Quality Assurance in Radiation Therapy

Purpose (from George)
- To make aware of the needs for quality assurance in radiation therapy
- To identify components of a quality assurance program in radiation therapy
- To identify some of the quality assurance criteria in radiation therapy

General comments
- Routine QA testing is repetitive in nature and can be dull
- However, it becomes exciting when an important problem is found (maybe during routine testing)
- Physicists must have suspicious minds
- Can not become complaisant
- Redundant checks are necessary
What’s important

- Small deviations unlikely to injure patient or even be noticed
- Real problem is large errors - 15% - 400%
  - Miscalculation
  - Wrong machine data
  - Misinterpretation of written instructions
  - Incorrect decay
  - Wrong calculation factors, etc., etc.

Real life QA mistakes

-Large errors have life-threatening impact on patients

Cancer Patients Got Extra Radiation
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TAMPA - Because of a medical error discovered last month, 77 brain-tumor patients received incorrect doses of radiation at the H. Lee Moffitt Cancer Center & Research Institute, the hospital disclosed Friday.
From May 2004 to March 7, the patients were given 50 percent more radiation than intended during a procedure known as stereotactic radiosurgery, or "knifeless" brain surgery, Moffitt Director William Dalton said.
The mistake occurred when a $3 million stereotactic radiosurgery machine, installed at Moffitt in May, was incorrectly calibrated by one of the hospital’s medical physicists.
This statement informs radiation therapy system users of radiation overexposures that occurred at Panama’s National Institute of Oncology. The statement describes FDA’s investigation and provides recommendations for radiation therapy system users.

Radiation Overexposures

Twenty-eight patients at the Panama National Institute of Oncology were overexposed to radiation during radiation therapy for colon, prostate, and cervical cancer. The overexposures ranged from 20 to 100 percent over the prescribed dose. Reports to date indicate that nine of the patients have died, with five of the deaths attributed to radiation overexposure. Many of the remaining patients are expected to develop serious radiation related complications.

Review of the available reports indicates the following factors contributed to the overexposures:
- A lack of treatment plan verification at the Panama National Institute of Oncology
- The method of entering beam block data into the Multidata software
- Interpretation of beam block data by the Multidata software

The first serious accident with a medical source happened in a hospital in Columbus, Ohio, USA. Between 1974 and 1976, a wrong calibration, due to an error in the cobalt 60 half-life, caused the overexposure of 426 patients; their doses were 15-45% higher than the prescribed doses, depending on the time when they received their treatment.

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**Percent Overdose vs Month Treated and Patients Started During 2-Month Intervals**

Fig. 1: Progressive overdosage with time between October 1974 and February 1975.
Among the 183 patients who were still alive one year after their treatment, more than one third had severe complications of the central nervous system (brain and spine) and the gastrointestinal tract (oropharynx, colon, rectum).


ROSI

- http://www.clin.radfys.lu.se/default.asp
- ROSI is short for "Radiation Oncology Safety Information System"
- a voluntary web-based safety information database for Radiotherapy.
- The system is based on professional front-line staff in radiotherapy clinics reporting incidents and corrective actions over the Internet to a database.

Avoid large errors

- Incorporate redundancy
  - Independent check of measurements and calculations
- Suspect computer calculations
- Check cumulative dose at least weekly
- Check machine output at least weekly
- Check machine output whenever alterations or repairs are made
- State-to-state regulations can vary
- State regulations are limited and sometimes vague
- AAPM must provide leadership on QA guidelines

- 1. Acceptance testing of a new machine
  - The manufacturer owns the machine until all tests are satisfactory and the institution “accepts” (read: pays for) the machine.
  - Testing can take 2 or more weeks, if all goes well.
  - Beam data taking takes several more weeks
- 2. Develop a program to ensure that the machine is still “acceptable” (ongoing).
**QA schedule**

- Daily, monthly, annual
- Daily: test what is most unstable and/or critical
- Annual: unlikely to change over the year; tests on a monthly basis done more in depth

**What to check**

- Mechanical parameters
- Radiation parameters
- Imaging parameters
- Measurement equipment
- Safety procedures

**Table 2.2 - QA of medical accelerators**

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Procedure</th>
<th>Tolerance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daily</td>
<td>Dosemetry</td>
<td></td>
</tr>
<tr>
<td></td>
<td>X-ray output constancy</td>
<td>2%</td>
</tr>
<tr>
<td></td>
<td>Electron output constancy</td>
<td>2%</td>
</tr>
<tr>
<td></td>
<td>Mechanical</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Localization errors</td>
<td>1mm</td>
</tr>
<tr>
<td></td>
<td>Distance indicator (LED)</td>
<td>2mm</td>
</tr>
<tr>
<td></td>
<td>Safety</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Door interlock</td>
<td>Functional</td>
</tr>
<tr>
<td></td>
<td>Audiomonitor</td>
<td>Functional</td>
</tr>
</tbody>
</table>

Field size
Mechanical aspects of the machine
- Rotation of gantry, collimator, couch
- Jaw settings

Radiation aspects must coincide with mechanical

Mechanical is then “surrogate” for radiation when using daily for patient treatment
- **mechanical isocenter**
  - collimator rotation
  - gantry rotation
  - table rotation

- **radiation isocenter**
  - collimator
  - treatment table
  - gantry

- **x-ray beam performance**
  - energy
  - percent depth dose
  - field flatness
    - variation of dose relative to the central axis over the central 80% of the field size at 1 cm depth in a plane perpendicular to the central axis
    - plus or minus 3% is considered acceptable
  - field symmetry
    - divide profile in half by central axis, area under each half of the curve can not differ by more than 2%
Linear Accelerator Safety

- radiation survey
  - test of exposure levels outside room
  - head leakage
  - area survey
  - interlock tests
  - warning lights
  - emergency switches
  - survey evaluated for conditions expected in clinical use
    - workload
    - use factors
    - occupancy factors

Table 3.3 - QA of simulators

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Procedure</th>
<th>Tolerance ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daily</td>
<td>Locating lamps</td>
<td>1mms</td>
</tr>
<tr>
<td></td>
<td>Distance indicators (ODS)</td>
<td>1mms</td>
</tr>
<tr>
<td>Monthly</td>
<td>Field size indicator</td>
<td>1mm</td>
</tr>
<tr>
<td></td>
<td>Gantry/linear accelerator indicators</td>
<td>1 Bq</td>
</tr>
<tr>
<td></td>
<td>Cross-over receptor</td>
<td>1 mrad</td>
</tr>
<tr>
<td></td>
<td>Head size beam indicator</td>
<td>1mm</td>
</tr>
<tr>
<td></td>
<td>Pictures of image quality</td>
<td>Baseline</td>
</tr>
<tr>
<td></td>
<td>Emergency radiation escrometer</td>
<td>Baseline</td>
</tr>
<tr>
<td></td>
<td>Light/indicators radiation field uniformity</td>
<td>1% of %</td>
</tr>
<tr>
<td></td>
<td>Film dosimeter</td>
<td>Baseline</td>
</tr>
</tbody>
</table>

*The tolerance value that the parameter should not exceeded. The measured internal quality must be checked at least once a month.
More and more technology coming into the clinic

QA developed for every piece of new equipment and new process

Develop a systematic QA program that balances patient safety and quality vs available resources

TG100 risk based approach to QA
    - Hazard analysis for broad classes of radiotherapy procedures, develop the framework of the QA program