# METHODS OF OPTIMIZATION IN PELVIC RADIOGRAPHY

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**Abstract.** Two alternative methods of optimization in pelvis examinations have been investigated as part of a complete optimization exercise for pelvis examination within both a CR and a DR room. Following a preliminary study using an anthropomorphic phantom, the methodology of each technique was assessed by the examination of patient doses and image quality. It was determined that by increasing the focus to detector distance (FDD) within a DR room, entrance surface dose could be reduced by 30%, and that by orienting the patient so that the ilium did not cover the outer automatic exposure control chambers the entrance surface dose could be reduced by 37% for a DR room and 49% for a CR room. Increasing FDD gave no significant reduction on image quality, however altering patient orientation did result in a slight reduction. It could however be argued that the 'poorer' image quality is still adequate and therefore that this work shows that by altering the orientation of the patient, a slightly higher patient dose could be justified for certain indications by a higher image quality.

## 1. BACKGROUND AND PURPOSE

A major hospital in the North West of England has recently installed a single direct digital X ray room. In order to optimize the examinations as required by UK legislation [1] a research group was formed consisting of senior radiographers, the local radiation protection advisor (RPA)/medical physics expert (MPE) and the local university. The continuing objectives of the group are to look at imaging techniques to see if any changes could be made in order to reduce patient dose whilst maintaining adequate image quality. It was decided that the relatively common and higher dose pelvis examination would be chosen as the one to optimize.

The group decided upon three methods of optimization, with each being tackled in turn. Preliminary work on each method would be performed by a student, and only if the method appeared to show a dose reduction whilst maintaining adequate image quality would the study progress to a patient trial. The three methods chosen were:

- Increase the focus to detector distance (FDD);
- Patient orientation;
- Centring point.

Currently the first two methods (increased FFD & patient orientation) have been researched and results are available, therefore they will be described in the next section. The third method (centring point) will be described under the future work section.

## 2. METHOD

### 2.1. Increased FDD

It was initially assumed that increasing the FDD whilst maintaining the area exposed on the patient would reduce the patient entrance surface dose (ESD) along the ratio of the FDD to the focus to patient skin distance (FSD) with no degradation in image quality due to the wider latitude of digital imaging. Historical reasons for keeping a short FDD include:

- Tube depreciation due to the increased mAs required in order to maintain a constant detector dose at the increased distance;

- The risk of motion blurring from the longer exposure times as a consequence of the increased mAs.

However, in private correspondence with a manufacturer, it was stated that any tube depreciation due to increased mAs values is likely to be insignificant and most modern generators are capable of keeping exposure times short with mA increasing to increase the mAs.

An initial calculation was performed based on the assumptions that the mAs will increase purely to compensate for the decreased dose to the detector due to the inverse square law. For a standard patient thickness of 30 cm the ESD would be reduced to 87% of initial value for a change in FDD of 115 cm to 144 cm. A phantom study was performed to confirm this dose reduction and to ensure that image quality was at least maintained [2] before a patient trial commenced.

For the patient trial, patients attending for a pelvis examination were randomized into two groups, group one having the standard technique applied (115 cm) and group two having the extended FDD (144 cm). ESD was calculated for each patient from the exposure factors and knowledge of the normalized output at 1 m from the tube [3]. The whole body effective dose (WBD) was calculated using bespoke software that utilizes Monte Carlo data for standard examination data [4]. Image quality was also assessed blindly by three experienced assessors using an established method [5] that uses a rating system adapted from the European Guidelines on Quality Criteria for Diagnostic Radiographic Images [6].

The results of this work have recently been submitted to a UK based medical physics conference.

## 2.2. Patient orientation

Following a straw poll amongst radiographers, it was discovered that many did not know the orientation of the automatic exposure control (AEC) chambers on the table bucky, and simply oriented the patient based upon convenience or historical training rather than reasons of dose or image quality. For examinations of the pelvis, the anatomy covering the AEC chambers could vary, for example the ilium could cover the outer chambers if the patient is oriented in one direction, but in the other direction there would be just tissue. This would have an effect on the AEC performance in terms of the mAs required to produce an adequate image, which in turn will affect the patient dose.

Again, a phantom study was performed to confirm that there was a difference in ESD and WBD between orientations [7] before a patient trial was commenced. This study revealed a difference in 37% between ESD to a phantom in either orientation.

For the patient trial, it was decided to obtain more data and that two rooms would be used. The DR room would be used in addition to a standard computed radiography (CR) room. The default examination parameters would be selected in each room.

All patients attending for a pelvis examination were randomized into four groups, two groups in each room, with one group oriented with the outer chambers towards the head (‘head-towards’) and the other group oriented in the opposite direction (‘feet-towards’). See Figure 1.

*FIG. 1. Placement of AEC chambers in the 'head-towards' position.*

The ESD & WBD were calculated as per the previous study in order to assess any differences between the two groups. Image quality (IQ) was again assessed by the same experienced viewers using the same method described above.

## 3. RESULTS

### 3.1. Increased FFD

Patient studies have shown that the ESD was reduced from 2.3 mGy to 1.6 mGy between the normal FFD (115 cm) and the extended FFD (144 cm). This reduction was greater than the predicted values. The WBD for the normal FFD was 0.38 mSv and the extended was 0.27 mSv. This reduction was in line with predicted values.

TABLE I. ESD, WBD & IQ SCORE FOR DIFFERENT FFDS

| | ESD (mGy) | WBD (mSv) | IQ score (% max possible score) |
|---|---|---|---|
| 115 cm FFD | 2.3 | 0.38 | 90.0 |
| 144 cm FFD | 1.6 | 0.27 | 97.0 |

### 3.2. Patient orientation

The ESD for the ‘head-towards’ patients was shown to be reduced by 37%, which is similar to the phantom study. When using CR, the reduction was 48%, although for both rooms there was a noted reduction in image quality

TABLE II. ESD, WBD & IQ SCORE FOR BOTH ORIENTATIONS IN EACH ROOM

| Patient orientation | DR | | | CR | | |
|---|---|---|---|---|---|---|
| | ESD (mGy) | WBD (mSv) | IQ score (% max possible) | ESD (mGy) | WBD (mSv) | IQ score (% max possible) |
| ‘Head-towards’ | 1.5 | 0.20 | 92.4 | 6.5 | 0.79 | 98.0 |
| ‘Feet-towards’ | 0.94 | 0.13 | 79.3 | 3.4 | 0.39 | 88.6 |

## 4. CONCLUSIONS

According to a recent study [8], pelvis examinations consist of about 3.5% of all medical X rays in the UK, making this the 6$^{th}$ most common examination. This examination contributes almost 2% of the population dose from medical exposures, making this the 16$^{th}$ highest contributor (3$^{rd}$ highest plain film examination). Local data from the hospital radiology information system (RIS) shows that pelvis make up 3.26% of all medical X rays and 3.95% of all plain film examination at this Trust.

As this study has not looked at the effects of both methods of optimization in conjunction with one another, it would be wrong to state the combined possible dose reduction at this stage; however, it is clear that there are currently at least two alternative methods for optimization of pelvis examinations. Therefore, this study shows that by using one of the two methods, a significant dose reduction can be obtained which given the frequency and population dose contribution is highly desirable.

The limitations of one method of optimization (for example a restriction on the possible increase of FFD) would mean that the other could be chosen. The orientation method is of particular interest as there is a significant difference in the image quality between orientations; this could be utilized for examinations where slightly better image quality is required.

## 5. FUTURE WORK

The third component of this optimization project is to look at the effects that a reasonably foreseeable variation in centring point for pelvis examinations will have on organ dose, and therefore effective dose. Initially the organ dose will be modelled on a 16×16 matrix of possible centring points with image quality assessed on a phantom for each centring point.

In addition, once the third component has been completed, there will need to be a study to assess if these methods should be used singly or, if used in combination, the reduction in dose still produces acceptable image quality.

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