Our digital world has a new paradigm

- 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 new digital paradigm is all about getting a great image using the least amount of radiation possible.
- The other paradigm shift has to do with higher kVp’s.

All of our technique experiments finally began after we received 4 of these 5 phantoms.

Stuart Bushong and the penguin
Low Flier

- Out of over 175 slides I have, 15 Low Flier’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.
  - And it’s contrasty and beautiful.
  - Of course it is extremely well collimated, which is why we can’t use such a high kVp.
  - On the other hand...

Barry Burns – the CR guru

Barry Burns - MS, RT(R), DABR – 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 kVp from film/screen techniques.

The following slides show a hand and shoulder 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
These are the “new” digital Optimum kVp’s as developed by Barry Burns

<table>
<thead>
<tr>
<th>Body Part - Adult</th>
<th>kVp</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chest (Bucky/Grid)</td>
<td>100-130</td>
</tr>
<tr>
<td>Chest (Non-Grid)</td>
<td>80-90</td>
</tr>
<tr>
<td>Abdomen</td>
<td>80-85</td>
</tr>
<tr>
<td>Extremities (Non-Grid)</td>
<td>65-75</td>
</tr>
<tr>
<td>Extremities (Bucky)</td>
<td>85-95</td>
</tr>
<tr>
<td>Hand</td>
<td>66-80</td>
</tr>
<tr>
<td>Foot</td>
<td>70-90</td>
</tr>
<tr>
<td>Finger</td>
<td>63-1.25</td>
</tr>
<tr>
<td>Universal CR Technique Chart using a standard 2.1 LgM</td>
<td></td>
</tr>
</tbody>
</table>
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.

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!!
- Obviously there is still an optimum kVp, but it now controls only subject contrast.
- To a large 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 kVp 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 kVp on everything.
- If you do use too much kVp it will penetrate right through your patient and hit the plate or detector because of incorrect attenuation.
- This will cause the image to be over penetrated, (saturated) causing a permanent loss in contrast.
Differences Between Digital And Film

- Centering and collimation are very important whether it’s table top or bucky work.
- Dose Exposure Index/Indicator (DEI) numbers (S, LgM, EI, ReX, EXI, DEI) are how you tell if your technique was correct.

More Differences Between Digital And Film

- The concept of Agfa’s 2.0-2.3 LgM range, Fuji’s 400-100 (150-75) S range, GE’s (DR) 2-6 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 can also dramatically affect the DEI number.
- These DEI numbers are easily corrupted or skewed (but only up to 75% in most cases).

Centering and the Dose Exposure Numbers

- The following slides show the chest, elbow and shoulder phantoms and how a change in centering and or collimation can affect the dose exposure number.

Agfa CR

Perfectly centered and collimated to 14x14
117 kVp @ 5 mAs
S# is 187

Perfectly centered - now 17x14 - 117 kVp @ 5 mAs
S# is 163   23.3% change

Centered 1” high -117 kVp @ 5 mAs
S# is 130   56.7% change
Centered 2” high – 117 kVp @ 5 mAs
S# is 120       66.7% change

Now centered 1” low – 117 kVp @ 5 mAs
S# is 163            23.3% change

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
Off to one side – no collimation touching sides
LgM .737 -91.1% change

Top and side touching
LgM .868 -88.3% change

No collimation - please note contrast
LgM 1.94 46.7% change

Compare the contrast and brightness of the middle and right images compared to the perfect one on the left. This is an example of permanent loss of contrast.

Siemens DR built in detector
Perfect Centering – 4 sided collimation
70 kVp @ 1.1 mAs EXI 551

Off center to left side but not touching side
70 kVp @ 1.1 mAs EXI 577 4.7% change
Off center to left and is touching side
70 kVp @ 1.1 mAs  EXI 574  4.2% change

Touching the bottom
70 kVp @ 1.1 mAs  EXI 572  3.8% change

Kitty corner – not touching any sides
70 kVp @ 1.1 mAs  EXI 639  15.9% change

Touching bottom and left side
70 kVp @ 1.1 mAs  EXI 526  -9.1% 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

Multiple exposures on one CR plate
Here is a 2 on 1 calcaneus. You can see that the lateral had a better technique used. Only one algorithm and Look Up Table is used for both images. Almost always more than 1 exposure on a plate will cause a corrupted DE number.
To summarize the previous 27 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 DE 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.

**How different is DR?**

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

**Direct Radiography**

**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.
Here are 4 different Ferlic Filters.
Swimmers and x-table hip, Lateral C-spine,
X-table lateral L-spine and AP T-spines

Down while positioning the tube for the Lateral C-spine (x-table or standing)

Then just slip it up to shoot.
It stays in place with a magnet.
“Sliders” bags. Comes in 2 sizes. One for DR detector and grid, the other for CR cassette and grid.

Anchor-leg stabilizer

Decubitus (short axis) grids should be used on non bucky chests bigger than 25cm with both CR and DR.

Digital short axis grids for CR

- We found the perfect chest grid to be:
  - 178 LPI
  - 6:1 grid ratio
  - 48”–72” focus
- Carestream and Konica use 104 LPI because of their grid suppression software.
- We increase our technique 25 kVp and 1 step in mAs.
- We also picked a four sided grid where the cassette falls into it as opposed to a 3 sided grid where you slide the cassette in.

Non grid exposure with the digital portable.
Same patient the next day using the grid.

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.
- The DEI numbers are very dependable as long as your positioning, collimation and exposure factors are very good.
- Some DR control panels have no DEI indicator.

Ways to Critique a Digital (DR or CR) Image

- You definitely **need** to use the magnification mode to check for noise.
- You should always be able to Level and Window and make your image look well penetrated and contrasty.
- This won’t necessarily prove you didn’t **overexpose** the patient, but it will confirm that it is a passable image.

Witness the awesome power of **Automatic Rescaling**

In the film world this is how much darker (or in other words how much more radiation the patient is getting) when you increase the mAs.

**Fuji** 85 kVp @ 4 mAs - S# 357
Agfa 85 kVp @ 4 mAs LgM 2.11

85 kVp @ 8 mAs LgM 2.40

85 kVp @ 16 mAs LgM 2.70

85 kVp @ 32 mAs LgM 2.96

85 kVp @ 40 mAs LgM 2.99
GE built in detector (0.36 - 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
**mAs Dose Creep (Creeping Dose/mAs)**
- National problem.
- The unfortunate ability for a radiographer to use far too much mAs and have the computer “fix” the problem and give a very readable image.
- Over time techs slowly start using more and more mAs.
- Some hospitals can be 10 generations deep from using film/screen.

**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 (23 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 .7 mR hits the plate, then any given technique will work with all the vendors if the x-ray tubes are all shooting the same.

**To use a universal chart, what needs to be done?**
- Make sure all the tubes are shooting the same.
- All of your control panels will need to be set with the new kVp’s.
- The readers are all giving the same DEI number.
- Agfa might need the MUSI Contrast in the MUSICA factory setting changed in the reader to do this.
- Fuji and others may change the GT (Look Up Table type) and GA (slope of Look Up Table).

**How did your vendor set up your QC viewer?**
- We were told from day 1 that we would not need to change our techniques at all.
- This way we would only be learning computer work, not new techniques.
- We weren’t given the choice to do the 15% Rule (or told that it was even possible).
- They set the image up to look like film (soft) instead of more digital (like DR).
- It wasn’t until we had DR for about 2 years that we even realized what digital images should really look like.

**Is the DEI range given by the vendor perfect for your facility?**
- We (my colleague Ramiro Villanueva and I) believed that the 2.0-2.3 range with perfect being a 2.1 needed to be changed.
- 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.**
Here is a X-table lateral knee with a 1.81 LgM. Again there is no discernable 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

<table>
<thead>
<tr>
<th>Part</th>
<th>View</th>
<th>kV</th>
<th>mAs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abdomen</td>
<td>LgM 2.1</td>
<td>85</td>
<td>10-15</td>
</tr>
<tr>
<td></td>
<td></td>
<td>85</td>
<td>20-25</td>
</tr>
<tr>
<td></td>
<td></td>
<td>85</td>
<td>30-40</td>
</tr>
<tr>
<td>Ankle</td>
<td>AP</td>
<td>66</td>
<td>1.25</td>
</tr>
<tr>
<td></td>
<td></td>
<td>66</td>
<td>1.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>66</td>
<td>1.6</td>
</tr>
<tr>
<td></td>
<td>Obl</td>
<td>66</td>
<td>0.75</td>
</tr>
<tr>
<td></td>
<td></td>
<td>66</td>
<td>1</td>
</tr>
<tr>
<td>Hand</td>
<td>Lat</td>
<td>70</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>70</td>
<td>1.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>70</td>
<td>1.5</td>
</tr>
</tbody>
</table>

Universal CR Technique Chart

<table>
<thead>
<tr>
<th>Part</th>
<th>View</th>
<th>kV</th>
<th>mAs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hip</td>
<td>AP (tt)</td>
<td>77</td>
<td>1.6</td>
</tr>
<tr>
<td>Hip</td>
<td>X-Table Lat (Grid)</td>
<td>90</td>
<td>16-25</td>
</tr>
<tr>
<td></td>
<td></td>
<td>90</td>
<td>30-40</td>
</tr>
<tr>
<td>Zygomatic</td>
<td>Arch SMV view (tt - 30&quot;)</td>
<td>70</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>70</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>70</td>
<td>7</td>
</tr>
</tbody>
</table>

Universal CR Technique Chart

<table>
<thead>
<tr>
<th>Part</th>
<th>View</th>
<th>kV</th>
<th>mAs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lat (Bucky)</td>
<td></td>
<td>70</td>
<td>1.25</td>
</tr>
<tr>
<td>Lat</td>
<td></td>
<td>70</td>
<td>1.4</td>
</tr>
</tbody>
</table>

Differences between the 1.8, 1.9, 2.0 and 2.1 LgM technique charts

- Remember that in the Agfa system, every .3 means 100% more or 50% less dose.
- So each .1 change is 33% or 1/3rd different.
- For example: the 1.9 chart uses 33% more mAs than the 1.8 chart.
- This means that the 2.1 chart uses twice the mAs (so twice the dose) of the 1.8 chart.
This is the proof of how much dose you save your patient when you increase the kVp and decrease the mAs and/or decrease the DEI.

<table>
<thead>
<tr>
<th>SID</th>
<th>kVp</th>
<th>mAs</th>
<th>Dose Saved (%)</th>
<th>50% DEI Decrease (mAs)</th>
<th>50% DEI Dose (mR)</th>
<th>Total Dose Reduction (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>40</td>
<td>70</td>
<td>20</td>
<td>221.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>81</td>
<td>10</td>
<td>162.4</td>
<td>10.90%</td>
<td>4.0</td>
<td>67.4</td>
</tr>
<tr>
<td>40</td>
<td>85</td>
<td>8</td>
<td>134.6</td>
<td>39.00%</td>
<td>4.0</td>
<td>67.4</td>
</tr>
<tr>
<td>40</td>
<td>90</td>
<td>6.3</td>
<td>120.0</td>
<td>45.70%</td>
<td>3.2</td>
<td>60.6</td>
</tr>
<tr>
<td>40</td>
<td>96</td>
<td>4</td>
<td>117.0</td>
<td>66.60%</td>
<td>2.0</td>
<td>43.5</td>
</tr>
</tbody>
</table>

This should be one of the Golden Ages of Radiology!!

How Low Can You Go?

- This is my new version of ALARA.
- With the new optimum kVp’s already in place, it’s figuring out how low can we 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 needed for any given view.
- You have to be willing to blow the shot a couple of times as you learn what the minimum mAs can be.

Speaking of the Golden Age... here is the DR UNIVERSAL TECHNIQUE CHART.

How similar is CR to DR?

- After careful analysis we discovered that CR generally uses at least 75% more radiation, especially on spines and extremities.
- We realized many of the DR techniques were similar to the CR 1.8 LgM techniques.
The DUKE phantom.
The next 2 slides will show how the dose directly relates to the mAs (as seen with both the LgM and ESE).

The next LgM should be 2.64 and the ESE should be 166.

You can’t get more exact than that!! All of these prove if you double the mAs you double the dose.

Post processing collimation (shuttering) for CR.

Our radiologists do not allow any post collimation as they are legally responsible for everything that is on the original image (there is a caveat for some DR).

C-spine algorithm changed to a Pelvis.
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.
- 3 different techs who took newborn PCXR’s.
- 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.
- Who will be sued?

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

This presentation was written by Dennis Bowman, who is solely responsible for its content. He acknowledges that Community Hospital of the Monterey Peninsula (CHOMP) and Cabrillo College are in no way accountable for any of the material presented.

Radiographic Image Analysis
by Kathy McQuillen Martensen

Third Edition

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