ASSESSMENT OF PATIENT SKIN DOSES IN DIAGNOSTIC RADIOLOGY

J.P. Wade, K.E. Goldstone and P.P. Dendy

East Anglian Regional Radiation Protection Service
and Medical Physics Department
Addenbrooke's Hospital
Cambridge, England

ABSTRACT

In the light of recent UK legislation and the increased awareness of patient doses by the general public, there was a need for more extensive direct measurement of the doses received by patients. A program was introduced in Autumn 1990, in the East Anglian Health Region to monitor the skin entrance doses for a range of common radiographic procedures. The results already obtained have raised questions about the suitability of some of the equipment and techniques used. For very low doses the relationship between dose and image quality is also being investigated.

INTRODUCTION

In the last few years there has been much interest in reducing the doses received by patients during routine diagnostic x-ray investigations. In the U.K. this has been backed up in legislation by the Ionising Radiation (Protection of Persons Undergoing Medical Examination or Treatment) Regulations 1988 which require a person physically directing an exposure to ensure the dose is as low as reasonably practicable while achieving the required diagnostic result. Furthermore, x-ray departments are required to formulate a strategy for dose reduction.

The National Radiological Protection Board (NRPB) with the Royal College of Radiologists (RCR) published a report on "Patient Dose Reduction in Diagnostic Radiology" (1) where it is recommended that each x-ray department should make measurements on skin entrance doses and these should be compared with national norms and, in time, their own previous results. As very few x-ray departments have the facilities for doing this, the East Anglian Regional Radiation Protection Service undertook the task of providing this service for all the x-ray departments in the East Anglian Health Region, in both the public and private sectors.

PROGRAM ORGANISATION

Because of the geographical spread of the x-ray departments involved in this program, a postal system had to be used. Batches of sachets containing thermoluminescent dosemeters (TLD) were sent out to each participating x-ray department with an instruction sheet, record sheet and padded return envelope. The TLD's used are lithium floride extruded chips which were read out in a Toledo reader; the batch was calibrated for diagnostic energies and all doses are quoted for diagnostic energies. On the record sheet details of the exposure factors (kVp, mA and time), focus-film distance and whether an automatic exposure control device had been used were recorded, and space was provided to attach the exposed TLD sachets. The instruction sheet included advice on the selection of patients for dose measurements; patients were to be of average size and no children under 16 years of age were to be included. The TLD sachet (which contains two chips) was stuck on to the patient at the centre of the entrance field during the radiographic view being measured. Where a repeat radiograph was required, the TLD sachet was to be left on the patient for the repeat and this would reflect the dose actually received by the patient. The TLD's and record sheet were returned to the Radiation Protection Service for processing and the x-ray department was informed of the results.

Thirty six x-ray departments, eight of which are in private hospitals or clinics, have participated in one or more parts of the study. Each participating department was issued with an identifying code which was used in all correspondence and in particular when results were sent out and comparisons between departments were made. A selection of simple radiographic views have been chosen, covering a range of anatomy and exposure factors. The views selected were AP Abdomen, PA Chest, Lateral Lumbar Spine and Lateral Skull. The average entrance dose for each department was then compared to guideline doses recommended by the NRPB (2) for the radiographic view being studied. Any department with average doses above the guideline dose was contacted with a view to reducing their doses by looking at the techniques and equipment used.

DOSE RESULTS

For the AP Abdomen view the individual entrance doses ranged from 0.97 to 41.6 mGy with an average of 7.9$\pm$ 6.5 mGy and the departmental average doses varied from 3.7 mGy up to 19.4 mGy. Every department with an average dose over 10 mGy (the guideline dose for AP Abdomen) was contacted with a view to assessing how dose reductions might be made and several

departments have already made changes which have resulted in dose reductions up to 65% with very little reduction of image quality. Examples of changes have included the change of film/screen combination or the change in kVp where the response of the film/screen combination is energy dependent.

From early results on PA Chest skin entrance doses it rapidly became apparent that two very different radiographic techniques were being employed. The first technique uses 60 -75 kVp and a chest stand without a grid; this is good for imaging the soft tissue in the lungs. For this technique the average skin entrance dose measured was 0.16 mGy with a range of 0.01 mGy (the minimum dose measurable) to 0.88 mGy. The second technique utilises 120 - 130 kVp and a high factor grid in the chest bucky. The average skin dose for this technique was 0.25 mGy with a range 0.01 to 1.57 mGy. The departmental average skin doses varied from 0.04 mGy up to 0.48 mGy. The NRPB guideline dose for PA chest is 0.3 mGy. In our survey all the departments with average doses greater than this were using the high kVp technique. These results and their implications are being discussed elsewhere (British Institute of Radiology Annual Conference, Birmingham England, May 1992).

For lateral lumbar spine radiographs the individual entrance doses range from 3.2 mGy up to 103.8 mGy with an average of 19.3 mGy. The departmental average doses vary from 6.6mGy up to 45.3 mGy; the NRPB guideline dose is 30 mGy. The departments with higher than average doses were those which also showed higher than average doses for AP Abdomens but for various reasons have not yet made any dose-reducing changes to their equipment and/or techniques.

Skin entrance dose measurements have not yet been made on lateral skull radiographs.

PATIENT DOSE AND IMAGE QUALITY

It is well known that, because of the statistical nature of the interaction of x-ray photons with the image receptor, the detection of small objects which have low contrast difference with their surroundings is dose dependent. Therefore, in pursuing a policy of patient dose reduction it is important not to reach a point at which relevant clinical information is lost.

A number of theoretical analyses have been carried out to determine the minimum dose required to detect an object of given dimensions and contrast (3). To test these predictions we have designed a phantom consisting of small aluminium discs of different sizes, in the range 5-30 mm diameter and varying thickness up to 2 mm, that can be randomly arranged on a perspex plate and immersed in a tank of water. Contrast may

be adjusted by adding contrast medium to the water. A team of observers will be asked to examine films for "objects" and 50% detection limits will be established at different doses and compared with theory. Preliminary studies show that, for 70 kVp, a contrast C ($=0.4343\gamma(\mu_2-\mu_1)x$) of about 0.21, a surface dose of approximately 0.13 mGy is required to perceive a 10 mm diameter aluminium disc.

CONCLUSION

Radiography staff have found the procedure for making direct measurements of the patient entrance dose easy and the results very informative. Comparison of results between departments has readily indicated those departments consistently giving higher than recommended doses where priority should be given to reducing doses. Several departments have already reviewed their practices and made changes which have been assessed for their effectiveness in dose reduction by making repeat measurements after the change.

Perception studies have been initiated to determine whether there is a serious risk of loss of image detail for some of the lowest doses reported in the survey.

REFERENCES

1. NRPB/RCR Documents of the NRPB, Volume 1, No.3, 1990. Patient Dose Reduction in Diagnostic Radiology. Published by HMSO, London, U.K.

2. Shrimpton, P.C. ,Wall, B.F. and Hillier, M.C. Suggested Guideline Doses For Medical Examinations. Proceedings of the 25th Anniversary Symposium of the Society for Radiological Protection, Editor: E.P. Goldfinch. (Bristol: IOPP) 1989.

3. Dance, D.R. Diagnostic Radiology with X-rays. in "The Physics of Medical Imaging". Edited by S. Webb. Medical Science Series, published by Adam Hilger, Bristol, U.K. 1988. pp 22-30.