

Cognitive impairment after sudden cardiac arrest

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Abstract

Aim: To evaluate the incidence and severity of the impairment of selected cognitive functions in patients after sudden cardiac arrest (SCA) in comparison to patients after myocardial infarction without SCA and healthy subjects and to analyze the influence of sociodemographic and clinical parameters and the duration of cardiac arrest on the presence and severity of the described disorders.

Material and methods: The study group comprised 30 cardiac arrest survivors, the reference group comprised 31 survivors of myocardial infarction without cardiac arrest, and the control group comprised 30 healthy subjects. The Mini-Mental State Examination (MMSE), the Digit Span test from the Wechsler Adult Intelligence Scale, Lauretta Bender's Visual-Motor Gestalt Test, and the Benton Visual Retention Test (BVRT) were used to assess the presence of cognitive impairment. An original questionnaire developed by the author was used for overall mental state assessment.

Results: The Bender test demonstrated a significant difference in the presence and severity of visual-motor skills between the study group and the control group, while BVRT and MMSE revealed increased incidence of cognitive impairment in the study group. The Bender and BVRT (D/D)/SS (version D, method D, scaled score) scales indicated cognitive impairment in 53.3% of these patients, while the BVRT (C/A)/SS test indicated cognitive impairment in 40%. For the reference group, the values were 32.3% and 12.9%, respectively. No correlation was found between the severity of cognitive impairment and the duration of cardiac arrest.

Conclusions: Impairment of visual-motor skills, short-term visual memory, concentration, and visual-motor coordination occurs much more frequently and is more severe in individuals after SCA than in healthy individuals. Impairment of memory trace storage and recall after delay occurs more frequently in patients after SCA than in patients after myocardial infarction without cardiac arrest and in healthy individuals. SCA duration did not have any influence on the severity of the described disorders.

Key words: cognitive function, cardiac arrest, coronary heart disease.

Streszczenie

Cel: Ocena częstości występowania i nasilenia zaburzeń wybranych funkcji poznawczych u pacjentów po nagłym zatrzymaniu krążenia (NZK) w odniesieniu do osób po przebyłym zawale mięśnia sercowego bez NZK i osób zdrowych oraz analiza wpływu niektórych parametrów socjodemograficznych i klinicznych oraz czasu trwania NZK na obecność i nasilenie opisywanych zaburzeń poznawczych.

Materiał i metody: Grupę badaną utworzyło 30 osób po NZK, grupę odniesienia – 31 osób po zawale serca bez NZK, a grupę kontrolną – 30 osób zdrowych. Do oceny obecności zaburzeń wybranych funkcji poznawczych użyto Krótkiej skali oceny stanu psychicznego (MMSE), Testu powtarzania cyfr ze Skali inteligencji Wechslera dla dorosłych, Testu zdolności wzrokowo-motorycznych Lauretty Bender oraz Testu pamięci wzrokowej Bentona (BVRT). Oryginalnie opracowany kwestionariusz posłużył do ogólnej oceny stanu psychicznego.

Wyniki: W teście Lauretty Bender stwierdzono istotną różnicę w występowaniu i nasileniu zaburzeń zdolności wzrokowo-motorycznych w grupie badanej w stosunku do grupy kontrolnej, a w teście BVRT i MMSE – częstsze występowanie zaburzeń poznawczych w grupie badanej. U tych osób zaburzenia poznawcze mierzone skalami Bender i BVRT (D/D)/WP występowały u 53,3% badanych, a testem BVRT (C/A)/WP – u 40% osób. Dla grupy odniesienia wartości te wynosiły odpowiednio 32,3% i 12,9%. Nie wykazano zależności nasilenia zaburzeń poznawczych od czasu trwania NZK.

Wnioski: Zaburzenia zdolności wzrokowo-motorycznych, krótkotrwałej pamięci wzrokowej, koncentracji oraz koordynacji wzrokowo-ruchowej u osób po przebyłym NZK występują znacznie częściej i są bardziej nasilone niż u osób zdrowych. Zaburzenia zdolności przechowywania śladu pamięciowego i odtwarzania go po odroczeniu występują u chorych po przebyłym NZK częściej niż u pacjentów po przebyłym zawale mięśnia sercowego bez NZK i u osób zdrowych. Czas trwania NZK nie miał wpływu na nasilenie opisywanych zaburzeń.

Słowa kluczowe: funkcje poznawcze, zatrzymanie krążenia, choroba wieńcowa.

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Introduction

Brain tissue ischemia and hypoxia associated with sudden cardiac arrest (SCA) trigger a series of detrimental biomechanical mechanisms [1, 2]. The interruption of blood supply to the brain that occurs during SCA may result in cognitive deterioration. According to the literature, the longer the SCA episode, the higher the risk of cognitive impairment, especially of short-term memory as well as immediate and delayed recall [3–5]. Attention deficits and executive function disorders are second in terms of frequency [6].

When searching for factors affecting the occurrence of these disorders, Sauve *et al.* discovered that the duration of coma after resuscitation (time-to-awakening) positively correlates with the presence of cognitive deficits [6, 7]. Another study showed that cardiopulmonary resuscitation (CPR) has a positive influence on cognitive function regardless of its initiation time, which was explained by the patient-specific sensitivity of nerve tissue to hypoxia and different CPR quality [6]. The available methods of preventing ischemic brain tissue damage provide some hope for improving the functioning of patients [8, 9], but the effectiveness of such methods varies [8, 10]. The etiological factors of cognitive deterioration mainly include hypertension, atherosclerosis, peripheral artery diseases, myocardial infarction, and cardiac arrest. In the course of ischemic heart disease, cognitive impairment mainly involves the deterioration of attentional selectivity, visual memory, understanding by analogy, and psychomotor speed [11].

Aim

The aim of the study was to assess the incidence of the impairment of certain cognitive functions in patients after SCA in relation to individuals who experienced myocardial infarction without SCA and healthy individuals as well as to analyze the influence of certain sociodemographic and clinical factors and SCA duration on the occurrence and severity of the described cognitive disorders.

Material and methods

Patients after SCA which occurred at least 1 month and less than 6 months before the study were examined at the “Repty” Upper Silesian Rehabilitation Center, an independent public health care institution. The reference group was composed of individuals after myocardial infarction without cardiac arrest with the same time criteria. The control group included healthy individuals appropriately selected with respect to sex and age, without any significant mental or somatic disorders. Individuals with mild hypertension without organ lesions as well as individuals with stable coronary artery disease with no previous myocardial infarction were also allocated to the control group. The influence of the following factors on the risk of cognitive impairment was analyzed: sex, age, marital status, education, treatment with medications potentially affecting mental state, duration of SCA (due to the difficulties in establishing the precise

duration of SCA episodes, the patients were divided into two general categories: patients in whom the SCA episode was shorter than 3 min and patients in whom the SCA was longer than 3 min), invasive cardiac treatment, presence of ischemic heart disease, hypertension, and other diseases. The exclusion criteria were the following: withdrawal of consent for participation in the study, mental disorders diagnosed before the SCA episode, currently present stressors of high intensity in the patients’ subjective assessment, addiction to drugs and/or alcohol, moderate or severe dementia, and age over 65 years. The following standardized clinical research tools were used for assessing cognitive function: the Mini-Mental State Examination (MMSE), a subscale of Wechsler Adult Intelligence Scale – the Digit Span test, Lauretta Bender’s Visual-Motor Gestalt Test, and the Benton Visual Retention Test (BVRT). An original questionnaire developed by the author was used for overall mental state assessment. When analyzing the parameters for BVRT, two versions of the scale were used – C and D. In version C the most common method was applied – method A (C/A), which consists in immediately reproducing a pattern that was previously displayed for 10 s. In version D method D was employed (D/D), which includes a time delay between the process of viewing and reproducing the pattern [12]. The Digit Span test measures memory and resistance to distractors interfering with the concentration of awareness. It is one of the subtests of the Wechsler Intelligence Scale WAIS-R(PI) and can be used independently due to its standardization. The Bender test measures a series of functions depending on the efficient operation of different areas of the brain: the ability to see and recognize patterns, to understand relations between elements of the patterns and to recall them, graphomotor skills, and the integration of those abilities. The MMSE scale was used as a screening tool to detect dementia syndromes. The Bioethical Committee of the Medical University of Silesia in Katowice granted its approval to conduct the study (NN-013-216/03).

Statistical analysis

The study employed the following statistical tests: the Shapiro-Wilk test, Kruskal-Wallis test, Mann-Whitney *U* test, χ^2 test with Yates’ correction, Fisher’s exact test, and Spearman’s rank correlation coefficient. The level of $p \leq 0.05$ was considered statistically significant.

Results

Characteristics of the study group

The SCA group was composed of 30 patients; their demographic characteristics are presented in Table I. Five (16.67%) patients were taking medications that affect the mental state (in the majority of cases, these were β -adrenolytics and calcium channel antagonists) and a few individuals were taking antihistamine medications and corticosteroids. There were 10 (33.33%) individuals who underwent percutaneous transluminal coronary angioplasty (PTCA), in most cases accompanied by stent implantation;

Tab. I. Patient group characteristics

Group	N	Women	Men	Age x ± SD	Education		
					Primary/vocational	Secondary	Higher
Study group	30	8 (26.7%)	22 (73.3%)	52.9 ±8.8	12 (40.0%)	13 (43.3%)	5 (16.7%)
Controls	30	8 (26.7%)	22 (73.3%)	52.4 ±6.5	11 (36.7%)	13 (43.3%)	6 (20.0%)
Reference group	31	11 (35.5%)	20 (64.5%)	55.3 ±7.0	13 (41.9%)	13 (41.9%)	5 (16.1%)
Group comparison		χ^2 test: NS ($p = 0.68$)		Kruskal-Wallis test NS ($p = 0.33$)	χ^2 test: NS ($p = 0.88$)		

26 (86.67%) patients suffered from coronary artery disease. The most common comorbidity in the group was hypertension, which was present in 15 (50%) patients. Other diseases (most frequently diabetes, COPD, allergies, and stomach ulcers) were found in 43.33% of patients. The causes of SCA in all the studied patients were cardiovascular. In most patients the cardiac arrest was accompanied by myocardial infarction; in three individuals it was associated with myocarditis, and in two it occurred as a result of atrioventricular conduction abnormalities. In three patients the SCA episodes took place during cardiac surgery.

Selected sociodemographic factors

No statistically significant differences were found between the groups with regard to age, sex, education, marital status, and treatment with medications that may influence mental state. No significant differences were revealed between the number of patients undergoing invasive treatment in the study group and the reference group. Hypertension was present significantly more frequently in the study group and the reference group than in the control group.

Cognitive functions

In order to simplify the analysis, only scaled scores (SS) of the BVRT and Digit Span test were studied. In the Bender test, a statistically significant difference was revealed in the incidence and severity of visual-motor impairment in the study group in comparison to the control group (Fig. 1), while the BVRT test (version C) demonstrated that cognitive impairment in the study group occurred significantly

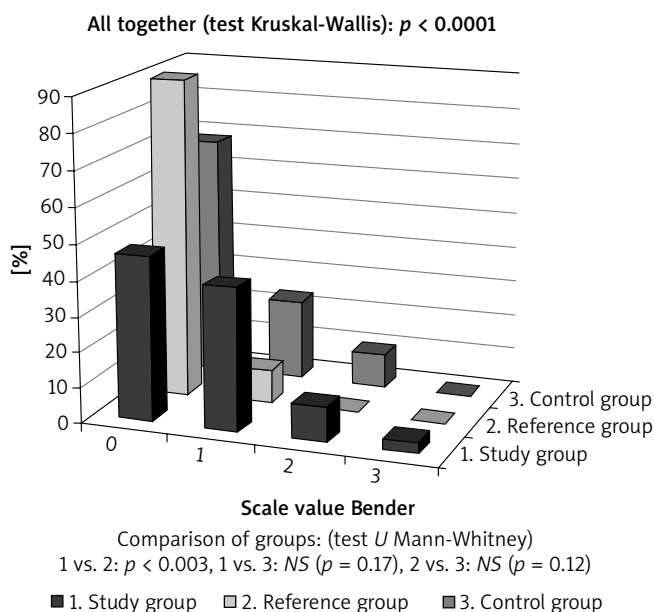


Fig. 1. Bender test scores in each group (0 – no disorder, 1 – low severity, 2 – moderate severity, 3 – significant severity)

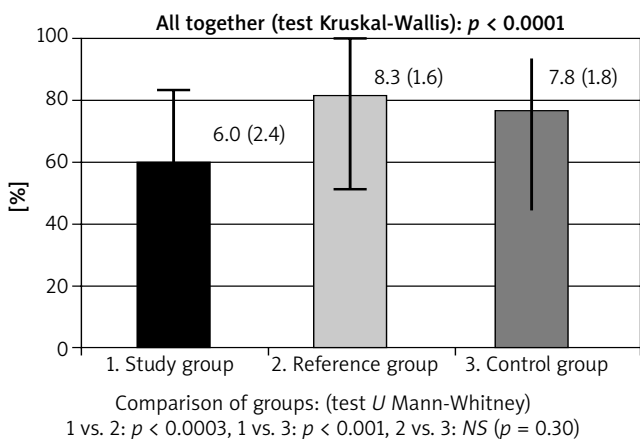


Fig. 2. Mean values and standard deviations on the BVRT (C/A)/NCR (number of correct reproductions) scale in each group

more frequently in comparison to the remaining groups. For version D, disorders were found more frequently in the study group and the reference group in comparison to the control group (Figs. 2–7). No statistically significant differences were found between the groups in terms of the Digit Span test results, while cognitive impairment on the MMSE scale was significantly more frequent in the study group as compared to the control group (Fig. 8). No statisti-

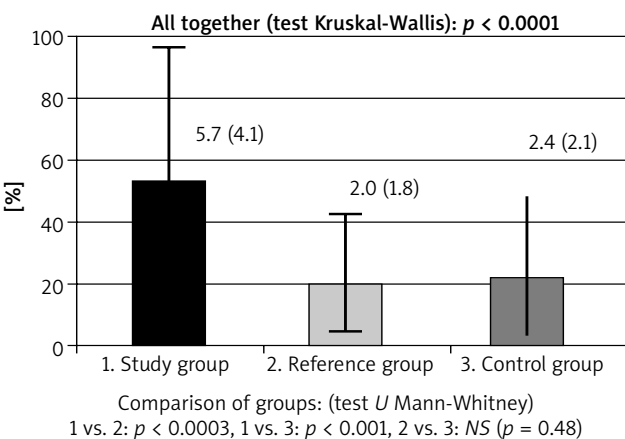


Fig. 3. Mean values and standard deviations on the BVRT (C/A)/NM (number of mistakes) scale in each group

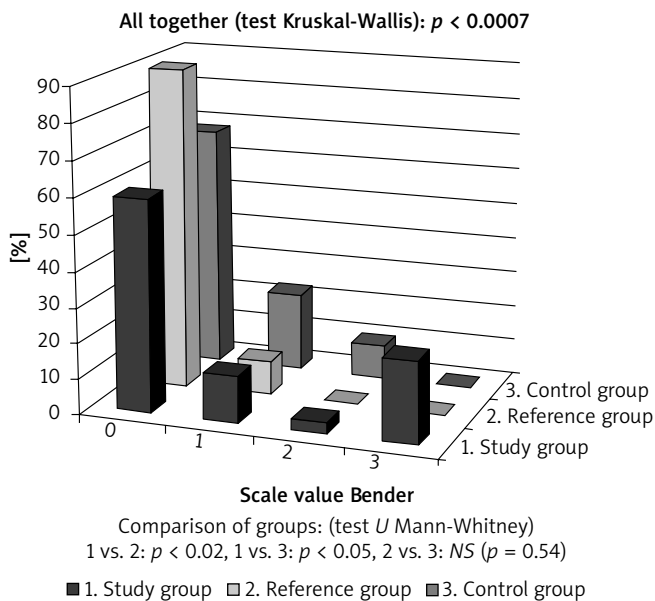


Fig. 4. Values on the BVRT (C/A)/SS scale in each group (0 – no disorder, 1 – low severity, 2 – moderate severity, 3 – significant severity)

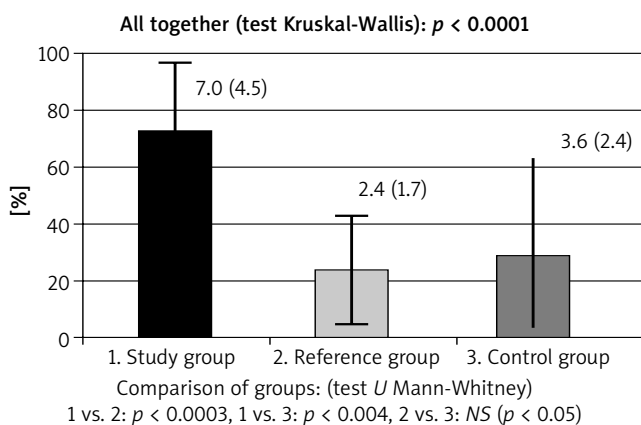


Fig. 6. Mean values and standard deviations on the BVRT (D/D)/NM (number of mistakes) scale in each group

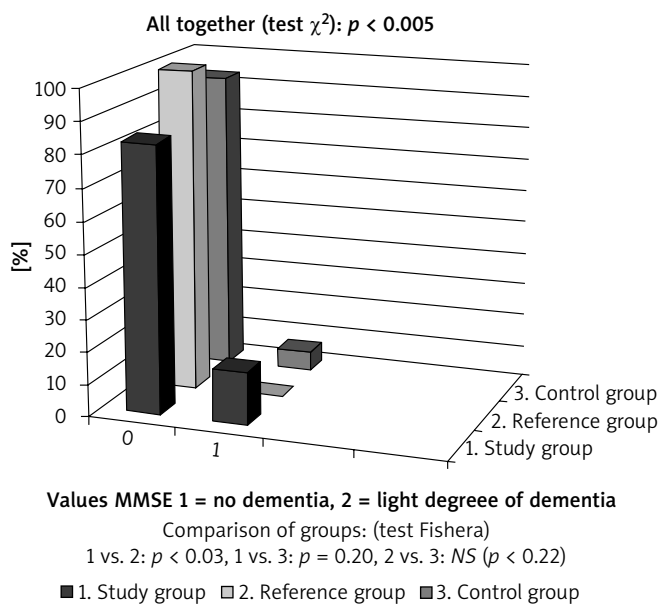


Fig. 8. Incidence of dementia in each group according to the MMSE

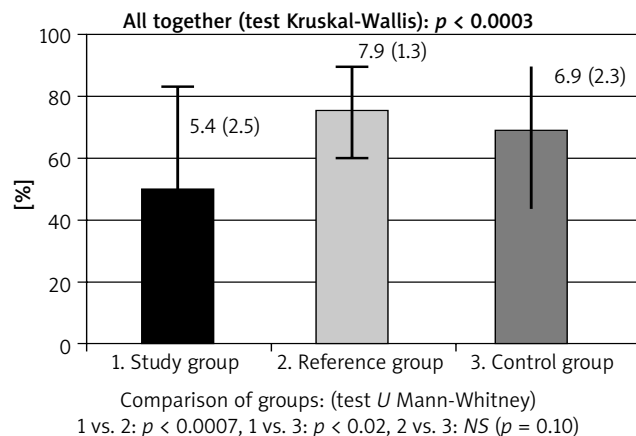


Fig. 5. Mean values and standard deviations on the BVRT (D/D)/NCR (number of correct reproductions) scale in each group

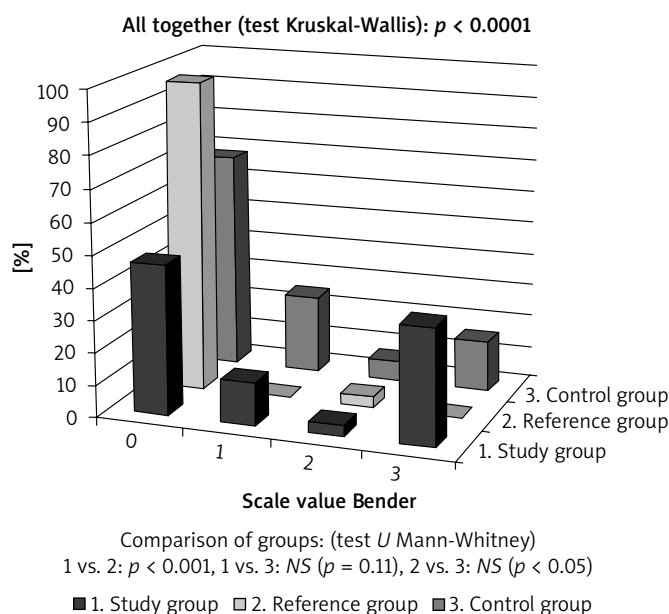


Fig. 7. Values on the BVRT (D/D)/SS scale in each group (0 – no disorder, 1 – low severity, 2 – moderate severity, 3 – significant severity)

ally significant differences were found between the study group and the reference group with regard to the Bender test, MMSE, and version C of the BVRT test. The percentage of patients with cognitive impairment from each group according to individual scales is presented in Table II.

It was discovered that the values on the Bender scale were higher in older individuals, and the tendency for lower values in the Digit Span test increased together with higher levels of education (Tab. III). No correlation was found between the scale scores and marital status, taking medications, invasive treatment, presence of ischemic heart disease, hypertension, or other diseases.

There was a visible, but statistically insignificant dependence of the Bender test results on SCA duration.

Discussion

Standardized methods of neuropsychological diagnostics were used to evaluate the severity and incidence of

Tab. II. Percentage of patients in each group with diagnosed function impairment according to the scales

Scale	Study group	Controls	Reference group
Bender	16 (53.3%)	3 (10.0%)	10 (32.3%)
BVRT (C/A)/SS	12 (40.0%)	1 (3.3%)	4 (12.9%)
BVRT (D/D)/SS	16 (53.3%)	1 (3.3%)	10 (32.3%)
Digit Span SS	9 (30.0%)	4 (13.3%)	6 (19.4%)
Cochran's Q test	$p < 0.05$	NS ($p = 0.36$)	$p < 0.005$

BVRT – Benton Visual Retention Test, C/A – version C, method A, D/D – version D, method D, SS – scaled score.

the specified cognitive disorders in the study, control, and reference groups and to assess the extent of cognitive impairment [13–15]. The following functions were studied: visual-motor skills, short-term visual memory, awareness concentration and visual-motor coordination, memory trace storage and recall after delay, as well as short-term auditory-categorical memory. Considering the known relationship between the duration of central nervous system hypoxia and the degree of brain tissue damage, the severity of organic cognitive impairment in patients after SCA should depend on the duration of the episode. This relationship was not confirmed; however, the higher incidence of cognitive impairment that we found in patients after SCA was in line with the results obtained by other centers. Roine diagnosed cognitive impairment in 60% of patients examined 3 months after the occurrence of SCA, while Sauve demonstrated the impairment of some cognitive functions in 29% of individuals 6 months after the cardiac arrest [7, 16, 17]. Due to methodological differences, comparative analysis is difficult [14]. Most authors focus on the assessment of memory disorders, even though the results of some studies suggest concomitant impairments of numerous cognitive functions caused by diffuse CNS damage after SCA [18]. According to Drysdale *et al.*, areas of weaker blood flow, such as the hippocampus, are especially susceptible to damage [19]. As a result, there is significant risk of memory impairment in SCA survivors. Drysdale points to the fact that memory impairment occurs in approximately 1/3 of patients examined approximately 8 months after SCA. Pusswald *et al.* describe chronic memory, orientation, and attention impairments in individuals after SCA [20]. In our study, patients after SCA exhibited reduced intellectual capacity, mild-to-moderate memory impairment, and amnesic syndromes. Lim *et al.* also emphasize the co-occurrence of visual-motor disorders with memory impairment. No isolated amnesia was observed among the patients studied by this team [18]. After studying a group of 68 patients 3 months after SCA, Roine found cognitive disorders in approximately 60%. At 12 months after the SCA episode, 48% of the 54 patients remaining alive still exhibited moderate-to-severe impairment of cognitive functions [16]. Sauve *et al.* also noted the occurrence of cognitive impairment in 29% of patients 6 months after SCA [7, 17]. Furthermore, Sunnerhagen *et al.* point to a reduction in cognitive function and activity in individuals studied approximately 25 months after an SCA episode

Tab. III. Results of Spearman's rank correlation coefficient only for those factors characterizing the study group for which statistical significance was achieved with the results on the scales

Factor	Bender scale	BVRT SS/CA scale	BVRT SS/DD scale	Digit Span test SS
Age	$R = 0.38$ $p < 0.04^a$	$R = -0.18$ NS ($p = 0.33$)	$R = -0.26$ NS ($p = 0.16$)	$R = 0.24$ NS ($p = 0.19$)
Education	$R = -0.19$ NS ($p = 0.30$)	$R = -0.13$ NS ($p = 0.49$)	$R = -0.09$ NS ($p = 0.65$)	$R = -0.49$ $p < 0.01^b$

R – correlation coefficient, p – statistical significance, ^ahigher scale values with age, ^blower scale values with higher levels of education, SS – scaled score.

[21]. Weigl *et al.* studied the presence of cognitive disorders in patients who experienced short-term SCA during cardiac procedures. Interestingly, they point out that even a short episode of brain hypoxia may lead to the occurrence of cognitive disorders [5]. Polanowska *et al.* revealed that from 100% (early after SCA) to 57% (12 months after SCA) of study participants exhibited cognitive impairment co-occurring mainly with neurological symptoms. Memory disorders proved to be the most common and significant problem. Executive, attention, language (mainly anomia), and visual-spatial deficits were less severe. Even though the disorders were characterized by a tendency to subside with time, more than 50% of patients continued to exhibit certain deficits and, in 30% of cases, significant disability 12 months after SCA. The results of examinations conducted in the third month after SCA showed that 76% of the patients who were able to cooperate required therapy – mainly neuropsychological rehabilitation [22]. In the present study, we observed a tendency for individuals with higher education levels to achieve lower values in the Digit Span test. This may be explained by the fact that longer periods of education translate into longer training of cognitive capacity involved in the process of learning, including the functions analyzed in this study. A higher number of years devoted to education may also directly point to the ambition of such individuals to expand their theoretical knowledge and practical skills even after completing formal education. As indicated by data obtained through imaging examinations, the brain structure continues to change even in individuals over 50 years of age, while the study of cognitive functions indicates that the brain maintains its ability to develop crystallized intelligence even at old age. In light of the results obtained by the authors, the level of involvement in intellectual activities, measured by years of education, can be considered a protective factor reducing the consequences of disruptions in brain activity.

We also used the described research material to assess the presence of symptoms of depression and anxiety or symptoms of post-traumatic stress disorder. The data obtained from this research served as a basis for other publications. It is, therefore, important to consider the possible influence of emotional disorders on the results of tests used to measure cognitive functions. In patients after SCA, the most commonly occurring disorder turned out to be

depression, which may distort the results of tests measuring cognitive functions.

Study limitations

No methodology is perfect; in certain thematic areas, methodological compromises may even be necessary for a study to be conducted. In the case of individuals after cardiac arrest, comparing them only to healthy individuals may be misleading as SCA mainly occurs in people with heart disorders, which are frequently associated with cognitive impairment. This is why a decision was made to create another group for comparison, which was referred to as the "reference group". It was, however, not possible to create a group of SCA patients composed only of individuals after myocardial infarction, so the results should be interpreted cautiously. The small size of the group and the relatively simple set of psychological instruments may also be considered limitations. Still, the results proved to be interesting and we decided to publish our work.

Practical aspects of the study

One of the practical aspects of this study is that it emphasizes the importance of constant training of cognitive function, especially in individuals after cardiovascular episodes. This patient group should be provided with qualified care and neuropsychological rehabilitation focused on the training of cognitive functions.

Conclusions

Impairment of visual-motor skills, short-term visual memory, concentration, and visual-motor coordination occurs much more frequently and is more severe in individuals after SCA than in healthy individuals. Impairment of memory trace storage and recall after delay occurs more frequently in patients after SCA than in patients after myocardial infarction without cardiac arrest and in healthy individuals. The SCA duration did not have any influence on the severity of the described disorders.

Disclosure

Authors report no conflict of interest.

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