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Differences in patterns of failure between the Imaging and Radiation Oncology Core (IROC Houston) Lung and Spine phantoms

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IROC Houston Phantom Credentialing

- Clinical trial participation (Followill et al. 2012)
 - Irradiate phantoms that represent human anatomy
 - Over 2000 institutions in U.S. and abroad



Fig. 1 Thoracic phantom

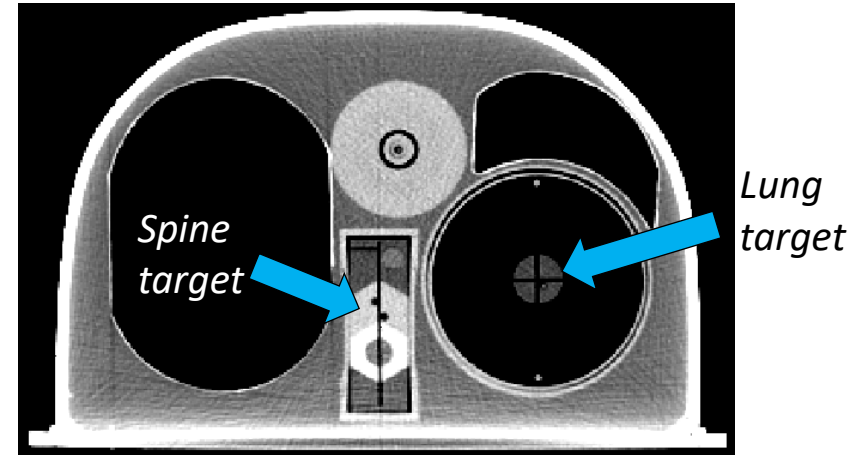


Fig. 2 CT cross-sectional image

IROC Houston Phantom Credentialing

- Deliver 6 Gy to TLD and film

Moving lung phantom

Criteria:

- TLD $\pm 7\%$, gamma 7% , 5 mm

Failure rate:

- $^{141}/_{1052} = 13\%$ (2012-2018)

SBRT spine phantom

Criteria:

- TLD $\pm 7\%$, gamma 5% , 3 mm

Failure rate:

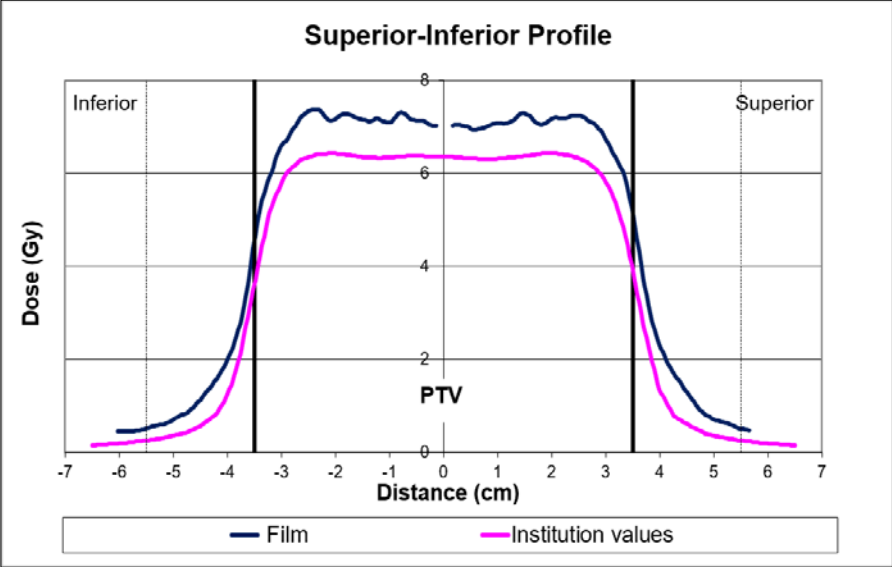
- $^{46}/_{263} = 17\%$ (2012-2018)

What types of failures exist in these phantoms?

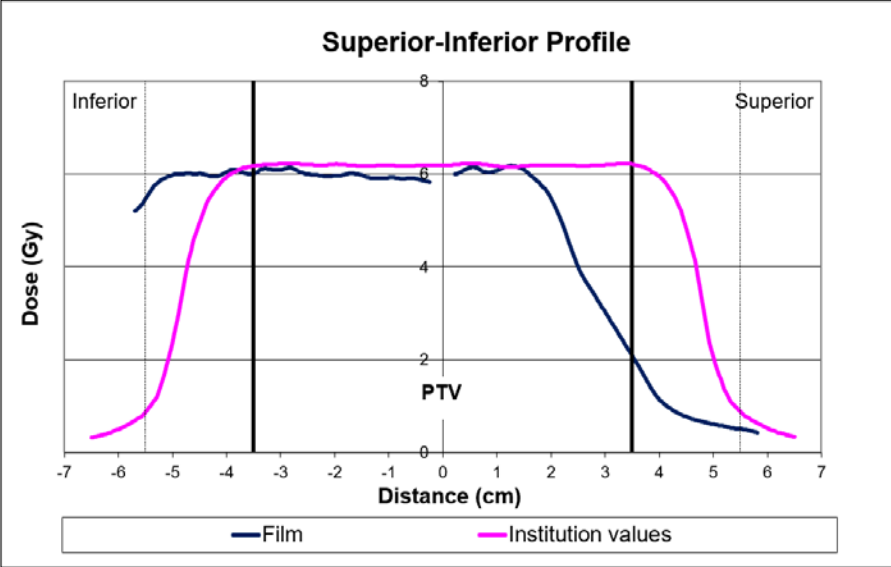
Qualitative analysis of lung and spine

- Evaluated 158 phantoms total
 - 116 lungs
 - 42 spine
- Reviewed dose profiles & gamma results
- Categorized by failure type

Lung phantom results

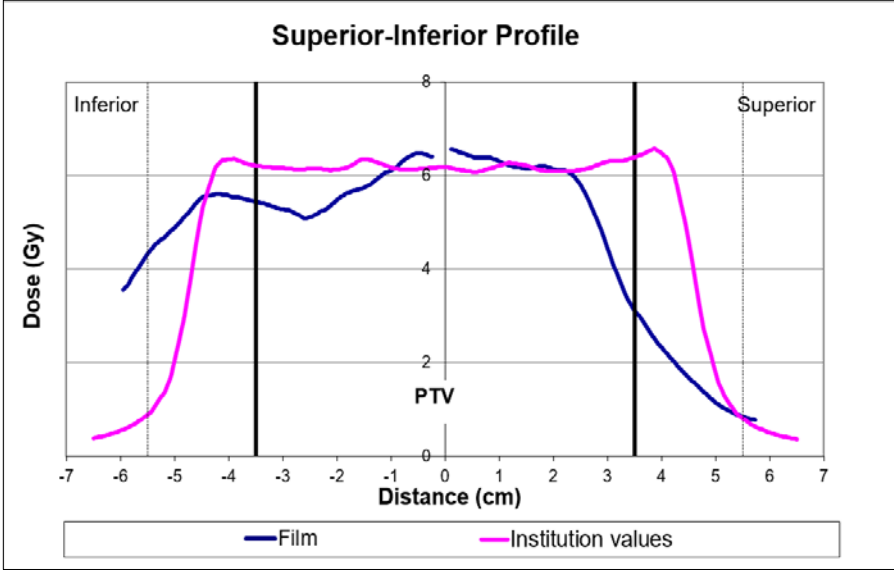


Systematic overdose

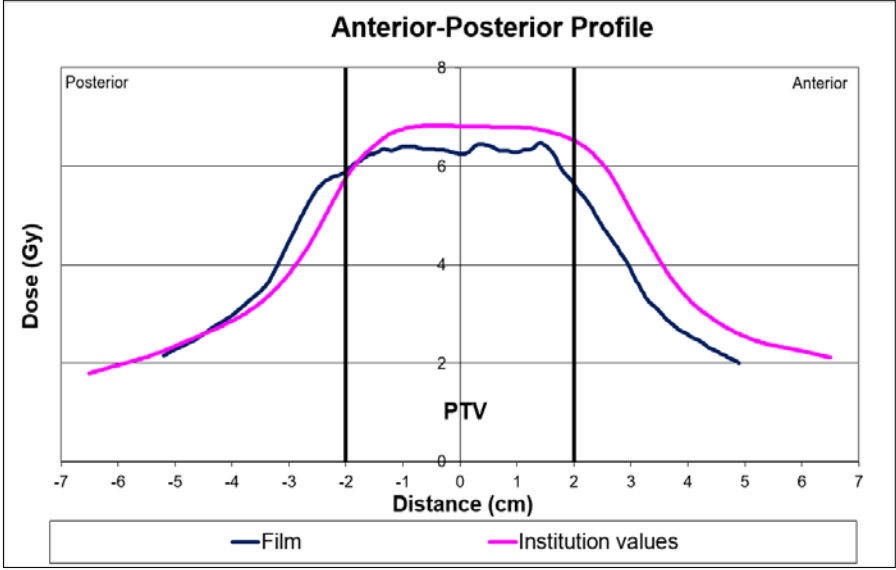


Localization: superior-inferior direction

Lung phantom results



Global Error: irregular dose distribution

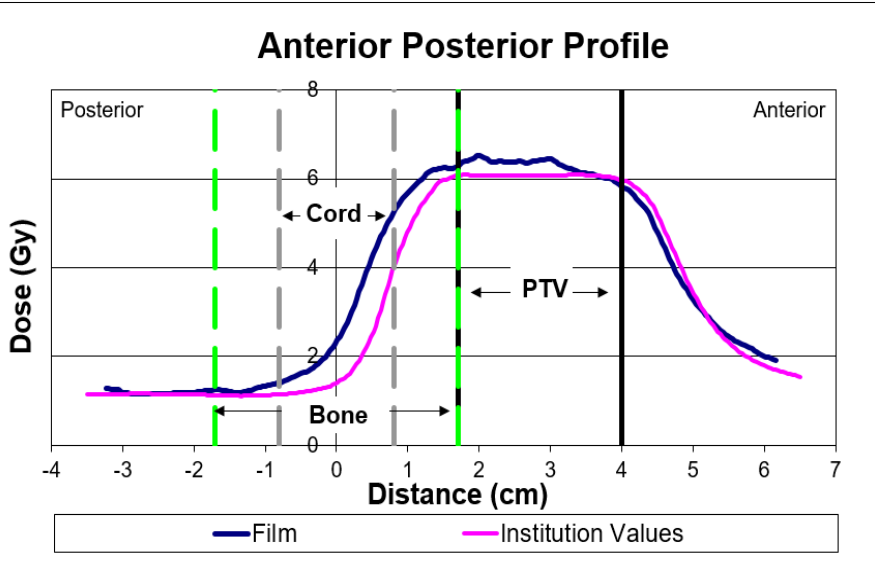


Combo: AP localization + systematic underdose

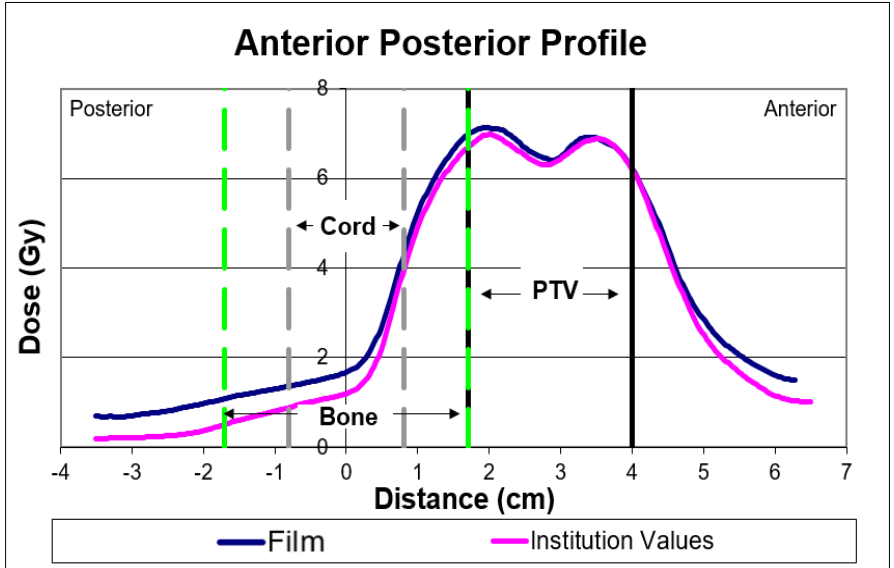
Lung phantom results

Failure Type	Number of phantoms	Description
Systematic dose	35 (28%)	Underdosing or overdosing of PTV
Localization	79 (62%)	Dose distribution shift
Global	3 (2%)	Grossly irregular dose distribution
Combination category	10 (8%)	Two dependent failure modes

Spine phantom results



Dose fall-off region



OAR overdose

Spine phantom results

Failure Type	Number of phantoms	Description
Systematic dose	25 (60%)	Underdosing or overdosing of PTV
Localization	6 (14%)	Dose distribution shift
Dose fall-off region	5 (12%)	Error in high dose gradient between PTV & spinal cord
OAR overdose	6 (14%)	Overdose of the spinal cord structure

Conclusion

- **Lung:** mostly **localization errors** in direction of motion (50%)
 - Equivalent for gating and ITV/free-breathing
- **Spine:** mostly **systematic dose errors** (60%)
 - Head & Neck, also highly modulated IMRT treatment, showed similar results: 62% dosimetric (Carson et al. 2016)

Conclusion

- Clinically relevant errors likely to manifest in patient cases
 - Not due to mistakes, but errors in clinical process
 - Loose IROC criteria:
 - lung: 7%, 5 mm spine: 5%, 3 mm
- Part of larger efforts at IROC to identify, quantify, and rectify institution errors

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