Dose evaluation related image quality on paediatric chest examination with dedicated flat-panel

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Purpose

The aim of this study is to verify if the Fujifilm digital imaging systems FRD DEVO allows a reduction of the dose in pediatric examination compared to equivalent technologies of main competitor.

The FujiFilm manufacturer sates to offer "a gentle solution for pediatric imaging supported by extensive technological expertise", providing high quality pediatric and neonatal imaging "in a safe medical environment", with a significant reduction of the exposure dose in particular in the chest study. The manufacturer said:

"Our products are being challenged to new levels of patients safety and dose efficiency." In particular, they declared that the FDR D-EVO equipment can help reduce exposure radiation by 20% compared to other DR systems.
Methods and materials

First of all, we tried to reproduce an image of good quality at a fair dosimetric compromise with the FDR D-EVO device.

The work was set in order to comply with "European guidelines on quality criteria for diagnostic radiographic images in paediatrics": radiological table horizontally or vertically depending on the age (in this case horizontal), focal spot size <1.3 cm, removal of the anti-diffusion grid, sourcedetector distance from 100 to 150 cm, voltage from 60 to 80 kV, automatic exposure control: central chamber, exposure time: <20ms. The beam was collimated in order to include only the entire lung field (as stated by ImageGently in compliance with the basic rules of radiation protection), it was possible to draw with a pen on the puppet's skin the field limits in order to ensure that in the successive exposures the irradiated area was maintained constant.

After setting the standard algorithm of the Fujifilm manufacturer called "PEDIATRIC CHEST", several tests were made varying the exposure parameters and distances. Initially we set FFD = 150 cm, 250 mA, 5 ms with gradually increasing kilovoltage (kV 70,80,85,90). Visually, the resulting images appear very blurring. Not being able to increase the mA because the small focal spot bear up to 250 mA, FFD was reduced to 120 cm. In order to decrease the dose, kV were raised to 90 and 100 (exceeding even the limits of the guidelines). Nevertheless, the noise level in some points such as the anterior chest near the mediastinum and the intersection of the diaphragms has not allowed to consider these images acceptable. By reducing the FFD more and bringing it up to 115 cm (minimum distance that the tube can reach), the following efforts were made:

<table>
<thead>
<tr>
<th>kV</th>
<th>mA</th>
<th>Exp Time</th>
<th>mAs</th>
<th>DAP (dGy x cm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>90</td>
<td>250</td>
<td>5 1</td>
<td>0,15</td>
<td></td>
</tr>
<tr>
<td>85</td>
<td>250</td>
<td>5 1,2</td>
<td>0,16</td>
<td></td>
</tr>
<tr>
<td>80</td>
<td>250</td>
<td>5 1,5</td>
<td>0,17</td>
<td></td>
</tr>
</tbody>
</table>
The two images obtained with 90 and 85 kV visually appear to have higher quality than the previous ones. The acquisition at 90 kV shows a flattening of the image even if here, compared to the image at 85 kV,

the front area near the mediastinum and the ribs look a bit better. But for diagnostic purposes, the area of the diaphragms is more important, because it is where we usually find the hoards, and it is arguably more defined in the image generated with 85 kV which is the best despite a minimal dose increase compared to the previous one (1.2 mAs vs 1mAs).

With the same parameters set manually (FFD 115cm, 85kVp, 250mA, 5ms) the same image was reproduced with the GE Discovery XR656, setting the specific algorithm called "PEDIATRIC MEDIUM CHEST" and removing the grid. The result obtained was not satisfactory visually, as

far as quality is concerned the image produced could not be compared with the previous one. The same procedure with the EIDOS 3000, but, setting the algorithm for the pediatric chest, the grid could not be removed. Trying with the algorithm "HAND" we obtained the same result.

Obviously the image obtained with the same parameters but with the use of the grid required a considerable increase of the dose to the patient (DAP dGy x = 1.9 cm² more than ten times greater than the Fuji).

Finally, by setting a protocol for quality control, it was possible to remove the grid, but the image produced was extremely flat and diagnostically irrelevant. At the end, in the same way, by setting the parameters in manual, the same exposure was performed with the DRX Evolution choosing "SIDE DECUBITUS INFANTE CHEST" among the many algorithms for the paediatric chest given by the Carestream manufacturer. The produced image immediately seemed satisfactory and of good quality; visually it appeared to have

the peculiarities to "compete" with the FDR D-EVO one. At that moment saying what image was the best was not certainly possible, but doubtless it deserved a more in-depth analysis that will be faced later.

(Appendix Tab.1) This result, yet to be confirmed, has led to an attempt to produce a new image that could maintain the diagnostic high quality of the previous one but that would result in a reduction of the dose to the pediatric patient. With this aim, after setting the automatic exposure control with central chamber, some exposures were made increasing kilovoltage and 320 mA. The radiographers who have followed this study, guided by their experience, were unanimous in considering the image obtained with 95 kV, 320 mA and 3 ms, an image of high quality where the findings of diagnostic importance were visible and where the dose to the patient was greatly diminished compared to the exposure with 85 kV, 250 mA and 5 ms (DAP dGy x =0.128 cm² versus DAP dGy x = 0.146 cm²).
Results

The initial project included the SNR5 and CNR6 comparison of images realized with equal dose. Unfortunately the execution of this analysis turned out not be technically applicable: as a matter of fact, the LUT7 of the images and their PV8 belong to completely different scales and so they are not mathematically comparable without a re-elaboration. In order to make a comparison between the LUTs, it would be necessary to have technical data of answer function of the LUTs that are not always available. Therefore, even if we found evidence concerned quality, the conclusions that we can draw are strongly influenced by the parameters linked to the elaboration of the LUTs. (Appendix Tab.2)

At this point, we found a solution by involving a team of ten expert radiologists from whom to obtain a psychometric evaluation. They were shown two of the numerous images produced with different DR systems, that we described earlier, with the same exposure parameters: the first one was obtained with the FujiFilm FDR DEVO and the latter with Carestream EVOLUTION. The Physicians were asked to choose the most diagnostic image between the two, to motivate their answer and to describe the evaluation criteria they adopted. One radiologist out of ten preferred the image produced with FDR DEVO because it was in his opinion qualitatively better than the other one, describing it "less blurry"; the other nine, instead, agreed to state that the best one was the image obtain with Carestream EVOLUTION. The ninth radiologists spotted in this image a better spatial and contrast resolution from the anatomic structures that we have taken into consideration (the lung apexes are more visible; the lung thickening looks less blurry; the outline of the ribs and the vessels profile are clearer; the diaphragm zone is more defined). In other words, according to the majority of radiologists the image obtained with Carestream system allows a more accurate study of the entire lung parenchyma.
Images for this section:

Fig. 2

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Fig. 3

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Fig. 1

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Conclusion

In conclusion, we did not observe a relevant dose reduction between FDR DEVO by FujiFilm and EVOLUTION by Carestream. Compared to other DR systems involved in the study there is a significant dose reduction.
References


Effect of X-ray incident direction and scintillator layer design on image quality of indirect-conversion flat panel detector with GOS phosphor.

Medical imaging.


Health Phys.


Best Practice in Digital Radiography.

Issue of Radiologic Technology.