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Disclosure

I have nothing to disclose.

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Contents

1. introduction of breast cancer treatment
2. IB-IORT system
3. IB-IORT for breast cancer
4. IB-IORT QAs

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1. Introduction
---- Breast Cancer treatment

- 1. The standard of care currently for locoregional treatment of breast cancer is breast conserving surgery followed by whole breast external beam radiotherapy (EBRT),
- 2. An alternative to standard EBRT is intraoperative radiation therapy (IORT) in which at the time of breast conserving surgery a single dose of radiation is delivered.
- 3. Spherical applicator based Zeiss Intrabeam system is one of the emerging techniques for breast IORT treatment.

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Rationale for using IB-IORT

- Fowler [1] postulated that breast cancer has an α/β ratio of 4, rather than the ratio of 10 that is characteristic of most squamous cell carcinomas. The lower α/β ratio corresponds to a lower radiosensitivity to low doses, favoring a high single dose treatment, such as IORT.
- The use of a 20 Gy dose of IB-IORT (Carl Zeiss Surgical, Oberkochen, Germany) as a monotherapy following breast conserving surgery was compared to the standard of a 50 Gy dose of EBRT in the TARGIT-A clinical trial [2].

[1] Fowler JF: The linear-quadratic formula and progress in fractionated radiotherapy. Br J Radiol 62:679-94, 1989
[2] Silverstein MJ, Fastner G, Maluta S, et al: Intraoperative radiation therapy: a critical analysis of the ELIOT and TARGIT trials. Part 2--TARGIT. Ann Surg Oncol 21:3793-9, 2014

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Carl Zeiss Intrabeam System

Low energy,
40 or 50 kV x-ray,
Shielding is easy
to handle.

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2. Carl Zeiss Intrabeam IB-IORT system

- 1. mostly used to treat breast and brain cancer after surgery.
- 2. **Advantage**: Because the treatment site can be seen by MD before treatment, so the accuracy of applicator placement is superior,
- 4. **Advantage**: Because it is one time treatment after tumor removal, so patient does not have to come back for a protracted treatment course seen in EBRT,
- 5. **Advantage**: Equipment is compact and mobile, so it can be used to treat patients from one OR after another.

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Carl Zeiss Intrabeam System

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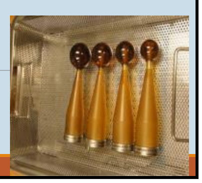
Intrabeam Components-

Spherical Applicators for breast (2 to 5.0 cm)
Brain IORT needs smaller applicators.



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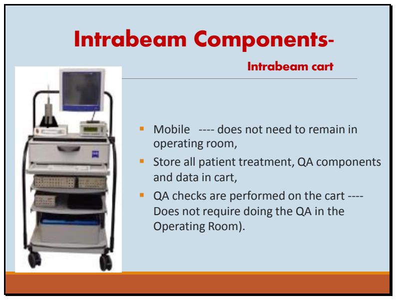

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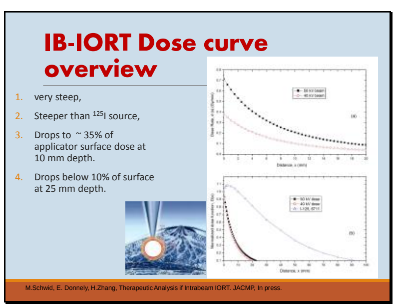

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IB-IORT Planning/treatment Steps

1. MD examines the cavity after surgery, check the size with applicator (or dummy), decides a applicator size, MD mounts the applicator onto the arm, inserts the applicator into cavity and secure it.
2. Physicist enters the applicator size and prescription dose into computer. For TARGIT A clinical trial, dose is 20 Gy at the applicator surface.
3. Compare the computer calculated treatment time with a ready-made look-up table. 10% difference is acceptable, otherwise physicists need to investigate the cause. [3]
4. MD double check the entry and treatment time with the look-up table.
5. Treat patient.

[3] Eaton DJ, Duck S: Dosimetry measurements with an intra-operative x-ray device. Phys Med Biol 55:N359-69, 2010.

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Northwestern Memorial Hospital/ Department of Radiation Oncology Look-up Table for Intra-beam IORT Treatment Time

SN: 507211 **NMH Source** Zeiss Calibration date: 5/18/2016

Hualin Zhang, Ph.D. /6-27-2016

50 kV, 40 µA. Prescription Dose: 20 Gy

(Output: 2.361 Gy/min at XRS tip)

Applicator size (cm)	Surface (min)	@ 5 mm (min)	@ 10 mm (min)
3.0	29.76	56.32	95.83
3.5	21.30	44.08	79.22
4.0	29.43	57.32	97.53
4.5	39.65	72.59	118.91
5.0	52.47	92.12	145.26

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4. IB-IORT QAs ---Why monthly QA is needed?

- 1. Performance of IB-IORT XRS or electronic brachytherapy source depends on a lot of working conditions, such as target, vacuum, voltages, etc. It is like a small accelerator, its output may need to be checked frequently.
- 2. Daily QA output check is not completely fool-proof.
- 3. measurement in water tank will give a convincing verification of XRS source's dose output each month.
- 4. clinical trial requires institution to maintain a solid monthly QA record.

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Zeiss Intrabeam Monthly QA

- Monthly QA always starts from the daily QA,
- Daily QA is performed on each treatment day before patient receives IORT,
- Manufacturer provided radiation shielded QA instruments:
  (1). PDA (Photodiode Array)
  (2). PAICH (Probe adjuster/ionization chamber holder)
  (3). High precision water phantom for absolute dose rate measurement.

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Daily QA – PDA
(Photodiode Array)

- PDA Contains five photodiodes
- Used for Isotropy check ,
- Electronic alignment of XRS probe
- Align the electron beam direction with the mechanical center of the probe.
- Steering of electron beam based on the photodiode readings

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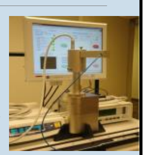
Daily QA – with PAICH
(Probe Adjuster Ion Chamber Holder)

- PAICH used for XRS probe straightening. If needed, Manually straighten the Probe using a plunger
- Measure Output (cGy/min) with ion chamber
- Does not provide absolute dose rate in any water depth, but possible to compare the in-air measurement with the in-water measurement at factory to determine absolute dose rate.



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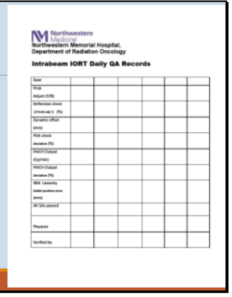
Daily QA form



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Northwestern Memorial Hospital,
Department of Radiation Oncology

Intrabeam IORT Daily QA Records

Date						
Prob Adjust (Y/N)						
Deflection check [illegible] (%)						
Dynamic offset (mm)						
PDA check deviation (%)						
[illegible] Output (Gy/min)						
[illegible] Output deviation (%)						
[illegible] Linearity radial position error (mm)						
All QAs passed						
Physicist						
Verified by						

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MonthlyQA – with Water Phantom

- To perform independent verification of depth dose and dose distribution in water,
- use Radiation shielded (lead glass) water tank,
- Mechanical positioning accuracy of +/- 0.1 mm

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Monthly QA
XRS- output water tank measurements

1. Checking the lateral position using current measurement with the dosimeter. The probe tip has been centered above the measuring window of IC ionization chamber from the previous steps.
2. Move the probe tip downward until it almost touches the measuring chamber.
3. Watch the shadow of a flashlight from other side, moving the probe tip downward until the shadows from two sides connect each other and there is no light you can see at the tip.
4. The position where you just reached is the exact position of the probe tip.

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Monthly QA
XRS- output water tank measurements

5. This is the minimum reachable distance r1 from the source tip,
6. on the other hand, calculate the shortest achievable distance of the XRS tip from IC ionization chamber, r1.
   a) d_{IC}: distance between the entrance foil and chamber top: 0.245 mm, as indicated in the ion-chamber manual.
   b) d_A is the air gap between the upper surface of ionization chamber and the inner surface of ion-chamber housing, dA=0.5 mm
   c) d_H is the thickness of measuring chamber housing wall. dH=1.001
   d) $r1= d_H+d_A+d_{IC}=1.746$ mm

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Monthly QA
XRS- output water tank measurements

7. We find 1.746 mm is 47.415, so the 3 mm will have the threading value of 46.161, 25 mm will have reading of 23.161.
8. Move ion chamber upward from 3 mm to 25 mm.
9. Use manual mode in Unidos E Dosimeter, set 1 minute of time for integration.
10. Use charge mode, use integration key to record readings at each depth,
11. Get readings all the way from 3 mm to 25 mm.

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Monthly QA
XRS- output water tank measurements

Get charge readings Q(r) ,all the way from 3 to 25 mm. Calculate the dose rate output of the XRS source:

$$\dot{D}_{XRS}(r) = N_K \bullet Q(r) \bullet C_{TP} \bullet k_Q \bullet k_{Ak \to DW} \bullet F_{ph}(r)$$

(1) N_k=5.841*10^9 Gy/C, ion-chamber calibration factor provided by ACDL;

(2) C_{TP} is the temperature and pressure correction factor; C_{TP}=(t+273.12)*760/(295.12*P)

(3) k_Q is the beam quality factor, 1.002 for 50 kV beam;

(4) $K_{Ak\to DW}$ is the air-kerma to dose in water conversion factor, 1.054 as indicated in the manual.

(5) F_{ph} (r) is the phantom factor due to Zeiss QA phantom is different from Zeiss calibration phantom.

Output=6.169 *1.0e9 * Q * F_{ph}*C_{tp}

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XRS source water phantom measurement data table

N_K=	5.841E+09	G/C	Ctp=	1.019
t=	21.60	°C	K_Q=	1.002
P=	745.00 mmHg		$K_{AK\text{-}DW}$=1.054	
XRS	S/N: 507316	Loaner XRS	Ion-chamber	S/N: 000366

==

Table 1. Measured depth doses without applicators. (2/25/2015)

Z Threading	Depth r(mm)	R1 (nc)	R2 (nc)	R3 (nc)	Avg (nc)	F_{ph}(r)	Output-measured (Gy/min)	Manual output (Gy/min)	difference
46.19	3	11.46	11.45	11.45	11.4533	0.63731	45.874	40.151	-14.25%
44.19	5	3.488	3.493	3.495	3.4920	0.71176	15.620	14.458	-8.04%
39.19	10	0.55	0.555	0.55	0.5517	0.81339	2.820	2.7549	-2.37%
34.19	15	0.186	0.185	0.186	0.1857	0.85652	0.999	0.9973	-0.21%
29.19	20	0.086	0.086	0.085	0.0857	0.87693	0.472	0.4767	0.96%
24.19	25	0.046	0.046	0.047	0.0463	0.8885	0.259	0.2663	2.85%

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Output comparison

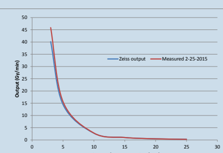

Figure. Comparison of the measured and Zeiss provided XRS dose rate output without applicators at different depths.

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Monthly QA report

A monthly QA report will be written.

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Thanks for your attention!