

The Quality of Emergency Room Radiograph Interpretations

Paul L. McLain, MD, and C. Richard Kirkwood, MD
Davenport and Seattle, Washington

Primary care physicians often make patient management decisions based in part on their own interpretation of radiographs. This important area of clinical decision making has not been previously analyzed in the literature. In this series of 294 consecutive radiographs from rural practice, interpretative disagreement between primary care providers and backup radiologists occurred 9.2 percent of the time, a discordance rate similar to that seen among radiologists in other studies. Although a majority of the films for which interpretative disagreement occurred had potential implications for influencing patient management, in only seven cases did actual case management vary from appropriate norms. Follow-up of cases where interpretative disagreement occurred revealed that in only two cases did unsatisfactory outcomes occur. Primary care physicians can provide high-quality radiographic interpretations that, when coupled with clinical information, yield extremely low rates of error or potential for poor patient outcomes.

The primary care physician, especially in a rural practice, is frequently required to make patient management decisions in the hospital emergency room guided by his own interpretation of radiographs. Formal radiologic consultation and backup reading of emergency room x-ray films may be available only when films are transported to a distant secondary or tertiary care center, or when a consulting radiologist visits the rural primary care center on some regular schedule. Appropriate disposition and treatment for emergency room pa-

tients requiring radiographic examinations thus depends on skillful, on-the-spot interpretation of x-ray films by the primary care physician.

This investigation was done to evaluate the performance of primary care providers in radiographic interpretation and management decisions in the setting of a rural hospital emergency room. To date, this important aspect of clinical decision making has not been described in the literature. As the accuracy of radiograph interpretation may have an important bearing on patient outcome and as backup confirmation of the reading by the primary care provider may occur late in the course of the disease, there are several questions that can be asked about the process. First, do primary care physicians interpret x-ray films accurately enough to insure high-quality patient care? Second, does a

From the North Basin Health Services, Davenport Clinic, Davenport, and the Department of Family Medicine, University of Washington School of Medicine, Seattle, Washington. Requests for reprints should be addressed to Dr. Paul L. McLain, Davenport Clinic, PO Box 28, Davenport, WA 99122.

second reading by a radiologist add significantly to the process? Finally, are there clinical situations or types of films that are more or less likely to occasion errors of interpretation in this setting?

Location and Practice

Lincoln Hospital is a 24-bed public hospital located in Davenport, a wheat and cattle agricultural-support community of approximately 1,500 persons in eastern Washington state. The hospital service population is about 13,000. Referral and consulting facilities are 40 miles distant at tertiary care centers in Spokane (population 172,000). A stable average of 1,200 patient visits are made to Lincoln Hospital emergency room annually. Additional emergency treatment and radiographic capability are available during clinic hours in nearby physician offices. The hospital radiology department performs 900 examinations yearly, which includes special studies done by consulting radiologists from Spokane who also read the accumulated emergency room films during their weekly visits.

Primary care in the Lincoln Hospital emergency room and on-site interpretation of x-ray films were provided during the study period solely by two board-certified family physicians, one board-certified general surgeon, and two physicians' assistants, all members of a comprehensive care group who have been practicing in Davenport for ten years. Immediate physician-preceptor backup is utilized by the physicians' assistants for any questionable radiograph interpretation or clinical situation. Second readings on all emergency room films are done weekly by consulting radiologists, and each primary provider receives typewritten reports on the studies he has ordered.

Methods

Two hundred thirty-seven consecutive emergency room visits, generating 294 radiographic ex-

aminations, were reviewed by the senior author to determine the level of agreement between on-the-spot x-ray film interpretation by primary care providers and a second reading by a consulting radiologist. Charts and reports for review were taken in sequence covering the months of January 1981 through October 1982 (22 months), and the type of radiologic study was tabulated. Where disagreement occurred between the radiologist's dictated report and the clinician's film interpretation indicated on the emergency room record, further analysis was done. Omission of an abnormal radiologic finding or report of normal on the provider's emergency room record when the radiologist's report indicated an abnormality present was termed an underreading error. An overreading error meant that the provider stated something was abnormal when the consultant indicated that no abnormality was present. The clinical significance of error was assessed by assigning error to two groups. A primary error was one judged to be of significance or of potential significance for patient care, while secondary errors were those that would not affect clinical decision making or patient prognosis.

For all cases where radiograph reading errors had occurred, an evaluation was conducted of the patient's diagnosis, prognosis, and management. Long-term follow-up was obtained by office and hospital record review and by personal contact for all patients whose management was judged inappropriate for the corrected radiologic diagnosis. Statistics were performed using chi-squared analysis with Yates correction.

Results

Interpretive disagreement occurred in 27 out of the 294 (9.2 percent) radiologic studies ordered and read by primary care providers during the 22-month study (Table 1). X-ray films of the extremities were ordered most frequently, 64.3 percent of the time, and performance in interpretation of extremity films was somewhat better than the overall reader error rate. While films of the lumbar and cervical spine were ordered only one-fifth as

Table 1. Distribution of Radiographic Examinations and Discrepancies Between Primary Care Provider and Radiology Interpretations

Type of Radiograph Examination	No.	Percentage of Total Examinations	Errors No. (%)
Upper extremity (including clavicle) and scapula	87	29.6 64.3	6 (2.0)
Lower extremity	102	34.7	7 (2.4)
Skull and face	26	8.8	2 (0.6)
Lumbar spine*	18	6.1	3 (1.0)
Cervical and thoracic spine*	24	8.2	4 (1.4)
Chest	14	4.8	0 (0)
Ribs	14	4.8	5 (1.7)
Pelvis	6	2.0	0 (0)
Miscellaneous	3	1.0	0 (0)
Total	294		27
Overall discrepancy rate			9.2

* $\chi^2 = 7.91, P < .05$

Table 2. Error Type and Patient Care Outcome For Clinically Significant (Primary) and Clinically Insignificant (Secondary) Reading Discrepancies Between Primary Care Providers and Radiologists

Significance of Error	Type of Error		Management Outcome		
	No.	Over-reading	Under-reading	Appropriate	Not Appropriate
Primary (of potential importance in patient management)	24	12	12	17	7
Secondary (of unlikely importance in patient management)	3	1	2	3	0

frequently, disagreements in interpretation in this sensitive category occurred more than twice as often as in extremity examinations and were statistically significant ($\chi^2 = 7.91, P < .025$). Surprisingly error-free were the interpretations of the chest films ($\chi^2 = 18.23, P < .025$), which are generally felt to be subject to relatively high variability of interpretation.¹

Table 2 shows an analysis of the 27 errors that

occurred. The majority of reading errors (24 out of 27) were judged to be primary and thus significant enough to have some potential implication for patient management, disposition, or prognosis. Despite these errors, initial case management and disposition from the emergency room was felt to be appropriate in 20 of the cases where disagreements in radiographic interpretation occurred. In seven instances neither clinical grounds nor initial

Table 3. Outcome Analysis of Cases for Which Reading Discrepancies Between Radiologists and Primary Care Providers Existed and Case Management Was Judged Inappropriate

Patient	Type of Examination	Features of Error	Initial Management	Outcome
1	Hand	Underread nondisplaced fracture, 4th metacarpal	Ice; splint immobilization until pain free	Wore splint one week; completely normal function; satisfactory
2	Cervical Spine	Underread anterior compression fracture, C-6	Hospitalized in cervical collar; treated for intoxication and multiple contusions	Transferred to neurosurgeon when quadiparesis evident; subsequent films showed fractured lamina, C-5, without instability; treatment with corticosteroids and cord rehabilitation; no surgery; unsatisfactory
3	Shoulder	Underread acromioclavicular separation	Sling and early exercise	Aching shoulder for one month with elevation exercise; full function; satisfactory
4	Foot	Underread nondisplaced fracture, proximal phalanx great toe	No weight bearing for one week	Full function with no further treatment; satisfactory
5	Hand	Overread fracture, base of second metacarpal	Sort-arm cast; hospitalized for treatment of facial injuries	Wore cast for 3 weeks; intermittent pain 4 months later; no follow-up x-ray abnormality; unsatisfactory
6	Ankle	Underread avulsion fracture, lateral malleolus	Aircast splint; cryotherapy, active exercise	Returned to varsity basketball in splint in 5 days; currently full function without further treatment; satisfactory
7	Clavicle	Overread fracture, mid-third clavicle	Clavicle strap immobilization until pain free	Discarded strap; wore sling and exercised for 1 month; follow-up films at Spokane orthopedist showed healing fracture; still aches occasionally; satisfactory

x-ray film interpretation led to management judged appropriate for the eventual radiologic diagnosis, and all of these involved primary errors. Overreading and underreading errors occurred with equal frequency for both primary and secondary errors.

Table 3 is an outcome analysis of the patients

for whom initial errors in radiograph interpretation or clinical judgment apparently led to inappropriate management decisions. All patients in this group were evaluated for trauma, and two of the seven patients were hospitalized with multiple injuries. It should be noted that for some of these

situations initial management as described may not have been thought to be harmful, but was judged inappropriate if an erroneous diagnosis or prognosis was given to the patient without specific provision for reevaluation of the injury and possible revision of the treatment.

Outcome was judged satisfactory in underreading and undertreatment if patients reported normal function of the injured area with no further treatment. For overreading and overtreatment, outcome was judged satisfactory if the overtreatment did not result in limitations on normal function and behavior longer than one week. Using these criteria, two patients had unsatisfactory outcomes when there was a discrepancy in film interpretation between the primary care provider and a radiologist.

Discussion

The concept of an error rate inherent in the interpretation of radiographs read by radiologists has emerged from a number of performance studies and analyses.¹⁻⁵ Initial readers of x-ray films, with only minor variation due to level of experience, make errors in the interpretation of approximately 30 percent of films. A second reading, such as the one by backup radiologists in this study, will discover about one third of the initial errors and therefore will show an error rate for the initial reader of approximately 10 percent. This generally accepted figure^{1,2,4,5} is strengthened by the finding of Rhea et al³ of an error rate of 11 percent in a study of 3,300 emergency room reports at a university hospital. This rural emergency room study showed a slightly lower overall error rate of 9.2 percent.

While the data of Rhea et al suggest about the same chance of reader error regardless of the type of radiographic study, it appears that primary care providers in this study had more difficulty interpreting films of the spine and ribs. Relatively better performance on extremity films may reflect the wider experience of family physicians in evaluating injuries of these areas as opposed to those of the spine. Also, the greater complexity of spinal

radiographs doubtlessly contributes to the higher error rate in this category.³

Swensson and colleagues⁴ have pointed out that if the search of an x-ray film is "focused" or directed to certain areas of the film, the reader unconsciously alters his criteria for what ambiguous image perceptions shall be called abnormal and overreads a larger percentage of films than does the unfocused or "free" searcher. Certainly the primary care providers in this study would be considered "focused" by the results of their clinical examinations, which may account for an unusually high percentage of errors in interpreting the notoriously ambiguous x-ray films of the ribs. Overreading as a result of a clinically acquired bias may also explain why the overreading-to-underreading ratio is higher than in previous reports.³

In addition to demonstrating concordance between the primary care providers and their radiologist consultants in 267 of 294 emergency room x-ray film interpretations, these data indicate a high level of clinical performance on the part of the treating professionals and satisfactory outcome in 235 of 237 patients. Although radiographic studies are of unquestioned value in determining management of emergency room patients, of the 27 situations in which the primary provider's radiologic judgments, even if faulty, conflicted with clinical impressions, care was nevertheless appropriate to the eventual diagnosis provided in 20. Apparently information from the radiographic examination was most often utilized as an important supplement to the overall evaluation of patients but was not regarded as absolute or infallible by the physicians or physicians' assistants.

Because this study was performed in a rural area of relatively stable population, and because of the small numbers involved, it was possible to obtain detailed follow-up of those patients for whom both reading and management errors occurred. Their outcomes were for the most part little affected by error, and only two patients were judged to have unsatisfactory results. In the most serious case, it is unclear to what extent underreading of the cervical spine films contributed to the unsatisfactory outcome (transverse myelitis). Transfer of the patient from the admitting hospital to a neurosurgeon was delayed because of error in film interpretation and a neurologic examination compromised by the patient's intoxication. When

quadriplegia was definite, the patient was promptly transferred, but his care under the neurosurgical consultant continued to be as conservative and supportive as it had been in the primary care facility.

One patient wore a short-arm cast for three weeks after an overreading error on an x-ray film of the second metacarpal. Although follow-up films never revealed bony abnormality, the initial cast immobilization was maintained because of continued pain. Soft tissue immobilization could probably have been accomplished using a splint with less patient inconvenience, and earlier exercise might have been beneficial.

In another case, the emergency room diagnosis of fractured clavicle, although not supported by the backup film interpretation and, thus, an error by this study's definition, was eventually confirmed by subsequent radiographic examination.

Primary care physicians often must make clinical judgments based on their readings of x-ray films. The rural hospital emergency room is prototypic in this regard. Yet the widespread practice remains that an after-the-fact reading by a radiologist is obligatory⁶ in spite of a lack of data to support whether patient care is enhanced in the process.

Although the present report has several limitations, including being confined to one western rural practice where the primary care providers are accustomed to reading a fairly high volume of x-ray films, these data do suggest that primary care providers using a combination of radiographic and clinical information to draw patient management conclusions can have an acceptably low rate of discrepancy between their and a radiologist's reading of diagnostic radiographic examinations. Indeed the overall error by these providers was as low as those published comparing radiologists with each other. In addition, in only two of 294 cases did an unsatisfactory outcome occur when a reading discrepancy existed. It is possible to infer from these data that redundant interpretation by radiologists of all routine films taken in the hospital emergency room added little (except perhaps cost) to the overall quality of care. Further studies are needed to see whether this conclusion can be generalized to other settings.

This study of rural family physicians' performance in emergency room x-ray film interpretation

indicates a skill level comparable to and perhaps slightly better than that demonstrated in previous reports. The access to firsthand clinical information, which can influence the primary care providers' on-the-spot x-ray film interpretations, probably assists in avoiding underreading errors but may introduce some overreading errors as the result of clinical bias.

The data indicate that certain types of x-ray examinations may be more subject to reader error than others. Development of reader skills in high-error x-ray examination categories may be emphasized in family practice training programs and courses in continuing medical education. That the outcome was satisfactory for the large majority of patients in the study indicates that even when errors in film interpretation are committed, proper clinical impressions most often prevail in management decisions, and errors in x-ray film interpretation only rarely lead to unacceptable results.

Acknowledgment

This study was supported by the Washington Academy of Family Physicians.

References

1. Herman PG, Hessel SJ: Accuracy and its relationship to experience in the interpretation of chest radiographs. *Invest Radiol* 1975; 10:62-67
2. Berlin L: Does the "missed" radiographic diagnosis constitute malpractice? *Radiology* 1977; 123:523-526
3. Rhea JT, Potsaid MS, DeLuca SA: Errors of interpretation as elicited by a quality audit of an emergency radiology facility. *Radiology* 1979; 132:277-280
4. Swensson RG, Hessel SJ, Herman PG: Omissions in radiology: Faulty search or stringent reporting criteria? *Radiology* 1977; 123:563-567
5. Tuddenham WJ: Visual search, image organization, and reader error in roentgen diagnosis. *Radiology* 1962; 78:694-704
6. Accreditation Manual for Hospitals. Chicago, Joint Commission on Accreditation of Hospitals, 1984, p 151