# IMPLEMENTATION OF SOME DOSE REDUCTION METHODS IN QUALITY ASSURANCE OF DIAGNOSTIC RADIOLOGY IN SOME HOSPITALS IN IRAN

**M. Sohrabi, S. Borhan Azad and B. Aghahadi**

National Radiation Protection Department
Atomic Energy Organization of Iran
P.O. Box 14155-4494, Tehran, Iran

## INTRODUCTION

Although quality assurance (QA) programmes have been implemented in medicine and in particular in diagnostic radiology in Iran since a long time ago through periodic inspections, education and training, determination of genetically significant dose (1), patient and personnel monitoring, etc., a systematic national programme has been recently implemented by sending a detailed questionnaire to about 1000 diagnostic radiology departments. In 1991, the participation in an IAEA co-ordinated research programme on radiation dose in diagnostic radiology and methods for dose reduction showed up to 79% reduction in entrance skin dose (ESD) by keeping or improving the image quality (2,3). As an extension of this work, the programme was implemented on 520 patients in 13 X-ray rooms of 11 hospitals in Tehran using the image quality criteria defined in a CEC Working Document (4). The relationship of ESD to radiographic technique and to image quality was analyzed. In this paper, the results are presented and discussed.

## MATERIALS AND METHODS

Based on the returned 350 questionnaires, the per caput average number of examinations, number of films per examination, the frequency of certain examinations and the technical factors applied (mA, kV and exposure time, focus to film distance or FFD, field size, etc.) as well as the departments volunteer to implement the QA programme were deduced. From the voluntary departments, ten hospitals and one mammography clinic in Tehran were selected.

The projections of chest PA and abdomen AP in 12 X-ray rooms and four mammography projections including medio-lateral left and right and cranio-caudal left and right in one X-ray room were considered. A multi-function meter (RMI, Model 240-A), a Rad-Chech PLUS (Victoreen Model 06-526), a dual color sensitometer (X-rite, Incorporated, model 334), a B/W transmission densitometer (X-rite, Incorporated, model 331), a HVL attenuator set (RMI Model 115A), TLD-100 dosimeters (LiF, Harshaw) were used. The conditions of one darkroom in each department including light tightness, fog level, safe light, processor (developer, temperature and rinsing) and cassettes (speed, cleaning, light leakage and air trapping) were tested. The ESD of 520 patients were directly measured by TLDs on the patient's skin at the center of the X-ray field. The following procedures were completely implemented in selected departments:

1- Determination of ESD, kV, mA.s, FFD and image quality scores of 260 patients weighing 60 to 70 kg prior to QA including 10 patients for each selected examination (chest PA, abdomen AP, mammography CCR, CCL, MLR and MLL). The image quality scores was given by field radiologists based on the CEC image quality criteria (4); scores of 1, 2 and 3 respectively for poor, satisfactory and good image qualities.
2- Determination of means values of ESD, kV, mA.s, FFD and image quality score of each group of 10 patients stated in part 1.
3- Based on the information obtained in parts 1 and 2, necessary corrective measures were made reduction such as reduction of mA.s by improving the film developing conditions, reducing the optical density of the film and/or increasing the speed class of film screen combination as well

as optimizing the kV, filtration and FFD by using an anthropologic phantom (Randoman phantom from Alderson Research Lab. Inc.).

4- Repeating parts 1 and 2 after QA in part 3 for another 260 patients applying the same procedure.

## RESULTS AND DISCUSSION

Although many QA parameters, both related to the equipment and techniques, seemed necessary to be corrected, due to some existing problems only some parameters were considered for corrective measures including radiological techniques such as increasing kV and FFD as well as decreasing mA.s. Also in a few cases, some other possible corrective measures such as improving the darkroom conditions, selection of best film screen combinations and improving total filtration were also applied. The implementation of the above led to a significant decrease in the mean ESD values while increasing the image quality due to changes in the technical parameters, as shown in table 1. It should be mentioned that in the case of mammography, only type of film and the anti-scattered grid were changed. Under the conditions applied, the mean ESDs have been decreased up to 72%.

Table 1. Effects of applying dose reduction methods on ESD and image quality.

| QA parameters | | | Variations of the means (%) ± SD | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Chest PA | Abdomen AP | Mammography* | | | |
| | | | | | CC-R | CC-L | ML-R | ML-L |
| Dose | kV | increased | 61±21 | 37±14 | 0±5 | 0±5 | 0±5 | 0±6 |
| Reduction | mA.s | decreased | 76±14 | 63±19 | 0±12 | 4±23 | 7±8 | 9±12 |
| Methods | FFD | increased | 30±16 | 16±6 | 0±0 | 0±0 | 0±0 | 0±0 |
| Image quality increased | | | 42±20 | 38±9 | 30±10 | 30±10 | 30±10 | 30±10 |
| ESD decreased | | | 72±14 | 54±17 | 12±14 | 28±16 | 31±12 | 28±13 |

* CC-R=Crano Caudal Right, CC-L=Crano Caudal Left, ML-R=Medo Lateral Right, ML-L=Medo Lateral Left.

Figures 1 and 2 show mean ESD values of patients undergoing respectively chest and abdomen examinations in different X-ray rooms. It is observed the ESD has been significantly decreased after implementation of the QA in all departments. Figures 3 and 4 show the mean scores of image quality, respectively for chest and abdomen examinations. From these figures, it can be concluded that while Figs. 1 and 2 show significant ESD reductions, Figs. 3 and 4 show significant improvement in the image quality of the radiographs. Also table 2 shows the maximum, minimum and their ratios as well as the mean values of the ESD before and after the QA. From table 2, it can be also concluded that the range of the ESDs and in turn the maximum to minimum ESD ratios have been significantly reduced after the QA. It can be concluded that by adjusting the exposure techniques for different X-ray units and using a written protocol for these techniques, the requirement for repeating the radiographs due to over or under exposures will be reduced.

Regarding the rejected films, during the first set of measurements, about 500 films were analyzed by field radiologists from which 18.8% were rejected for repetition. The main reasons for repeating of rejected films included patient movement (5.4%), over exposure (4.2%), exposed by light (3%), under exposure (2.9%), positioning (1.2%), repeated radiographs by mistakes (0.8%) and developing conditions (0.4%). It can be concluded that by using a technical protocol, about 7.1% of the overall rejected films (due to over or under exposure) may be reduced.

As shown in table 1, the limited QA programme applied has been very effective in dose reduction in the X-ray units used in this study. Based on the data collected from the questionnaires, the frequency of chest and abdomen examinations were respectively 4.3 million and 1.6 million in 1994.

So reduction of 72% ESD for chest and 54% for abdomen can lead to a significant reduction of collective effective dose in Iran.

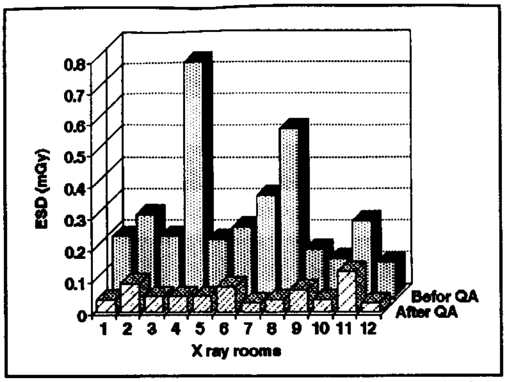


**Figure 1**. Mean ESD per film for CHEST, before and after QA.

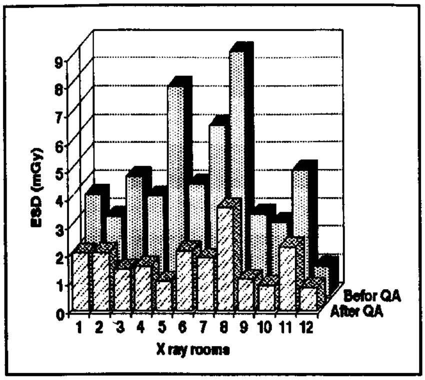


**Figure 2**. Mean ESD per film for ABDOMEN, before and after QA

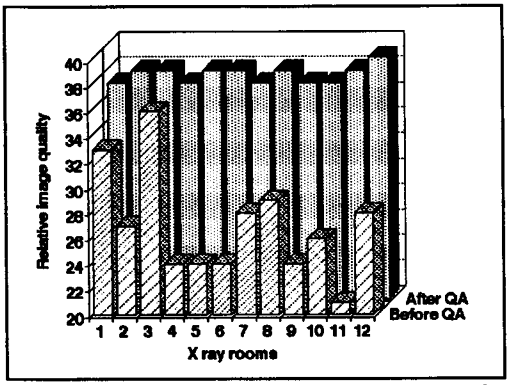


**Figure 3**. Mean score of image quality per film for CHEST, before and after QA.

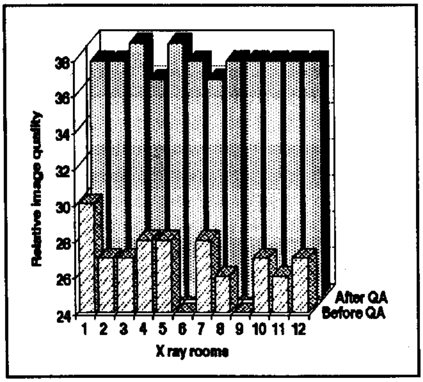


**Figure 4**. Mean score of image quality for ABDOMEN, before and after QA.

Table 2. ESD ranges by examination

| Examination type | Min (mGy) | Max (mGy) | Mean±SD (mGy) | Max/Min |
|---|---|---|---|---|
| Chest PA before QA | 0.05 | 1.69 | 0.27±0.23 | 34 |
| Chest PA after QA | 0.02 | 0.17 | 0.06±0.03 | 8.5 |
| Abdomen AP before QA | 0.26 | 13.73 | 4.23±2.77 | 52.8 |
| Abdomen AP after QA | 0.76 | 3.83 | 1.66±0.77 | 5 |

**REFERENCES**

1. M. Sohrabi, S. Borhan Azad and J. Shooshtarian, Procs. of Regional IRPA Congress: Asia Congress on Rad. Protection, 384-386, Beijing, China (1993).
2. M. Sohrabi, S. Borhan Azad and B. Aghahadi, IAEA-TECDOC-796, pp. 63-69 (1995).
3. P. Ortiz, C. Maccia et al. Radiat. Prot. Dos. 57, 95-99 (1995).
4. CEC, Working Dodument XII/173/90, 2a. edition (CEC), (1990).