Estimation of patient doses from x-ray examinations in the Bryansk region hospitals

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Perquisites for the study

- 2009: Development and implementation of DRL system started in St-Petersburg (StP)
- 2009-2012: Development of data collection and dose estimation systems; data collected from 110 x-ray departments
- 2012: Dose distributions estimated for 13 procedures; preliminary DRLs for StP set as 75% percentile of dose distributions
- 2012: Necessity to compare StP data to regional data (rural preferably)
Region selection

- Representative in terms of equipment and state of clinical practice to other rural regions of Russian Federation
- Relatively high number of hospitals in a short distance
- Good relations with the local healthcare authorities
- Connection to other projects (Chernobyl-related)

Region of choice - Bryansk region, Klintzi and Novozibkov areas
Objectives of the study

- Evaluate the current state of conventional radiology practice
  - Perform QA of the x-ray units
  - Collect the standard procedure parameters from the selected area hospitals
  - Assess patient doses and establish dose distributions
  - Identify and determine the reasons of dose outliers
- Compare the patient doses and the state of radiology practice between Bryansk region and St-Petersburg
- Make recommendations on optimization in conventional radiology
A total of 4 expeditions took place during 2012-2013
Hospital and unit overall information

Hospitals examined by type

- General practice: 7
- Tuberculosis prophylactic center: 2

Units distribution by filtration

- 2.5 mm Al + 0.1 mm Cu: 9
- 3 mm Al + 0.2 mm Cu: 5
- 2.5 mm Al: 1
- 3 mm Al: 1
- 3.5 mm Al: 1

Units distribution by time of service

- <5 years: 3
- 5-10 years: 5
- >10 years: 9

Units distribution by type and film

- Analogue - blue film: 10
- Analogue - green film: 1
- Digital + blue film: 1
- Digital only: 1
QA and data collection

- QA procedures on all units inspected:
  - kV, exposure time and HVL consistency check
  - Field size and image quality (high and low contrast, spatial resolution) tests
  - Radiation output measurement

- Procedure parameters collection
  - Procedures: Skull (AP and LAT projections), Chest (PA and LAT), Ribs (AP), Cervical spine (AP and LAT), Thoracic spine (AP and LAT), Lumbar spine (AP and LAT), Abdomen (AP), Pelvis (LAT)
  - Parameters: tube voltage (kV), tube current (mA), exposure time (s), focal-image distance (cm), image field size (cm²)
  - Data was collected by questioning the operators
  - Image quality was presumed to be acceptable
Dose assessment

- Dose quantity for DRLs - Effective dose (mSv)
- Doses were calculated:
  - For standard procedures for standard patients (174 cm height, 70±5 kg weight, average constitution)
  - For each operator on the same unit separately
  - Using “EDEREX” (Effective dose Estimation in Roentgen Examinations) software (IRH developed, tissue weighting factors from ICRP 103 pub used)
Examples of Chest PA dose distributions (hystograms)
Examples of Chest PA dose distributions (per units)
StP Chest PA dose distributions, mSv
Dose distributions, all procedures, mSv

![Graph showing dose distributions for various procedures.](image-url)
Bryansk and StP 75-percentile comparison, mSv
Results

- Influence of procedure factors (especially for lumbar spine, pelvis and abdomen regions):
  - Low tube voltage
  - Relatively high tube current and exposure time
  - Lack of image intensifier screens
  - Unnecessary large field sizes (30x40 for spine examinations), either on purpose or due to lack of the necessary film cassettes
  - Difference in parameters used by different operators working on the same unit
  - High dependence on processing chemicals quality
    - Parameters changed significantly during the chemicals lifespan
Influence of technical factors:
- All units passed QC tests except for field size consistency
- Frequent collimation device malfunctions lead to maximum field size images
- No significant difference between old and relatively new x-ray unit doses
- No significant difference between manual and machine film processing unit doses
- Units with additional copper filtration (0.1-0.2 mm) showed the lowest doses
- Clinical dosimeters out of service on majority of the units
Influence of staff training and radiological practice:

- High patient flow (up to 100 patients per shift - 5 hours)
- High operator flow of change (4-6 months for operator at average)
- Operators with >2 year experience show best results regardless of state of equipment
- Operators don’t receive sufficient training when analogue x-ray unit is replaced with a digital one
  - Tendency to use maximum field size regardless of area of interest
  - Tendency not to use DAP-meters in everyday work
### Operator dose spread, Chest PA, mSv

<table>
<thead>
<tr>
<th>X-ray unit</th>
<th>Median</th>
<th>Min-Max</th>
<th>Raw Data</th>
<th>Outliers</th>
<th>Extremes</th>
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<td>0.052</td>
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**Diagram:**
- Median
- Min-Max
- Raw Data
- Outliers
- Extremes

**X-axis:** X-ray unit

**Y-axis:** E, mSv
Effects of equipment replacement and training

Replacement: analogue to digital
Operator training: before and after

Chest PA Effective dose, mSv

<table>
<thead>
<tr>
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<th>Unit 1 before</th>
<th>Unit 1 after</th>
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<th>Unit 2 after</th>
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<td>Unit 1 2013</td>
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Chest PA Effective dose, mSv

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Conclusions

- Patient doses in conventional x-ray in Bryansk region were estimated
- Dose distributions were established and 75-percentiles were set as the preliminary regional DRLs
- Main reasons for dose exceedings were identified:
  - Sub-optimal procedure parameters
  - Unnecessary large field sizes
  - Collimator malfunctions
  - Inadequate operator training
- 75-percentiles of dose distributions are comparable to St-Petersburg ones
Plans for the next years

- Focus on studying image quality and its relation to patient dose
- Perform film reject analysis on analogue x-ray units
- Perform a survey to determine an actual state of operators and practitioners level of training
- Determine the effect of high patients flow on quality of practice
Thank you for your attention