

# Associated reactions of the upper extremity as an important part of neurological and functional assessment of patients in the acute phase of ischemic stroke

Krzysztof Głowacki<sup>1</sup>, Jakub Stolarski<sup>2</sup>, Agata Zdrowowicz<sup>2</sup>, Karolina Krzysztoń<sup>2</sup>, Izabela Domitrz<sup>2</sup>

<sup>1</sup> Department of Neurology, Bielański Hospital, Warsaw, Poland

<sup>2</sup> Department of Neurology, Faculty of Medical Sciences, Medical University of Warsaw, Warsaw, Poland

**Correspondence to:** Krzysztof Głowacki, email: krzysztglowacki@gmail.com

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## Abstract

**Background:** Associated reactions (ARs) are involuntary movements that significantly affect the functioning of stroke patients. Due to a lack of scientific evidence, physiotherapists provide ARs therapy based mainly on individual experience. This common phenomenon remains poorly recognized among neurologists.

**Aims:** The aim was to assess the relationship between patient's ability to independently change positions within the bed and the occurrence of upper limb ARs in the rehabilitation process in the acute phase of ischemic stroke.

**Material and methods:** Group of 53 patients after an acute ischemic stroke underwent physiotherapeutic examinations. On the first day of the physiotherapy evaluation, the patient's ability to independently change positions within the bed was assessed. During the rehabilitation process, occurrence of the upper limb ARs was evaluated using the modified Associated Reaction Rating Scale (ARRS).

**Results:** It was reported that 20.75% of patients presented ARs of the upper limb during the rehabilitation process. Significant differences were found between patients with and without ARs when comparing the ability to shift to a long sitting position and to rotate on to the more affected side, examined on the first day of physiotherapy assessment.

**Conclusions:** Assessment of the patient's ability to change positions on the first day of physiotherapy can provide information that could help predict the occurrence of ARs. There is a need to adjust the ARRS for use in the acute phase of stroke. It is necessary to promote knowledge about ARs among neurologists and neurosurgeons.

## Key words

associated reactions, synkinesis, mirror movements, stroke rehabilitation, spasticity, upper motor neuron syndrome.

## Introduction

Associated reactions (ARs) are defined as: „Unwanted, effort-dependent limb movements that occur following cerebral damage, where there may be sensorimotor dysfunction or insufficient postural control, such that when a stimulus is applied that exceeds the individual's level of inhibitory or modulatory control, it results in intermittent or sustained involuntary, heterogeneous muscle activation with abnormal limb posturing, most visible in the hemiplegic upper limb” [1]. Their functional causes are multifactorial and include, but are not limited to, postural instability, disturbances in muscle strength and tension, pain, and anxiety. Despite its high prevalence (29–88% of stroke patients) and proven negative effects on functioning, ARs are a little-studied phenomenon [2–5].

There is no consensus on the terminology of ARs. In the literature, this phenomenon can be found interchangeably under the following terms: „associated reactions”, „mirror movements”, „motor overflow”, and „synkinesis”. Previous studies used different definitions of ARs, so it is not always clear whether the research results are comparable. Additionally, in other articles, on the subjects of muscle tone after central nervous system (CNS) damage, in which this taxonomy is not used, information about phenomena that meet the criteria for ARs can be found [6–8]. There is not enough new research available on this new phenomenon. Some of the studies were performed in small groups and raised methodological concerns [9–11].

For the abovementioned reasons, the physiotherapy of patients with ARs is most often based on the subjective experiences of therapists and firm beliefs, often not supported by scientific evidence. This implies the need for in-depth research on the occurrence of ARs in patients after stroke. ARs are a factor that significantly impairs the functioning of patients and are a frequent target of neurorehabilitation [4]. Knowing this phenomenon and being able to identify it are important for neurologists, to communicate effectively with the physiotherapist as part of the work of the interdisciplinary team.

## Aims

This paper aimed to assess the relationship between the patient's ability to independently change positions within the bed and the occurrence of upper limb ARs in the rehabilitation process in the acute phase of ischemic stroke. The additional goal was to check the possibility of using a modified Associated Reactions Rating Scale (ARRS) in the assessment of examined patients. The last goal was to retrospectively measure the difference in the severity of selected neurological symptoms between patients with and without ARs.

## Materials and methods

The study was conducted at the Department of Neurology at the Medical University of Warsaw. The data were collected during a routine physiotherapeutic examination, commonly performed on patients hospitalized due to a stroke. The inclusion criteria for the study were the state after the first-ever hemispheric or brainstem ischemic stroke. The exclusion criteria were orthopedic dysfunctions that did not allow for the performance of the examined activities and cerebellar stroke.

The collected data were statistically analyzed using SAS version 9.4. The variables were presented using descriptive statistics appropriate to the measurement scale: qualitative variables were presented using the absolute frequency  $n$  and percentage frequency, and the quantitative variables were presented as the mean and standard deviation or as median and quartiles (first and third), depending on the distribution of the data. The normality of the distributions was checked by the Kolmogorov-Smirnov test. The comparison of scores in the Scandinavian Stroke Scale (SSS) and limbs muscle strength and tone of patients who experienced ARs with patients who did not were performed using the chi-square test or the accurate Fisher test for qualitative variables. To check whether the ability to change positions, to the more affected side, to the less affected side, and to a long sitting position, provides information to

predict the occurrence of ARs during acute stroke hospitalization, the sensitivity, specificity, and positive predictive value (PPV) were calculated. In the statistical calculations, the level of significance  $\alpha=0.05$  was assumed.

In the research process, data were collected from N=53 patients, including 37 women (69.8%) and 16 men (30.2%). The patients' age was on average  $76.34\pm 10.03$  years old and ranged from 44 to 94 years. Death was reported in 13 patients (24.53%

of the study group). The stroke affected the left side in 49.06% of cases and the right side in 45.8% of patients. The prognostic score of the SSS had a median of 20 with a range of 0 to 22 points. The duration of hospitalization lasted a median of 10 days. The shortest time of hospitalization was 2 days and the longest was 55 days. Data on the elements of the neurological examination were summarized in **Table 1**, including specific values of muscle tone and strength and SSS scores.

**Table 1.** Characteristics of the test group.

Variable	Value	Range (min-max)
N	53	
Sex, female:male, n (%)	37:16 (69.8:30.2)	
Age, years, average $\pm$ SD	76.34 $\pm$ 10.03	44-94
Death, n (%)	13 (24.53)	
Time of hospitalization, days, median, Q1;Q3	10 (8.00;16.00)	2-55
More affected side, n (%)		
Left side	26 (49.06)	
Right side	24 (45.8)	
Both sides	3 (6.66)	
Thrombolysis	10 (18.87)	
Prognostic SSS, median (Q1;Q3)	20.00 (10.00;22.00)	0-22
Upper limb strength SSS scale, n (%)		
0	10 (18.87)	
2	6 (11.31)	
4	3 (5.66)	
5	19 (38.85)	
6	15 (28.3)	
Lower limb strength, SSS scale, n (%)		
0	8 (15.09)	
2	8 (15.09)	

4	4 (7.55)	
5	14 (26.42)	
6	19 (35.85)	
Increased muscle tone, upper limb	11 (21.15)	
Decreased muscle tone, upper limb	18 (34.62)	
Increased muscle tone, lower limb	8 (15.38)	
Decreased muscle tone, lower limb	18 (36.54)	

On the first day of physiotherapeutic evaluation (first day of hospitalization, excluding weekends and holidays), patients' mobility capabilities regarding the change of positions within the bed were also examined. Patients were asked to

change the positions themselves. If a patient was not able to communicate verbally, he received manual guidance from a physiotherapist. Data on the possibility of changing positions were presented in **Table 2**.

**Table 2.** The ability of patients to change their position on their own during the first day of physiotherapeutic assessment.

Position	Number of patients
Change of position to more affected side only	2
Change of position to less affected side only	1
Change of position to long sitting only	0
Change of position on both sides	2
Change of position on both sides and to long sitting	31
Change of position on more affected side and to long sitting	0
Change of position on less affected side and to long sitting	1
Inability to change any position	2
Assessment unable	14

In the next stage of the study, the incidence of upper limb ARs in patients was checked when changing the position to the highest possible position (sitting, standing, lying sideways). Standardization of verticalization time to individual positions was not possible due to the variety of patient's clinical conditions. In each case, the assessment of the occurrence of ARs was made during the first ac-

tive attempt to perform a higher position. The assessed positions were: standing on one leg, moving from unsupported sitting to standing, moving from lying sideways to sitting on the edge of the bed, and moving from lying supine to lying on the affected side. If the patient was unable to perform any of the above actions, the attempt to induce ARs was carried out by provoking coughing in the

supine position. The study was conducted based on the Associated Reactions Rating Scale (ARRS), adapted to the conditions of the study in the acute phase of ischemic stroke. On this basis, the ARs were assessed on four levels. The score on a scale from "0" to "3" was determined by the most common rating in all four planes.

## Results

The analysis showed that in the study group during hospitalization, 11 patients (20.75%) presented ARs during the rehabilitation process, and 42 patients (79.25%) did not present them. All patients with AR received an ARRS score of "1", indicating a "mild" upper limb response [12]. **Table 3** shows the positions in which ARs were observed in patients.

The next stage of the statistical analysis examined whether patients who developed ARs differed significantly from patients without ARs in terms of neurological symptoms assessed on the first day of physiotherapeutic evaluation. Statistical analysis showed no significant differences in the SSS in muscle strength and muscle tone in the upper and lower limbs. The relationship between the ability to independently change the position within the bed on the first day of physiotherapeutic assessment and the occurrence of ARs during the hospital rehabilitation process was tested.

No statistically significant differences were observed between the occurrence of ARs and the ability to change position to the less affected side ( $p=0.19$ ). Patients presenting ARs on the first day of physiotherapeutic evaluation were shown to be significantly less capable to change the position to the affected side than patients without ARs: 33.3% vs 3.3%,  $p=0.03$ . The inability to change the position to the affected side provides prognostic information. The results were as follows: sensitivity=0.33; specificity=0.97; positive predictive value=0.75.

Significant differences were found between patients with and without ARs when comparing the ability to change to a long sitting position, examined in patients on the first day of physiotherapeutic assessment. Among patients who did not have ARs, 90% of these individuals were able to perform the task, and among patients with ARs, it was 55.6%,  $p=0.03$ . Furthermore, to test whether the inability to change to the long sitting position provides information to predict the occurrence of ARs during hospitalization in the acute phase of stroke, sensitivity, specificity, and positive predictive value for this variable were calculated. The results were as follows: sensitivity= 0.44; specificity=0.9; positive predictive value=0.52.

**Table 3.** Number of patients with ARs observed during achieving patients' highest active position possible

Assessed position changing	Number of patients with ARs
Provocation of ARs in supine	1
Rotation from supine to the more affected side	4
Transition from lying sideways to sitting with legs hanging down	0
Standing up from a sitting position	3
One leg standing	3

## Discussion

The available research on ARs indicates the multifactorial nature of the causes of this phenomenon. In this study, additional attention was paid to the occurrence of muscle strength and tension disorders during patients' neurological assessment for psychotherapy purposes. According to the existing evidence, these are neurological deficits that have been proven to be associated with the occurrence of ARs. Deficits in muscle strength and tone were found in both patients with and without ARs. No significant differences were found between the groups for these parameters, contradicting the conclusions of other authors' work [13-15].

In the present study, by comparing patients with and without ARs, there was a significant difference between the occurrence of ARs in the rehabilitation process and the ability to change positions from a supine position to lying on the affected side and from supine to sitting for a long time. The ability to change positions was observed on the first day of physiotherapeutic evaluation. These results provide information that the observation of the ability to change position may be a symptom with predictive significance for the occurrence of ARs of the upper limb. Finding early predictors and validating them in a larger sample size would enable clinicians to define therapeutic goals for early rehabilitation more accurately [13].

To date, one tool for clinical measurement of ARs has been developed, and it only allows assessment of this phenomenon in the upper limb. In addition, this tool is based on assessing the patient while standing up from a sitting position. This makes it difficult to use in the acute phase of stroke due to the occurring contraindications to verticalization during this rehabilitation period and with the inability to perform this activity more often than in later phases. The ARRS scale does not take into account the patient's functional status, which is particularly important in the context of the occurrence of ARs in situations that require the patient to exert intense effort. Therefore, it may be

inadequate for patients with high functional capabilities and impossible to use for patients with low capabilities. This hypothesis corresponds with the results of this study. Only 3 out of 11 patients with ARs were seen in a standing position. In 5 patients, ARs could not be assessed using the ARRS scale due to insufficient level of functioning, while 3 patients presented only a higher position. This paper proposes an adaptation of the ARRS scale, enabling its implementation in hospital treatment settings, where high positions are often impossible to achieve. It consisted of assessing the patient according to the criteria proposed by its authors not only when getting up from a sitting position, but during the most difficult and possible change of position to a higher one. This is in line with the suggestion of the authors of the scale that it should also be tested during other types of activities [12]. To date, a limitation of studies on the occurrence of ARs in other positions is the inability to reliably compare results between patients in whom ARs were observed during other activities. However, this allows the scale to be applied to a larger group of stroke patients and does not limit the possibility of assessment to those tested at a high level of functioning.

Despite the existence of the ARRS, only a few studies employ it [16, 17]. The methods most commonly used to evaluate ARs are: surface electromyography, goniometry, and dynamometry. Testing with these methods is usually done in stable positions, which does not take into account the functional nature of this phenomenon [1, 18]. The variety of measurement tools used makes it impossible to effectively compare research results and engage in a scientific discussion about ARs. Examination with expensive tools is often not possible in clinical practice, and the relationship between objective tool testing and the ARRS scale is not known. Most of the assessment methods used do not take into account the patient's activity level and the impact of ARs on functioning and are therefore barely useful in clinical practice.

In the present study, upper limb AR was observed in 20.75% of patients enrolled in the study. This is a lower incidence than previously reported in the literature, but it should be emphasized that it is usually determined in the chronic phase after stroke, where compensatory mechanisms can be expected to be more common than in the acute phase [19, 20]. Obtaining a score of "1" on the ARRS scale by all subjects may indicate a comparable intensity of this phenomenon in different patients in the acute phase of stroke and variation in the intensity of ARs in later stages of rehabilitation.

Testing the ability to independently change positions on the first day of physiotherapeutic care was aimed at a preliminary assessment of the trunk muscles' strength and functional status. Their paresis is considered the main functional cause of the occurrence of ARs. Due to contraindications to verticalization in some patients, the study of position changes was limited to those performed within the hospital bed. In the case of impaired verbal-logical contact and the patient's inability to understand the command, the change of position was evaluated as impossible to test.

Articles on ARs are mainly published in rehabilitation journals [13, 18, 21]. Cooperation between a physician and a physiotherapist as part of an

interdisciplinary team requires a neurologist to be able to recognize symptoms that limit the patient's functioning. ARs are a frequent target of therapies aimed at improving upper limb function after stroke [4]. Knowledge of this phenomenon among specialists in various medical professions is important for a comprehensive assessment of the patient's health and functioning and has implications for further rehabilitation planning.

## Conclusions

Assessment of the patient's ability to independently change positions on the first day of physiotherapy may provide information that can help predict the occurrence of upper limb ARs in the further rehabilitation process. There is a need to adapt the ARRS for use in the acute phase of stroke by validating it on groups of patients with different functional capabilities and creating ARs assessment scale for lower limbs. It is necessary to promote knowledge about ARs after a stroke among neurologists and neurosurgeons.

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