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Diagnostic test performance of Amsterdam wrist rules in diagnosing wrist fracture in adults with wrist trauma

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Abstract: **Objective:** Wrist trauma is a common chief complaint in emergency departments and radiography is used to make the diagnosis. Excessive usage of radiographs would utilize resources, exert risk of radiation exposure, and overcrowding. Amsterdam wrist rules (AWR) have been proposed as a tool for clinical decision-making regarding the need for wrist fracture diagnosis. This study assessed the diagnostic test performance of this rule in wrist trauma for wrist fracture.

Methods: All patients over 18 years old with the chief complaint of acute wrist trauma were included. They were excluded if Glascow coma scale (GCS) was below 15, needed emergency surgery without an X-ray, and had a history of wrist fracture in the past 3 months. Anteroposterior and lateral radiographs were obtained and the AWR predictors were assessed before going to the radiology unit. The presence of a fracture of the distal radius was confirmed by treating emergency physician or radiologist.

Results: 205 participants were recruited in this study, of which 6 patients (2.9%) were excluded due to missing data. The median age was 40 (IQR: 30-50) and 74 (37.2%) patients were female. There were 66 (33.2%) patients with a wrist fracture, which distal radius accounted for most of them. The AWR had sensitivity and specificity of 0.71 (95% CI: 0.49,0.87) and 1 (95% CI: 0.92,1), respectively. Although the negative likelihood ratio of AWR was 0.29 (95% CI: 0.16,0.54), the positive likelihood ratio was infinite. The positive predicted value was 1 (95% CI: 0.80,1), whereas the negative predictive value was 0.86 (95% CI: 0.74,0.94).

Conclusion: The AWR showed great specificity and positive predictive. It had fair sensitivity, negative predictive value, and negative likelihood ratio for diagnosis of wrist fracture in patients with wrist trauma.

Keywords: Amsterdam Wrist Rule; Decision Rule; Wrist Fractures; X-ray

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1. Introduction

Wrist trauma is one of the most common chief complaints in emergency departments (EDs) and it is the cause behind 16% of all fractures (1-5). For example, in the Netherlands, 20 out of 10,000 people suffer from wrist fractures every year. However, in the elderly, this figure reaches 124 out of 10,000 (1). Many of these cases have distal radius fractures (2). Radiography is used to diagnose fractures; however, its excessive usage would utilize resources and exert risk of radiation exposure (5). In addition, the request for radiography increases the patient's stay in the ED, which in turn causes overcrowding (6).

Despite the high prevalence of fractures, unlike ankle and knee trauma, there is no specific strategy to guide performing radiographs (7-10). Having a rule can prevent unnecessary X-rays of the wrist and thus reduce radiation exposure, waiting time in the ED, and health care costs.

Amsterdam wrist rules (AWR) has been proposed as a tool for clinical decision-making regarding the need for patients to perform wrist radiography in cases of acute wrist trauma. This rule has been proposed for 2 purposes; prediction of distal radius fracture and prediction of any fracture in wrist. For the latter diagnosis, the AWR criteria components include old age, wrist swelling, obvious deformity, tenderness of distal radius on palpation, pain during palmar flexion, pain during supination, and painful radioulnar ballottement test (Table

1) (6). External validation studies are common studies that should be conducted to evaluate the accuracy of a diagnostic rule in another setting before any recommendation on a rule (11,12). Therefore, this study aims to examine the predictive power of AWR in reducing the need for X-ray in adults with wrist trauma for the diagnosis of distal radial fracture.

2. Methods

2.1. Eligibility criteria

This is a diagnostic test study that was conducted on patients with wrist trauma who were referred to the ED of Shohada Hospital in the first half of 2022. As in the AWR study, the inclusion criterion for the study included all patients over 18 years old with the chief complaint of acute wrist trauma either in isolation or in multiple trauma who were referred to the ED. Patients who had a Glascow coma scale (GCS) below 15, or who were transferred to the operating room due to the need for emergency surgery without an X-ray, or who had a history of wrist fracture in the past 3 months were excluded from the study. This study has been approved by the Ethics Committee of our institute (IR.TBZMED.REC.1400.268).

2.2. Data collection

According to the existing medical directive in the Shahada Hospital, for all patients with isolated wrist trauma, an X-ray was requested in triage. For multiple trauma patients, the request for the wrist imaging was performed along with other imaging according to the treating physicians' decision. Of note, there was no protocol for AWR assessment in the study center and in both the cases, treating physicians assessed the patients for eligibility and would determine the AWR predictors before going to the radiology unit. In the radiology unit, according to the hospital protocol, anteroposterior and lateral radiographs were obtained. The result of radiologists' interpretation of radiographs was recorded and compared with the result of AWR. Of note, the patients were treated irrespective of the result of AWR predictors as no therapeutic or diagnostic intervention was performed on the patient.

2.3. Outcome

Like the derivation study, the presence of a fracture of the distal radius, ulna, or the carpal bones was assessed. Disruption of one or more of the cortices was considered as the definition of fracture. Also, avulsion was recorded as a fracture. This diagnosis was made by attending radiologist or emergency physicians on the X-ray. We did not take findings on additional imaging such as computed tomography (CT) scans or magnetic resonance imagings (MRI) into account to define the presence of the fracture.

2.4. Statistical analysis

The categorical variables are reported as proportion and percentage. Continuous variables are reported in mean and standard deviation or median and interquartile range (IQR) whichever appropriate.

Using a 2 by 2 contingency table, diagnostic test performance indices (sensitivity, specificity, negative predictive value (NPV), and positive predictive value (PPV)) were calculated and reported with a confidence interval equal to 95%. The P-value of less than 0.05 was considered statistically significant. For sample size calculation, considering sensitivity of 98.4% and specificity of 25.1%, with margin of error of 3% from the original study, 185 cases were needed for the power of 80%. We considered 10% of drop rate and reached the final sample size of 205 for this study. All the collected demographic information and the studied data were analyzed by IBM® SPSS® release 20.0.0 software.

Table 1 Amsterdam wrist rules (AWR) diagnostic criteria

Painful radioulnar ballottement test
Old age
Wrist swelling
Obvious deformity
Tenderness of distal radius on palpation
Pain during palmar flexion
Pain during supination

3. Results

3.1. Characteristics of study participants

A total of 205 participants were recruited into the study, of which 6 patients (2.9%) were excluded due to missing data. The median age was 40 (IQR: 30-50) and 74 (37.2%) of patients were female. Also, there were 66 (33.2%) patients with a wrist fracture. The detailed clinical and demographic characteristics of participants in both groups are provided in table 2. The AWR had sensitivity and specificity of 0.71 (95% CI: 0.49,0.87) and 1 (95% CI: 0.92,1), respectively. Although the negative likelihood ratio of the rule was 0.29 (95% CI: 0.16,0.54), the positive likelihood ratio was infinite. The positive predicted value was 1 (95% CI: 0.80,1), whereas the negative predictive value was 0.86 (95% CI: 0.74,0.94).

4. Discussion

In our study, the AWR showed great specificity and positive predictive value of 100%. It had fair sensitivity, negative predictive value, and negative likelihood ratio for diagnosis of wrist fracture in patients with wrist trauma.

There were few similar studies on the diagnosis of wrist fractures. Rivera et al. examined 116 patients and stated that clear deformity and point tenderness are the best predictors for detecting the possibility of fracture and it detects wrist fracture with a sensitivity and specificity of 81 and 82% (13). In the AWR derivation study, the researchers followed the recommended methodology to derive a decision rule. They derived two rules for the diagnosis of "any wrist fracture" and "distal radial fracture". These two rules had 3 common predictors (increased age, swelling of the wrist, and visible de-

Table 2 Clinical and demographic characteristics of derivation cohort and validation cohort

Characteristics		Patients without fracture, n=131	Patients with fracture, n=68	Total, n=199
Age, year, median (IQR)		40 (29-50)	42 (32-49)	40 (30-50)
Female, n (%)		49 (37.4%)	25 (36.8%)	74 (37.2%)
Mechanism of injury, n (%)	Accident	30 (22.9%)	17 (25%)	47 (23.6%)
	Dispute	21 (16%)	11 (16.2%)	32 (16.1%)
	Falling	71 (54.2%)	34 (50%)	105 (52.8%)
	Punch 9 (6.9%)	6 (8.8%)	15 (7.5%)	
	Multiple trauma	9 (6.9%)	4 (5.9%)	13 (6.5%)

IQR: Interquartile range; mm: Millimeter; n: Number

formation) and 4 other different items in each of them. For the diagnosis of any fracture, distal radius tender to palpation, pain on palmar flexion, pain on supination, painful radioulnar ballottement test was also incorporated (6). In the validation part of that study, sensitivity, specificity, and NPV for all fractures of wrist bones were 98.2%, 21%, and 90%, respectively. Sensitivity and specificity for distal radius fracture were 98.4 and 25.1%, respectively. Based on this study, 10% of wrist X-ray requests could have been reduced (14). For "all fractures" diagnosis, the area under the curve (AUC) was 0.81 (95 % CI: 0.77,0.85). By using the rule, they claimed they would miss 4 fractures, which did not require surgery. In the implementation study, there was an absolute reduction in wrist radiographs by about 10% (15). There would be a potential 6% cost savings with a wrist injury according to a cost reduction analysis (16).

Among the pediatric population, a study conducted in 2006 showed the presence of deformity, wrist swelling, and abnormal supination, and pronation had a sensitivity of 99.1% and a specificity of 24% (17). In an extension of AWR study in this age group, 787 patients were examined. The sensitivity of the rule for the diagnosis of wrist fracture was 95.9% and the specificity was 37.3%. The authors stated that the X-rays could be potentially reduced by 22%, which claimed to cause significant reduction in cost, waiting time in the hospital, and the patient's stay in the ED similar to adults. Although 4.3% of fractures could be missed, according to the study, these fractures were treated with splints and serious complications did not occur in the treatment process of these patients (18). In an implementation study of AWR in the pediatric population, this rule had a sensitivity of 97.7% and a specificity of 33.2% for wrist fracture in wrist trauma. These criteria caused a 19% decrease in X-ray requests and a 26-minute reduction in the stay of the patients who were not candidates for X-ray. Eight fractures were missed using AWR but as per the results, only four of them were clinically relevant (19).

The findings from the original study in adults can be compared to our study with high specificity and PPV and low sensitivity and NPV of our study. Using the rule we might miss 7 patients with distal radial fracture. Some reasons can explain the difference; The distal radius fracture was much more prevalent in our patient population. While the high prevalence has been reported in other studies (7), this difference, not only could explain the high PPV, but also it is worth mentioning that there is some evidence that it would also have some effect on other indices of test performance such as sensitivity and specificity (20,21).

5. Limitations

Our study is limited in several ways. First, it is a study conducted in a single center. As a result, the findings are limited in generalizability. Second, we did not consider the findings of diagnostic modalities other than X-ray such as CT scan and MRI for the fracture diagnosis. In this way, there is a risk of missing fractures and hence undifferentiated information bias. Third, we did not assess the AUC in our study and were unable to assess the discrimination ability and compare with the original study. Fourth, the reliability of the predictors was not assessed similar to the derivation study.

6. Conclusion

In contrast to the original study, AWR had great specificity, PPV, and positive likelihood ratio. This makes this rule a perfect rule to confirm the wrist fracture diagnosis.

7. Declarations

7.1. Acknowledgement

All the authors thank Shohada hospital staff for their help in conducting this research.

7.2. Authors' contribution

All the authors met the standards of authorship based on the recommendations of the International Committee of Medical Journal Editors.

7.3. Conflict of interest

None.

7.4. Funding

None.

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