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Contralateral Breast Dose among Young Patients Receiving Breast Radiotherapy: Incidence and Implications

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INTRODUCTION

- The incidence of breast cancer in young patients is increasing.
- For these patients, survivorship often spans decades, increasing the population at risk for radiation-associated late effects, including secondary malignancies.
- Dose to the contralateral breast is a well-established risk factor for radiation-associated secondary malignancies.
- However, the magnitude of contralateral breast dose (CBD) in modern radiotherapy remains incompletely characterized.
- Cherenkov imaging enables real-time visualization of treatment beam delivery on patients and may provide a practical method to detect unintended off-target dose, including CBD.

AIM

To use Cherenkov imaging to provide accurate determination of CBD among a cohort of young patients treated with modern breast radiotherapy techniques.

METHODS

- Cherenkov images for patients receiving breast radiotherapy at 1 academic and 1 community medical center were prospectively reviewed over 16 months.
- Patients treated in the supine position were evaluated for evidence of CBD on Cherenkov images.
- Root cause analysis (RCA) was conducted for all CBD cases, and CBD was scored as "planned" or "unplanned."
- A subset of patients consented to *in vivo* dosimetry measurements at the site where CBD was visualized.

RESULTS

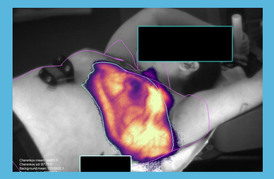
Among the 4532 images from 310 unique patients reviewed, there were 587 images for 43 unique patients who were age 50 or younger and treated in the supine position.

In this cohort of young patients, CBD was detected in **40.5%** (238 / 587) of **treatment deliveries**. CBD was identified during at least 1 fraction for **44%** (19 / 43) of **patients**.

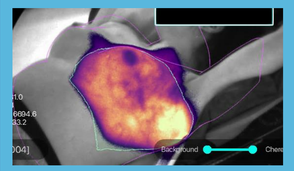
Techniques with CBD in the young patient cohort:

Treatment Technique	Patients with CBD
Tangent whole breast / chest wall	6
Wide tangent whole breast / chest wall	9
VMAT whole breast / chest wall	2
VMAT aPBI	2

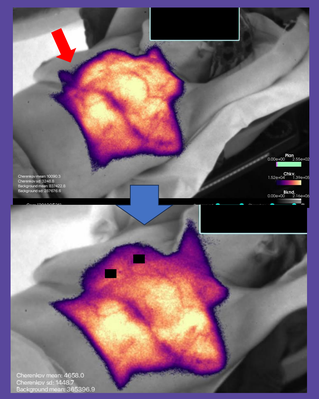
Root cause analysis (RCA) revealed that CBD was unplanned in **16%** (94 / 587) of **deliveries** for young patients and that **30.2%** (13 / 43) of **young patients** experienced an instance of unplanned CBD.



Planned CBD visualized with Cherenkov imaging during treatment to the left breast and supraclavicular region with wide tangents.



Unplanned CBD visualized with Cherenkov imaging during treatment to the left breast and supraclavicular region with wide tangents.



In vivo dosimetry workflow. Top: Cherenkov image demonstrating CBD (red arrow) during a fraction of radiotherapy to the left chest wall and supraclavicular region. Bottom: Subsequent treatment fraction for same patient, during which TLDs were placed at the site of visualized CBD. Black squares indicate region of TLD placement. Cherenkov image confirms that dosimeters were placed at region of interest.

In vivo dosimetry measurements for a subset of the young patient cohort:

Patient Age	Treatment Technique	TLD (cGy)	Cumulative Dose (cGy)*	CBD Cause
32	Wide Tangents	36.2 101.5	905.0 2537.5	Unplanned
41	Tangents	122.7 19.5	1963.2 312.0	Planned
42	VMAT	91.2 120.2	1459.2 1923.2	Planned
43	Wide Tangents	21.0	525.0	Unplanned
45	Tangents	161.1 24.8	2577.6 396.8	Unplanned
47	Wide Tangents	34.8 144.3 140.9	870.0 3607.5 3522.5	Unplanned
50	VMAT	55.8 121.7	892.8 1947.2	Planned

Incidence and causes of CBD for entire breast cohort

	Total Fractions	% Fractions	Unique Patients	% Patients
Patients age ≤ 50	587	21.9% (587 / 2676)	43	18.5% (43 / 233)
Unplanned CBD	94	16.0% (94 / 587)	13	30.2% (13 / 43)
Planned CBD	144	24.5% (144 / 587)	6	14.0% (6 / 43)
No CBD	349	59.5% (349 / 587)	24	55.8% (24 / 43)
Patients age > 50	2089	78% (2089 / 2679)	190	81.5% (190 / 233)
Unplanned CBD	149	7.1% (149 / 2089)	22	11.6% (22 / 190)
Planned CBD	447	21.4% (447 / 2089)	49	25.8% (49 / 190)
No CBD	1493	71.5% (1493 / 2089)	119	62.6% (119 / 190)

CONCLUSIONS

Cherenkov imaging can be used to identify CBD among patients receiving breast radiotherapy, including young patients who are at greatest risk for radiation-associated malignancies.

The detection of CBD in substantial portion of young patients underscores the need for further investigation in this high-risk cohort.

Next steps include analyzing absolute, spatially-resolved dose distributions to better quantify off-target exposure and leveraging RCA findings to implement risk-reduction strategies aimed to minimizing CBD in young patients.

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