Balloon-Based IORT using Xoft Source

Yixiang Liao, PhD
Disclosures

• No conflict of interest
• Number of cases/year has been doubled over the past 4 years (2012 – 2016)
Applicators

- Silicone w/ barium sulfate
  - Latex free
  - No need for contrast
  - ~6% attenuation

- Three sizes:
  - Small (3 – 4 cm) spherical:
    - 30 – 45 cc
  - Medium (4 – 5 cm) spherical:
    - 45 – 75 cc
  - Large (5 – 6 cm) spherical:
    - 65 – 130 cc

- Filled with Saline

Photo Credit: Xoft, a subsidiary of iCAD, Inc
Xoft Source

- Miniature X-ray source
- Water cooled
- Operates at 50 kVp
  - Average Energy
    ~ 28keV
- Source strength:
  - Nominal: 110000 U
  - Actual: 120000-140000 U
  - 3X Ir-192 HDR: ~ 40000 U
  - New NIST calibration standard
    - Air Kerma Strength → Air Kerma Rate

8/2/2017

Photo Credit: Xoft, a subsidiary of iCAD, Inc
Xoft Source Spec.

• Ramp up time (0 → 50 kVp):
  – 20 seconds
  – Equivalent to ~2 seconds treatment time

• Source Travel:
  – 0.7 seconds per 5mm
    • Vs. Nucletron MicroSelectron: 35 mm in 0.1 second
  – 7.5 cm source travel limitation
IORT Prescription

**IORT**
- Single fraction
- 20 Gy to tumor bed / surface of balloon
- Heart: V5% ~ 10%

**EBRT**
- 25 fractions
- 40-50 Gy
- Heart: V5%
  ~ up to 50% or higher
Xoft Protocol

• Safety and efficacy study
• 1200 subjects (~100 to go)
• Up to 10-year follow-up
• Evaluate:
  – Primary: Ipsilateral breast tumor recurrence (IBTR)
  – Secondary: Regional Recurrence, Safety, DFS, OS, Cosmetic Outcome, and Quality of Life
IORT Patient Selection (Xoft Protocol)

- **General inclusion criteria:**
  - Invasive ductal carcinoma or DCIS
  - Female > 40 yr (TARGIT: 45yr)
  - Tumor < 3 cm
  - Tis, T1 or T2 (< 3cm), N0, M0
  - Negative pregnancy test within 1 wk

- **Intra-Operative Inclusion:**
  - Balloon surface-to-skin distance >= 1 cm
  - Satisfactory balloon conformance

- **General exclusion criteria:**
  - Pregnant or nursing
  - Pacemaker in the field
  - Significant auto-immune disease
  - Multi-focal > 3cm
  - Multi-centric
  - Known lympho-vascular invasion
  - Invasive lobular cancer
  - Neo-adjuvant chemo/endocrine
  - Previous radiation
  - Etc.

- **Intra-Operative Exclusion:**
  - Positive sentinel node
  - Positive surgical margins
Imaging - Ultrasound

- Conformance
- Surface to skin distance
  - Multiple directions
  - > 1 cm
- Decide the filling volume of the balloon
- Done twice:
  - First with foley balloon / Cavity Evaluation Balloon
  - Second with the applicator balloon
Atlas Plan

- 33 plans
  - 30 – 130 cc
  - in 5 cc increments
  - Preplanned in Eclipse (TG43): assuming water
  - Based on nominal source strength
  - Loaded on USB
Dwell Positions

Single Dwell

Multiple Dwell
Case vs. Volume Distribution

Normalized Case Frequency

Balloon Volume (cc)

Small: 7-13 min.

Medium: 13-20 minutes
DOSIMETRY DISCUSSION
Dose Falloff Comparison

Dose Falloff

Relative Dose (%)

Distance from Source (mm)

Xoft
Ir-192

50%
30%

Y. Liao, AAPM 2017
Tissue Heterogeneity

![Graph showing tissue heterogeneity with various tissue types plotted against photon energy.]

AAPM Task Group 186
Studies of Dosimetric Effect

• R. Holt & J DeMarco (UCLA), 2010:
  – Air bubbles (5mm x 10mm): Dose increase 23% at surface

• S. White et. al. Med. Phys. 41 (6), June 2014:
  – Skin dose reduction ~ 0.5 – 24%
  – Rib dose increase ~ 300%

• Rush study:
  – Saline effect: ~ 5% reduction compared to atlas plans
Shielding and Radiation Protection

- HVL of 50 kVp = 0.06 mm Pb
- Patient
  - FlexiShield:
    - Tungsten drape, 0.45 mm Pb equivalent thickness
    - ~ 200X reduction
- Portable Shield
  - 100X – 1000X reduction
- Lead apron
  - ~ 100X reduction
- Rigid shield:
  - 0.2 mm Pb equivalent thickness
  - 10X reduction
- ~ 40 µR/hr behind portable shield

Photo Credit: Xoft, a subsidiary of iCAD, Inc
QA

• Daily QA
  – Water level/cooling tubes
  – Mechanical interlocks:
    • Wheel locks
    • Applicator connection
    • Source connection
    • Pullback obstruction
  – Position
QA

• Monthly QA
  – Daily QA
  – Electrometer test
  – Emergency stop test
  – Timer test

• Annual QA
  – Monthly QA
  – FlexiShield integrity
Thank you!