OPTIMISATION IN MEDICINE : THE POTENTIAL AND THE PROBLEMS

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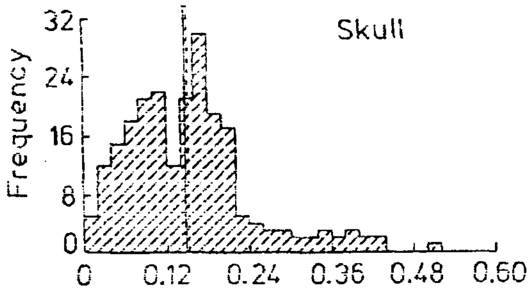
THE POTENTIAL

High profile uses of ionising radiations, such as nuclear power automatically get significant attention from the radiological protection community. Conversely the resources and attention paid to the use that has been with us the longest, medical diagnostic procedures, are lower. In the light of this it is perhaps instructive to look at the levels of individual and collective doses in the medical sector. In almost every country the largest component of the population dose from artificial sources is to patients from medical diagnostic procedures. Over the last few years the NRPB has carried out studies in the UK to determine the frequency with which various examinations are carried out [1] and the associated patient doses [2]. The total annual frequency of all X-ray examinations, excluding dental, for 1983 were 488 per 1000 inhabitants. Dental X-rays provided a further 156 per 1000 inhabitants.

Table 1
Collective doses to the Great Britain population from diagnostic medical radiology

Practice	Collective effective dose equivalent (man Sv)
Medical X-ray (excluding CT)	15 500
Computerised tomography (CT)	500
Dental X-ray	200
Nuclear medicine	950
All diagnostic radiology	17 150

From Table 1 it can be seen that the annual collective dose is of the order of 17 000 man Sv, which accounts for approximately 90% of the UK exposure arising from artificial origins. The individual effective dose equivalents from different types of examinations cover a tremendous range; from dental and chest radiography at ≤ 0.05 mSv per examination to between 5 and 50 mSv for barium enema X-ray examinations and nuclear medicine scans of the thyroid and pancreas. The per caput annual dose was about 0.3 mSv. A particularly important part of the studies was the determination of the distributions of doses for the same types of examinations conducted on different patients and in different hospitals; examples are shown in Fig. 1.



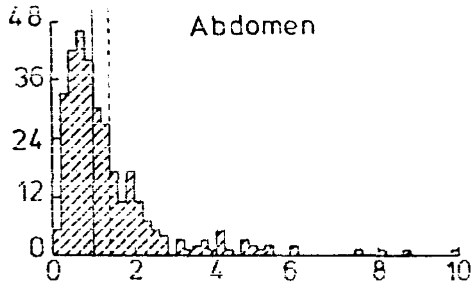


Fig. 1 Examples of distributions of effective dose equivalents for adult patients undergoing simple types of examinations

It is clear that there must be potential for eliminating the high doses from the distribution of patient doses and thus shifting downwards the mean doses for each type of examination. Given the size of the collective dose from medical examinations this potential assumes very significant proportions. For example, every 1% reduction in the annual collective dose is just under twice the current annual collective dose in the UK from occupational exposure in the nuclear power industry (92 man Sv). Many patient dose reduction options, e.g. rare earth screens and carbon fibre cassette facings, grid facings and table tops are known to be cost effective but have not been widely used. Indeed in the statement from the ICRP Paris meeting, 1985, the Commission positively expressed regret that such changes were not being introduced as rapidly as possible. It is also relevant to note here the striking disparity between the sums spent on radiation protection in the nuclear power industry (£10^4 to £10^6 man Sv^{-1}) and those spent in medicine £10 to 10^3 man Sv^{-1}.

ADDRESSING THE PROBLEMS

The numerical values of the dose limits do not apply to patient exposure but the basic principles of Justification and Optimisation do apply, and as shown above there is a significant potential for dose reduction. In the light of this the NRPB has a programme of work with two broad elements that are attempting to focus attention on this area. Firstly, it is considered that in common with other sectors the use of decision aiding techniques such as cost benefit analysis (CBA) together with formal ALARA Audits, have a valuable role to play in the assessment of competing protection options and indeed in decisions on justification and the allocation of resources. The ALARA Audits are essentially systematic and regular reviews to determine the relevance and adequacy of the existing radiation protection measures. They provide a mechanism for identifying problems that need to be addressed, whilst CBA, used within a structured 'ALARA Procedure' [3] provides a means to aid the subsequent decisions that have to be made. Fundamental to the use of CBA is the need for a value of unit collective dose that is appropriate in the context. Russell and Webb [4] have recently considered the special factors that apply here, in particular

1. the magnitude and range of effective dose equivalents associated with particular types of examination

2. the age distribution of the irradiated population

3. the direct benefit to the patient

4. the general view of medical exposures as beneficial.

The age distribution is particularly important. In diagnostic radiography, exposure is not uniform throughout life. In children in their first decade, the frequency of examination is about one third of that found in those aged over 60, and in general the radiation dose for an examination is less in children. A large proportion of a lifetime's exposure to diagnostic X-rays occurs in the last illness when radiogenic cancer is irrelevant. Conversely, the doses given in paediatric and obstetric radiography will be associated with higher somatic and genetic risk factors than would apply to an average population. Russell and Webb concluded that a value in the range £5,000-£10,000 man Sv^{-1} would seem reasonable for most purposes, i.e. a general radiography department. However, doses in paediatric and obstetric departments should be valued 5 times higher, in the range £25,000-£50,000 man Sv^{-1}.

Although many optimisation case studies have been done in the nuclear power sector, there are relatively few examples in the medical sector. The NRPB has therefore put effort into encouraging such studies. One aspect of this has been to demonstrate the technique by performing a case study [5] for a hypothetical 6 room X-ray department considering expenditure on the protection options of slot radiography, rare earth screens, carbon fibre table tops, grid facings and interfacings, etc. This produced incremental cost effectiveness figures of between £2 and £8,900 man Sv^{-1}. Apart from indicating the desirability of implementing the options it also provided a ranking or implementation priority listing. Further studies are being planned and it is hoped that such work will encourage others to put the techniques into practice. Although the main focus of such studies is likely to be on equipment and facilities, it is felt that the techniques could also be used in quality assurance, training and enforcement programmes, and as part of the justification process when considering routine X-ray screening programmes.

Whilst encouraging further studies, it must be recognised that within the medical sector there is reticence to accept the use and validity of these techniques. This is probably because many of those with direct budgetary control are making overt short term life and death decisions daily and do not recognise a reduction in long term detriment as a sufficiently real source of income to be balanced against direct expenditure. This problem may partly be attached by looking towards the higher decision levels concerned with resource allocation, but at a practical level we need to integrate protection with existing facets of medical programmes. This is where the second element of the NRPB's programme of work is relevant. Quality Assurance (QA) programmes are becoming widely implemented in radiological departments, partly due to the radiologist's prime interest in image quality. The encouragement of routine patient dose monitoring as a part of QA programmes is considered of prime importance. Also to demonstrate the cost effectiveness of radiation protection measures relative to medical procedures, other economic techniques are being explored. Cost utility analysis provides one method of doing this in terms of the cost per life year saved and this has the advantage of being a technique that is already in use to some degree within medical circles.

In common with other sectors, the availability of good data bases is a major problem and if we are to make use of the various techniques, action is required now to build these up, particularly in relation to workload and doses per examination. Work is in hand to develop a simple patient dosimetry protocol to enable hospital X-ray departments routinely to monitor patient doses as part of their quality assurance programme. Two of the options being pursued are entrance skin dose measurements using a TLD system and the use of Diamentor ionisation transmission chambers to deduce the total energy imparted. Shrimpton et al. [2] have shown that there is reasonable correlation between the total energy imparted and the effective dose equivalent over a range of two orders of magnitude and for examinations of widely varying complexity.

CONCLUSION

Overall the control of patient exposure from diagnostic radiology has not achieved the objective of ALARA and significant potential exists for dose reductions. This is an area that warrants increasing attention from the radiation protection community.

REFERENCES

1. Wall, B.F. et al., An update on the frequency of medical and dental X-ray examinations in Great Britain for 1983. Chilton, NRPB-R201 (1986).

2. Shrimpton et al., A national survey of doses to patients undergoing a selection of routine X-ray examinations in English hospitals. Chilton, NRPB-R200 (1986).

3. Webb, G.A.M. et al., Development of a general framework for the practical implementation of ALARA, Proceedings of International Symposium on the Optimisation of Radiation Protection. IAEA Vienna, 10-14 March, 1986.

4. Russell, J.G.B. and Webb, G.A.M., Valuing the Man-Sievert in X-ray diagnosis. British Journal of Radiology, Vol. 60, No. 715, 1987.

5. Croft, J.R. and Hudson, A.P., Optimisation in Medicine with Illustrative Exercises, in press.