Experience in Use: A Physician’s Viewpoint

Use of CR Roentgenography in X-Ray Diagnostic Departments of Primary Treatment-and-Prophylaxis Institutions

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In the early XXI century, domestic public health service is in crisis. Local treatment-and-prophylaxis medical organizations (TPMO), particularly, departments using sophisticated equipment, are in the most difficult position. In 2006, 75% of medical equipment used in TPMO was obsolete and required replacement. Average wear of X-ray equipment in the Russian Federation is 80%.

The total number of X-ray apparatuses (including chest X-ray survey devices, mobile and dental X-ray apparatuses) in the Russian Federation is 35,000. According to the National Program for Health, ~3000 (9%) X-ray apparatuses should be upgraded in 2006 [1]. In 2007 modern digital X-ray apparatuses should be introduced.

There are now many digital X-ray diagnostic systems. The image conversion in these systems is implemented using direct (XRI, CCD-matrix) or indirect (luminescence screens) devices. Direct conversion X-ray apparatuses, i.e., DR-direct radiography systems, would be certainly appropriate for Russian TPMO, but they are very expensive. The apparatuses of the second type, i.e., CR-computed radiography systems (CR-systems) are more economical (3-5 times less expensive) and compatible with all analog X-ray apparatuses including mobile X-ray devices. The use of these systems provides digital archiving, improvement of image quality, data processing and storage in a unified carrier, and hence clear X-ray diagnosis.

FGUZ TsMSCh No. 165, Federal Medico-Biological Agency, Kolomenskoe Medical Center, Moscow, Russia, purchased a digital Optiscan-A X-ray system from Amico, Ltd. The Optiscan-A X-ray system is based on the Optiscan analog-to-digital converter available from Protec (Germany) (Fig. 1).

A total of 4000 patients with different types of pathology (therapeutic, surgical, urological, otorhinolaryngological, and gynecological) were examined. X-Ray photographs were taken using standard cassettes with luminescence screens with subsequent scanning using a laser beam. Digital image was stored in computer memory.

CR-roentgenograms were also taken using analog X-ray apparatuses Philips Diagnost-56 (1997) and AMICO Amigraf Russia (2006). The method of processing of X-ray images obtained using X-ray film based on A. N. Kishkovskii table of coefficients was suggested [3].

X-Ray tube anode voltage was calculated using the Longmore equation:

\[ V = A + 2X, \]

Fig. 1. General view of the Optiscan-A X-ray system.
where \( V \) is voltage; \( X \) is thickness of area of interest, cm; \( A \) is constant specific for given object (for bones and joints of adult humans, 27; thoracic cavity organs, 22; for bones and joints of children, 22; thoracic cavity organs of children, 17).

For adult human femur with thickness 25 cm, \( V = 77 \text{ kV} \) (\( V = 27 + 50 \)). Given the fact that the generator is three-phase, this value should be reduced by 10\%, i.e., \( V = 69 \text{ kV} \) (77 \( - \) 8). For a medium-frequency generator this value should be 20\% reduced, i.e., \( V = 61 \text{ kV} \) (77 \( - \) 16). This is consistent with physicotechnical parameters given in Table 2.

In case of CR-graphy and medium-frequency generator, this parameter should be 25\%-reduced: \( V = 58 \text{ kV} \) (77 \( - \) 19), because reference images contain more information.

The dynamic range of CR-systems is broader than the dynamic range of X-ray film. Therefore, physicotechnical conditions can be changed without decreasing image quality. The dynamic range test object was measured using the Optiscan-A digital system using standard software of monitor brightness regulation [2]. The resulting dynamic range was shown to be 200. The dynamic range of X-ray kits determined using the same system was found to be <50 because of the properties of X-ray film.

Contemporary X-ray screen–film kits fall into 5 groups with different sensitivity and image quality. Higher sensitivity corresponds to poorer image quality. Digital X-ray systems were compared with contemporary gadolinium X-ray screen–film kits sensitive in the green spectral region (domestic screen EU-IZ and Agfa X-ray film CP-GU). This X-ray kit is universal and meets contemporary requirements.

Clinical and experimental tests were performed to determine four optimal working modes of analog X-ray apparatuses Philips Diagnost-56 (1997) or Amico Amigraph (2006) (Table 1).

CR-diagnosis of lung diseases should not be performed at X-ray tube anode voltage >100 kV, because the software of the automated physician’s workplace is not appropriate for this working mode.

Digital image is discrete [4]. Image plane is divided into pixels. The number of pixels determines the sampling volume. Each pixel contains discrete information about image brightness. The level of quantization corresponds to the number of detected pixels. Digital image detector provides binary information about the image. Resolution of a digital image detector is characterized by the discretization matrix (number of horizontal and vertical pixels; pixel size, 16 \( \mu \text{m} \)). Many pixels of the CR-screen during primary screening are not read.

The level of quantization of the detector limits the dynamic range of digital systems. The level of quantization of the Optiscan-A is 10 bit, which corresponds to maximum 1024 signal levels. Noise level and contrast level decreases the dynamic range. The number of quantization levels is selected to be lower than the dynamic range to maintain the gradation characteristics of the system at a high level. In the CR-system described in [2] the diameter of the scanning laser beam can be varied, changing thereby the system resolution from 3 to 12 pairs of lines/mm. The increase in resolution causes an order-of-magnitude increase in the radiation dose against the background of invariable signal/noise ratio. The working diameter of the laser beam is 100 \( \mu \text{m} \) providing resolution 4.5 pairs of lines/mm, which is appropriate for medical diagnosis.

Exposure parameters for straight X-ray and CR-graphy using apparatuses Mediks-R-Amico and Diagnost-56 are given in Table 2.

X-Ray tube BD-46 was used with the same physicotechnical modes.

### Table 1.

<table>
<thead>
<tr>
<th>Anatomical structures (adult)</th>
<th>Roentgenogram</th>
<th>CR-gram</th>
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<tbody>
<tr>
<td>Shoulder, forearm, hand, foot, nose bones</td>
<td>42-44 kV</td>
<td>40-42 kV</td>
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<tr>
<td>Ephippium, temporal bone, cribiform bone, maxillary bone, lower jaw, ocular cavities, teeth, cervical vertebrae, upper chest vertebrae in straight projection, ribs, sternum, blade bones, clavicles, larynx, shoulder and knee joints, sacroiliac joints, pubic symphysis, urinary ducts</td>
<td>60-63 kV</td>
<td>55-60 kV</td>
</tr>
<tr>
<td>Cranium, paranasal sinuses, occipital bone, lower chest vertebrae in lateral projection and lumbar vertebrae in straight projection, hip, hip joints, femur, thoracic cavity organs, gastrointestinal tract</td>
<td>77-81 kV</td>
<td>70-77 kV</td>
</tr>
<tr>
<td>Lungs, heart and large blood vessels, lumbar section of spine in lateral projection, sacrum in lateral projection</td>
<td>83-86 kV</td>
<td>80-81 kV</td>
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