The Calibration Chain: Role of BIPM, PSDLs and ADCLs

J. Seuntjens and M. McEwen
McGill University & National Research Council
CANADA

Clinical Dosimetry for Radiotherapy, 2009 AAPM Summer School
a talk about jargon...
Rhetoric Question

• What is a “Round Robin”?  
   a) An orange-bellied bird with constipation issues  
   b) A dosimetry intercomparison program carried out between ADCLs, in which the comparison is not made to a primary standard, but just between secondary standards laboratories  
   c) A friendly, open-minded Summer School arrangement committee member
Radiotherapy Treatment Consistency

• Standardization and quality control

• Radiation therapy
  – Diagnosis
  – Planning
  – Delivery
  – Post-treatment evaluation

• In radiation therapy a standard can be a procedure and/or an artifact
Radiation Dosimetry

Traceability

Calibration Chain

Verification, QA and audits
CALIBRATION CHAIN

PSDL (NIST or NRCC) → \( \Delta T \) → \( N_{D,w} \) ADCL

SSDL or ADCL beam → \( Q \) → \( N_{D,w} \) clinic

AAPM-CLA → \( D_w \) clinic

Clinical beam → \( Q \) → \( D_w \) clinic

RPC
What is a PSDL?

- Primary Standards Dosimetry Laboratory
- The national laboratory designated by the government for the purpose of developing, maintaining and improving primary radiation standards
- NIST (Gaithersburg) or NRCC (Ottawa)
- In some countries there are no PSDLs
Primary Dosimetry Standard

• Instrument that allows the determination of absorbed dose according to its definition
• Preferably with a direct path to SI quantities not involved with ionizing radiation
• SI base unit: meter, kilogram, second, ampere, kelvin, mole, and candela
• SI derived units: J, Gy, etc.
• the path to base SI units is not always as “direct” as we would like
<table>
<thead>
<tr>
<th>Ionizing Radiation Related Quantities</th>
<th>SI derived Unit</th>
<th>Method</th>
<th>SI base quantities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Absorbed dose to water</td>
<td>Gy (J/kg)</td>
<td>calorimetry</td>
<td>Temperature, mass, length, time</td>
</tr>
<tr>
<td>Exposure</td>
<td>C/kg</td>
<td>Free-air or cavity ionization chamber</td>
<td>current, mass, time</td>
</tr>
<tr>
<td>Air kerma</td>
<td>Gy</td>
<td>Free-air or cavity ionization chamber</td>
<td>current, mass, time(*)</td>
</tr>
</tbody>
</table>

(*) requires the use of the product W/e \((L/\rho)_{c,\text{air}}\)
Water calorimeter

Measurement of energy, mass and temperature

\[ \text{energy} = \text{mass} \times \frac{\text{length}^2}{\text{time}^2} \]

No ionizing radiation needed to determine this quantity

Green: SI base unit
Orange: SI derived unit
Free air ionization chamber or cavity ionization chamber

Measurement of current, time

Length, density

Density = mass / length³

Green: SI base unit
Orange: SI derived unit

No ionizing radiation needed to determine the volume
Free air ionization chamber or cavity ionization chamber

Measurement of current, time

Length, density

Density = mass / length^3

Green: SI base unit
Orange: SI derived unit

No ionizing radiation needed to determine the volume

Does require the use of ionizing radiation
“Absolute dosimetry”

• Measurement of absorbed dose using a primary standard

• Absorbed dose measurement in absolute terms in clinical context (in reference field and at reference depth): clinical reference dosimetry
The “Bureau International des Poids et Mesures” (BIPM)

- BIPM = International laboratory created by the metre convention; has an Ionizing Radiation Division
- Role: development, maintenance of standards and intercomparison programs between primary standards laboratories
- Intercomparison programs involve the use of secondary standards, maintained at PSDLs
- [www.bipm.org](http://www.bipm.org)
The BIPM (cont’d)

• Through the BIPM intercomparison program the NMi can declare its calibration and measurement capabilities (CMCs)
• Key comparisons and database (http://kcdb.bipm.org)
• Mutual recognition agreement (MRA)
• Mutual recognition arrangement (MRA)
• CCRI Meetings (in Paris, dans la ville des villes, with excellent wine)
Secondary Standards Dosimetry Laboratories (SSDLs)

- SSDL = Laboratory designated by a competent national authorities to provide the necessary link in traceability of radiation dosimetry to national/international standards for users within that country.
SSDL characteristics

• Must take part in comparisons organized by the SSDL network (IAEA-WHO administered)

• Two types of SSDLs
  1. SSDLs that fulfill a national metrological function (often there is no PSDL)
  2. SSDLs that serve a group of local clinical centres without formal national mandate
SSDL network
What is an ADCL?

• Accredited Dosimetry Calibration Laboratory (the SSDL equivalent in NA but different...)
• Accredited by the AAPM
• Provides calibrations to users for instruments and radioactive sources for dosimetry in radiotherapy and diagnostic imaging
• Currently three ADCLs:
  – University of Wisconsin (Madison)
  – K&S Associates (Nashville)
  – MD Anderson Cancer Centre (Houston)

http://uwrcl.medphysics.wisc.edu/
http://www.kslab.com
http://rpc.mdanderson.org/adcl/
The AAPM CLA subcommittee: what does it do?

“Oversee all activities regarding the operations of the ADCLs. The Subcommittee’s task is to accredit, supervise and maintain the highest level of confidence in the quality of the ADCL system, with sufficient capacity in the system to prevent undue delays in satisfying the membership’s calibration needs while providing a choice of ADCLs.”

Main forum for discussion of issues relating to calibration of ion chambers and brachytherapy sources
Some history

• In 1971 the AAPM formed a task group to develop guidelines for the establishment of a system of secondary standard calibration laboratories.
  – The laboratories would be accredited by the AAPM to provide high precision dosimetry calibrations.
  – They would be outside of the National Institute of Standards and Technology (National Bureau of Standards as it was then) but traceable to NIST.

• Purpose:
  – To reduce the time required for precision calibrations
  – To create a system of secondary standard laboratories,
  – To establish a technical resource for the membership of the AAPM
Time progresses ...

• A sub-committee of the Radiation Therapy Committee of AAPM has overseen the development of the program to this day.
• Names have changed but the focus is still the same
• At the summer meeting of the AAPM in 1995, the Subcommittee initiated a major revision of the accreditation protocol which has resulted in the present criteria that now conform to ISO standard 17025:2005.
What does the CLA do?

- Develops criteria
- Accredits laboratories
- Carries out assessment visits
- Monitors performance
- Makes recommendations
What does the CLA not do?

- Does not set prices
- Does not recommend any one ADCL over another
- Does not distinguish between commercial and academic organizations
- Does not try to “spread the business around”
Accreditation

Procedure by which an authoritative body gives formal recognition that a body or person is competent to carry out specific tasks
ADCL Accreditation

• Formal recognition that a testing laboratory is competent to carry out specific tests or types of tests

• Key Words:
  – competent
  – specific tests (scope of testing)

• Accreditation means having a Quality System and demonstrating competency.

• Requires assessment (audit) visits to the laboratory to verify competency.
Activities of ADCLs in the context of maintenance of accreditation

- Perform proficiency tests = inter comparisons with the PSDL (NIST) on a rigid schedule
- Perform round robins = inter comparisons amongst ADCLs on a rigid schedule
- Undergo site visits from the CLA
- Undergo surveillance visits from the CLA
- Report activities to the CLA
Radiological Physics Center

• See next presentation...
Summary

• Clinical dosimetry in NA is traceable to national standards through a chain connecting clinics to ADCLs and PSDLs.
• National standards are declared equivalent through an MRA and key-comparisons
• In NA, ADCLs are monitored by the CLA subcommittee of the AAPM
  – ADCLs are accredited by CLA subcommittee by testing them against the AAPM criteria
  – Proficiency tests
  – Audits, Site visits
• ADCLs in NA are first class
Thank You