IMRT FOR TREATMENT OF THE INTACT BREAST WITH RADIATION THERAPY

Use Of An Inverse-Planned,
Direct Aperture Optimization (DAO) Approach

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Why IMRT For Intact Breast?

- Two **prospective randomized Phase III** trials have demonstrated clinical benefit.
- This is two more randomized studies than have shown a clinical benefit for IMRT for all other treatment sites cumulatively!
- One trial was performed in Canada and the other was performed in the United Kingdom. IMRT is not reimbursed in either country! So . . .
- Even if you don't get paid for it, it's still better and . . .
- You can do breast IMRT better than it was done on those trials, and . . .
- It's easy!

What Are The Clinical Benefits?

1. IMRT significantly decreased the risk of developing moist desquamation during RT (from 48% to 31%; p = 0.002). (Pignol *et al*, JCO, 26(13): 5/1/08)
2. IMRT significantly increases the likelihood that the treated breast will demonstrate **no** change in appearance 5 years after RT (from 42% to 60%; p = 0.008). (Donovan *et al*, Radiother Oncol, 82(3): pp, 254-64, 2007)
3. IMRT significantly decreased the likelihood that the irradiated breast developed palpable induration 5 years after RT (from 61% to 37%; p < 0.001). (Donovan *et al*, 2007)

Why Does IMRT Result in Superior Outcomes?

- SUPERIOR DOSIMETRY!
- In Donovan *et al*, larger V105 volumes correlated with higher rates of
  - Inferior cosmetic outcome and
  - Development of induration within the treated breast
- Two V105 thresholds were predictive of inferior outcome:
  - V105 > 1% of PTV
  - A hot spot (i.e. one area) exceeding 105% of Rx dose that was larger than the ICRU 50 definition of a clinically significant hot spot (which is a 15 mm diameter volume which = 1.76 cc)

What Is The Ideal Beam Arrangement For Breast IMRT?

- TANGENTS! (with co-planar deep border)
- Why?
- Less scattered dose to the opposite breast and ipsilateral lung.

Why Is 'Tangents' The Ideal Beam Arrangement For Breast IMRT?

- LESS SCATTERED DOSE!
- Using multiple (4 or 6) non-coplanar beams increases scatter dose, esp. to the opposite breast and ipsilateral lung. (Landau *et al*, RO, 60(3): 247-55, 2001)
- Relative to non-IMRT tangent techniques, IMRT with tangents has been shown to decrease scattered dose:
  - to the **opposite breast** in all **5 studies** that examined the issue.
  - to the **ipsilateral lung** in all **7 studies** that examined the issue.

Does Scattered Dose Really Matter?

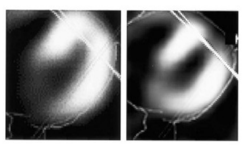
- The Early Breast Cancer Trialists' Collaborative Group (EBCTCG) performed a meta-analysis of 63 randomized trials involving 32,793 women.
- RT was associated with
  - a 1.8% excess risk of developing contra-lateral breast cancer at 15 years.
  - a 0.43% excess risk of dying from a second malignancy at 15 years.
  - NOTE: Older techniques used in most studies.
- YES, Virginia, just like Santa Claus, scattered dose does exist and it matters!

Does irradiating the heart matter?

- YES!
- In the EBCTCG study, left breast cancer patients receiving radiation had an ~1.72% excess risk of cardiac mortality at 15 years.
- Long-term observational studies from 3 populations (Sweden, United States, and Ontario, Canada) have all demonstrated an increased cardiovascular death rate among left-breast cancer patients that received adjuvant RT.

Does irradiating the heart matter?

- More recent data has shown that 'modern' techniques that result in incidental cardiac irradiation cause perfusion defects, wall motion abnormalities, declines in LV ejection fraction, and episodes of chest pain (likely pericarditis).



Pre-RT (a) Post-RT (b)

Fig. 1. Representative axial images pre-radiation therapy (RT) (a) and post-RT (b) cardiac single-photon emission computed tomography scans. The deep tangent border is shown as the solid line. A new perfusion defect in the anterior left ventricle after radiation is seen.

Marks *et al*, IJROBP, 63(1):214-23, 2005.

Does IMRT spare the heart?

- NOT WITH TANGENT FIELDS!
- With tangent fields, you cannot spare the heart any more with IMRT than you can by using a heart block.
- Again, you don't want to use non-tangential fields because of an increase in scattered dose.

What is the best way to spare the heart if target coverage is compromised by a heart block?

- modified Deep Inspiration Breath Hold (mDIBH)
- Patient is treated while holding their breath.
- Requires special monitoring.
- Inspiration increases the separation between the heart and the left breast/chest wall
- Allows tangents to be used (which minimizes scattered dose)

So, we're going to use tangents and IMRT . . . the next question is:

What's the best way to do IMRT?

And the answer is:

Inverse Planning Using DAO

What is DAO and why should we use it?

- With tangent beams, what does IMRT actually do?
  - Wedge acts as '1D Compensator'
  - IMRT acts as '2D Compensator'
  - IMRT cannot overcome physics of attenuation so if beam energy is too low for a given patient separation, can still get hot spots out laterally but should never see hot spots near nipple
  - Attenuation is function of separation and tissue density (i.e. mix of soft tissue and lung at deep border)

What is DAO and why should we use it?

- IMRT can modulate the beam to account for patient anatomy (2D compensator), but cannot eliminate hot spots if separation in too large for beam energy (i.e. need higher beam energy).
- With forward planning, first the apertures are created and then their weighting is somewhat optimized.
- With DAO, the computer simultaneously optimizes the aperture shape and dose delivered through each aperture (& creates perfect compensator).
- In theory, DAO therefore should give better plans.
- However . . .

Willard Duncan Vandiver

In a speech at a Naval banquet in 1899 said,

"I come from a state that raises corn and cotton and cockleburs and Democrats, and frothy eloquence neither convinces me nor satisfies me. I am from Missouri. You have got to show me."

Why Inverse-Planned With DAO?

Results: Forward-Planned

Institution & Author	# pts	Median V95 ± SD (range)	Median V105 ± SD (range)
William Beaumont Vicini *et al* 2002	95	Recommend 90% isodose line covers PTV	11.1% (0% - 67.6%)
Canadian Randomized Trial, Pignol *et al* 2008	170	Not Given	7.7%
ROC Hybrid Technique 2007	70	98.0% ± 6.2%	5.7% ± 16.1% (0% - 63.3%)

Why Inverse-Planned With DAO?

Results: Inverse-Planned with DAO

Institution & Author	# pts	Median V95 ± SD (range)	Median V105 ± SD (range)
NKI Van Asselen et al 2006	12	99.4% ± 0.4%	0.1% ± 0.3%
ROC – Logsdon 2007	70	99.1% ± 0.9%	0.1% ± 0.3%
ROC Dosimetrists 2007	71	98.7% ± 1.4%	0.3% ± 0.5% (1 case > 2%)
ROC-Hybrid Technique '07 (for comparison)	70	98.0% ± 6.2%	5.7% ± 16.1% (0% - 63.3%)

Why Inverse-Planned With DAO?

- The short answer is . . . BETTER PLANS.
- Additional Benefits
  1. DAO also results in even lower scattered dose than does forward-planned IMRT.
  2. DAO is faster and easier than forward planning **<u>for the dosimetrists</u>**.

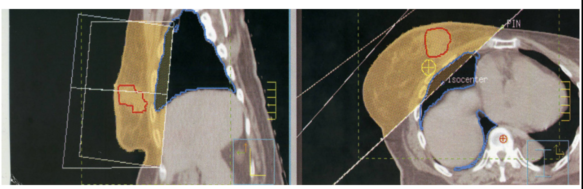
Definition of PTV

- There is not a single universally accepted definition of PTV.
- We use the William Beaumont definition, which has been incorporated into the NSABP B-39 trial.
- ‘Irradiated Volume’ = all of the tissue encompassed by the edges of both tangent beams, excluding any tissue that is ‘deep’ to the deep edge of the chest wall (i.e. excluding lung, heart, liver)
- PTV = ‘Irradiated Volume’ contracted by 5 mm in all directions

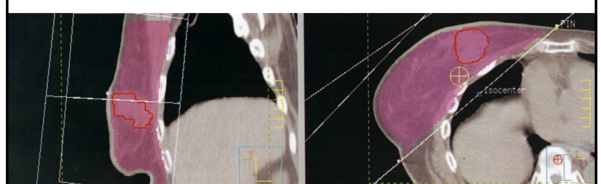
DAO Step-By-Step

1. Tangent beams are placed.
2. Dosimetrist auto-contours lung and contours heart (up to the deep edge of the chest wall).
3. Physician approves above and contours lumpectomy cavity.
4. Dosimetrist creates ROI’s.

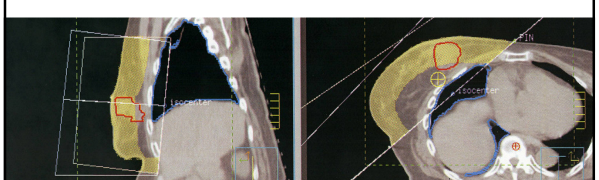
Tangent Volume



PTV



Constraint Volume



DAO Step-By-Step

5. 80% of dose given through open beams.
6. Beam energy (or mix of beam energies) determined by separation

Separation	Suggested Starting % 15 – 20 MV	Range Used	Suggested % to Change Between Trials
≤ 20.5 cm	0	0	0
20.6–23.0	0	0 – 30	10
23.1-27 cm	40	20 – 100	20
> 27 cm	100	100	20

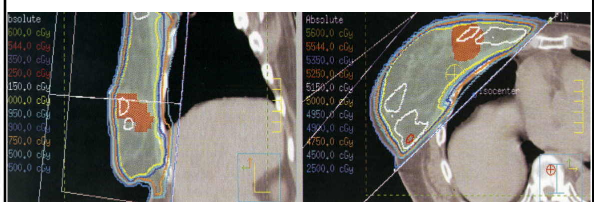
Objectives

ROI	TYPE	DOSE	WEIGHT
PTV	Uniform Dose	PTV Rx	5
PTV	Min Dose	PTV Rx	1
PTV	Min Dose	95% PTV Rx	1
Tangent Vol	Max Dose	105% PTV Rx	Constraint
Constraint Vol	Max Dose	103% PTV Rx	Constraint
Lung	Max Dose	95% PTV Rx	1
Heart	Max Dose	95% PTV Rx	1

Goals

Structure / Parameter	ROC GOAL
PTV	
V90	≥ 99%
V95	≥ 95%
V105	≤ 1% or 1 cc
Lung V 20 Gy	< 15%
Heart V50	≤ 1 cc

Example – Differentially Dosed



QUESTIONS?