Preparation For Peak Skin Dose Estimation

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Please jot down the Slide Number where you would like to ask a question at the end of the presentation.

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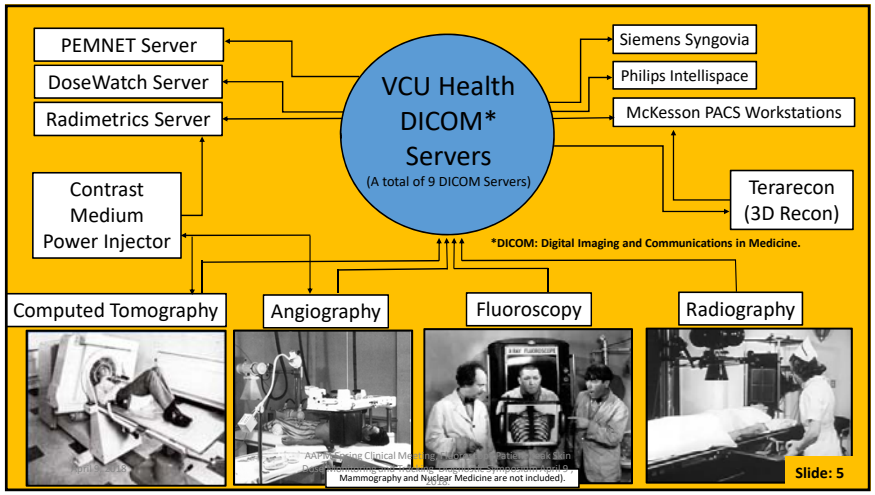
Pre-presentation Remarks

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.
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.

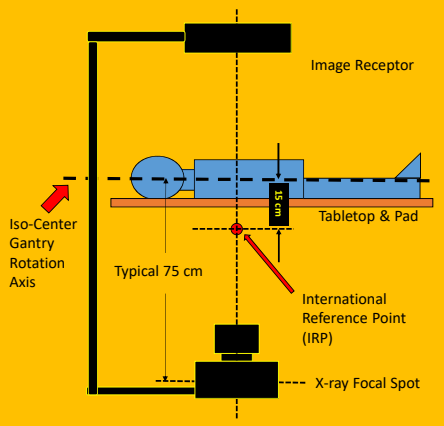
*[1] DICOM: Digital Imaging and Communications in Medicine.
*[2] MPPS DICOM Standard is being retired.

5) There are approximately (more than) 14 PRDMT programs available on the commercial market according to *Imaging Technology News* ["ITN, Sept. 2017, https://www.itnonline.com/article/basics-radiation-dosemonitoring-medical-imaging"]; such as, "Agfa HealthCare, Bayer Healthcare, GE Healthcare, Imalogix, Infinitt, Medic Vision Imaging, Novarad, PACSHealth, Sectra, Siemens Healthineers, 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.**



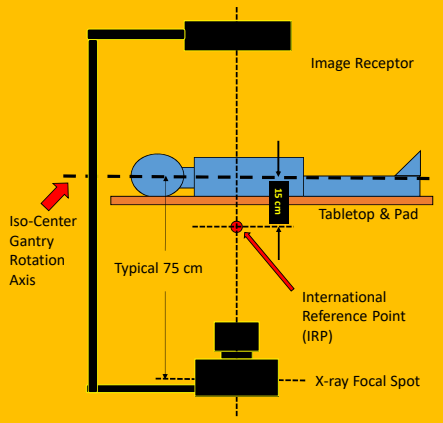
The **International Reference Point (IRP) air kerma value,** at this point in time, is reported by PRDMT systems.

To continuously monitor the radiation "LIVE", the physical DAP-meter (Dose Area Product) is mounted on the faceplate of the collimator.

The **IRP** is defined due to this "mechanical" constraint, and as such it is not the same as the patient peak skin dose.

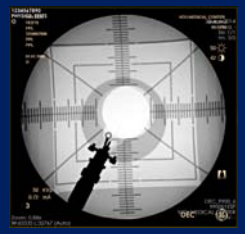
To achieve more accurate and realistic estimation of the **Peak Skin Dose (PSD)** various corrections must be applied.

All PRDMT programs including PEMNET, Radimetrics and DoseWatch provide various parameters that need to be included for correction from **IRP to PSD**, and they are;



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.

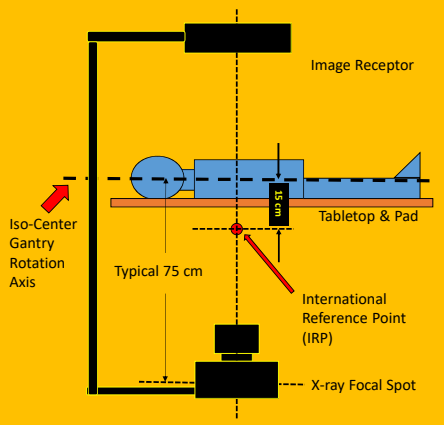
The DAP-meter accuracy depends on three factors.

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.prg]

AAPM Report TG190

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

For PSD estimation, 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.

Vendor:	PRDMT	Dose Mapping Corrections					Collection and Analysis of Statistical Data
		Examination Table (Panning) Geometrical Correction			C-arm and L-arm Gantry Angles		
PEMNET Radimetrics DoseWatch	(PMMS) RDSR Compatible	Vertical	Longitudinal	Lateral	Primary	Secondary	Export Data

Table 1. Sample PEMNET Spreadsheet in Microsoft Office Excel Format

Target Region	ACQ Plane	Dose RP (mGy)	DAP (uGy-m^2)	Prime Angle (deg)	Secondary Angle (deg)	Event Type	KVP (kV)	MA (mA)	Exposure Time (ms)	Exposure (uAs)	Pulses	Pulse Width (ms)	Pulse Rate (p/s)	Source To Detect (mm)	Source To Isocenter (mm)	Table Long (mm)	Table Lat (mm)	Table Height (mm)	Focal Spot Size (mm)	Filter Min (mm)	Filter Max (mm)	Filter Type	Filter Material	Corrected Dose (mGy)
Entire body	Plane A	1.3	20.6	0.1	-0.1	Fluoroscopy	71	58	587.6	34080	52	11.3	10	1071	750	-4.6	46	197.5	0.3	0.3	0.3	Strip Filter	r Copper c	1.4
Entire body	Plane B	0.7	12.4	-89.5	-0.2	Fluoroscopy	70	40	184	7360	23	8	10	1217	750	-6.6	104	197.5	0.3	0.2	0.2	Strip Filter	r Copper c	0.8
Entire body	Plane A	139.1	2151.4	0.1	11.5	Stationary Acquisition	83	285	2386.5	679913	37	64.5	4	1069	750	-5	120	171.4	0.6			No Filter		130.4
Entire body	Plane B	78.3	933.5	-89.5	-0.2	Stationary Acquisition	85	136	2386.5	325041	37	64.5	4	1217	750	-7.1	141	171.3	0.3			No Filter		73.3
Entire body	Plane A	50.2	1398.4	-98.5	-0.1	Rotational Acquisition	70	384	917.7	352763	133	6.9	30	1201	750	-2.1	131	187.8	0.6			No Filter		49.7
Grand To	9347.6																					Grand Tot		9680.8

This is just a small fraction of data presented by the PRDMP (patient radiation dose monitoring and tracking program). For this specific study, there were some 230 exposure steps (event) made.

Corrections must also be applied according to the "kVp", "Spectral Shaping Filter" and whether it is acquired under "MOTION"; stepping mode or "Rotational" mode .

Table 1. Sample PEMNET Spreadsheet in Microsoft Office Excel Format

		Correction to a square FOV (cm X cm)			Large FOV with small angle will Overlap		Appropriate Correction factors?!	These parameters are important but may not be needed for correction purposes.											DICOM Definition & Interpretation			Attenuation due to the Tabletop and TablePad				
	Target Region	ACQ Plane	Dose RP (mGy)	DAP (μGy-m²)	Calculated FOV (cm) (Square)	Prime Angle (deg)	Secondary Angle (deg)	Event Type	kVP (kV)	MA (mA)	Exposure Time (ms)	Exposure (μAs)	Pulses	Pulse Width (ms)	Pulse Rate (p/s)	Source To Detect (mm)	Source To Isocenter (mm)	Table Long (mm)	Table Lat (mm)	Table Height (mm)	Focal Spot Size (mm)	Filter Min (mm)	Filter Max (mm)	Filter Type	Filter Material	Corrected Dose (mGy)
3	Entire body	Plane A	1.3	20.6	12.59	0.1	-0.1	Fluoroscopy	71	58	587.6	34080	52	11	10	1071	750	-4.6	46	198	0.3	0.3	0.3	Strip Filter	Copper or Copper compound	1.3
14	Entire body	Plane B	0.7	12.4	12.94	-89.5	-0.2	Fluoroscopy	70	40	184	7360	23	8	10	1217	750	-6.6	104	198	0.3	0.2	0.2	Strip Filter	Copper or Copper compound	0.8
15	Entire body	Plane A	139.1	2151.4	12.44	0.1	11.5	Stationary Acquisition	83	285	2386.5	679913	37	65	4	1069	750	-5	120	171	0.6			No Filter		130.4
17	Entire body	Plane B	78.3	933.5	10.92	-89.5	-0.2	Stationary Acquisition	85	136	2386.5	325041	37	65	4	1217	750	-7.1	141	171	0.3			No Filter		73.3
18	Entire body	Plane A	50.2	1398.4	16.70	-98.5	-0.1	Rotational Acquisition	70	384	917.7	352763	133	6.9	30	1201	750	-2.1	131	188	0.6			No Filter		49.7
65		Primary Angle				Every 30° or finner increments? Continuous angle inregration?		Stepping DSA																		Peak Skin Dose
239																										

Table 1. Sample

	Correction to a square FOV (cm X cm)					Large FOV with small angle will Overlap	Appropriate Correction factors?!
Target Region	ACQ Plane	Dose RP (mGy)	DAP (μGy-m²)	Calculated FOV (cm) (Square)	Prime Angle (deg)	Secondary Angle (deg)	Event Type
Entire body	Plane A	1.3	20.6	12.59	0.1	-0.1	Fluoroscopy
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Entire body	Plane A	139.1	2151.4	12.44	0.1	11.5	Stationary Acquisition
Entire body	Plane B	78.3	933.5	10.92	-89.5	-0.2	Stationary Acquisition
Entire body	Plane A	50.2	1398.4	16.70	-98.5	-0.1	Rotational Acquisition
	Primary Angle				Every 30° or finner increments? Continuous angle inregration?		Stepping DSA

One might attempt to apply corrections of Field-of-View (FOV) to account for the field overlap which is also dependent on the "Primary Angle".

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

Visceral angiography will cover a somewhat larger body areas ---- the Tabletop geometrical parameters need to be examined, i.e., **Stepping Mode**.

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.

Table 1. Sample

	Correction to a square FOV (cm X cm)					Large FOV with small angle will Overlap	Appropriate Correction factors?!
Target Region	ACQ Plane	Dose RP (mGy)	DAP (μGy-m²)	Calculated FOV (cm) (Square)	Prime Angle (deg)	Secondary Angle (deg)	Event Type
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	Primary Angle				Every 30° or finner increments? Continuous angle inregration?		Stepping DSA

The 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 programing, 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 272** (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.

DICOM Definition & Interpretation				Attenuation due to the Tabletop and TablePad				
Table Long (mm)	Table Lat (mm)	Table Height (mm)	Focal Spot Size (mm)	Filter Min (mm)	Filter Max (mm)	Filter Type	Filter Material	Corrected Dose (mGy)
-4.6	46	198	0.3	0.3	0.3	Strip Filter	Copper or Copper compound	1.3
-6.6	104	198	0.3	0.2	0.2	Strip Filter	Copper or Copper compound	0.8
-5	120	171	0.6			No Filter		130.4
-7.1	141	171	0.3			No Filter		73.3
-2.1	131	188	0.6			No Filter		49.7
								Peak Skin Dose

DICOM Definition and Conventional Understanding of "Longitudinal" and "Lateral".

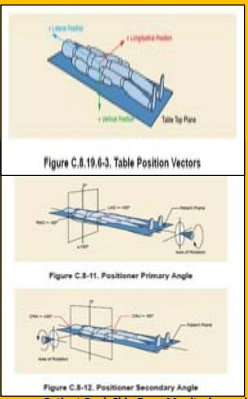

Figure C.8.19.6-3. Table Position Vectors

Figure C.8-11. Positioner Primary Angle

Figure C.8-12. Positioner Secondary Angle

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.

DICOM Definition & Interpretation				Attenuation due to the Tabletop and TablePad				
Table Long (mm)	Table Lat (mm)	Table Height (mm)	Focal Spot Size (mm)	Filter Min (mm)	Filter Max (mm)	Filter Type	Filter Material	Corrected Dose (mGy)
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-7.1	141	171	0.3			No Filter		73.3
-2.1	131	188	0.6			No Filter		49.7
								Peak Skin Dose

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.

List of Correction Factors

Physical Parameters	Correction
Backscatter	1.3
Tissue-to-Air Ratio	1.06
No Spectral Shaping Filter (SSF)	0.5~0.65
All Other SSF [GE and Siemens]	0.7
Rotational Angiography	0.25?

Transmission Factor

SSF	X-ray Tube Potential (kVp)								
mmCu	50	60	70	80	90	100	110	120	average
0.0	0.59	0.61	0.63	0.64	0.65	0.66	0.67	0.68	0.64
0.1	0.64	0.66	0.68	0.68	0.69	0.70	0.70	0.71	0.69
0.2	0.65	0.68	0.69	0.70	0.70	0.71	0.71	0.72	0.70
0.3	0.66	0.68	0.70	0.71	0.71	0.72	0.72	0.73	0.71
0.6	0.68	0.70	0.71	0.72	0.72	0.73	0.73	0.74	0.72
0.9	0.69	0.71	0.73	0.72	0.73	0.73	0.74	0.74	0.73
average	0.65	0.67	0.69	0.69	0.70	0.71	0.71	0.72	

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

	60 kVp				70 kVp				80 kVp				90 kVp				100 kVp				110 kVp				120 kVp			
	Table & Pad		In Air		Table & Pad		In Air		Table & Pad		In Air		Table & Pad		In Air		Table & Pad		In Air		Table & Pad		In Air		Table & Pad		In Air	
mmCu	µGy	mmAl	µGy	mmAl	µGy	mmAl	µGy	mmAl	µGy	mmAl	µGy	mmAl	µGy	mmAl	µGy	mmAl	µGy	mmAl	µGy	mmAl	µGy	mmAl	µGy	mmAl	µGy	mmAl	µGy	mmAl
0.0	293.2	2.49	479.8	2.24	423.7	2.96	674.5	2.66	564.3	3.47	882.3	3.09	720.4	3.95	1104.0	3.54	890.0	4.44	1346.0	4.00	1071.0	4.92	1601.0	4.46	1266.0	5.39	1873.0	4.92
0.1	139.6	3.42	211.8	3.20	225.3	4.11	333.7	3.89	323.6	4.76	473.6	4.56	438.0	5.35	634.0	5.13	568.6	5.94	813.9	5.67	710.6	6.45	1010.0	6.19	867.8	6.95	1226.0	6.68
0.2	81.8	4.05	121.0	3.89	144.2	4.81	209.8	4.68	221.8	5.59	318.3	5.40	315.2	6.22	447.5	6.05	423.9	6.82	596.3	6.65	545.6	7.36	763.3	7.19	684.0	7.88	948.7	7.68
0.3	51.4	4.50	75.1	4.39	98.5	5.41	141.3	5.27	160.9	6.21	227.7	6.09	238.2	6.93	334.0	6.78	330.7	7.53	460.0	7.39	435.2	8.06	602.9	7.91	556.6	8.57	767.4	8.44
0.6	18.0	5.41	25.7	5.36	42.7	6.48	60.1	6.39	79.8	7.44	111.2	7.36	130.2	8.20	180.2	8.15	193.9	8.88	266.1	8.81	270.3	9.42	369.3	9.38	360.5	9.99	490.3	9.94
0.9	7.7	6.0	10.9	6.0	22.3	7.2	30.7	7.1	46.7	8.1	64.6	8.1	83.0	8.9	113.8	8.9	131.3	9.6	179.0	9.6	191.6	10.1	260.4	10.1	266.3	10.7	361.0	10.7
	Ratio	HVL Ratio	Ratio	HVL Ratio	Ratio	HVL Ratio	Ratio	HVL Ratio	Ratio	HVL Ratio	Ratio	HVL Ratio	Ratio	HVL Ratio	Ratio	HVL Ratio	Ratio	HVL Ratio	Ratio	HVL Ratio	Ratio	HVL Ratio	Ratio	HVL Ratio	Ratio	HVL Ratio	Ratio	HVL Ratio
0.0	0.61	1.11	0.63	1.11	0.64	1.12	0.65	1.12	0.66	1.11	0.67	1.10	0.68	1.10														
0.1	0.66	1.07	0.68	1.06	0.68	1.04	0.69	1.04	0.70	1.05	0.70	1.04	0.71	1.04														
0.2	0.68	1.04	0.69	1.03	0.70	1.04	0.70	1.03	0.71	1.03	0.71	1.02	0.72	1.03														
0.3	0.68	1.03	0.70	1.03	0.71	1.02	0.71	1.02	0.72	1.02	0.72	1.02	0.73	1.02														
0.6	0.70	1.01	0.71	1.01	0.72	1.01	0.72	1.01	0.73	1.01	0.73	1.00	0.74	1.01														
0.9	0.71	1.00	0.73	1.01	0.72	1.00	0.73	1.00	0.73	1.00	0.74	1.00	0.74	1.00														

Table 1. Sample PEMNET Spreadsheet in Microsoft Office Excel Format

	Target Region	ACQ Plane	Dose RP (mGy)	DAP (uGy-m^2)	Prime Angle (deg)	Secondary Angle (deg)	Event Type	KVP (kV)	MA (mA)	Exposure Time (ms)	Exposure (uAs)	Pulses	Pulse Width (ms)	Pulse Rate (p/s)	Source To Detect (mm)	Source To Isocenter (mm)	Table Long (mm)	Table Lat (mm)	Table Height (mm)	Focal Spot Size (mm)	Filter Min (mm)	Filter Max (mm)	Filter Type	Filter Material	Corrected Dose (mGy)
13	Entire body	Plane A	1.3	20.6	0.1	-0.1	Fluoroscopy	71	58	587.6	34080	52	11.3	10	1071	750	-4.6	46	197.5	0.3	0.3	0.3	Strip Filter	Copper c	1.4
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17	Entire body	Plane B	78.3	933.5	-89.5		Acquisition																No Filter		73.3
64	Entire body	Plane A	50.2	1398.4	-98.5	-0.1	Rotational Acquisition	70	384	917.7	352763	133	6.9	30	1201	750	-2.1	131	187.8	0.6			No Filter		49.7
238	Grand Total		9347.6	DISPLAYED DOSE															CORRECTED DOSE				Grand Total		9680.8

Details of calculation formula will be discussed in the second talk of this Symposium, presented by Frank Corwin.

Other aspect and features of a PRDMT program is discussed in the third talk of this Symposium, presented by Allen Goode.

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.

Investigation Level	Evaluation Level		Reporting Level		TJC Sentinel Event	
(2,000 mGy-5,000 mGy)	(>5,000-10,000 mGy)		(>10,000-15,000 mGy)		(>15,000 mGy)	
	To A Single Anatomical Area		To A Single Anatomical Area		To A Single Anatomical Area	
Single Dose	Single Dose	Cumulative Dose	Single Dose	Cumulative Dose	Single Dose	Cumulative Dose

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The real question is then wha… …e Caring of Patient.
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(2) The technical and physi… …Radiation Physics and Biology, Department of…
(3) Need to establish "leve… …ry.
(4) An enterprise wide "un… …blished.

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.

Investigation Level (2,000 mGy-5,000 mGy)	Evaluation Level (>5,000-10,000 mGy) To A Single Anatomical Area		Reporting Level (>10,000-15,000 mGy) To A Single Anatomical Area		TJC Sentinel Event (>15,000 mGy) To A Single Anatomical Area	
Single Dose	Single Dose	Cumulative Dose	Single Dose	Cumulative Dose	Single Dose	Cumulative Dose

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.)

Direct your questions to my E-mail Address at < pei-jan.lin@vcuhealth.org>

Summary of Reports/References

IEC Report 60601
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 of the isocenter.

AAPM Report TG190
Lin PJ, Schueler BA, et.al. "Accuracy and Calibration of Integrated Radiation Output Indicators In Diagnostic Radiology: A Report of the AAPM Imaging Physics Committee Task Group 190", Radiography / Fluoroscopy Subcommittee, Imaging Physics Committee, Science Council", AAPM, Med. Phys. 42(12), December 2015. pp 6815-6829.
http://www.aapm.org/pubs/reports/

AAPM Report TG 125 (Full Report)
Lin PJ, Rauch P, et.al. AAPM Report 125 Report, Functionality and Operation of Fluoroscopic Automatic Brightness Control/Automatic Dose Rate Control Logic in Modern Cardiovascular and Interventional Angiographic Systems, June 2012.
{**AAPM TG 125 (Executive Summary);** Medical Physics, 2012, Vol. 39, Issue 5, pp 2826-2828.}
http://www.aapm.org/pubs/reports/

AAPM Report TG 246: Patient Skin Dose with Fluoroscopy (*A Review of Present Methodology and DICOM Information*) Joint Report of the American Association of Physicists in Medicine (AAPM) Task Group 246 and the European Federation of Organizations for Medical Physics (EFOMP) (Being Reviewed)
AAPM Report TG 272: Comprehensive Acceptance Testing and Evaluation of Fluoroscopy Imaging Systems (In Progress)

AAPM Spring Clinical Meeting, Fluoroscopy Patient Peak Skin Dose Monitoring and Tracking Diagnostic Symposium April 9 , 2018.