II Zoom Journal Club 2012

Coordinatore: Luigia Nardone

Centro Congressi EATALY

Roma, 25 Gennaio 2013

IV SESSIONE

IGRT vs 3D-CRT: Vantaggi e Limiti

a cura di: Elisa D'Angelo, Lucia Anna Ursini, Alba Fiorentino, Enzo Fusco, Giovanni Silvano

Moderatori: Laura Lozza, Marica Valli

Rapporter: Alba Fiorentino

Discussant: Giovanni Silvano

Associazione Italiana Radioterapia Oncologica
Gruppo di Studio per la Patologia Mammaria

Breast Cancer

- Another tumor site in which little or no changes are thought to occur
- Most likely due to the preponderance of early stage patients treated with adjuvant RT
- However, even in those women, a variety of morphologic changes occur during RT

TARGET — OAR

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CLINICAL INVESTIGATION | Breast

PLANNING THE BREAST TUMOR BED BOOST: CHANGES IN THE EXCISION CAVITY VOLUME AND SURGICAL SCAR LOCATION AFTER BREAST-CONSERVING SURGERY AND WHOLE-BREAST IRRADIATION

KEVIN S. OH, M.D.,* FENG-MING KONG, M.D., PH.D.,* KENT A. GRIFFITH, M.P.H., M.S.,† BETH YANKE, C.M.D.,* AND LORI J. PIERCE, M.D.*

*Department of Radiation Oncology, University of Michigan Medical School, Ann Arbor, MI; and †Biostatistics Unit of the University of Michigan Comprehensive Cancer Center, Ann Arbor, MI

- 30 early stage breast cancer pts
- Conventional CT pre-RT and at 40 Gy
- 95% had significant reductions in the lumpectomy volume
- Mean volume pre-RT = 32.1 cc
- Mean volume at 40 Gy = 25.1 cc
- Overall mean reduction of 22.5%
- No change in the overall breast volume (0.11% reduction)

Oh et al. Int J Radiat Oncol Biol Phys 2006;66:680

TARGET

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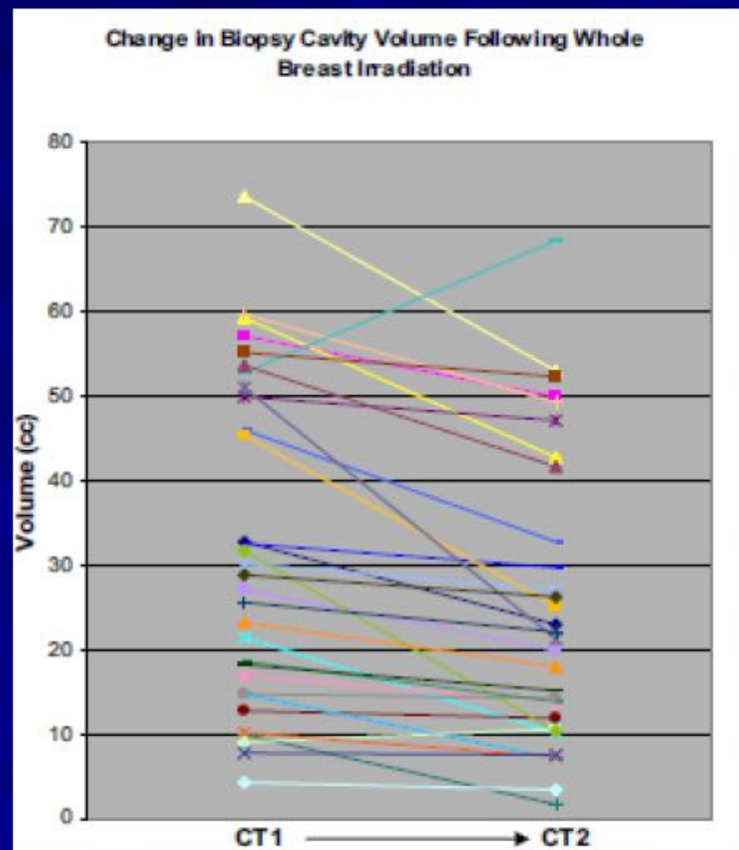


Would adapting help?

Nichols et al.
ASTRO 2009

- 40 early stage breast cancer patients
- CT pre-RT and again at 37.8-41.4 Gy
- In women with >35% reduction in lumpectomy cavity, replanning significantly reduced the V90% volume of the boost sparing more breast tissue
- Mean difference 119 cc
- 25/40 patients had clinically significant changes in boost plans: 13 lower electron energy, 11 smaller cone

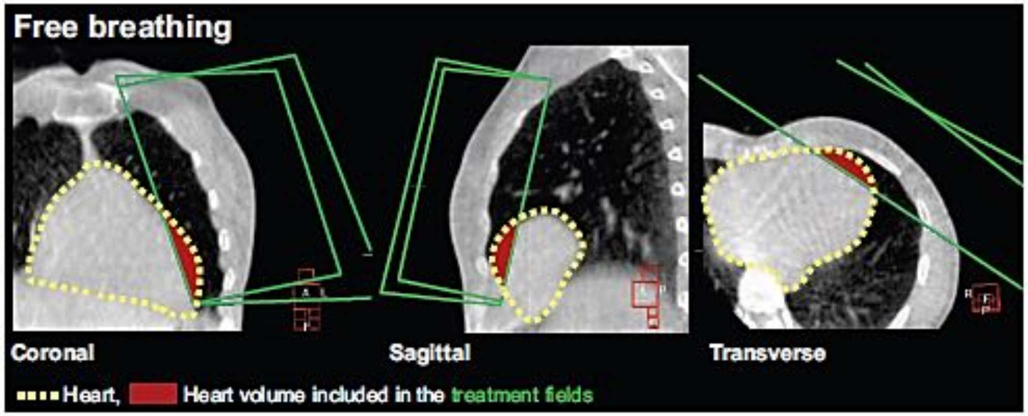
Nichol et al. Int J Radiat Oncol Biol Phys [abstract] 2009:75:S212

Image Guidance for Deep Inspiration Breath-hold

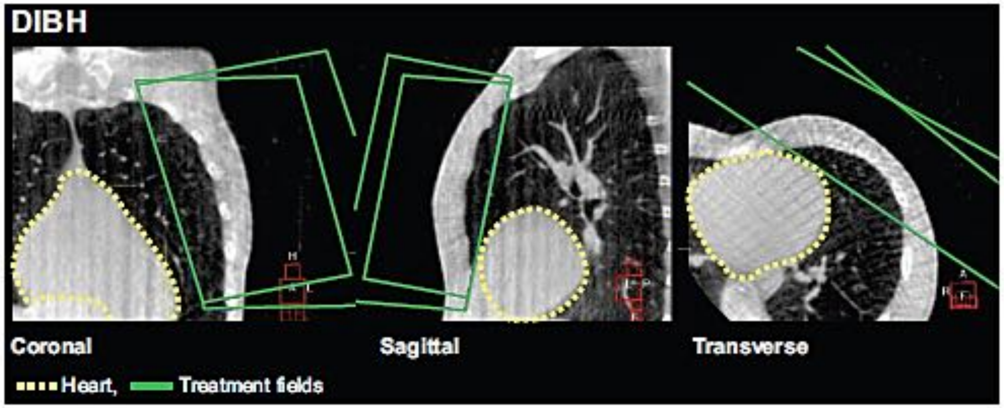
O A R

Topolnjak et al. IJROBP 2008

- Left-sided breast cancer radiation
  - Increased risk for long term heart disease

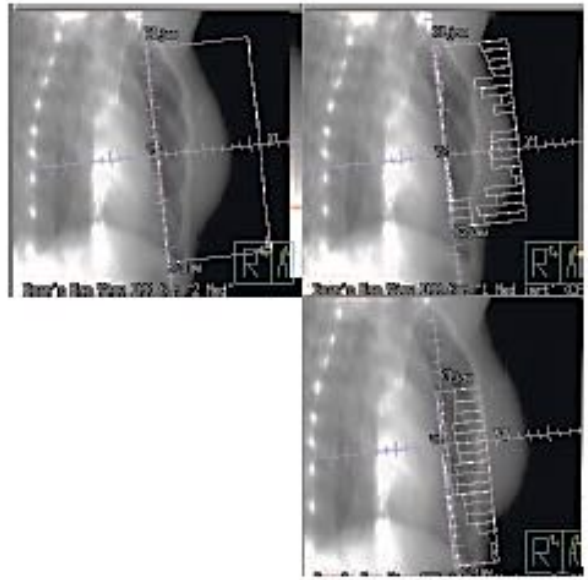


- To decrease the irradiated heart volume
  - Voluntary deep inspiration breath hold (DIBH)



Planning:

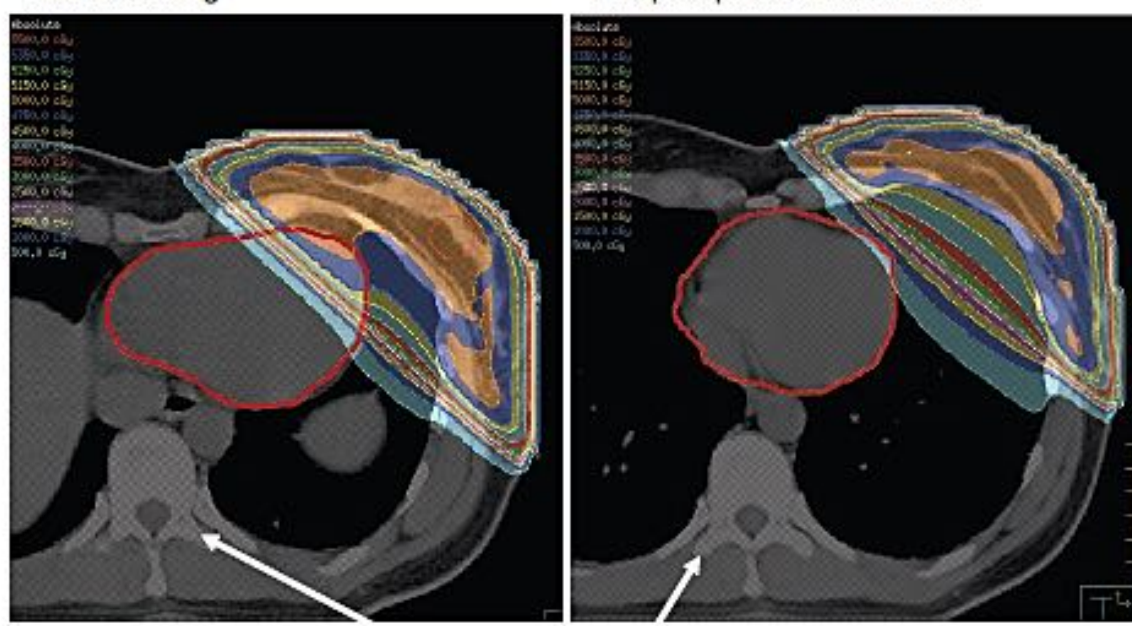
- IMRT plan
- Max.l 3 segments per beam
- 1 open en 2 IMRT segments



planning

Free Breathing

Deep Inspiration Breath Hold



Same vertebra

Topolnjak et al. IJROBP 2008

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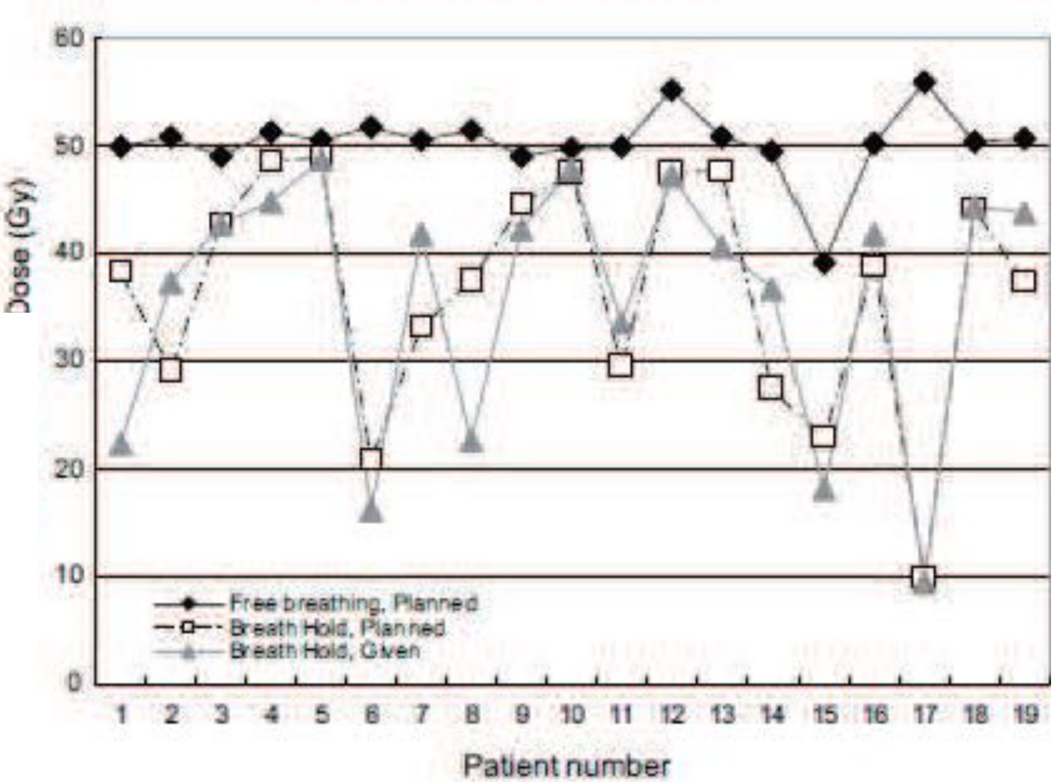
Adaptive RT for breast cancer

Heart Dose



Summary

- Considerable geometrical uncertainties limit the precision in breast RT
- Image guided correction strategies effectively manage setup errors
- Adaptive RT has the potential to account for shape and volume changes

Borst et al. IJROBP 2010

Journal of Breast Cancer

J Breast Cancer 2012 March; 15(1): 105-110 http://dx.doi.org/10.4048/jbc

ORIGINAL ARTICLE

Dose-Volume Analysis of Lung and Heart according to Respiration in Cancer Patients Treated with Breast Conserving Surgery

Jae-Goo Shim[1,2], Jeong-Koo Kim[1], Won Park[2], Jeong-Min Seo[3], Chae-Sun Hong[2], Ki-Won Song[2], Cheong-Hwa Hong-Ryang Jung[1], Chan-Hyeong Kim[4]

[1]Department of Radiological Science, Hanseo University, Seosan; [2]Department of Radiation Oncology, Samsung Medical Center, Sungkyun School of Medicine, Seoul; [3]Department of Radiological Technology, Daewon University College, Jecheon; [4]Department of Nuclear Enginee University, Seoul, Korea

Table 1. Dose and volume of lung and heart in FB, EBH, DIBH

	Lung		Heart	
	D_5 (Gy)	V_{20} (cm^3)	D_5 (Gy)	V_{18} (cm^3)
FB	43.46±6.01	13.18±4.17	15.33±8.12	4.50±1.21
EBH	38.73±9.12	10.66±4.61	9.53±6.79	3.43±1.82
DIBH	38.23±8.08	10.98±4.22	5.26±3.48	1.83±1.23
p-value	0.170	0.369	0.004	0.004

FB=free breathing; EBH=expiration breath hold; DIBH=deep inspiration breath hold; D_5=minimum dose which reached >5% of the lung volume; V_{20}=volume of the left lung was exposed to 20 Gy; V_{18}=heart volume was exposed to 18 Gy.

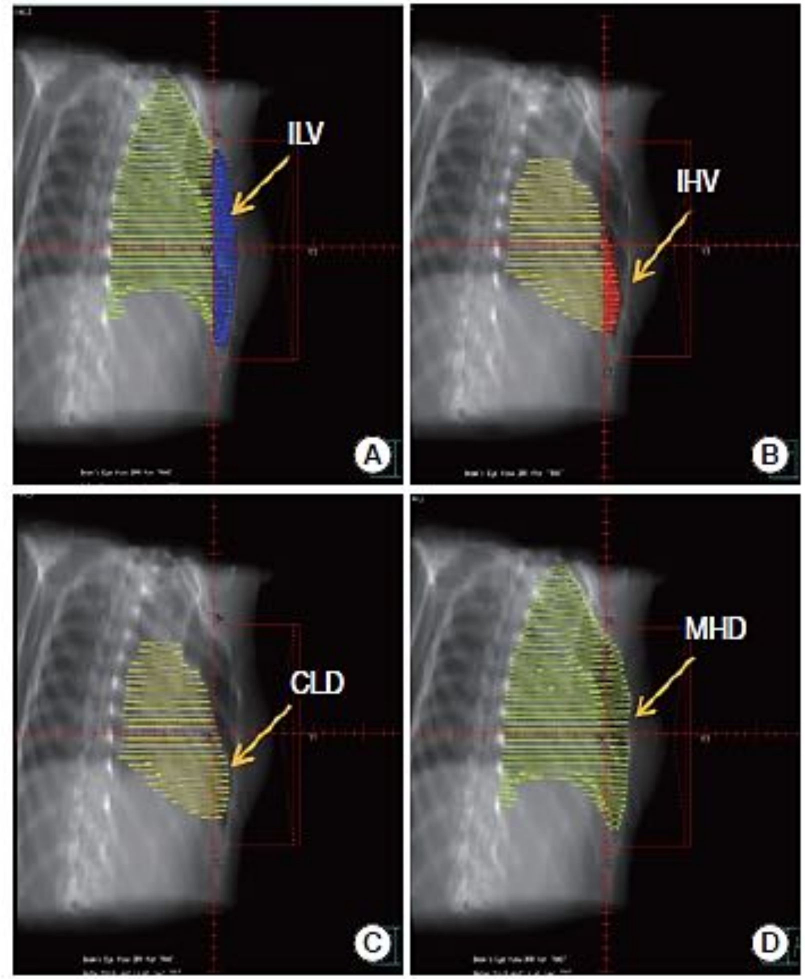
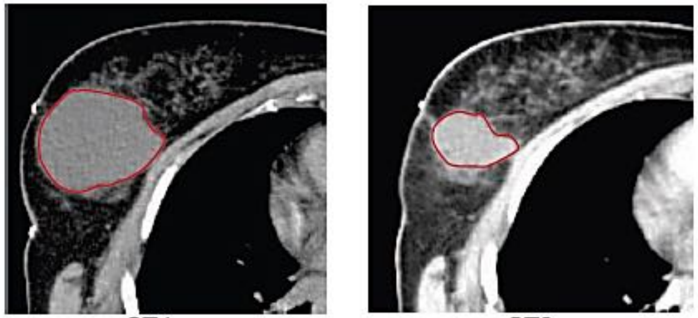


Figure 2. Digitally reconstructed radiograph images in chest. (A) Lung volume. (B) Heart volume. (C) Maximum heart distance. (D) Central lung distance.
ILV=irradiated lung volume; IHV=irradiated heart volume; CLD=central lung distance; MHD=maximum heart distance.

http://dx.doi.org/10.4048/jbc.2012.15.1.105

Dosimetric Impact of Seroma Reduction on Boost Planning Volume

- Seroma reduction during RT



CT1 scan | CT2 scan

CT1: initial planning CT obtained before whole-breast irradiation
CT2: second CT obtained during a patient's RT course

Dosimetric Impact of Seroma Reduction on Boost Planning Volume

- Retrospective comparison between three different boost RT delivery and planning techniques:
  - SEQ: a sequential boost plan
  - SIB: a simultaneous integrated boost plan
  - SIB-ART: a SIB adaptive radiation therapy plan

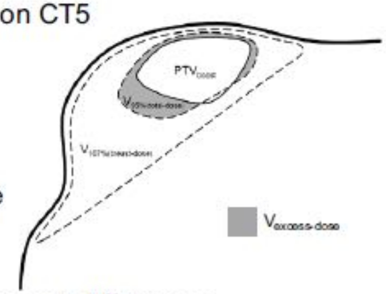
	SEQ	SIB	SIB-ART	
Whole breast	CT1 25x2Gy	CT1 28x1.81Gy	CT1 15x1.81Gy	CT2 13x1.81Gy
Boost	CT3 8x2Gy	CT1 28x0.49Gy	CT1 15x0.49Gy	CT2 13x0.49Gy

Dosimetric Impact of Seroma Reduction on Boost Planning Volume

- 21 Patients
- Seroma volume reduction:
  - Significant total reduction during RT (p<0.001, one sample t test)
  - Mean (Range): 62 (38~85)%
  - 77% of total reduction in first three weeks of RT
- Evaluation on CT scans used for planning:
  - Target coverage: relative volume of TV_{breast} and PTV_{boost} receiving ≥95% of the prescribed dose
  - $V_{excess\text{-}dose}$: undesired volume (outside PTV_{boost}) receiving ≥95% of the total dose

Dosimetric Impact of Seroma Reduction on Boost Planning Volume

- Evaluation of total dose distributions on CT5
  - Target coverage
  - $V_{excess\text{-}dose}$
  - $V_{107\%(breast\text{-}dose)}$
  - $V_{95\%(total\text{-}dose)}$
  - HD_{max}: maximum physical heart dose
  - LD_{mean}: mean physical lung dose



- Correlation seroma volume / reduction and differences between the treatment plans for
  - $V_{excess\text{-}dose}$
  - $V_{107\%(breast\text{-}dose)}$
  - $V_{95\%(total\text{-}dose)}$

Borst et al. IJROBP 2010

Dosimetric Impact of Seroma Reduction on Boost Planning Volume

Variable		mean		Friedman	Wilcoxon
	SEQ	SIB	SIB-ART	*p*	
$V_{107\%(breast\text{-}dose)}$ (cm³)	584.5	536.8	485.5	<0.001	SIB-ART<SIB<SEQ
$V_{95\%(total\text{-}dose)}$ (cm³)	273.6	289.4	234.2	<0.001	SIB-ART<SEQ<SIB
$V_{excess\text{-}dose}$ (cm³) *Planning*	134.4	58.3	36.1	<0.001	SIB-ART<SIB<SEQ
$V_{excess\text{-}dose}$ (cm³) *CT3*	134.4	150.1	95.0	<0.001	SIB-ART<SEQ<SIB
HD_{max}* (Gy) Left	39.9	36.9	35.8	0.001	SIB-ART<SIB<SEQ
LD_{mean}* (Gy)	4.2	4.6	4.5	0.001	SEQ<SIB-ART<SIB

Borst et al. IJROBP 2010

VOLUME 24 · NUMBER 25 · SEPTEMBER 1 2006

JOURNAL OF CLINICAL ONCOLOGY | ORIGINAL REPORT

Late Cardiac Mortality and Morbidity in Early-Stage Breast Cancer Patients After Breast-Conservation Treatment

Eleanor E.R. Harris, Candace Correa, Wei-Ting Hwang, Jessica Liao, Harold I. Litt, Victor A. Ferrari, and Lawrence J. Solin

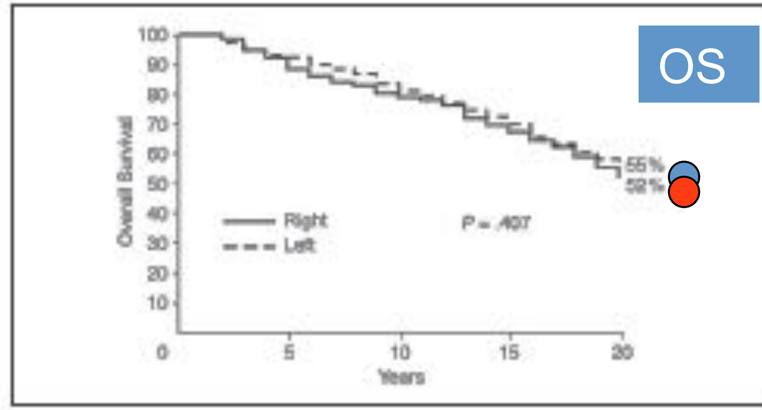


Fig 1. Overall survival versus time by Kaplan-Meier analysis demonstrates no significant differences in survival between left- and right-sided irradiated patients up to 20 years after irradiation.

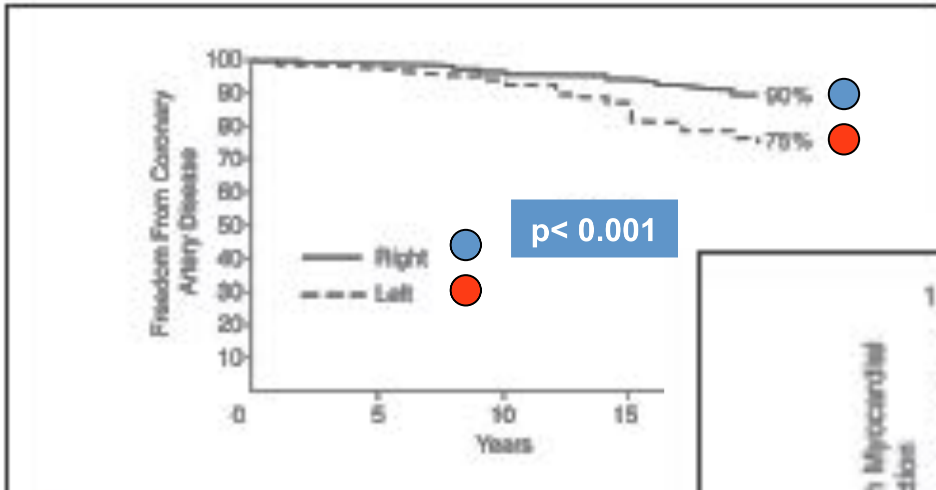


Fig 2. Freedom from coronary artery disease. A signific
and nonfatal diagnoses of coronary artery disease was s
compared with right-sided patients using Kaplan-Meier

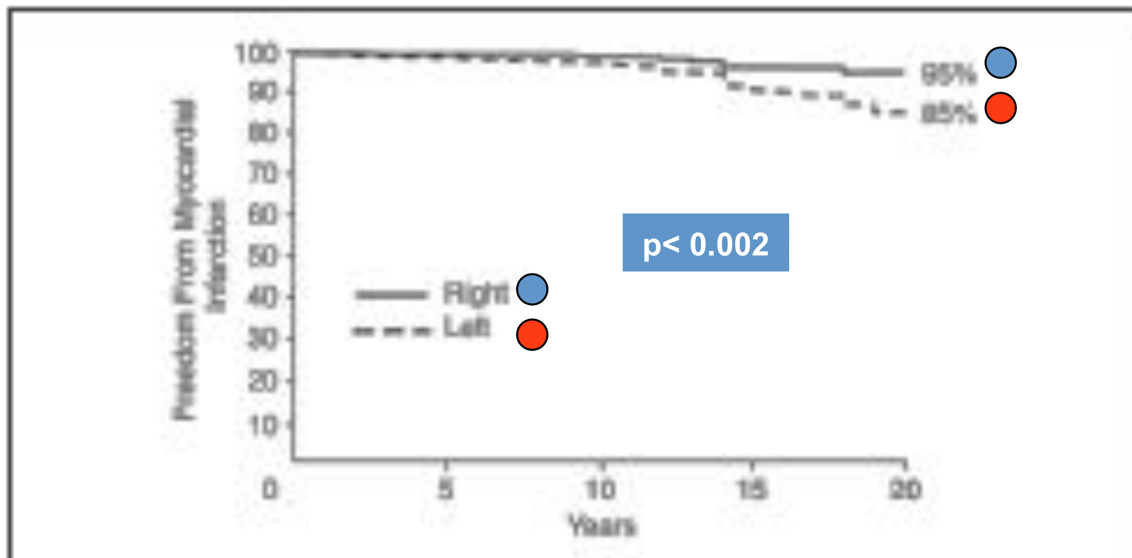
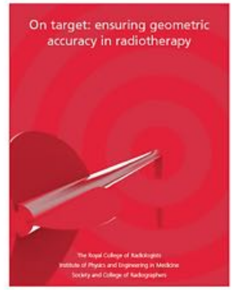


Fig 3. Freedom from myocardial infarction. A significantly higher rate of any diagnosis of myocardial infarction, fatal or nonfatal, was seen in left-sided compared with right-sided patients; however, deaths as a result of myocardial infarction were not significantly different between the two groups.

7.4 Breast

7.4.1 *Suggested protocol for breast verification*

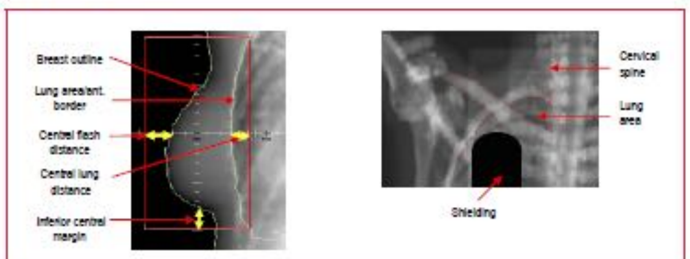


Fraction 1 (images acquired and actioned before treatment delivery)	• For standard whole-breast radiotherapy, acquire images of either or both treatment fields and all nodal fields, avoiding dose critical structures (where possible) • Double exposures not necessary • Set-up error should be determined as a measure of central lung distance and skin rather than isocentre displacement (critical aspects of whole-breast RT) • For partial field irradiation or dynamic IMRT deliveries, use other pretreatment checks to verify the MLC pattern and use open field images to verify anatomy • Opposed fields cannot resolve set-up errors into all three orthogonal directions. Based on the planar image, correction is made by either: – Estimating changes to isocentre and re-imaging to check correction – Determining isocentre shift using simulation equipment
Fractions 2 & 3	• **Further images only applicable where isocentre displacements are calculable and actionable** • A more accurate evaluation of the systematic component of the set-up error in each planar image will be obtained by repeat imaging over a number of fractions • Calculation of corrective couch shifts is difficult with tangential images. Accurate correction of a systematic set-up error will generally require re-simulation • Any systematic set-up correction should be applied before Fraction 4 and imaging repeated (typically 2 or more fractions). Any corrections applied to the treatment set-up must be verified.
Weekly	• Acquire images of tangential fields each week to assess shape change or trends • Assess each image and correct gross errors for each fraction where necessary if set-up error is greater than the tolerance value, check by repeat imaging (typically two or more fractions)

- A more accurate evaluation of the intrafractional variability of set-up will be obtained by using multiple intrafractional imaging such as cine acquisition or movie loops. Intrafractional verification to be considered where possible to inform planning margins
- Daily verification may be required for tumours planned for IMRT or partial organ irradiation
- Patient immobilisation devices to help maintain treatment position are essential
- Control of systematic and random set-up errors is more effectively achieved on a treatment population basis by improved immobilisation, adherence to protocols and training
- Tolerances and action levels to use will vary, particularly with the immobilisation and treatment technique used as well as compliance of the patient and should be chosen accordingly

Anatomical match structures

It is recommended that at least three structures visible within the field be outlined. The anatomies identified below indicate the most stable features. It is recommended that these structures should be used for comparison, wherever they fall within the field arrangement chosen.



7.4.2 *Evidence for breast verification guidelines*

Immobilisation and patient positioning

Verification is an important component of breast radiotherapy. Uncorrected gross and large systematic set-up errors may result in reduced treatment efficacy and increased complications.[129,130] Daily variations arise from two main sources, the reproducibility of the patient positioning and the internal movement of the breast tissue and nodes caused by respiratory and cardiac motion. Patient positioning can be improved by using effective immobilisation; breast position and shape are altered by the arm position and angulation of the immobilisation device. Footrests, knee and bottom supports may minimise patient slippage.

Set-up reproducibility

The immobilisation used will affect the set-up reproducibility. Set-up errors of 2.1 mm and 6.5 mm have been reported, varying between immobilisations such as arm poles and tilted boards and alpha cradle.[68,131]

From a comprehensive survey of set-up errors reported in the literature,[70] median values for the 'standard' immobilisation method of angled board, arm support and various combinations of foot, knee and buttock supports were derived and are reproduced below.

Anatomical parameter	$\Sigma_{set-up\ (mm)}$	$\sigma_{set-up\ (mm)}$
Central lung distance (CLD)	3.0	2.4
Central flash distance (CFD)	2.8	3.1
Inferior central margin (ICM)	3.8	3.2
Mean	**3.2**	**2.9**

Therefore 3 mm may be used as suitable starting value for both Σ_{set-up} and σ_{set-up} and action levels should be set appropriately. A shrinking action level or fixed action level is therefore most appropriate.[40] For example, a fixed action level of twice the random set-up error, σ (typically around 6 mm) could be employed. Where possible, local values of σ should be ascertained from a portal imaging study. Breast swelling during radiotherapy may affect the relative accuracy of the measurements used for assessment.

Internal organ motion

Breathing and cardiac motion are challenging and verification protocols should explore the use of 4D detection and correction strategies.[69] The contribution to set-up accuracy from respiration can be measured by taking multiple images through the treatment fraction.[132]

Imaging and radiotherapy fields to image

Where the planned treatment field covers the whole breast, sufficient anatomical information should be available with which to make a decision and double exposures will not be necessary. For non-IMRT techniques, central lung distance is the most reliable landmark for anatomy matching.[131] Both tangential fields should be imaged where there is a need to verify non-rectangular field shaping, or where the variation in lung volume treated throughout the entire fraction needs to be assessed.[132]

Correction of systematic errors is difficult for breast radiotherapy as orthogonal images are not usually acquired. Tangential opposed fields alone cannot resolve set-up errors into all three orthogonal directions. Accurate correction of a systematic set-up error will generally require re-simulation. Control of systematic and random set-up error is more effectively achieved on a treatment population basis by improved immobilisation, adherence to protocols and training.

It has been demonstrated that breast volume changes occur between the 5–8 fractions,[133] which may have dosimetric consequences.[134] Weekly imaging is recommended for detecting surface outline changes and systematic trends.[39] For standard whole-breast radiotherapy, there is only small benefit in using daily imaging protocols over weekly after the initial assessment of the first few fractions.[132,135]

A national study aims to assess the imaging protocols needed for partial breast irradiation and IMRT (IMPORT).[136] For partial field irradiation or dynamic IMRT deliveries, other pretreatment checks can be used to verify the MLC position or pattern and an open field image used to verify anatomy position.[137]

National Cancer Action Team
Part of the National Cancer Programme

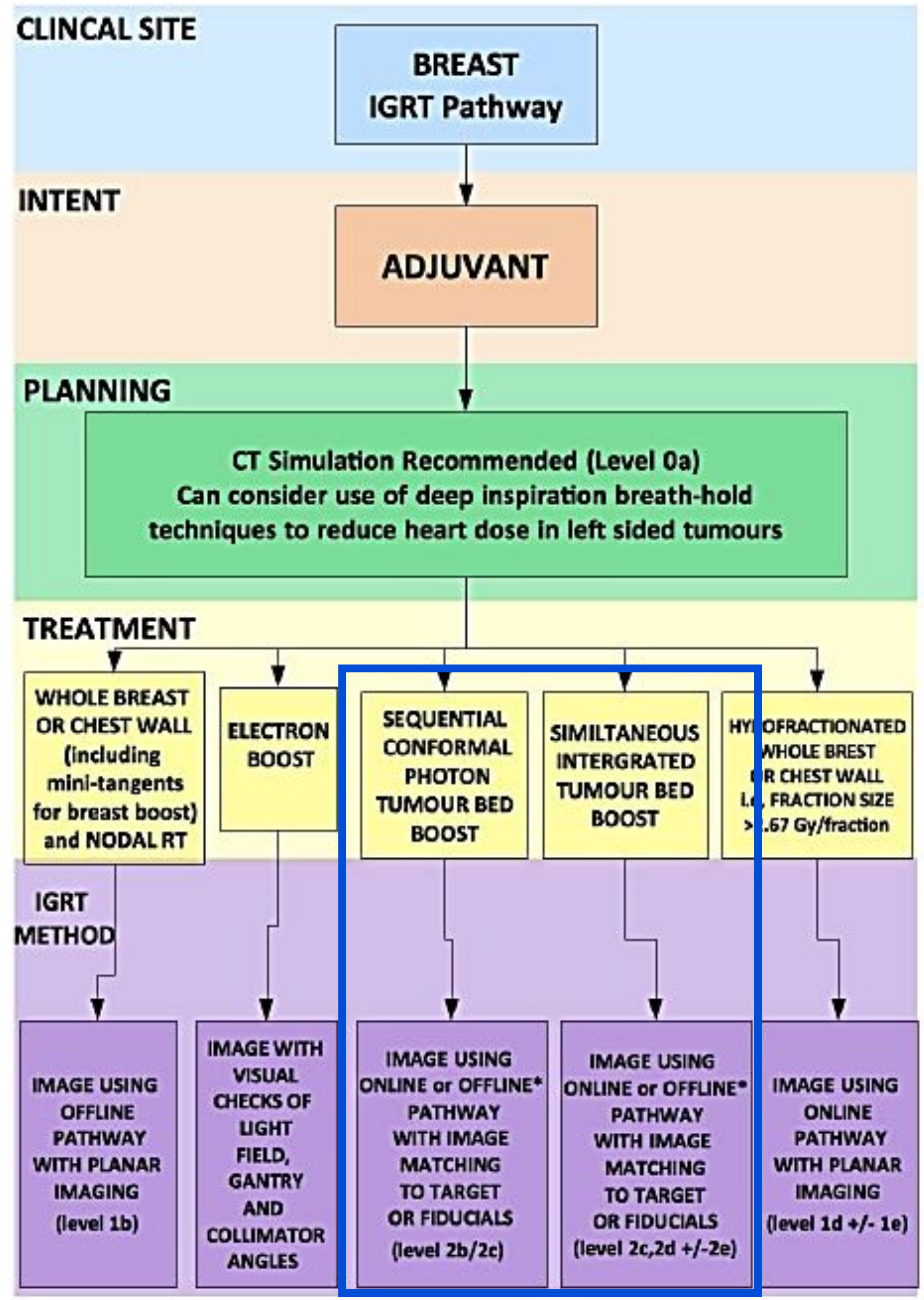
NHS

National Radiotherapy Implementation Group Report

Image Guided Radiotherapy (IGRT)

Guidance for implementation and use.

2012



* Especially if significant changes seen in 1st 3-5 fractions