Breast CT as a Platform for Image-Guided Therapies of Breast Cancer

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Breast CT as a Platform for Image-Guided Therapies of Breast Cancer

Introduction
Breast CT Imaging
Robotic Biopsy
Radiofrequency Ablation
External Beam Radiation Therapy
Summary
Mammography

Breast CT
Breast CT scanner: Excellent device for Rx
Breast CT as a Platform for Image-Guided Therapies of Breast Cancer

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Albion

Bodega

bCT scanner design & fabrication
PRE CONTRAST

POST CONTRAST

SUBTRACTION

PRE CONTRAST

POST CONTRAST
17 sec scan
Same dose as mammo
204 patients (UCD)
49 Contrast enhanced
CT technology development

64 $\rightarrow$ 320 slice CT (state of the art)

768 slice CT

$\rightarrow$ >200 pts since 2004
PET / CT for dedicated breast imaging

Whole-body PET/CT

Dedicated breast PET/CT

ramsey badawi
simon cherry
abhijit chaudhari
spencer bowen
Breast CT as a Platform for Image-Guided Therapies of Breast Cancer

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Summary
- Patient comfortably prone on table
- CT images have high spatial accuracy
- Good access to breast
- No magnetic field issues
- Excellent opportunity for Bx / IGI
From a DD patient (201)

Robotic guidance with fluoroscopic monitoring
bCT guided biopsy

breast CT image guidance

breast biopsy needle
to pathology
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bCT guided RFA

breast CT image guidance

radiofrequency ablation needle
Radiology 217: 471-476, 2000

Coagulation > 3 cm diameter
Coagulation volume up to 29 cc

17 pts, 14 pts finished procedure with path findings
μ = 12.8 mm diameter
mean time = 21 minutes (35.5 Watts)
13/14 pts (93%) showed no evidence of malignancy

Ultrasound guided RFA
OR setting before lumpectomy
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conventional whole-breast radiation therapy
fractionated radiation therapy

Week 1

Monday Tuesday Wednesday Thursday Friday

Week 2

Monday Tuesday Wednesday Thursday Friday

Week 3

Monday Tuesday Wednesday Thursday Friday

Week 4

Monday Tuesday Wednesday Thursday Friday

Week 5

Monday Tuesday Wednesday Thursday Friday

partial-breast radiation therapy

Courtesy Dr. Stavros Prionas
whole breast (fractionated)

partial breast (hypo-fractionated)

dose

position
bCT Rad Therapy Hypotheses:
- prone, not supine
- better re-positioning accuracy
- more patient dignity
- CT imaging during treatment
- high kVp x-ray beams

linac-based radiation therapy

bCT guided radiation therapy
bCT guided radiation therapy
dynamically adjustable collimators needed
Breast CT as a Platform for Image-Guided Radiation Therapy of Breast Cancer

- Physical Experiments
- Monte Carlo simulations
- Analytical computations
polyethylene is a reasonable surrogate for breast adipose tissue
24 mm Farmer chamber

used existing bCT with max 120 kVp
120 kVp results
Breast CT as a Platform for Image-Guided Radiation Therapy of Breast Cancer

Physical Experiments
  - Monte Carlo simulations
  - Analytical computations
typical orthovoltage tubes

320 kVp W-anode spectrum*

depth-dose curve in polyethylene

~178 keV monoenergetic beam

*thanks to Dr Jim Clayton at Varian for this spectrum
Monte Carlo results for different diameter collimations
Monte Carlo S/P (dose) across field of view

~3.5%

data from various collimated fields (last slide)
Breast CT as a Platform for Image-Guided Radiation Therapy of Breast Cancer

Physical Experiments

Monte Carlo simulations

Analytical computations
Analytical = primary only
Monte Carlo = prim + scat

2D dose distribution
2 cm beam

14 cm diameter breast

10%

20%
inverted dose distribution

100%

60%

14 cm beam
20% 5 mm & 10 mm diameter beamlets
14 cm diameter breast

multiple 5 mm diameter beamlets
whole breast
(fractionated)

partial breast (hypo-fractionated)

position

dose
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breast CT platform

breast CT data ($512^3$)

enhanced localization and targeting

3D volume display & analysis