

Intensity Modulated Radiation Therapy (IMRT)

Presented by John T. Gwozdz, M.D.
at the “Cancer Updates for the
Primary Care Provider” conference
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Background:

What is External Beam Radiation?

- A high energy beam that passes through living tissue.
- It enters on one side of the body and exits on the other side of the body without deviating in direction.
- It kills cancer by damaging DNA, causing cells to die at cell division.
- Unfortunately, normal tissue can be harmed in the same way.

The Evolution of Sparing Normal Tissue

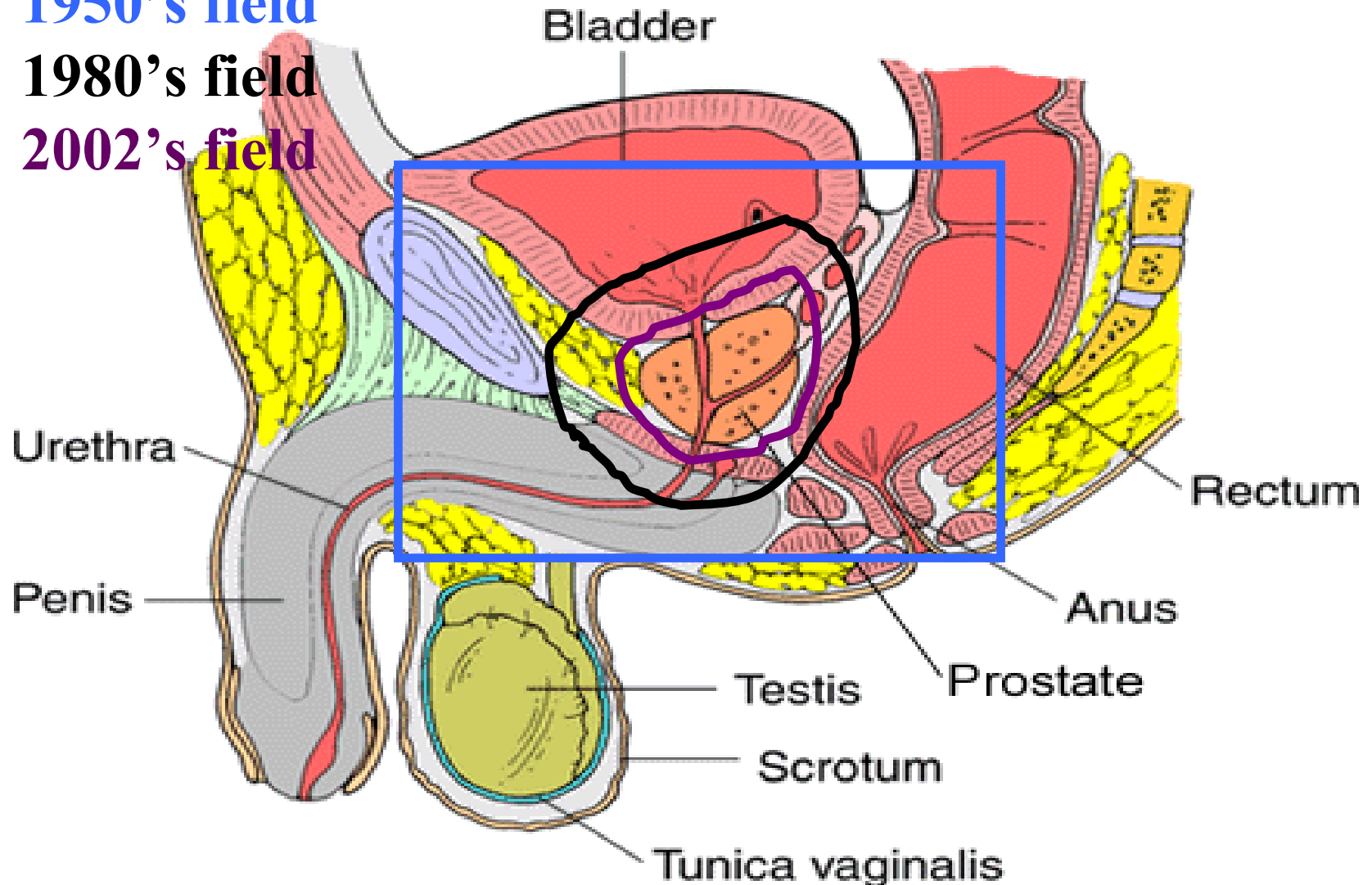
- **1950's:** square/rectangle fields
- **1960's:** stacked lead blocks to shape field
- **1970's – 80's :** Cerrobend –liquid shielding built to shape fields
- **1990's – 2000's:** - multileaf shaping by treatment machine – one shape per field.
- **IMRT** – continuous shape change while machine is on to focus intensity on tumor.

Graphical Representation of Sparing Normal Tissue

1950's field

1980's field

2002's field



Example of the evolution of Benefits vs. Harm of XRT for Prostate Cancer

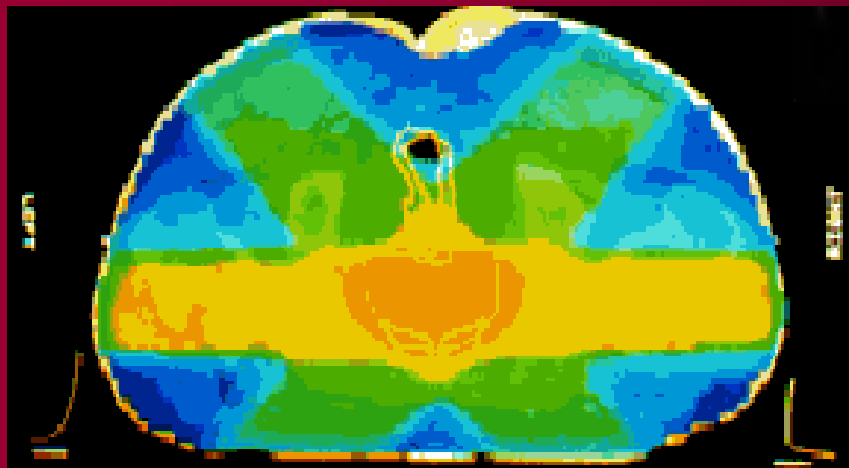
- 1950's – more people were harmed than benefited
- 1980's – approximately 70% of the people benefited and 10% were harmed
- 2002 – approximately 90% of the people are benefiting and 1-2% are harmed

Overview of IMRT

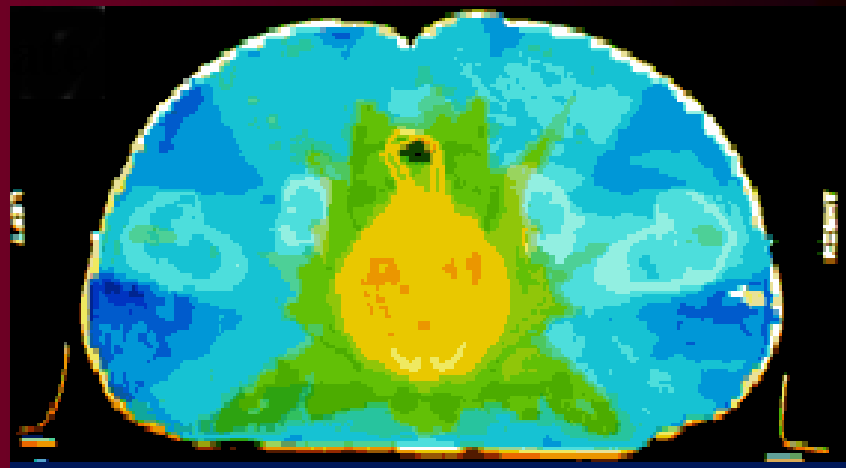
- IMRT is a type of external beam radiation therapy
- The beam is divided into thousands of tiny thin radiation beams allowing the beam to enter the body from many angles to intersect on the cancer.
- Allows a high dosage of radiation at the tumor and a lower dosage to the surrounding healthy tissue.
- Results in higher cancer control rate and a lower rate of side effects.

Standard vs. IMRT dose distribution

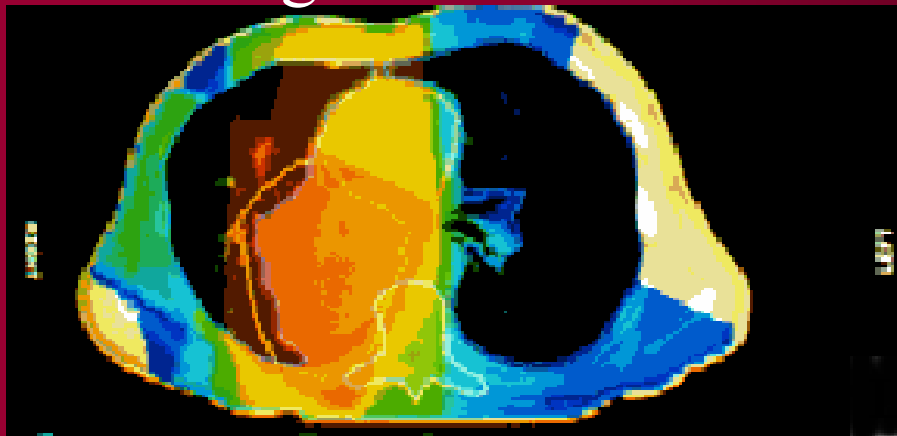
3-D prostate



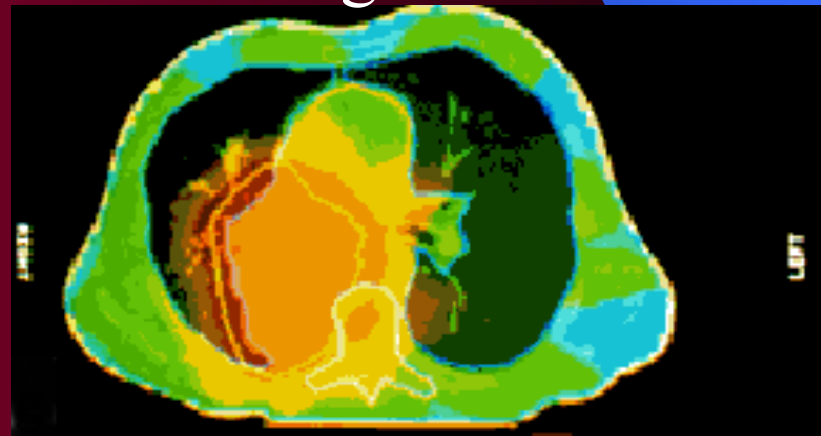
IMRT prostate



3-D Lung



IMRT Lung

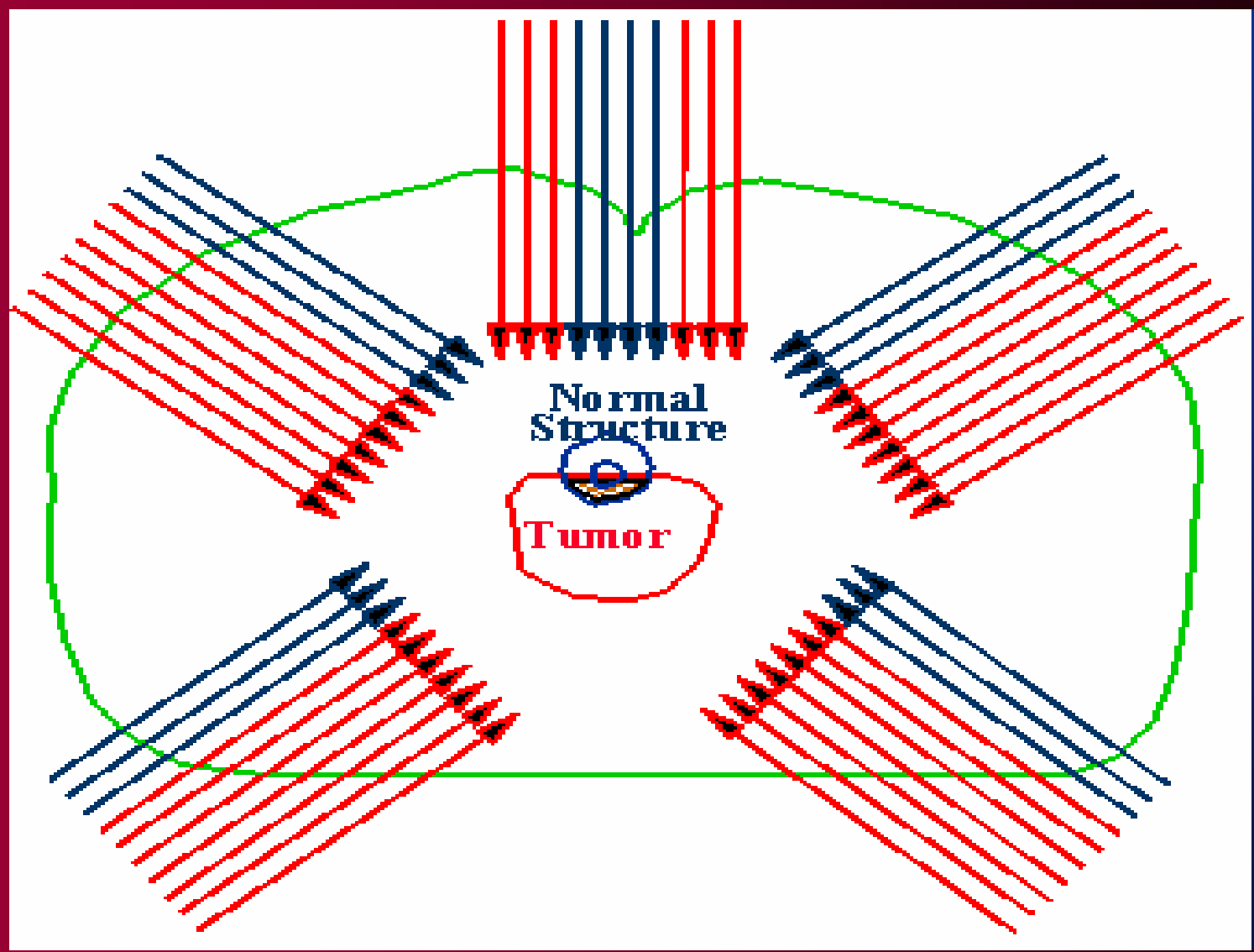


Much higher dose volume of normal tissue with standard XRT

Treatment Design/Optimization

- The physician
 - Identifies & manually circles all pertinent structures slice by slice on CT.
 - Determines the optimum number and direction of beams.
 - Determines the optimum dose parameters for each structure (normal tissue and tumor).
- Very sophisticated computer hardware & software summarizes the physician input noted above and presents the best plan.

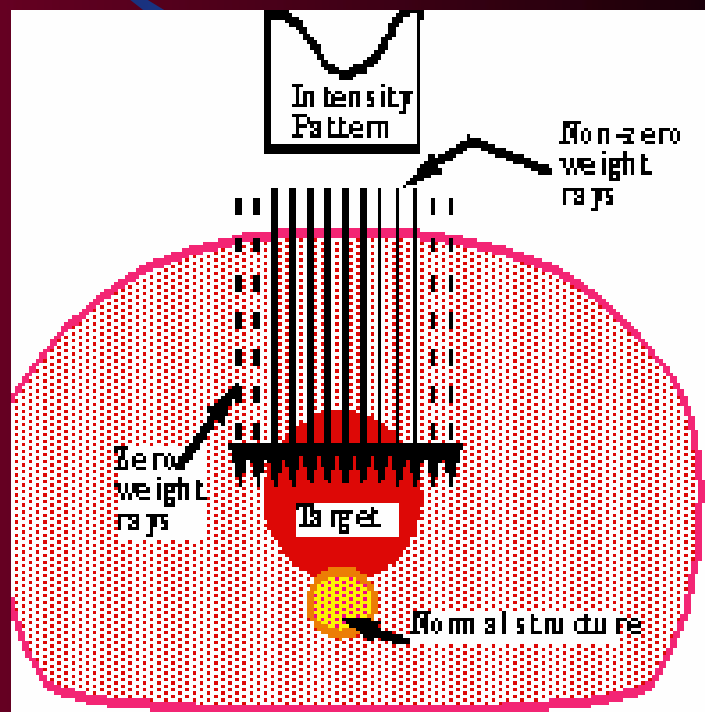
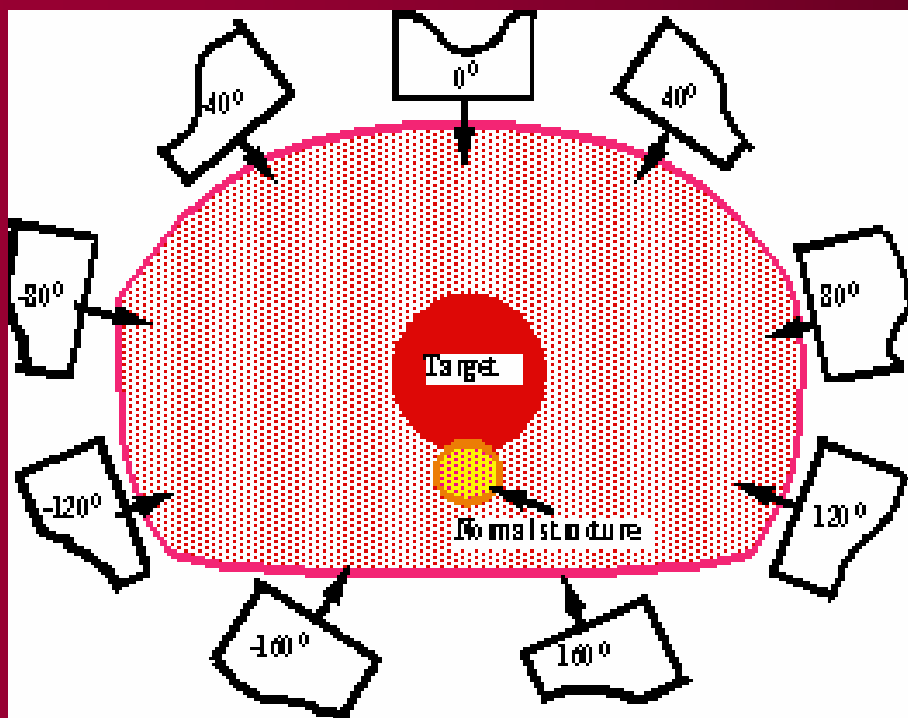
Optimization Process



Optimal Intensity Modulation

Sum of beamlets

One beamlet



Optimum assignment of non-uniform intensities to tiny subdivisions of beams

Number and Orientation of Beams

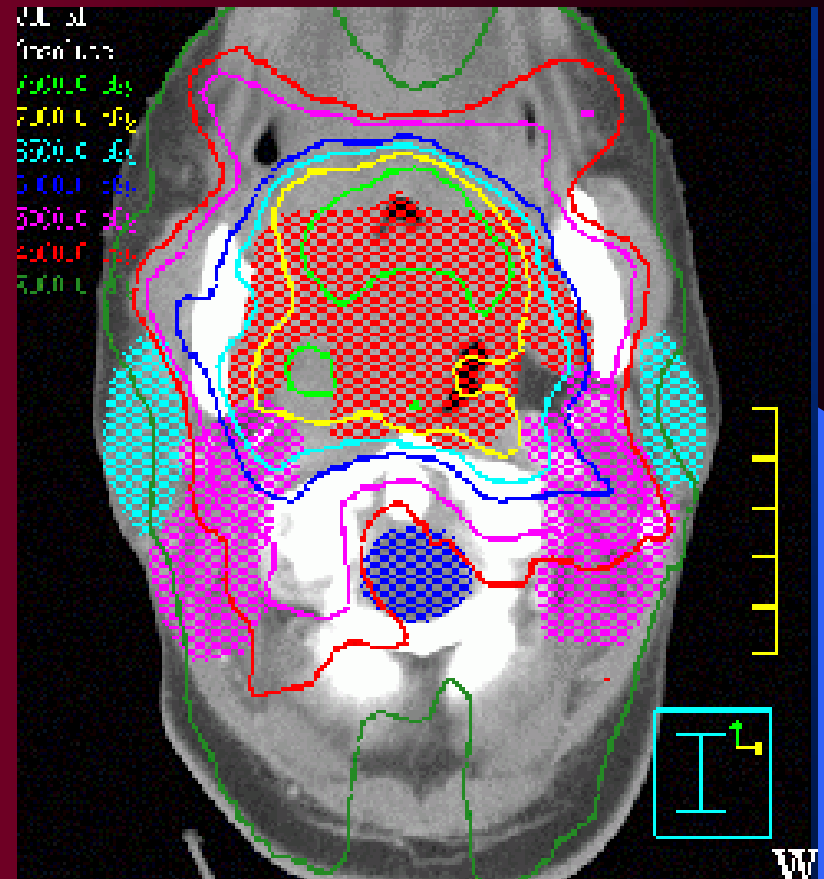
- Research has been done that shows typically 5 to 9 beams that are non coplanar are best.

(This means that the exit out the other side of the patient is not where another beam is entering.)

H&N 9 beam vs. 5 beam IMRT



9 beam



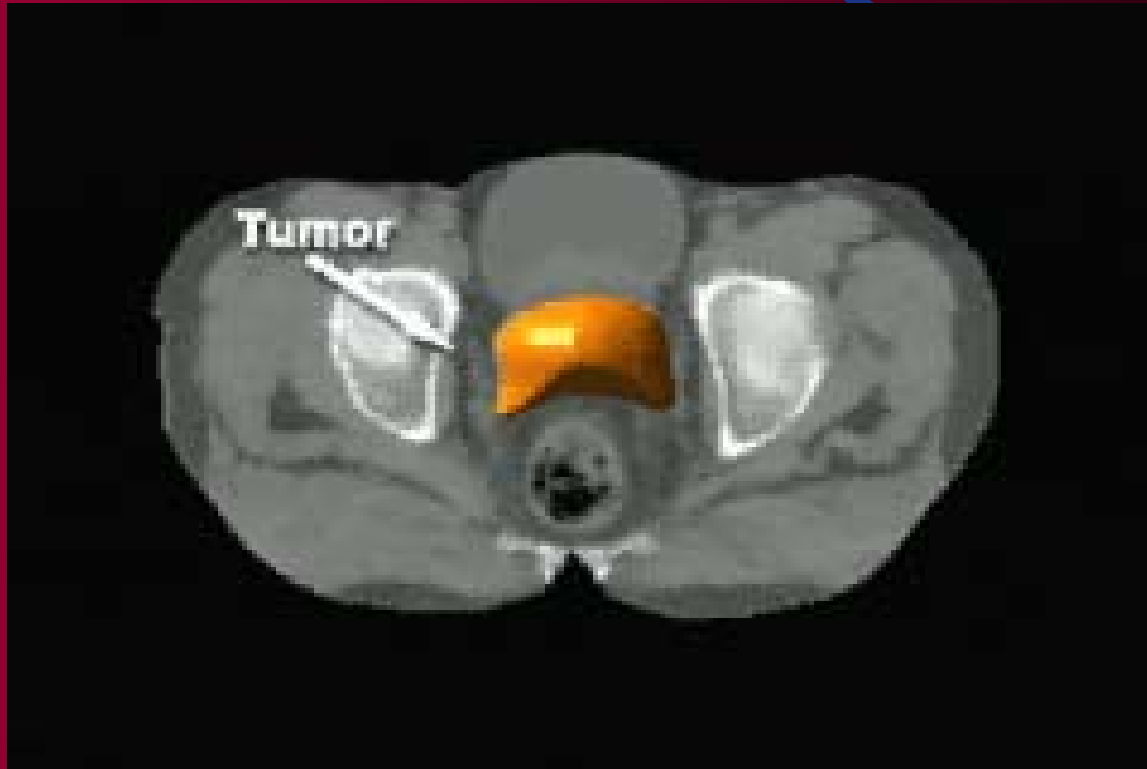
5 beam

The End Result

- Higher number of beams on tumor
- More homogeneous target dose
- Reduced margins around tumor
- Reduce normal tissue exposure and hence complications
- Allows higher total tumor dose without overdosing normal tissue, increasing chance of tumor control
- Eventual efficiency in planning and delivery
- Reduced cost of care as a result of less complications and more cures.

The next slide is a short video by
Varian Corp. showing how
IMRT works.

Video on how IMRT works



Critical Issue #1

Issue: Can we define tumor extent to 2mm margin vs. 2cm margin in standard XRT?

Resolution: Almost always no. CT scans never show microscopic tumor extension. Only a pathologist using a microscope can optimally define the location of the tumor. A tumor must be thought of as an octopus with microscopic tentacles that cannot be seen on a CT or MRI. A margin of “normal” tissue must be treated.

Critical Issue #2

Issue: Can we prevent internal & external body movement to safely use a 2mm margin around the tumor (If the tumor is shifted more than 2mm then the optimal dose may not reach the target.)?

Resolution: We cannot entirely prevent motion, but we can minimize it. We treat a margin outside of the precise tumor so if a shift occurs the radiation is still sent to it's target. We use skin markers, lasers and ultrasound to locate the tumor when positioning the patient for treatment.

Critical Issue # 3

Q: How much dose to normal tissue can a patient tolerate without permanent injury?

A: We know what will work most of the time. Every patient's normal tissue is different. We attempt to choose a dose that will typically have a 95 - 100% chance of not harming the patient.

Critical Issue #4

Q: How much dose do we need to kill the cancer?

A: We know what will work most of the time. Every tumor is different. We attempt to choose a dose that will typically have a 90% or better control rate. Unfortunately 90% is not possible on some tumors (glioblastoma, lung cancer)

Example

For the most favorable prostate cancers with PSA < 10, Gleason score of 6 or less and T2a or smaller tumor size, 74Gy typically gives about a 80% to 90% chance of controlling the cancer and a 1% to 2% chance of severe injury to the rectum or bladder. All of these numbers are discussed when a patient is consented for treatment.

The Art & Science of Medicine

Intelligent utilization of IMRT requires that the radiation oncologist be diligent:

- Must use adequate margins to assure adequate coverage of tumor
- Must secure patient to avoid excessive movements
- Must utilize known information to avoid overdose to normal tissue
- Must utilize known information to provide adequate dose to tumor

Treatment delivery

- Lay the patient down
- Line the patient up utilizing skin marks, lasers & ultrasound
- The computer does the rest in accordance with the approved plan
- Very different from older methods of delivering XRT that involved lifting heavy blocks and extensive user data entry for each treatment field. The heavy utilization of computer control has greatly reduced errors.

Conclusion

IMRT can be effective in improving cancer treatment outcomes by curing more patients and harming fewer patients as well as being a more efficient form of treatment than standard radiation treatment.

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