Lessons Learned & Implementation Challenges of a SGRT DIBH Breast Program

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Disclosures

- I receive royalties from the University of Chicago for software licensed for computer aided detection of breast cancer.
- I am co-Chair of TG-302: Surface Image Guided RT.

Outline

1. Overview of SGRT for DIBH in breast cancer
2. Issues to consider when implementing SI
3. Clinical challenges for DIBH with SI

1. Overview of SGRT for DIBH

» Clinical Rationale

The NEW ENGLAND JOURNAL of MEDICINE

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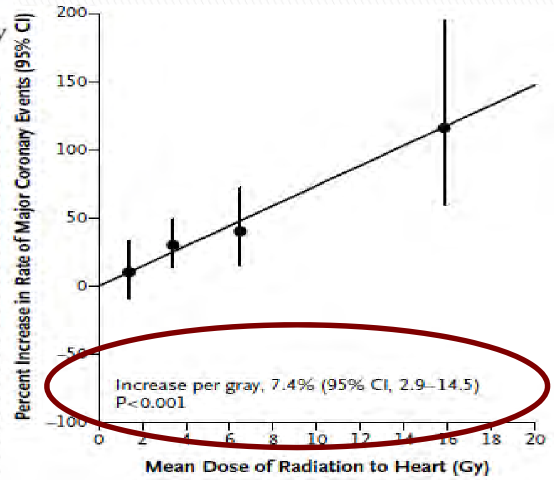
Risk of Ischemic Heart Disease in Women after Radiotherapy for Breast Cancer

- Population-based study in Sweden & Denmark
- Breast RT from 1958-2001:
  - 963 major coronary events
  - 1205 controls
- Heart dose estimated:
  - "CT scan of a woman with typical anatomy"



NSABP B-51 Sets De Facto Standard

Ipsilateral lung:

- **Arm 1/Group 1A:**
  - ≤ 15% of the ipsilateral lung should receive ≥ 20 Gy
  - ≤ 35% of the ipsilateral lung should receive ≥ 10 Gy
  - ≤ 50% of the ipsilateral lung should receive ≥ 5 Gy
- **Arm 2/Groups 2A and 2B:**
  - ≤ 30% of the ipsilateral lung should receive ≥ 20 Gy
  - ≤ 50% of the ipsilateral lung should receive ≥ 10 Gy
  - ≤ 65% of the ipsilateral lung should receive ≥ 5 Gy

Contralateral lung:

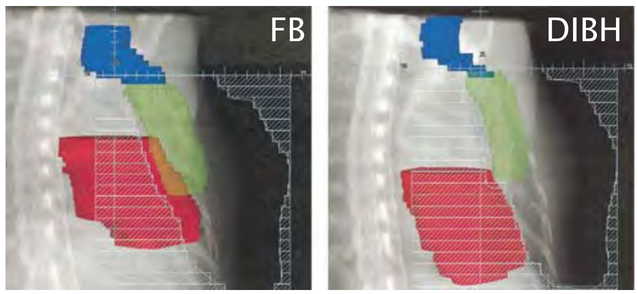
- ≤ 10% of the contralateral lung should receive ≥ 5 Gy

Heart:

- **Arm 1/Group 1A**
  - ≤ 5% of the whole heart should receive ≥ 20 Gy for left-sided breast cancers, and 0% of the heart should receive ≥ 20 Gy for right-sided breast cancers
  - ≤ 30% of the whole heart should receive ≥ 10 Gy for left-sided breast cancers, and ≤ 10% of the heart should receive ≥ 10 Gy for right-sided breast cancers
  - Mean heart dose should be ≤ 400 cGy
- **Arm 2/Groups 2A and 2B**
  - ≤ 5% of the whole heart should receive ≥ 25 Gy for left-sided breast cancers, and 0% of the heart should receive ≥ 25 Gy for right-sided breast cancers
  - ≤ 30% of the whole heart should receive ≥ 15 Gy for left-sided breast cancers, and ≤ 10% of the heart should receive ≥ 15 Gy for right-sided breast cancers
  - Mean heart dose should be ≤ 400 cGy

Advantages of DIBH

- Freeze organ/tumor motion
- Separate heart from target (breast, IMN)
- Increase total lung volume



Remouchamps et al, *IJROBP*, 55(2): 392–406, 2003.

1. Overview of SGRT for DIBH

» DIBH Techniques

Active Breathing Control (ABC) with Spirometer at William Beaumont

- Largest U.S. institutional experience:
  - 87 patients with ≤T2 disease
  - 50% treated with simple tangents only (FIF)
  - Median dose of 46Gy + 16Gy boost
- Compared to free-breathing (FB), moderate DIBH significantly *decreased*:
  - Mean heart dose (4.23Gy vs. 2.54Gy)
  - Mean left lung dose (9.08Gy vs. 7.86Gy)
  - All dosimetric parameters (V5, V10, V15, V20) for lung/heart

Swanson et al, *Am J Clin Oncol.* ,36(1): 24–30, 2013.

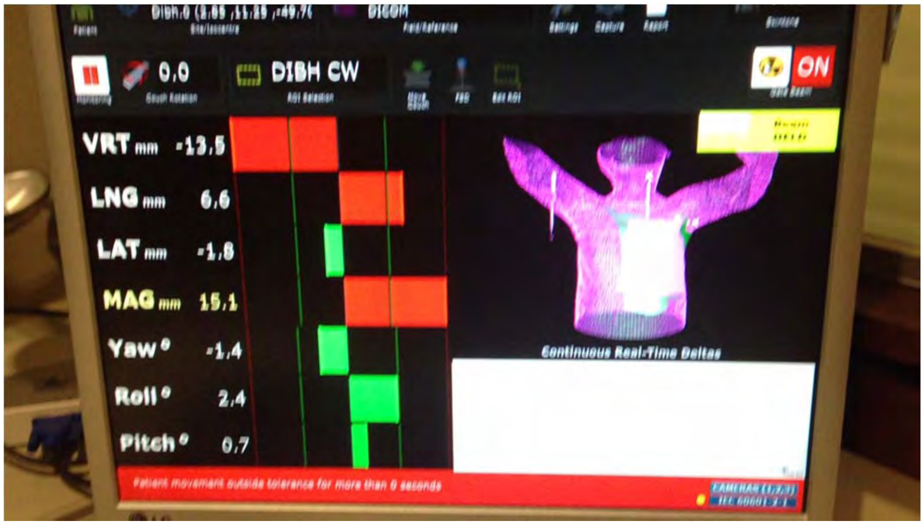
Voluntary Breath Hold vs. ABC

- 23 patients receiving 40 Gy in 15 fractions:
  - Randomized to v_DIBH or ABC_DIBH for 7 fractions & vice versa
  - Daily portal imaging & CBCT for 6 fractions
- No significant Δ: setup errors, normal tissue doses
- *Patients & therapists significantly preferred v_DIBH!*

Free breathing v_DIBH ABC_DIBH

Bartlett et al, *Radiother Oncol*, 108 :242–247, 2013.

WBRT DIBH: INTRA-FRACTION MONITORING



Breast/Chest Wall Surface vs. ABC

TABLE 4 Intra-DIBH stability and intrafraction reproducibility from 31 left-sided patients in this analysis compared to those of spirometry-based results from seven patients as reported on in Fassi et al.

	Intra-DIBH variability (mm)			Intrafraction reproducibility (mm)		
	A/P	S/I	R/L	A/P	S/I	R/L
Fassi et al. (*n* = 7) Surface monitoring + spirometry	1.37	1.78	0.74	2.16	2.30	1.88
This analysis (*n* = 31) SI + voluntary DIBH	0.66	0.58	0.49	2.17	1.98	1.52
% within 2 mm	72.1	76.3	84.6	–	–	–
% within 3 mm	98.2	98.8	99.6	74.6	76.0	88.4
% within 4 mm	99.4	99.6	100.0	88.1	89.5	95.7
% within 5 mm	–	–	–	94.9	96.5	98.2
% within 7 mm	–	–	–	99.2	99.5	99.6

Xiao, et al, *JACMP*, 19(4):205-213, 2018.

2. Issues to Consider

Patient Selection

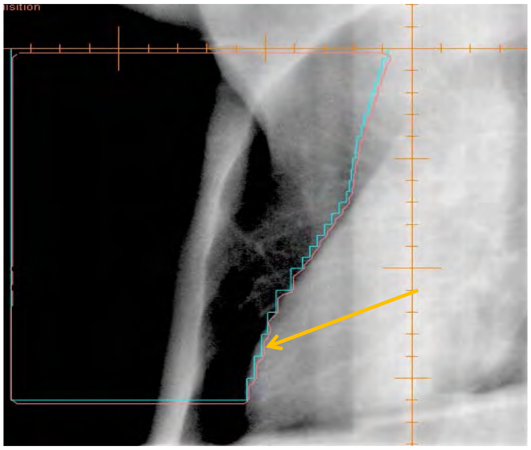
Patient Selection for voluntary DIBH

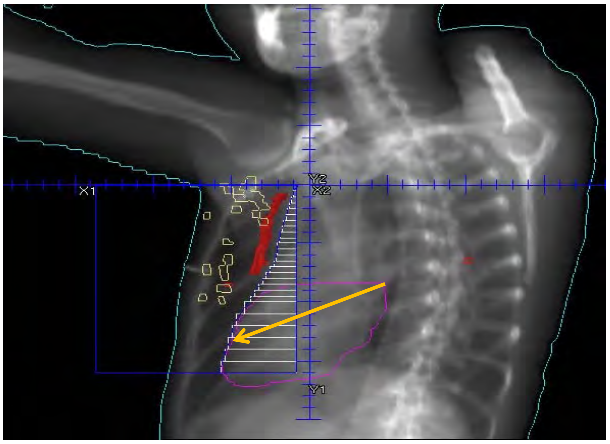
- Compliance
- Reproducibility of BH
- Breast size or pendulous shape
- Dosimetric threshold?

2. Issues to Consider

- Reconciling SGRT results vs other-IGRT modalities

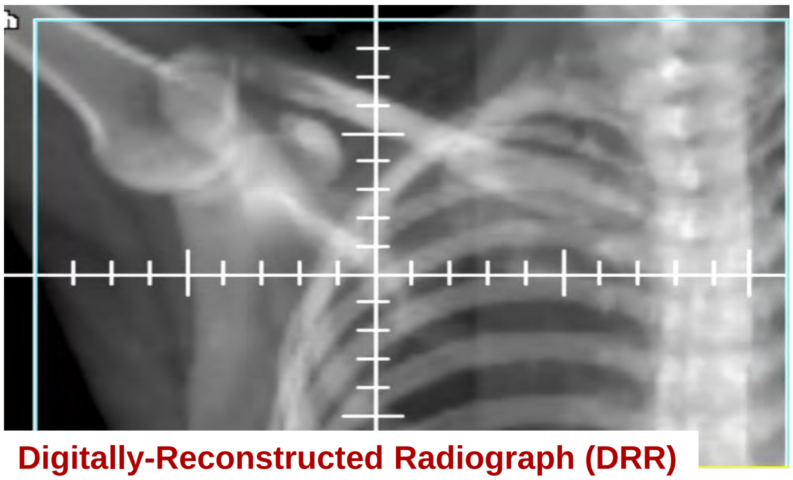
Verification of Heart Position: MV portal





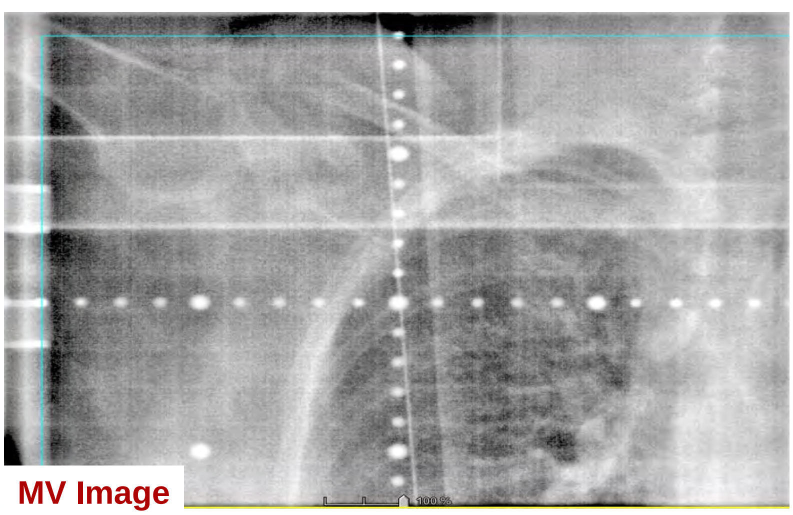
Mean heart dose reduced from 4.8Gy (FB) to 1.2Gy (vDIBH)

Verification with Weekly MV Imaging



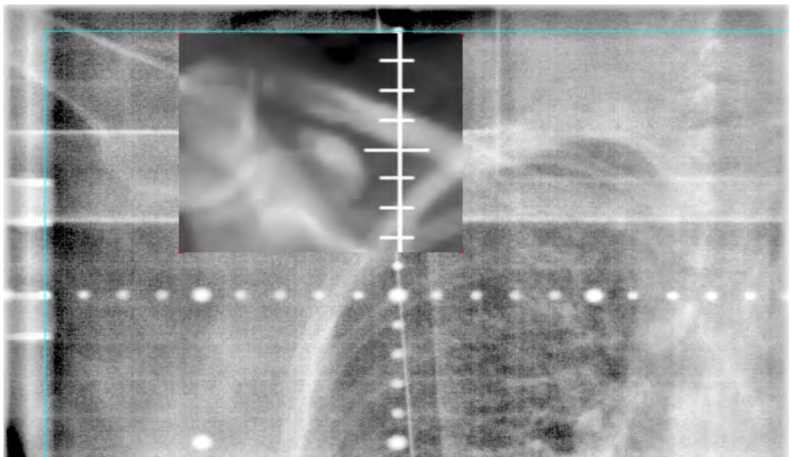
Digitally-Reconstructed Radiograph (DRR)

Verification with Weekly MV Imaging



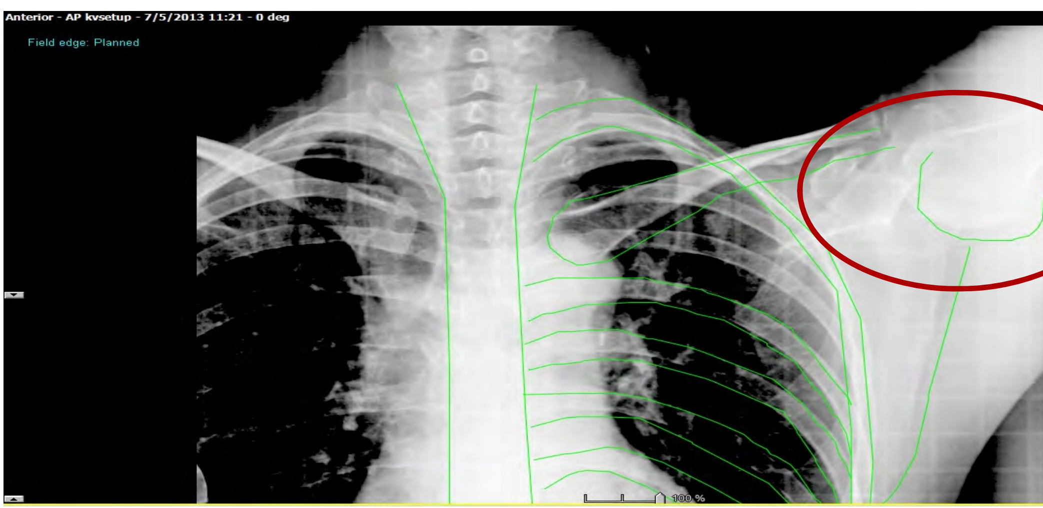
MV Image

Verification with Weekly MV Imaging



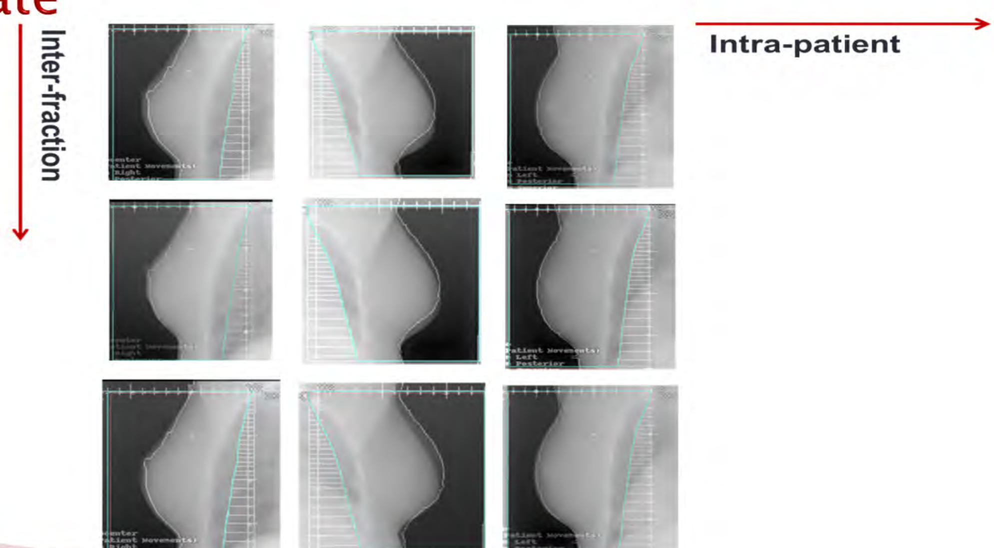
Landmark Matching of DRR & MV Image

Following Adoption of kV Imaging



kV Orthogonal Films

Breast Surface & Bony Anatomy Do Not Always Correlate



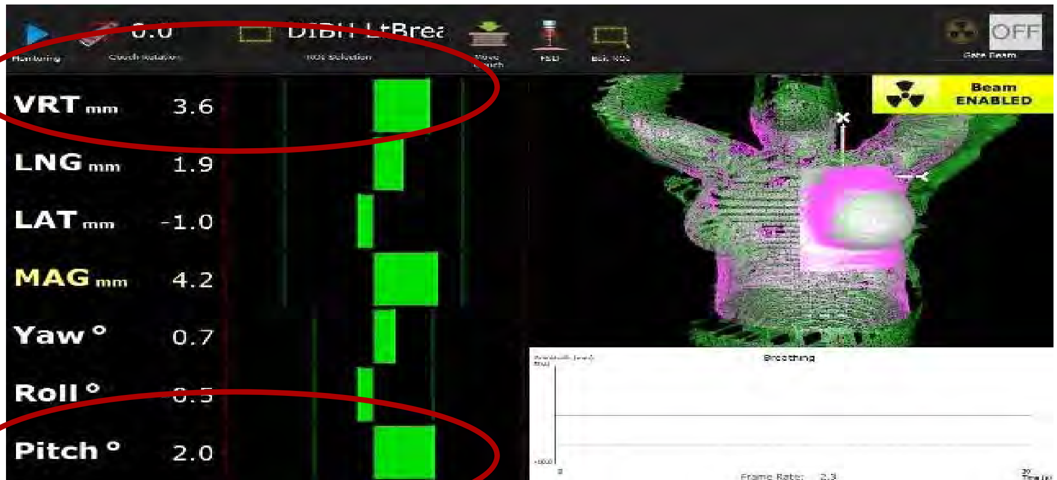
Padilla et al, JACMP 15: 4921, 2014.

2. Issues to Consider

- Learning Curve for SGRT

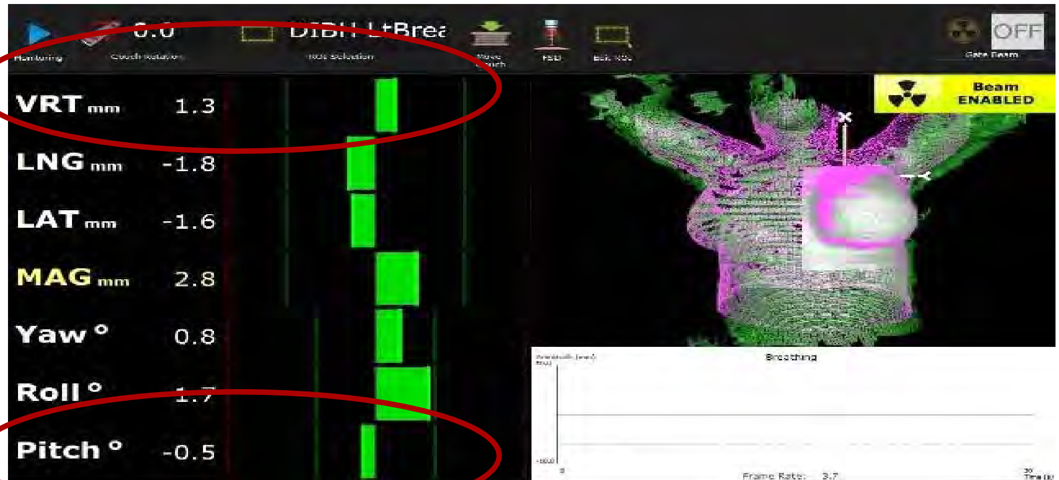
WBRT Example: Setup Variability Day 7

WBRT Example:
AlignRT Detects ↑ Pitch & VRT on Day 7



WBRT Example:
Setup Variability Day 8

WBRT Example:
AlignRT No Pitch or VRT on Day 8



2. Issues to Consider

- Field Matching

Field matching

- SI accuracy better at isocenter (Wiersma et al 2013), which coincides with the matchline for plans in which tangential and supraclavicular fields have a common isocenter
- Kügele et al showed that DIBH isocenter reproducibility with SI was better for patients with tangential and supraclavicular fields compared to those with tangential fields only, possibly due to the isocenter placement at the matchline rather than in deformable breast tissue
- Xiao et al found significantly smaller setup errors in CC direction for 3-field vs 2-field DIBH treatments

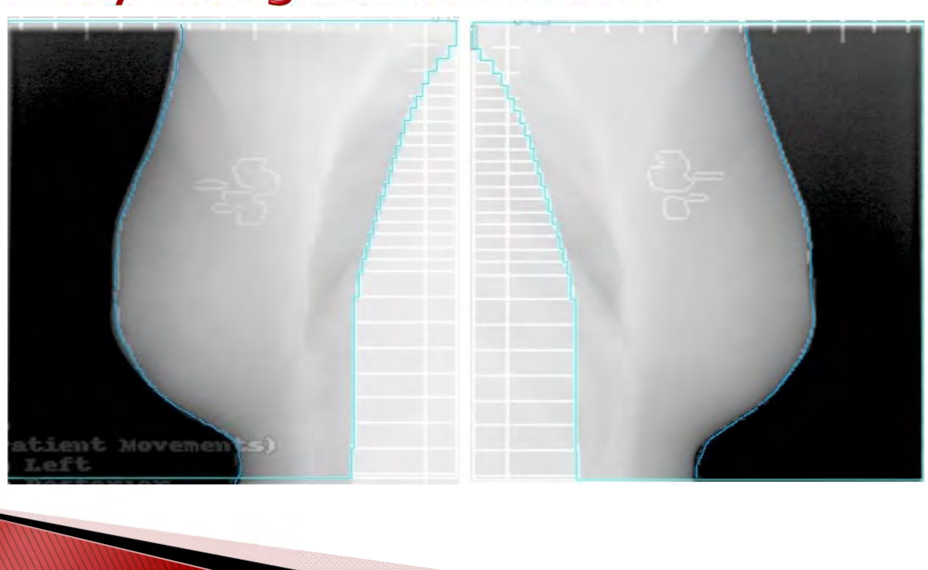
Kügele et al, *JACMP*, 19(1):25-38, 2017.
Xiao, et al, *JACMP*, 19(4):205-213, 2018.

3. Clinical Challenges of DIBH

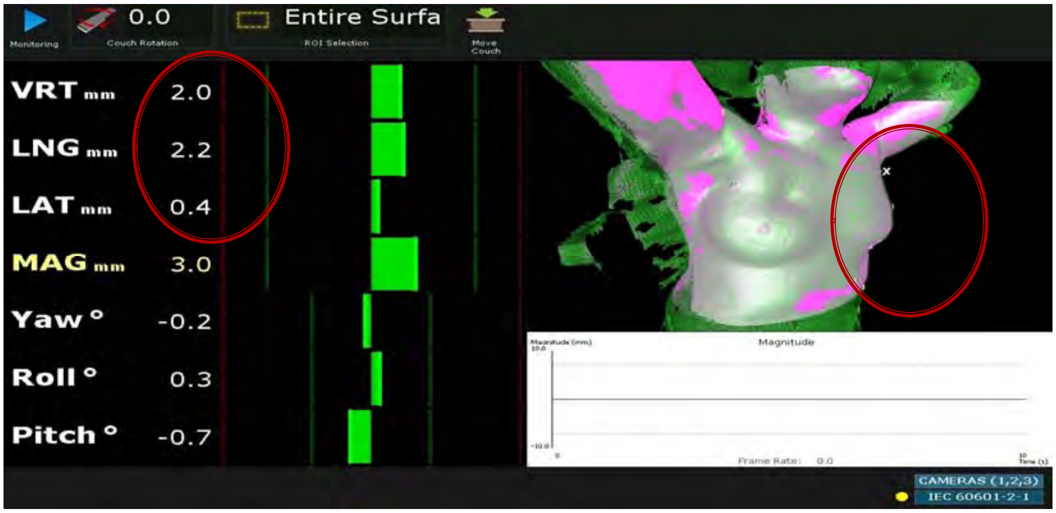
» Anatomic Changes

WBRT Example:
First Day Orthogonal kV Films

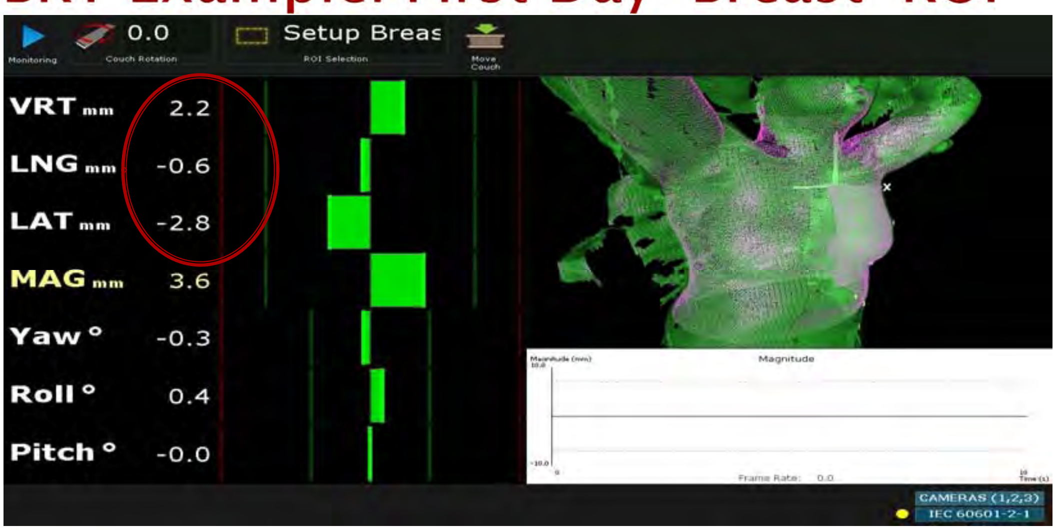
WBRT Example:
First Day Tangent MV Films



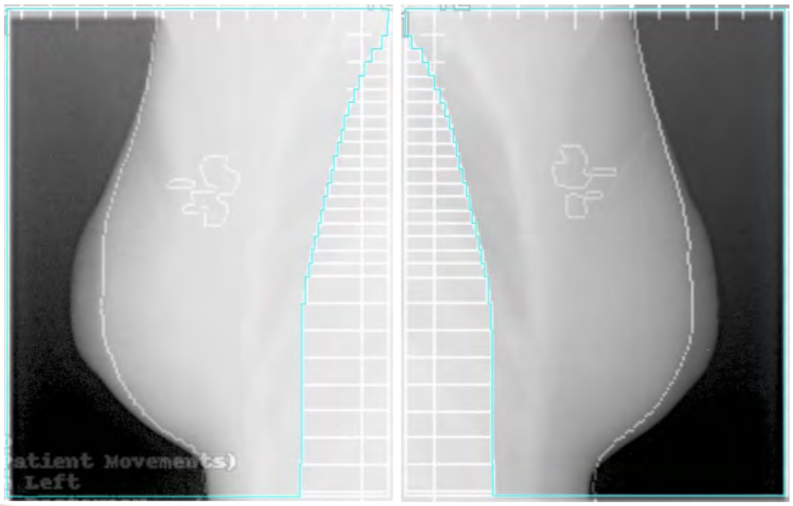
WBRT Example: First Day 'Entire' ROI



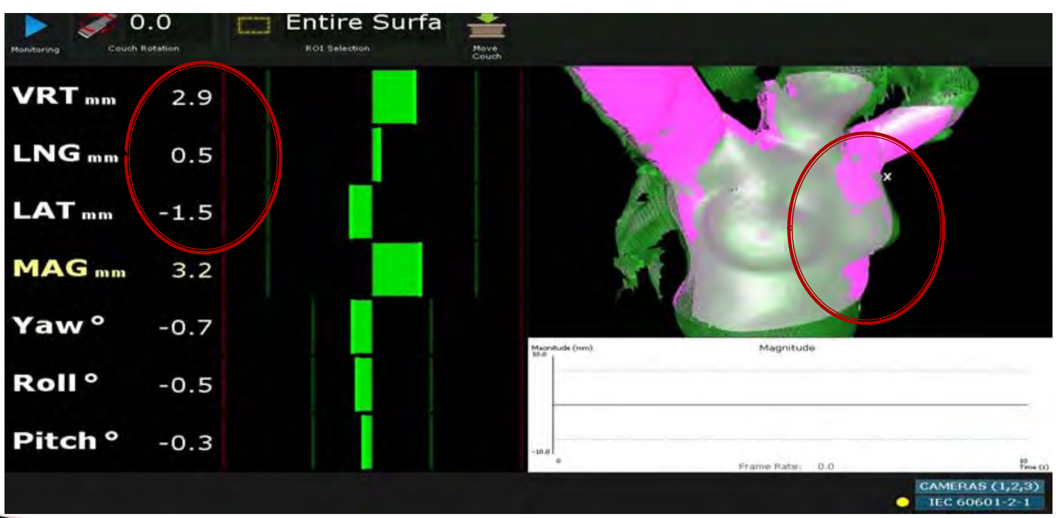
WBRT Example: First Day 'Breast' ROI



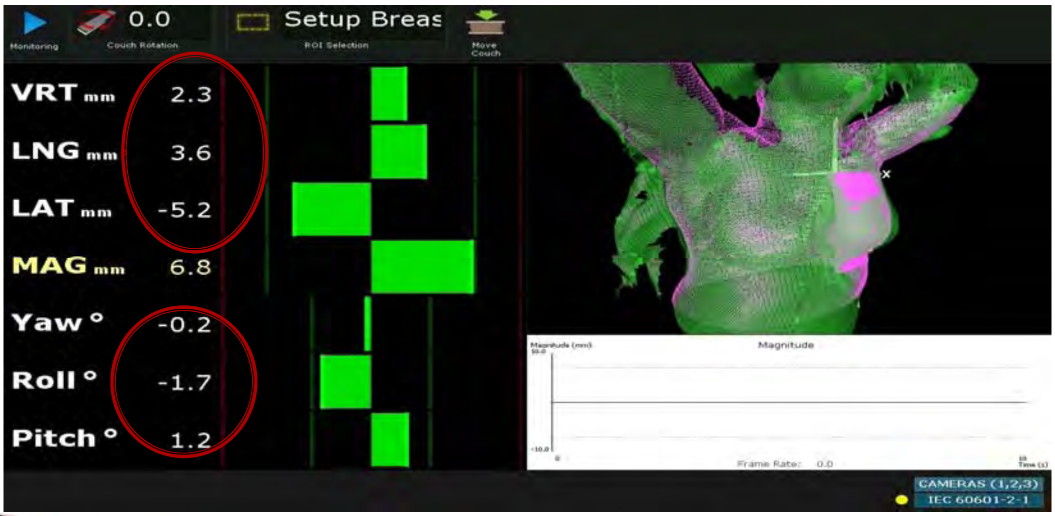
WBRT Example:
24th Treatment Tangent Films



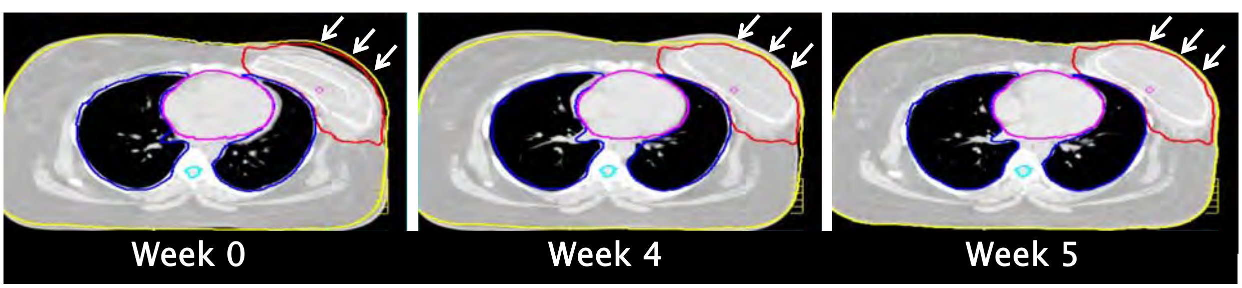
WBRT Example: 24th Fraction 'Entire' ROI



WBRT Example: 24th Fraction 'Breast' ROI



Effects of filling tissue expander during RT

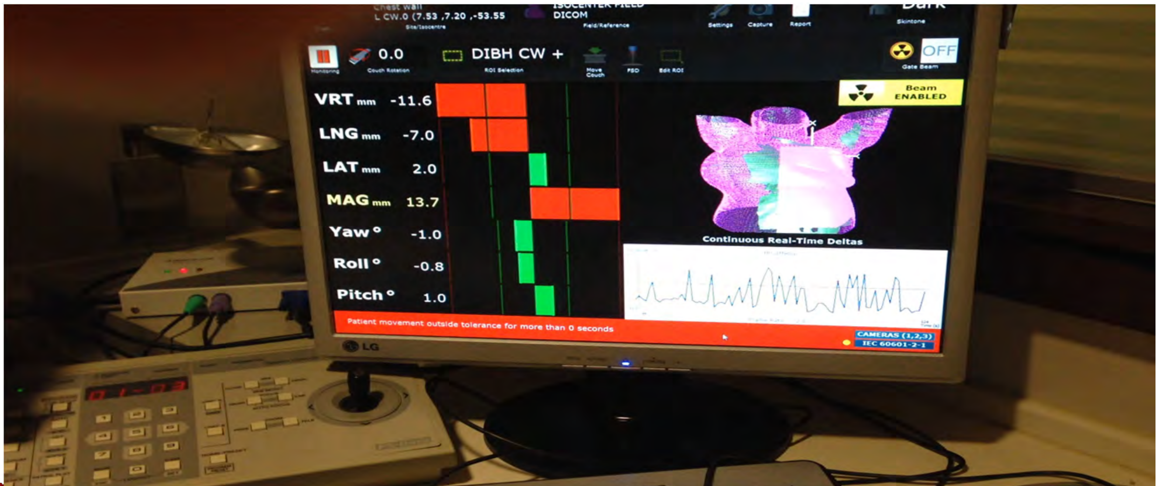


3. Clinical Challenges of DIBH

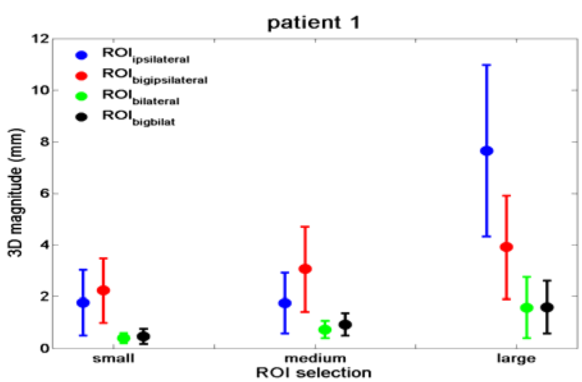
» Skin-Tone Darkening

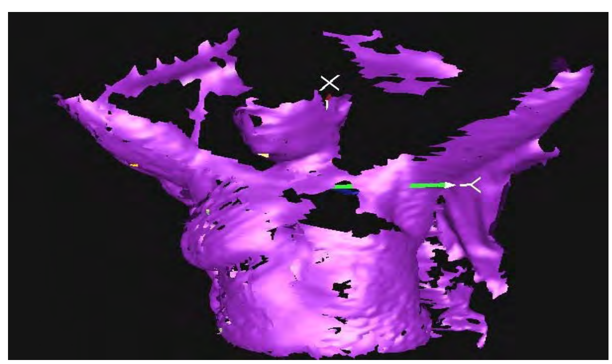
Skin Darkening Degrades SI Quality

Skin Darkening Due to Bolus Causes Registration Instability



Skin Darkening Degrades SI Quality

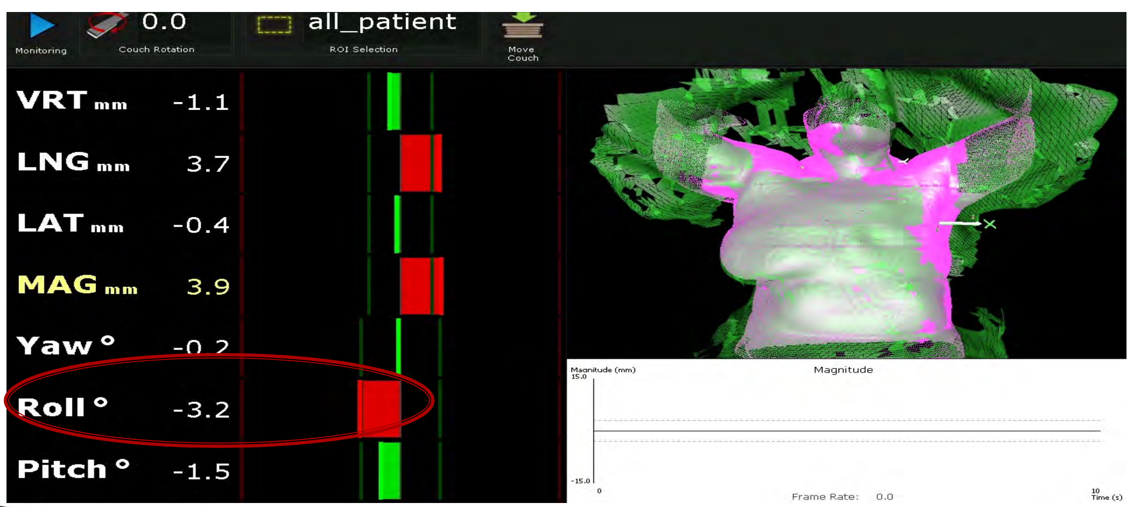




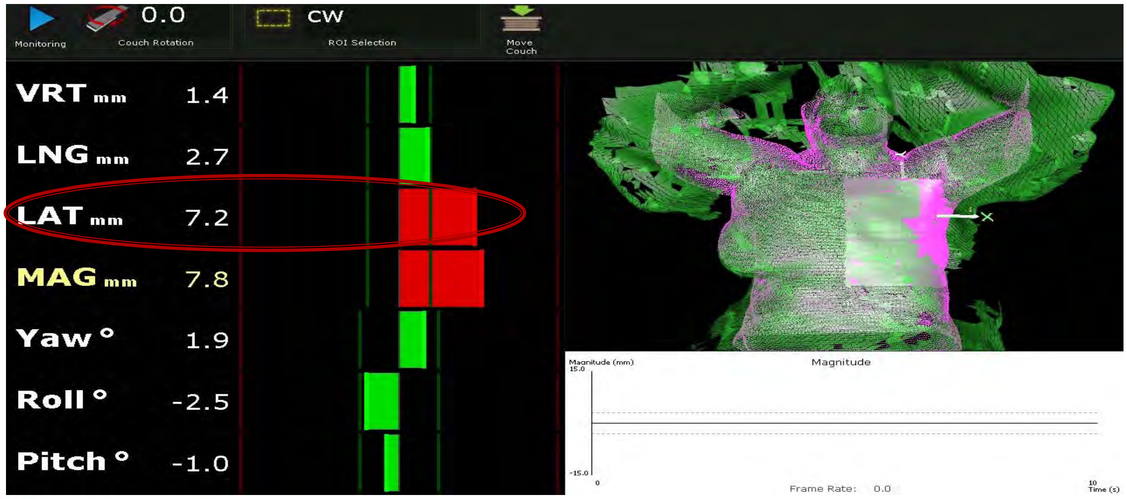
3. Clinical Challenges of DIBH

- Non-specific topography

Registration of 'Entire' ROI Identifies Roll



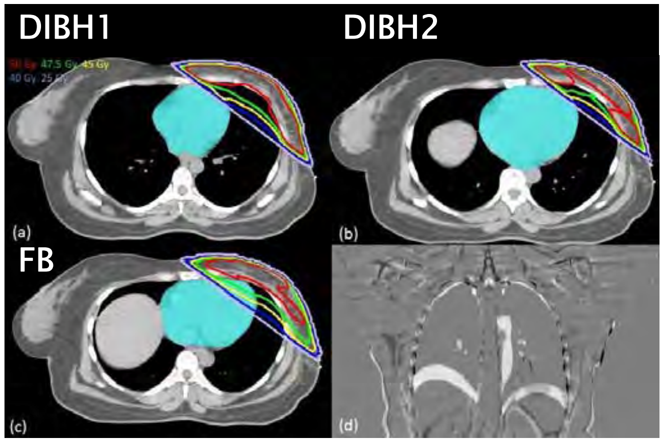
Registration of ‘CW’ ROI Misinterprets Roll as LAT shift



3. Clinical Challenges of DIBH

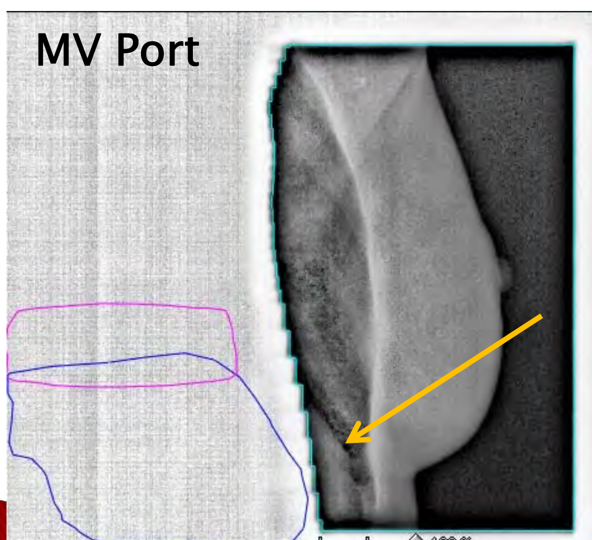
- Changes in Breath-hold Pattern

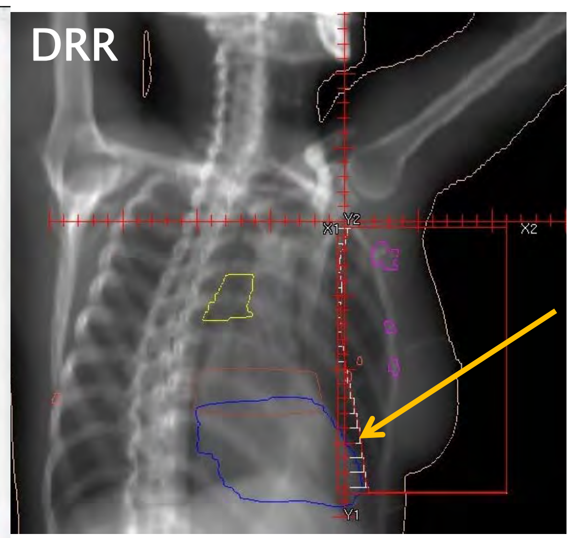
ΔDose Between Breath-Holds



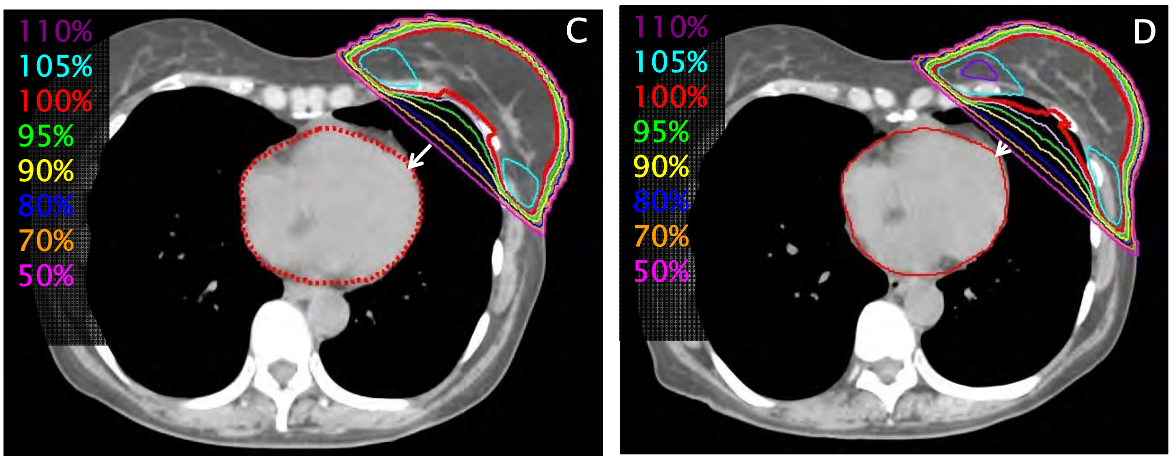
	DIBH1	DIBH2	FB
Heart Mean Dose (Gy)	1.8	2.5	8.7
Lung V20 (%)	24%	29%	39%

Identifying Changes in Breath-hold





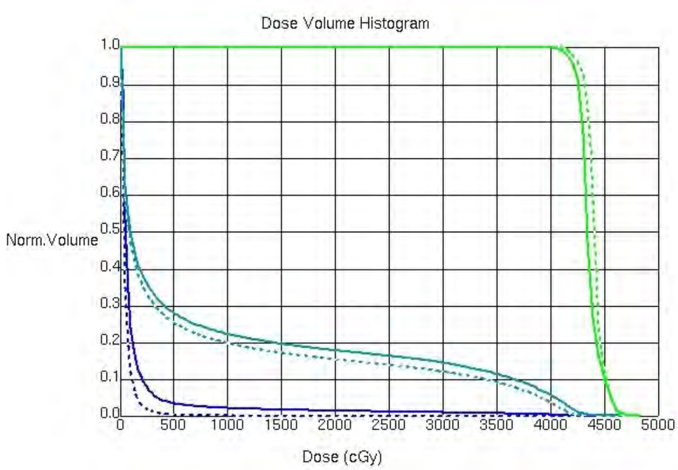
Identifying Changes in Breath-hold



Planning CT DIBH

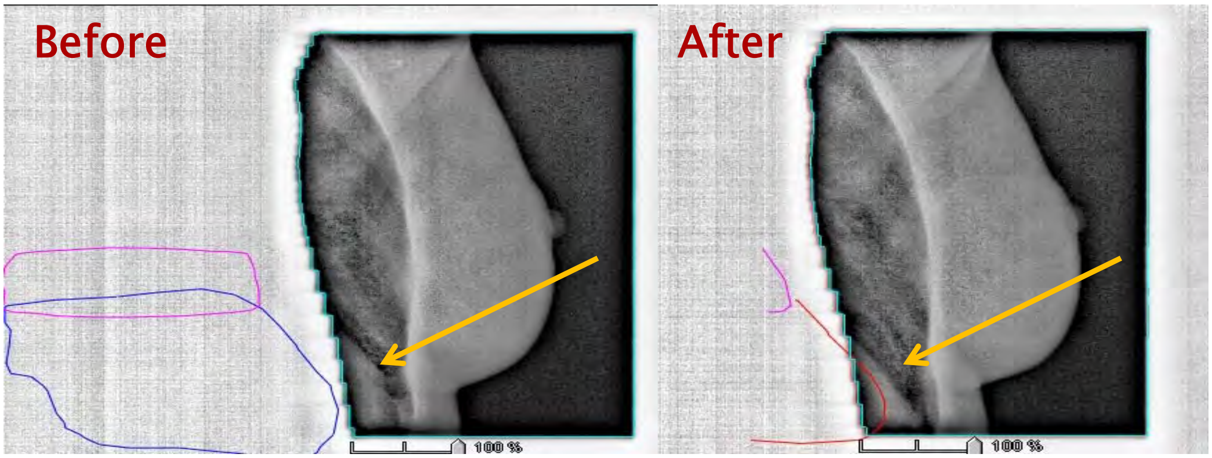
Repeat CT DIBH2

Identifying Changes in Breath-hold



	CT1	CT2	FB
Mean Heart Dose (Gy)	0.5	1.4	2.7
Lung V20Gy	15%	17.7%	23%

MV Ports Pre & Post Re-simulation



Identifying Changes in Breath-hold

- Verify with internal imaging
- Adapt the plan as necessary
- Acknowledge that variability exists!

Conclusions

- SGRT guidance of DIBH reduces OAR doses, improves efficiency & treatment quality
- Challenges encountered:
  - Patient selection
  - Learning curve
  - Congruence with other-IGRT modalities?
  - Patients change (anatomic, breath-hold, skin darkening)
- Potential solutions:
  - Good immobilization
  - Develop departmental workflows
  - Support therapists & communicate with MDs

Thank you for your attention!

Acknowledgements:

Colleagues & therapists at

University of Chicago Hospitals