Digital Exposure & Radiation Safety

CSRT 2012

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So here's one little bit of foolishness before we begin

- It's your first kiss and several questions come to mind.
- Is it the right time?
- Is anyone watching?
- Is your breath fresh?
- Is your partner ready?
- Then you just decide it's now or never…

Our digital world has two new paradigm's

- In the film/screen world, when a film was light there was nothing you could do to fix it.
- Hence, the motto was: "when it doubt, dark it out."
- This meant whenever you weren't sure about a technique, you would always opt for the dark side (which is why the hot light was so handy).
- That concept *should* be completely different in the digital world. The first new digital paradigm is all about getting a great image using the *least* amount of radiation possible.
- The other paradigm shift is using higher kV's.

Thinking outside the box, especially when it's a brand "new" box.

- CT first used in 1972.
- Fuji's first CR out in 1983.
- The kVp on a foot CT is…
- 120 kVp.
- Of course it is extremely well collimated, which is why we can't use such a high kVp.
- But we need to remember the CT story.

Barry Burns –the CR guru

- Barry Burns - MS, RT(R), DABR – Retired adjunct Professor of Radiologic Science, University of North Carolina School of Medicine in Chapel Hill, North Carolina, stipulates that when using CR everyone can **increase 15-20 kV** from film/screen techniques (except Konica which is 5-10 kV).

The following slides show a hand phantom exposed from 50 to 100 kV to demonstrate the minute differences visualized on an image using higher kV's with both CR and DR.

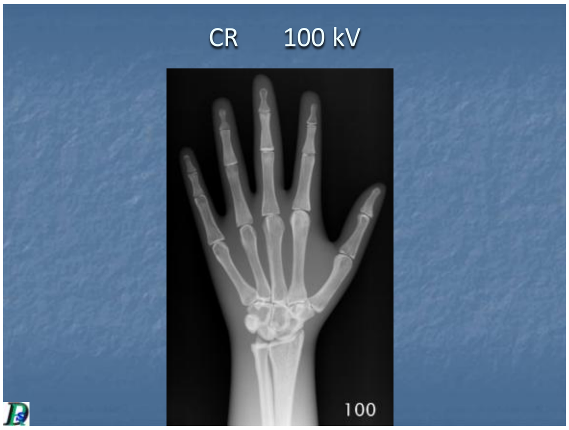
CR 50 kV

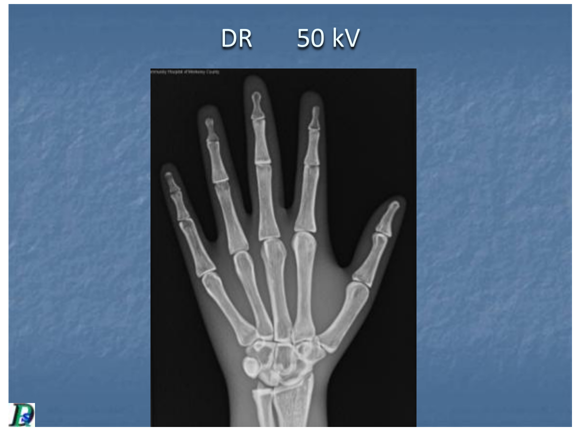
CR 60 kV

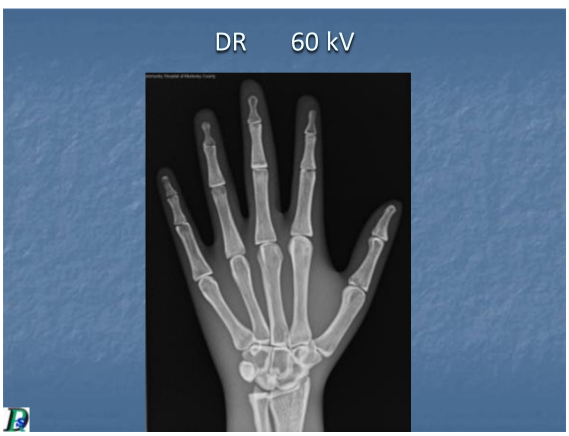
CR 70 kV

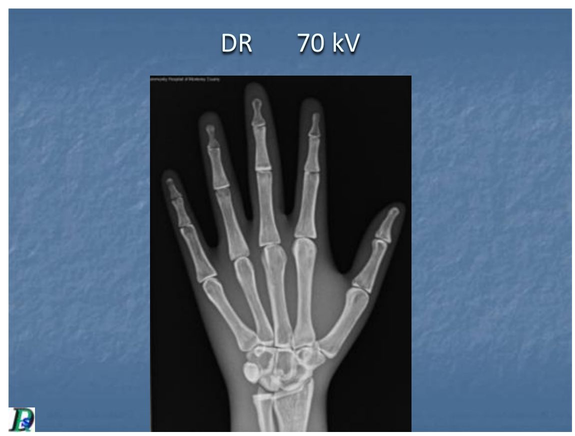
CR 80 kV

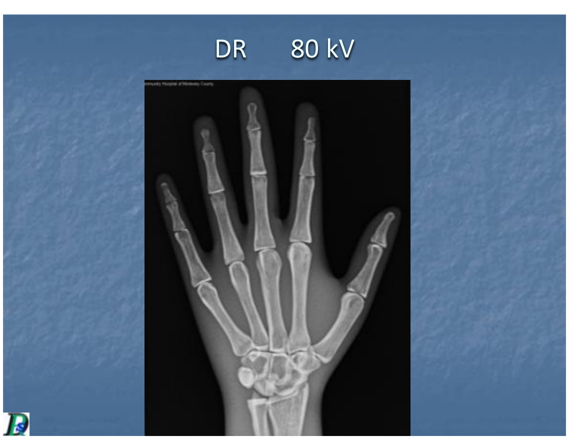
CR 90 kV

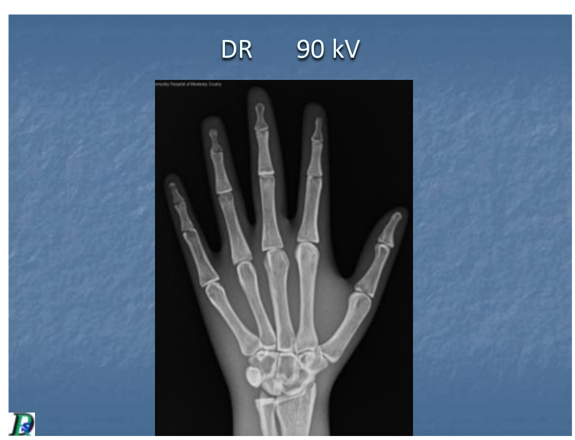

CR 100 kV
100


DR 50 kV


DR 60 kV

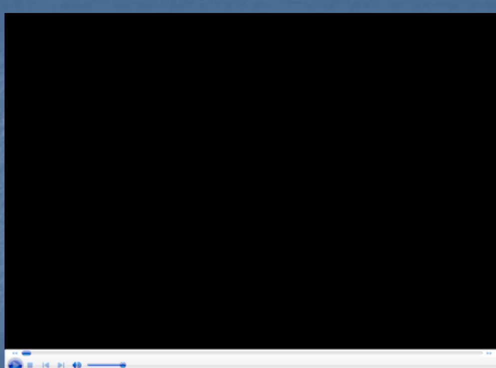

DR 70 kV


DR 80 kV


DR 90 kV

DR 100 kV

Stewart Bushong and the penguin



Low Flier

- Out of over 145 slides I have, 15 Low Flier's.

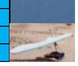
These are the "new" digital Optimum kVs as developed by Barry Burns

DIGITAL OPTIMUM kV

Body Part - Adult	kV
Chest (Bucky/Grid)	110-130
Chest (Non-Grid)	80-90
Abdomen	80-85
Extremities (Non-Grid)	65-75
Extremities (Grid)	75-90
Extremities (Bucky)	85-95
AP Spines	85-95
C-Spine Lateral	85-100
T-Spine Lateral	85-100
L-Spine Lateral	85-100
Ribs	80-90
Skull	80-90
BE (Air Con)	110-120
Abdomen (Iodine)	76-80
Pediatric:	
Infant Extremities	50-60
Pediatric Chest (Screen)	70-80

Konica CR OPTIMUM kV

Body Part - Adult	kV
Chest (Bucky/Grid)	110-130
Chest (Non-Grid)	80-90
Abdomen (Iodine)	70-75
Extremities (Non-Grid)	60-65
Extremities (Grid)	65-70
Extremities (Bucky)	70-75
AP Spines	75-80
C-Spine Lateral	75-90
T-Spine Lateral	75-85
L-Spine Lateral	75-90
Ribs (Upper and Lower)	70-75
Skull	75-80
BE (Air Con)	100
Pediatric:	
Infant Extremities	50-60
Pediatric Chest (Screen)	70-80



Universal CR Technique Chart using a standard 2.1 LgM (Most Dose)

UNIVERSAL CR TECHNIQUE CHART LgM 2.1

Part	View	Small		Medium		Large	
		kV	mAs	kV	mAs	kV	mAs
Abdomen	AP (Grid)	85	10 -15	85	20 - 25	85	30 - 40
Ankle	AP	70	1.8	70	2	70	2.5
Ankle	Obl	70	1.6	70	1.8	70	2.2
Ankle	Lat	70	1.5	70	1.6	70	2
Chest -Adult	AP (400 - tt -72")	85	2 - 2.5	85	3.2 - 4	90	5 - 6.4
Chest -Adult	Lat (400 - tt - 72")	90	4.5 - 5.5	90	7.5 - 9	90	12.5 - 15
Chest - Child	PA (400 - 72")	80	2	80	2.5	80	3.2
Chest - Child	Lat (400 - 72")	86	4	86	5	86	6.4
Chest - Infant	AP (400 - 40")	70	1	72	1	74	1
Chest - Infant	Lat (400 - 40")	74	2	76	2	78	2
C-Spine	AP (Bucky - 72")	85	12.5	85	15	85	18 - 20
C-Spine	AP (Bucky - 40")	85	5	85	6.4	85	8 - 10
C-Spine	Odontoid (72")	85	16	85	18 - 20	85	25
C-Spine	Odontoid (40")	85	6	85	8	85	10
C-Spine	Lat (Bucky - 72")	85	12.5 - 15	85	15 - 20	85	20 - 25
C-Spine	Swimmers (40")	90	40 - 60	95	50 - 60	100	50 - 75
C-Spine	Trauma Obl. (50"-tt)	77	10	77	15	77	20
C-Spine	AP (100 - 40")	77	7.5	77	9	77	11 - 12
C-Spine	Lat (100 -72")	77	25	77	30	77	35
Elbow	AP	70	2.2	70	2.5	70	2.8
Elbow	Obl	70	2.5	70	3	70	3.2
Elbow	Lat	70	2.2	70	2.5	70	2.8
Femur - Distal	Lateral (400 - tt)	77	3	77	4	77	5
Finger	All Views - (100)	63	0.8	63	1	63	1.25
Foot	AP	70	1.8	70	2.2	70	2.8
Foot	Obl	73	2	70	2.5	70	3.2
Foot	Lat	73	2.5	70	3.2	70	3.5
Forearm	AP (100)	70	2.5	70	3	70	3.5
Forearm	Lat (100)	70	2.5	70	3	70	3.5
Hand	PA	66	1.25	66	1.6	66	2
Hand	Obl	66	1.5	66	2	66	2.5

Size of the Patient – The techniques are of a small, medium and large **male**

- Small = 120-160 lbs.
- Medium = 160-200 lbs.
- Large = 200-240 lbs.
- Females would be approximately 10 lbs. lighter.

Page 2 of the LgM **2.1** (Most Dose) Universal CR Technique Chart

UNIVERSAL CR TECHNIQUE CHART   LgM 2.1

Part	View	Small		Medium		Large	
		kV	mAs	kV	mAs	kV	mAs
Hip	AP - (400 - tt)	77	3	77	4	77	6 - 4
Hip	X-Table Lat (Grid)	90	30 - 50	90	60 - 80	90	100 - 120
Humerus	AP (100)	70	3	70	5	70	7
Knee	AP (Bucky)	81	3.5	85	3.5	85	4
Knee	Obl (Bucky)	81	3.2	85	3.2	85	3.5
Knee	Lat (Bucky)	81	3.2	85	3.2	85	3.5
Knee	Sunrise (100 - tt)	70	4	70	5	70	6
Knee	X-Table Lat (400 - tt)	70	2.5	70	3.6	70	4.5
L-Spine	AP	90	8 - 12	90	16 - 20	90	25 - 30
L-Spine	X-Table Lat (Grid)	95	80 - 100	95	125 - 160	95	200 - 320
Mandible	Obl (100 - 40")	77	10	77	12.5	77	16
Pelvis	AP (Grid)	85	10	85	20	85	30
Ribs	Upper (72")	80	8 - 12	80	14 - 20	80	25 - 30
Ribs	Lower (40")	85	10 - 15	85	20 - 25	85	30 - 40
Ribs	Obl (72")	80	10 - 20	80	20 - 30	80	30 - 40
Shoulder	AP (100)	77	4.5	77	6 - 7	77	9 - 10
Shoulder	Mercedes (100)	77	12	77	16 - 20	77	25 - 30
Shoulder	Axillary (100)	77	6	77	8	77	10
Sinus	Caldwell	85	8	85	10	85	12
Sinus	Waters	85	10	85	12	85	14
Sinus	Lateral	85	4	85	5	85	6
Skull	AP	85	12	85	15	85	18
Skull	Lat (Grid)	85	5	85	6	85	7
Tib-Fib	AP (100)	77	3	77	3.5 - 4	77	4.5
Tib-Fib	Lat (100)	77	2.5	77	3.2	77	4
Toe	All Views	63	1.25	63	1.25 - 1.5	63	1.5 - 2
T-Spine	AP	90	7.5 - 10	90	16 - 20	90	30
T-Spine	Lat (2 sec)	90	15 - 25	90	35 - 40	90	60 - 70
Wrist	PA	66	1.5	66	1.8	66	2
Wrist	Obl	66	1.8	66	2	66	2.2
Wrist	Lat	70	2	70	2.2	70	2.5
Zygomatic Arch	SMV view (100 - 30")	70	2	70	2.5	70	3

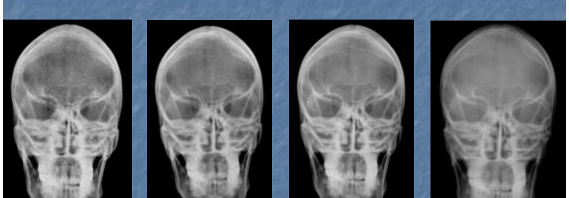
If you have never seen these kind of techniques before…

- They are definitely going to be a bit on the scary side.
- Any radiographer who really knows their film/screen (or low kV digital) techniques will hardly be able to believe that they are possible.

So what does kVp and mAs do?

- Not what it did in the film world, that's for sure!!
- There is still an optimum kVp, but it now controls only subject contrast.
- To a huge extent, mAs does not really control density/brightness any more.
  - Density and brightness are now mainly controlled by processing algorithms.
- You just need enough mAs or your image will have quantum noise (pixel starvation, mottle).

Quantum mottle or noise



Horrible | Bad | Perfect | Over Saturated (Permanent Loss of Contrast)

What does optimum kV mean?

- Optimum means the best!!
- Even though it's digital, you still have to stay in the optimum range, you can't start using 120 kV on everything.
- If you do use too much kV it will penetrate right through your patient and hit the IR because of incorrect attenuation.
- This will cause the image to be over penetrated, (saturated) causing a **permanent** loss in contrast.
- Or if too little mAs is used it may cause mottle.

Differences Between Digital And Film

- Centering and collimation are very important whether it's table top or bucky work.
- Exposure Index (EI) numbers (S, LgM, EI, ReX, EXI, DEI) are how you tell if your technique was correct.
  - The EI number is only true if the centering and collimation are very good.

More Differences Between Digital And Film

- The concept of Agfa's 2.0-2.3 LgM range, Fuji's 400-100 S range, GE's (DR) .2-.6 (or .8-2.4) range and Siemens' 200-900 range.
- Even with the range you should always be shooting for the "best" number in that range (which means the lowest dose).
- Lead shields and metal in the body will dramatically affect the EI number.
- If you are not able to use at least 33% of the IR you will probably have a corrupted EI number.

Centering and the Dose Exposure Numbers

- These EI numbers are easily corrupted (but only up to 75% in most cases).
- The following slides show the elbow, chest and shoulder phantoms and how a change in centering and or collimation can affect (corrupt) the dose exposure number.

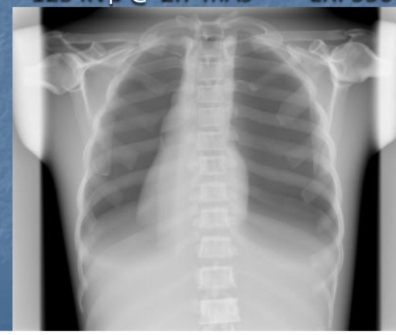
Perfect centering – 4 sided collimation
LgM 1.81

Kitty Corner – touching at both corners
LgM 1.81 0% change

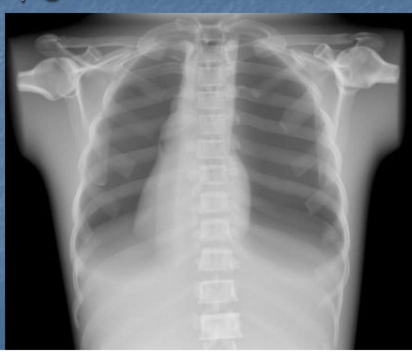
Long side touching edge
LgM 1.85 13.3% change

Centered – top side touching
LgM 1.85 13.3% change

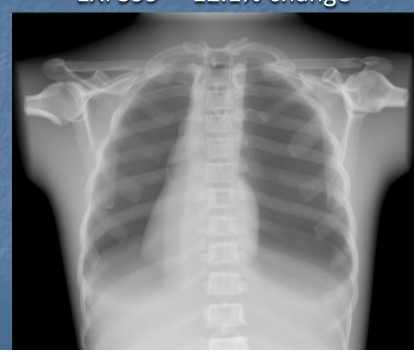
Seimens portable detector in bucky
Perfectly centered and collimated to 14”x14”
125 kVp @ 2.7 mAs EXI 356



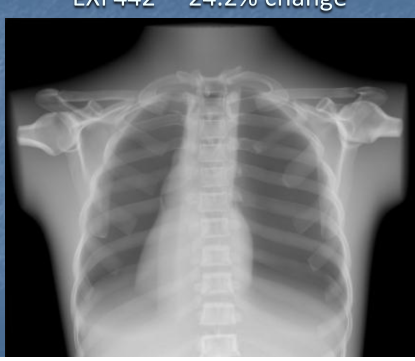
Perfectly centered, no collimation
125 kVp @ 2.7 mAs EXI 351 2.8% change



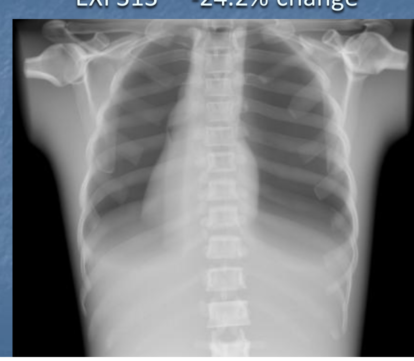
Centered 1” high - 125 kVp @ 2.7 mAs
EXI 399 12.1% change



Centered 2” Low - 125 kVp @ 2.7 mAs
EXI 442 24.2% change



Centered 1” low - 125 kVp @ 2.7 mAs
EXI 313 -24.2% change



Shoulder phantom with 3 sheets of Polyethylene to make it the thickness of a large adult male.

These experiments will show the difference in EXI numbers when the collimation is left more and more open.

GE built in detector (DEI range .42 -1.27)

8”x8” DEI .60 0.0% change

GE built in detector

9”x9” DEI .66 10.0% change

GE built in detector

10”x10” DEI .71 18.3% change

GE built in detector

11”x11” DEI .80 33.3% change

GE built in detector

12”x12” DEI .89 48.3 % change

GE built in detector
13"x13" DEI .96 60.0 % change

To summarize the previous 15
corrupted dose exposure number slides.

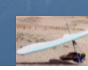
- With all the examples, the technique always stayed the same. It was just the centering or collimation changes that corrupted the EI number.
- Even though the dose exposure number (EXI, S, LgM, DEI) has been corrupted up to 75%, the image is still perfectly passable in any facility.
- If your EI number is above 75% over what is considered perfect, this means you over exposed.

Ways to Critique a Digital (DR or CR) Image

- You must use the EI numbers.
- You definitely **need** to use the magnification mode to check for noise and burn.
- You should always be able to Level and Window and make your image look well penetrated and contrasty.


Problems with critiquing digital images

- It is ***impossible*** to prove you used the ideal technique if all you are using is the finished image contrast and density as a gauge.



Witness the *awesome power* of
Automatic Rescaling

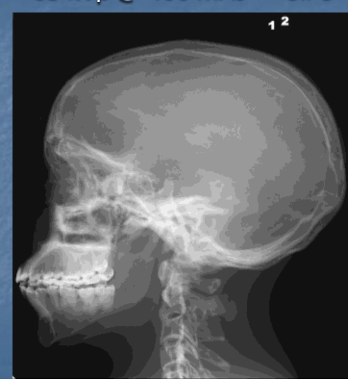
Fuji 85 kVp @ 4 mAs - S# 357

85 kVp @ 8 mAs - S# 171

85 kVp @ 32 mAs - S# 38

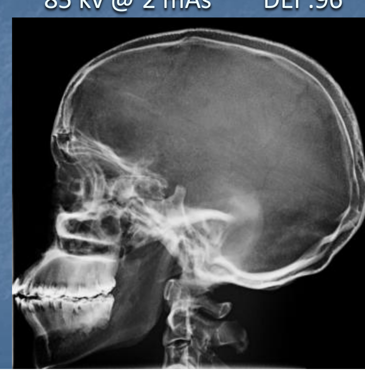
85 kVp @ 200 mAs - S# 6

85 kVp @ 400 mAs - S# 3



85 kVp @ 500 mAs - S# 4

GE built in detector (.36 – 1.07)
85 kv @ 2 mAs DEI .96



85 kv @ 4 mAs DEI 1.97

85 kv @ 8 mAs DEI 4.0

85 kv @ 16 mAs DEI 7.72

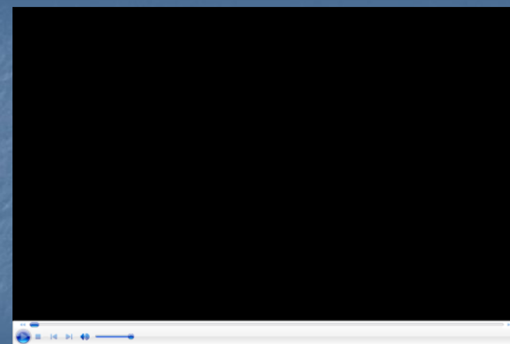
85 kv @ 32 mAs DEI 14.67

85 kv @ 64 mAs DEI 27.41

Exposure Creep
(mAs Dose Creep - Creeping Dose/mAs)

- National (probable worldwide) problem.
- Occurs because a radiographer can use far too much mAs and have the computer "fix" the problem and give a very readable/passable image.
- Over time techs slowly start using more and more mAs.
- Some hospitals can be 10, 15 even 20 generations deep from using film/screen.

How different is DR?

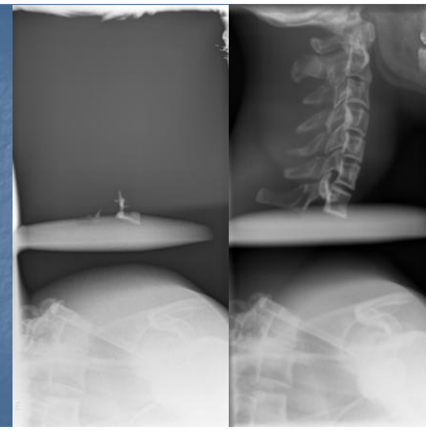


Direct Radiography

- It is now WAY TOO EASY to repeat an image!!!
- It's like taking a picture on your digital camera.
- Techs have forgotten that any exposure may cause **tissue or cell damage** to their patient.

The Ferlic Filter

- Typical hard to get, thick cm. shots like Swimmers, x-table lateral lumbar, x-table lateral hip are noticeably uglier.
- The Ferlic Filter is definitely needed.



Down while positioning the tube for a Swimmers or cross table lateral hip and then back up as the magnet holds it in place.

In this position the filter is lifted and the round magnets hold it in place and for the exposure the filter is dropped down.

<u>"Sliders" bags</u>. Comes in 2 sizes.
One for DR detector and grid,
the other for CR cassette and grid.

<u>Anchor-leg stabilizer</u>

How can there be a *Universal* CR/DR technique chart?

- As we all well know, this would have been impossible in the film/screen processor days.
- All modern generators (25 years or newer) are high frequency, so if the tubes are in calibration they should all be shooting the same.
- Since the CR/DR manufacturers set their systems up to have the perfect Dose Exposure Indicator # appear when 1 mR hits the plate, then any given technique will work with all the vendors if the x-ray tubes are all shooting the same.

Is the **EI** range given by the vendor perfect for your facility?

- My colleague Ramiro Villanueva and I believed that the 2.0-2.3 range with perfect being a 2.1 could be lowered.
- We wanted to cut the dose in half by changing the LgM range from 2.0–2.3 to 1.8–2.1 (and having the perfect DEI number change from 2.1 to 1.8).
- What are your rads willing to accept?

Here is a nicely shot PA chest using the AEC. The LgM is a 1.81 and there is absolutely no mottle.

This hip had an LgM of 1.81.
The mottle seen on the mag view is acceptable.

This lateral C-Spine also had an LgM of 1.81.
It has totally acceptable mottle.

Universal CR Technique Chart
LgM 1.8 (Lowest Dose)

UNIVERSAL CR TECHNIQUE CHART LgM - 1.8

Part	View	Small		Medium		Large	
		kV	mAs	kV	mAs	kV	mAs
Abdomen-**(LgM 2.1)**	AP (Grid)	85	10-15	85	20-25	85	30-40
Ankle	AP	66	1.25	66	1.4	66	1.6
Ankle	Obl	66	1.2	66	1.2	66	1.5
Ankle	Lat	66	1.1	66	1.2	66	1.4
Chest -Adult	AP (tt - 72")	85	1 - 1.2	85	1.6 - 2	90	2.5 - 3.2
Chest -Adult	Lat (tt - 72")	90	2.2 - 2.8	90	3.6 - 4.5	90	6.3 - 8
Chest - Baby	PA (72")	80	1.6	80	2	80	2.5
Chest - Baby	Lat (72")	80	3.2	80	4	80	5
Chest - Newborn	AP (40")	70	1.2	72	1.2	74	1.2
Chest - Newborn	Lat (40")	74	2	76	2	78	2
C-Spine	AP (Bucky - 72")	85	6.3	85	7.5	85	9.0 - 10
C-Spine	AP (Bucky - 40")	85	2.5	85	3.2	85	4 - 5
C-Spine	Odontoid (72")	85	8	85	9.0 - 10	85	12.5
C-Spine	Odontoid (40")	85	3.2	85	4	85	5
C-Spine	Lat (Bucky - 72")	85	6.3 - 8	85	8.0 - 10	85	10 - 12.5
C-Spine	Swimmers (40")	90	20 - 32	95	25 - 32	100	25 - 36
C-Spine	Trauma Obl. (tt)	70	5	77	7.5	77	10
C-Spine	AP (tt - 40")	70	2.5	70	3	70	3.5 - 4
C-Spine	Lat (tt - 72")	70	8	70	10	73	12
Elbow	AP	70	1.1	70	1.2	70	1.4
Elbow	Obl	70	1.1	70	1.4	70	1.6
Elbow	Lat	70	1.1	70	1.2	70	1.4
Femur - Distal	Lateral (tt)	77	1.6	77	2	77	2.5
Finger	All Views	63	0.6	63	0.8	63	1
Foot	AP	70	0.9	70	1.1	70	1.4
Foot	Obl	70	1	70	1.2	70	1.6
Foot	Lat	70	1.2	70	1.6	70	1.8
Forearm	AP	70	1.2	70	1.5	70	1.8
Forearm	Lat	70	1.2	70	1.5	70	1.8
Hand	PA	66	0.6	66	0.8	66	1
Hand	Obl	66	0.75	66	1	66	1.2

Universal CR Technique Chart LgM 1.8 (Lowest Dose)

UNIVERSAL CR TECHNIQUE CHART LgM - 1.8

Part	View	Small		Medium		Large	
		kV	mAs	kV	mAs	kV	mAs
Hip	AP (tt)	77	1.6	77	2	77	2 - 3.2
Hip	X-Table Lat (Grid)	90	16 - 25	90	30 - 40	90	50 - 60
Humerus	AP (tt)	65	1.25	65	2	65	2.5
Knee	AP (Bucky)	81	1.8	85	1.8	85	2
Knee	Obl (Bucky)	81	1.6	85	1.6	85	1.8
Knee	Lat (Bucky)	81	1.6	85	1.6	85	1.8
Knee	Sunrise (tt)	70	2	70	2.5	70	3.2
Knee	Non-Bucky	70	1.8	70	2	70	2.2
L-Spine	AP	90	4.0 - 6.3	90	8.0 -10	90	12.5 - 16
L-Spine	X-Table Lat (Grid)	95	40 - 50	95	60 - 80	95	100 - 160
Mandible	Obl (tt - 40")	70	3	70	4	70	5
Pelvis	AP (Grid)	85	5	85	10	85	16
Ribs	Upper (72")	85	4.0 - 6.3	85	7.0 -10	85	12.5 - 16
Ribs	Lower (40")	80	5.0 - 8	80	10 - 12.5	80	16 - 20
Ribs	Obl (72")	80	5.0 - 10	80	10.0 - 16	80	16 - 20
Shoulder	AP	70	1.6	70	2.0 - 3.2	70	3.6 - 4
Shoulder	Mercedes	77	6.3	77	8.0 - 10	77	12.5 - 16
Shoulder	Axillary	70	2	70	2.5	70	3.2
Sinus	Caldwell	85	4	85	5	85	6.3
Sinus	Waters	85	5	85	6.3	85	7
Sinus	Lateral	85	2	85	2.5	85	3.2
Skull	AP	85	6.3	85	8	85	9
Skull	Lat (Grid)	85	2.5	85	3.2	85	3.6
Tib-Fib	AP	70	1.6	70	1.8 - 2	70	2.2
Tib-Fib	Lat	70	1.4	70	1.6	70	2
Toe	All Views	63	1.2	63	1.6	63	2
T-Spine	AP	90	3.6 - 5	90	8.0 - 10	90	16
T-Spine	Lat (2 sec)	90	8 - 12.5	90	18 - 20	90	32 - 36
Wrist	PA	66	0.8	66	0.9	66	1
Wrist	Obl	66	0.9	66	1	66	1.1
Wrist	Lat	70	1	70	1.1	70	1.2
Zygomatic Arch	SMV view (tt - 30")	70	5	70	6	70	7

Differences between the Lowest Dose, 33% More, 66% More and Most Dose technique charts

- For example: the 33% More chart uses 33% more mAs than the Lowest Dose chart.
- This means that the Most Dose chart uses twice the mAs (so twice the dose) of the Lowest Dose chart.
- So start with the Most Dose chart and then if possible go down to the 66% More chart.

Agfa/Fuji/Carestream DEI Comparisons

CR DEI Comparisons

Agfa - LgM	Fuji - S	Carestream - EI	Agfa - LgM	Fuji - S	Carestream - EI
1.80	400.0	1700	2.10	200.0	2000
1.81	393.3	1710	2.11	196.7	2010
1.82	386.7	1720	2.12	193.3	2020
1.83	380.0	1730	2.13	190.0	2030
1.84	373.3	1740	2.14	186.7	2040
1.85	366.7	1750	2.15	183.3	2050
1.86	360.0	1760	2.16	180.0	2060
1.87	353.3	1770	2.17	176.7	2070
1.88	346.7	1780	2.18	173.3	2080
1.89	340.0	1790	2.19	170.0	2090
1.90	333.3	1800	2.20	166.7	2100
1.91	326.7	1810	2.21	163.3	2110
1.92	320.0	1820	2.22	160.0	2120
1.93	313.3	1830	2.23	156.7	2130
1.94	306.7	1840	2.24	153.3	2140
1.95	300.0	1850	2.25	150.0	2150
1.96	293.3	1860	2.26	146.7	2160
1.97	286.7	1870	2.27	143.3	2170
1.98	280.0	1880	2.28	140.0	2180
1.99	273.3	1890	2.29	136.7	2190
2.00	266.7	1900	2.30	133.3	2200
2.01	260.0	1910	2.31	130.0	2210
2.02	253.3	1920	2.32	126.7	2220
2.03	246.7	1930	2.33	123.3	2230
2.04	240.0	1940	2.34	120.0	2240
2.05	233.3	1950	2.35	116.7	2250
2.06	226.7	1960	2.36	113.3	2260
2.07	220.0	1970	2.37	110.0	2270
2.08	213.3	1980	2.38	106.7	2280
2.09	206.7	1990	2.39	103.3	2290
			2.40	100.0	2300

Konica/Shimadsu/SwissRay DEI Comparisons

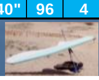
Dose Exposure Index Comparison

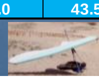
S (Konica)	EXI (Shimadsu)	DI (Swissray)	S (Konica)	EXI (Shimadsu)	DI (Swissray)
400	200	25.0	275	325	37.5
395	205	25.5	270	330	38.0
390	210	26.0	265	335	38.5
385	215	26.5	260	340	39.0
380	220	27.0	255	345	39.5
375	225	27.5	250	350	40.0
370	230	28.0	245	355	40.5
365	235	28.5	240	360	41.0
360	240	29.0	235	365	41.5
355	245	29.5	230	370	42.0
350	250	30.0	225	375	42.5
345	255	30.5	220	380	43.0
340	260	31.0	215	385	43.5
335	265	31.5	210	390	44.0
330	270	32.0	205	395	44.5
325	275	32.5	200	400	45.0
320	280	33.0	190	440	47.5
315	285	33.5	180	480	50.0
310	290	34.0	170	520	52.5
305	295	34.5	160	560	55.0
300	300	35.0	150	600	57.5
295	305	35.5	140	640	60.0
290	310	36.0	130	680	62.5
285	315	36.5	120	720	65.0
280	320	37.0	110	760	67.5
			100	800	70.0

This is the proof of how much dose you save your patient when you increase the kV and decrease the mAs.

Radiation Dose Saved

SID	kV	mAs	Dose (mR)	Radiation Saved (%)	50% EI Decrease (mAs)	50% EI Dose (mR)	Total Dose Reduction (%)
40"	70	20	221.0				
40"	81	10	152.8	30.90%	5.0	76.4	65.43%
40"	85	8	134.8	39.00%	4.0	67.4	69.50%
40"	90	6.3	120.0	45.70%	3.2	60.0	72.85%
40"	96	4	87.0	60.60%	2.0	43.5	80.32%






How Low Can You Go?

- This is how I now teach ALARA.
- With the new optimum kVp's already in place, it's figuring out how low can you take the mAs and get an image with no, or acceptable, mottle.
- I'm hoping that everyone will make it a competition or goal to see what is the **minimum** dose they can use for any given view.

This *should* be one of the

Golden Ages of Radiology!!

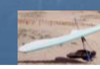
- Screens first invented.
- Rare Earth Screens.
- CR developed.
- DR developed.

Speaking of How Low We Can Go…Here is the

CESIUM DR UNIVERSAL TECHNIQUE CHART.

CESIUM DR UNIVERSAL TECHNIQUE CHART

Part	View	Small		Medium		Large	
		kV	mAs	kV	mAs	kV	mAs
Abdomen	AP (Grid)	85	4 to 5	85	8 to 10	85	16 -20
Ankle	AP	70	1.5	70	2	70	2.5
Ankle	Obl	70	1.3	70	1.8	70	2
Ankle	Lat	70	1	70	1.25	70	1.5
Chest -Adult	AP (Grid)	117	1.6	117	2	117	3.2
Chest -Adult	AP (Non Grid)	90	1	90	1.6	90	2
Chest (2-9 lb)	AP (Non Grid - 45")	71	1.0	73	1.3	75	1.5
Chest (2-9 lb)	Lat (Non Grid - 45")	73	1.4	75	1.6	77	2
Chest (10-20 lb)	PA (Non Grid - 72")	81	1.1	81	1.2	81	1.4
Chest (10-20 lb)	Lat (Non Grid - 72")	85	1.4	85	1.6	85	1.8
Chest (21-35 lb)	PA (Non Grid - 72")	81	1.4	81	1.6	81	1.8
Chest (21-35 lb)	Lat (Non Grid - 72")	85	1.8	85	2.0	85	2.2
C-Spine	AP (Bucky - 72")	85	6.0-8.	85	8.0-11	85	11.0-14
C-Spine	AP (Bucky - 40")	85	2	85	3	85	4
C-Spine	Odontoid (72")	85	8.0	85	11.0	85	14
C-Spine	Odontoid (40")	85	2.5	85	3.5	85	4.5
C-Spine	Lat (Bucky - 72")	85	4	85	6.3	85	8
C-Spine	Swimmers (40")	90	12.5	95	16.0	95	25
Elbow	AP	66	1.0	66	1.2	66	1.4
Elbow	Obl	66	1.2	66	1.4	66	1.6
Elbow	Lat	66	1.4	66	1.6	66	1.8
Finger	All Views	60	0.63	60	0.7	60	0.8
Foot	AP	66	1.0	66	1.2	66	1.6
Foot	Obl	66	1.2	66	1.4	66	1.8
Foot	Lat	66	1.8	66	2.2	66	2.8
Forearm	AP	68	1.2	68	1.6	68	2.2
Forearm	Lat	68	1.4	68	1.8	68	2.5
Hand	PA	63	0.6	63	0.8	63	1
Hand	Obl	63	0.8	63	1	63	1.2
Hand	Lat	66	1	66	1.2	66	1.6



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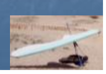
CESIUM DR UNIVERSAL TECHNIQUE CHART.

CESIUM DR UNIVERSAL TECHNIQUE CHART

Part	View	Small		Medium		Large	
		kV	mAs	kV	mAs	kV	mAs
Hip	AP	85	4 to 5	85	8	85	12
Hip	X-Table Lat (Grid)	90	14	90	20	90	36
Humerus	AP (Non Grid)	66	1.6	66	2	66	2.5
Knee	AP (Bucky)	77	3.2	77	4	77	6.4
Knee	Lat (Bucky)	77	2.5	77	3.2	77	5
Knee	Sunrise	70	1.6	70	2	70	2.5
Knee	Non-Bucky	70	2.5	70	3	70	3.6
L-Spine	AP	90	4	90	8	90	14
L-Spine	X-Table Lat (Grid)	95	16	95	28	95	40
Mandible	Obl (40")	81	8	81	10	81	12
Pelvis	AP (Grid)	85	8	85	12	85	16
Ribs	Upper AP (72")	81	6	81	12	81	18
Ribs	Upper Obl (72")	81	8	81	16	81	25
Ribs	Lower AP (45")	85	6.0	85	12	8	18
Shoulder	AP (Bucky)	77	4	77	7	77	12
Shoulder	Mercedes	77	8	77	15	77	25
Shoulder	X-T Axillary (N-Grid	70	3	70	3.5	70	4
Sinus	Caldwell	85	4	85	6	85	8
Sinus	Waters	85	5	85	7	85	9
Sinus	Lateral	85	2	85	3	85	4
Skull	AP	85	4	85	6	85	8
Skull	Lat (Grid)	85	2.5	85	3.2	85	4
Tib-Fib	AP	77	2	77	2.5	77	3.2
Tib-Fib	Lat	77	1.6	77	2	77	2.5
Toe	All Views	60	0.63	60	0.8	60	1
T-Spine	AP	85	5	85	8	85	11 to 12
T-Spine	Lat	90	10	90	18	90	28
Wrist	PA	63	0.8	63	1	63	1.25
Wrist	Obl	63	1	63	1.25	63	1.5
Wrist	Lat	67	1.2	67	1.5	67	1.8
Zygomatic Arch	SMV view	70	5 to 6	70	8	70	10

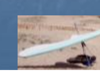


Here is the

GADOLINIUM DR UNIVERSAL TECHNIQUE CHART.

GADOLINIUM DR UNIVERSAL TECHNIQUE CHART

Part	View	Small		Medium		Large	
		kV	mAs	kV	mAs	kV	mAs
Abdomen	AP (Grid)	85	6 to 8	85	10 to 16	85	20 -32
Ankle	AP	70	2	70	2.5	70	3.2
Ankle	Obl	70	1.6	70	2.2	70	2.8
Ankle	Lat	70	1.25	70	1.6	70	2
Chest -Adult	AP (Grid)	117	2	117	2.5	117	4
Chest -Adult	AP (Non Grid)	90	1.6	90	2	90	2.5
Chest (2-9 lb)	AP (Non Grid - 45")	71	1.3	73	1.5	75	1.8
Chest (2-9 lb)	Lat (Non Grid - 45")	73	1.8	75	2.0	77	2.5
Chest (10-20 lb)	PA (Non Grid - 72")	81	1.4	81	1.6	81	1.8
Chest (10-20 lb)	Lat (Non Grid - 72")	85	1.8	85	2.0	85	2.5
Chest (21-35 lb)	PA (Non Grid - 72")	81	1.8	81	2.0	81	2.3
Chest (21-35 lb)	Lat (Non Grid - 72")	85	2.2	85	2.6	85	3
C-Spine	AP (Bucky - 72")	85	8.0 - 10	85	11.0 - 14	85	14 - 20
C-Spine	AP (Bucky - 40")	85	3	85	4	85	6.3
C-Spine	Odontoid (72")	85	8 to 11	85	11 to 14	85	14 to 18
C-Spine	Odontoid (40")	85	3.5	85	4.5	85	5.5
C-Spine	Lat (Bucky - 72")	85	6.3	85	8	85	10
C-Spine	Swimmers (40")	90	16.0	95	25.0	95	32
Elbow	AP	66	1.4	66	1.6	66	1.8
Elbow	Obl	66	1.6	66	1.8	66	2
Elbow	Lat	66	1.8	66	2.0	66	2.2
Finger	All Views	60	0.8	60	1	60	1.2
Foot	AP	66	1.4	66	1.6	66	1.8
Foot	Obl	66	1.6	66	1.8	66	2.2
Foot	Lat	66	2.2	66	2.6	66	3.2
Forearm	AP	68	1.8	68	2.4	68	3
Forearm	Lat	68	2	68	2.6	68	3.2
Hand	PA	63	1	63	1.2	63	1.6
Hand	Obl	63	1.2	63	1.5	63	1.8
Hand	Lat	66	1.4	66	1.8	66	2.2



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GADOLINIUM DR UNIVERSAL TECHNIQUE CHART.

GADOLINIUM DR UNIVERSAL TECHNIQUE CHART

Part	View	Small		Medium		Large	
		kV	mAs	kV	mAs	kV	mAs
Hip	AP	85	5 to 7	85	10 to 12	85	14 to 16
Hip	X-Table Lat (Grid)	90	20	90	32	90	50
Humerus	AP (Non Grid)	66	2.2	66	2.8	66	3.2
Knee	AP (Bucky)	77	4	77	6.4	77	8
Knee	Lat (Bucky)	77	3.2	77	5	77	6.4
Knee	Sunrise	70	2.4	70	3	70	3.8
Knee	Non-Bucky	70	3.8	70	4.5	70	5.4
L-Spine	AP	90	7	90	12	90	20
L-Spine	X-Table Lat (Grid)	95	25	95	36	95	60
Mandible	Obl (40")	81	10	81	12	81	15
Pelvis	AP (Grid)	85	2.5	85	16	85	20
Ribs	Upper AP (72")	81	8	81	6	81	25
Ribs	Upper Obl (72")	81	12	81	25	81	35
Ribs	Lower AP (45")	85	8.0	85	16	8	25
Shoulder	AP (Bucky)	77	6.3	77	10	77	14
Shoulder	Mercedes	77	12	77	20	77	32
Shoulder	X-T Axillary (N-Grid	70	4.5	70	5.5	70	6.3
Sinus	Caldwell	85	6	85	8	85	10
Sinus	Waters	85	7	85	9	85	12
Sinus	Lateral	85	3	85	4	85	5
Skull	AP	85	6	85	8	85	10
Skull	Lat (Grid)	85	3	85	4	85	5
Tib-Fib	AP	77	3.2	77	4	77	5
Tib-Fib	Lat	77	2.5	77	3.2	77	4
Toe	All Views	60	0.8	60	1	60	1.2
T-Spine	AP	85	7	85	11	85	Sixteen
T-Spine	Lat	90	16	90	25	90	36
Wrist	PA	63	1.2	63	1.5	63	1.8
Wrist	Obl	63	1.4	63	1.8	63	2.2
Wrist	Lat	67	1.8	67	2.2	67	2.8
Zygomatic Arch	SMV view	70	eight	70	10	70	12

How similar is CR to DR?

- We realized that most CR techniques used *twice* the mAs of Cesium detectors.
- Gadolinium detectors need 25-50% more radiation over Cesium detectors to make a similar exposure.

Post processing collimation (shuttering) for CR.

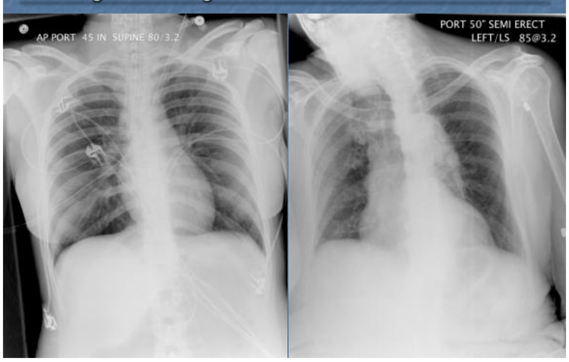
Courtesy of Becky Daley, TCC

C-spine algorithm changed to a Pelvis.

Courtesy of Becky Daley, TCC

2 different patients with no markers.

The image on the right had the initials marker annotated.

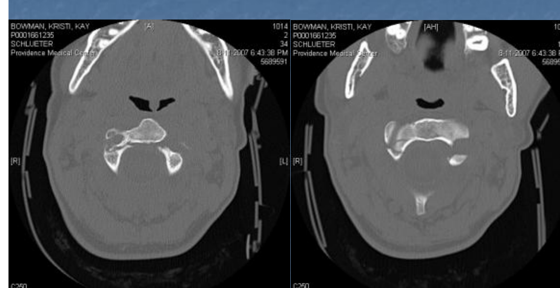


Abdomen shot with no marker.

No annotated marker was even added later.

Legal issues

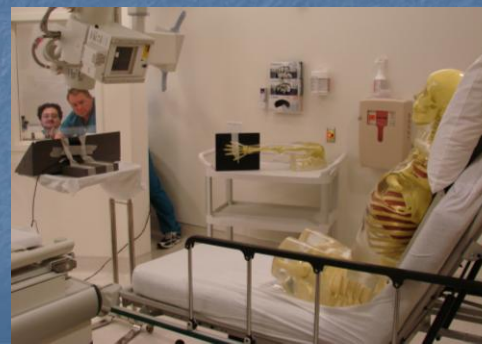
- Annotating right/left and your initials.
- Some departments have 100% marking policy.
- Department in lawsuit for reprocessing image.
- I believe it's only a matter of time before there is a lawsuit concerning the use of too much mAs (not adhering to standard or care-ALARA).



Legal issues

- *Also coming will be a lawsuit for post collimation (shuttering).
- To use post collimation you **must** show a border of white to prove you did not crop out any anatomy.
- Who will be sued?

How much Dose are you getting from scatter radiation coming out of your patient?



We did this experiment many times with and without grids, at 115 and 85 kVp, and at 3 different angles. This one is taken at 90 degrees to the patient.

This one is taken at 45 degrees to the patient.

And this one we are calling 0 degrees.

Here are all the doses for 0, 45 and 90 degrees (arrows at 6')

85@3.2 and 115@4

Dose exposure due to scatter from Portable Chest Xrays

Angle of Chamber (Deg)	Distance (ft)	Dose #1 (microR)	Dose #2 (microR)	Average Dose (microR)
90	1	96.0	94.6	95.3
90	2	42.7	42.0	42.4
90	3	21.1	22.0	21.6
90	4	13.3	12.7	13.0
90	5	10.6	9.0	9.8
90	6	6.9	6.1	6.5
45	1	195.5	196.2	195.9
45	2	79.3	80.7	80.0
45	3	38.3	39.2	38.8
45	4	24.3	23.8	24.1
45	5	16.2	17.9	17.1
45	6	11.6	12.0	11.8
45	7	9.4	9.1	9.3
45	8	7.1	6.4	6.8
0	6	34.0	33.1	33.6
0	7	24.5	23.0	23.8
0	8	17.4	16.0	16.7
0	9	14.0	14.2	14.1
0	10	10.5	11.6	11.1
0	11	8.4	8.9	8.7
0	12	6.3	7.5	6.9
0	13	5.3	6.4	5.9
0	14	0.0	0.0	0.0
0	15	0.0	0.0	0.0
0	16	0.0	0.0	0.0

Chest technique of 85@3.2 was used for all exposures. Ionization Chamber angle is measured from mid sagittal plane.

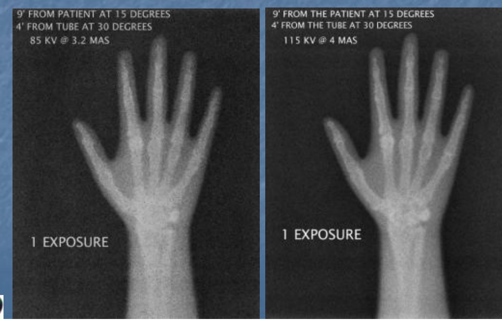
Dose exposure due to scatter from Portable Chest Xrays

Angle of Chamber (Deg)	Distance (ft)	Dose #1 (microR)	Dose #2 (microR)	Average Dose (microR)
90	1	316.0	320.0	318.0
90	2	125.8	127.2	126.5
90	3	68.3	67.6	68.0
90	4	42.2	41.0	41.6
90	5	27.1	28.3	27.7
90	6	19.7	19.7	19.7
45	1	744.0	778.0	761.0
45	2	295.0	295.0	295.0
45	3	150.7	151.2	151.0
45	4	98.3	97.6	98.0
45	5	66.2	65.2	65.7
45	6	48.6	47.4	48.0
45	7	33.6	32.7	33.2
45	8	27.6	27.5	27.6
0	6	76.0	75.1	75.6
0	7	50.5	51.8	51.2
0	8	39.3	39.8	39.6
0	9	32.3	31.9	32.1
0	10	25.4	27.0	26.2
0	11	22.4	21.8	22.1
0	12	17.0	16.9	17.0
0	13	14.3	14.4	14.4
0	14	12.6	12.5	12.6
0	15	10.2	9.9	10.1
0	16	8.3	8.2	8.3

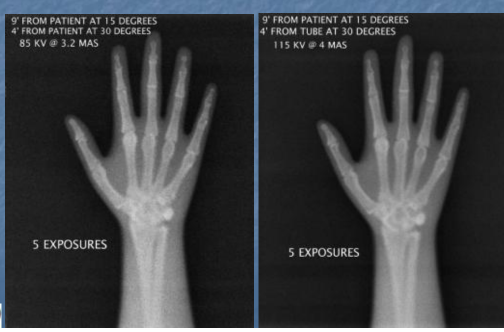
Chest technique of 115@4 was used for all exposures. Ionization Chamber angle is measured from mid sagittal plane.

This experiment used the arm/hand phantom and a 10x12 CR cassette processing at 1200 speed. We set it up where many techs stand when making a PCXR exposure. This photo and the following two images have the cassette at: 9' from the patient at 15 degrees and 4' from tube at 30 degrees.

Yep; Believe it or not!! Even though the scatter dose is way down in the micro R's, there is enough radiation to make this image – with 1 exposure!!



These are the images after 5 exposures.



How much does everybody (anybody) know?

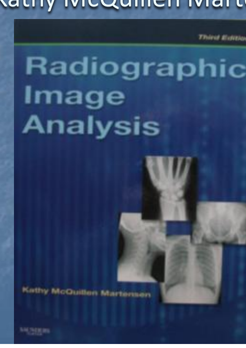
- There is the distinct possibility that students have more accurate information about digital radiography than their teachers and the techs.
- Even though teachers don't use the equipment, they can still be more knowledgeable than the techs (depending on the classes and courses they've had).
- Who taught most techs how to use the equipment?
  - How reliable are the vendors/trainers for complete information?
  - How aware are vendors about patient dose?

Information On the Ferlic Filter

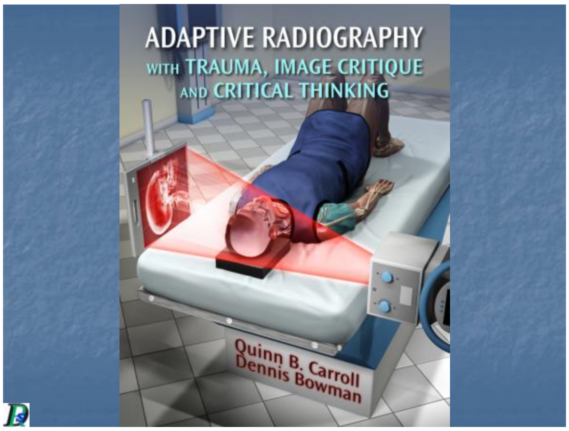
- **Ferlic Filter Co. LLC**
  4770 White Bear Parkway
  White Bear, MN 55110
  Phone: 877-429-9329
  Fax: (651)846-5745
  Email: dan@ferlicfilter.com

Radiographic Image Analysis

by Kathy McQuillen Martensen



Third Edition



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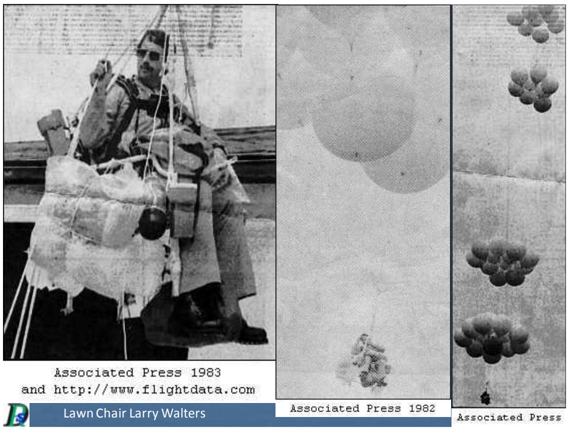
Cluster Ballooning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