ORIGINAL PAPER

Would it be possible to develop a set of Ottawa wrist rules to facilitate clinical decision making?

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Purpose. To analyze the possibility of creating clinical decision-making rules to facilitate the assessment of conventional x-rays in acute wrist trauma.

Materials and methods. This is a prospective observational study. Data was collected on patients treated at the Emergency Department of our hospital further to sustaining acute wrist trauma. 179 patients were included in the study. 46 clinical interview and physical examination variables were used for each patient. Inter-examiner concordance was analyzed for the variables, as well as their statistical association with positive wrist radiology. Data was subsequently analyzed by means of multivariate analysis.

Results. All 57 patients with positive wrist x-ray images presented with at least one of these characteristics: age equal to or higher than 35, edema of the dorsum of the wrist; limited supination or active radial deviation; and pain or instability on the distal radioulnar drawer test. This clinical decision-making rule is 100% sensitive and 37.7% specific to detect patients with positive wrist x-ray images further to acute trauma. Its use in the sample under study would have reduced the number of x-ray requests by 15.6%.

Conclusions. A broader study should be undertaken in order to assess the acceptance of a series of clinical decision-making criteria for the carrying out of radiographs further to acute wrist trauma.

Key words: *wrist injury, sensitivity, specificity, clinical decision-making rules, emergency department.*

Criterios de decisión clínica: ¿es posible desarrollar unas normas de Ottawa de muñeca?

Objetivo. Valorar la posibilidad de crear reglas de decisión clínica para el uso de la radiología convencional en los traumatismos agudos de muñeca.

Material y método. Se desarrolló un estudio observacional prospectivo. Se recogieron datos de pacientes que acudieron al Servicio de Urgencias de nuestro hospital tras sufrir un traumatismo agudo de muñeca; 179 pacientes fueron incluidos en el estudio. Se recogieron 46 variables de entrevista clínica y exploración física de cada paciente. Se analizó la concordancia inter-examinador de las variables, así como su asociación estadística con la radiología positiva de la muñeca. Los datos fueron posteriormente analizados mediante un análisis multivariante.

Resultados. Los 57 pacientes con imagen radiológica positiva de muñeca presentaron, al menos, una de las siguientes características: edad igual o superior a 35 años, edema en el dorso de la muñeca, limitación de la supinación o desviación radial activa y dolor o inestabilidad en la prueba del cajón radiocubital distal. Esta regla de decisión clínica es 100% sensible y 37,7% específica para detectar pacientes con imagen radiológica positiva de muñeca en traumatismos agudos. Su uso en la muestra estudiada hubiera ahorrado un 15,6% de peticiones radiográficas.

Conclusiones. Es necesario desarrollar un estudio más amplio para valorar la aceptación de unos criterios de decisión clínica para la realización de radiografías en los traumatismos agudos de muñeca.

Palabras clave: *lesiones de muñeca, sensibilidad y especificidad, reglas de decision clinica, Servicio de Urgencias.*

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Acute wrist trauma is one of the most frequent reasons why people visit trauma emergency services[1-3]. Most hospitals routinely carry out a radiological examination of patients presenting with acute wrist trauma. Nonetheless, the majority of x-rays performed do not show a bone or ligament lesion, which means that they constitute a waste of resources and lead to an increase in patient waiting times and an unnecessary exposition to ionizing radiation.

Stiell et al have shown that the number of requests of conventional knee, ankle and foot films could be brought down in emergency services by using a set of simple clinical decision making criteria[4,5]. To date, however, no similar study has been carried out for the wrist.

We hereby present a pilot study whose aim is to explore the possibility to develop a series of clinical decision making rules that may be capable of detecting 100% of the wrist fractures diagnosed in the conventional radiographic series performed in emergency services, with as much specificity as possible.

Table 1. Inclusion and exclusion criteria for patients in the study

Inclusion criteria	Exclusion criteria
Patient older than 18	Pregnant women
Acute wrist trauma	Neurological alterations in upper limbs
	Multiple-trauma
	Bilateral wrist trauma
	Pain in elbow or in ipsilateral forearm
	Evolution of more than 7 days
	Patient with x-rays from another hospital
	Patient already treated in another hospital
	Intense pain and deformity preventing patient physical examination

MATERIALS AND METHODS

Type of study

A prospective observational study was performed in our Hospital between 1 January and 31 December 2005. The project was approved by the Ethics and Research Committee of our Hospital.

Population under study

Inclusion criteria

Patients over 18 years of age who had sustained acute wrist trauma (direct blow, fall on the hand or torsion of the hand on the wrist) (table 1).

Exclusion criteria

Patients with simple cuts, pregnant women, patients with neurological alterations in the upper limbs (syringomyelia, hemiplegia, brachial plexus lesion, etc.), multiple-trauma patients, patients with involvement of both wrists, ipsilateral elbow or forearm trauma, patients where the onset of symptoms occurred 7 days before presentation or who had been treated previously in some other hospital. Furthermore, we excluded patients who came to the emergency department with severe deformity and pain in the affected wrist since in those cases it was impossible to administer the physical exploration protocol (table 1).

Data collected from physical examination

Prior to the beginning of the study, we collected data on the physical examination of the wrist (signs and symptoms) at the Emergency Department. Those variables that, in principle, were more sensitive and repeatable were incorporated to a data collection protocol. The protocol included 4 clinical interview variables, 6 inspection variables, 17 painful areas on palpation of the wrist, 12 active and passive mobility variables, one prehensile strength test and 6 functional tests: a total of 46 variables (table 2).

All patients included in this study were interviewed and examined by, at least, one of the four physicians (ICL, JZE, ALL, XAG) who had participated in the development of the data collection protocol. The study only included patients seen to by one of these 4 physicians. In order to determine inter-examiner concordance, 25 patients were independently explored by 2 physicians, without either obtaining any information about the results of the physical examination of the other.

Six months into the study, a first statistical assessment was made ("preliminary study") on the first 125 patients, where we selected the variables with a statistically significant association ($p < 0.05$) with positive x-rays as well as variables where, even if a statistically significant association with positive x-rays was not found, it could be expected that when the amount of data collected increased, the association could be confirmed. After this first assessment, clinical variables shrank to 24 (table 2).

Collection of data from the radiological diagnosis

The radiological series of the patients included in the study (anteroposterior [A/P], lateral and special views if a scaphoid fracture or an acute carpal instability were suspected) were debated and analyzed by the trauma surgery team that was on duty. Radiographs were classified into: a) negative and b) positive. They were considered positive when the image revealed a fracture or a wrist ligament lesion (the wrist was considered to be the area extending

Table 2. Clinical interview and physical exploration variables included in the study

Clinical interview	Age*
	Gender*
	Personal history
	Mechanism of injury
Inspection	Deformity*
	Edema*
	Eccymosis*
	Wounds
	Crepitus
	Ganglia
Palpation of painful areas	Distal radius*
	Distal ulna*
	Radial styloid
	Lister's tubercle*
	Ulnar head*
	Anatomical snuffbox
	Scapholunate joint line
	Triquetrohamate joint line
	Ulnar snuffbox
	Base of 1st-5th metacarpals
	Scaphoid tubercle
	Hook of hamate
	Pisiform
Mobility	Active-passive flexion*
	Active-passive extension*
	Active-passive radial deviation*
	Active-passive lunar deviation*
	Active-passive pronation*
	Active-passive supination*
Prehensile strength test	Comparison with the strength of the uninjured hand*
Functional tests	Distal radioulnar drawer test*
	Anteroposterior drawer test
	Telescoping
	Pain on active finger extension with the wrist flexed*
	Watson
	Reagan

*Variables selected following the preliminary study.

from the distal radius and ulna to the bases of the metacarpals, with the exception of the base of the first metacarpal).

In order to evaluate the quality of the A/P and lateral wrist x-rays performed at the Emergency Department, we analyzed 40 A/P and 40 lateral radiographs. Visualization of the depression in the extensor carpi ulnaris tendon was considered an indication of good quality in anteroposterior radiographs; quality was considered excellent if the said depression was clearly seen on the x-ray and poor if it could not be seen[6]. The scaphopisocapitate index was the quality criterion used to classify lateral radiographs into excellent, acceptable or poor[7].

In order to determine the inter-examiner concordance regarding the radiological diagnosis, 46 x-rays were subsequently analyzed by two experienced trauma surgeons who were unaware of the radiological diagnosis made in the Emergency Department. In order to determine the intra-examiner concordance regarding the radiological diagnosis, the same trauma surgeons reanalyzed all 40 radiological series 2 months after having evaluated them for the first time and without any knowledge of the previous results.

Statistical analysis

The statistical association between the different clinical variables and the x-ray result was studied by means of Fisher's Exact Test (nominal variables) and the Student's "t" test (continuous variables). For the calculation of inter- and intra-observer concordance indices, the kappa index was used. The clinical variables that showed an acceptable inter-observer concordance (kappa > 0.6) and a statistically significant association with the x-rays ($p < 0.05$) were included in a multivariate analysis. Using binary logistic regression methods, possible confounding factors were sought. In order to calculate combinations of clinical variables that were 100% sensitive and as specific as possible we used stepwise forward logistic regression. The data was analyzed with the SPSS 12.0 statistical software (LEAD Technologies, Chicago, Illinois, United States).

RESULTS

One hundred and seventy nine patients who had sustained acute wrist trauma were included in the study; 57 (31.8%) suffered some sort of radiologically positive wrist injury (table 3).

Univariate analysis

Twenty-two of the 24 variables selected in the preliminary study were statistically associated to the radiological analysis (table 4).

"Age" was the only continuous variable selected. It was analyzed by means of a ROC curve (*receiver operating characteristic curve*) with which we obtained the age significance at different cut-off points. The most favorable cut-off point (with a p value < 0.05 and the highest sensitivity and specificity possible) was an age equal to or higher than 35 years. The variable "age equal to or higher than 35 years" was selected as a dichotomic variable.

Only 10 of the 24 clinical variables obtained an inter-observer kappa value higher than 0.6. Since no clinical decision-making criterion that was 100% sensitive could be obtained with those variables, it was decided to lower the kappa index to 0.55. In that way, only 5 variables were discarded: pain on palpation of distal radius, pain on palpation of distal ulna, pain on passive flexion and extension and pain on active extension of the fingers with a flexed wrist.

Table 3. Characteristics of patients included in the study

Characteristics	Number (n = 179)	Percentage %
Age (mean ± standard deviation)	44.7 ± 19.8 years	
Range	18-88 years	
Gender (males/females)	103/76	57.5/42.5
Laterality (right/left)	100/79	55.9/44.1
Cause		
Fall on the hand	155	86.6
Hand-wrist torsion	13	7.3
Direct blow	11	6.1
Personal history		
Inconsequential	154	86
Prior wrist fracture	2	6.7
Bone protectors	10	5.6
Bone weakeners (corticoids, etc.)	3	1.7
Negative radiology	122	68.2
Positive radiology*	57	31.8
Radial fracture	25	
Ulnar fracture	4	
Radius + ulna fracture	9	
Scaphoid fractures	7	
Lunate fracture	1	
Fracture of the dorsal triquetrum	3	
Fracture of the base of the metacarpal	7	
Distal radioulnar instability	2	
Scapholunate instability	1	
*Patients may have more than one fracture diagnosed in one same wrist		
Quality of A/P x-ray		
Excellent	29	72.5
Poor	11	27.5
Quality of lateral x-ray		
Excellent	13	32.5
Acceptable	19	47.5
Poor	8	20

A/P: anteroposterior.

Table 4. Variables having a statistically significant association with the x-ray diagnosis

	Variable	Nr, of patients with a positive and variable positive radiographs
Clinical interview	Age (mean years of patients with positive x-rays ± standard deviation)*	56.3 ±20
Inspection	Deformity	15
	Edema	46
	Eccymosis	9
Palpation of painful areas	Distal radius	17
	Distal ulna	13
	Lister's tubercle	33
Passive mobility	Extension	51
	Flexion	49
	Radial deviation	35
	Ulnar deviation	32
	Pronation	29
	Supination	42
Active mobility	Extension	47
	Flexion	39
	Radial deviation	37
	Ulnar deviation	31
	Pronation	26
	Supination	44
Loss of prehensile strength		49
Functional tests	Distal radioulnar drawer test	33
	Pain on active finger extension with the wrist flexed	35

Fisher's Exact Test; *Student's "t" test.

Table 5. Decision-making protocol for the wrist x-ray series in acute wrist trauma

Only one x-ray series is necessary is at least one of the following criteria is fulfilled:
a) Age equal too r higher than 35 years
b) Edema on the dorsum of the wrist
c) Supination or active radial deviation are impossible
d) The distal radioulnar drawer test elicits pain and/or instability

Moreover, a study of confounding factors was carried out by means of logistical regression methods. The following pairs of variables that could in principle cause a confounding bias showed themselves to have no significant influence on the radiology: gender-age; eccymosis-edema; pain on passive flexion-pain on active extension of the fingers with a flexed wrist.

The inter-observer kappa value for x-ray diagnosis was 0.66. The intra-observer kappa value was 0.7.

72.5% of A/P views were rated as excellent in quality, whereas 80% of lateral views were rated as Esther excellent or good.

Multivariate analysis

Through stepwise forward logistic regression we obtained a set of clinical variables against which no radiologically positive wrist injury would have been misdiagnosed. Indeed, the 57 patients with a positive wrist x-ray presented, at least, with one of the following characteristics: age equal to or higher than 35 years, edema in the dorsum of the wrist, limitation to supination or active radial deviation (as compared with the contralateral wrist) and pain or instability on the distal radioulnar drawer test (table 5).

In our series, the use of these criteria world have meant not performing 28 unnecessary x-ray series (15.6%), with a sensitivity of 100% and a specificity of 37.7% (fig. 1).

DISCUSSION

The medical literature contains studies that attest to the high degree of reliability of wrist examination for diagnosing

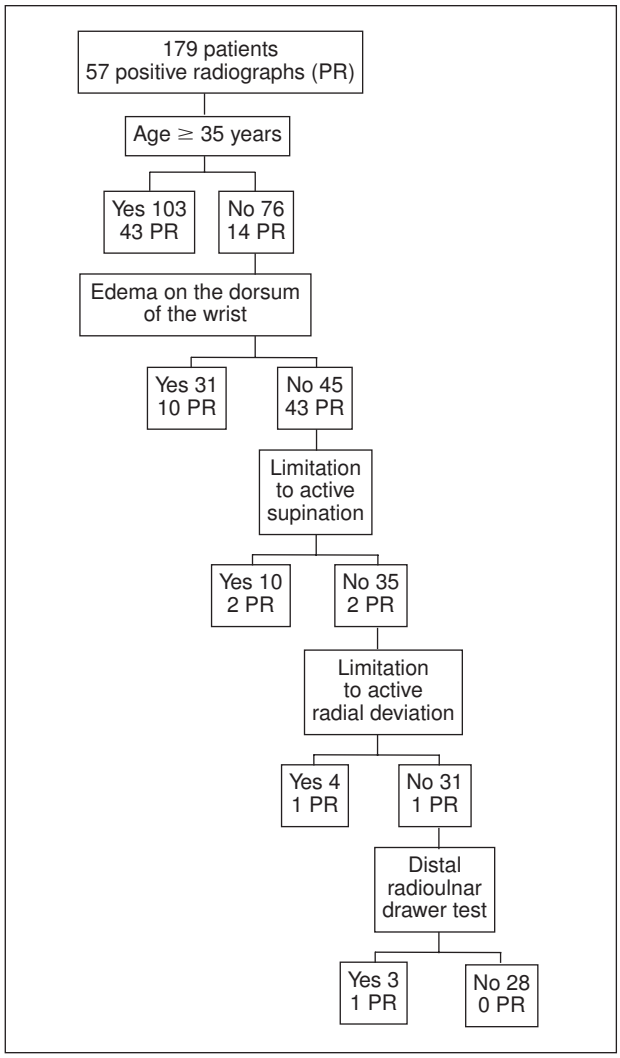

Figure 1. *Patient distribution and radiological diagnosis according to the clinical decision-making protocol. PR: positive radiographs.*

injuries in that joint[8-10]. Pain in specific locations, in response to active/passive mobilization or holding an object is a simple clinical sign that is also specific and sensitive enough to detect a wrist fracture[8]. Other clinical signs, such as functional tests, are more complex[11] and less repeatable, and many of them lack enough reliability to be used as fracture predictors[12].

In the present study, we have attempted to observe as strictly as possible the principles and standards of the clinical decision making criteria described by several authors[13-15]. Furthermore, we have followed the same procedure used to develop the Ottawa rules for the ankle, the foot and the knee, adapting them to the characteristics of the joint under study. In the Ottawa rules for the knee, the ankle and the foot, the radiographic presence of clinically non-significant fractures (such as undisplaced avulsions) was not regarded as a fracture. In the present study, three instances of undisplaced avulsions of the dorsum of the triquetrum were found, which were considered to be images of significant fractures. We believe that generalizing a clinical decision-making rule for the wrist that is not capable of detecting those lesions could lead to problems of a medical-legal nature.

We have monitored the quality of the A/P and lateral radiographs performed in the Emergency Department. Over 70% of them were of excellent or acceptable quality. It would be interesting to compare these findings with those of other hospitals, since a significant difference as to x-ray quality could have an influence on the capacity of radiographs performed in an emergency department to detect radiologically positive lesions.

In addition, in order to optimize the validity of results, we have controlled inter-observer concordance of the data collected at the physical exploration as well as the inter- and intra-observer concordance of the radiological diagnosis. All physical examination variables that did not obtain a high kappa value (equal too r higher than 0.55). Inter-(0.66) and intra-(0.7) observer kappa values for x-ray diagnosis guarantee that the interpretation of radiographs in the Emergency Department was correct.

In spite of obtaining 100% sensitive criteria, the results of this study are not comparable to those obtained by Stiell et al for the knee and the ankle. On the one hand, the specificity of our criteria (37.7%) is very low as compared with those for the knee (54%), although they are similar to those for the ankle (40%). Besides, the savings in the amount of x-rays required (15,6%) are lower to the figures obtained with the knee (28%) or the ankle (36%) criteria are applied.

Alternatively, a more specific clinical decision making protocol could have been developed by eliminating the variable "edema in the dorsal area of the wrist" variable. This would increase specificity to 39.4% and World permit a 20.1% saving in the number of x-rays ordered. Nevertheless, in our study group this rule would have led to the loss of a patient that had sustained a fracture, which World have brought down sensitivity to 97.2%, an unacceptable level for these kinds of clinical decision-making protocols.

If we wanted to apply this clinical decision making protocol to our daily practice, it would be necessary to carry out a study on a larger number of patients, develop a prospective validation and check its effectiveness. Although the study group is large and diverse, a much larger amount of patients is required to demonstrate that the clinical decision-making protocol proposed does not have any exception. Prospective validation is mandatory for the validation of any clinical decision-making protocol. Such a validation has been found for the Ottawa ankle[16-21] and knee[22-24] rules. Finally, it is necessary to demonstrate the effectiveness and the impact of the rule in daily clinical practice[25].

The results obtained in the pilot study seem to question the usefulness of this clinical-decision making protocol for daily practice as well as the advisability of extending the scope of the current study. In the first place, the age used as a cut-off point, equal to or higher than 35 years, is lower than the mean age of the whole group of patients (44.7 years), with no statistical advantages being found with the use of other cut-off points. The fact that the mean age is higher than the cut-off point suggests that, in clinical practice, over half of the patients that have sustained acute wrist will be excluded from the clinical decision-making protocol and, therefore, they will be administered a wrist x-ray series. This largely reduces the x-ray economies that World be achieved by applying the clinical decision-making protocol.

Secondly, the rule must be easy to remember and to apply. Edema in the dorsal region of the wrist has shown itself to be a highly sensitive and reliable sign in our study. However, one must consider the time-dependency of wrist edema following trauma.

Before accepting this sign in a clinical decision-making protocol it is essential to determine the influence of the time elapsed between trauma and physical examination on its positiveness or negativeness.

Limitation of active supination was an excellent predictive factor, both for its reliability and its specificity, especially in cases of distal radial fractures. Limitation of radial deviation and the distal radioulnar drawer test were less reliable criteria, which obtained a kappa value of less than 0.6.

Finally, we believe that the results obtained should not be taken as gospel truth. In spite of having fulfilled our goal to develop a fully sensitive rule, this has only been possible at the expense of significantly reducing its specificity. Moreover, the surprisingly high percentage of positive radiographic series detected in the study (31.8%) seems to indicate that, in clinical practice, a clinical decision-making protocol that is only capable of reducing the amount of x-rays ordered by 15% is not really very helpful.

To conclude, the aim of this pilot study was to explore the possible development of a clinical decision making protocol for requesting x-ray series in acute wrist trauma. Our results indicate that radiograph series will only be necessary in those patients that present with at least one of the following criteria: age equal to or higher than 35 years, edema in the dorsum of the wrist, limitation to supination or active radial deviation (as compared with the conrtralateral wrist), and pain or instability on performing the distal radioulnar drawer test.

In spite of the fact that our protocol is 100% sensitive, its low specificity (37,7%) and the scant reduction in the number of x-rays required (15%) indicate that, if these results are confirmed by larger-scale studies, its applicability in clinical practice would be very limited.

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Conflict of interests

The authors have declared that they have no conflict of interests.