Use of radiography in acute ankle injuries: physicians' attitudes and practice

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Objectives: To examine the efficiency of the current use of radiography in patients with acute ankle injury. To study the judgements and attitudes of experienced clinicians in their use of ankle radiography and to thereby assess the potential for improved efficiency.
Design: Two-stage study: retrospective chart review and prospective survey.
Setting: Emergency departments of two adult teaching hospitals and one community hospital.
Participants: The records of 1831 adults presenting with acute blunt trauma to the ankle over 5 months were examined; another 732 patients were seen by 21 full-time emergency staff physicians over a subsequent 6-month period.
Measures and main results: Of the 1831 patients with an ankle injury in stage 1, 94.9% had had at least one radiographic series; the yield for clinically important fractures was 12.8%. In stage 2, experienced physicians predicted the probability of fracture to be 0% or 10% in 57.8% of cases. The κ (kappa) level for interobserver agreement in 98 patients seen independently by two physicians was 0.55 (95% confidence interval [CI] 0.39 to 0.72). The area under the receiver operating characteristic curve for physicians' predicted probability was 0.88 (95% CI 0.84 to 0.92), reflecting good discrimination between fracture and nonfracture cases. Likelihood ratios for predicted probabilities ranged from 0.08 for the 0% level to 151 for the 100% level. The physicians indicated that they would feel comfortable or very comfortable in not ordering radiography in 45.9% of cases (κ level 0.52; 95% CI 0.34 to 0.70).
Conclusions: Emergency physicians order radiography for most patients with ankle injury even though they can accurately discriminate between fracture and nonfracture cases and clearly expect most of the radiographs to give normal results. These findings suggest great potential for a more efficient use of radiography in patients with ankle injury, possibly through the use of guidelines.

Objectifs : Examiner l'efficacité de l'utilisation des radiographies dans les cas de blessure grave à la cheville. Étudier les jugements et les attitudes des cliniciens chevronnés dans l'utilisation des radiographies de la cheville et évaluer ainsi les possibilités d'amélioration de l'efficacité.
Conception : Étude en deux volets : analyse rétrospective des dossiers et sondage prospectif.
Contexte : Services d'urgence de deux hôpitaux d'enseignement pour adultes et d'un hôpital communautaire.

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Participants : On a examiné les dossiers de 1 831 adultes victimes d'un traumatisme contondant aigu de la cheville sur une période de 5 mois; 21 médecins à plein temps des services d'urgence ont examiné 732 autres patients au cours d'une période ultérieure de 6 mois.

Mesures et résultats principaux : Parmi les 1 831 patients victimes d'une blessure à la cheville au cours du premier volet, 94,9 % avaient subi au moins une série de radiographies, qui ont révélé 12,8 % de fractures importantes sur le plan clinique. Au cours du deuxième volet, des médecins chevronnés ont prédit que la probabilité de fracture serait de 0 % ou 10 % dans 57,8 % des cas. Le niveau κ (kappa) d'entente entre les observateurs dans 98 cas examinés indépendamment par deux médecins a été de 0,55 (intervalle de confiance [IC] à 95 % de 0,39 à 0,72). L'aire couverte par la courbe d'efficacité de la probabilité établie par les médecins a été de 0,88 (IC à 95 % de 0,84 à 0,92), ce qui témoigne d'une bonne discrimination entre les cas de fracture et d'absence de fracture. Les rapports de vraisemblance dans le cas des probabilités prévues ont varié de 0,08 pour le niveau 0 % à 151 pour le niveau 100 %. Les médecins ont indiqué qu'ils se sentiraient à l'aise ou très à l'aise de ne pas prescrire de radiographie dans 45,9 % des cas (niveau κ 0,52; IC à 95 % de 0,34 à 0,70).

Conclusions : Les médecins des services d'urgence prescrivent une radiographie dans la plupart des cas de blessures à la cheville même s'ils peuvent distinguer avec précision les cas de fracture et d'absence de fracture, et s'attendent clairement à ce que la plupart des radiographies donnent des résultats normaux. Ces résultats indiquent qu'il serait très possible d'utiliser avec plus d'efficacité les radiographies chez les patients victimes d'une blessure à la cheville en suivant peut-être des lignes directrices.

An ankle radiographic series is one of the two most commonly performed musculoskeletal examinations in emergency departments.[1] Physicians order radiography for patients with acute ankle injuries primarily to exclude the presence of clinically important fractures. However, despite the low prevalence of such fractures (less than 15% of patients presenting with acute ankle injury[2-7]) most of these patients are routinely referred for a radiographic examination.[8,9]

This conservative approach entails much unnecessary radiologic study, radiation exposure and waiting time for the patient and additional cost to the health care system.[10-12] The Ontario Ministry of Health reports that more than 180 000 radiographic series of the ankle are performed annually in this province.[13] By extrapolation, some 6 million ankle radiographs are taken yearly in Canada and the United States. Large savings would ensue from a modest reduction in the proportion of patients with ankle injury undergoing radiography.

At present there are no widely accepted guidelines for ankle radiography analogous to those successfully introduced for skull radiography.[14,15] The few studies attempting to develop guidelines have had a number of methodologic shortcomings in terms of reliability, accuracy, utility and effectiveness and have given inconsistent results.[16] Without the support of recognized guidelines emergency physicians tend to follow the expedient route of ordering radiography for most patients with an ankle injury.[17] We suspected that experienced clinicians could identify patients with an ankle injury who were at low risk for fracture and did not need radiography, but we had no data to support this theory. If our suspicions are correct, well-validated guidelines might reduce the use of radiography by reinforcing rather than replacing the acumen of clinicians.

Our goals in conducting this study were to examine the efficiency of the current use of radiography in patients with an ankle injury and to assess the potential for improvement. We wished to survey the attitudes of experienced clinicians toward ankle radiography and to study their ability to accurately predict the presence of clinically important fractures. We hoped that this information would indicate the potential for practice guidelines to improve the efficiency of the use of radiography in patients with an ankle injury.

Methods

The study was conducted in two stages. The first involved development of a baseline profile of patients with ankle injuries and of their radiographs during a 5-month period at three emergency departments — two in adult teaching hospitals (Ottawa Civic Hospital [OCH] and Ottawa General Hospital [OGH]) and one in a community hospital (Queensway-Carleton Hospital [QCH]). The second stage involved a prospective survey of physicians' judgements and attitudes over 6 months at the two teaching hospitals.

In both stages we included patients who presented with any pain or tenderness of the ankle after they had sustained acute blunt injuries from any mechanism. "Ankle" was broadly defined to include the area involved in common twisting injuries and was subdivided into two zones representing the malleolar

region and the midfoot. These zones corresponded to the areas that generally require assessment by a standard radiographic series of the ankle (the malleolar region) or the foot (the midfoot). We defined the zones to include the following anatomic structures and their overlying soft tissues: (a) the malleolar region (distal 6 cm of tibia, distal 6 cm of fibula, and talus) and (b) the midfoot (navicular, cuboid and cuneiform bones, the anterior process of the calcaneus and the base of the fifth metatarsal bone).[18,19] We excluded patients who were under 18 years of age, were pregnant, had isolated injuries of the skin, were referred, with radiographs, from outside the hospital, had suffered the ankle injury more than 10 days earlier or had returned for reassessment of the same injury.

In the first stage we retrospectively examined the treatment records of all patients with an ankle injury seen between Feb. 1 and June 30 (in 1990 at OCH and OGH and in 1991 at QCH). The records were identified by a manual review of all patient charts for this period. Data abstraction was performed for demographic, clinical and radiographic features by three registered nurses and one physician (H.A.). The accuracy of the data abstraction was verified for the first 100 cases at each hospital by the principal investigator (I.G.S.). Patients were seen by full-time and part-time emergency physicians at all hospitals and also by residents and interns at the teaching hospitals. The few patients who did not undergo radiography were not followed up, but the negligible rate of repeat visits of these patients indicated that missed fractures were very unlikely. Fractures were classified as clinically important if they were larger than 3 mm across. This definition reflects clinical management, in that smaller avulsion fractures are not generally treated at the study institutions with plaster immobilization. The costs of the radiographic examinations were based on the 1991 Ontario Ministry of Health schedule of benefits for physician services and represent both the technical and the professional fees for performing two-view or three-view radiographic series for the ankle (code X067) or foot (code X069) or four-view series for the ankle (code X227). Descriptive statistics only were tabulated for this stage, since no hypothesis was being tested.

In the second stage we prospectively surveyed attending staff emergency physicians at OCH and OGH about eligible patients whom they saw from July to December 1990. Part-time emergency physicians and house staff were excluded from this survey. The physicians filled out a questionnaire after examining the patient but before seeing the results of radiography. The physicians estimated the probability (to the closest 10%) that the radiographic series ordered would show a clinically important fracture. Using a five-point scale (very comfortable to very uncomfortable) they also indicated their theoretic level of comfort in not ordering radiography for that patient. To measure interobserver agreement we asked that, when feasible, patients be independently assessed by two physicians. All patients in the survey underwent an ankle or a foot radiographic series or both, depending on the physicians' judgement of where the pain or tenderness was.

The data from the second stage were tabulated in a simple descriptive format indicating the number of patients with and without fractures for each level of physicians' predicted probability and for each level of comfort. The scales were dichotomized as follows: for probability, 0% to 10% versus 20% to 100% and for comfort, very comfortable to comfortable versus neutral to very uncomfortable. The interobserver agreement for the dichotomized form of each scale was measured by calculating the κ (kappa) coefficient, the proportion of potential agreement beyond chance that was achieved.[20-22] A κ of 1.0 represents perfect agreement, and values greater than 0 represent observed agreement greater than that due to chance. Guidelines for interpreting the strength of agreement from κ values have been suggested: less than 0.40 poor to fair, 0.41 to 0.60 moderate, 0.61 to 0.80 substantial, and greater than 0.80 almost perfect.[20] The numbers of fracture and nonfracture cases at each level of predicted probability were used to construct a receiver operating characteristic (ROC) curve and to calculate likelihood ratios.[23-25] The ROC curve is a graphic method for indicating the trade-off between the true-positive rate (sensitivity) and the false-positive rate (1 − the specificity) of a test or diagnostic manoeuvre. Generally, the most discriminating tests have the largest area under the ROC curve, the maximum being 1.0. Likelihood ratios are another method of denoting the discriminatory power of a test and allow the post-test probability of a disease to be calculated by means of a nomogram or calculator. This appeals to clinicians, who are able to assess the implications of specific levels of a test result.

Results

Table 1 demonstrates the demographic characteristics of the 1831 patients in stage 1 and the clinical aspects of their ankle injuries. The patient profiles were similar at the three hospitals, and further remarks will refer to the overall descriptive statistics. On average the patients were young (mean age 35.9 years), although the upper limit of the age range was 92 years. Men and women were equally represented. Most had experienced a twisting injury. The prevalence of clinically important fractures was

14.5%: 10.8% in the malleolar region and 3.7% in the midfoot. A further 4.2% of the patients had clinically unimportant avulsion fractures. There was a striking increase in the prevalence of malleolar fractures with age: one-third of the fractures were found in patients aged 55 years or older (13.3% of all the patients). More patients presented in June, but the prevalence of fractures (8.0%) in that month was considerably lower than that in February (18.7%).

The use of radiography was similar at the three hospitals: the proportion of patients referred for radiography was 96.2% at OCH, 92.3% at OGH and 96.5% at QCH (Table 2). Overall, 84.2% of the patients were referred for an ankle series and 29.1% for a foot series; 18.4% of the patients had both an ankle and a foot series. There was an overall mean of 1.13 radiographic series per patient. The proportion of radiographic series that showed a clinically important fracture was 12.8% for the ankle series and 12.6% for the foot series; 87.2% (1809) of the 2074 radiographic series performed gave negative results for a clinically important fracture. If a patient was referred for a radiographic series the mean time he or she spent in the emergency department was extended by 36 minutes at OGH and by 42 minutes at QCH (the data were unavailable at OCH). The use of radiography was very similar for all levels of experience of physician.

In the second stage of the study the attending staff physicians filled out the questionnaire for 732 of the 882 eligible patients they saw (compliance rate 83%). The characteristics of the patients not included were similar to those of the patients included. Two physicians independently assessed 98 patients, who were similar in characteristics to the overall group except that a higher proportion (18%) had fractures. The physicians clearly expected a low yield from radiography in many cases: in 57.8% of the 682 cases in which an ankle radiographic series was ordered the physician felt that there was only a 0% to 10% probability of a clinically important fracture (Fig. 1). Furthermore, they stated that theoretically they would have been comfortable or very comfortable in not ordering radiography for 45.9% of the patients for whom they did order it (Fig. 2). The κ value for this response was 0.52 (95% confidence

Table 1: Characteristics of adult patients and their ankle injuries obtained from records over a 5-month period at three Ottawa hospital emergency departments

Characteristic	No. (and %) of patients (n = 1831)
Male	986 (53.9)
Mechanism of injury	
Twisting	1569 (85.7)
Direct blow	140 (7.6)
Fall from a height	42 (2.3)
Vehicle accident	22 (1.2)
Other	58 (3.2)
Clinically important fractures	265 (14.5)
Malleolar region*	198 (10.8)
Lateral malleolus	174
Medial malleolus	47
Posterior malleolus	28
Talus	4
Midfoot*	67 (3.7)
Base of fifth metatarsal bone	55
Anterior process of calcaneus	10
Navicular bone	7
Cuboid bone	5
Cuneiform bones	2
Unimportant fractures*†	76 (4.2)
Lateral malleolus	31
Talus	13
Cuboid bone	10
Medial malleolus	8
Navicular bone	8
Anterior process of calcaneus	7
Base of fifth metatarsal bone	7
Cuneiform bones	2
Posterior malleolus	2

*Patients may have fractures in more than one location.
†Defined as avulsions 3 mm or less across and generally not requiring plaster immobilization.

interval [CI] 0.34 to 0.70). There was moderate agreement between physicians' predictions of a 0% or 10% probability of fracture (κ = 0.55; 95% CI 0.39 to 0.72).[20] The physicians estimated a 0% to 10% probability of fracture in 47% of the 224 foot radiographic series ordered (data not shown).

Table 2: Details of radiographic examinations

Variable	OCH* (n = 657)	OGH† (n = 633)	QCH‡ (n = 541)	Total (n = 1831)
Patients referred for radiography, no. (and %)	632 (96.2)	584 (92.3)	522 (96.5)	1738 (94.9)
Type of series performed, no. (and %) of patients				
Ankle	544 (82.8)	505 (79.8)	492 (90.9)	1541 (84.2)
Foot	204 (31.1)	169 (26.7)	160 (29.6)	533 (29.1)
Both	116 (17.7)	90 (14.2)	130 (24.0)	336 (18.4)
No. of series performed				
Total	748	674	652	2074
Mean per patient	1.14	1.07	1.21	1.13
No. (and %) of series showing clinically important fracture				
Ankle series	73 (13.4)	65 (12.9)	60 (12.2)	198 (12.8)
Foot series	30 (14.7)	19 (11.2)	18 (11.3)	67 (12.6)
Total	103 (13.8)	84 (12.5)	78 (12.0)	265 (12.8)
Cost§ of series performed, $				
Ankle, 2 or 3 views	–	10 731.25	10 455.00	21 186.25
Ankle, 4 views	17 326.40¶	–	–	17 326.40
Foot, 2 or 3 views	4 335.00	3 591.25	3 400.00	11 326.25
Total	21 661.40	14 322.50	13 855.00	49 838.90
Mean time spent in emergency department, min				
Overall	NA	110.3	80.7	
Radiography done	NA	113.1	82.6	
No radiography done	NA	77.3	40.2	
Difference	NA	35.8	42.4	

*Ottawa Civic Hospital. NA = not available.
†Ottawa General Hospital.
‡Queensway–Carleton Hospital.
§An ankle series with two or three views costs $21.25 and one with four views $31.85; a foot series with two or three views costs $21.25 (1991 fee schedule of the Ontario Health Insurance Plan: technical and professional fees).
¶OCH now routinely uses two or three views for ankle series.

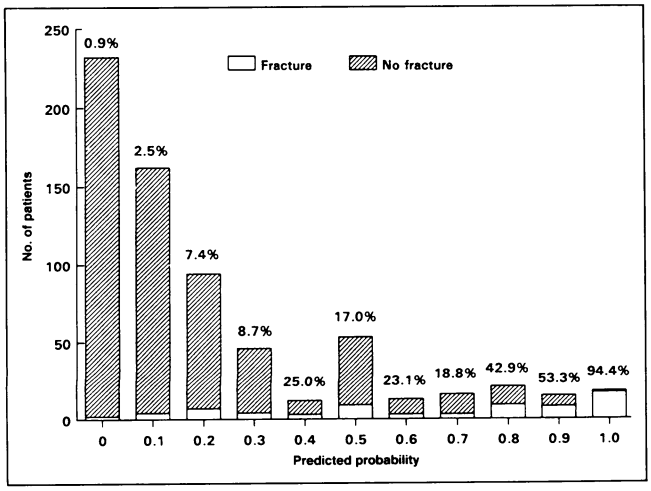

Fig. 1: Distribution of 682 patients with and without a clinically important fracture of the malleolar region by physicians' predicted probability of fracture. The percentages are the proportions of patients with such a fracture in each probability group.

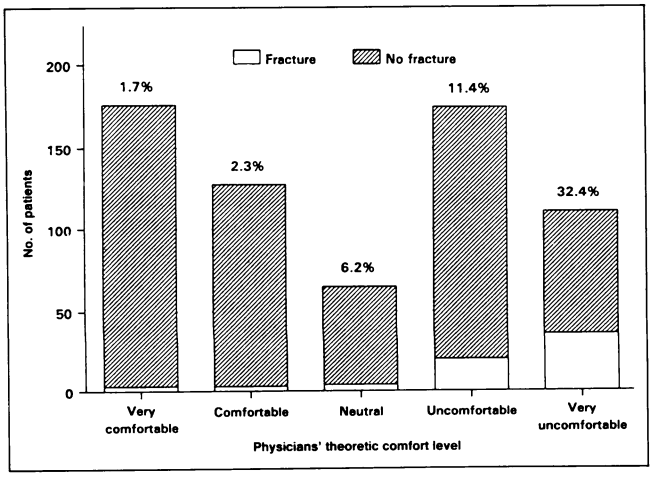

Fig. 2: Distribution of the same patients by physicians' theoretic level of comfort in not ordering radiography. The percentages are the proportions of patients with such a fracture in each comfort-level group.

The shape of the ROC curve for the physicians' probability predictions indicated good discrimination between fractures and nonfractures in the malleolar region (Fig. 3). The area under the ROC curve was 0.88 (95% CI 0.84 to 0.92). For two randomly selected patients, one with and one without a fracture, the probability that the physician would correctly identify the patient with a fracture was 88%. Inspection of the curve revealed that the physicians never quite reached 100% sensitivity in predicting a fracture at any level of specificity. Nevertheless, to use the physicians' predicted probability of 0% as the basis for a decision not to order radiography would result in a sensitivity of 97.1% for fractures and would reduce the frequency of ankle series radiography by 34%. The two clinically important fractures that would have been missed were both small, and in only one case did the patient receive a cast. There was also a low prevalence (2%) of fractures among patients for whom the physicians indicated that they would have been comfortable or very comfortable in not ordering radiography.

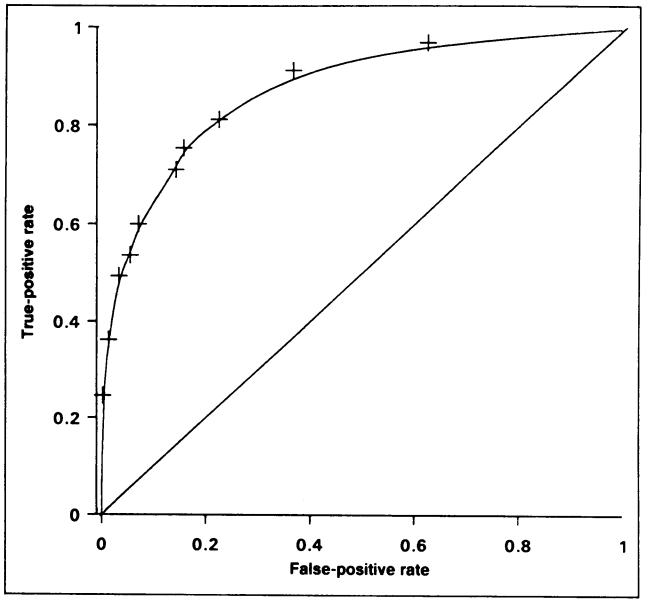

Fig. 3: Receiver operating characteristic curve for physicians' predicted probability of such fractures.

The likelihood ratios listed in Table 3 indicate the power of the physicians' predictions in identifying the probability of a clinically important fracture in the malleolar region. At the 0% level of prediction the likelihood ratio is 0.08, which means that the calculated probability of fracture is 0.8%. Similarly, at the 100% level of prediction the likelihood ratio is 151, which leads to a calculated probability of fracture of 94.4%. Interestingly, the physicians consistently overestimated the probability of fracture.

Discussion

This study revealed that ankle injuries are a common problem in the emergency department and seldom involve a fracture. More than 4000 patients with acute ankle injury are seen annually at the three study hospitals, and most are found not to have a fracture. Our data confirm that emergency physicians rely heavily and rather inefficiently on radiography: 94.9% of the patients with an ankle injury were referred for at least one radiographic series, and the 12.8% yield of clinically important fractures from the approximately 5000 radiographic series performed was relatively low.

This study suggests that physicians have the potential to be more efficient in their use of radiography for ankle injuries. The physicians stated they would have been comfortable or very comfortable in not ordering radiography in almost half the cases. Furthermore, they expected most patients to have a 0% or 10% probability of fracture, and indeed there were very few fractures in such cases. These experienced clinicians clearly have the clinical judgement to discriminate between fracture and nonfracture cases. They could immediately reduce the number of radiographic examinations by one-third simply by not ordering radiography for patients

Table 3: Likelihood ratios for different levels of physicians' predicted probability of a clinically important fracture of the malleolar region in patients seen over a 6-month period at two Ottawa hospital emergency departments

No. (and %) of patients (n = 682)	Predicted probability	Likelihood ratio	Post-test probability*
232 (34.0)	0%	0.08	0.8%
162 (23.8)	10%	0.2	2.4%
140 (20.5)	20% to 30%	0.8	7.7%
94 (13.8)	40% to 70%	2.1	18.7%
36 (5.3)	80% to 90%	7.9	46.8%
18 (2.6)	100%	151	94.4%

*Based on pretest probability or prevalence of 10% for clinically important fractures of the malleolar region.

whom they judged not to have a clinically important fracture.

The findings of this study are limited in several regards. First, the inefficient use of ankle radiography found in Ottawa–Carleton may not be common to all hospitals in Canada. From our discussions with colleagues and from our review of the literature we suspect that this problem is widespread, but clearly each institution needs to review its own performance. Second, inexperienced physicians or those working only occasionally in emergency departments may not share the clinical skill in assessing an ankle injury possessed by the experienced emergency physicians in our study. If this is so, we suspect that all physicians given simple guidelines could easily learn the key findings that distinguish a patient who is at low risk for a fracture. Third, even our experienced physicians might have missed a few small fractures if they had not submitted almost everyone to radiography. The expectations of society in this regard need to be further assessed. Fourth, did the physicians' knowledge of the survey alter their usual behaviour and lead them to be more efficient in their use of radiography? Apparently not: the referral rates for ankle and foot radiography were no less than in the first stage of the study. Finally, the physicians' predictions and comfort levels were only theoretic and did not represent their actual use of radiography. We do not know how difficult it may be to convince our colleagues to trust their judgement and order fewer radiographs.

Many nonclinical factors likely play a substantial role in the emergency physician's decision to order radiography for most patients.[26-29] The transient nature of the physician–patient relationship, the high patient volume, the lack of follow-up, the fear of medicolegal repercussions and the demands of patients in emergency departments all contribute to the expediency of routine ordering of ankle radiography. However, there is clearly a lack of widely accepted clinical guidelines to help the inexperienced physician and to support the experienced physician in their decision not to order radiography. We believe that there is a need for accurate and reliable guidelines that have been validated and shown to be effective in altering clinical practice. From investigation of more than 2000 patients with an ankle injury our research group has developed and validated such guidelines;[30,31] their implementation is currently being studied at OCH and OGH.

What are the economic implications of ankle radiography, a relatively inexpensive test compared with some newer, "high-tech" diagnostic aids? In Ontario the annual cost of ankle radiographic series is more than $4 million.[13] Such "little-ticket" items, the many small tests and procedures used by physicians, may contribute more to rising health care costs than the "big-ticket" items, such as computed tomography and coronary artery bypass grafting.[32,33] The annual billings to the Ontario Health Insurance Plan for a high-volume procedure like ankle radiography exceed those for a low-volume, high-tech procedure such as coronary catheterization.[13]

Our study suggests that experienced emergency physicians can accurately identify patients at low risk for fracture and should be capable of more efficient use of radiography in the management of patients with an ankle injury. By relying more heavily on clinical judgement than on technology they could make better use of health care dollars. Guidelines for the use of radiography have been developed and, once fully tested, may reinforce the ability of physicians to identify patients at low risk for a fracture.

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Conferences

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Jan. 29-30, 1993: Sport Med '93 — Annual Sports Medicine Symposium (sponsored by the Ontario Medical Association's Section on Sports Medicine)
Toronto
Ms. Erna Walker or Ms. Susan Teslak, meetings planning, Ontario Medical Association; tel (416) 599-2580 or (800) 268-7215

Jan. 29-31, 1993: 2nd International Congress on Biological Response Modifiers (organized by the Inter-American Society for Chemotherapy)
San Diego
Abstract deadline: Nov. 2, 1992
CME, Inc., PO Box 712, Princeton Junction, NJ 08550; tel (609) 799-2300, fax (609) 275-8745

Feb. 6-13, 1993: 11th Winter Congress: Diagnostic Imaging
Courchevel, France
Dr. Ronald J. Friedman, Winter Congress, Medical Seminars International, Inc., 303-18981 Ventura Blvd., Tarzana, CA 91356; tel (818) 774-9077, fax (818) 774-0244

Feb. 9-13, 1993: 8th International Hypoxia Symposium: High Altitude Physiology and Medicine
Lake Louise, Alta.
Abstract deadline: Dec. 1, 1992
Ingrid Ellis, Hypoxia '93 administrative committee, McMaster University, 1200 Main St. W, Hamilton, ON L8N 3Z5; tel (416) 525-9140, ext. 2182

Feb. 11, 1993: Computer Based Records Supporting Patient Care Management Seminar
Vancouver
CME credits available.
Heather Pastorchik, conference coordinator, Computer Based Records Supporting Patient Care Management, c/o Clinicare Corporation, 4306-10th St. NE, Calgary, AB T2E 6K3; tel (403) 291-3949, fax (403) 250-8950

Feb. 21-25, 1993: Medical Society of PanAmerican Doctors 48th Annual Meeting
Manzanillo, Mexico
Papers requested in English or Spanish.
Dr. J.R. Brummitt, Canadian program chairperson, Medical Society of PanAmerican Doctors A.C., 91 Edgemont Estates Dr. NW, Calgary, AB T3A 2M3; tel (403) 239-7790

Feb. 25-26, 1993: 1st Biannual Respiratory Care Conference for Health Professionals
St. Boniface, Man.
Manitoba Lung Association, 629 McDermot Ave., Winnipeg, MB R3A 1P6; tel (204) 774-5501, fax (204) 772-5083