White paper:

Radiographic Technique Still Matters

Shirley Bartley, M.B.A., RT (R) (N)

Integrated Science Support, Inc.

In the field of radiology we are able to take advantage of a revolution in medical imaging. Moving from analog systems of photographic film and wet film processor is a cause for celebration. In many radiology suites you will see a brightly lit area with a computer terminal and a table with a few chairs. This may have once been the scene of a dark noisy room with only a red light and flat hard work surfaces. With maybe a pass box to communicate with the outside world. There may also be a large area that has a new radiographic unit or a comfortable reception area. This could have once been the file room. Rows and rows of packed shelves bowing form the weight of overstuffed film jackets just waiting to be misfiled or lost.

With film/screen systems one of the most frustrating problems is rejected films. With digital imaging many of the film/screen problems do not plague the radiographer anymore. The problem of repeating an image because it was too light or too dark rarely happens in digital image. Automatic rescaling is an image processing function that will produce an image at the correct preset brightness level even when the exposure is too high or too low. New technology has provided a high level of automation that streamlines work flow. However technique still matters to image quality and patient dose.

This paper will describe that the right technique will penetrate the anatomy correctly and deliver the appropriate quantity of radiation to the image receptor. Even with automatic rescaling image quality problems occur when the wrong kVp and mAs are used. Radiographic units are designed differently. The same technique will not produce the same quantity or quality of radiation with the same technique settings.

There is a wide range of image receptors in use, such as, film/screen, phosphor plates and solid state detectors. These IRs respond to radiation with different levels of efficiency. One may require more radiation than another to produce a quality image. Due to all these factors each radiographic unit must have a unique technique chart. With a technique chart an accurate and consistent radiation exposure is used for each patient and each projection. The technique chart is the standard for each technologist to use as a guide to produce the optimum exposure for each patient. In digital image the correct technique is a balance of image quality and patient dose.

Good radiographic technique will penetrate the anatomy correctly.

When the technologist selects the kVp for the exposure the energy level, wave length and penetrating ability of the x-ray beam is set. With higher kVp the x-ray tube becomes more efficient and produces a greater number of x-rays as well. When developing technique for specific anatomy the first factor to consider is penetrating the part successfully. As the thickness, mass density or atomic number of the tissue increases the anatomy will be harder to penetrate and a higher kVp must be used. Part of the beam must make it through the anatomy, exit the patient and interact with the imager receptor to produce an image. An comparison would be the mammogram that uses 22 to 28 kVp to penetrate the breast and the chest x-ray that requires 110 to 130 kVp the penetrate the heart and mediastinum . If the anatomy is underpenetrated you will not see the features and fine lines in the densest areas of the body part. Instead of light shades of gray you will see flat white. If the part is over penetrated with a kVp that is too high there will also be a loss of detail. When too much of the beam has penetrated the part we say it is “Burned Out”. The subtle difference in the density of different structures is just not demonstrated. When the kVp is higher than required the IR can be saturated with x-rays and produce an image that has no detail at all in the over penetrated areas of anatomy. The image will be at the correct brightness level or the right shade of gray but there will be no fine lines to show the anatomy. With the correct kVp these image failures can be avoided and more of the anatomy can be visualized to optimize the diagnostic quality of the image.

“How do I choose the standard kVp for a procedure?” It is best to start by asking an expert. The radiographic equipment manufacturers will customarily provide a technique chart with the equipment. There may be technique available if you have anatomic programming available on the unit. The image receptor manufacturers will also provide a suggested technique chart. With this information choose a standard kVp level that will work for your patients and equipment. Keep in mind when making your choice for the standard kVp that higher kVp will allow you to reduce the mAs and reduce patient dose. This concept and procedure will be developed future later in the paper.

If you are unable to find technique charts from these sources research the current textbooks for radiologic technology. They will have suggested technique for all procedures. Two good sources are: Radiographic Positioning & Related Anatomy, 7th edition Bontrager, K. & Lampignano, J. and Principles of Radiographic Imaging An Art and a Science, Adler, A. & Carlton, R.

In the clinical setting there are many patients who vary from the average. This requires the technologist to vary the standard kVp to tailor the technique to the individual patient. A good example to this is athletes. This population of patients will have greater tissue density with stronger bones and muscle. The standard kVp for the average patient may need to be increased. On the other end of the spectrum, if you have a geriatric patient that is likely to have osteoporosis or other degenerative processes the standard kVp may need to be reduce to optimize the technique.

When varying from the standard kVp small changes are best. kVp makes a big difference in the characteristics of the beam. Limit variation to no more that 15% of the standard kVp. Remember that increasing the kVp will also increase the quantity of radiation produced. If you want to keep the same quantity of radiation in the exposure increase the kVp by 15% and cut the mAs to ½ the original amount.

Changes in kVp will also change the contrast in the image. In digital imaging the contrast on the finished image is controlled by the preset image processing. However, there will be a wider range of tissue densities displayed in the higher kVp image.

Good radiographic technique will deliver the appropriate quantity of radiation to the image receptor.

mAs is the technical factor that is used to control the quantity of radiation in the x-ray exposure.

When the mAs is doubled, the quantity of radiation produced will double.

With film/screen image receptors there is a clear indication of the exposure to the IR. Under exposures produce light films. Over exposed films are dark. A common recommendation is,” If you are going to make a mistake make it too dark because we can use the hot light." Film has a narrow exposure latitude. Latitude is defined as the range of exposure over which an acceptable image is produced. With most film/screen IRs if you have an error and actual mAs is ½ of the optimum the film with be too light and will need to be repeated. On the dark side, if the mAs is double the optimum the film will be too dark and need to be repeat. This does not leave much margin for error.

Digital imaging systems have much wider latitude. The image receptors are sensitive to very low levels of radiation and very high levels of radiation. An image can be produced with very low mAs or very high mAs. The image processing function will produce an image with the correct preset brightness and contrast.

The exposure to the image receptor is communicated with a number called the exposure indicator (EI). With equipment that is in current use there is no common unit across manufacturers. The manufacture of the image receptor recommends a range of numbers for the exposure indicator that will produce an acceptable image. This range is broad and covers a wide range of radiation exposure. For example, the Fuji computed radiography system uses an exposure indicator called the S value. The S value is inversely proportion to the radiation exposure on the plate. When the radiation goes up the S value goes down.

For most adult images Fuji recommends a range of 400 S to 100 S. The high radiation end of the range, 100 S will keep the radiation high and the patient dose will be at the high end of acceptable. The 400 S value will keep the radiation level lower and will produce an image that has a low level of noise.

The EI range is a recommendation only. At your facility you determine the target EI value that is acceptable for your patient population. This decision must be made in collaboration with the radiologist that will be interpreting the images. If you work in a large facility that has many radiologists ask the group to designate one radiologist to make decisions for the group. As the exposure to the IR goes down the images can become noisy. It is important for the radiologist to review images at the target exposure index to insure the images are acceptable. The appearance of noise or a grainy look in the image does not occur until the exposure to the image receptor is well below the manufacturer's recommendation.

"The best practice is to select the appropriate exposure technique factors for the patient's size and condition, based on a planned exposure system designed in collaboration with radiologists, to determine adequate image quality for diagnosis." ASRT White Paper, Best Practices in Digital Radiography

Developing Radiographic Technique to Reduce Patient Dose

The benefits of a planned standardized exposure system such as a tested technique chart are worth the effort required to develop, test and implement. When students or new staff members join your group they need the resource of techniques that work. Images will be consistent from one operator to another. The radiologist will be able to evaluate follow up comparison images with more accuracy because the technical factors are consistent. Images repeated due to technique errors will be reduced. Work flow will improve. Patient outcomes will improve. These benefits should be communicated to the staff. The expectation that everyone use the standard technique should be in place. This will reduce patient dose and maintain image quality.

Each radiographic unit will need a unique technique chart. There must be technique for each procedure that is performed with the unit. Techniques can be on a paper spread sheet, in a card file or programed into the operator's consol.

The reason a unique chart must be made of each unit is that x-ray generators have a wide variety of designs. With the same technique, high efficacy generators produce x-ray exposures with more radiation and higher quality radiation. You can't use the same technique in Room 1 as Room 2. Another reason is that grids can vary greatly in the quantity of radiation absorbed. When a higher ratio grid is used the technique must be increased to deliver the correct exposure to the IR.

The design of the image receptor will determine the efficiency of absorbing and using the radiation present. If you change the IR system, you may need to modify the chart.

Don't start a technique chart until you are sure the x-ray producing equipment in calibrated and QC is within limits. The radiographic unit must be inspected by a qualified expert to be sure it is functioning properly.

The kVp must be accurate. If you set 80 kVp, the peak energy will be 80 kV.

The exposure must be linear. 200 mA must produce twice as much radiation as 100 mA.

Exposures must be reproducible. 80 kVp @ 10 mAs must produce the same quantity of radiation time after time on that machine.

The Automatic Exposure Control (AEC) must produce the same quantity of radiation for every exposure.
Perform the quality control recommended by the manufacturer. If you are using a CR system make sure the plate reader has been properly calibrated by the service engineer.

Make a template for the technique chart. An excel spread sheet works. Boldly record the room or radiographic unit the chart is made for. For each projection make a data field for the target exposure index, the patient cm measurement, kVp, mA, time, SID, grid, and the type of image receptor. Most experts are recommending a fixed kVp technique chart. This method uses a fixed kVp level for each patient the varies the mAs to deliver the correct quantity of radiation to the IR.

Get started by making a list of the procedures performed on the radiographic unit. Begin with the most common procedures. Decide the kVp to be used for each projection. Remember higher kVps will allow you to reduce the mAs and lower the patient dose. A rule that has been proven to work is the 15% rule. When you have a good radiographic technique you can increase the kVp by 15% and cut the mAs in half. kVp can change the contrast level on the processed image so limit kVp changes to 15%.

Using phantoms or a good patient exposure, write down the good technique in the center of the chart. The technique should be for an average patient. Now you can extrapolate a technique for patients of different sizes. Let's say the technique for the abdomen on a patient measuring 22 cm was 80 kVp @ 20 mAs. As thickness measurements increase for other patients, double the mAs every 6 centimeters of thickness.

Example: Target 300 S

Cm	kVp	mAs	SID	Grid
22	80	20	40”	bucky
23	80		40”	bucky
24	80		40”	bucky
25	80		40”	bucky
26	80		40”	bucky
27	80	40	40”	bucky

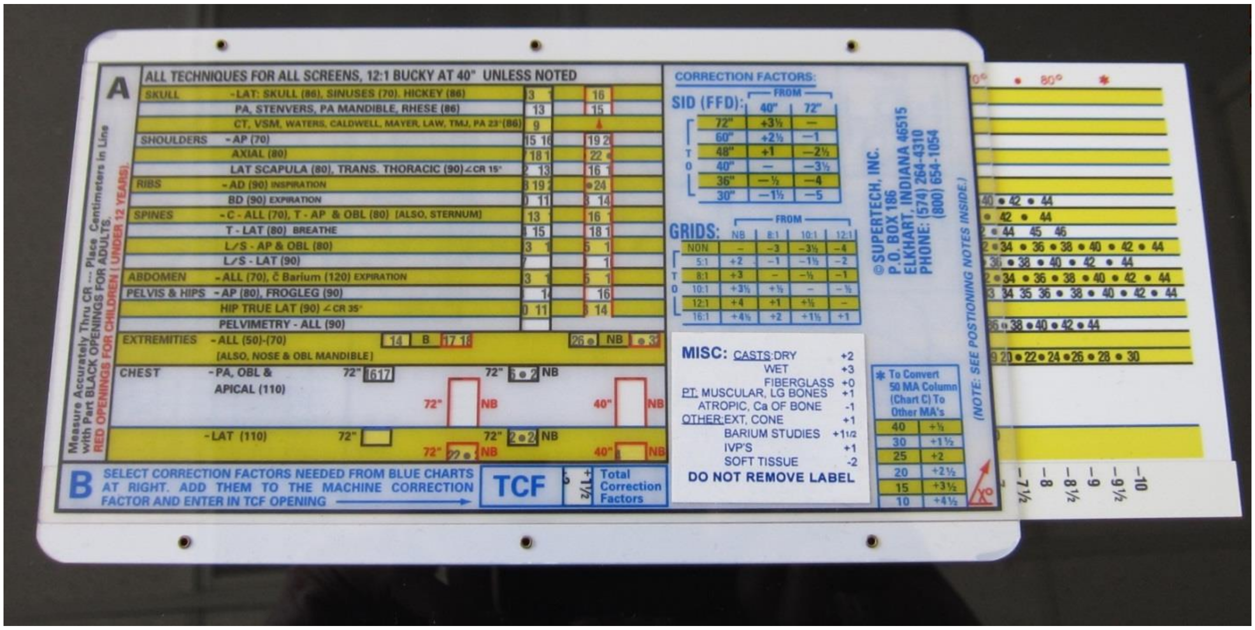
Now fill in the cm measurement with mAs setting present on the consol.

KUB	Room 1	Target 300 S		Fuji CR
cm	kVp	mAs	SID	Grid
16	80	10	40”	Table bucky
17	80	12	40”	Table bucky
18	80	15	40”	Table bucky
19	80	17	40”	Table bucky
21	80	18	40”	Table bucky
22	80	20	40”	Table bucky
23	80	25	40”	Table bucky
24	80	28	40”	Table bucky
25	80	30	40”	Table bucky
26	80	35	40”	Table bucky
27	80	40	40”	Table bucky

If the technologist must set mA and time on the console include both values on the chart.

Using this method to make the chart requires that you have a good technique for each projection on each procedure to be performed in the room. Good technique is defined as exposure factors that will produce an exposure index at the pre-determined level.

There is a proven method that will allow you to make a technique chart for all the projections that will be done using the same tube, grid and SID. For example when you have a good technique for an abdomen, a chart can be produced for the spine, pelvis, hips, and skull. This is done by using a tool called "Supertech calculator slide rule"



This device is a time saver when producing a chart. The extrapolated techniques are accurate. This device is copyright protected and can be purchased through their web site.
www.supertechx-ray.com/Calculator/SlideRuleKit.

Radiographic techniques that use Automatic Exposure Control must also be on the chart. The kVp level must be standardized for each projection. The backup time or backup mAs must be set for patient safety. Designate the AEC cells to be used for each projection. This will ensure consistent images and exposure index values at the target level. The AEC must be calibrated to produce exposures that result in the correct exposure index.   This will need to be adjusted by the service engineer. This can be done with a phantom or a thickness of material that simulates the attenuation of a patient. The process can take some time. The procedure is to make an exposure using the correct image receptor and a specific AEC cell. Process the image and check the exposure index. Adjust the AEC for more or less radiation. Repeat until all the cells are producing exposures at the target exposure index.

When the chart is completed test it yourself in the clinical setting to be sure it works before turning it over to the other technologists. Don't throw out the technique chart if it doesn't work on one patient. It might be the patient.

When the chart has been proven with clinical trials, release it for use with all the staff. Make the chart easily available. If you have anatomic programing, save the new techniques in the console.

Communicate to everyone that the technique chart is now in use.

Problems

If your technique chart has been working for months and suddenly you are getting exposure indicator values that are off there is a system change somewhere. If you are using phosphor plates, check the plate reader. The signal output from the PM tube can drift. This produces an EI that indicates low radiation levels when that is not the case. The service engineer can recalibrate the plate reader. The radiation output on the x-ray machine may need calibrated. The kVp can drift producing kVp that is below or above the level set on the machine. This can also be corrected by the service engineer.

A quality assurance activity is to randomly check the exposure index values of a sample of patient images. Find the average exposure index value and the standard deviation. The average should be at your standard. The standard deviation should be low and consistent over time.

Summary

Although exposure technique charts take time and effort to develop accurately, they prevent exposure technique errors. Routine use of the charts ..can provide consistent and accurate radiation exposure to the image eceptor, thereby reducing patient dose. ASRT White Paper, Best Practices in Digital Radiography