HDR Brachytherapy 1: Overview of QA

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Disclosures:

- Nondisclosure agreement with Varian Brachytherapy
- Shareholder- Varian, Inc.
- Honorarium from Varian, Inc.

Learning Objectives

- Review regulations and task group reports regarding HDR QA
- Review patient specific QA for HDR brachytherapy
- Introduction to IGBT

Why are we talking about this topic again?

A review of safety, quality management, and practice guidelines for high-dose-rate brachytherapy: Executive summary

Thomadsen, et al Practical Radiation Oncology 2014

From the abstract:

The (HDR) events were not due to lack of guidance documents but a failure to follow those recommendations or human failures in the performance of tasks.

HDR QA includes

1. Daily hardware functionality
2. Treatment planning system QA
3. Patient specific QA
4. Applicator QA
5. Imaging System QA
6. All of the above, plus anything else you can think of

Review of 10 CFR35

10CFR35.643- Periodic (daily) spot checks

-door interlocks
-source exposure indicator lights
-camera and intercom system
-emergency response equipment
-Primalert
-timer accuracy
-date and time
-source activity

The periodic spot checks do not need to be performed by an AMP
Reviewed by AMP within 15 days

Review of 10 CFR35

Source Calibrations

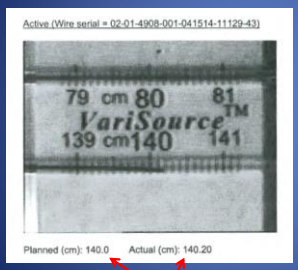
- Before first use of the unit
- After source exchange
- After repair that required removal of the source
- Output is measured within 5%
- "Full calibration measurements…..must be performed by the authorized medical physicist"

Review of 10 CFR35

Other QA

- Source positioning accuracy within 1 mm
- Source retraction with battery backup
- Length of source transfer tubes
- Timer accuracy and linearity

Source Position Verification (PVT test)



PermaDoc film

The authorized medical physicist needs to review the daily QA

33% A. Prior to the daily treatment

13% B. The day of the treatment

13% C. weekly

20% D. Within 15 days

20% E. monthly

Answer: D

Reference: 10 CFR35.643

A full calibration of the HDR afterloader needs to be performed by

20% A. Any Physicist

17% B. A physics resident supervised by a senior physicist

23% C. A physics resident supervised by an authorized user

10% D. Any physicist supervised by an Authorized Medical Physicist

30% E. An Authorized Medical Physicist

Answer: E

Reference: 10 CFR35.633

Review of TG reports

TG53: TPS QA (1998)
TG56: Code of Practice for Brachytherapy Physics(1997)
TG59: HDR Brachytherapy Treatment Delivery (1998)

TG56:

Low Probability catastrophic scenarios (e.g.- failure of the source to retract) should not be emphasized to the exclusion of more common but less severe human errors (wrong source strength, source position, transfer guide tubes not properly attached)

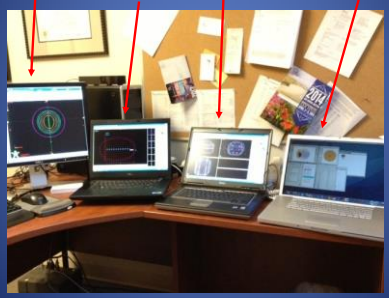
Develop QA check off forms to ensure procedures properly followed

TG53

TPS QA

Brachytherapy Planning Systems

BrachyVision VariSeed Vitesse BeBig Eye Plaque



Carleton UNIVERSITY

Canada's Capital University

The CLRP TG-43 Parameter Database for Brachytherapy

R. E. P. Taylor and D. W. O. Rogers

http://www.physics.carleton.ca/clrp/seed_database

Along-Away dose data data for the VariSource VS2000 source

Dose rate per unit air-kerma strength (cGy h^{-1} U^{-1})

Dose rate per unit air-kerma strength (cGy h^{-1} U^{-1})

[illegible]

BrachyVision Annual QA

Comparison of Dose Calculated by BrachyVision to The Carlton University TG-43 Parameter Database

Treatment Time: 94 s = 0.026 Hours

Source Strength 30600.4 U

Carlton University Data:

Distance	Dose (U)
1 cm	1.099
2 cm	0.2817
3 cm	0.1258
4 cm	0.0709
5 cm	0.0453

BrachyVision Dose Points / Carlton University Dose Points

Distance	Dose (cGy)	Dose (cGy)	Difference (%)
1 cm	875	874.4	0.07
2 cm	224.2	224.1	0.03
3 cm	100	100.1	-0.09
4 cm	56.1	56.4	-0.55
5 cm	35.6	36.0	-1.24

TG59

UVa switched entirely to HDR 8/1/2012

Advantage:
(almost) Entirely out-patient treatments
Initiation of new programs- prostate HDR, IORT breast
Faster work flow

Disadvantage:
Patients from a vast geographic area so out-patient treatments may not be as convenient
High dose delivered in a short period of time
Issues with faster work flow – Interfering Tasks

Interfering Tasks

More important in HDR as compared to LDR, because more actions are compressed into a very short duration, and distractions can divert attention long enough to cause a problem (Thomadsen, et al IJROBP 57:5)
Anything that takes attention from the task at hand

Radiation Oncologist going to see a consult
Nurses asking if the plan is done
Radiation Oncologist checking e-mail on phone
Unnecessary conversations or other distractions
Especially important with a scan-plan-treat workflow

A disadvantage of HDR brachytherapy is_____?

0% A. It used smaller applicators than LDR

0% B. The compressed time frame delivering a large dose

0% C. The dose distribution is generally worse than that for LDR

0% D. The distance between the applicator and normal tissue is smaller

0% E. An HDR procedure is not as well documented as an LDR procedure

10

Answer: b, reference TG59

Review of errors on NRC website

http://www.nrc.gov/reading-rm/doc-collections/nuregs/brochures/br0117/

Review of errors on NRC website

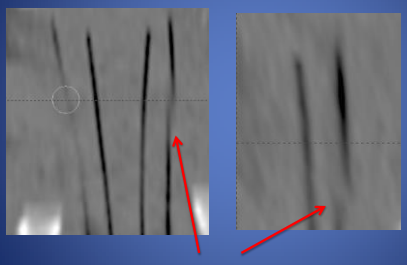
Patient specific QA

1. Was the applicator placed properly to begin with?
2. Was the applicator reconstructed in the TPS correctly?
3. Dose check
4. Applicator length check
5. Proper transfer guide tube connection
6. Contouring (volume of the contoured balloon vs. the volume used to inflate the balloon)
7. Proper applicator is used (cylinder diameter)
8. Proper library plan is used
9. Applicator position (ie- has the applicator moved during the time it takes to image, plan, etc)

1. Incorrect Catheter/Applicator Placement

In 2013, for the first of three prescribed fractions, a licensee inserted the applicator into the patient's rectum instead of the intended treatment site (the vagina). As a result, the intended treatment site was underdosed and the patient's rectum received 132 percent of the expected dose. The Agreement State ultimately determined that a reportable medical event did not occur in this case, because the intended area still received 69 percent of the prescribed dose for the first fraction. Based on the licensee's dose evaluation, the Agreement State also concluded that the incident did not meet the reportable medical event criteria due to the doses received by the unintended treatment areas, because the fractionated dose to the unintended tissue did not differ from the expected dose by 50 percent or more. Subsequent fractions were delivered as originally planned, and the total dose to the treatment site was within 20 percent of the prescribed dose. Corrective actions included adding a step to double check the location and positioning of the applicator.

2. Applicator Reconstruction in TPS



Crossed Catheters

3. Dose check (examples)

Contura double check

University of Virginia Health System
Department of Radiation Oncology
Contura Approximate Second Check

Patient
MRN#:

Date

Table 1					340 cGy		400 cGy		1250 cGy	
Nom. Fill Vol.	Width	Length	Dose rate cGy/min/Ci	C*sec for 340 cGy	TPS C*sec	C*sec for 400 cGy	TPS C*sec	C*sec for 1250 cGy	TPS C*sec	11162.76
34	4.00	4.00	8.43	2420	#VALUE!	2847	#VALUE!	8897	./.	
36	4.05	4.05	8.20	2688	#VALUE!	2927	#VALUE!	9146	0.859	
38	4.15	4.1	7.98	2556	#VALUE!	3008	#VALUE!	9398	0.842	
40	4.2	4.1	7.79	2619	#VALUE!	3081	#VALUE!	9628	0.842	
42	4.3	4.15	7.58	2691	#VALUE!	3166	#VALUE!	9894	0.886	
44	4.35	4.2	7.44	2742	#VALUE!	3226	#VALUE!	10081	0.903	
46	4.45	4.25	7.27	2806	#VALUE!	3301	#VALUE!	10316	0.924	
48	4.5	4.3	7.10	2873	#VALUE!	3380	#VALUE!	10563	0.946	
50	4.55	4.3	6.97	2927	#VALUE!	3443	#VALUE!	10760	0.964	
52	4.65	4.35	6.83	2987	#VALUE!	3514	#VALUE!	10981	0.984	
54	4.7	4.35	6.70	3045	#VALUE!	3582	#VALUE!	11194	1.003	
56	4.75	4.4	6.58	3100	#VALUE!	3647	#VALUE!	11398	1.021	
58	4.85	4.4	6.44	3168	#VALUE!	3727	#VALUE!	11646	1.043	
60	4.9	4.45	6.35	3213	#VALUE!	3780	#VALUE!	11811	1.058	
62	4.95	4.5	6.26	3259	#VALUE!	3834	#VALUE!	11981	1.073	
64	5	4.55	6.15	3317	#VALUE!	3902	#VALUE!	12195	1.092	
66	5.05	4.6	6.05	3372	#VALUE!	3967	#VALUE!	12397	1.111	
68	5.1	4.6	5.97	3417	#VALUE!	4020	#VALUE!	12563	1.125	
70	5.15	4.65	5.89	3463	#VALUE!	4075	#VALUE!	12733	1.141	

Physicist Attending Date/Time

3. Dose check (examples)

CATHETER DATA
Channel 1
Treatment Strength 19266.40 cGy cm² / h

Position [cm]	DwellTime [s]	X [cm]	Y [cm]	Z [cm]
115.2	15.6	-5.38	1.3	-67.65
114.7	23.6	-5.82	1.39	-67.42
114.2	45.8	-6.25	1.48	-67.19
113.7	18.2	-6.7	1.58	-67.01
113.2	0.6	-7.18	1.69	-66.89
112.7	0.1	-7.66	1.79	-66.8
112.2	38.2	-8.14	1.9	-66.73

REFPOINT DATA

Id	X [cm]	Y [cm]	Z [cm]	TG43Dose [cGy]	SecondCalcDose [cGy]	Pct Error [%]
F1						
dose pt		-7.88	-0.13	-69.43	347	339.94	-2.03

Physics approval: Bruce Libby Date: 7/14/2014 8:39
MD approval: Date: 7/14/2014 8:39

4. Applicator length check

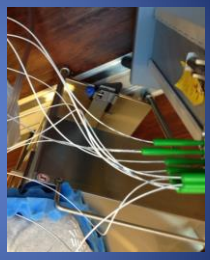
Multi-Catheter Simulation Sheet
Patient Name:
MR #:
Treatment Site:

Catheter Number	Length -1.4cm =total	Catheter Number	Length -1.4cm =total
1		11	
2		12	
3		13	
4		14	
5		15	
6		16	
7		17	
8		18	
9		19	
10		20	

Treatment Diagram

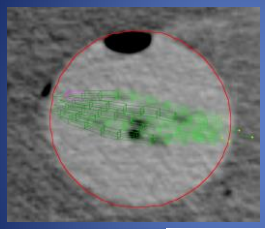
5. Proper transfer guide tube connection

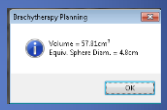
Good



Not as good (but usual clinical Environment)

6. Contouring Check





57.8 cm³ measured. vs. 58 cm³ fluid insertion.

7. Was the correct applicator used?

Vaginal Cylinder treatment
Check the metal band to confirm cylinder size

8. Was the correct library plan used?

Vaginal cylinder library plans used at UVa- 5 cylinder diameters, 3 treatment lengths

2 cm, 4 cm	Unapproved	Physicist			Brachy	
2 cm, 5 cm	Unapproved	Physicist			Brachy	
2 cm, 6 cm	Unapproved	Physicist			Brachy	
2.3 cm, 4 cm	Unapproved	Physicist			Brachy	
2.3 cm, 5 cm	Unapproved	Physicist			Brachy	
2.3 cm, 6 cm	Unapproved	Physicist			Brachy	
2.6 cm, 4 cm	Unapproved	Physicist			Brachy	
2.6 cm, 5 cm	Unapproved	Physicist			Brachy	
2.6 cm, 6 cm	Unapproved	Physicist			Brachy	
3 cm, 4cm	Unapproved	Physicist			Brachy	
3 cm, 5cm	Unapproved	Physicist			Brachy	
3 cm, 6 cm	Unapproved	Physicist			Brachy	
3.5, 4cm	Unapproved	Physicist			Brachy	
3.5, 5cm	Unapproved	Physicist			Brachy	
3.5, 6cm	Unapproved	Physicist			Brachy	

9. Applicator position (ie- has the applicator moved during the time it takes to image, plan, etc)

Studies have shown T&O can be displaced by moving patient from simulation to treatment table and then back to simulation

In vaginal cuff brachytherapy, even when insertion is performed by the same MD with the same immobilization and patient set up, variations in cylinder geometry seen between insertions

(see Chapter 21, Perez and Brady 6th edition)

What is meant by the term "IGBT" anyway?

Analogy to External Beam

2D Orthogonal X-rays, plaster contours, single slice CT->
3DCRT (1990's) CT simulation->
IMRT (2000) inverse planning->
IGRT (2005??) image with kV, CBCT immediately prior to treatment->
IGART

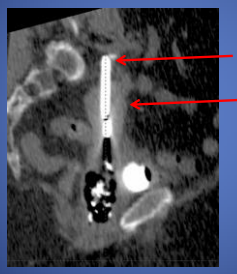
- references to IGBT in the literature discuss use of CT,MR for planning
- Example:"Image Guided Intracavitary HDR Brachytherapy for Cervix Cancer: A single institutional experience with 3D CT-based planning" Brachytherapy 2009

Normal patient flow

Applicator is placed (in OR???) ->
Patient is moved to recovery ->
Patient is moved to imaging system ->
Patient is moved to brachytherapy suite ->
Patient is treated

What happens to the applicator each time the patient is moved?

Y applicator placed in OR



IGBT Suite at UVa

Imaging System QA (in dedicated suites)

- TG 66 …….. (but)
- No external lasers
- No CT to density calibrations (if using TG-43)
- Annual QA may be simpler (no pediatric patients)

Scan-Plan-Treat Workflow

- Patient is not moved from scan position
- Vaginal Cuff- brachytherapy underwear holds applicator in place
- T&O- Fixation device is used to hold applicator in place
- Interstitial- patients maintained under anesthesia during process

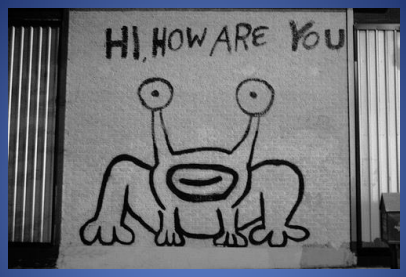
Planning (and QA) Times

- Vaginal cylinder- ~10 minutes
- T&O- ~ 25 minutes
- Interstitial- ~60 minutes

(time from CT scan to initiation of treatment)

Conclusions

- QA programs should use TG reports and regulations as a guide
- Patient specific QA does not just involve dose check but involves many aspects
- IGBT and scan-plan-treat workflows require establishment of policies and procedures to ensure safe patient treatment
- Makes things easier when you are preparing for ACR accreditation



(I'm a huge Daniel Johnston fan!)