

So CR & DR image processing annoys. This talk is gonna be a sort of a brief, (stand back here), rather quick overview of the types of problems you can expect to encounter when trying to roll out CR & DR modalities in an institution that is currently still using film, and we'll address a few of the implications for what happens when you try to send those images to a PACS as well. So we'll talk about image quality, and what kind of changes you need to think about for technique factors, how post processing works, image quality control, and reprocessing for images that don't quite come out right, and what impact all this has on controlling dose. Digital radiography, like film screen radiography requires the technologist to position the patient and then you do down shielding and then pick an appropriate set of technique factors to make an exposure. Once the image is acquired however, the process is quite different from film screen.

Instead of taking the image over, taking the cassette over to a processor to be run through a film processor the image data is sent to a computer where the types of algorithms that Don just described are applied to the image data, when the levels are determined, values of interest are found and then the presentation look up table is applied. From there then the images are either printed on a hard copy device or sent off to the PACS for display on a workstation. One of the first things that you need to begin to worry about, is because this is a digital image data set, and you have an array of pixels in the image data. If you're using a grid and it's a fixed grid you can expect that under certain circumstances you may encounter more a pattern artifacts between the, which is really B frequency between the grid lines, and the, and the sampling matrix and the image. Solution to that is to use a much higher line rate grids, so that you don't see that B

pattern as readily, or some systems employ low pass filters to smooth out the appearance of the, of the, or the high resolution, high frequency details in the image, but of course in the process you smooth out high frequency details in the patient data that you would like to preserve if you could, so it has a negative effect on system resolution, and it's really inappropriate to do any sorta low pass filters or grid artifact control for 8x10, or 10x12 views, because we never use grids for 8x10, or 10x12 views. Technique selection of the console is still being driven by the need to produce an appropriate penetration and signal value, penetration through the patient, and signal value at the imagery receptor and so that voltage selection has to be consistent with the energy dependence of the detector, the dynamic range of the data, or of the tissues that are in the patient, and then of course you always have to worry about patient dose and the process. Two

current needs to be high enough so that the exposure times are short enough to minimize blur in the image, as with film screen, and then this will also depend upon the total amount of charge that's passed through the tube, and the total amount of radiation delivered to the plate will depend on its sensitivity, and the need to develop a sufficient signal to noise ratio in the final image. So this graph shows traditional, this is plots of detector quantum efficiency as a function of photon energy for several detectors out there, including film screen, which is again gadolinium oxysulfide detector, barium fluorobromide is CR. _____ is a DR device and _____ is a DR device as well, and you can see that the peaks in those energy absorption curves occur at different energies from the gadolinium curve, so the energy selection may not be the same for film screen as it is for DR and CR detectors. There maybe some shifts, and I think

there's work to be done in this area. I don't think we've optimized our techniques as well as we

could have by now. CR has been around for 20 years, and we're still using film screen techniques in CR and it may be inappropriate. Different detector sensitivity and will then require that you have new technique charts for your operation. The techniques that you use for film screen may not work anymore. You may have to re-calibrate the automatic exposure control devices, because of the changes in energy sensitivity of the new detectors, and the very wide dynamic range of the digital systems is very beneficial and will allow you to acquire decent images over a wide range of exposure, but that has some downsides that you need to be careful about. Under and over exposure on many of the CR and DR systems is no longer presented to operator as a dark or light image. What happens in an over exposure or, I'm sorry, what happens in an under exposure is that you use fewer photons to create the image, but the systems

automatically corrects that, and displays the appropriate gray scale in the image. So the only way you know that you've got an under exposed image is that you'll start to notice noise in the under penetrated areas of the final image. If you over expose on the other hand, you get nice strong signal strength, so you have a very low noise image that the radiologists are gonna love. On the other hand they may love the images, but you have now overdosed the patient, you've used more radiation than is necessary. So wide dynamic range is a very nice feature but it can lead to higher dose if it is not properly managed. Don talked about histogram recognition is what I call it, but the ability to identify the values of interest in the histogram and some systems are very robust in the way that they do this, because of the wide dynamic range, much of the data that's in the dynamic range that's available to the system is not used to present to the image. So

the values of interest lie in this region right here, and systems today have, or many of them have automated methods for identifying where the min and max points are in that value of interest range that's to be displayed and processed. This is not perfect algorithm on a lot of systems if you, if you have items in the, areas of the histogram that are significantly altered due to surgical, post surgery situations or if you over caluminate some cases, or are a little bit too aggressive in the use of gonadal shielding, you can introduce peaks to the, to the histogram that wouldn't normally be there and the system will become confused and will no longer use the appropriate set of, appropriate values of interest. One way to get around this is for prosthetic techniques at least, to go in and define a set of fixed speed techniques on your system to prevent it from performing automated histogram recognition analyse. Here's an example, this is a chest radiograph that was

actually under exposed on our DR system and was called into imaging physics for help in trying to figure out what went wrong, and we looked at the technique factors and compared them to others that were typically used for patients of that size, and found them to be a little bit low, so we had the technologists repeat the exposure at a higher technique, and suddenly everything looks real nice. So our only explanation is that the system failed to recognize the histogram appropriately and apply the correct look up table to the VOI. It's important that image processing be highly, that this histogram recognition feature be very reproducible, so that technologist don't become confused by the way that the system is functioning. If they get inappropriate feedback and don't understand why, they're going to lose confidence in the systems and themselves and in you. Frequent post processing by technologists is going to result

in inconsistent image quality at the radiologist viewing console, and to a certain extent customization is, customization of vendor looks is going, is gonna required because when you first put your system in you receive a set of canned look up tables which may work very well for your site. If it does count yourself lucky, we have had to augment every post processing algorithm on our system to meet the needs of our radiologists. So you need some processing algorithm development tools on this system, and you probably need to understand what those look like, and how they work and how robust they are, before you submit the purchase order. For image quality, you still have to do image quality on these systems. One thing you don't want to have to do is reprocess the image frequently as I said before, and so that the system should be

robust enough to process the image correctly, virtually every time. At our site we require that the default or that loading default processing parameters be restricted only to authorized users in the physics group, and the technologist are not to have access to those. Reprocessing at the QC console itself reduces throughput in the room. That is not the place where you want to be reprocessing a large number of images, especially for a new system, where you will probably have to reprocess a great number of images in the beginning until you get the parameters to where you feel comfortable that they're gonna work every time. So you need to understand what your vendor's strategy is for reprocessing the images is, preferably off line, if possible until you get stabilized. Here's an example. This is a pediatric exam that we did an hour chest processing parameters were designed for adults. The ones that came with it, the system did not come with

processing parameters for pediatric chest, and as you can see the images come quite dark and were unacceptable, so we send those of to a QC work station which we, which our vendor provided for us for this purpose, and then reprocessing produce a very acceptable image. Other issues on image quality. This is a site down the street from us where the image consists of essentially four independent detectors. One in each quadrant of the image there's, and then they're stitched together. There's one here, one here, one down here, and then one over here, and they have to be balanced regularly through routine calibration, which is suppose to be performed by the technologist on like a daily basis. The technologists were not doing this, and we found out that the service crews weren't even doing when they came in on a regular basis to do their periodic maintenance. So, as a result you can see the seam lines between that bottom

left panel, and the other three. Now quality control manual reprocessing by the tech at the QC console must assure that you get a uniform appearance on any calibrated display device once the image leaves that console. This requires then, that the calibration console itself must be calibrated to the same standard as the PACS device is. Otherwise the images seen on PACS don't look right and the technologist will get blamed for bad techniques, when actually it's not their fault if you didn't calibrate your QC console. QC consoles, LCD's suffer from a problem with viewing angle dependents, an inexpensive LCD at the QC console can actually cause you some problems because the, because asymmetries and the molecular orientation within the LC layer of the panel. You get significant changes in contrast and brightness when the image is viewed from off axis from other than normal. These can be addressed by some of the

technologies that I've listed here, but typically they, they will rob the system of brightness, and in order to maintain a high brightness and to reduce the off, the viewing angle dependence of the monitor, it's gonna cost a lot more money. This is a clinical example of that situation. This is

one of our technologists adjusting a CR image at a QC console. She's viewing the console from an angle that is essentially normal to the panel. She sees this image and adjusts her brightness and contrast settings or G-shift, and S-shift in this case to get the image that she wants. This is her supervisor and obviously he was on the high school basketball team, and he views that image from a much steeper angle than she does. So the image that he sees is much, much darker and lower in contrast, but he will do what he is suppose to do and adjust the brightness and contrast at the console before he sends it to PACS. So they both see the same image on the QC console

when they push the, the send button, but the radiologist when he pulls the images up to view it sees a very nice image from Gloria's images there but Mike's in trouble. You can discipline Mike, you can coach him, you can fire him. The problems not gonna go away until you get rid of the monitor. So LCD is not suitable as a QC monitor unless, it's calibrated to the DICOM gray scale standard display function, and unless it's, it can maintain a contrast to within plus or minus 10 percent in the vertical axis and plus or minus, I'm sorry, to within plus or minus 10 percent at plus or minus 15 degrees in a horizontal axis, and plus or minus 30 in the vertical, and that's just an MD Anderson standard. I don't know of a standard in the industry that you could look up. Let's see, and those monitors should not have room light sensors on them. It's inappropriate for the calibration on the monitor to shift just because somebody changes the room

lights in the console area. Technologists receive feedback on the adequacies of the exposure of the technique factors that they've selected for the exposure by getting a feedback from the system. That's called an exposure index. For the AGFA system this the LGM value, for Fuji it's the S number, Kodak uses the exposure index, and Canon uses REX. Other vendors also provide exposure indices, most of them do. I think there's only one that does not, and these are on CR systems. On DR systems there are very few vendors that provide exposure indexes, indices. The technologist cannot rely on the brightness and contrast in the image to tell him or her that they have chosen the adequate technique, so they must rely on exposure index value. Typically this is related to the exposure to the detector itself behind the patient. This should be accurate and very consistent, highly reproducible, and dose area product and patient innards exposure are not the

same thing at all, and do not provide adequate information about the technique to tell the technologist whether they should repeat or change their technique chart. But it would also be nice if the vendors provided some kind of QC tool to log these exposure index values so that they can be evaluated later as part of a QC program. Here's an example of a situation like this, it's a T-spine done at the techniques that you see there, and the exposure index value that's shown is 121, which on this system is inversely related to the exposure to the plate. So it was decided to repeat the examination and since the exposure index value was a little bit low, to back off on the technique just a little bit. The patient positioning was off as well, so upon, upon repeating the examination at a slightly lower technique, the technologist is completely fused, confused in this case because the exposure index changed dramatically in the wrong direction, and of course this

is due to the presence of the prosthetic spine supports in the image. So it's an example of histogram recognition failure. So consistency of exposure index is essential. It should be well understood by everyone that uses it and histogram recognition needs to work, needs to work well. If you don't, if you can't achieve those things then you're gonna end up doing a lot of repeats and every repeat doubles the patient dose. And in summary why dynamic range is a

double edge sword, and you must have, your technologist must learn to use exposure indices and not rely on image density to decide on repeats. They need a set of rules for pediatric exams that are separate, actually they need technique charts for every exam that they do. They need some way of, they need some rules for when to use special processing, like for use with prosthetic devices, and for pediatrics, and then they need to understand how gonadal shielding and

prosthetics can impact the histogram recognition and know that they need to use fixed exposure techniques or fixed processing techniques when performing those exams. And then finally we needed a strategy for reprocessing of exams, who's gonna do this and where are they gonna do it. Quality control is still important, equipment needs to be handled just the way it's always been handled. You need to QC the device on a regularly basis and now it has to include QC of the imaging system, the detector system, and the processing system as well. Need to keep a close eye on repeat reject rates, especially when you're transitioning from film screen into CR and DR, and work closely with a technologist who follows up on errors that are found in that. And dose control relies heavily on reliable exposure indices and you may have to re-celebrate the automatic exposure control devices for KV compensation because of the differences in energy

sensitivity of the detectors and for exposure rate compensation as thicknesses change from end to end. They won't function the same way with DR and CR as they did with film screen. And there's bibliography for you, it's a little bit lengthy, but it's in the handout, which is downloadable from the WPM website.