Automatic Dose Rate and Image Quality Control Logic of Interventional Fluoroscopy Systems

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Features Designed to Reduce Patient Exposure (Air Kerma)

(1) Last Image Hold (LIH)
“Last Image Hold” feature permits fluoroscopist to stop the radiation to the patient with the last frame of fluoroscopic image displayed on the monitor. This permits the fluoroscopist to attend to matters pertain to the catheterization and consider the “next” move with the last image displayed!

(2) Fluoroscopic image loop,
Typically, this feature will “loop” the last 10 seconds (300 frames) of fluoroscopic images.
This is a dynamic display which takes place of the “Last Image Hold”.

(3) Pulsed Fluoroscopy; 30, 15, 7.5 f/s
(a) Compared against the 30 f/s continuous fluoroscopy, the 30 f/s pulsed fluoroscopy generally has less motion unsharpness and can be setup to reduce patient exposure.
(b) Pulse rates less than 30 f/s show reduced patient exposure.

(4) Interleaved Pulsed Fluoroscopy; 15 f/s pulse rate displayed at 30 f/s,
(a) As the lower pulse rate of 15 f/s becomes the prerequisite to reduced patient exposure, one frame of 15 f/s image can be displayed twice before advancing to the next image.
(b) Displaying each frame of the 15 f/s images twice improves the continuity of motion. This is similar to the 30 f/s cine images were projected twice by the use of a shutter to achieve the 60 f/s motion continuity.
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(5) Pre-collimation under LIH mode.
Under the LIH mode, collimator can be adjusted to desired filed size without having to activate fluoroscopy.

(6) Spectral Shaping Filters
(a) Use of 0.1 mmCu ~ 0.3 mmCu in place of the aluminum filter resulted in reduced patient exposure in early version of spectral shaping filter application in cardiovascular imaging systems.
(b) Cu filters ranging 0.1 mm to 0.9 mm are being employed for cardiovascular angiographic equipment.

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(7) Automatic Image Quality & Exposure Control Logic
(a) A sophisticated software programming is required to respond to a change in the copper filter thickness.
(b) The automatic control logic may be designed to various imaging parameters including the focal spot size, kVp, mA, pulse width, etc.

(c) Heavy copper filter preferentially removed low energy photons and the mean x-ray beam energy is, thus, increased.
(d) For the same applied tube potential this would require a higher “tube current” to produce an acceptable image quality. Thus, a “high power” x-ray tube is required.

Automatic Dose Rate & Image Quality Control (ADRIQ) Logic
- Fluoroscopic exposure parameters vary as functions of “Patient Thickness”.
- Focal spot selection (switching) CAN be programmed into the ADRIQ depending on the Power Loading to the anode.
- Copper filters (mmCu) are introduced into the primary x-ray beam in accordance to the penetration sensed by the (flat panel) detector.
- Upon reaching the maximum allowable tube loading condition, the ADRIQ works just like the classical Automatic Brightness Control logic; iso-watt loading.

Verification Testing of the Automatic Dose Rate & Image Quality Control Logic
Why Better Image Quality & Lower Patient Dose?

- Image quality is “better” because of consistently lower tube potential is employed—higher image contrast!
- Radiation dose to the patients, especially, small and average size patient, is significantly reduced due to the use of spectral shaping filters --- considerable amount of low energy portion of spectrum is removed before hitting the patient.

Advances in Clinical Applications

- Rotational Angiography (RA)
- CT-like Images From (RA)
- 3D Image Display
The C-arm frontal plane is employed for the raw data acquisition.

Scan Parameters for CT-like 3D Imaging:
- Siemens File Name: SS-1KDR, 1DS-1KDR
- Angle of Rotation: 192°, 204.8°
- Angles Per Frame: 1.5°, 0.8°
- Number of Frames: 128, 256
- Periphery Dose (reference only): mR 452, 947 mGy 3.84, 8.05
- Center Dose (reference only): mR 9, 12 mGy 0.977, 0.102
- Matrix Size: 1024 X 1024

There are 128 projected images. Each image is composed of 1024 (lines) slices.

To save processing time, two rows and two columns of data may be fused (binned) together to form a 512 X 512 matrix CT-like image.

This is illustrated in the next slide.

Digitized values are assigned to each pixel. (in one dimension only is shown.)

In the case of Flat Panel Detector, the signal is digitized in the internal structure of flat panel assembly while the analog TV signal from the image intensified system is put through a digitizer.

This is a simulated image.

128 images of 512 X 512 matrix size CT-like images are reconstructed.

These images are further processed to generate 3D images.

There are 128 projected images. Each image is composed of 1024 (lines) slices.

To save processing time, two rows and two columns of data may be fused (binned) together to form a 512 X 512 matrix CT-like image.

This is illustrated in the next slide.
Projection "Raw" Fluoroscopy Image; notice the divergent beam of CONE shaped fluoroscopy beam causing distortion. (negative image)

Scout View of CT scanner shows minimal distortion or almost distortion less image. (positive image)

Slice width ramps in the center of image with four plastic pins for linearity test are clearly shown. Notice the similarity of the artifacts next to the slice width aluminum ramps.

This is the high contrast resolution section of CT phantom. The 0.75 mm square holes are resolved.

The resolution of this CT scanner under Standard Reconstruction algorithm resolves 0.55 mm square holes, and better with "BONE" reconstruction algorithm.

While CT scanners are designed for resolving "low contrast objects", the angiography equipment is able to show the nominal 2% contrast group under the CT scanner. Notice that the contrast level will not be the same due to the photon energy differences and the partial volume effect.

The water bath section of the phantom shows the relatively noisy image on the left as opposed to "smooth" looking CT image on the right.

Clinical Images; Courtesy of Arra S. Reddy, M.D.
Gracias por acompañarnos.

Thank you for coming.

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