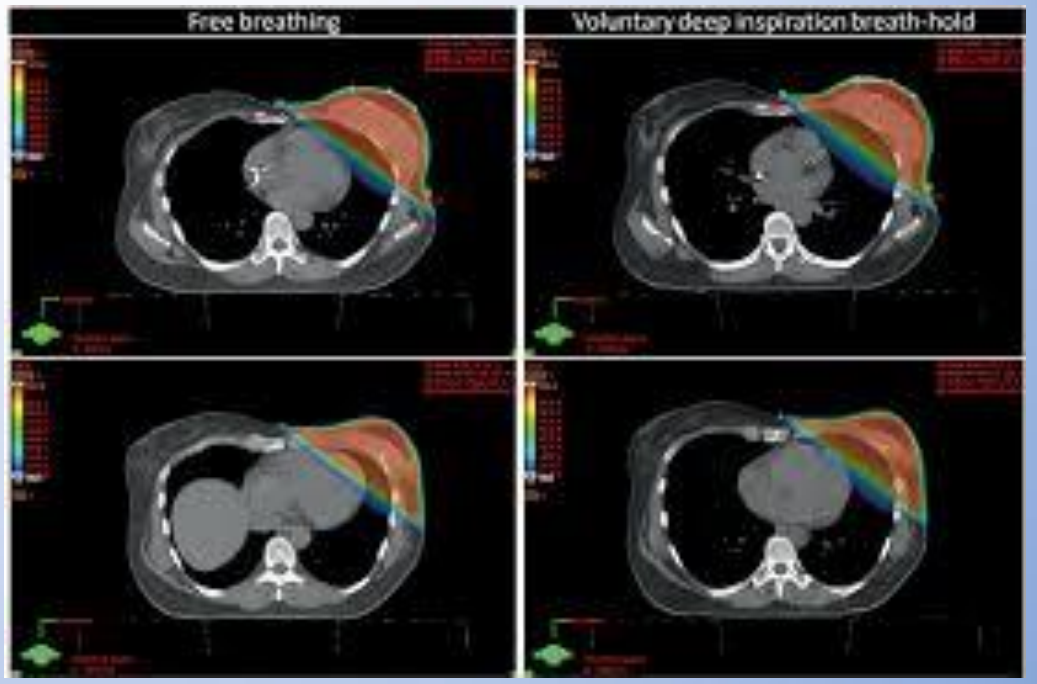

NDC 61570-131-50
SILVADENE® CREAM 1%
(silver sulfadiazine)
50 grams
℞ Only
Monarch Pharmaceuticals


My Girls™
Skin Care
10% Calendula ❀ Free of Toxins, Fragrance & Dyes ❀
Spreads Easily Over Delicate Skin ❀ Non-Greasy ❀ Non-Staining

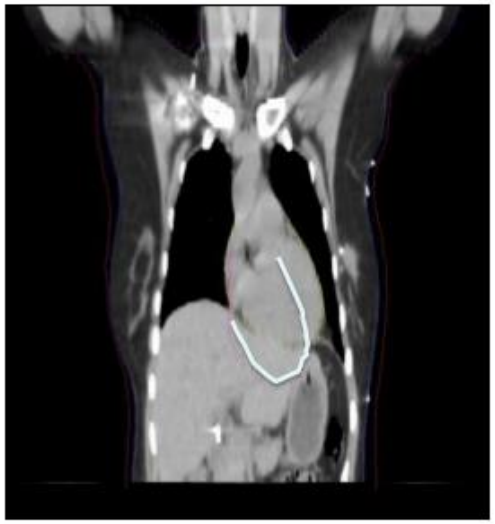

miaderm
radiation relief
Formulated by Radiation Oncologists for patients receiving radiation therapy as part of their cancer treatment
Clinically shown to reduce radiation-dermatitis and promote wound healing
Does not interfere with radiation therapy effectiveness
CALENDULA (>10%)
HYALURONATE (>10%)
ALOE VERA (>10%)

Breast



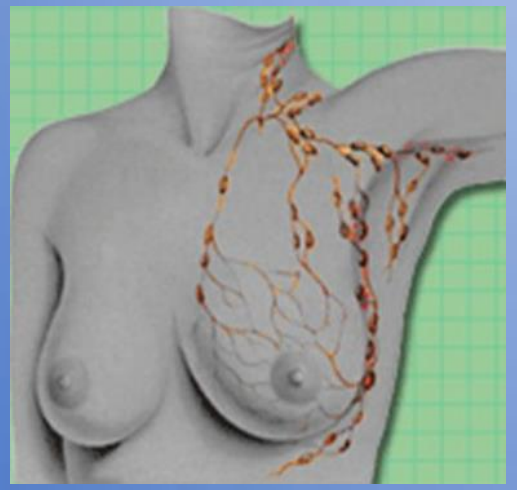


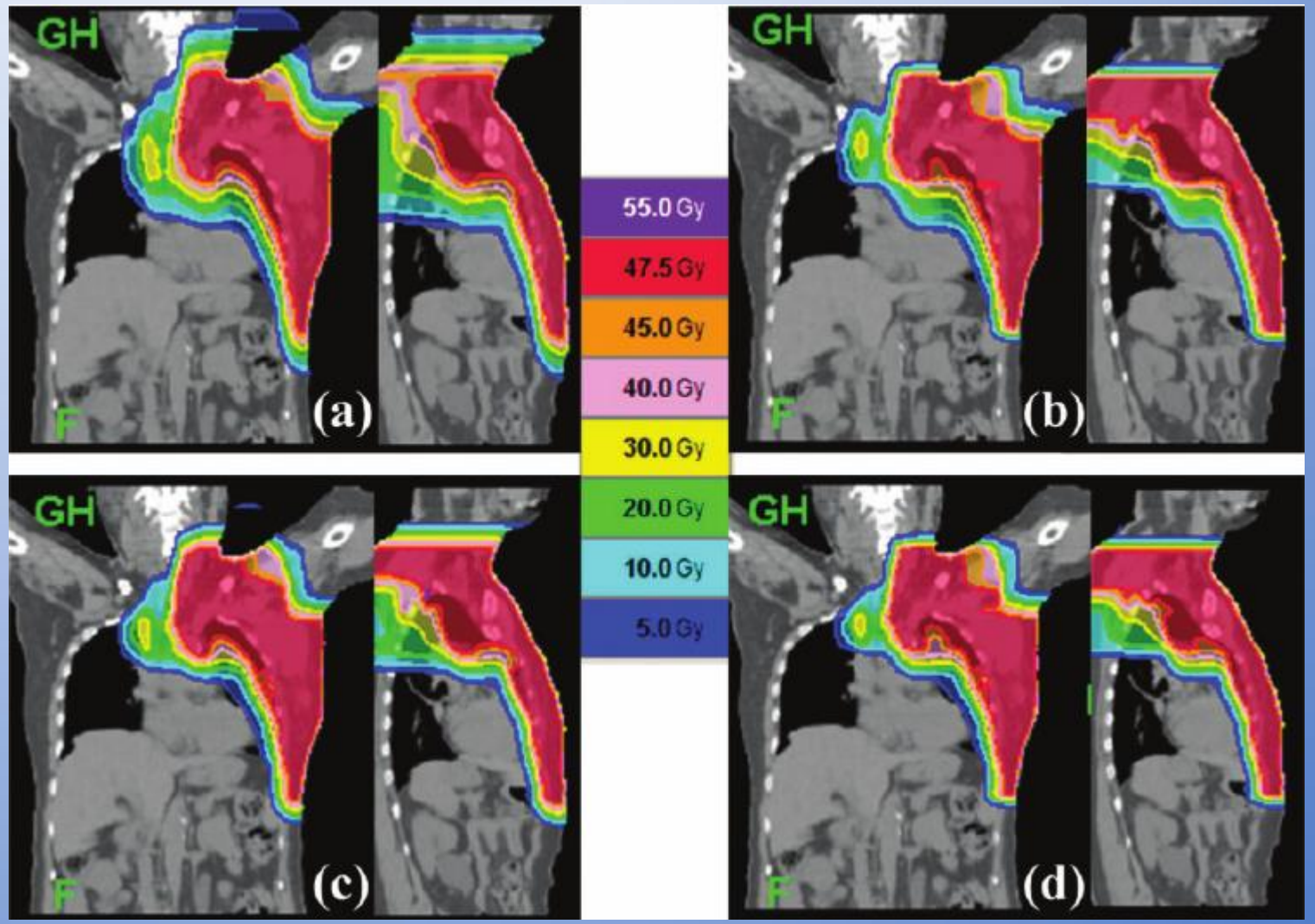
Moves the heart inferiorly & posteriorly



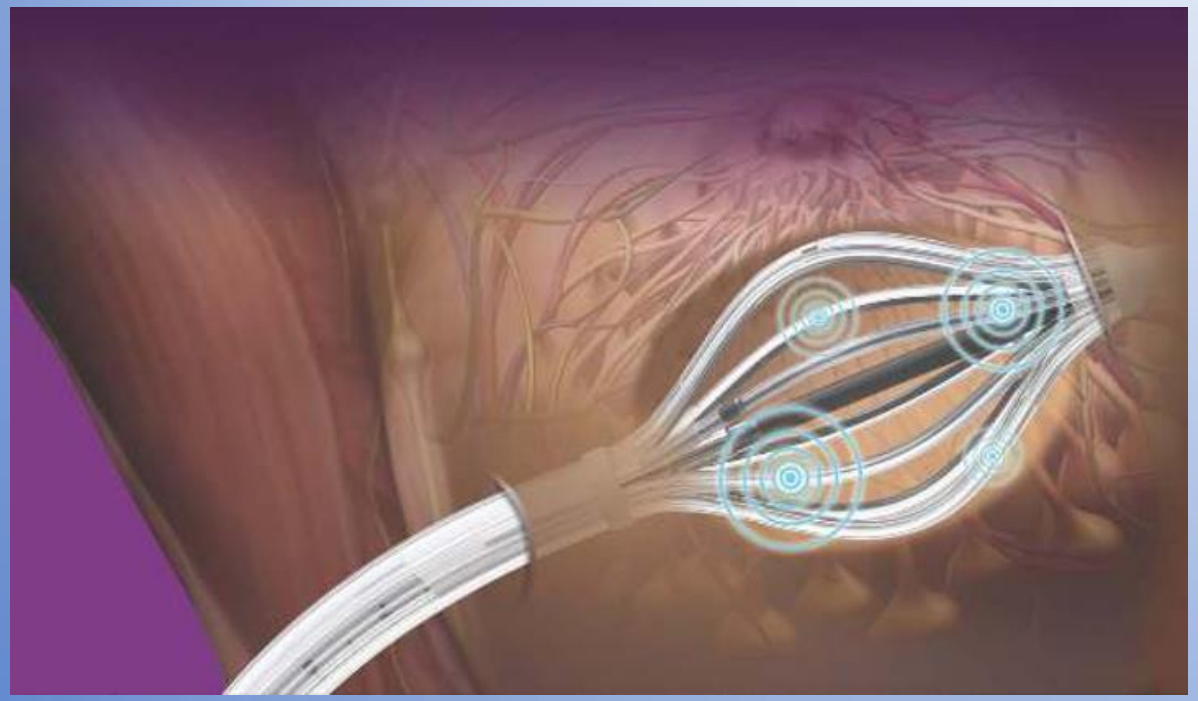
Regional lymph node Irradiation

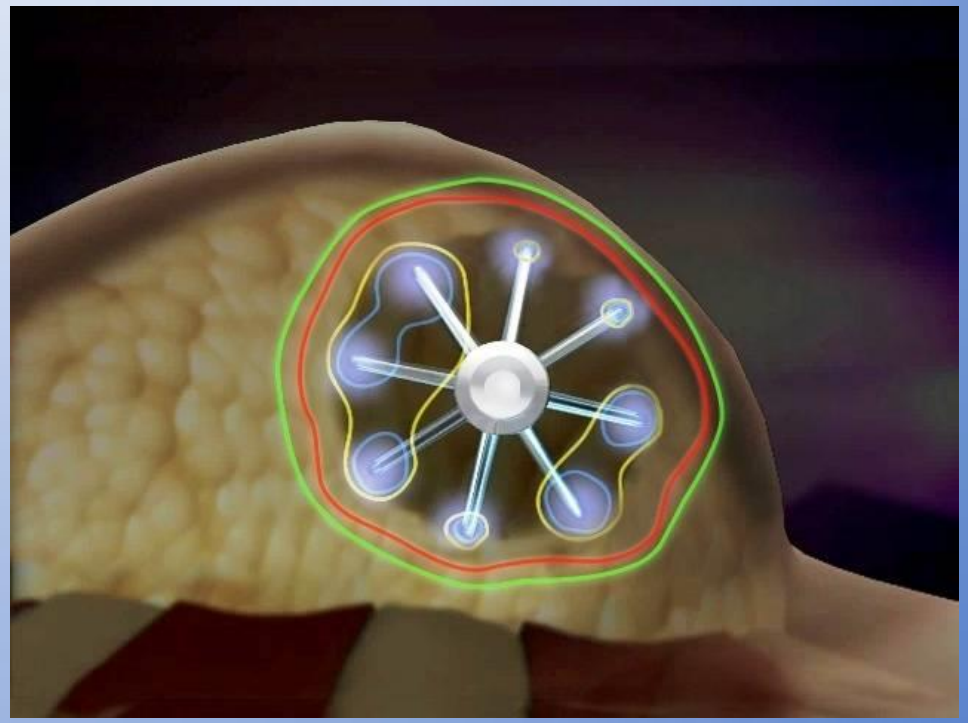
- Covers several lymph node basins
  - Axilla
  - Supraclavicular fossa
  - Low cervical neck
  - +/- internal mammary nodes



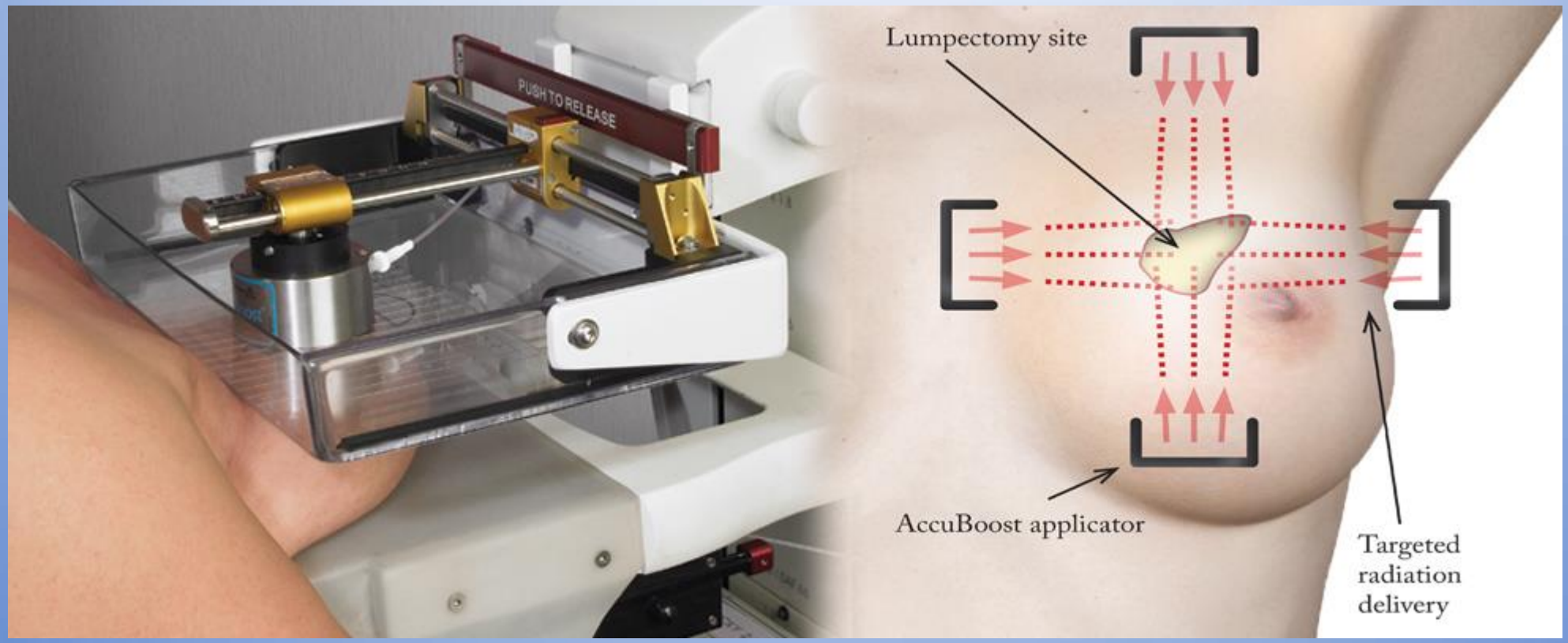


Partial Breast Radiation with Balloon Catheter (“Mammosite”)





Partial Breast radiation with Accuboost Machine



Post-Radiation	Time	Complications
Early	Weeks to months	Skin thickening with breast edema Fat necrosis Dystrophic calcifications Radiation-induced pneumonia Pleural effusion
Intermediate	Months to years	Skin retraction with breast fibrosis Glandular atrophy Lactation difficulty Overlying bone fracture Pulmonary fibrosis Pericardial disease
Late	More than 10 years	Cardiomyopathy Radiation induced malignancy

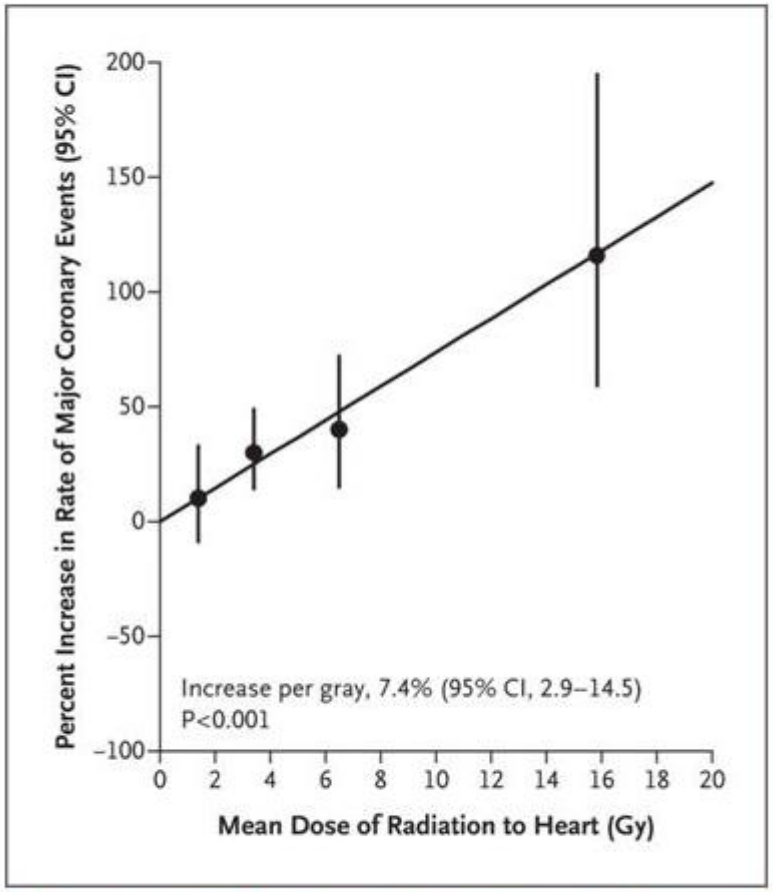
Figure 1: Radiation Dermatitis—Patient's breast radiation dermatitis in the 6th week of treatment.

- 10% risk of mild pain from surgery and radiation
- Heart – especially dose to the LAD
- 3% risk of pneumonitis
- Brachial plexopathy (rare) – when treating lymph nodes; more of an issue in the retreatment setting
- Lymphedema

- Many women receive btw 1-3 Gy for L Breast Ca
- ***Relative risk*** may increase by 20% (7.4% per Gy)
- Average woman has 7% risk of coronary event before 80. Radiation may raise this to roughly 8 or 9%

Risk of ischemic heart disease in women after RT for breast cancer

- A population-based case control study by Darby et al. demonstrated that the risk of MCEs increased progressively with the cardiac radiation dose, by 7.4 percent for each 1 Gy of radiation to the heart

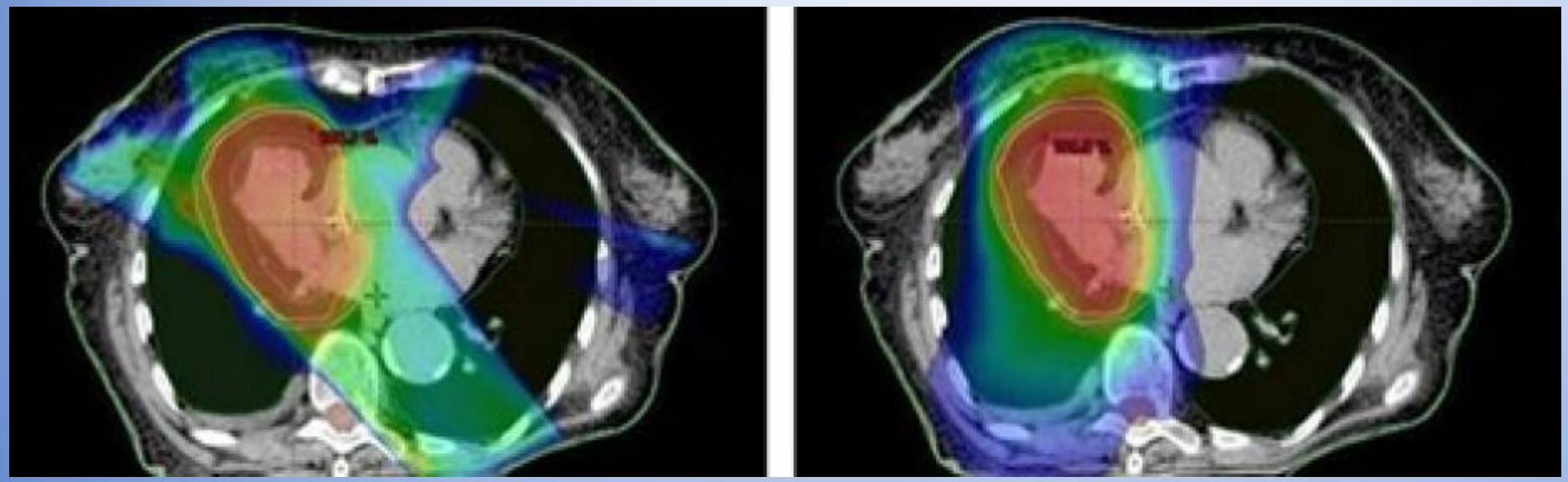


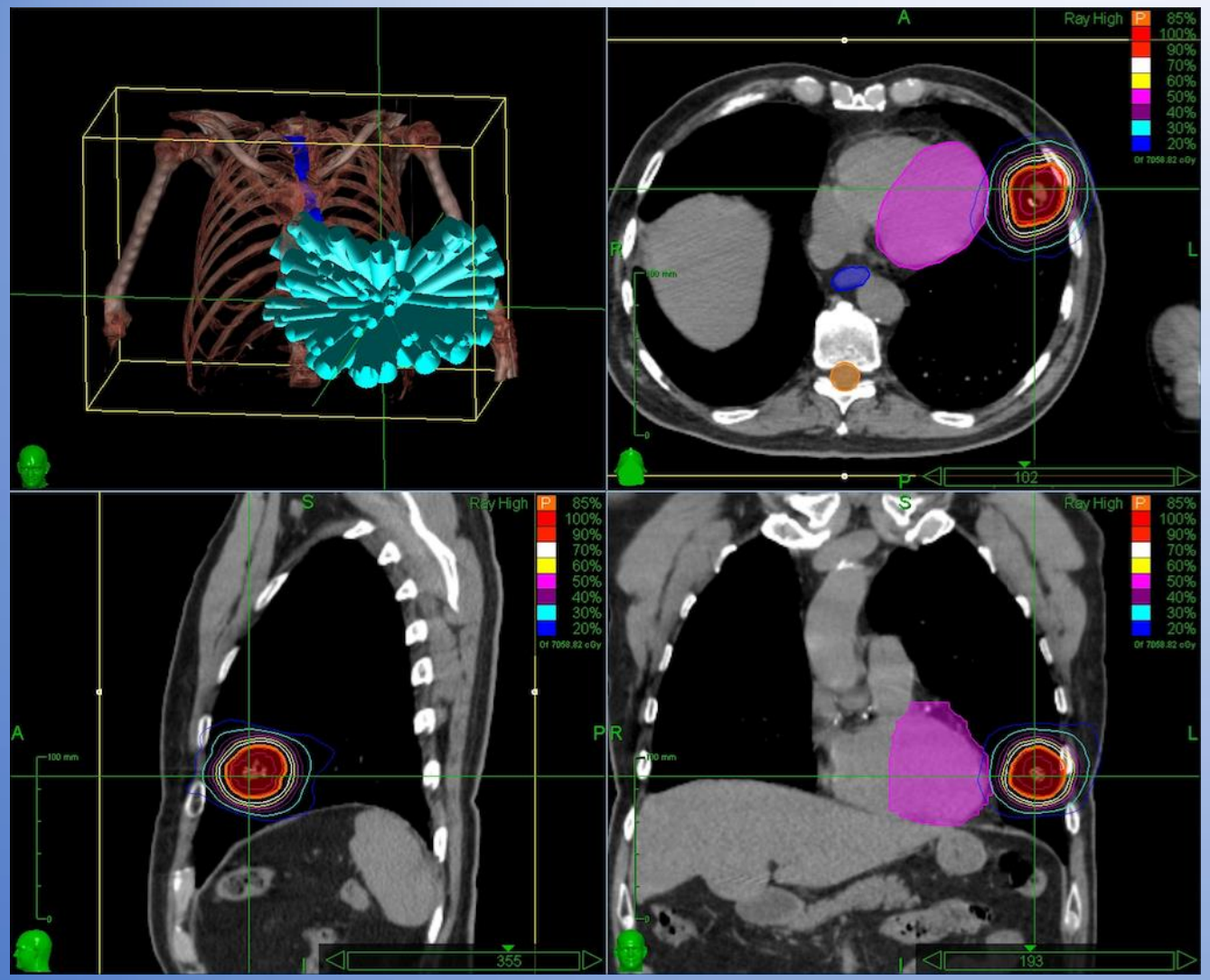
Rate of increase of major coronary events vs. mean RT dose to the Heart, as Compared with the estimated rate with no radiation exposure to the heart. (Darby et al., N Engl J Med. 2013;368(11):987-98

Radiation induced heart disease

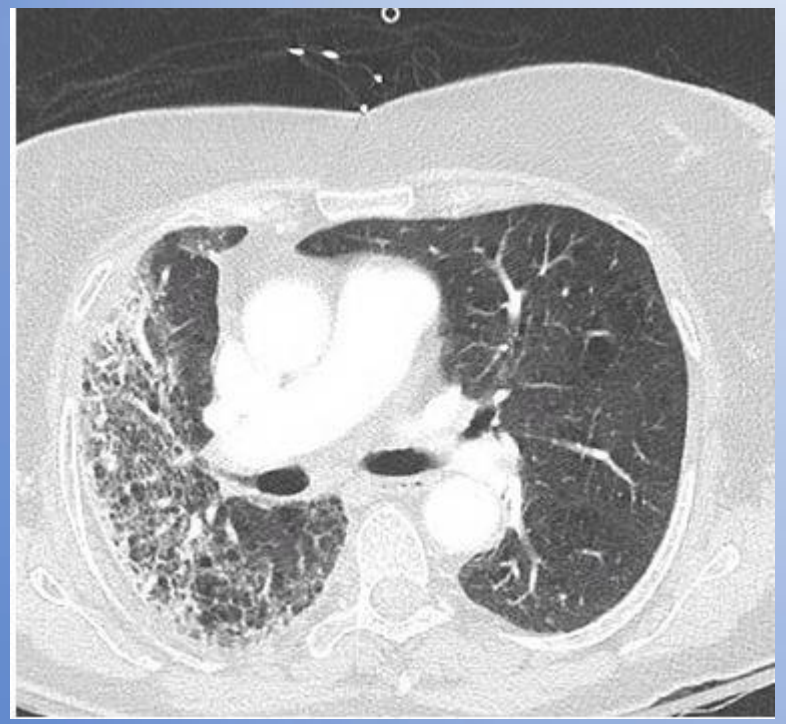
- Anterior or left chest irradiation location
- High cumulative dose of radiation (>30 Gy)
- Younger patients (<50 years)
- High dose of radiation fractions (>2 Gy/day)
- Presence and extent of tumour in or next to the heart
- Lack of shielding
- Concomitant chemotherapy (the anthracyclines considerably increase the risk)
- Cardiovascular risk factors (i.e. diabetes mellitus, smoking, overweight, ≥moderate hypertension, hypercholesterolaemia)

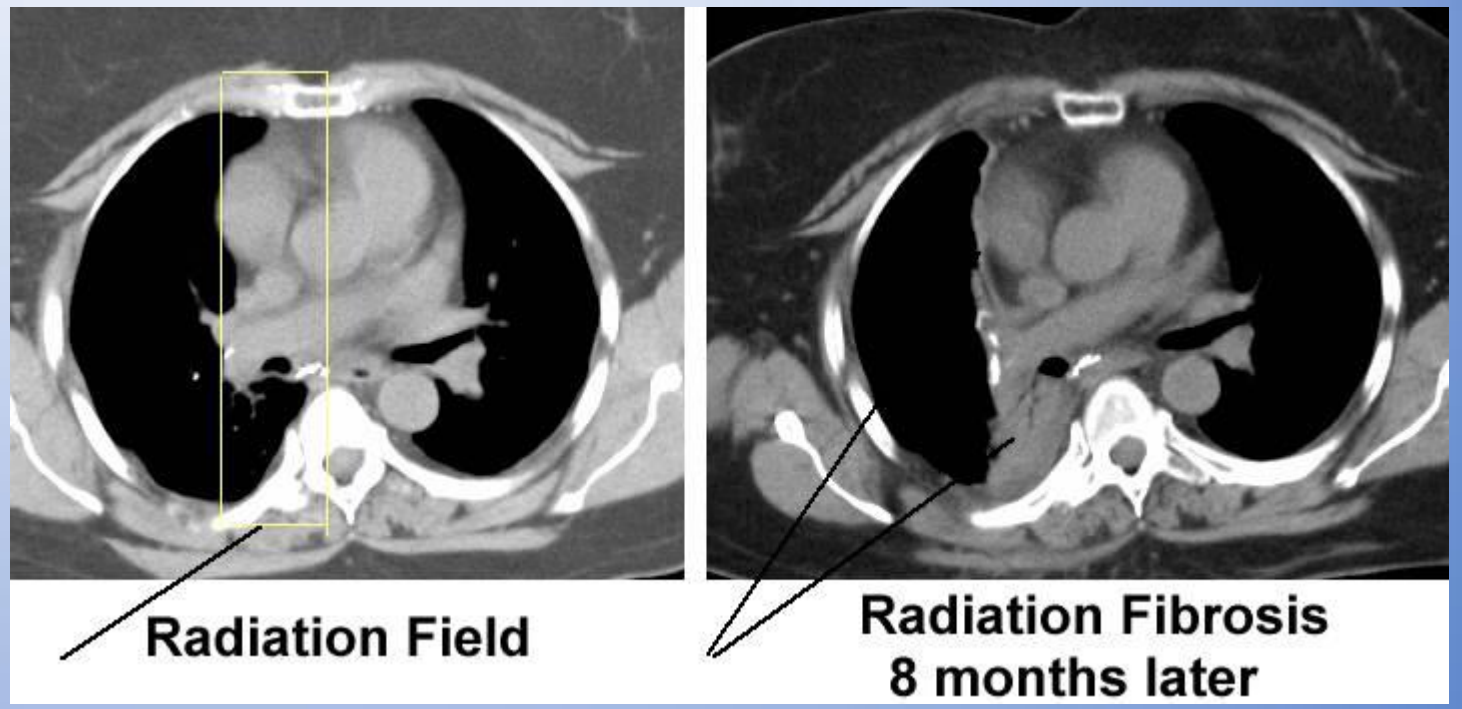
Lung





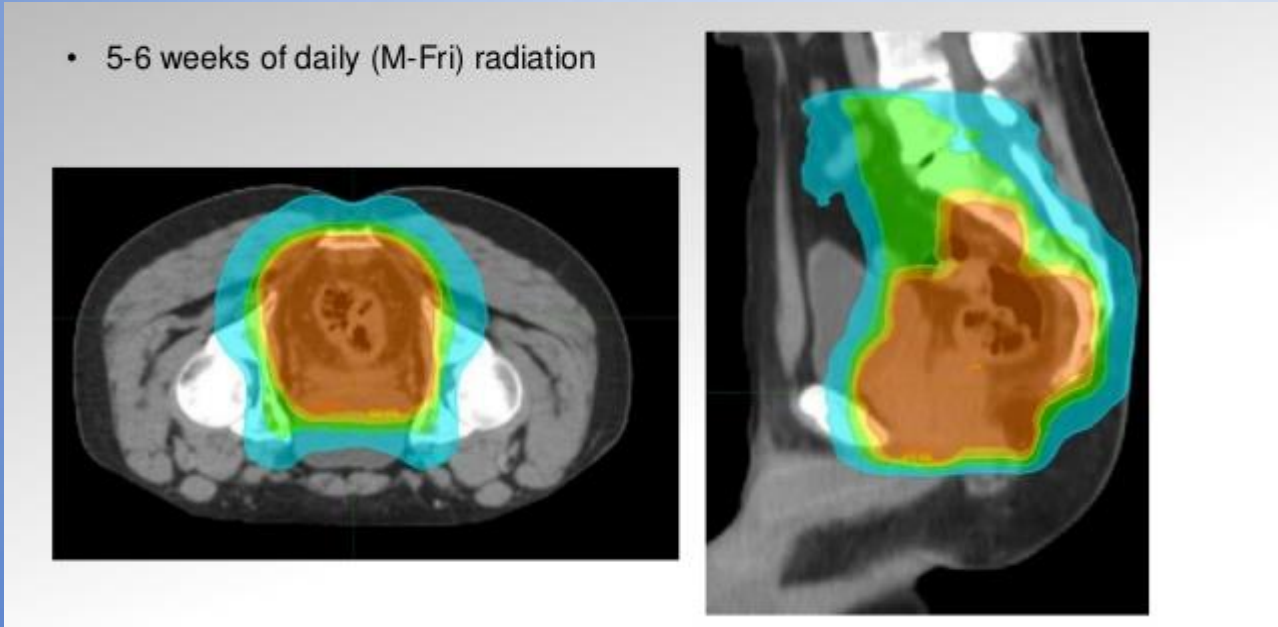
- Rib
- Lung
- Central Airway
- Heart
- Esophagus
- Spinal cord





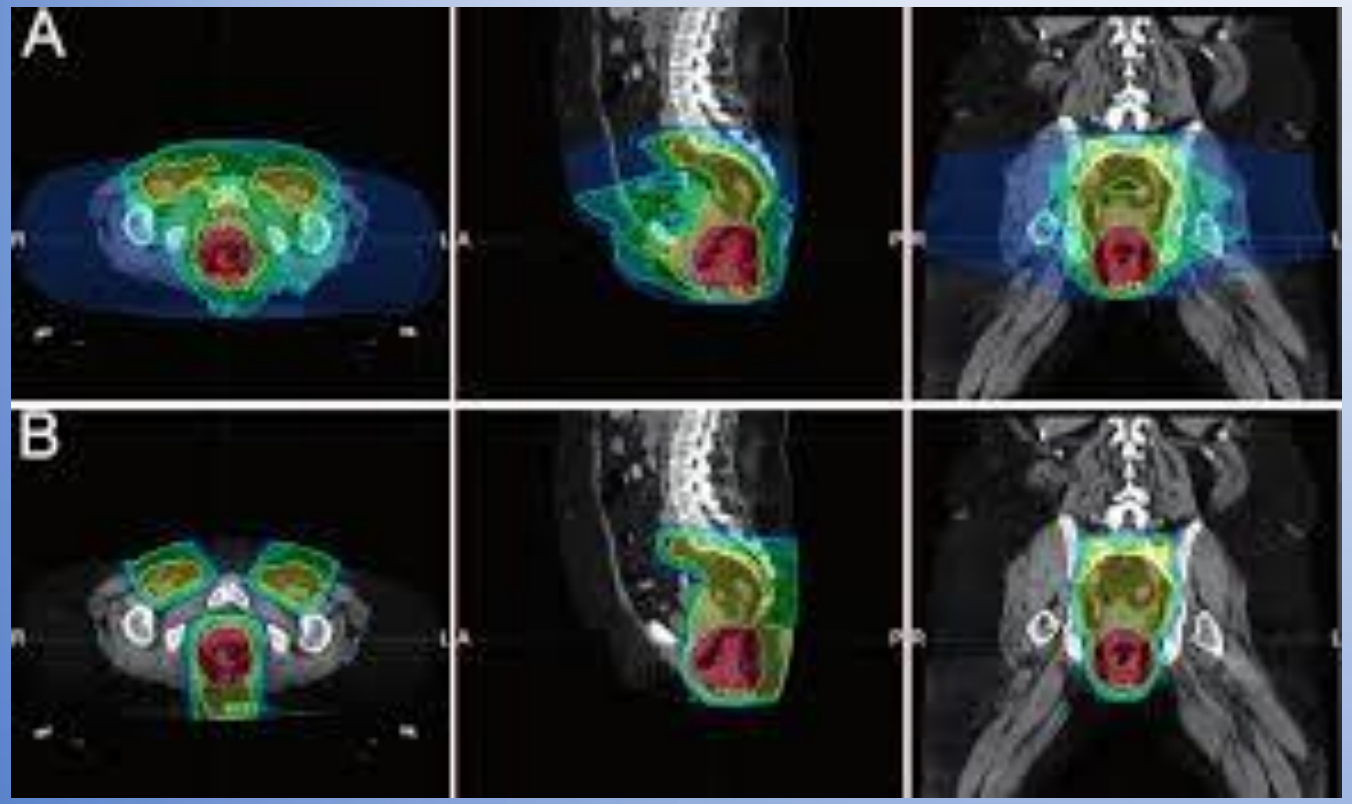
- Radiation pneumonitis

Rectal

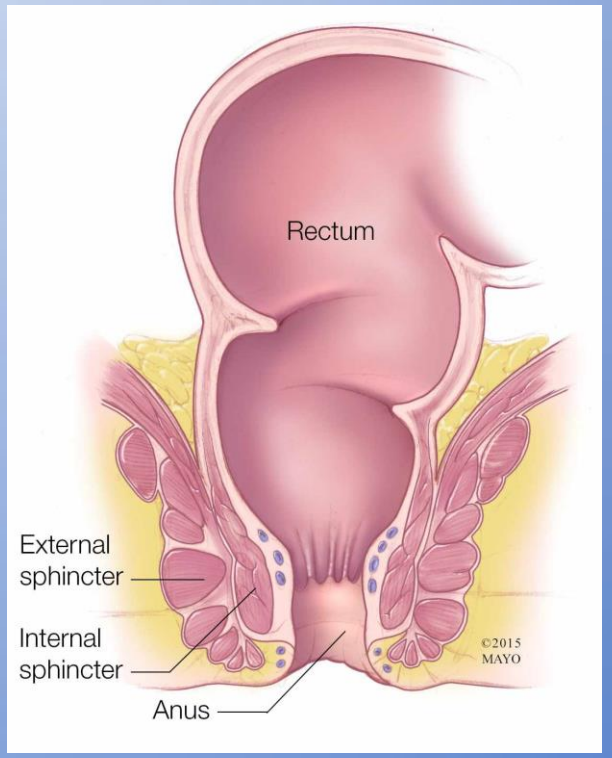


- Rectum
- Bladder
- Pelvic bones
- Sexual nerves
- Bowel

Anal Cancer

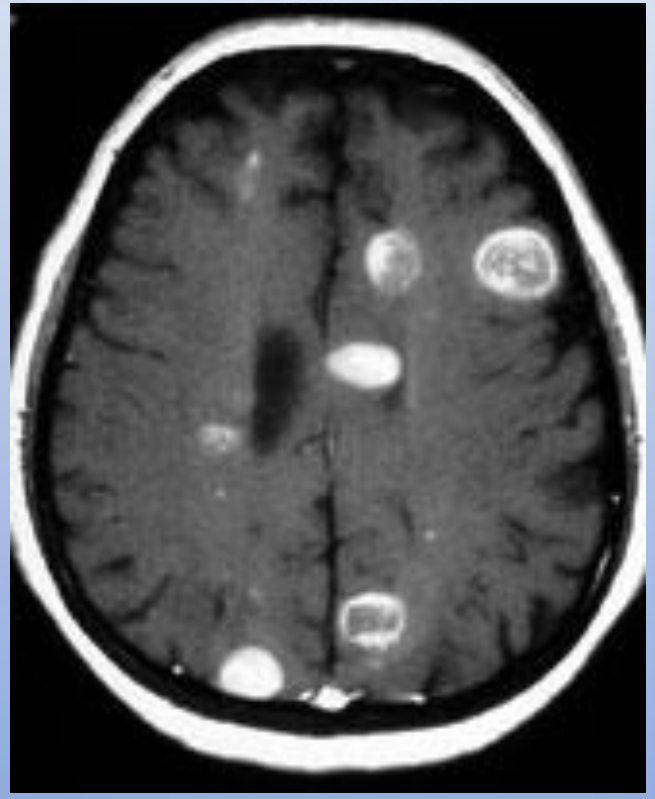


- Same as rectal
- Skin
- Anal Sphincter Muscles – fecal leakage/incontinence often dependent on lifestyle factors, esp. diet

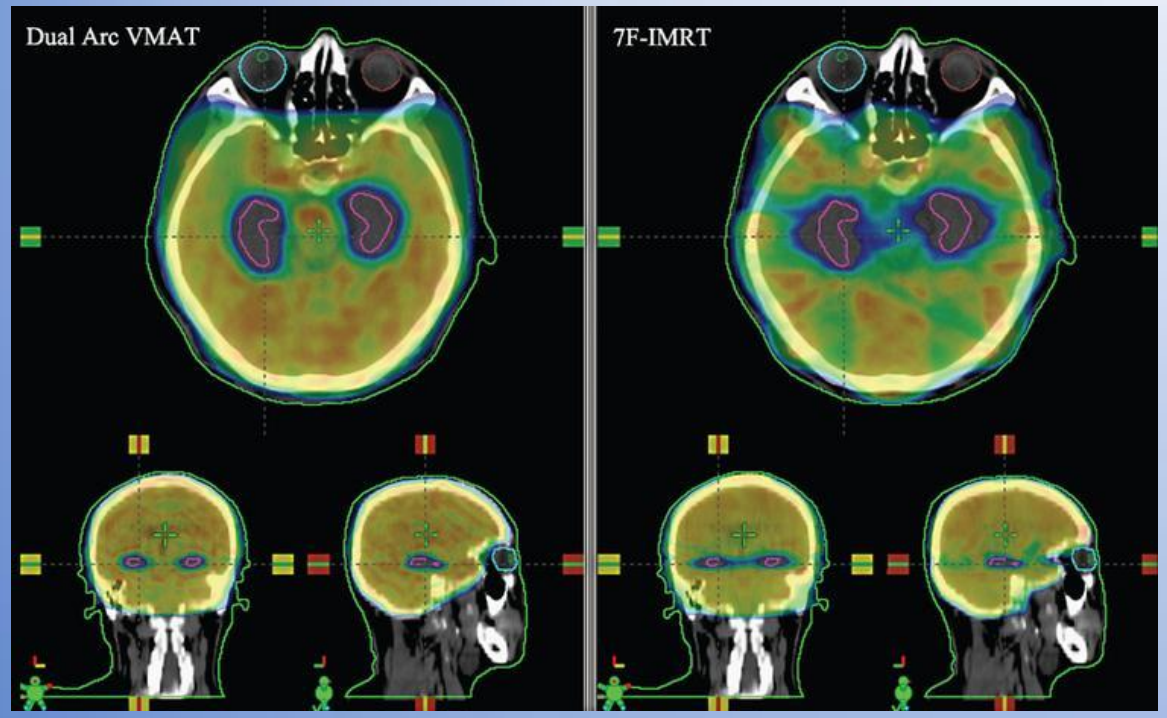


- Sacral insufficiency fracture

- Lymphedema



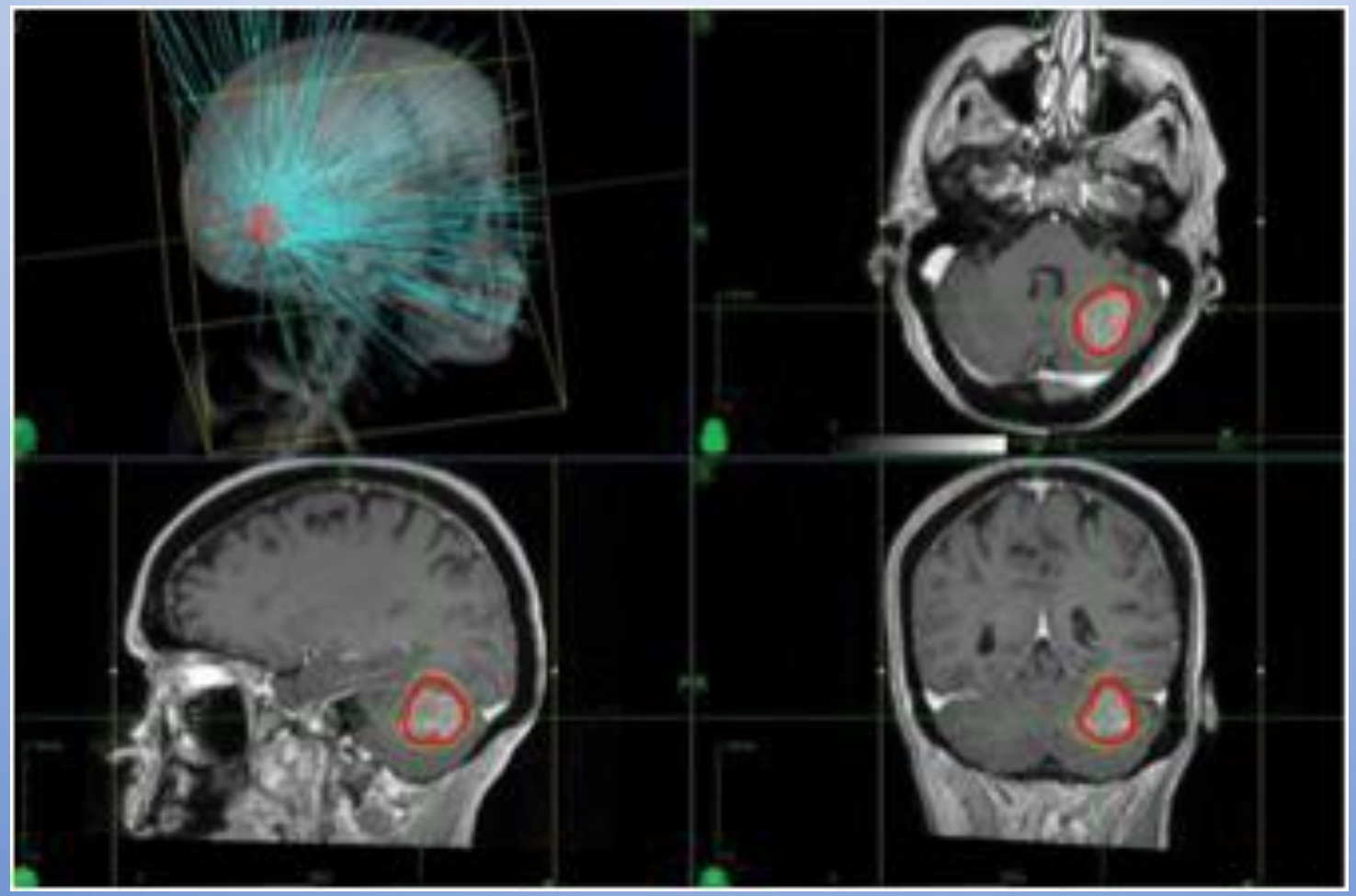
Brain



- Hippocampal sparing whole brain radiotherapy

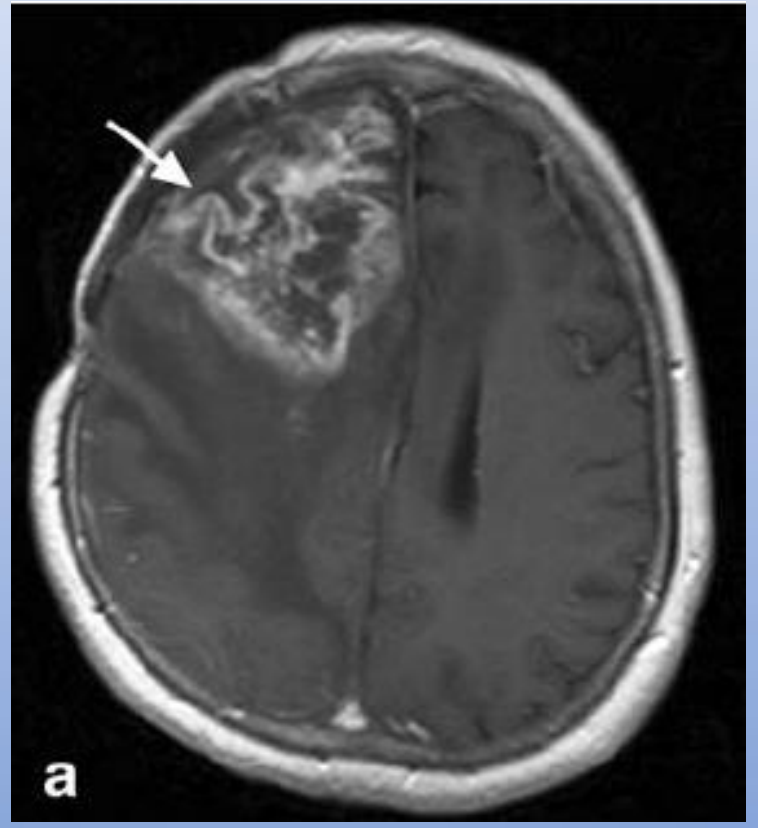
- Fatigue
- Skin
- Alopecia
- 10% risk for worsening edema
  - Headaches
  - n/v
  - photophobia
  - Can be serious if ventricles obstruct or brain herniates

Stereotactic Radiosurgery (SRS)

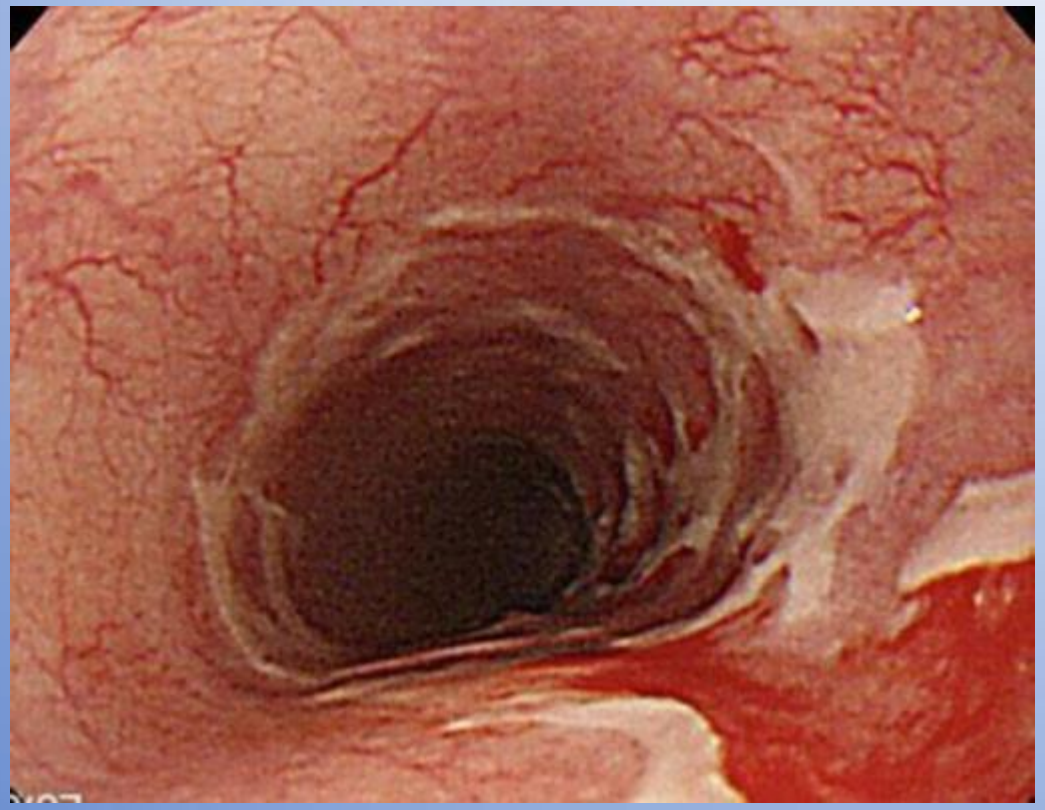


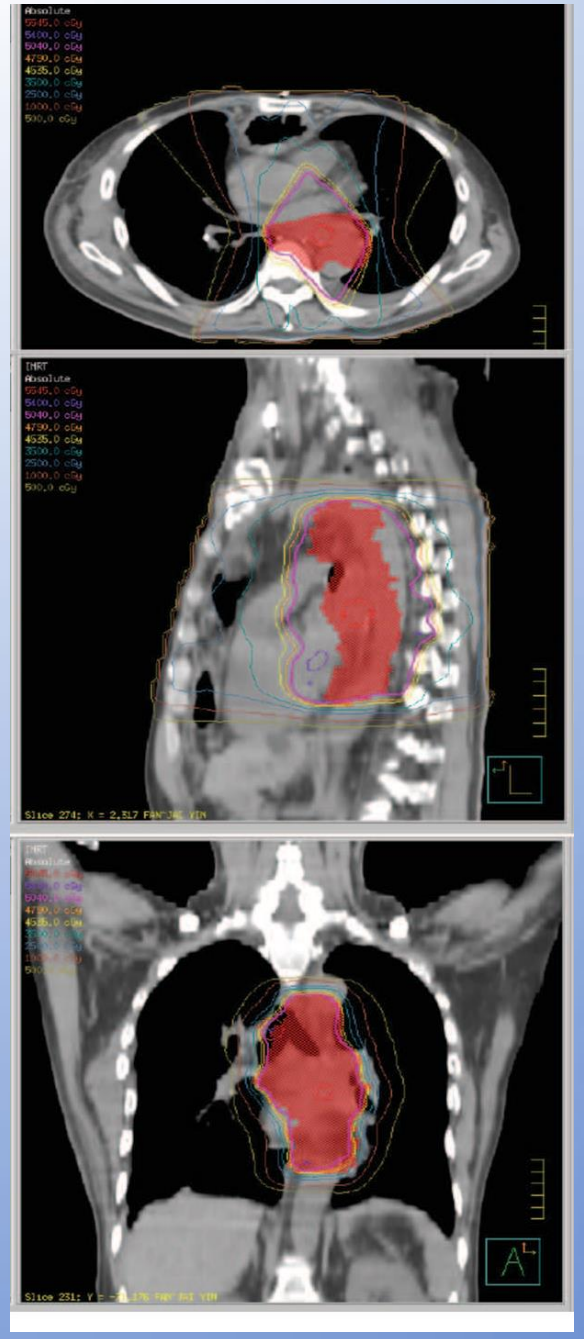
SRS complications

- Radiation necrosis
- Worsening in edema



Esophagus



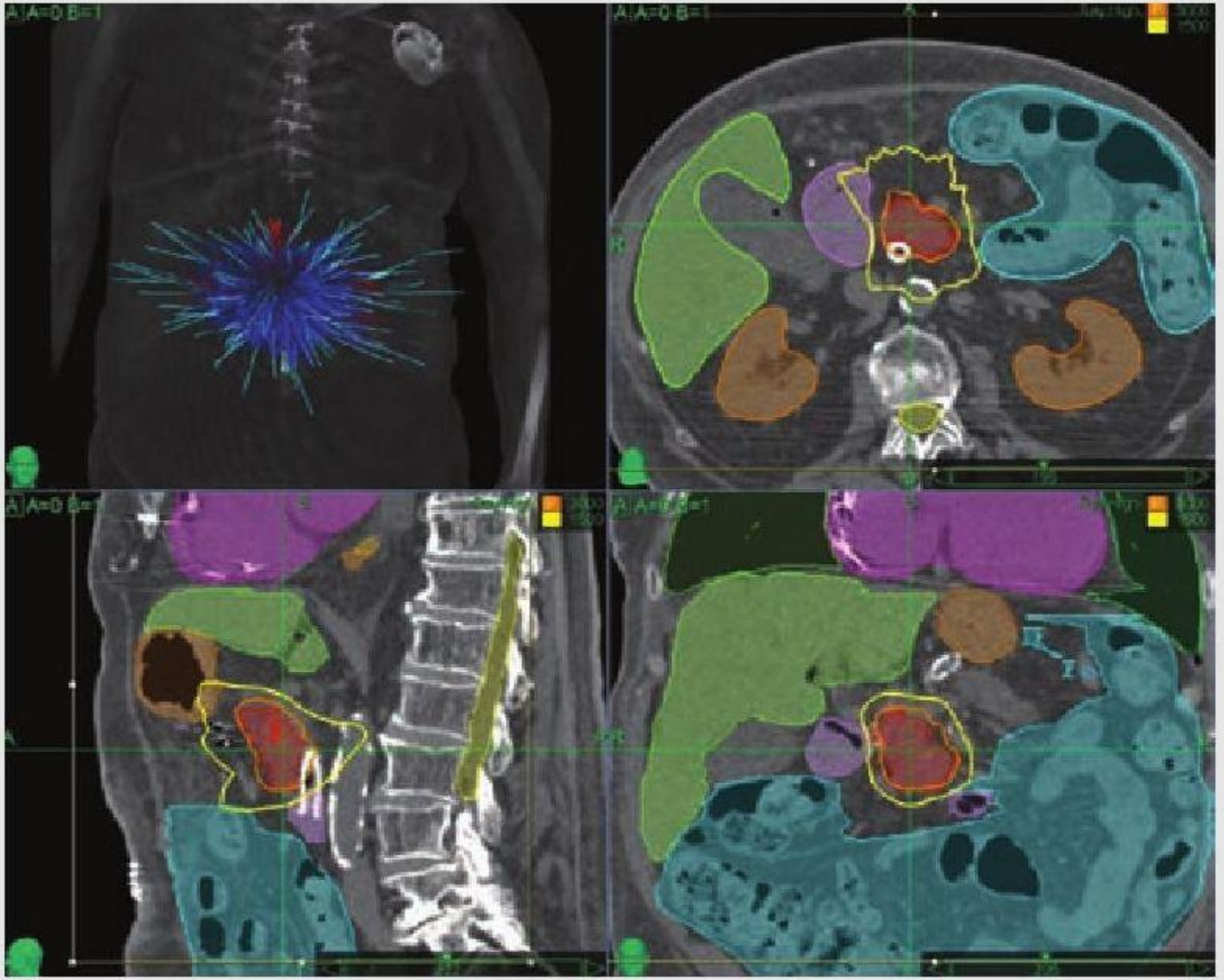

Absolute
5545.0 cGy
5400.0 cGy
5040.0 cGy
4730.0 cGy
4535.0 cGy
3500.0 cGy
2500.0 cGy
1000.0 cGy
500.0 cGy
THRT
Absolute
5545.0 cGy
5400.0 cGy
5040.0 cGy
4730.0 cGy
4535.0 cGy
3500.0 cGy
2500.0 cGy
1000.0 cGy
500.0 cGy
Slice 274:
Slice 231:

Pancreas SBRT

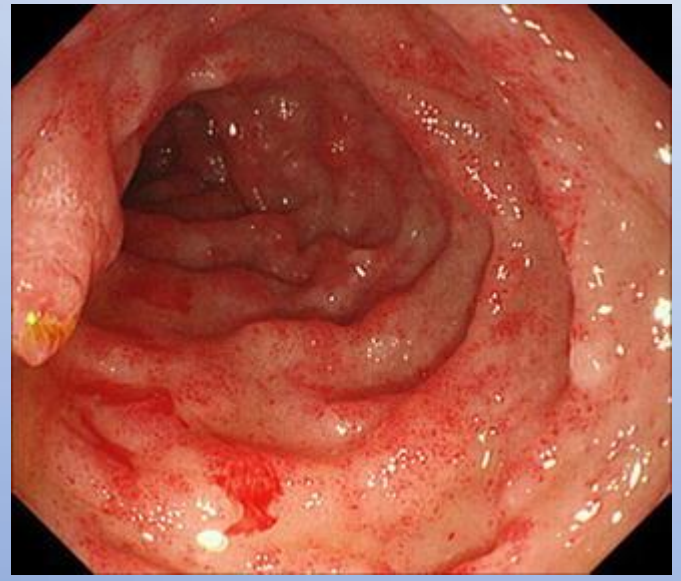
- Endoscopic fiducial Markers are required

Small bowel injury is The main risk

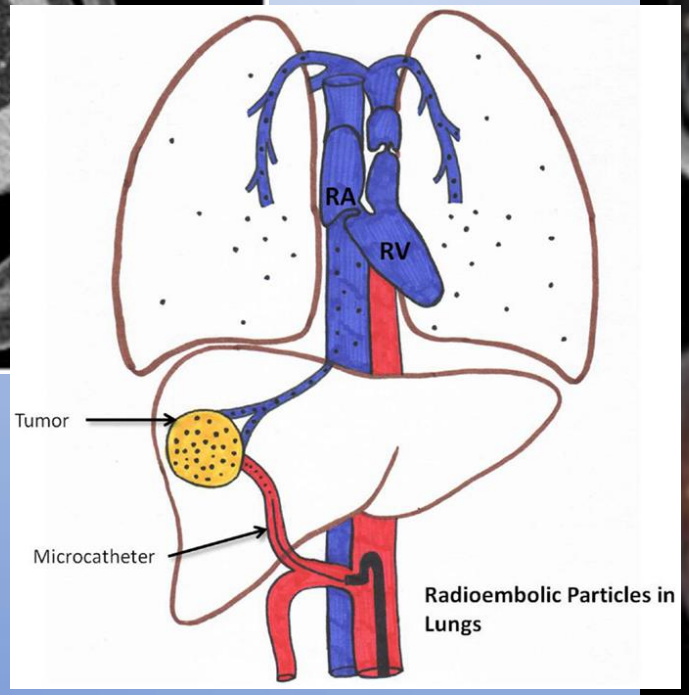
Most patients have mild-Moderate n/v, diarrhea

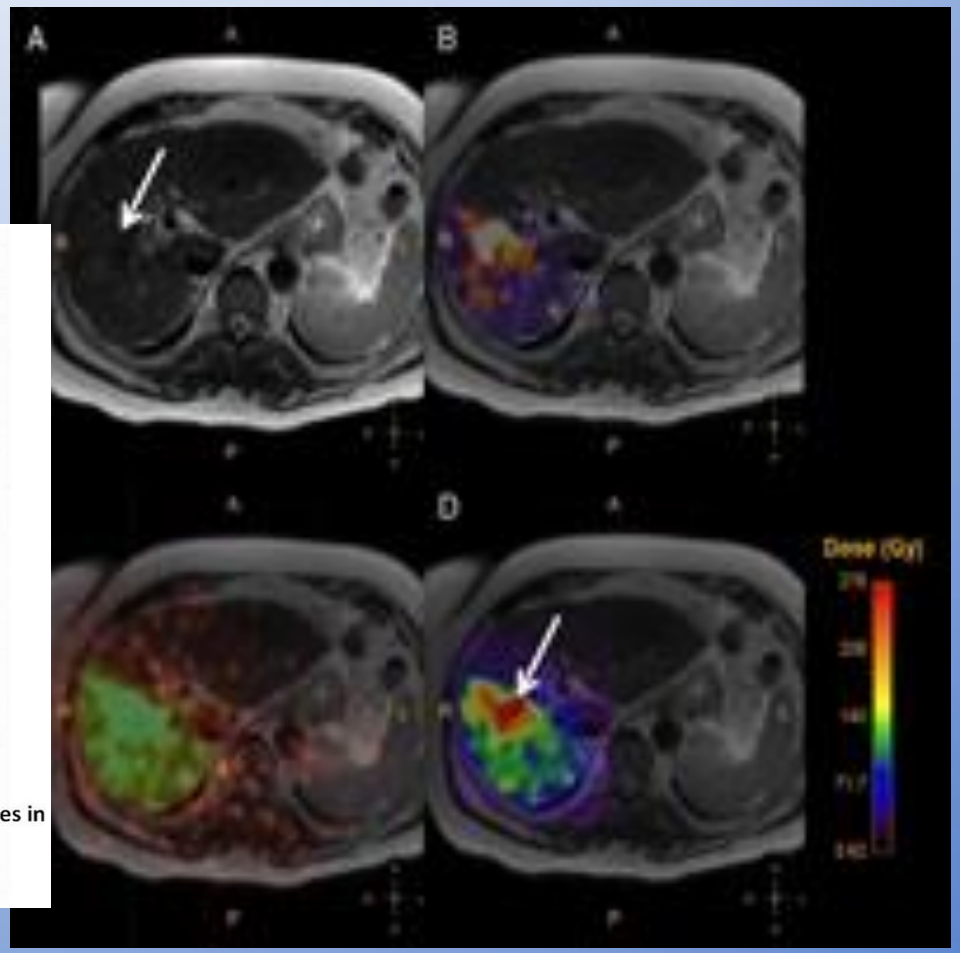


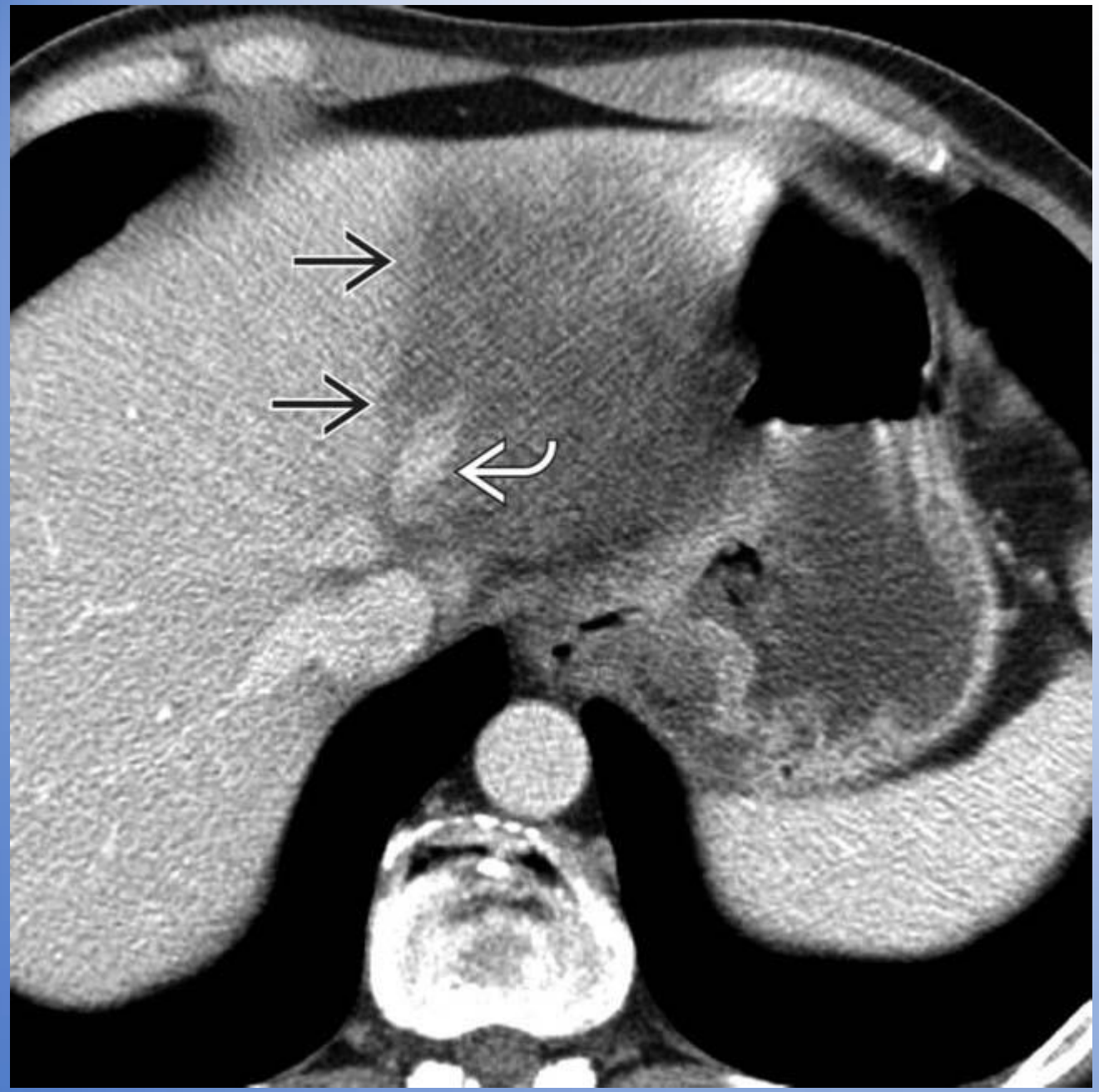
- Radiation induced hemorrhagic duodenitis



Liver

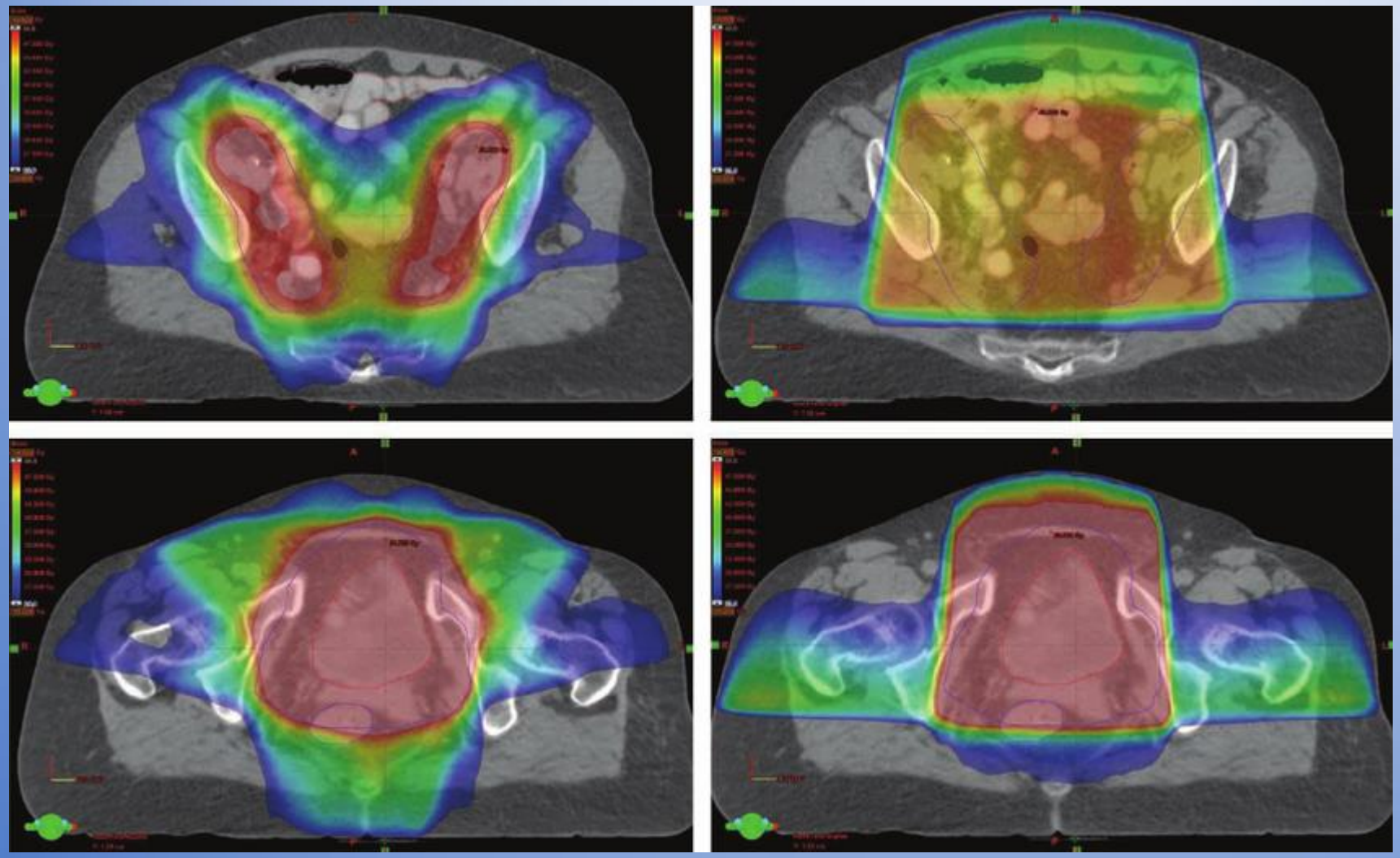

RA
RV
Tumor
Microcatheter
Radioembolic Particles in Lungs


A
B
D
Dose (Gy)

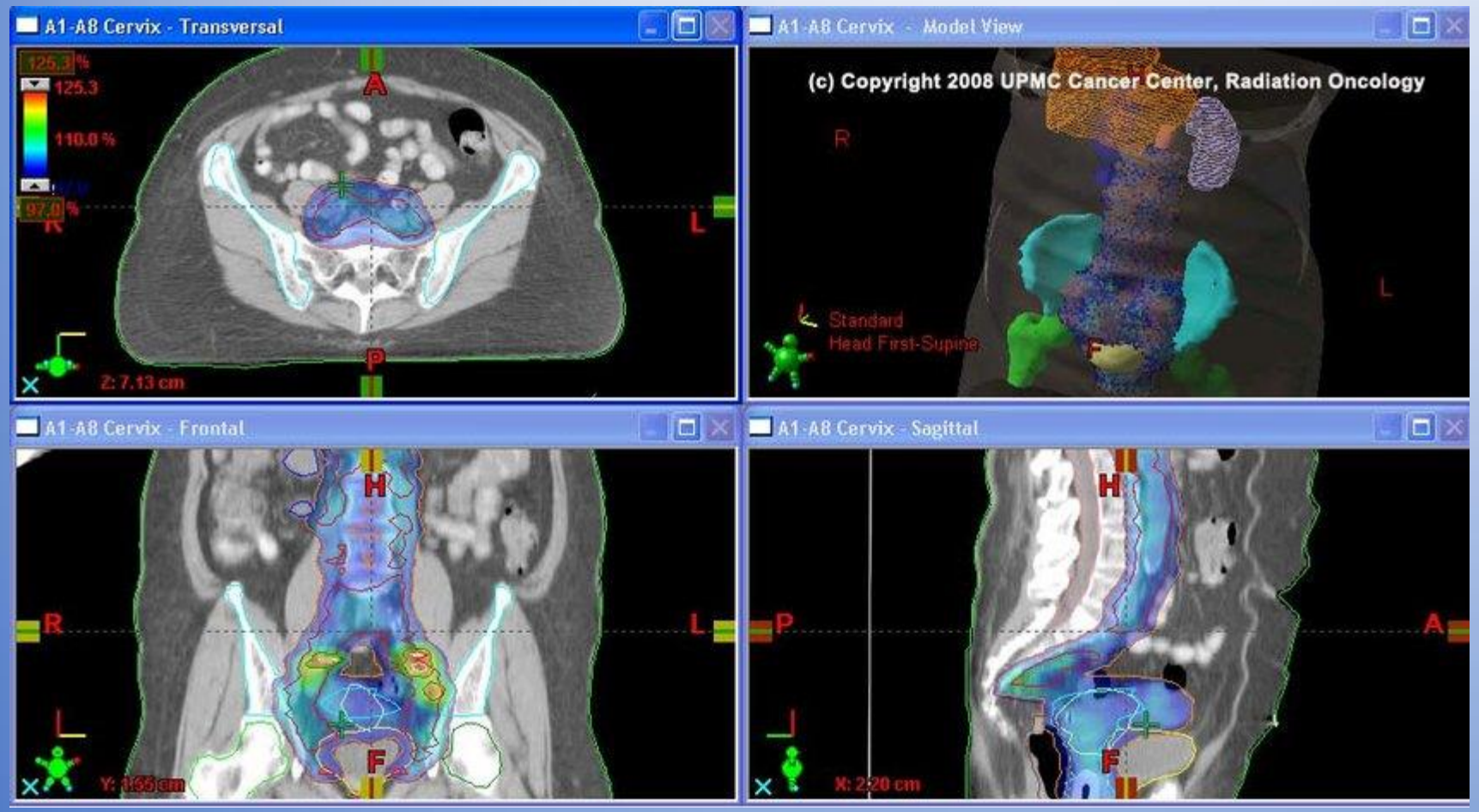


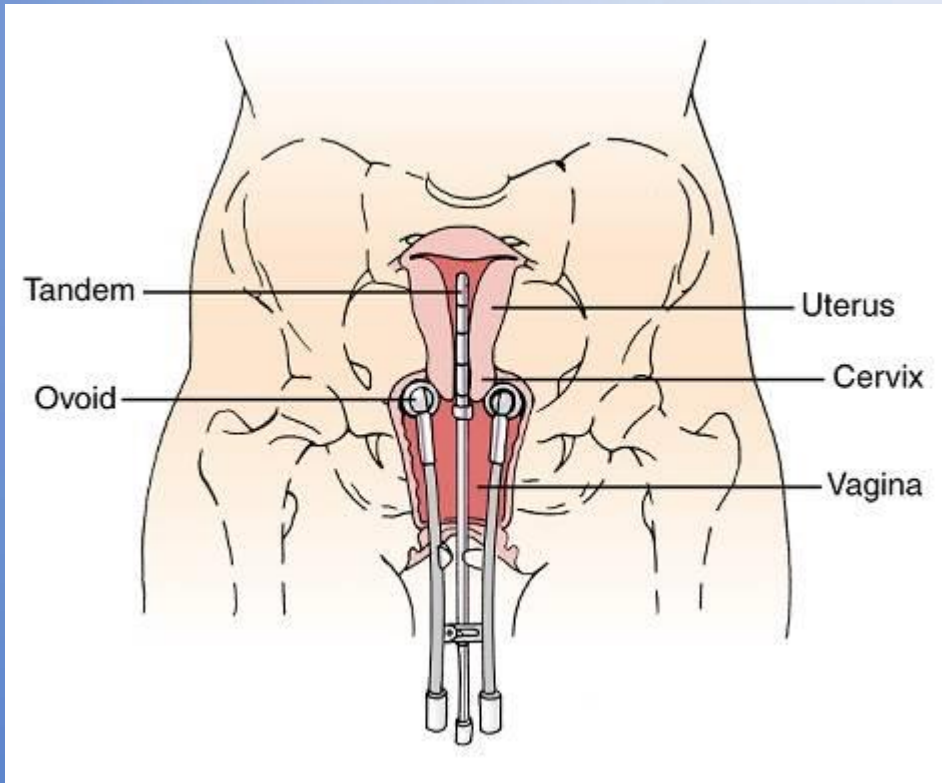
- Radiation induced liver disease

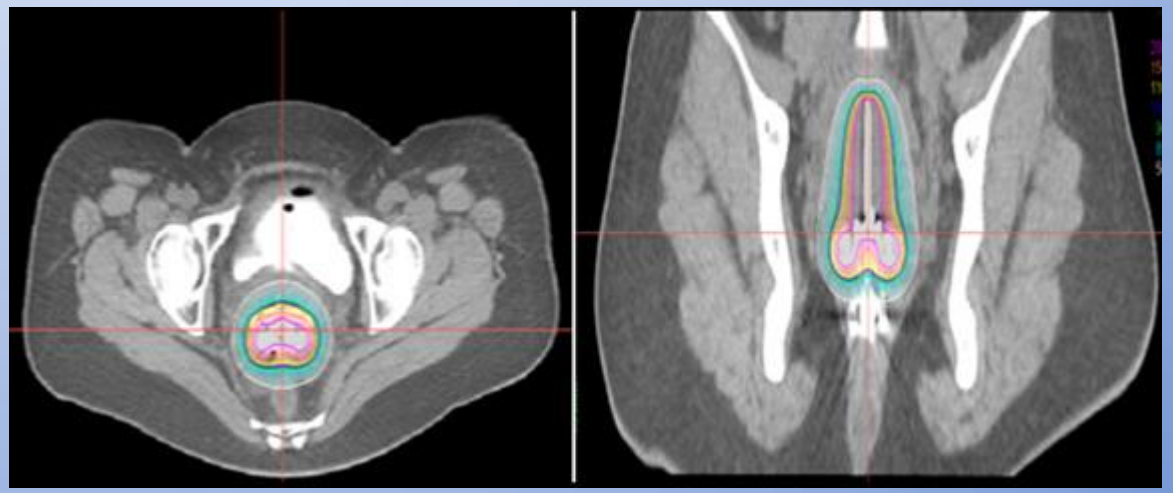
Bladder



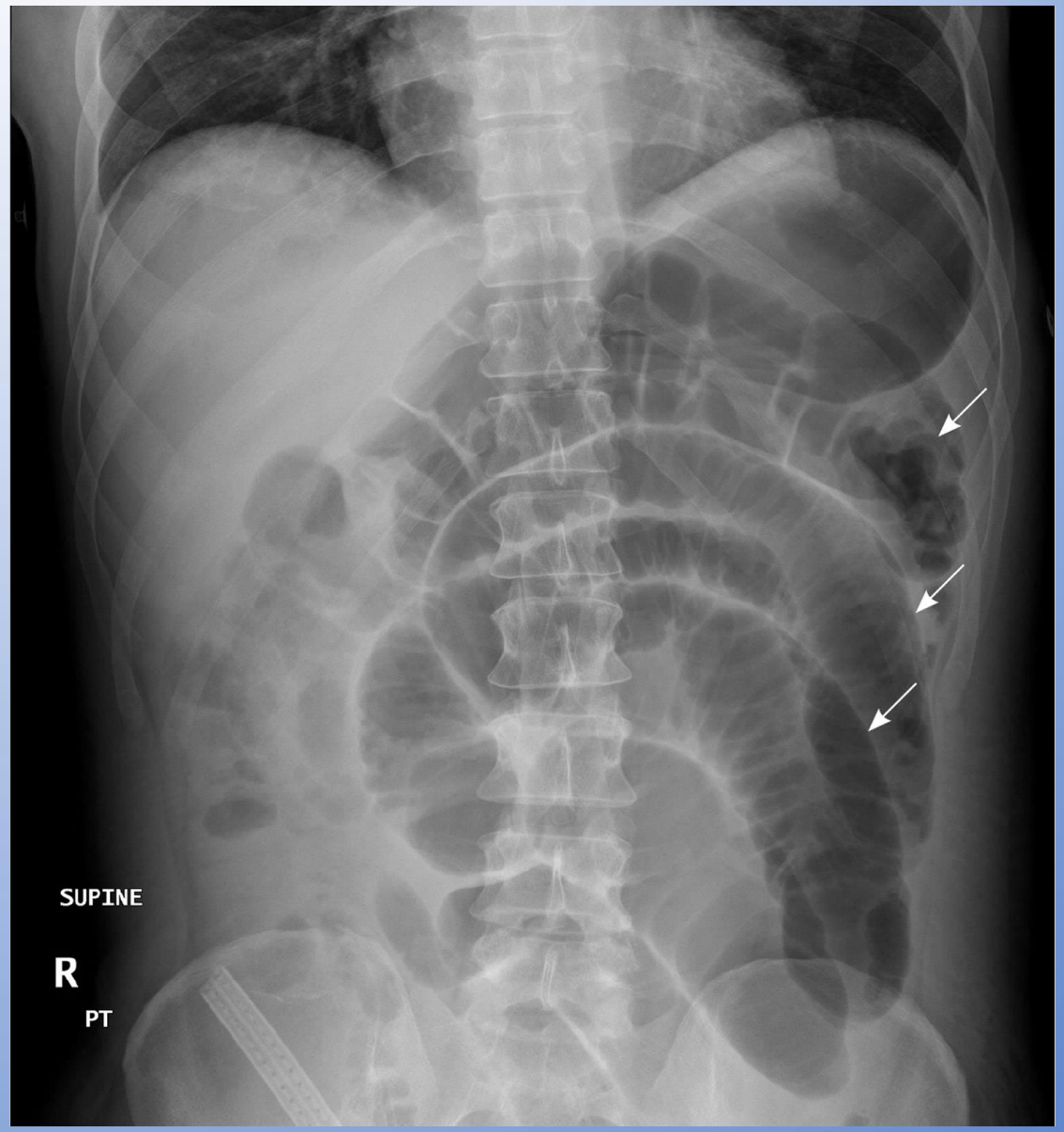
Cervix


A1-A8 Cervix - Transversal
125.3 %
125.3
110.0 %
97.0 %
A
P
L
Z: 7.13 cm
A1-A8 Cervix - Model View
(c) Copyright 2008 UPMC Cancer Center, Radiation Oncology
R
L
Standard
Head First-Supine
F
A1-A8 Cervix - Frontal
H
R
L
F
Y: 1.65 cm
A1-A8 Cervix - Sagittal
H
P
A
F
X: 2.20 cm


Tandem
Uterus
Ovoid
Cervix
Vagina

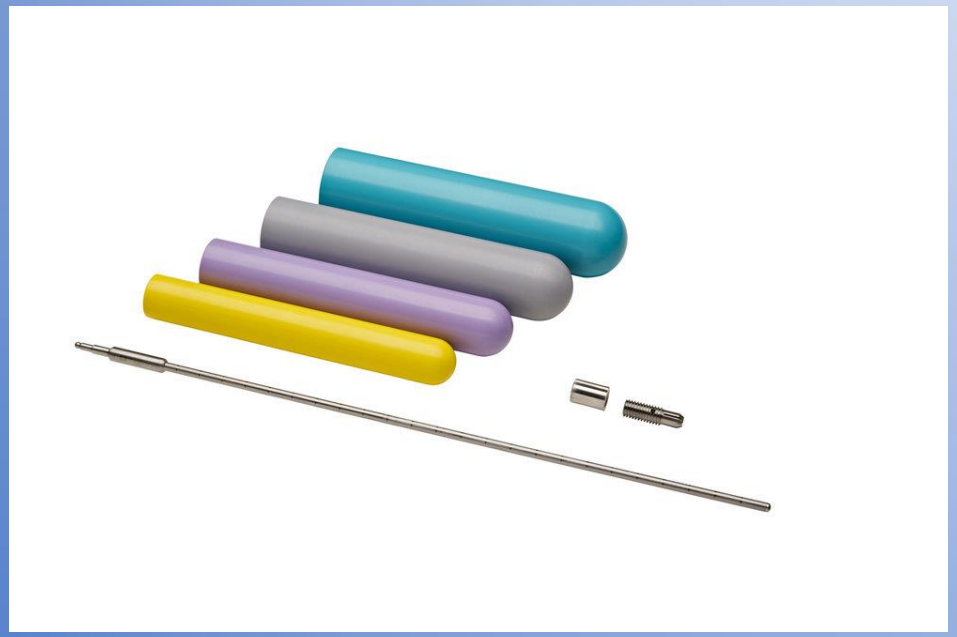


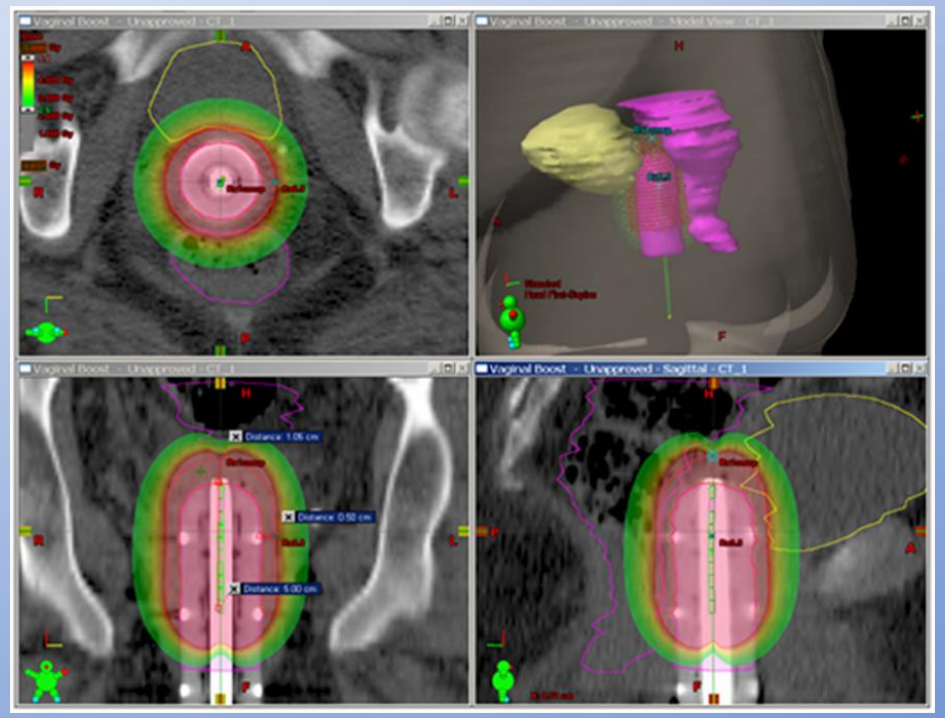
- Small bowel obstruction



Uterus

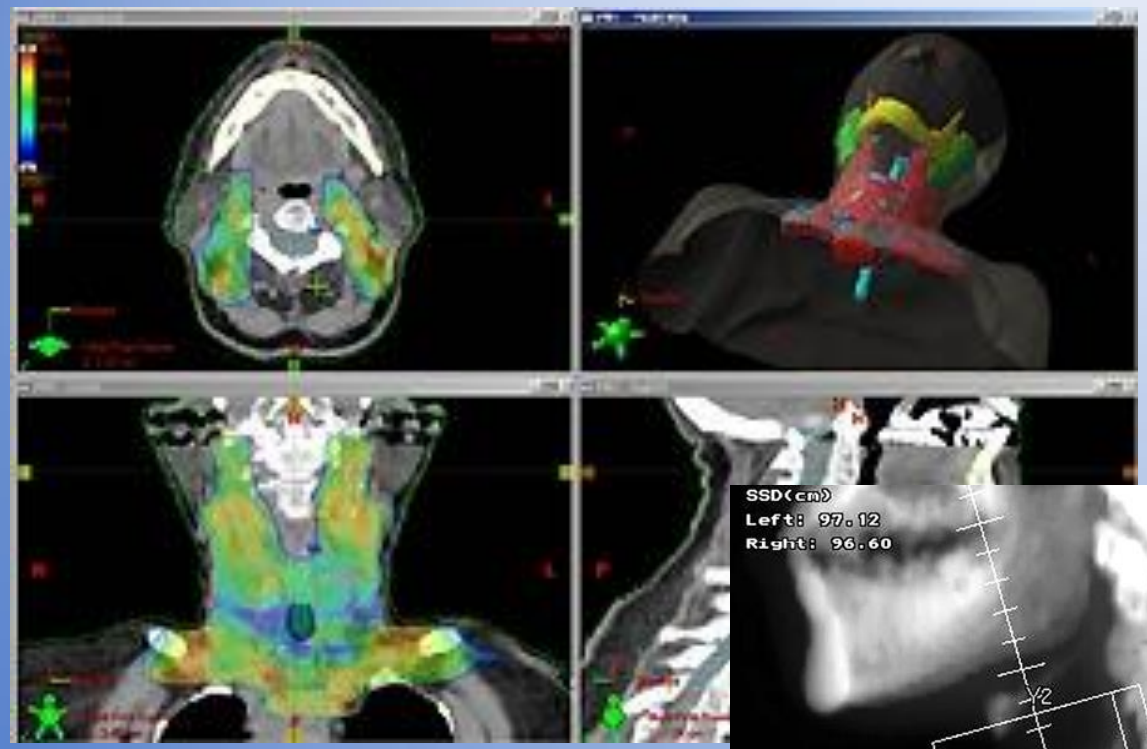
- Vaginal Cylinder Brachytherapy to reduce vaginal cuff recurrence

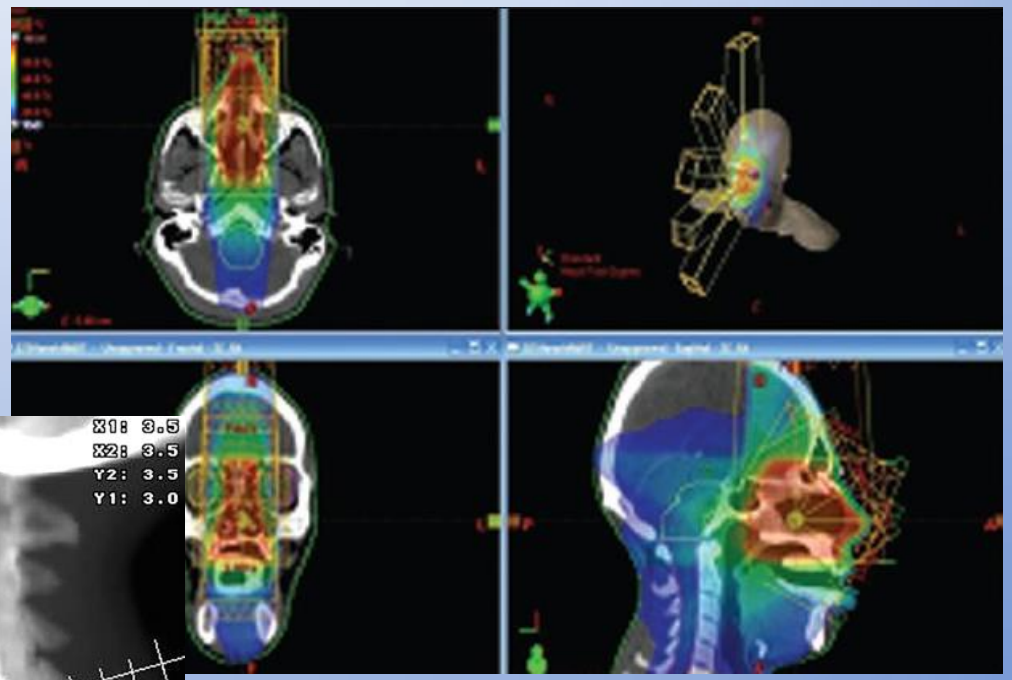





Intimate Rose
Dilator Medium Pack
7
6
5
4
3
2
1
0
INCHES
10 9 8 7 6 5 4 3 2 1 0

Head and Neck Cancer





World Health Organization's Oral Toxicity Scale

Severe Mucositis

Grade 1	Grade 2	Grade 3	Grade 4
Soreness ± erythema	Erythema, ulcers; patient can swallow solid food	Ulcers with extensive erythema; patient cannot swallow food	Mucositis to the extent that alimentation is not possible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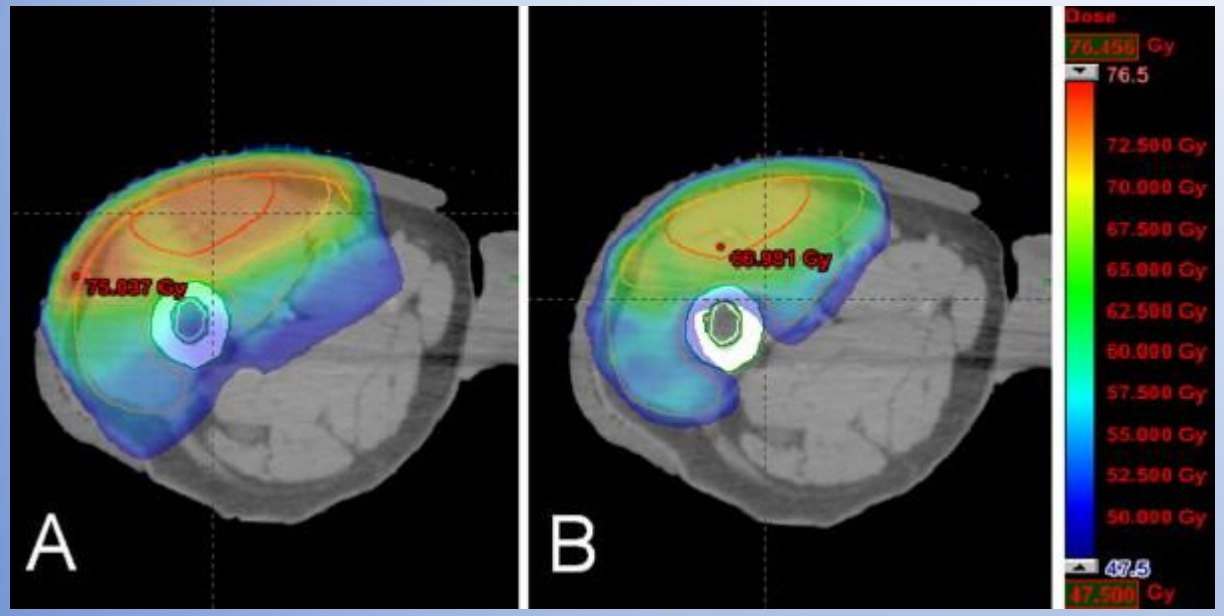
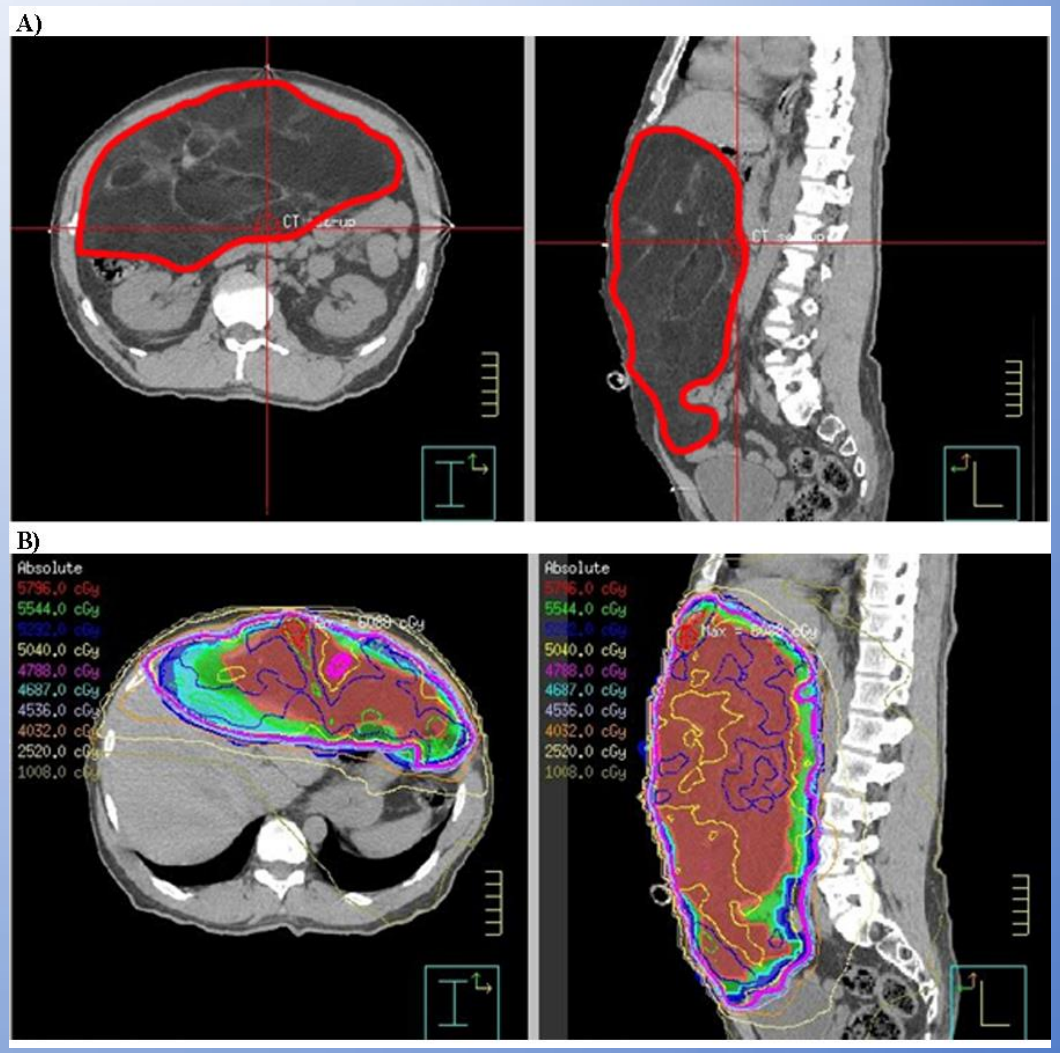
Sarcoma

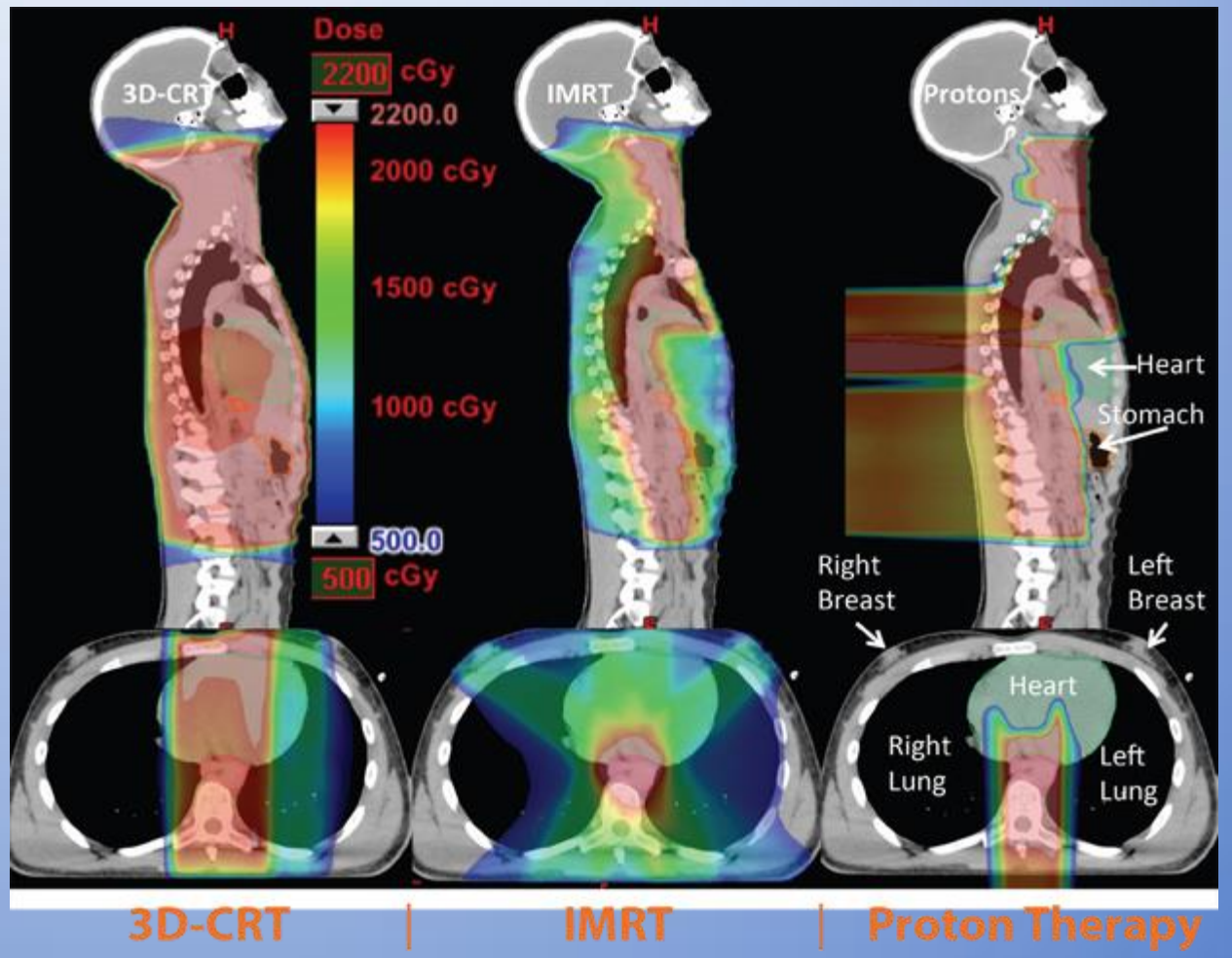

A
B
Dose
76.456 Gy
76.5
72.500 Gy
70.000 Gy
67.500 Gy
65.000 Gy
62.500 Gy
60.000 Gy
57.500 Gy
55.000 Gy
52.500 Gy
50.000 Gy
47.5
47.500 Gy


A)
B)
Absolute
5796.0 cGy
5544.0 cGy
5040.0 cGy
4788.0 cGy
4687.0 cGy
4536.0 cGy
4032.0 cGy
2520.0 cGy
1008.0 cGy

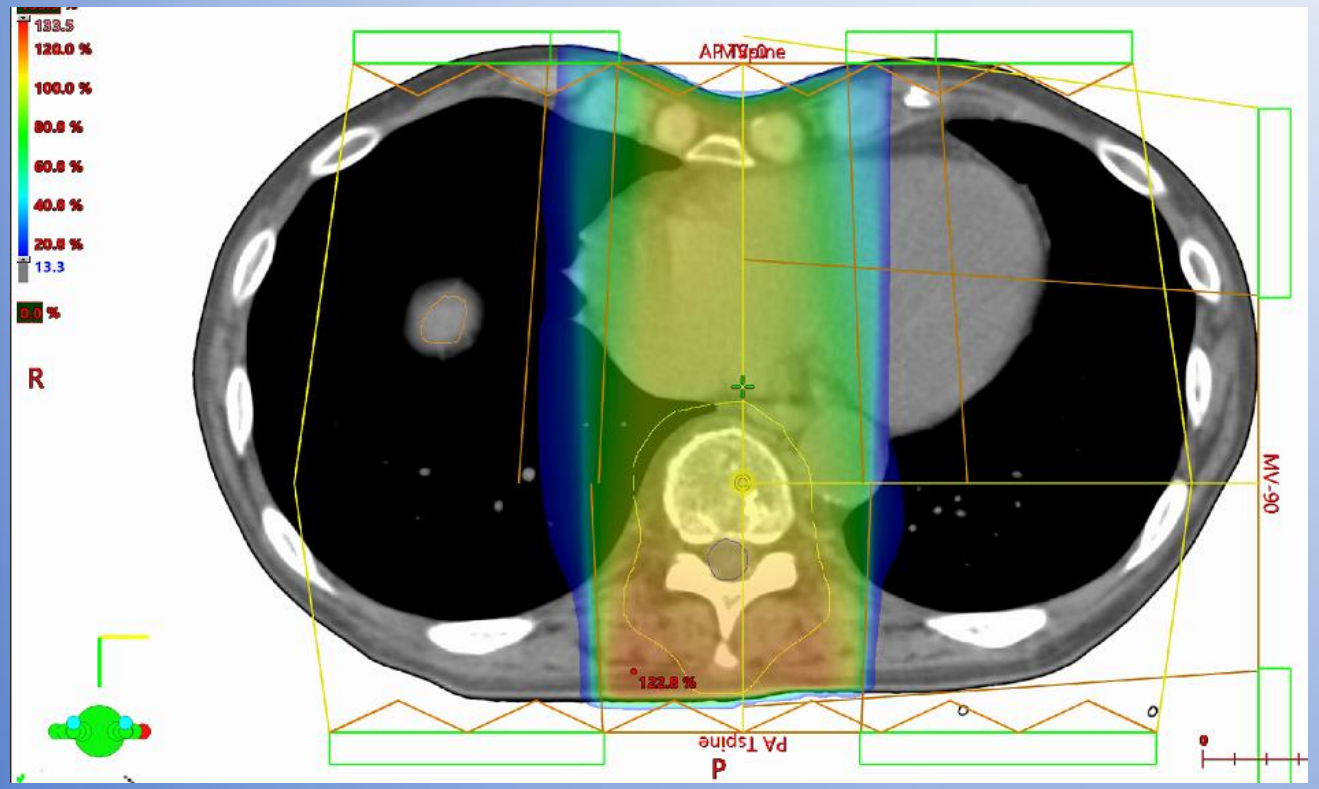
Pediatrics

- Major Late Effects
  - Cardiotoxicity
  - Second Malignancy
- Other late effects
  - thyroid dysfunction
  - pulmonary fibrosis
  - peripheral vascular disease
  - muscle atrophy
  - Growth abnormalities

Stage III Hodgkins Lymphoma, involving neck, mediastinum, and periaortics



- Surgery followed by postoperative radiation after incisions heal (roughly 2 weeks)



30 Gy in 10 fractions
AP and PA (opposed fields)

Sensitive normal tissues in field include

- heart
- spinal cord
- esophagus
- spinal bones
- skin

Conclusions

- Radiation Therapy is an important tool for locoregional treatment of cancer, with either curative or palliative intent
- Radiation complications depend on a variety of factors, including
  - Total Dose
  - Volume of Field
  - Surrounding normal tissues
  - Host factors, including comorbid conditions, lifestyle, and genetics*

- *In the future, genetic analyses may offer potential for more-personalized radiation treatments


WILD
one