Case studies of irradiators: Why do you need a QA program?
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Background

- **Medical x-rays**
  - Heavily regulated: FDA guidance, NRC, State regulation, etc.
  - Inspected routinely
  - Used day in and day out
  - QA requirements

- **Animal irradiators**
  - Guidance: AAPM TG-61 guidance
  - No validation method
  - No inspections
Importance of QA

- Consistent results
- Researcher would have an accurate dose to either animals or cells
- Determine when machine malfunction
- Build in cost for maintenance
- Provide information during audits of grants
Routine QA Preformed

- Linearity: kVp and mA
- Consistency
- Field Size- Verification on X and Y axis
- kVp Verification

- Cut off range: ~6 – 10 % variation in Consistency
X-Rad 320

Location: Sands
Installed: ~1999
X-Rad 320
History- original irradiator bought ~1999

- Highly used by researchers - Animals (mice/ rats) and Cells
- No QA performed on machine
- Machine would run into problems - no one would notice until results were off
- Dosimetry started to be completed: requested by grants - needed to know exact dose that animals or cells were being given
- QA started on the machine - Yearly - give or take
- Change in machine usage - daily to 3-5 times a week
- Continuous problems every 6-8 weeks
2010

- Machine started to having issues
- Complaints/ notices of results were inconsistent
- QA- during this time- was about every 6 months.
- Error messages would popped up
  - Ex. Arching, low voltage, cooling issues
- Would take close to 2-3 months before a service call would be put in
- Irradiator would be shut down during this time
- Filament got replace during this time
Film data with cell plate - 2010
2012

- After a few repairs
  - QA more routine
  - Consistency check being completed
  - Dosimetry being validated for various experiments
  - Continuous repairs/ errors every 6-8 weeks
Proof: Consistency checks

Monthly Consistency readings

- 320 kV - 2 minute readings
- 250 kV - 1.2 min readings
- 160 kV - 4.5 minute readings
Sands Pantex- After Tube Replacement

- New tube for Duke, but a used one; unsure of life of the new tube
- Full QA
- Full Dosimetry completed for routine items
- QA not used often- main use- Cell
- Weekly to bi-monthly Consistency check

Problem 1
- Within 8 weeks- cooling started to leak
- Cooling tubes were not installed properly
- O-Rings were being broken
- Consistency Re-check
Problem 2

- Secondary QA completed in Jan 2013
- 160 kVp and lower
  - Inconsistent readings
  - Error message: low voltage
  - Unable to register kVp - Random - nothing consistent

Currently advised:
- Use 250 kVp or higher only
- Any lower kVp - results are not guaranteed
- Look into buying a new irradiator
Xrad 160

New Machine- installed 10/2012
Xrad 160

- Anticipation for about 6 months
- Owner: Director of Cancer Research
- Strict use for Cells only
- Fruit Flies are allowed in

- Currently status- became operational as of 2/21/13
Xrad 160
Xrad 160 problems

- Initial/ After installation
  - X and Y axis- readings were not uniform- Major Heel Effect
  - Beam configuration change
    - Manufacture reconfigure the beam
- Design error with beam
Xrad 160 Heel Effect – After installation

Anode Heel Effect
Measured exposure along the x-axis

Exposure (R)

X-axial Distance from the center of the beam (inches)
Xrad 160- to correct the problem

- Reposition the beam
  - Tilted the X-ray tube
- Reposition in the holder to remove gap
After 2 months of waiting
Film validation
Xrad 160- Next set of problems

- Readers are not talking to each other
- May or may not turn on
- Replace computer, board, and HV
  - Completed in Jan 2013
- Most of the problem were intermittent
- Could not fully diagnose the problem
  - Worked well when service guy came out, could not duplicate the problem
- Finally diagnose the problem
  - Glitches in the computer board caused random false output
  - 2nd computer board replace
320 Irradiator
GSRBII
Xrad 320

- Problems existed: Mainly High Voltage error - dose reduction
- QA completed
- Potential Dose Reduction after long time use
- Machine continuously used
- Plan for potential replacement and servicing
Timing Error
Potential Problem

- Tube ramp-up in the beginning of exposure is not accounted for by the timer.
- Exposure during ramp-up is approximately worth one second of stable exposure.
- If uncorrected, timer error will result in considerable overdose in short exposures e.g. for a 15 sec exposure, ~7% overdose.
- Relative over-dose effect of timer-error diminishes with increased exposure time.
Observation: kVp & mA ramp-up

Exposure Rate

Ramp-up exposure

Total Exposure

Time (by timer)

Time
How does all these issues affect research?
Affects on Research

- Time and resources to complete new dosimetry every time machines are serviced
- Time wasted when the machine is down
- Potential replication in experiment- cells or animals
  - Cost in replicating animal study
    - Animal protocol to be resubmitted
    - Cost of animals to be replicated
    - Time and personnel to run the experiment
  - Cost in time for cell replication
    - Time for cell to be grown
    - Researchers frustration to figure out source of the problem
Why a QA program?

- Assist in detecting problems sooner than later
- Assist in planning for servicing to keep machines up and working
- Assist in planning for when we would need a new machine
- Validate dose accuracy in research,
- Publish accurate results
- Improve research
Implement a program

- Initial work
  - Verify current status
    - kVp output
    - Dose Readings
    - Linearity
    - Heel Effect

- Pick time frame for consistency check
  - Look at certain parameters
  - Verify those on a set time schedule
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