The Effective Use of Diagnostic Radiology

C. J. ROBERTS, MD, FFCM

Professor and Head of the Department of Epidemiology and Community Medicine, Welsh National School of Medicine, Cardiff

The Royal College of Radiologists' Working Party on the Effective Use of Diagnostic Radiology held its first meeting in August 1975. It was established with the blessing of the Faculty Boards and the Council of the College, and a further indication of the importance attached to this initiative is shown by the fact that the working party included, and continues to include as members, the then President of the College, Professor Steiner, and the then Warden of the College, and current President, Dr John Laws.

The minutes of this meeting stated: 'Radiologists are very concerned about the increasingly expensive and often inefficient use that is being made of diagnostic facilities. Correction of the situation would lead to greater efficiency in patient management, reduction in radiation exposure, and a reduction in the cost of the service thereby possibly obviating the need for future expansion to meet growing demands.' It was concluded that the College should produce a series of guidelines for use of the common diagnostic radiological techniques derived from information collected specifically to answer questions about effectiveness, safety and cost of the procedures in question.

The working party recommended the early establishment of a series of national multicentre studies of five commonly used diagnostic radiological procedures: pre-operative chest radiology (POCR) in elective surgery; skull radiology (SXR) in head injury; lumbar radiology in the management of back pain; radiology of injured extremities; and abdominal radiology in the management of the acute abdomen. The working party felt that it would need the help of an epidemiologist, and thus the facilities of the Department of Epidemiology and Community Medicine in the Welsh National School of Medicine became involved.

Method of Investigation

The design of each multicentre study was developed at the Welsh National School of Medicine in Cardiff. Once the method had been piloted successfully, permission was sought from a number of radiologists to use their hospital as one of the study centres. The proposed study would then be discussed with the local hospital staff and if their support was forthcoming, appropriate divisional approval was sought as well as that of the hospital administrator and the senior medical records officer. A senior radiologist was then designated local co-ordinator; his first task was to appoint a research assistant. Financial support for these studies came from a DHSS grant. Each co-ordinator assumed sole responsibility for the local conduct of the study. None of the work would have been possible without the invaluable contribution of local co-ordinators supported by their hospital colleagues.

Multicentre Study Number 1

Pre-operative Chest Radiology (POCR)

In 1979 the working party published the findings of its multicentre audit of 10,619 consecutive cases of elective non-cardiopulmonary surgery undertaken in eight centres throughout the UK[1].

The justification for such a survey was suggested by observing substantial variations in existing UK practice. There was a fivefold variation in utilisation, ranging from 11.5 per cent in centre 2, a long-established teaching hospital, to 54.2 per cent in centre 8, a new teaching hospital. The greater part of the variance could not be explained by differences in the ages of patients, by the proportion undergoing major surgery, or by an apparent difference in the mix of the specialties. The centre itself was by far the most important determinant of utilisation.

These findings were compared with existing expectations about the effectiveness of the procedure. This was done by posing three questions:

1. Is the procedure as effective as expected? There was no evidence that POCR influenced either the decision to operate or the use of an inhalation anaesthetic. POCR was prescribed for only half of those patients who were at high risk of post-operative pulmonary complications and this complication rate was of the same order of magnitude in the radiographed as in the non-radiographed high-risk group. The findings suggested that current users of POCR either do not subscribe to the view that POCR is a necessary base line for the management of post-operative complications, or that they do not act upon this belief in any rational way.

2. Is POCR as safe as we believed? In 1976 Rees *et al.*[2] reported on 667 consecutive patients undergoing elective surgery in a large hospital in Wales. Estimates of the radiation dosage received by these patients during the previous year, based on information relating only to radiographs taken at the study hospital, showed that the maximum recommended marrow dose[3] had been exceeded in 12.5 per cent of the study participants. Bengt-

somm *et al.*[4] calculated that 80 (10 per million) cancer deaths in Sweden each year could be attributed to radiation received during diagnostic radiology. Matthews[5] has estimated the UK risk to be of the order of 30 fatal cancers per year (5 per million).

3. What is the cost effectiveness of POCR? The working party found that the cost of avoiding one post-operative death in patients aged 20–59 without cancer or chronic cardiorespiratory disease was approximately £100,000 (Table 1). This was calculated by multiplying the incidence of post-operative deaths by a POCR cost of £15 per patient. This figure assumes that POCR will always avoid that outcome. The College study, however, failed to find 'any evidence at all for the effectiveness of pre-operative chest X-ray when used routinely'[1]. Making the generous assumption that it is likely to be only 10 per cent effective, the cost of avoiding one death is more likely to be of the order of £1,000,000[6].

As a result of this study the working party concluded that POCR was not as effective nor as safe as was thought and that the cost of producing a beneficial outcome was much higher than had been previously imagined.

Implementing Change in the Use of POCR

The next stage was for the working party to offer a general policy statement as a guide to future practice. Because of resistance at this time (1979) to the implications of this study it was decided that a low-key recommendation should be made, such as 'it would seem advisable to rationalise the use of POCR now, by establishing temporary norms of utilisation pending an early decision about whether the investigation should be abandoned as a routine procedure . . .' and utilisation for non-acute non-cardiopulmonary surgery was recommended at no more than 12 per cent. However, in South Wales there had been considerable interest in the College's work. Recommendations on utilisation were disseminated among local radiologists by word of mouth, at scientific and divisional meetings and by distribution of reprints of the working party's paper. Consequently it was decided to monitor the use of chest radiology in the surgical wards of two district general hospitals in South Wales to see if local initiatives about the use of POCR were having any effect on practice. In addition, it was decided to look for evidence of desirable or undesirable outcomes which might be caused by such changes in practice. Post-operative length of stay (as an indicator of post-operative morbidity) and post-operative mortality during the study period were measured.

There was a significant reduction ($P<0.001$) in the use of chest radiology in the surgical wards of both hospitals during the study period, 1976–80[7]. In hospital A the rate decreased from 52.3 per cent (of 11,616 admissions) in 1977 to 30.1 per cent (of 12,505 admissions) in 1980. In hospital B the use declined from 50.4 per cent (of 9,157 admissions) in 1978 to 37.1 per cent (of 9,909 admissions) in 1980. The reduction in utilisation achieved in these two hospitals effected potential savings of about £118,000. In hospital A there was no significant change in post-operative length of stay (4.9 days) or post-operative mortality (2.8 per 1,000 elective non-cardiopulmonary operations). In hospital B the post-operative length of stay and mortality both declined significantly (6.1 to 4.0 days, and 11 to 5 per 1,000 elective operations respectively). Possibly length of stay and mortality in both hospitals increased as a result of the reduction in chest radiology but this was masked by substantial falls in length of stay and mortality from other causes. Though possible, this seems an unlikely explanation of our findings.

By 1982 the resistance to change previously offered by some specialties had decreased. Evidence showed that a growing number of hospitals had accepted the recommendation that the use of POCR as a routine procedure should be abandoned. The levels of utilisation of POCR reported by the College in 1979 were no longer justified.

Encouraged by this development, the working party considered hardening the original guideline proposed in 1979. In 1982, it proposed the following stricter guideline for the use of POCR (Fig. 1), the principal change being a strengthening of the resolve that 'routine' POCR was no longer justified at any age.

Spurred on by these developments the working party sought and successfully obtained financial support from the King's Fund to study three different methods of implementing their guidelines on POCR in three different hospitals with a fourth and fifth acting as controls. Before the study could begin it was necessary for the guidelines to be approved in principle by the divisions of Surgery, Medicine and Anaesthetics in each of the five participating hospitals. This approval has been obtained and the study is now progressing.

Table 1. Some costs and possible benefits of pre-operative chest X-ray in elective non-cardiopulmonary surgery and skull X-ray in head injury.

Outcome	Frequency of outcome	Radiological costs* of possibly avoiding one death or serious outcome	
Post-operative deaths in patients aged 20–59 without cancer or chronic cardiorespiratory disease currently undergoing surgery	1 in 6,770	£101,550 (100% effective)	£1,015,000 (10% effective)
Clinically unsuspected intracranial haematoma in patients currently given SXR	1 in 4,829	£96,580 (100% effective)	£386,320 (25% effective)

*Assuming costs of £15 (POCR) and £20 (SXR) per patient.

'Routine' pre-operative chest X-ray is no longer justified. However, pre-operative chest radiography may be clinically desirable in certain patients in the following categories:

(i) those with acute respiratory symptoms
(ii) those with possible metastases
(iii) those with suspected or established cardiorespiratory disease who have not had a chest radiograph in the previous 12 months.
(iv) recent immigrants from countries where TB is still endemic who have not had a chest radiograph within the previous 12 months.

It should be noted that none of the above categories of request is routine and the reasons for examination should, therefore, always be given in the usual way.

Royal College of Radiologists 1982

Fig. 1. *Guideline for pre-operative chest X-ray use among patients admitted for elective non-cardiopulmonary surgery.*

Multicentre Study 2

Skull Radiology in Head Injury

In 1980 the working party published the first in a series of papers giving the findings of a multicentre study of 5,850 patients who underwent skull radiography for head injury in nine Accident and Emergency units in England, Wales and Scotland. The study involved 88 radiologists and 129 Accident and Emergency staff[8-11].

The study showed that methods of selecting patients for skull radiography in the UK were neither uniform nor satisfactory. Some of the more important findings are shown in Table 2. The proportion of patients referred for skull X-ray without a history of unconsciousness, an altered state of consciousness at examination, or other clinical signs or symptoms suggesting possible brain damage ranged from 44–78 per cent in the nine centres studied; the requesting doctor felt that a skull fracture was definitely absent on clinical examination in 17–36 per cent; between units, the highest yield of fractures was three times the lowest, which suggests that some centres were much more selective about the use of skull radiography than others.

Comparison was then made between these and existing expectations of the value of the procedure. This was done by posing two questions.

1. Is the procedure as effective as thought? The yield of potentially important radiological findings in 4,829 patients with uncomplicated head injury was two basal, one frontal and 65 vault fractures. Intracranial haematomas developed in four of these patients; three would have been suspected clinically and the patients admitted for observation even if skull radiography had not been available. In the 1,021 patients with complicated head injury (head injury with additional injury or pathological finding) there were four depressed, four basal and three frontal fractures. Four patients had intracranial haematomas, three dying within 48 hours. A further patient had a frontal aerocele which was diagnosed and treated successfully. In the complicated head injury group the presence of other clinical clues (e.g. co-existing injury, pathology, and neurological signs and symptoms suggesting brain damage) alerted the clinician's attention to the increased risk of intracranial haematoma and this led invariably to the patient being admitted. The asymptomatic patients of the uncomplicated head injury group provided the only opportunity for skull radiology to alert a previously unsuspecting doctor to the possibility of an intracranial haematoma. In our study this occurred once in 4,800 such patients.

2. How does the actual cost compare with believed costs? Table 1 shows that the cost of a screening service, using skull radiography, to detect the one asymptomatic case of intracranial haematoma is approximately £96,000[9]. This assumes that the detection of a skull fracture will always lead to the discovery of the intracranial haematoma and conversely that if this complication is not detected in this way it will always lead to a fatal or serious permanent outcome. This assumption does not take into account the likely effectiveness of home surveillance in suitable cases nor the fact that we found that 30 per cent of patients with a skull fracture are at present sent home[8]. Thus, using a cautious estimate of 25 per cent effectiveness for skull X-ray, the costs would rise to approximately £386,000 per case detected[6].

Implementing Change in the Use of SXR

It was realised that the important changes in practice resulting from these findings would take time to implement and would have to be handled with great care. To this end the working party published three papers[8-10], each moving the argument a little closer to the establishment of a plainly stated guideline of practice[11]. As with POCR there were foci of substantial resistance. Many believed that no risk, however small, was acceptable; others thought that the implications were morally unacceptable; others that the floodgates might be opened to

Table 2. Use of skull radiography in nine A & E Units throughout the UK[8-11].

Clinical features of patients referred for skull X-ray	A & E Unit									
	1	2	3	4	5	6	7	8	9	Overall
	Per cent									
No neurological signs or symptoms, nor unconsciousness	67	67	78	49	63	58	62	44	56	63
Skull fracture judged to be definitely absent on clinical examination	21	30	22	34	25	36	17	33	19	26
Skull fracture demonstrated radiologically	1.8	1.1	1.2	3.7	1.8	2.3	2.8	1.7	3.3	2.1

medical litigation. In February 1983 representatives of the working party were invited to participate in a small selected seminar organised by the DHSS in Harrogate. Participants were chosen to represent the views of all the specialties involved in the management of head injury; eight of the 40 participants were neurosurgeons. On the final morning the meeting agreed that some form of patient selection for skull radiography was essential, and that a plainly stated guideline to assist doctors in making this choice was desirable.

This is a most important development. For the first time in the UK, a multidisciplinary body representing the various specialties involved in the management of head injury has acknowledged that it is neither feasible nor desirable to X-ray the skull of every patient with head injury and has proposed that plainly stated clinical criteria should be devised to aid selection of patients for skull X-ray. Making selection explicit in this way would permit the introduction of a generally acceptable standard of practice which would remove the threat of medical litigation overnight. In any particular case the advisability or otherwise of skull radiography would be determined by these criteria.

A major step is to have the notion of a plainly stated guideline accepted in principle; it may take a little longer to achieve agreement on the detail. The working party has now developed guidelines for skull radiography based on the results of its multicentre study and these are being tested in several hospitals in the UK. These guidelines are similar to those shortly to be published by WHO in which it is proposed that ' . . . skull radiography is not recommended in patients with mild head trauma, who are asymptomatic, or who present one or more of the following symptoms such as headache, dizziness, simple scalp laceration, haematoma, and contusion or abrasion'[12].

Acknowledgements

The Royal College of Radiologists' Working Party on the Effective Use of Diagnostic Radiology wishes to thank the Department of Health and Social Security for financial support: the clinicians and other members of staff in the research centres for their cooperation: and the research assistants in the study centres.

References

1. Royal College of Radiologists (1979) *Lancet,* **2,** 82.
2. Rees, A. M., Roberts, C. J., Bligh, A. S. and Evans, K. T. (1976) *British Medical Journal,* **1,** 1333.
3. Department of Health and Social Security (1972) *Code of Practice for the Protection of Persons Against Ionising Radiations arising from Medical and Dental Use.* London: HMSO.
4. Bengtsomm, G., Blomgren, P. G. and Aberg, L. (1978) *Acta Radiologica Oncologica,* **17,** 81.
5. Matthews, I. P. (1983) Personal communication.
6. Roberts, C. J. (1982) *British Medical Journal,* **285,** 751, 754.
7. Roberts, C. J., Fowkes, F. G. R., Ennis, W. P. and Mitchell, M. (1983) *Lancet,* **2,** 446.
8. Royal College of Radiologists (1980) *Lancet,* **2,** 1234.
9. Royal College of Radiologists (1981) *Lancet,* **2,** 791.
10. Royal College of Radiologists (1983) *Lancet,* **1,** 115.
11. Royal College of Radiologists' Working Party on Effective Use of Diagnostic Radiology (1983) *Lancet,* **1,** 1164.
12. WHO (1983) A rational approach to radiodiagnostic investigations. Report of a WHO scientific group on the indications for and limitations of major X-ray diagnostic investigations. WHO Technical Report Series, in press.