

Control of patient exposure with true anatomy measurements

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Minimising radiation exposure for safer imaging

In the early days of x-ray, when film-screen radiology was standard, the relation between blackness of the film and detector (film) exposure was clear. Every x-ray technologist could adjust the dose (mAs) to achieve the requested blackness of the film, so exposure was more precise and specific for each image.

Traditional screen-film systems use overall film density as an exposure indicator. Direct feedback to the technologist regarding exposure is obtained by the appearance of the processed film image. Optimised technique factors (kVp and mAs) are based upon the patient size and body part and radiographic speed of the screen film combination being used. Particularly in situations where automatic exposure control is not used (for instance, in the majority of small paediatric patients), the use of fixed exposure parameters requires the technologist to use experience and appropriate judgment to set radiographic techniques.

Since the mid-1990s, a steady replacement of analogue screen-film detectors with digital radiology detectors has occurred, along with an expectation of lower dose because of minimal retakes and consistent image quality. Computed radiology and direct radiology devices have wide exposure latitude/dynamic range, and image post-processing capabilities that provide consistent image appearance even with underexposed and overexposed images. Determining correct exposure parameter settings and patient exposure by image appearance (e.g., density on a film image) is no longer possible. While underexposed images have smaller numbers of x-rays absorbed by the digital detector and can be recognised by a noisy appearance, overexposed images can easily go unnoticed, resulting in unnecessary radiation for the patient.

Maintaining quality and consistency

In today's digital x-ray world, modern systems use automatic image processing, so the ratio between detector exposure and image brightness is not always clear. The old visual control function for excessive dosage has been removed, so over/under exposures may go unnoticed on the screen with different brightness as this is corrected automatically.

Exposure index (EI) is the measure of the amount of exposure received by the x-ray detector and an indication of image quality. Equipment manufacturers provide a recommended EI range for optimal image quality. EI in digital radiography can be compared to film speed and blackening in film-screen. When film was used, the accuracy of the exposure was obvious based on the appearance of the image. Today errors in the EI calculation result in an inaccurate EI, which could be the case if the software fails to determine the true anatomy.

True anatomy - exposure index region calculation



Fig. 1-3: Images show three different (.raw) examples of a radiograph together with the corresponding calculated ROI mask (PA Hand, AP Bilateral Knee and LAT Chest)

Our exposure index module for digital x-ray enables automatic monitoring of the digital x-ray system to continue to deliver correct exposure to the patient, for each anatomy and projection. The true EI is developed to follow the latest regulations for dose monitoring according to the International Electrotechnical Commission Standard. It is based on an accurate measurement performed only on the relevant image region.

The module automatically segments the true anatomy in the actual image and from this calculates the average pixel value. The module delivers a binary image mask (ROI mask) of the segmentation and mean pixel value of the ROI/true anatomy. This functionality also allows the ROI mask to be modified by a self-developed UI, the average pixel value will then be based on the corrected ROI mask.

The EI allows the operator to judge if an image was taken at a detector exposure level suitable for the intended level of image quality.



The explicated EI is equipment specific and provided by the equipment manufacturer. EI is derived from the mean detector entrance exposure which is derived from the mean pixel value of the image.

The exposure index, EI calculated by the equipment manufacturer, according to IEC 62494-1;

$EI = c_o \cdot g(V)$, c_o is a constant and $g(V)$ is an equipment-specific inverse calibration function defined in the standard.

Exposure index benefits

In 2012, Germany was the first country to have regulatory demands that all manufacturers are to have an exposure index for digital x-ray units sold in the country, a trend that more countries will follow in the coming years. EI brings quality assurance to digital x-ray examinations, with higher safety for the operator and less exposure for the patient.

References

International Electrotechnical Commission (IEC) 62494-1, Medical electrical equipment - exposure index of digital x-ray imaging systems.