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Polish Helicopter Emergency Medical Service (HEMS) Response to Stroke: A Five-Year Retrospective Study

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Background: A stroke is a serious life-threatening emergency that requires immediate intervention in an appropriate therapeutic center. The aim of this study was to analyze the time of medical procedures at the scene and changes in the state of stroke patients during transport by HEMS in Poland. The presented research is the first nationwide study covering such a large group of stroke patients, for whom aerial support was used in the therapeutic process.

Material/Methods: A retrospective cross-sectional study of 48553 missions performed by Polish Medical Air Rescue (PMAR) during the 5-year study period resulted in 3906 stroke patients who, after medical rescue operations by HEMS crew, were transported by helicopters to hospitals.

Results: Helicopters in 3475 (88.97%) cases were utilized as a support for Ground Emergency Medical Service (GEMS). The maximum duration of HEMS operation from activation to patient transfer to the hospital did not exceed 108 min and the median was 60 min. Over 87% of patients with HEMS reported stroke symptoms and arrived at the medical center with the possibility of implementing thrombolytic therapy. The factor that affected the deterioration of patients' condition was the drawing out of the extent of time spent by the crew at the scene.

Conclusions: The use of HEMS in Poland in the case of patients with stroke symptoms ensures fast and professional assistance at the site of the medical emergency as well as safe transport to specialized centers, shortening the time of proper treatment implementation.

MeSH Keywords: **Air Ambulances • Emergency Medical Services • Stroke • Thrombolytic Therapy**

Abbreviations: **CV** – coefficient of variation; **GEMS** – Ground Emergency Medical Service; **GCS** – Glasgow Coma Scale; **HEMS** – Helicopter Emergency Medical Service; **IQR** – interquartile range; **NACA** – National Advisory Committee for Aeronautics; **RTS** – Revised Trauma Score; **PMAR** – Polish Medical Air Rescue

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Background

According to data from the World Health Organization, strokes are the second leading cause of death worldwide after heart disease, and account for over 6.2 million deaths annually. In Europe, the number of deaths caused by strokes is estimated at over 1.1 million annually [1,2].

Additionally, in Poland, the number of stroke patients is estimated at an average of 60 000 to 90 000 cases per year. Despite the similar incidence of stroke in other European countries, the mortality and disability rates due to stroke in Poland are among the highest in Europe [2–4].

The priority in the treatment of acute stroke is the maximum reduction of time from the onset of symptoms to the implementation of diagnosis and proper treatment. The best therapeutic effects are obtained in patients with stroke in whom thrombolytic treatment was implemented up to 4.5 hours from the onset of symptoms or up to 6 hours in the case of patients qualified for thrombectomy [5–7].

In order to reduce the time to treat patients with stroke, it is important to use emergency medical units, in which helicopter emergency medical services (HEMS) occupy the key place next to ground-based emergency medical teams [8]. The modern method of providing rescue procedures to stroke patients in urbanized areas is mobile stroke units [9].

HEMS crews in Poland are stationed in 21 year-round operated bases and 1 seasonal base. The crew includes a pilot, a doctor, and a rescue paramedic or nurse. The decision to expedite a ground-based or air medical rescue team is made by the medical dispatcher based on intelligence collected. Readiness for take-off for HEMS crews depends on the distance to the location of the emergency and takes 3 minutes in a radius of up to 60 kilometers, 6 minutes (radius between 60 and 130 kilometers), or 15 minutes (radius over 130 kilometers) from the moment the notification is accepted by an emergency responder. The HEMS team is available to support GEMS or as the first-contact team in the event of an emergency taking place in a hard-to-reach area or in the absence of an available ambulance [10,11]. The literature emphasizes the key role and importance of HEMS and the numerous benefits of its utilization, especially in the cases of patients with severe injuries, burns, or poisoning. The most frequently mentioned benefits of using HEMS include: shortening the time of emergency services reaching the scene of the incident, professional support of GEMS, and safe transportation to specialist centers that allow reducing the time needed for proper treatment implementation [12–18].

The aim of this study was to analyze the time of procedures at the scene and changes in the state of stroke patients during transport to the hospital by HEMS.

Material and Methods

Study design

The research was carried out using a cross-section retrospective analysis of 48 553 missions performed by the crews of HEMS Polish Medical Air Rescue during a 5-year period (01/01/2012 to 31/12/2016). The criterion of inclusion in the study group was the diagnosis of I 63 (cerebral infarction) and I 64 (stroke, not defined as hemorrhagic or infarct) according to the international classification of diseases and health problems ICD 10, and the correct level of glycemia. The exclusion criteria were cases of inter-hospital transport, missions during which victims were not taken on-board helicopters, and cases in which significant gaps in data were found that prevented a reliable statistical analysis. The 3906 HEMS missions that met the inclusion criteria were further examined.

Data collection

Data were collected from all 22 bases throughout the country, and the use of collected information was advised by the director of the PMAR. The analysis of the aviation data and medical documentation of patients in whom the HEMS crews identified symptoms of stroke after prior assessment of glycemia. The following data were collected for each rescue analyzed: time from dispatch to arrival, time of proceedings at the site of the incident, time of transport, distance to place of occurrence and transport, National Advisory Committee for Aeronautics (NACA) score, on-the-spot Revised Trauma Score (RTS) and Glasgow Coma Scale (GCS) scores and on transfer to the target medical center as well as symptoms incurred by the patients and the medical emergency procedures undertaken. The list of stroke units was obtained from the Ministry of Health.

The Polish healthcare system lacks a unified, national database for stroke patients. For this reason, it was impossible to obtain complete information on the fate of patients (implementation of thrombolytic therapy, neurological status at discharge from the hospital). The analysis has been narrowed down to the stage of assistance by HEMS teams and covers the time from helicopter activation to handing the patient over to hospital crews. There was no thrombolytic therapy given during HEMS missions. We do not have information about the time of the onset of symptoms and the delay in the disposition of air support at the level of patients and medical dispatchers.

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Statistical analysis

The data were collected on the basis of aviation documents and medical documentation of the Polish Medical Air Rescue and collected in the Microsoft Excel database of the MS Office 2016 for Windows 7 package. The obtained results were subjected to statistical analysis using STATISTICA version 13.3 (TIBCO Software, Inc.). Descriptive statistics were used to describe variables. For metric variables (continuous variables: age, time of HEMS arrival, time of dealing with the patient, transport time to the hospital, distance to the scene of the incident, distance to target hospital, GCS, RTS, and NACA scores), the following measures were determined: central tendency (mean, median), dispersion (standard deviation, quartile range, coefficient of variation), and location (minimum and maximum). However, for non-metric variables (qualitative variables: sex, symptoms of stroke, the performance of endotracheal intubation), the structure measure (frequency) was determined [19].

The impact of transport on the change in GCS and RTS parameters was estimated using the dependent *t* test for paired samples. The magnitude of the effect of the observed difference determined by Cohen's coefficient d. The following criteria were assumed to assess the measured effect size: very strong ≥0.80, strong 0.50–0.79, average 0.49–0.20, and poor <0.2 [20]. Conversely, the impact of transport on the change of the above parameters with the participation of additional factors, such as sex and age of the patient, the time spent on the scene, and the distance of transport to the target hospital, was determined based on the results of multivariate analysis of variance (MANOVA) [21]. The magnitude of the effect of the observed difference was determined by means of eta-squared (η^2). The following criteria were assumed to assess the measured effect size: 0.001 to 0.003: no effect, 0.004 to 0.04: small effect; 0.05 to 0.10 intermediate effect, 0.11 and higher: strong effect [20].

A multiple linear regression method was used to assess the influence of selected factors on the time of the on-the-scene proceedings. From the analyzed independent variables, the following parameters were evaluated: GCS, RTS, and NACA scores necessitated HEMS intubation performed, Ground Emergency Medical Service presence before HEMS arrival. The ordinary least squares (OLS) method was used to fit empirical data to the regression equation. The multicollinearity test was used to assess the degree of the predictor's correlation. Residual analysis was performed by assessing compliance with the normal distribution (Jarque-Bera test) and homoscedasticity (White test). A simple regression was applied, in which all predictors were introduced to the model at the same time. Standardized β regression coefficients were determined in order to estimate the strength of an individual predictors' effects on the dependent variable. The percentage of the explained variance of the dependent variable by the regression model was estimated by calculating the coefficient of determination (adjusted R-squared) [20].

For all analyses, the verification of the null hypothesis was carried out with an *a priori* stipulated statistical significance level of 0.05.

Results

In the analyzed period, the crew of the Helicopter Emergency Medical Service of the Polish Medical Air Rescue provided assistance and transported 3994 patients with a diagnosed stroke. After rejecting cases according to the exclusion criteria, 3906 patients with symptoms of stroke were analyzed. The ages of patients varied from 11 to 104 years, and the average age of patients was 72.75 (12.70) years. In the examined group of patients, there were 1968 (50.38%) women and 1938 (49.62%) men. Patients' condition after arrival at the scene was assessed using the GCS 11.96 (3.25), RTS 11.21 (1.25), and NACA 4.20 (0.57) scales. The most common symptoms among the examined patients with stroke were: paresis (in 3132 patients [80.18%]), anisocoria (in 219 patients [5.61%]), meningeal symptoms (in 130 patients [3.33%]), and convulsions (in 129 patients [3.30%]). HEMS crews were most often called on to help GEMS (3475 [88.97%]); intubations were performed in 215 (5.50%) cases, and the vast majority of patients were transported to hospitals equipped with a stroke care unit (Table 1).

The average time of arrival of HEMS crews at the scene of the incident was 23.19 (6.14) minutes, with an average distance to the site of 46.95 (16.96) kilometers. On the other hand, the average time spent helping the patient at the scene was 13.80 (6.66) minutes. The average transport time to the hospital was 25.61 (11.15) minutes, and the distance from the site to the target hospital was on average 45.15 (15.80) kilometers. The total mission time from the moment of HEMS activation to the transfer of the patient to the hospital did not exceed 108 minutes, and its average was 61.50 (12.97) minutes (Table 2).

An analysis of patient stability during transport was performed comparing the GCS and RTS scores upon arrival at the site with the values determined when the patient was transferred to the target medical center. Significant statistical changes were observed in the range of mean values for the GCS scores before and after transport (12.11±3.12 *vs.* 12.15±3.21, t=–2.459, P-value=0.014, d=–0.059). However, in the case of the RTS scores, no significant change was observed (11.28±1.16 *vs.* 11.26±1.29, t=1.553, P-value=0.121, d=0.037).

We also assessed which factors were correlated with changes in the patient's condition. MANOVA results suggest that the time

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Table 1. Characteristics of surveyed patients.

Age M (SD)	72.75	(12.70)
Sex (N, %)		
Female	1996	(50.38)
Male	1995	(49.62)
Anisocoria (N, %)		
No	3687	(94.39)
Yes	219	(5.61)
Meningeal signs (N, %)		
No	3776	(96.67)
Yes	130	(3.33)
Convulsions (N, %)		
No	3777	(96.70)
Yes	129	(3.30)
Paresis (N, %)		
No	774	(19.82)
Yes	3132	(80.18)
Intubation prior to HEMS (N, %)		
Yes	215	(5.50)
No	3691	(94.50)
Transport to Stroke Care Unit (N, %)		
Yes	3415	(87.43)
No	231	(5.91)
No data available	260	(6.66)
Assistance prior to HEMS (N, %)		
Yes	3475	(88.97)
No	431	(11.03)
GCS (M±SD)	11.96	(3.25)
RTS (M±SD)	11.21	(1.25)
NACA (M±SD)	4.20	(0.57)

Table 2. HEMS mission characteristics.

	M	SD	Me	IQR	Min	Max	CV [%]
Time to arrival at the scene*	23.19	6.14	23.00	7.00	6.00	58.00	26.46
Time at the scene*	13.80	6.66	12.00	6.00	1.00	58.00	48.29
Carrying time*	25.61	11.15	24.00	8.00	2.00	101.00	43.52
Total time*	61.50	12.97	60.00	17.00	7.00	108.00	21.09
Air travel distance**	46.95	16.96	46.60	21.90	3.30	144.40	36.13
Distance travelled to hospital**	45.15	15.80	44.20	20.00	2.80	134.70	34.99

M – mean, SD – standard deviation, Me – median, IQR – interquartile range, CV – coefficient of variation. * Time [minutes]; ** distance [kilometers].

spent at the scene has a significant impact on the GCS (Figure 1) and RTS (Figure 2) scores. It was observed that the change in the values of the 2 scores intensifies as the time spent at the scene increases, with this relation being more marked in the case of RTS (F=4.676, P-value=0.001, η^2=0.005) than GCS (F=2.618, P-value=0.033, η^2=0.003). Such variables as sex and age of the patient and the distance of transport to the target hospital did not have a significant impact on the patient's condition as measured by the change in the GCS and RTS parameters (data not shown).

The proposed multiple linear regression model was statistically significant (F=313.93 p=0.000, SEE=0.31) and well matched to the data, and the independent variables explained 30% of the variance of the dependent variable ($R2_{adjusted}$=0.30). All 5 analyzed factors were statistically significant predictors that had an impact on the time spent at the scene of the incident. The results of the regression analysis indicate that the higher the value on the GCS scale (β=–0.127, p=0.000) and RTS (β=–0.057, p=0.039) and when the Emergency Medical Service was present at the scene before the arrival of HEMS (β=–0.300; p=0.000), the shorter the procedure time at the scene of the incident. Conversely, higher NACA scores (β=0.065, p=0.000) and the need to perform intubation at the scene (β=0.330, p=0.000) were associated with longer times spent by HEMS crews at the scene of the incident (Table 3).

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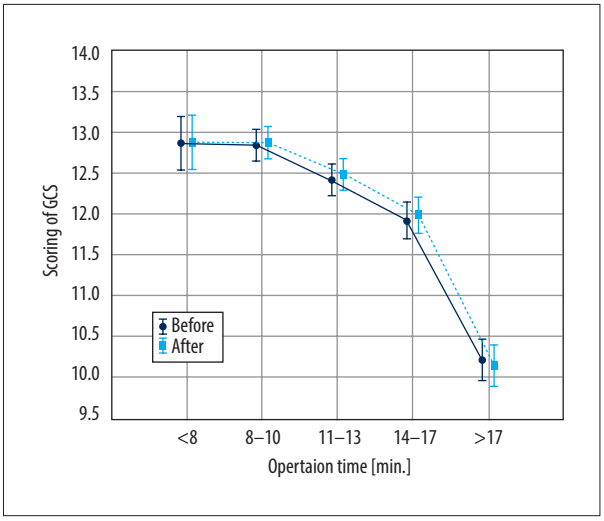

Figure 1. Trends in changes of value of the GCS scores before and after transport to the destination depending on the time spent by the response team at the scene of the incident.

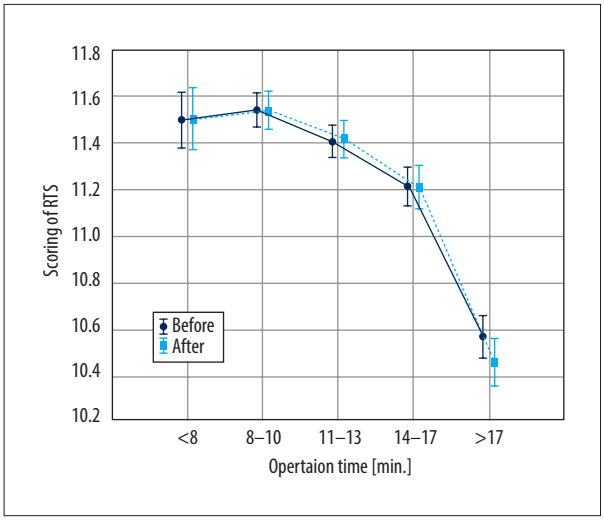

Figure 2. Trends in changes to value parameters of the RTS scores before and after the transport to the destination, depending on the time spent by the rescue team at the scene of the incident.

Table 3. Regression analysis for the variable procedural time at the scene of the incident.

Independent variable	b	β_{stand}	95% CI		*t*	*P*-value
			Low	High		
Intercept	23.618	–	–	–	17.344	0.000
GCS	–0.254	–0.127	–0.179	–0.074	–4.709	0.000
RTS	–0.299	–0.057	–0.112	–0.003	–2.068	0.039
NACA	0.748	0.065	0.037	0.094	4.537	0.000
Intubation by HEMS 0: no 1: yes	4.741	0.330	0.297	0.363	19.802	0.000
Presence of GEMS prior to HEMS 0: no 1: yes	–3.180	–0.300	–0.328	–0.273	–21.564	0.000

b – non-standardized regression coefficient; $\beta_{stand.}$ – standardized regression coefficient; 95% CI – 95% confidence interval for $\beta_{stand.}$; *t* – statistical value.

Discussion

Patients who are in a state of health crisis caused by internal factors (e.g., acute coronary syndrome or stroke) or external (e.g., trauma) require immediate pre-hospital care, implementation of an appropriate diagnostic and therapeutic process, and fast transport to the hospital provided by a competent and qualified medical team. An example of such a disease that poses a threat to human health and life is stroke [1,5–7,22–24]. Therefore, we analyzed the use of HEMS in patients with symptoms of stroke (predominantly disturbances of consciousness and paresis) in the Polish emergency medical system, with particular emphasis on the time of procedure at the scene (mean 13.80 minutes) and changes in the general condition of these patients during transport by HEMS to the hospital.

In studies on the use of HEMS in stroke patients, Funder et al. (2017) showed that the group they studied was dominated by men, and the median age was 69.8 (61.5–76.8) years [24]. Kesinger et al. (2015) found that the use of HEMS in patients with stroke symptoms was dominated by women, and the median age was 70 (59–82) years. Timler et al. (2015) also found that women dominated the use of HEMS in the therapeutic process of patients with stroke symptoms, and the average

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age of patients was 72 years [25,26]. The results of the present study showed that patients with suspected stroke were mainly women, and the average age was 72.75 years, which is in line with the results of Timler et al. (2015) [26]. Analysis our results also shows that paresis was the dominant symptom found in stroke patients transported by HEMS. Passler et al. (2016), in their studies on stroke symptoms in older adults with diabetes, showed that the most frequently reported symptom was a sudden loss of ability to understand and communicate with other people [27]. Hawkes et al. (2016) made an analysis of the perception of stroke symptoms and the use of emergency medical services in Buenos Aires, where they found that the main symptoms were motor symptoms (observed in 51% of patients) and speech disorders (present in 50% of patients) [28]. Multicenter observational studies on the use of emergency medical teams for patients with ischemic stroke in Korea were conducted by Park et al. (2016), who found that the dominant symptom in these patients was motor weakness, which occurred in 61.5% of patients [29]. In the present study, motor weakness (paresis) was found in 80.18% of patients.

Rapid patient transport, which requires special treatment and care in hospital conditions by ground-based as well as helicopter medical rescue teams, has been the subject of numerous studies [24–26,30–32]. Therefore, our next step in the present study was to assess the time spent at the scene of the incident by HEMS in the case of a patient with symptoms of stroke, and the factors affecting this. Olson and Rabinstein (2012), in their research on the benefits of using HEMS for stroke patients, showed that the time from dispatching the emergency medical team to delivering the patient to the hospital was significantly shorter in the case of transport by helicopter than by ground-based medical service crews (54 minutes *vs.* 69 minutes) [30]. Research by Timler et al. (2015) showed that the time spent by HEMS at the scene of the incident in stroke patients was on average 17.1 minutes, and the median duration of assistance was 14 minutes [26]. Østerås et al. (2017) carried out research on factors influencing the time spent at the scene in rural areas by the Norwegian HEMS. They found that most patients with cardiac arrest needed the most time at the scene of the incident (M=20 minutes), and cases of penetrating torso injuries needed the shortest time (M=5 min), while in the case of stroke patients, the median time spent at the scene was 8 minutes. The multivariate linear regression analysis conducted by them showed that important factors affecting the time of proceedings at the scene include age, NACA score, helicopter transport, intravenous analgesics, treatment before HEMS arrival, and intubation [24]. The present study showed that the average time spent by Polish HEMS at the scene of the incident for patients with symptoms of stroke in the 5-year analysis was 13.80 minutes, and the median time was 12 minutes. Further analysis showed that the factors significantly affecting the time spent at the scene were the results of the GCS, RTS, and NACA scores, implementation of intubation by HEMS, and assistance of ground-based medical rescue team prior to the arrival of HEMS.

In a large retrospective study, Hutton et al. (2015) assessed over 25 000 patients with suspected stroke, showing that the use of air support brings the greatest benefits when the symptoms of stroke are diagnosed up to 2.5 hours after their occurrence. In that study, 96% of patients transported by American HEMS reached target sites within 2 hours [31]. The results of the present study show that all patients from the studied population reached hospitals in less than 109 minutes from HEMS activation, which is in line with the results of Hutton et al. (2015) [31].

Reiner-Deitemyer et al. (2011) conducted a study involving a population of over 21 000 patients with ischemic stroke, of which 904 patients were transported to hospitals by the Austrian HEMS. They found that the median time of direct transport of patients from the scene of the incident to the target center using helicopters was comparable to the median time of ambulance transport with the doctor (90 minutes *vs.* 85 minutes), and patients attended to by HEMS crews were more likely to receive thrombolytic therapy than those transported by ground-based teams (24% *vs.* 18%) [32]. The present study found that the median time needed to reach the hospital from the moment of HEMS dispatch was 60 minutes.

The Pre-hospital Acute Neurological Treatment and Optimization of Medical Care in Stroke (PHANTOM-S) study showed that a relatively new conception of pre-hospital thrombolysis may increase the percentage of patients receiving proper treatment within the first hour of stroke onset [9,33]. Studies in Germany and Norway showed that the efficacy and cost-effectiveness of this innovative method is limited to a specific group of patients; its utilization requires large ground ambulances but can significantly reduce the time to exact diagnosis and definitive treatment. [34,35].

Further research on the utilization of HEMS for suspected stroke patients, especially in rural and hard-to-reach areas, should be conducted.

Conclusions

HEMS air transport is a fast and safe form of transport for patients with symptoms of stroke. The main factor affecting the deterioration of the patient's condition is the extension of the time spent providing emergency medical treatment at the scene of the incident. Support from GEMS significantly shortens HEMS operation time at the scene. Patients with stroke symptoms in Poland are transported by HEMS crews to centers with appropriate diagnostic and therapeutic procedures.

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Conflict of interests

None.

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