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EDITORIAL

Transition from Analog to Digital Imaging for Image Guided Surgeries

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C-arms and Cath-labs are sophisticated medical imaging equipment that finds extensive use in various operating room settings for image guided surgeries. Cath-labs are generally used for cardio-vascular procedures like angiography, angioplasty, and complex neurosurgeries. Mobile C-arms find usage in predominantly orthopaedic, urology, spine and general surgeries.

C-arms and Cath-labs are based on an x-ray platform and provide high-resolution x-ray images in real time during the surgery to allow medical professionals to carry out live complex surgical procedures minimally invasively. This makes the surgical procedure less painful for the patient and leads to a much quicker recovery.

The C-arm gets its name from the C-shaped arm that holds an x-ray tube at one end, an image intensifier, or a flat panel detector at the other. The patient is positioned between the x-ray tube and the image intensifier/flat panel detector. The arm can be moved horizontally, vertically and can be rotated around the swivel axis to properly position the patient in the x-ray field and acquire the desired images. The console of C-arm would generally house the high voltage power electronics needed for the x-ray tube, control electronics for managing the C-arm movement and embedded computer systems for image acquisition and processing.

C-arm technology has evolved continuously since its introduction in 1955, and most recent technology trend is migration from image intensifier based analog technology to flat panel detector based digital technology.

In analog image intensifier C-arms; the x-ray beam after penetrating the patient's body hits the input phosphor end of the image intensifier; the input phosphor converts the x-ray to light photons, where x-ray beam passes through a vacuum tube with an arrangement of photocathode, electrostatic focusing lens, photoanode finally reaching the output phosphor end of the image intensifier and forms a visible image of the x-rayed body parts. This image is then captured by a CCD camera and gets transmitted to the display monitors.

In case of analog C-arms, the image conversion happens in two steps; Step 1, x-ray to visible light image conversion by the image intensifier; Step 2, capture of a visible light image by CCD camera and further processing using analog means. Due to differences in high voltages at different electrodes the image intensifier tube, the accuracy of the image is diminished near the edges leading to distortion. Furthermore, due to multiple steps and electron optics involved in the imaging chain, the field of vision is reduced with every step of magnification.

Flat panel digital technology directly converts the x-ray to an electrical charge which gets digitized in the detectors' readout advanced electronic circuits. In this case, the x-ray field effective area sensed by detector matrix elements is larger than CCD camera sensing area of the light emitted by phosphor screen in image intensifier. An image processing software converts the digital input from the detector to a digital image with a plethora of image processing options leading to high contrast and high-resolution images that help visualize very minute anatomical structures. Digital C-arms provide distortion-free accurate images from edge to edge of the viewing field.

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