

PREHOSPITAL CARE

Can nurses working in remote units accurately request and interpret radiographs?

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Objective: Recent changes in the NHS have seen nurses take on roles that are traditionally filled by doctors, leading to the development of emergency nurse practitioners (ENPs). In addition to this, increasing interest has focused on telemedicine (literally, medicine at a distance) as a way of supporting remote emergency departments and minor injuries units from larger centres. The vast majority of these consultations are related to peripheral limb trauma and require a radiograph to be viewed as an integral part of the telemedical consultation. The aim of this study was therefore to determine whether nurses working alone in a peripheral unit are able to appropriately request, and accurately interpret, peripheral limb radiographs.

Methods: In this prospective study the four qualified nurses working in a peripheral unit were permitted to request a defined set of radiographs after limb trauma. A written protocol for nurse requested radiographs was supported by individual teaching sessions. At the time that the radiograph was requested basic demographic details were recorded and the patient was also assessed by two senior doctors in emergency medicine, one in person and one via a telemedicine link, both of whom independently considered whether the radiograph requested by the nurse was appropriate in that patient. Nursing staff were also asked to provide a provisional interpretation of each film, and this was compared with a gold standard derived from the interpretations of the two emergency physicians who had seen the patient and the final radiologist's report.

Results: The first 300 patients who had a radiograph requested by a member of the nursing staff were studied over a period of 12 months. Altogether 93 radiographs (31%) were positive for recent bony trauma or radio-opaque foreign body. Eleven radiographs (3.7%) were judged by both emergency physicians to be inappropriate. Three radiographs (1%) were requested outside the limits of the protocol, but all three were judged to be appropriate and occurred within the first two months of the study. A total of 32 (10.7%) of the radiographs were incorrectly interpreted by nursing staff with 26 false positives, four false negatives and two cases where the nurse observed an abnormality but failed to identify it correctly. The sensitivity of nurse interpretation was therefore 96%, with a specificity of 87%.

Conclusion: Experienced nurses, working without continuous medical supervision in a remote unit, are able to request appropriate radiographs of the peripheral limbs. Nurses requesting radiographs in this way can also interpret these films to a high standard, though with a tendency to err on the side of caution, generating many more false positive results than false negatives.

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Recent changes in the NHS have seen nurses take on roles that are traditionally filled by doctors. In emergency department practice this has led to the development of autonomous emergency nurse practitioners (ENPs) who are able to assess, treat and discharge patients without reference to medical staff.¹ Recently the role of ENPs in managing minor injuries has been rigorously evaluated in a randomised clinical trial, which concluded that "properly trained . . . nurse practitioners, who work within agreed guidelines, can provide care for patients with minor injuries that is equal or in some ways better than that provided by junior doctors."² Current government policy continues to support the development of the nurse practitioner as a way of reducing the burden on overworked medical staff.³

As well as working alongside doctors in large emergency departments experienced nurses (with or without formal recognition as ENPs) have traditionally played a significant part in the assessment and management of patients in smaller emergency departments and minor injuries units.¹ Medical support in such units is variable, but may comprise general practitioners, non-consultant career grades and/or visiting staff from larger centres. Recent interest has focused on telemedicine (literally, medicine at a distance, facilitated by modern video-conferencing techniques) as a way of supporting such units from larger emergency departments.⁴ However, the

vast majority of these consultations are related to peripheral limb trauma and require a radiograph to be viewed as an integral part of the telemedical consultation.⁵

An important step in developing telemedical support for minor injuries units is therefore to develop a means by which experienced nurses can request appropriate radiographs for peripheral limb trauma before initiating a telemedicine consultation.

The primary objective of this study was to determine whether nurses working alone in a peripheral unit are able to appropriately request peripheral limb radiographs. The secondary objective was to examine the accuracy of the nurse's initial interpretation of radiographs requested in this way.

METHODS

This prospective study was undertaken as a part of the SECT(A&E) project (Standards, Effectiveness and Costs of Telemedicine in Accident and Emergency). The overall research work was designed to provide a comprehensive

Abbreviations: ENP, emergency nurse practitioner; SHO, Senior House Officer

Table 1 Table of nurse requested radiographs judged appropriate and inappropriate

Radiograph	Number of appropriate investigations requested	Number of inappropriate investigations requested
Clavicle	3	
Acromio-clavicular joint	1	1
Shoulder	17	1
Humerus	1	
Elbow	8	1
Radius and ulna	7	
Wrist	49	1
Scaphoid	6	
Hand	28	
Thumb	13	
Finger	31	
Knee	8	
Tibia and fibula	4	
Ankle	51	
Calcaneum	3	
Foot	34	4
Toe	1	3
Foreign body	24	
Totals	289	11

assessment of telemedicine in the emergency environment, and following an initial technical evaluation concentrated on the safety, clinical effectiveness and economic implications of telemedicine through the medium of a randomised clinical trial. To facilitate this it was agreed that under the auspices of the trial the four qualified nurses working in the peripheral unit under study would be permitted to request a defined set of radiographs after limb trauma.

A written protocol for nurse requested radiographs was therefore devised following consultation with senior staff in radiology and emergency medicine. Named nursing staff were permitted to request radiographs for the following indications:

- (1) Suspected fracture in the upper limb (including the clavicle) or lower limb (excluding the hip and femur) as a result of trauma occurring in the previous 72 hours.
- (2) Suspected radio-opaque foreign body (for example, metal or glass) in the upper or lower limb.

The following patient groups were excluded:

- (1) Children under 5 years of age.
- (2) Patients in whom there was a possibility of multiple injuries or patients who were clinically shocked (in which case immediate medical assessment was mandatory).

General guidance was followed by specific consideration of each radiographic investigation in turn. Each nurse was given a copy of the protocol followed by an individual one to two hour teaching session with a designated member of the senior emergency department medical staff. When both trainer and

Table 3 "Two by two" table to calculate the sensitivity and specificity of informal nurse interpretation. Sensitivity = $89/93 = 96\%$. Specificity = $181/207 = 87\%$

	Gold standard positive	Gold standard negative
Nurse interpretation positive	89	26
Nurse interpretation negative	4	181

trainee were satisfied, a formal training sheet was completed by both and kept on file for future reference.

Patients undergoing radiographs on the basis of nurse requests were studied prospectively in both the emergency and radiology departments. This ensured that no patient was overlooked and a complete dataset was collected. At the time that the radiograph was requested basic demographic details were recorded and the patient was also assessed by two senior doctors in emergency medicine, one in person and one via a telemedicine link, both of whom independently considered whether the radiograph requested by the nurse was appropriate in that patient. A radiograph was judged inappropriate only if both doctors agreed that it was not required.

Although the protocol made it mandatory for every radiograph to be interpreted by a doctor before patient management the nursing staff were also asked to provide a provisional interpretation of each film, and this was compared with a gold standard derived from the interpretations of the two senior emergency physicians who had seen the patient and the final radiologist's report.

RESULTS

The 300 patients studied were radiographed over a period of 12 months, and comprised 133 women and 167 men. Sixty six patients (22%) were aged 15 years and younger. Ninety three radiographs (31%) were positive for recent bony trauma or radio-opaque foreign body.

The radiographs requested are listed in table 1.

Eleven radiographs (3.7%) were judged by both emergency physicians to be inappropriate, and were spread approximately equally between three of the four nursing staff. Three radiographs (1%) were requested outside the limits of the protocol: one in an injury more than 72 hours old and two in children both aged three years. All three were judged to be appropriate and occurred within the first two months of the study.

In 32 cases (10.7%) the informal nurse interpretation disagreed with the definitive "gold standard" interpretation. In four cases the nurse overlooked a bony abnormality and in a further two cases the nurse observed an abnormality but failed to identify it correctly. These six cases are listed in table 2. In the remaining 26 cases the nurse identified a possible abnormality that was subsequently judged to be normal. These 32 discrepancies in interpretation were spread approximately evenly among all four members of the nursing staff.

Table 2 Table describing the six cases in which the informal nurse interpretation overlooked or incorrectly interpreted a radiological abnormality

Radiograph	Provisional nurse interpretation	Final interpretation
Knee	Normal	Undisplaced fracture lower end of femur above knee prosthesis
Thumb	Normal	Fracture first metacarpal
Elbow	Normal	Fracture radial head
Foot	Normal	Fracture terminal phalanx great toe
Shoulder	Fracture proximal humerus	Fracture distal clavicle
Wrist	Fracture distal radius	Crystal arthropathy

The sensitivity and specificity of informal nurse interpretation can be derived from table 3.

DISCUSSION

The primary aim of this study was to examine whether experienced nursing staff working alone in a small, peripheral unit were able to request appropriate peripheral limb radiographs. Previous research has clearly shown that nurses working alongside doctors in a large emergency department are able to request radiographs effectively, usually at triage.⁶⁻⁸ This also has the benefit of reducing the time spent by patients in the department,⁹⁻¹⁰ and is currently practised in at least a third of emergency departments in the UK.¹¹ In the majority of previous studies, which describe an inappropriate radiograph rate of between 1.5% and 6%,⁶⁻¹⁰ appropriateness was judged by subsequent medical review only after the radiographs had been taken, leading to the possibility of bias. This study attempted to improve on this by assessing the patient before radiographs were taken, but the medical staff involved may still have been influenced by knowledge of whether the nurse had ordered a radiograph or not. This means that the figure of 11 inappropriate requests (3.7%) may be an underestimate, particularly as the only study in which there was a truly independent medical assessment of the patient before radiography suggested that 13% of requested radiographs were unnecessary.²

Deviations from the protocol were rare, did not lead to inappropriate radiographs, and only occurred during the first two months of the 12 month study period, suggesting that these were little more than early "teething problems".

Training is clearly an important issue,¹² but there is no universally recognised approach, with a great deal of variation throughout the UK.¹¹ The importance of experience is widely acknowledged, but this is invariably supplemented by some form of formal training.¹¹ As well as a written protocol and initial training programme the nurses in this study benefited from the presence of a senior emergency department clinician who was available for further discussion and education once all of the required study data had been collected and the patient discharged from the department.

Nurses in peripheral units, who are already used to assessing and managing patients in the absence of medical cover, may be particularly suited to the requisition of a limited set of radiographs within the limits of an agreed protocol, and this study certainly supports this approach. The patients excluded from such protocols will depend a great deal on local factors, though younger children are often excluded, presumably because of difficulties in assessment, while proximal injuries of the lower limb are also regarded as troublesome.⁹

In 1996 Freij and colleagues reported a comparison of nurses working in a minor injuries unit with senior house officers (SHOs) in a nearby hospital.¹³ This paper found that the nurses were "at least as good as SHOs in recognising the need for a radiograph, and as competent in their interpretation", but as many as 30% of the patients in both the nurse and SHO group were found to have undergone inappropriate radiographs. In the present study the nursing staff performed to a much higher standard, and the appropriateness of each radiograph was judged by comparison to senior, rather than junior, doctors in emergency medicine. It is interesting to note that 7 of 11 unnecessary radiographs were of the feet and toes. More careful education in this area would almost certainly reduce the inappropriate radiology rate quite considerably: in particular the toes rarely require a radiograph on clinical grounds, but are often over-requested by inexperienced staff.¹⁴

With regards to the interpretation of radiographs, table 3 shows very good rates of both sensitivity and specificity, comparable to the 94% and 93% respectively found by Freij *et al.*¹³

The actual rate of radiological abnormality (at 31%) is also similar to Freij *et al.*, and that reported by other authors.⁹ The most important overlooked abnormality (listed first in table 2) was a very subtle fracture of the femur just proximal to a total knee prosthesis; this was also missed by medical staff in the emergency department at the time of the patient's presentation, and was only detected by the reporting radiologist subsequently. Most of the errors in nurse interpretation relate to a tendency to suspect subtle fractures in actually normal radiographs. This is the safer type of error to make, and probably reflects a lack of experience that would be expected to improve over time. It is interesting to note that a recent evaluation of a year's work of a nurse led minor injuries unit reported a missed fracture rate of 1%, but a higher false positive rate of 3%, suggesting that this "over-reading" is a consistent finding.¹⁵ In all cases an additional safety net should be provided by early radiological reporting, and comparison with the nurse interpretation.¹⁶

In conclusion, experienced nurses, working without continuous medical supervision in a remote unit, are able to request appropriate radiographs of the limbs, for both trauma and foreign bodies. This requires the support of written protocols, training and regular feedback. Nurses requesting radiographs in this way can also interpret these films to a high standard, though with a tendency to err on the side of caution, generating a number of false positive results.

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