Pre-presentation Remarks

1) Application of patient radiation dose monitoring and tracking (PRDMT) systems is a relatively new implementation of “patient care”.

2) X-ray equipment must be compliant, at the minimum, with the DICOM*1 Modality Performed Procedure Step (MPPS) *2 to be compatible with most PRDMT systems. DICOM: Digital Imaging and Communications in Medicine. MPPS DICOM Standard is being retired.

3) New equipment manufactured today must be compliant with the DICOM Patient Radiation Dose Structured Report (p-RDSR).

4) All PRDMT systems/programs take advantage of p-RDSR. In fact, the RDSR is a prerequisite for most commercially available software programs.

5) There are approximately (more than) 14 PRDMT programs available on the commercial market according to Imaging Technology News[^1], such as, “Agfa HealthCare, Bayer Healthcare, GE Healthcare, Imalogix, Infinitt, Medic Vision Imaging, Novarad, PACSHealth, Sectra, Siemens Healthcare, Toshiba America, Volpara Solutions, Inc., etc.”

6) Most medical institutions have just one PRDMT system installed.

7) At Virginia Commonwealth University Medical Center (VCUMC) three PRDMT systems are installed; namely DoseWatch, Radimetrics and PEMNET.

8) University of Virginia Medical Center is installed with Radimetrics.

9) Some of the PRDMT systems are initially designed specifically for the imaging equipment manufacturers and may not be compatible with the equipment you may have in your institution.

10) In this Diagnostic Symposium, we will have to limit ourselves to two specific vendor products for the reasons spelled out in items (6) ~ (9).
**Definition of International Reference Point (IRP):**
**IEC Report 60601, 2010**

Medical electrical equipment-part 2-43: particular requirements for the safety of X-ray equipment for interventional procedures: Patient entrance reference point. IEC 2010. The patient exposure reference point or Interventional Reference Point (IRP). This reference point is commonly (but not always) defined at 15 cm towards the X-ray tube from the isocenter.

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1. The first order of correction; the air kerma values reported by the fluoroscopy equipment must be verified and/or calibrated. (AAPM TG 190 Report)

2. Attenuation due to The Examination Table and Patient Examination Pad/Mattress.

3. The Back Scatter

4. Geometrical Parameters:
   a) The Tabletop Motion (Panning) X-Z plane.
   b) The Source-to-Tabletop Distance Y-distance/rotation angles
   c) The C-arm Gantry Angulation; primary and secondary.
The physical or pseudo DAP-meter (Dose-Area Product Meter) is calibrated at “International Reference Point” (IRP). Therefore, the reported values ARE NOT patient skin dose (air kerma), and may differs from actual Patient's Skin LOCATIONS.

The IRP is physically fixed to the x-ray tube by definition. The “panning” of the examination table and the angulation of the C-arm gantry are not accounted for.

The DAP-meter accuracy depends on three factors:

a) Accuracy of the Dosimeter.
b) Accuracy of Field Size Measurement, and
c) The Geometry discrepancy between the Calibration Geometry and the Clinical Geometry. (AAPM Report TG 190) [www.aapm.org]

The “area” may be of secondary importance since the “PEAK SKIN DOSE” is what we are interested in.

With the background information provided, we are finally ready to discuss the process of estimating the Peak Skin Dose from the data made available by the patient radiation dose monitoring and tracking (PRDMT) systems.

AAPM Report TG190

Accuracy and Calibration of Integrated Radiation Output Indicators in Diagnostic Radiology:

For PSD estimation, the

AAPM Spring Clinical Meeting, Fluoroscopy Patient Peak Skin Dose Monitoring and Tracking Diagnostic Symposium April 9, 2018.
Corrections must also be applied according to the “kVp”, “Spectral Shaping Filter” and whether it is acquired under “MOTION”, stepping mode or “Rotational” mode.

Typically, the radiation field is “nearly” a square. So a square FOV can be assumed for most cardiac cases and neuro radiology examinations.

Ideally, the angular variable may be applied in a contiguous angle changes and account for the overlapped areas.

We initially applied a 30-degree increment and this correction is enhanced as the “SKIN DOSE MAPPING” becomes available.

An Event Type correction is more related to Table Attenuation, Spectral Shaping Filter correction. Typically, “Fluoroscopy” mode is operated with spectral shaping filters (SSF) that are (1) dynamically changed or (2) static/fixed once the “procedure” is selected. [See AAPM TG 125 Report.]

Depending on the system programming, the “Stationary Acquisition” mode may have no SSF or functions similar to fluoroscopy mode under dynamic SSF operation.

Rotational Angiography Acquisition — the correction factor may be suggested by AAPM TG 222 (in progress) in conjunction with AAPM TG 246 (in final review).

Stepping Digital Acquisition (DA/DSA) — currently only one Reference Point Dose is given. But, clearly the anatomical locations differ and corrections may be recommended if a high PSD is observed/reported.

The question here is: Whether the definition is: Patient Centric, or Operator Centric! The Software takes the DICOM RDSR Tags and Implement the definition in accordance to the “Conventional Understanding” While DICOM definition is “Operator” Centric, we “THINK” in “Patient” Centric orientation.
The spectral shaping filters employed are typically, 0.1, 0.2, 0.3, 0.6, and 0.9 mmCu. Other filters of varying materials and thicknesses are also employed in conjunction with the fluoroscopy “trajectories” or “curves”. The primary radiation beam may be attenuated by the examination tabletop and the patient pad (mattress). The radiation dose received by the patient will be lower for the PA-projections and any angled projection that is intercepted by the tabletop.

The most important parameter in estimating the PSD is the Tabletop Location; the Table Height in the case of PA-projection. On the other hand, the Table Lateral Location is definitely more important for the Lateral-projection.

Table Height Correction Is Most Important.

The attenuation is corrected with the transmission factor. It must be determined individually specific to the angiography equipment.

List of Correction Factors

<table>
<thead>
<tr>
<th>Physical Parameter</th>
<th>Correction Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Backscatter</td>
<td>1.3</td>
</tr>
<tr>
<td>Tissue-to-air Ratio</td>
<td>1.06</td>
</tr>
<tr>
<td>No Spectral Shaping Filter (SSF)</td>
<td>0.5/0.65</td>
</tr>
<tr>
<td>All Other SSF (GE and Siemens)</td>
<td>0.7</td>
</tr>
<tr>
<td>Rotational Angiography</td>
<td>0.257</td>
</tr>
</tbody>
</table>

This is the same slide as “Slide 12”. Line 238 shows what the Displayed Dose is, as opposed to, the Corrected Dose is.

So, when the peak skin dose for this patient was “estimated” at almost 10000 mGy (10 Gy). The real question is then what are we going to do about it; i.e., The Caring of Patient. It is essential that;

1. A systemic structure must be arranged to coordinate the data received and implement the process. At VCU Health, the Clinical Radiation Safety Office is assigned to oversee this patient care process/procedure.
2. The technical and physics support is provided by the Division of Radiation Physics and Biology, Department of Radiology, VCU.
3. Need to establish “levels” of PSD and what actions are necessary.
4. An enterprise wide “uniform” patient care policy must be established.
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Finally, it should be pointed out that the preparatory steps in attaining better accuracy of Peak Skin Dose is an evolving process. In other words:

i. There are still many more unsolved “parameters” that need to be considered for a more “exact" PSD estimation. Therefore, the slides and calculations discussed herein is still being improved.

ii. Most patient radiation dose monitoring and tracking (PRDMT) programs that are available on the commercial market do not provided PSD calculation.

iii. Those programs that do provide PSD calculation may not necessarily including all correction factors discussed in this presentation. Only vendor specific proprietary software may have most of the correction factors necessary to achieve the “close‐to‐real" patient PSD.

iv. The PSD obtained is NOT including the size and shape of the patient. It is therefore, reasonable to say, the PSD is estimated at the distance the radiation field is being projected on a cylindrical shape patient.

v. And, the registration of patient (anatomical) location is not specified. (IEC is working on this matter.)

Details of Organizational Structure and Administrative Operation of Institutional Infrastructure for Fluoroscopy Exposure Monitoring and Tracking; i.e., The Caring of Patient will be discussed in the last talk of this Symposium, presented by Jan Clark.

Summary of Reports/References

IEC Report 60601
Medical electrical equipment part 2-43: particular requirements for the safety of X-radiation equipment for interventional procedures: Patient entrance reference point. IEC 2010. The patient exposure reference point or Interventional Reference Point (IRP). This reference point is common (but not always) defined at 15 cm towards the X-ray tube of the isocenter.

AAPM Report TG190

AAPM Report TG 125 (Full Report)

AAPM Report TG 246; Patient Skin Dose with Fluoroscopy (A Review of Present Methodology and DICOM Implementation) Joint Report of the American Association of Physicists in Medicine (AAPM) Task Group 246 and the European Federation of Organisations for Medical Physics (EUFOMP) (Being Reviewed)

AAPM Report TG 272; Comprehensive Acceptance Testing and Evaluation of Fluoroscopy Imaging Systems (In Progress)