Dose management system as a practical tool to establish local DRLs in digital mammography

Poster No.: ESI-0097
Congress: EuroSafe Imaging 2019
Type: EuroSafe Imaging
Authors: A. Viñals Muñoz¹, R. Fayos-Sola Capilla¹, P. García Castañon¹, I. GALÁN GONZALEZ², C. Idoate Ortueta², C. Ansón Marcos¹, D. Hernández González², M. L. España López¹; ¹Medical Physics and Radiation Protection Department, University Hospital La Princesa Madrid/ES, ²Radiology Department, University Hospital La Princesa Madrid/ES

Keywords: Action 2 - Clinical diagnostic reference levels (DRLs), Action 4 - Dose management systems, Breast, Radioprotection / Radiation dose, Mammography, Dosimetry, Technology assessment, Dosimetric comparison

DOI: 10.26044/esi2019/ESI-0097

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Background/introduction

Mammography is the most effective technique for breast cancer detection, but entails by itself cancer induction risk; therefore, it is essential to optimize patient doses.

European directive EURATOM 2013/59 (1) emphasizes the implementation and review of Diagnostic Reference Levels (DRLs) use as an optimization tool for diagnostic radiology procedures like mammography.

According to International Commission of Radiation Protection (ICRP) recommendations, DRLs in a single facility (2) can be established by means of the median value of a distribution for the selected dosimetric quantity. The establishment of adequate DRLs require the acquisition of a representative patient dose sample, which is not always easy to achieve. In fact, ICRP recommends to include at least 50 patients (2) to establish DRLs in mammography, due to the great variation of the compressed breast thickness and glandularity. The development of dose management programmes (DMP), which allow the massive data exploitation, have nowadays facilitated the establishment and periodical review of local DRLs.

Several dose management online systems have been developed over the last decade by different manufacturers. The information attached to the digital images in the DICOM header is extracted by those programmes, including for each modality specific dosimetric quantities.

Generally, for mammography, the dosimetric quantities selected are the Entrance Surface Dose (ESD), Entrance Surface Air Kerma (ESAK) and Average Glandular Dose (AGD). Digital mammographic units provide, for each exposition, with dosimetric indices that consist of an estimation of those quantities. These indices can be easily extracted by DMP.

The aim of this study is the evaluation of patient radiation dose monitoring online systems as a suitable tool for local DRL establishment in mammography.
Description of activity and work performed

Materials and Method:

The study has been performed in a Siemens Inspiration unit installed at a University Hospital. Dose management online system connected to this modality is DoseWatch (General Electric Healthcare). 215 patients undergoing bilateral mammography with two projections: mediolateral oblique (MLO) view and craniocaudal (CC) view have been included.

AGD and ESAK values are provided by the mammographic system for each image as dosimetric indices, and therefore extracted by the DMP. Prior to its use for dosimetric purposes, indices have to be validated by a medical physics expert.

In order to validate these indices, both quantities have been calculated for each image. First of all, ESAK has been calculated from Robson’s parametric model (5), using technical data of the examination (kV, mAs, anode/filter combination) extracted from DMP and quality assurance data: tube yield and HVL for reference conditions.

Then, AGD has been calculated from ESAK using Dance Model (3, 4). Age of the patient, compressed breast thickness and beam quality (HVL, kVp) are taken into consideration in order to perform the calculation (3, 4), following the expression:

\[ \text{AGD} = \text{ESAK} \times c \times g \times s \quad [1] \]

Where c, g and s are tabulated coefficients which take into account X-ray quality and glandularity.

Median values of both AGD and ESAK distributions, calculated and indicated by the unit, have been obtained for CC and MLO projections. Differences for each patient and also average differences for both quantities have been analysed in order to evaluate the accuracy of the available indices.
Finally, median AGD and median ESAK, obtained from DMP values, have been presented as preliminary DRLs for the facility.

**Results:**

Median values and standard deviation of AGD and ESAK for CC and MLO samples, both calculated and provided by the unit, are summarized in tables 1 and 2. The average relative differences between them and standard deviation of differences is also presented.

The AGD value obtained with DMP is always higher than the calculated one, with an average difference of almost 20%, yielding a greater DRL.

Differences between calculated and indicated dose quantities have been analysed, in order to determine the main sources of uncertainty.

First of all, the mammographic system uses Dance model for calculation of AGD, as stated by manufacturer, but it does not take into account the glandularity, and therefore it ignores coefficient c in equation [1]. Furthermore, the real HVL and tube yield of this particular unit are not taken into account; instead, tabulated parameters for every Inspiration unit are used. These differences entail a limitation in the use of AGD index obtained by DMP for DRL establishment.

On the other side, ESAK values are much more alike when both methods are compared, but in this case indicated ESAK is slighter than the calculated kerma for every patient. The average differences are less than 6%, so DMP programme would constitute a useful tool in order to establish ESAK based DRLs.

Hence, a validation of each unit's indices is mandatory prior to establishment of DRLs making use of DMP, particularly if these values are going to take part for development of national or even local DRLs.
However, if used as an internal optimization tool at the facility, in order to detect some problems regarding unit operation or even staff differences, DMP constitutes a powerful instrument.

Care must be taken, though, when periodically comparing doses with DRLs for optimisation purposes, since indicated values should always be chosen.

Table 3 shows preliminary DRLs, established for CC and MLO, in terms of AGD and ESAK. As it can be shown in table 3, MLO projection DRLs are greater than for CC, due to average larger thickness of compressed breast for that projection.
Images for this section:

<table>
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<th>DoseWatch</th>
<th>Calculated</th>
<th>Difference</th>
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<tbody>
<tr>
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<td>Std. Deviation (mGy)</td>
<td>Median (mGy)</td>
</tr>
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<td>ESAK</td>
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<tr>
<td>AGD</td>
<td>1,05</td>
<td>0,90</td>
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**Table 1**: Median values and standard deviation of AGD and ESAK for CC view, both calculated and provided by the unit.

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<tr>
<td>Median (mGy)</td>
<td>Std. Deviation (mGy)</td>
<td>Median (mGy)</td>
</tr>
<tr>
<td>ESAK</td>
<td>3,66</td>
<td>3,84</td>
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<tr>
<td>AGD</td>
<td>1,24</td>
<td>1,04</td>
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**Table 2**: Median values and standard deviation of AGD and ESAK for MLO view, both calculated and provided by the unit.

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Table 3: Preliminary mammography DRLs established with Dose management programme, for CC and MLO views.

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Conclusion and recommendations

Dose monitoring online systems constitute a useful tool for DRLs establishment, due to large samples of data which can be acquired.

Validation of dosimetric indices has to be always performed by a medical physics expert prior to DRLs establishment based on these quantities.

These results and preliminary presented DRLs shouldn't be extrapolated to other mammographic systems, due to differences in dose calculation method among different units.
**Personal/organisational information**

Mr. Alberto Viñals Muñoz

Degree in Physics

Medical Physicist trainee, second year.

Medical Physics and Radiation Protection Department

University Hospital la Princesa

Madrid
References


