IMRT FOR BEGINNERS

PERSONAL VIEW AND TEACHING COURSE



WHAT... INTENSITY MODULATION

WE HAVE BEEN DOING IT FOR YEARS! SERIOUSLY?













SEGMENTS

















FORWARD PLANNED IMRT COMPENSATOR BASED

(C) NIKOLAY NEDEV

FORWARD PLANNED IMRT COMPENSATOR BASED



(C) NIKOLAY NEDEV

FORWARD PLANNED IMRT COMPENSATOR BASED



THAN WHAT IS NEW?

THE WAY WE GET THE INTENSITIES

INVERSE PLANNING

COMPLEXITY OF THE INTENSITY MAPS

INVERSE PLANNING

SPECIFY THE DOSE AIM

D PTV & ORGANS AT RISK

DVH PARAMETERS

TOTAL DOSE,

MINIMUM DOSE,

MAX DOSE

LET THE COMPUTER DO THE REST

DETERMINE THE BEAM ANGLES

THE MORE ANGLES THE GREATER THE CHANCE OF ACHIEVING A GOOD PLAN

MORE GENTRY ANGLES - LONGER DELIVERY TIME

USUALLY 3-5-7 EVENLY SPACED BEAMS

DO NOT USE OPPOSING BEAMS



72 DEGREES APART

DETERMINE THE INTENSITY LEVELS AND MIN FIELD SIZE

THE MORE INTENSITY LEVELS - THE BETTER IS THE CONFORMITY

SMALLER MIN. FIELD SIZE - BETTER CONFORMITY

LONGER TIME TO DELIVER THE TREATMENT



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DETERMINE THE INTENSITY LEVELS AND MIN FIELD SIZE

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WHAT DOES THE COMPUTER DO?

COVER THE PTV

] LIMIT THE DOSE TO OAR

LOCAL MINIMUM

U USING THE PRIORITY SYSTEM

DVH-REQUIREMENTS

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GLOBAL MINIMUM

GETTHE PRIORITIES RIGHT

TUMOR (GTV) NEEDS TO BE COVERED =1

CTV NEEDS TO BE COVERED =1

PTV NEEDS TO BE COVERED = 2

CORD/OPTIC NERVE DOSE < 50GY = 2

BOTH PAROTID VOLUME 50% 24GY = 3

 \Box SKIN = 10

DEAL WITH OVERLAPS

THE PROBLEM WITH OVERLAPS

$$CTV = 66GY$$

$$OPTIC NERVE = 54GY$$

$$OVERLAP AREA = 54-56 GY$$

$$OVERLAP COVERVE$$

COMMISSIONING OF IMPT PROGRAM

THE IMRT PROCESS



CONTOURING

ALL STRUCTURES OF INTEREST NEED TO BE OUTLINED

- O NOT CONTOURED STRUCTURES DO NOT EXIST FOR THE CALCULATION ALGORITHM
- GENERALLY MORE WORK THAN FOR STANDARD 3D-PLAN
- SLIGHTLY DIFFERENT OUTLINING LOGIC

STRICTLY REINFORCED GTV, CTV AND PTV DEFINITION

CONTOURING



MAKE CERTAIN THAT THE VOLUMES DO NOT PREDETERMINE THE PLAN

INVERSE PLANNING SINGLE BUTTON AFFAIR

SPECIFY THE DOSE AND LEAVE THE COMPUTER TO DO THE REST

U USUALLY A BIT MORE COMPLICATED PROCESS

DIFFERENT DOSE LEVELS FOR DIFFERENT PTV'S

TOLERANCE DOSES

ADHERING TO THE TRADITIONAL TOLERANCES GIVES POOR PLANS

SEGMENTATION - REALITY CHECK

UNSEGMENTED PLAN

INFINITE NUMBER OF SEGMENTS

INFINITE NUMBER OF DOSE INTENSITY LEVELS

SEGMENT OPTIMIZATION

PLAN ASSESSMENT

REVIEW OF UNSEGMENTED PLANS

WASTE OF TIME

LEARN TO LIVE WITH DOSE INHOMOGENEITY

DEPARTING FROM ICRU-50 PRINCIPLES

□ 95-107% VS 90-110%

DVH CAN ONLY BE ASSESSED IN THE CONTEXT OF THE PLAN

PLAN DELIVERY - STEP AND SHOOT



STEP AND SHOOT



3. MLC field Set-Up

DYNAMIC IMRT

- SLIDING WINDOW
- ONLY ON VARIAN MACHINES
- MORE DIFFICULT TO VERIFY
- REQUIRES
 - VERY PRECISE LEAF CALIBRATION
 - DOSERATE ON THE


IMRT VERIFICATION

NO REAL FIELDS TO VERIFY

USUALLY 2 ORTOGONAL IMAGES TO SEE THE ISOCENTER

] NOTHING TANGIBLE TO SEE

WE ARE USING SMALL FIELDS WITH UNPREDICTABLE DOSE DISTRIBUTION

ARE WE DOING IT BLINDLY?





WE CAN MEASURE DOSE

SQUARE PHANTOM

FILM FOR DOSIMETRY

I IONIZATION CHAMBER



THE IMRT APPROACH



- ABSOLUTE DOSIMETRY SPOT MEASUREMENT
- VERY SMALL SAMPLE OF DATA -VERY DEPENDANT ON POSITIONING.
- SMALL CHAMBER VOLUME -REQUIRE GOOD ELECTROMETERS & CABLES.
- FILM DOSIMETRY.

- HIGH RESOLUTION VERY LARGE DATA SAMPLE.
- DIFFICULT TO CALIBRATE

PLAN WITH PATIENT CONTOURS

SAMEPLAN ON SQUAREPHANTOM

DOSE FLUENCY MAP

COMPARE DOSE FLUENCY MAPS

DOSE FLUENCY MAPS

FROM THE PLANNING SYSTEM

MEASURED

COMPARING ISODOSES



STRAIGHT SUBTRACTION



GAMMA FUNCTION

DOSECOMPARISON

POSITION COMPARISON





LINAC COMMISSIONING

SMALL BEAM PROFILES

THE EDGE OF THE BEAM IS NOT SHARP WHEN THE SIZE IS SMALL

FOR REALLY SMALL BEAMS THE WHOLE BEAM IS PENUMBRA

OUTPUT FACTORS

DOSE BEYOND THE TREATMENT FIELD

> NOT A ISSUE FOR STANDARD PLANNING

SMALL LEAKAGE OF THE DOSE OUTSIDE OF THE FILED MULTIPLIED 120 (TYPICAL NUMBER OF SEGMENTS) LEADS TO SIGNIFICANT DOSE CHANGES

PLANNING SYSTEM COMMISSIONING



ALGORITHMS:

CLARKSON

CONVOLUTION

MONTE CARLO





ALGORITHMS ARE IMPORTANT



DEPTH





TONGUE AND GROOVE



TONGUE AND GROOVE



IMRT FOR PROSTATE CANCER

PROSTATE CANCER SEVERAL BASIC POSTULATES

DOSE ESCALATION IS IMPORTANT

PROSTATE IS A MOVING TARGET

IT NEEDS TO BE HIT WITH HIGH PRECISION EVERY DAY

DVH ASSESSMENT

SEMINAL VESICLES - TO TREAT OR NOT TO TREAT

DOSE ESCALATION IS IMPORTANT

M.D.ANDERSON FIGURES 78 VS.70GY





Prostate Cancer Dose Response				
	Pronounced Gains From <70 to 70 Gy In All Risk Groups			
	Risk Group	Gains From 70 to >75.6 Gy		
	Favorable	Pronounced?		
	Intermediate	Pronounced		
	High	Modest		

INTERNET EXCITEMENT

IMRT Prostate Treatment Plan



Note: Arrows showing prostate draped over the rectum, and how the isodose lines are curved to avoid the rectum.

UNIVERSITY OF NEBRASKA



VARIAN WEBSITE

THE PROSTATE IS A MOVING TARGET

THE PROSTATE IS A MOVING TARGET



THE PROSTATE IS A MOVING TARGET









MARGINS

MARGINS: 0.7CM LR 0.7CM SI 1.1CM AP*



(C) NIKOLAY NEDEV

*ANTOLAC AT AL, JROBP, 42:661, 1998

WHAT DOES THE IMRT DO?

WRAPS THE ISODOSES AROUND CRITICAL STRUCTURES





RECTAL SPARING





WHAT IS "RECTUM" AND HOW THE DEFINITION IS RELATED TO THE DVH



DVH IS A FORM OF STATISTICS



THE WAY AHEAD

MORE SOPHISTICATED PLANNING

GOOD ENOUGH)

] IMRT

WHEN SEMINAL VESICLES TO BE TREATED

DAILY VERIFICATION IS MORE IMPORTANT



DAILY VERIFICATION CONE BEAM RECONSTRUCTION

MEGAVOLTAGE CBR- SIEMENS	ORTHOVOLTAGE CBR- SIEMENS & VARIAN
NO EXTRA ATTACHMENTS	ADDITIONAL LOW
REMOVE THE FLATTENING FILTER	ENERGY SYSTEM
DOSEPER IMAGE ~8MU	DEFINITION LOWER DOSE PER
FLAT PANEL	IMAGE

DEPENDENT

HIGHER BED

FAN VS. CONE BEAM RECONSTRUCTION



DETECTORS





FAN VS. CONE BEAM RECONSTRUCTION



DETECTORS



DETECTORS

FAN VS. CONE BEAM RECONSTRUCTION



DETECTORS



DETECTORS

CONE BEAM USES CONE BEAM



- THIS IS VOLUME ACQUISITION
- ALL SLICES ARE OBTAINED IN ONE GO
- ACTUALLY SLICES DO NOT EXIST
- SINGLE GENTRY ROTATION
- 210 DEGREES (270-110)
- REMOVE THE FLATTENING FILTER
- SOFTEN THE BEAM

45 SECONDS AFFAIR
















CONE BEAM IMAGES ARE GOOD FOR PLANNING



GOOD CT DENSITY REPRESENTATION

D METAL HIPS ARE NOTA PROBLEM (PAIR PRODUCTION)

ONLY PROBLEM - NO PATIENTS CONTOUR (SMALL FIELD OF VIEW)































CONE BEAM IMAGE DOSE DISTRIBUTION

+



CONEBEAM



ORIGINAL PLAN



NO OPTIMIZATION



SIMPLE OPTIMIZATION

DOSE ESCALATION BY BEING MORE ACCURATE

- PROSTATE TUMORS STAY POSTERIORLY
- WE ARE MISSING THE TUMOR IN AT LEAST 10% OF THE CASES EVEN WITH 1CM POST MARGIN
- GEOGRAPHICAL MISS
- BY DAILY VERIFICATION AFFECTIVELY WE ARE INCREASING THE TUMOR DOSE WITH 10%
 - RECTAL DOSE WOULD BE THE SAME OR LOWER

IMRT FOR HEAD AND NECK CANCER

IMMOBILIZATION

HEAD REST
MASK
ORFIT
U VIVAC
U U-FRAME THICK TERMOPLASTIC
STEREOTACTIC TYPE IMMOBILIZATION
BITE BLOCK WITH HEAD FRAME

WHICH NODAL AREA TO BE COVERED

- SKIN PRIMARY VS OROPHARYNX PRIMARY
 - BILATERAL NECK IRRADIATION
 - U UVULA
 - BASE OF TONGUE
 - SUPRAGLOTTIS
- WHAT ABOUT LEVEL 6 NODES



THE CONTRALATERAL NECK NODES

SURGEONS

DISSECTION TO THE BASE OF SKULL

VERY DIFFICULT TO SPARE THE CONTRALATERAL PAROTID IF CONTRALATERAL CTV CONTOUR EXTENDS TO THE BASE OF SKULL

RETROSTYLOID SPACE

ABOVE: DIGASTRIC M. CROSSING THE CAROTID

INFERIOR BOARDER OF LAT PROCESSUS OF C1

THE SUPERIOR EXTENSION



THE SUPERIOR EXTENSION



THE SUPERIOR EXTENSION



THE RETROSTYLOID SPACE CONTOURING IMPLICATIONS



THE RETROSTYLOID SPACE CONTOURING IMPLICATIONS



THE RETROSTYLOID SPACE CONTOURING IMPLICATIONS



THE RETROSTYLOID SPACE CONTOURING IMPLICATIONS - 2



THE PRESCRIPTION

PHASE I, II, III TYPE PRESCRIPTION (FOGY IN 35 FRACTIONS, FWEEKS)

-] PTV1-50GY (5 WEEKS)
-] PTV2 EXTRA 10GY (EXTRA WEEK)
-] PTV3 EXTRA 10GY (EXTRA WEEK)

CONCURRENT PRESCRIPTION CONCURRENT PRESCRIPTION -DIFFERENTIAL (DOSE PAINTING)

- PTV1 56GY
-] PTV2 COVERED BY 115% ISODOSE (64.4GY IN 28#, 2.3GY/#, JUST UNDER 6 WEEKS)

ALL PHASES IN ONE GO



CONCURRENT BOOST IS A POWERFULTOOL

$$\frac{A/B + D}{A/B + 2}$$

66GY/30# = 2.2GY/#

A/B=3GY ID2=68.64 A/B=10GY ID2=67.10 A/B=5GY ID2=67.78

ESPECIALLY TAKING OVERALL TREATMENT TIME INTO ACCOUNT

$$A/B + D$$

 $ID2 = D - -0.7(T-28)$
 $A/B + 2$

FOR A/B = 540 DAYS ID2T = 59.48GY

70GY/35# 47 DAYS 1D27=58.69GY

ESPECIALLY TAKING OVERALL TREATMENT TIME INTO ACCOUNT

$$A/B + D$$

 $ID2 = D - -0.7(T-28)$
 $A/B + 2$

FOR A/B = 540 DAYS ID2T = 59.48GY

66GY/30=70-72GY/2GY#

THE PLAN



LIES, BIG LIES AND DVH DVH – HOW TO ASSESS THEM

RTOG HOO22

>95% OF THE VOLUME NEEDS TO RECEIVE THE PRESCRIBED DOSE

>99% NEED TO RECEIVE THE 90-93% OF THE PRESCRIBED DOSE

<20% SHOULD RECEIVE MORE THAN 110% OF THE PRESCRIBED DOSE



MELANOMA OF THE OCCIPITAL AREA WITH BILATERAL NODAL INVOLVEMENT





THE SAME CASE DIFFERENT VIEWS

5


IMRT FOR GYNAECOLOGICAL CANCERS

REDUCETOXICITY

	SMALLBOWEL
	SBO, MALABSORBTION, ENTERITIS
	RECTUM
	PROCTITIS, RECTAL BLEEDING
	BONEMARROW
	BONE MARROW SUPPRESSION, ESP WITH CHEMO
	PELVICBONES
	FRACTURES
	ESCALATE DOSE IN THE HIGH RISK AREAS
	D PARAMETRIUM, NODAL DISEASE
	ALTERNATIVE OR REPLACEMENT OF BRACHYTHERAPY FOR CA CERVIX



MUNDT ET AL., INT J RADIAT ONC BIOL PHYS, 2003 AUGUST 1; 54 (5): 1354-1360 BRIXEY ET AL., INT J RADIAT ONCOL BIOL PHYS. 2002 DEC 1;54(5):1388-96.

























THE PLANS





SMALL BOWEL SPARING

RECTUM AND BLADDER SPARING

THE PLANS -2





GYNAE IMPT IS ONE OF THE MOST PROMISING AREAS FOR IMPT PLANNING

THE USE OF MORE CONFORMAL PLANS WILL PRODUCE VERY QUICKLY VERY NOTICEABLE DIFFERENCES

THE TRIAL ON SUBSTITUTING OF BRACHYTHERAPY WITH IMRTARE UNDERWAY

CONCLUSIONS MYTHS ABOUT IMRT

- IMRT IS COMPLETELY DIFFERENT FROM EVERYTHING WE'VE DONE BY NOW
- IMRT IS VERY EXPENSIVE
 -] IMRT IS VERY SLOW PLANNING AND TREATMENT
- ACUTE EFFECTS DOES NOT MATTER, IF THERE IS NO REDUCTION OF XEROSTOMIA, NO POINT OF IMRT

IMRT CAN BE DONE BY SINGLE PERSON

IMRTFOR BREAST CANCER

EVERYBODY BENEFIT FROM BETTER PLANNING

3D CONFORMAL TREATMENT IS BETTER THAN SIMULATED TANGENTS

BETTER DOSE UNIFORMITY

THE SIDE EFFECTS ARE DEPENDENT ON CERTAIN AREAS RECEIVING MUCH HIGHER DOSES

ADVANTAGES WHEN IM NODES ARE IRRADIATED

DOTENTIAL ROLE FOR PARTIAL BREAST RADIOTHERAPY

PROBLEMS WITH BREAST RADIOTHERAPY

THE BREAST IS EVEN MORE "MOVING TARGET" THAN THE PROSTATE



THE BREAST HOLD TECHNIQUE IS PROBABLY MORE IMPORTANT IS SPARING THE LUNG AND HEART

BREAST IMRT - SUMMATY

- MULTISEGMENT TANGENTS IS PROBABLY EVERYTHING ONE NEEDS
- FULL MULTIANGLE IMPRT IS POSSIBLE
- SOME POTENTIAL PROBLEMS WITH DOSE IN BUILD UP REGION
- MOST OF THE BENEFIT WILL COME FROM BREATH HOLDING TECHNIQUES
- THEJURY IS STILL OUT:
 - "LESS IS MORE" (PARTIAL BREAST RADIOTHERAPY)
 - "MORE IS MORE" (COMPREHENSIVE CHEST