APPH 226: Density

Objectives:

5.2 Discuss the effect photographic properties have on diagnostic quality

5.5 Manipulate exposures in order to achieve density maintenance

MRT Program

Factors

For selection of an optimal radiographic technique, three groups of factors must be considered:

- Image Quality factors
- Exposure Technique factors
- Patient factors

Photographic Properties

- Is the visibility of recorded detail
  - How much anatomy can be seen on the image
- Visibility is achieved with the balance of:
  - Radiographic _____
  - Radiographic _____

Photographic Properties

- Technologist views the image and makes the call.
  - Mainly based on common sense and training
  - Can all the required anatomy be seen?
  - Is the visibility of the recorded detail maximized?
- If the answer is no to any of those questions, the image is unacceptable
  - How do we fix it?
  - Must determine the factors to adjust to improve visualization

Radiographic Density

- Defined as: the amount of overall blackness produced on the image after processing
  - Must achieve balance
  - Must have sufficient density
    - Allows us to visualize the structures
    - Excess or insufficient density results in poor visualization of anatomy
  - Knowledge of factors affecting density is critical to problem solve for best image possible

Prime Factors

- These are the factors that alter radiographic density of images
  - Aka **prime exposure factors**
- kVp
- Exposure Time
- mA
- SID (Source-Image Receptor-Distance)

This matters because…

- Patient dose
- Image quality
- Patient condition
- Adaptations
- Professionalism

Optical Density

- Defined as: the degree of blackening of the finished radiograph
- This is how we measure the blackness
  - Rather than naming each shade of grey, numbers are assigned to them
  - Measured with numerical value
- Normal range for human vision is: 0.25-2.5OD
- Varying degrees
  - OD > 3 will be seen as _____
  - OD < 0.2 will be seen as _____
  - Measured between 0 and 4

Light vs Dark

- Common issue in medical imaging
- Can result in repeat exposures
- What does it mean when an image is said to be too dark?
  - Has a high OD
  - Caused by overexposure
  - More information
- Too light?
  - Has a low OD
  - Caused by underexposure
  - Less information

Major Factors Affecting Density

- OD can be controlled by two major factors:
  - mAs
  - SID
- When SID is continually changed, many issues will arise
  - Specific SIDs for exams
  - When SID is no longer variable, mAs is the primary factor to control OD
  - Direct relationship between mAs and OD

mA and mAs

- mA
  - # of electrons available to produce x-rays
  - No effect on the kinetic energy of the electrons
- Time
  - How long the electrons will be crossing over to the anode for
  - Must have balance between mA and time
- mAs
  - Often the only setting offered
  - Will not always have capability to set mA and time separately
  - Total # of electrons conducted

mAs and Exposure

- Main controlling factor of radiographic density for technologists
  - Many other factors that have influence, but mAs is the one primarily used
- Determines the number of x-rays produced (quantity)
- Direct relationship
- Double the mAs = _____ the exposure
  - Provided nothing else changes
  - Also generally doubles the density

Reciprocity Law

- The density produced on a radiograph remains the same for any combination of mA and exposure times as long as the value of mAs is the same
  - As long as the resultant mAs is the same, regardless of the mA and time combination used, the OD produced on the image will be the same
- Failure of law occurs with:
  - Extremely short exposures
  - Extremely long exposures

More About mAs

- When do we use the reciprocity law?
  - Motion
  - Focal Spot Size
  - Breathing Technique

mAs and Density

- For us to notice a visible change in radiographic density
  - mAs needs to be changed by at least 30%
- What if the mAs is changed by 10%?
  - The change will not be noticeable, it will not be visible to us
- What if the mAs is changed by 50%?
  - There will be a noticeable difference in the radiographic density of the image

General Rule....

- 30% is quite a large technique change, to adjust image density just enough for us to notice.
- The general rule of thumb for mAs changes is to make adjustments in _____or _____

Relationships – Density and mAs

- What happens to density when mAs is decreased?
  - Radiographic density is decreased
- What happens to density when mAs is increased?
  - Radiographic density is increased
- What conclusion can we draw about mAs and density?
  - mAs controls density; _____proportional

How about kVp?

- What role does kVp play?
  - Affects intensity of the beam
  - Controls energy (strength) with which the electrons hit the target (anode)
  - Major player in quality
    - Some effect on x-ray quantity
- Primary controller of x-ray beam quality and controls _____.
- What is contrast?
  - Shades of grey on the image.

Contrast

- Function: to make anatomy more visible
  - The difference in OD between adjacent structures, or the variation of OD on an image
  - Without it, would not be able to discern structural borders
- Is a result of the x-ray beam being attenuated differently as it passes though the tissues of the body

kVp and Density

- Has an effect on density because it alters the penetrability of the beam
  - This also affects the amount of radiation that reaches the image receptor
- If the kVp is decreased, less radiation reaches the image receptor, resulting in:
  - Decreased OD
- If the kVp is increased, more radiation reaches the image receptor, resulting in:
  - Increased OD

kVp Adjustments

- In order to adjust the radiographic density of an image with kVp, a few different ranges were established
  - Between 30-50 kVp: 4-5% change
  - Between 50-90 kVp: 8-9% change
  - Over 90 kVp: 10-12 % change
- This was tough to remember, so a general rule was made.

15% Rule

- Increasing the kVp by 15% will have the equivalent effect on radiographic density, as doubling the mAs.
- This rule can be applied for maintaining or adjusting density.
- If the initial kVp is high, (>90kVp) a greater change will be needed as compared to when the initial kVp is low (<70kVp).

kVp vs. mAs

- So… if both affect radiographic density, how do we decide what to adjust?
  - mAs is the simplest adjustment to make, as it has a direct relationship with density
- When do we adjust kVp?
  - When we want to change the contrast of the image
  - When we want to control motion
    - As kVp is increased, mAs is decreased, meaning shorter exposure times can be achieved

Let's try... maintain density

- 1) Decrease the kVp
- 2) Decrease the mAs
  - 80 kVp and 10 mAs
  - 75 kVp and 24 mAs
  - 55 kVp and 1.8 mAs
  - 60 kVp and 32 mAs
  - 120 kVp and 12 mAs
  - 95 kVp and 6.4 mAs

Readings

- Radiologic Science for Technologists 11th ed
  - Pg 212-213 (Reciprocity Law)
  - Pg 237-239
  - Pg 245-251 (Up to Detail)