

Received: 11.04.2023
Accepted: 28.08.2023

A – Study Design
B – Data Collection
C – Statistical Analysis
D – Data Interpretation
E – Manuscript Preparation
F – Literature Search
G – Funds Collection

QUALITY OF LIFE OF A PATIENT AFTER ENDARTERECTOMY OF THE INTERNAL CAROTID ARTERY (ICA) FOLLOWING AN ACUTE ISCHEMIC STROKE (AIS) DURING COVID-19

Ksenia Cielebąk¹[A-E,G] , Mikołaj Kobos²[A,C-F] ,
Jolanta Góral-Półrola³[A-D,G] 

¹ Chair of Neuropsychology and Neurorehabilitation, Andrzej Frycz-Modrzewski Kraków University, Kraków, Poland

² 2nd Department of Internal Medicine, The Joseph Dietl Specialist Hospital, Kraków, Poland

³ The Old Polish University, Kielce, Poland

Background:

Case study:

Conclusions:

SUMMARY

The aim of the study was to evaluate the quality of life of a patient after endarterectomy (CEA) of the Internal Carotid Artery (ICA) following an Acute ischemic stroke (AIS) during COVID-19.

A right-handed, 51-year-old patient, a visual artist, single, in good health and no chronic illnesses to date, became infected with SARS-CoV-2 and contracted COVID-19. The presence of SARS-CoV-2 virus was confirmed by a RT PCR antigen test. The patient was hospitalized, and required mechanical ventilation at an Intensive Care Unit (ICU) before an acute ischemic stroke (AIS) onset. Except for untreated hypertension, her medical history was unremarkable. Her blood pressure was 180/100 mm Hg; her pulse was 76 beats per minute and was regular. AIS from the left middle cerebral artery (MCA) has resulted primarily in damage to the left hemisphere, and secondary effects on the right side resulting in body weakness and mild anomic aphasia. Magnetic resonance imaging (MRI) confirmed stroke and detected brain tissue damaged by an AIS. It revealed hyperintense foci in the T2 and FLAIR sequences, 21 mm in size in the left hemisphere of the brain. In search of the cause of AIS, CT angiography was performed. It revealed a large (90%) ICA occlusion. The patient was admitted to the emergency room at the Vascular Surgery Clinic with an Endovascular Subunit. The revascularization procedure (CEA) was performed under general endotracheal anesthesia with the use of the protocol and techniques (elaborated at the Department of Vascular Surgery and Endovascular Procedures, The John Paul II Hospital in Krakow). The CEA procedure improved her general health: she regained the ability to name objects and her HRQoL also improved in her perception. The improvement achieved was statistically significant. She returned to painting and functions well in society.

The patient's perception of HRQoL measured by the SF-36 domains was better after the CEA: a significant improvement in self-reported overall health has occurred. The HRQoL outcome measures may be valuable in future clinical trials of comparing different methods of treatment offered after AIS.

Key words: Covid-19, NeuroCOVID-19, AIS, CEA, Anomia, HRQoL

INTRODUCTION

Coronavirus disease 2019 (COVID-19)¹, infectious respiratory disease caused by SARS-CoV-2 virus (Hui et al 2020), was first diagnosed and described in November 2019², in central China (Wuhan city, Hubei province). This disease during a series of cases initiating a pandemic of this disease, and has become a global pandemic, affecting millions of people. Globally, as of 2nd August 2023, there have been 768 983 095 confirmed cases of COVID-19, including 6 953 743 deaths, reported to WHO. As of 30 July 2023, a total of 13 492 099 754 vaccine doses have been administered³.

Since the beginning tens of thousands of scientific articles have been written providing insight into the multifaceted (multiple and complex) symptomatology across multiple body systems: including the respiratory, osteoarticular, circulatory and gastrointestinal systems in patients who have experienced COVID-19 (Huang et al 2020; Sadeghi et al 2020; Gorbalenya et al 2020; Fiani et al 2021; Taquet et al 2021), as well as the central nervous system, named NeuroCOVID-19 in the literature (Aknin et al 2021; MacQueen & MacQueen 2021; Pačhalska et al 2021).

Aknin et al (2021), based on an extensive review of the literature, divided the neurological symptoms and complications that occur following SARS-CoV-2 infection and COVID-19 survival into:

1. *mild*, which include loss of smell (anosmia), loss of taste (ageusia), latent blinking (heterophila), headache and dizziness, disorientation, among others;
2. *severe* which include cognitive impairment, seizures, delirium, psychosis and strokes.

Acute ischemic stroke (AIS), is a life-threatening recognized complication of coronavirus disease 2019 (COVID-19) infection. Clinical characteristics and outcomes of COVID-19 patients with a history of stroke in Wuhan, China were reported by Qin et al (2020). Also case series with stroke in patients with SARS-CoV-2 infection were described (Morassi et al 2020). One of the very first documented studies was also article about SARS-CoV-2 and stroke in a New York healthcare system (Yaghi et al 2020). Cerebral ischemic and hemorrhagic complications of coronavirus disease were also documented by Sweid et al (2020), and other authors (Tan et al. 2020; Hu et al 2023).

Increasing number of reports suggest association between inflammation, endothelial dysfunction, and coagulopathy might be the pathophysiologic mechanisms involved in the development of arterial thrombotic events. (Tan et al 2020; Mao et al 2020; Sashindranath & Nandurkar 2021; Sagrais et al 2021; Mbonde et

¹ Coronaviridae Study Group of the International Committee on Taxonomy of Viruses. The species *Severe acute respiratory syndrome-related coronavirus*: classifying 2019-nCoV and naming it SARS-CoV-2. *Nat Microbiol* **5**, 536–544 (2020). <https://doi.org/10.1038/s41564-020-0695-z>.

² The first COVID-19 case originated on November 17, according to Chinese officials searching for 'patient zero', [businessinsider.com](https://www.businessinsider.com/2020-03-21), 13 marca 2020 [dostęp 2020-03-21] (ang.).

³ WHO Coronavirus (COVID-19) Dashboard | WHO Coronavirus (COVID-19) Dashboard With Vaccination Data.

al 2022). It was found that severe course of the COVID-19 may increase the risk of AIS similar to the increased risk of 3.2-fold to 7.8-fold seen within the first 3 days after other respiratory tract infections (Merkler et al 2020; Warren-Gash et al 2018; Oxley et al 2020).

While we already know that AIS can occur as a result of COVID-19, but risk factors, in-hospital events, and outcomes are not well studied in large cohorts. Qureshi et al (2021) identified risk factors, comorbidities, and outcomes in patients with COVID-19 with or without acute ischemic stroke and compared with patients without COVID-19 and acute ischemic stroke. The authors analyzed the data from 54 health care facilities using the Cerner deidentified COVID-19 dataset. The dataset included patients with an emergency department or inpatient encounter with discharge diagnoses codes that could be associated to suspicion of or exposure to COVID-19 or confirmed COVID-19.

Tan et al (2020) performed a systematic review to characterize the clinical characteristics, neuroimaging findings, and outcomes of AIS in COVID-19 patients. A literature search was performed in PubMed and Embase using a suitable keyword search strategy from 1st December 2019 to 29th May 2020. All studies reporting AIS occurrence in COVID-19 patients were included. A total of 39 studies comprising 135 patients were studied. The pooled incidence of AIS in COVID-19 patients from observational studies was 1.2% (54/4466) with a mean age of 63.4 ± 13.1 years. It was found that AIS was infrequent in patients with COVID-19 and usually occurs in the presence of other cardiovascular risk factors such as hypertension, diabetes, hyperlipidemia, atrial fibrillation. The risk of discharge to destination other than home or death increased 2-fold with occurrence of acute ischemic stroke in patients with COVID-19.

Nannoni et al (2021) characterize the incidence, risk factors, clinical-radiological manifestations, and outcome of COVID-19-associated stroke. Three medical databases were systematically reviewed for published articles on acute cerebrovascular diseases in COVID-19 (December 2019-September 2020). The review protocol was previously registered (PROSPERO ID = CRD42020185476). Data were extracted from articles reporting ≥ 5 stroke cases in COVID-19. The data were complied with the PRISMA guidelines and used the Newcastle-Ottawa Scale to assess data quality. Data were pooled using a random-effect model. The authors found that of 2277 initially identified articles, 61 (2.7%) were entered in the meta-analysis. Out of 108,571 patients with COVID-19, acute CVD occurred in 1.4% (95%CI: 1.0-1.9). The most common manifestation was AIS (87.4%), and less common was intracerebral hemorrhage (11.6%). There were also other causes of AIS: one of them was critical stenosis of the internal carotid artery (ICA), a symptom that greatly increases the risk of recurrence of TIA or even full-blown stroke (Katzan et al. 2021; Qureshi et al (2021; Hydzik et al 2023). Treatment for patients with AIS is guided by the time from the onset of stroke, the severity of neurologic deficit, and findings on neuroimaging. The most important rule to treat AIS, is to restore blood flow to the brain **as soon as possible**. Type and description of treatment is presented in Table 1.

Table 1. Type and description of treatment

Type of the treatment	Description of the treatment	Results
Emergency intravenous (IV) medication	An IV injection of recombinant tissue plasminogen activator (TPA) — also called alteplase (Activase) or tenecteplase (TNKase) — the gold standard treatment for AIS. An injection of TPA is usually given through a vein in the arm within the first 3 hours up to 4.5 hours after stroke symptoms started. This drug restores blood flow by dissolving the blood clot causing the stroke. By quickly removing the cause of the stroke, it may help people recover more fully from a stroke. It is necessary to consider certain risks, such as potential bleeding in the brain, to determine whether TPA is appropriate for the patient.	Quick treatment with drugs that can break up a clot not only improves the chances of survival but also may reduce complications.
Emergency endovascular procedures - treating ischemic strokes directly inside the blocked blood vessel. Should be performed as soon as possible	Medications delivered directly to the brain. Doctors insert a long, thin tube (catheter) through an artery in the groin and thread it to the brain to deliver TPA directly where the stroke is happening. The time window for this treatment is somewhat longer than for injected TPA but is still limited.	Endovascular therapy has been shown to significantly improve outcomes and reduce long-term disability after ischemic stroke.
	Removing the clot with a stent retriever. It is possible to use a device attached to a catheter to directly remove the clot from the blocked blood vessel in the brain. This procedure is particularly beneficial for patients with large clots that can't be completely dissolved with TPA. This procedure is often performed in combination with injected TPA.	
The time window when these procedures can be considered has been expanding due to newer imaging technology. Perfusion imaging tests (done with CT or MRI) might help determine how likely it is that someone can benefit from endovascular therapy.		
Carotid endarterectomy (CEA)	Carotid arteries are the blood vessels that run along each side of the neck, supplying the brain (carotid arteries) with blood. This surgery removes the plaque blocking a carotid artery and may reduce the risk of ischemic stroke.	A carotid endarterectomy also involves risks, especially for people with heart disease or other medical conditions.
Angioplasty and stents (CAS)	In an angioplasty, a surgeon threads a catheter to the carotid arteries through an artery in the groin. A balloon is then inflated to expand the narrowed artery. Then a stent can be inserted to support the opened artery.	
To decrease the risk of having another stroke or transient ischemic attack, it is used a procedure to open up an artery that's narrowed by plaque. Options vary depending on the situation. Recent work in the field of vascular disease continues to debate on the safety and effectiveness of two methods of revascularization of critical stenosis of the internal carotid arteries: endarterectomy (CEA) and angioplasty with stent implantation (CAS) which might improved the HRQOL after stroke (Trystuła 2017; Kakkos et al 2017).		

Source: elaboration of Ksenia Cielebağ on the basis of van der Worp & van Gijn (2007). Musuka et al 2015; Trystuła 2017.

As a result of AIS, various major consequences appear that affect the patient's state of health and his subsequent functioning in society. All of them cause to lower his health-related quality of life (HRQOL). The concept of Health Related Quality of Life (HRQoL) is used as an important parameter for measuring outcome in modern medicine and is highly important in the assessment of the multifaceted impact of disease on the patient's life and evaluation of the utility and disability associated with various health states (Ware & Sherbourne 1992; Cunnillera et al 2010). HRQoL is defined as the way health is empirically estimated to affect QoL or use the term to only signify the utility associated with a health state (Karimi et al 2018).

HRQoL measures encompass emotional, physical, social, and subjective feelings of well-being and hence can be used in identifying and prioritizing areas of need of individual patients and patients with special needs [Trystuła 2017]. HRQOL measures are also useful in the evaluation of the effectiveness and cost-benefit of various old and emerging prophylactic, therapeutic, and rehabilitative interventions [Pačhakska, Kaczmarek, Kropotov 2014]. These instruments facilitate patient caregiver communication and clinical decision-making and uncover hidden problems.

A poorer HRQOL is reported much more often by the survivors of AIS in comparison with the general population. [Sturm et al 2004; Paul et al 2005; Kwok et al 2006]. Although HRQOL is a multidimensional concept, it is usually measured by physical or mental attributes associated with overall health status (Hobart et al 2002; Carod-Artal & Egido 2009). For stroke survivors, the physical attributes of HRQOL include the interference they perceive in performing physical activities such as the ability to walk 1 block or by responses to pain levels associated with performing activities (eg, work outside the home and housework), and mental attributes are often measured by the perception of subjective feelings of interference in participating in social activities (Hobart et al 2002; Carod-Artal & Egido 2009).

HRQOL associated with the health status of patients is one of the most objective characteristics of the effectiveness of broadly understood treatment in all its areas, and thus also in vascular surgery regardless of the operating method used [Kakkos et al 2017]. From the observations and examinations of clinicians it is known that the given treatment/surgery method is effective when it leads to improvement of health, without complications that make the patient not coped with everyday life, and after returning home and the social environment his real life begins drama. Those factors have a direct impact on the patients' quality of life.

Therefore the aim of the study was to evaluate quality of life of a patient after endarterectomy (CEA) of Internal Carotid Artery (ICA) of Acute ischemic stroke (AIS) during COVID-19 disease.

CASE STUDY

A right-handed, 51-year-old patient, visual artist, a single, with good health and no chronic illnesses to date, became infected with SARS-CoV-2 and con-

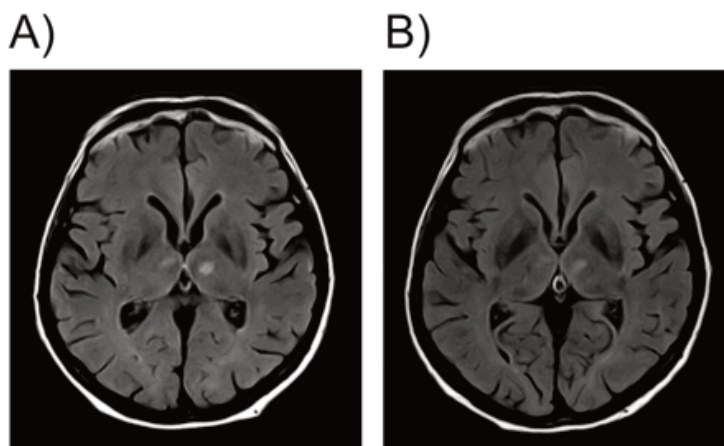


Fig.1. MRI of the brain in the FLAIR sequence; Transverse plane: A) and B) hyperintense foci in the anterior part of the right thalamus and the anteromedial part of the left thalamus, of a vascular nature

Source: own material

tracted COVID-19 in November 2021. Allegedly flu symptoms (a runny nose, cough, a scratchy throat, a fever of up to 39.5 degrees Celsius, and fatigue) appeared first. After a few days, shortness of breath joined in.

The presence of SARS-CoV-2 virus was confirmed by RT PCR antigen test. The patient was hospitalized, and required mechanical ventilation on Intensive Care Unit (ICU) before acute ischemic stroke (AIS) onset. Except for untreated hypertension, her medical history was unremarkable. Her blood pressure was 180/100 mm Hg; her pulse was 76 beats per minute and was regular. AIS from left middle cerebral artery (MCA) has resulted primarily effects in damage to the left hemisphere, an secondary effects present on the right side weakness of the body and mild anomic aphasia). The mean duration of AIS from COVID-19 symptoms onset was 11 days, and the mean NIHSS score was 19 (moderate to severe stroke). Laboratory investigations revealed an elevated mean d-dimer (11.2 mg/L) and fibrinogen (6.2 g/L). However antiphospholipid antibodies were not found.

The patient was consulted by an interdisciplinary team: a neurologist, neuropsychiatrist and neuropsychologist to see how the AIS affected her nervous system. Magnetic resonance imaging (MRI) confirmed stroke and detected brain tissue damaged by an AIS It revealed hyperintense foci in the T2 and FLAIR sequences, 21 mm in size in the left hemisphere of the brain (Fig. 1).

In search of the cause of AIS, CT angiography was performed. It revealed large (90%) of ICA occlusion. The patient was admitted to the emergency room at the Vascular Surgery Clinic with the Endovascular Subunit. The revascularization procedure (CEA) was recommended to reduce the risk of additional strokes because the carotid artery was severely narrowed.

EVERSION ENDARTERECTOMY PROCEDURE (BY EXCISION)

The procedure of eversion endarterectomy (by excision) was performed under general endotracheal anesthesia with the use of the protocol and techniques (elaborated at the Department of Vascular Surgery and Endovascular Procedures, The John Paul II Hospital in Krakow [Trystuła 2017]). A transverse skin incision was made on the anterolateral surface of the neck about 6-7 cm long, at the level of the thyroid cartilage. The right common carotid artery (RCCA), external carotid artery (RECA) and internal carotid artery (RICA) were reached and dissected. After inserting a shunt for the collateral circulation (as cerebral antegrade protection), the RICA was cut off from the RCCA at the level of the RCCA division. The wall of the RICA was turned up (like a sleeve), which caused it to detach from the atherosclerotic plaque. This made possible to remove the detached atherosclerotic plaque. The continuity of the vessel was reconstructed by suturing the RICA back to the RCCA at the site of severance, with a non-absorbable suture, removing the shunt before the vessel wall was fully sutured. Once homeostasis was achieved, a drain was placed and the surgical wound was closed in layers with sutures. A wound dressing was applied. The procedure was performed by experienced vascular surgeons (with about 5. 000 procedures previously performed) [see: Trystuła 2017].

Ethics statement

According to the guidelines of the Helsinki Declaration (2008), the patient participating in the experiment was informed in detail about the test procedure and they provided written consent for their participation in the project. The study protocols received ethical approval from the Ethical Committee of the Regional Medical Chamber (KB6/16).

NEUROPSYCHOLOGICAL TESTING

The neuropsychological testing was designed to detect cognitive disorders in the patient, and to serve as a quantifiable outcome to assess the impact of endarterectomy.

Confrontational word retrieval (naming)

We used the Polish version of the Boston Naming Test (BNT) (Pałchalska 1994) to study confrontational word retrieval. This is an adaptation of the test introduced in 1983 by Edith Kaplan, Harold Goodglass and Sandra Weintraub (1983), a widely used neuropsychological assessment tool for measuring confrontational word retrieval in people with aphasia or other language disorders caused by a variety of brain dysfunctions (Nicholas et al 1988; del Toro et al 2010). The BNT contains 60 drawings graded in difficulty (Goodglass et al 2001), because patients with anomia often have greater difficulties with naming not only difficult and low frequency objects, but also easy and high frequency objects (Nicholas et al 1988).

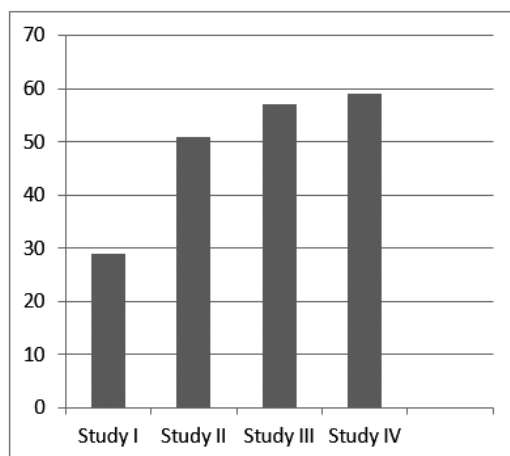


Fig. 2. Results obtained in Polish version of the Boston Naming Test (BNT) by the patient in the study I (before CEA), study II (two weeks after CEA), study III (3 months after CEA) and study IV (6 months after CEA)

It was found that in study I (before CEA), the patient named 29 of 60 drawings, which means moderate anomic aphasia. In study II (two weeks after CEA), the patient named 51 of 60 drawings, which is indicating mild anomic aphasia. In study III (3 months after CEA) the patient named 57 of 60 drawings, which is the norm for her age, indicating no anomic aphasia (Fig. 2). In study IV (6 months after CEA) the patient named 59 of 60 drawings, which is almost 100% of norm in naming.

HEALTH-RELATED QUALITY OF LIFE ASSESSMENT (HRQOL)

The HRQOL was tested with the use of the Medical Outcomes Study Short-Form 36 (SF-36) validated to assess HRQOL in post-TIA and post-stroke patients, as well as in patients with critical carotid artery stenosis undergoing revascularization (Trystuła 2017; Paçhalska & Trystuła 2020). It was aimed to evaluate the differences between the patient's results before and after CEA procedures. It includes a 36-item, patient-reported survey of patient health, and their measure of health status. The SF-36 consists of eight scaled scores, which are the weighted sums of the questions in their section. Each scale is directly transformed into a 0-100 scale on the assumption that each question carries equal weight. The eight sections are:

- vitality
- physical functioning
- bodily pain
- general health perceptions
- physical role functioning

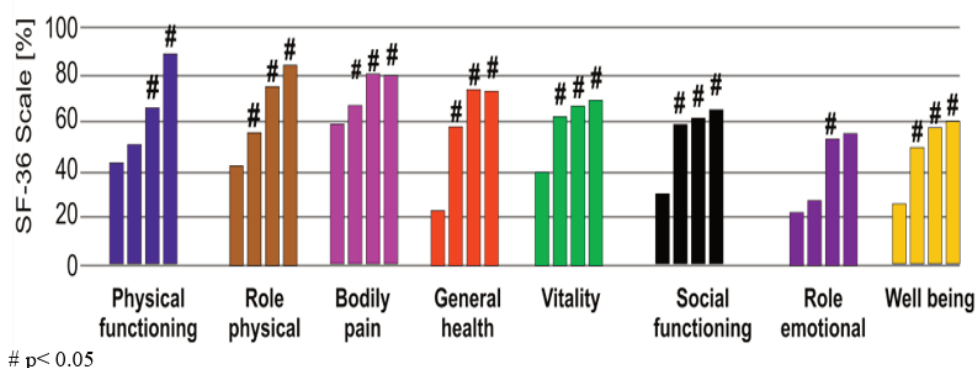


Fig. 3. Assessment of the patient's health-related quality of life (HRQoL) across eight spheres of the SF-36. The four bars show sequentially the mean score obtained in study I (before CEA), study II (two weeks after CEA), study III (3 months after CEA) and study IV (6 months after CEA)

- emotional role functioning
- social role functioning
- mental health.

In the current study, SF-36 scores are presented in a way in which higher scores correspond to fewer complaints, indicating better health and higher quality of life (Trystuła, Tomaszewski, Paçhalska 2019).

The patient's perception of HRQoL measured by the SF-36 domains is illustrated in Fig. 3. In study I (before CEA), the patient was found to have a reduced health-related quality of life across all eight spheres of the SF-36. Study II, conducted two weeks after CEA showed significant improvement in HRQoL compared to study I. This improvement was associated with a significant reduction in complaints about both mental and physical health. In study III, 3 months after CEA, there was a further increase in the HR-QoL score. In study IV, six months after CEA, there was a further significant improvement in HRQoL, which was statistically significant compared to baseline in study I and study II, 2 weeks after CEA.

Return to painting

One of the most important achievements achieved after the CEA operation is the return to painting. The artist, who lost the ability to paint as a result of a stroke and could not paint even the simplest geometric forms, not to mention the human figure, began to intensively copy the works of other authors. We will present here the last work painted after 5 months of training after CEA (Fig. 4).

The patient emphasized many times that she was very happy that she survived such serious illnesses and surgery. What's more, she was proud to be able to paint again, and even have recognition among connoisseurs and sell her newly painted paintings.



Fig. 4. The last work painted after 5 months of training after CEA

DISCUSSION

Tan et al. 2020 performed a systematic review to characterize the clinical characteristics, neuroimaging findings, and outcomes of AIS in COVID-19 patients. A literature search was performed in PubMed and Embase using a suitable keyword search strategy from 1st December 2019 to 29th May 2020. All studies reporting AIS occurrence in COVID-19 patients were included. A total of 39 studies comprising 135 patients were studied. The pooled incidence of AIS in COVID-19 patients from observational studies was 1.2% (54/4466) with a mean age of 63.4 ± 13.1 years. The mean duration of AIS from COVID-19 symptoms onset was 10 ± 8 days, and the mean NIHSS score was 19 ± 8 . Laboratory investigations revealed an elevated mean d-dimer (9.2 ± 14.8 mg/L) and fibrinogen (5.8 ± 2.0 g/L). Antiphospholipid antibodies were detected in a significant number of cases.

Our patient was younger (51 years old) but other characteristics were similar to those presented in the article Tan et al (2020). The mean duration of AIS from COVID-19 symptoms onset was 11 days, and the mean NIHSS score was 19. Also laboratory investigations revealed an elevated mean d-dimer (11.2 mg/L) and fibrinogen (6.2 g/L). However antiphospholipid antibodies were not found. It was found that the mean duration of AIS from COVID-19 symptoms onset was 10 ± 8 days, and the mean NIHSS score was 19 ± 8 . Laboratory investigations revealed an elevated mean d-dimer (9.2 ± 14.8 mg/L) and fibrinogen (5.8 ± 2.0 g/L).

Requena et al. (2020) wrote that an increased rate of thrombotic events has been associated to Coronavirus Disease 19 (COVID-19) with a variable rate of AIS. Therefore he directed the study for finding the rate of acute stroke in COVID-19 patients and identify those cases in which a possible causative relationship could exist. A single-center analysis of a prospective mandatory database. All studied patients had confirmed COVID-19 and stroke diagnoses from March 2nd to April 30th. Demographic, clinical, and imaging data were prospectively col-

lected. Final diagnosis was determined after full diagnostic work-up unless impossible due to death. Of 2050 patients with confirmed SARS-CoV-2 infection, 21 (1.02%) presented an AIS and 4 (0.2%) suffered an intracranial hemorrhage. After the diagnostic work-up, in 60.0% ischemic and all hemorrhagic strokes patients an etiology non-related with COVID-19 was identified. Only in 6 patients the stroke cause was considered possibly related to COVID-19, all of them required mechanical ventilation before AIS onset. The authors also found that the presence of acute stroke in patients with COVID-19 was below 2% and most of them previously presented established stroke risk factors. Without other potential cause, stroke was an uncommon complication and exclusive of patients with a severe pulmonary injury.

We want to emphasize that in our patient in whom the stroke cause was considered as related possibly to COVID-19, additionally etiology non-related with COVID-19 was identified (ICA stenosis), and that she, like the AIS patients presented by Requena et al. (op. cit), also required mechanical ventilation on Intensive Care Unit (ICU) before acute ischemic stroke (AIS) onset. However our patient did not presented any established stroke risk factors except for ICA stenosis without family history of this condition.

Shahjouei et al. (2021) published the largest study that comprehensively presents the characteristics and stroke subtypes of stroke in SARS-CoV-2–infected patients at a multinational level. These authors stated that stroke is reported as a consequence of severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) infection in several reports. However, data are sparse regarding the details of these patients in a multinational and large scale. The authors conducted a multinational observational study on features of consecutive AIS, intracranial hemorrhage, and cerebral venous or sinus thrombosis among SARS-CoV-2–infected patients. They also further investigated the risk of large vessel occlusion, stroke severity as measured by the National Institutes of Health Stroke Scale, and stroke subtype as measured by the TOAST (Trial of ORG 10172 in Acute Stroke Treatment) criteria among patients with acute ischemic stroke. In addition, we explored the neuroimaging findings, features of patients who were asymptomatic for SARS-CoV-2 infection at stroke onset, and the impact of geographic regions and countries' health expenditure on outcomes. It was found that among the 136 tertiary centers of 32 countries who participated in this study, 71 centers from 17 countries had at least one eligible stroke patient. Of 432 patients included, 323 (74.8%) had AIS, 91 (21.1%) intracranial hemorrhage, and 18 (4.2%) cerebral venous or sinus thrombosis. A total of 183 (42.4%) patients were women, 104 (24.1%) patients were <55 years of age, and 105 (24.4%) patients had no identifiable vascular risk factors. Among acute ischemic stroke patients, 44.5% (126 of 283 patients) had large vessel occlusion; 10% had small artery occlusion according to the TOAST criteria.

It was also observed a lower median National Institutes of Health Stroke Scale (8 [3–17] versus 11 [5–17]; $P=0.02$) and higher rate of mechanical thrombectomy (12.4% versus 2%; $P<0.001$) in countries with middle-to-high health expenditure

when compared with countries with lower health expenditure. Among 380 patients who had known interval onset of the SARS-CoV-2 and stroke, 144 (37.8%) were asymptomatic at the time of admission for SARS-CoV-2 infection.

Our patient had also interval onset of the SARS-CoV-2 and stroke and she was asymptomatic at the time of admission for SARS-CoV-2 infection.

It was concluded that a considerably higher rate of large vessel occlusions, a much lower rate of small vessel occlusion and lacunar infarction, and a considerable number of young stroke when compared with the population studies before the pandemic. The rate of mechanical thrombectomy was significantly lower in countries with lower health expenditures.

The majority of AIS neuroimaging patterns observed was large vessel thrombosis, embolism or stenosis of ICA (62.1%, 64/103), followed by multiple vascular territory (26.2%, 27/103). A high mortality rate was reported (38.0%, 49/129). We report the pooled incidence of AIS in COVID-19 patients to be 1.2%, with a high mortality rate. Elevated d-dimer, fibrinogen and the presence of antiphospholipid antibodies appear to be prominent in COVID-19 patients with concomitant AIS, but further mechanistic studies are required to elucidate their role in pathogenesis.

Nannoni et al (2021) found that patients with COVID-19 developing acute cerebrovascular diseases, compared to those who did not, were older (pooled median difference = 4.8 years; 95%CI: 1.7-22.4), more likely to have hypertension (OR=7.35; 95%CI: 1.94-27.87), diabetes mellitus (OR=5.56; 95%CI: 3.34-9.24), coronary artery disease (OR=3.12; 95%CI: 1.61-6.02), and severe infection (OR=5.10; 95%CI: 2.72-9.54). Compared to individuals who experienced a stroke without the infection, patients with COVID-19 and stroke were younger (pooled median difference = -6.0 years; 95%CI: -12.3 to -1.4), had higher NIHSS (pooled median difference = 5; 95%CI: 3-9), higher frequency of large vessel occlusion (OR=2.73; 95%CI: 1.63-4.57), and higher in-hospital mortality rate (OR=5.21; 95%CI: 3.43-7.90).

Shahjouei et al. (2021) pointed out that their study results showed a considerable number of young strokes. The authors found out that 36% of the AIS patients in the study were <55 years of age and 46% were <65 years of age. These proportions are considerably higher than the population-based reports before the pandemic (12.9%–20.7%) (Cabral et al; 2017; Kissela et al 2012). The median age of AIS patients in our study was 68 (58–78) years. We would like to point out that our patients with COVID-19 and AIS was also young (51 years old). Although the definition of young stroke is debatable, the majority of the studies considered 50 or 55 years as the cutoff (Cabral et al 2017). A case series from New York on 32 AIS patients with SARS-CoV-2 showed a median of 63 years for these patients. This finding was significantly lower than AIS patients without SARS-CoV-2 in the same study and same interval (median, 70 years) or the historical cohort of AIS patients presented to the same center in 2019 (median, 68.5 years) (Yagi et al 2020). A multinational study on 174 AIS patients with SARS-CoV-2 infection reported a median age of 71 years (Ornello et al 2018).

Our patients with COVID-19 and AIS had also higher NIHSS (19 moderate to severe stroke), and she had large vessel occlusion (90% of ICA occlusion).

The internal carotid endarterectomy (CEA), i.e. surgical removal of atherosclerotic plaque and thrombi, from a longitudinal incision of the carotid arteries, with subsequent reconstruction of the wall continuity, and when the diameter of the vessels is too small, also with sewing a patch from the vascular prosthesis. This method offering cutting off the internal carotid artery from the common carotid artery and removing the atherosclerotic plaque by eversion of the internal carotid artery wall (eversive method). After cleaning the wall of atherosclerotic lesions, the internal carotid artery is sawing back into the common carotid artery (see also: Trystuła 2017).

As it was stated by Trystuła (2017), the patients, such as ours, should be offered radical treatment of the cause of AIS, i.e. CEA revascularisation. Qualification for urgent surgery in the case of symptomatic stenosis of ICA is determined by the degree of stenosis and its symptomatic character; on the scale of severity, this includes the TIA, temporary loss of vision in one eye (amargosis fugax), and AIS. It is especially important to propose an urgent CEA in the case when the atherosclerotic plaque has an irregular shape, is long and extensive, as it was in our patient, or features of plaque ulceration are found within it. It is worth to emphasize that in the case of major stroke there is obligatory to use neuroprotection (distal or proximal depending upon the anatomic and hemodynamic conditions of intracerebral and intracranial arteries) during CAS and shunt protection during CEA [Kakos et al 2017; Trystuła 2018].

HRQOL, which of course strongly links to successful CEA [Cohen et al 2011; Shan et al. 2015; Trystuła et al 2018], is also associated with resolution of symptoms, including hemiparesis, muscle weakness and aphasia. Anomic aphasia, which was found in the patient we studied, is one type of fluent aphasia, along with Wernicke's aphasia, transcortical sensory aphasia and conductive aphasia [Kaplan et al 1983; del Toro et al 2010]. We can agree with Trystuła et al (2019) findings that Carotid revascularization has a major positive impact on stroke survivor patient-reported HRQoL, because we found similar results in our patient. However it should be also stressed that HRQOL could be associated with long-term COVID-19 sequelae, i.e. longCOVID and post-COVID syndrome. Fortunately, our patient did not develop such symptoms until 6 months after contracting COVID-19.

How can we explain such a big change in our patient's perception of herself after the CEA procedure?

The basic mechanism lies in better blood supply to the brain after removal of atherosclerotic plaque and unblocking of ICA. This ensures better functioning of the brain and better exchange of information between one and the other hemisphere of the brain, The development of the logical and spatial coherence of the self system is conditioned by the proper functioning of the entire brain. This is ensured not only by properly functioning structures, but also by connections within each hemi - sphere, between both hemispheres and their connections with subcortical structures (Paçhalska, Kaczmarek and Kropotov 2014). Differences in the functioning of the right and left hemispheres of the brain within the self system are illustrated in Fig. 5.

It can be seen that the dominant hemisphere of the brain (usually the left in right-handed persons) is closely related to language functions. Therefore, it provides logical coherence possible thanks to linguistic images, which includes language models, grammar and vocabulary, as well as internal narration and dialogue. An important role is also played by the ability of linguistic expression, which is enabled by efficiently functioning articulatory organs and limbs (writing and signalling language statements). Based on this, language texts are created, among which a special role is played by narrative and external dialogue that enables contact with other people. Patterns of neural network connections that evoke thoughts (and thus behaviours) that promote the well-being of the body are permanently encoded, while useless ones disappear (Carter 1999; Pałchalska, Kaczmarek, Kropotov 2014). The subdominant hemisphere of the brain is closely related to nonlinguistic functions (generally the right in right-handed persons). Thus, it provides spatial coherence based on nonlinguistic images: image models and „body grammar,” i.e., images evoked by facial expressions, gestures and a sequence of movements (pantomime).

This enables, through the use of the facial expressions, phonic organs (vocalization), limbs (gestures) and the whole body (pantomime, „body language”) nonlinguistic expression. This creates nonlinguistic messages: acoustic (voice, sound) and visual (drawing, gesture). People with brain damage exhibit disturbances in logical or spatial coherence depending on the location of the damage (structures and neural connections) in the right or left hemisphere of the brain. Linguistic representations are more or less disintegrated, which makes creating language constructions more difficult, as a result of which the process of creating

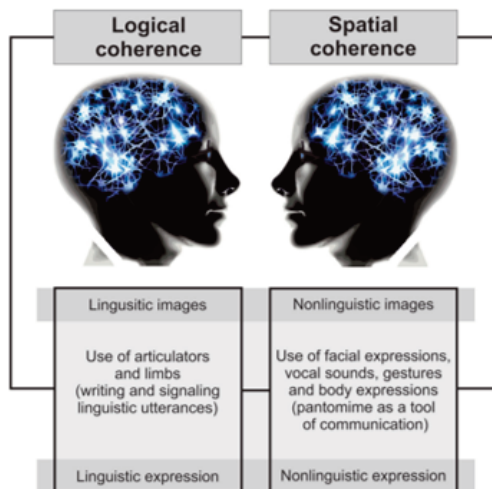


Fig. 5. Differences in the functioning of the right and left hemispheres of the brain within the Self system

Source: Pałchalska, 2019: 362, with permission from AW Medsportress

ideas about yourself and the world is disturbed, which is why the image of oneself and, as a result, the whole system of the self is disintegrated. Damage to the subcortical structures and connections is also not without significance, however, the picture of disorders is different, something which is described in more detail as detailed in another work (Pačhalska, Kaczmarek, Kropotov 2014),

Such brain work allows the return of the naming function, which of course occurred in our patient. Regaining the ability to name, in turn, improved the imagination and contributed to better drawing and painting. As a consequence, the patient regained self-confidence, joy of life, and thus improved her self-esteem, which translated into an improved quality of life.

To sum up

Obtained results are important from a practical point of view (application dimension) because they can have a direct impact on the course of surgery, and thus on the final outcome of treatment and the quality of life of the stroke survivors. They can also play a big role in the approach to treating the patient by offering him a larger package of assistance activities, allowing to increase his quality of life.

The revascularization procedures as well as pre- and postoperative standards of care for patients after AIS elaborated and utilized at the Department of Vascular Surgery with Endovascular Procedures in the John Paul II Hospital, Krakow, may be of use in conducting further research to discover the optimal effectiveness of CEA. It also creates a possibility of introducing these procedure in other clinical centers.

Study limitations

We are aware of the potential limitations of this study. The most important of these stem from the fact that this is case study treated in a single center. We are planning to extend our research on this subject in the future.

CONCLUSIONS

Patients' perception of HRQoL measured by the SF-36 domains was better after the CEA: significant improvement in self-reported overall health appears. HRQoL outcome measures may be of value in future clinical trials of comparing different methods of treatment offered after AIS.

Acknowledgements

Recognition is due to the whole team of neuropsychologists from the Reintegration and Didactic Center of the Polish Neuropsychological Association. In particular, we would like to thank **Prof. Maria Pačhalska** for her immense help in interpreting the results, and **Prof. Mariusz Trystuła** for his invaluable comments while writing this article.

REFERENCES

- Aknin, L. B., De Neve, J. E., Dunn, E. W., Fancourt, D. E., Goldberg, E., Helliwell, J. F., ... Amor, Y. B. (2021). The neurological consequences of contracting COVID-19. The Lancet's COVID-19. Commission Mental Health Task Force. *Acta Neuropsychologica*, 19(3), 301–305. doi: 10.5604/01.3001.0014.9953.
- Cabral, N. L., Freire, A. T., Conforto, A. B., Dos Santos, N., Reis, F. I., Nagel, V., ... Longo A. L. (2017). Increase of stroke incidence in young adults in a middle-income country: a 10-year population-based study. *Stroke*, 48(11), 2925–2930. doi: 10.1161/STROKEAHA.117.018531.
- Carod-Artal, F. J., Egido, J. A. (2009). Quality of life after stroke: the importance of a good recovery. *Cerebrovascular diseases*, 27(suppl 1), 204–214. doi: 10.1159/000200461.
- Carter, R. (1999). *Tajemniczy świat umysłu*, tłum. Kamiński, B. Poznań: Oficyna Wydawnicza Atena.
- Cohen, D. J., Stolker, J. M., Wang, K., Magnuson, E. A., Clark, W. M., Demaerschalk, B. M., ... CREST Investigators. (2011). Health-related quality of life after carotid stenting versus carotid endarterectomy: results from CREST (Carotid Revascularization Endarterectomy Versus Stenting Trial). *Journal of the American College of Cardiology*, 58(15), 1557–1565. doi: 10.1016/j.jacc.2011.05.054.
- Cunillera, O., Tresserras, R., Rajmil, L., Vilagut, G., Brugalat, P., Herdman, M., ... Ferrer, M. (2010). Discriminative capacity of the EQ-5D, SF-6D, and SF-12 as measures of health status in population health survey. *Quality of Life Research*, 19, 853–864. doi: 10.1007/s11136-010-9639-z.
- Del Toro, C. M., Bislick, L. P., Comer, M., Velozo, C., Romero, S., Rothi, L. J. G., Kendall, D. L. (2010). Development of a short form of the Boston naming test for individuals with aphasia. *Journal of Speech, Language, and Hearing Research*, 54(4), 1089–100. doi: 10.1044/1092-4388(2010/09-0119).
- Fiani, B., Fowler, J. B., Figueras, R. A., Hessamian, K., Mercado, N., Vukcevic, O., Singh, M. K. (2021). Ruptured cerebral aneurysms in COVID-19 patients: a review of literature with case examples. *Surgical Neurology International*, 26(12), 187. doi: 10.25259/SNI_214_2021.
- Goodglass, H., Kaplan, E., Barresi, B. (2001). *Boston Diagnostic Aphasia Examination, 3rd edition*. Austin, TX: Pro-Ed Inc.
- Gorbalenya, A. E., Baker, S. C., Baric, R. S., de Groot, R. J., Drosten, C., Gulyaeva, A. A., ... Ziebuhr, J. (Coronaviridae Study Group of the International Committee on Taxonomy of Viruses.) (2020). The species severe acute respiratory syndrome-related coronavirus: classifying 2019-nCoV and naming it SARS-CoV-2. *Nature microbiology*, 5(4), 536–544. doi: 10.1038/s41564-020-0695-z.
- Hobart, J. C., Williams, L. S., Moran, K., Thompson, A. J. (2002). Quality of life measurement after stroke: uses and abuses of the SF-36. *Stroke*, 33, 1348–1356. doi: 10.1161/01.STR.0000015030.59594.B3.
- Hu, Y., Qian, H., Shi, X. (2023). Treatment of chronic internal carotid artery occlusion by ipsilateral external carotid endarterectomy. *British Journal of Neurosurgery*, 37(4), 925–927. doi: 10.1080/02688697.2020.1725440.
- Huang, C., Wang, Y., Li, X., Ren, L., Zhao, J., Hu, Y., ... Cao, B. (2020). Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. *The Lancet*, 395, 497–506. doi: 10.1016/S0140-6736(20)30183-5.
- Hui, D. S., Azhar, E. I., Madani, T. A., Ntoumi, F., Kock, R., Dar, O., ... Petersen, E. (2020). The continuing 2019-nCoV epidemic threat of novel coronaviruses to global health – The latest 2019 novel coronavirus outbreak in Wuhan, China. *International journal of infectious diseases*, 91, 264–266. doi: 10.1016/j.ijid.2020.01.009.
- Hydzik, A., Oplawski M., Trystuła M., Pačalska M. (2023). Quality of life of a patient with persistent complications after SARS-CoV-2 infection requiring urgent surgical intervention – endarterectomy with emergency angioplasty of an inflamed, bleeding right internal carotid artery (RICA) using the trans-carotid artery revascularization (TCAR). *Acta Neuropsychologica*, 21(3), 259–278.
- Kakkos, S. K., Kakisis, I., Tsolakis, I. A., Geroulakos, G. (2017). Endarterectomy achieves lower stroke and death rates compared with stenting in patients with asymptomatic carotid stenosis. *Journal of Vascular Surgery*, 66(2), 607–617. doi: 10.1016/j.jvs.2017.04.053.
- Kaplan, E., Goodglass, H., Weintraub, S. (1983). *Boston Naming Test*. Philadelphia: Lea & Febiger.

- Karimi, M., Brazier, J. (2016). Health, Health-Related Quality of Life, and Quality of Life: What is the Difference? *PharmacoEconomics*, 34, 645–649. doi: 10.1007/s40273-016-0389-9.
- Katzan, I. L., Schuster, A., Daboul, L., Doherty, C., Speaker, S., Uchino, K., Lapin, B. (2021). Changes in Health-Related Quality of Life After Transient Ischemic Attack. *JAMA Network Open*, 4(7), e2117403. doi: 10.1001/jamanetworkopen.2021.17403.
- Kissela, B. M., Khoury, J. C., Alwell, K., Moomaw, C. J., Woo, D., Adeoye, O., ... Kleindorfer, D. O. (2012). Age at stroke: temporal trends in stroke incidence in a large, biracial population. *Neurology*, 79(17), 1781-1787. doi: 10.1212/WNL.0b013e318270401d.
- Kwok, T., Lo, R. S., Wong, E., Wai-Kwong, T., Mok, V., Kai-Sing, W. (2006). Quality of life of stroke survivors: a 1-year follow-up study. *Archives of Physical Medicine and Rehabilitation*, 87, 1177–1182. doi: 10.1016/j.apmr.2006.05.015.
- MacQueen, B. D., MacQueen, W. D. (2021). Neuro-COVID: A preliminary review. *Acta Neuropsychologica*, 19(3), 389-402. doi: 10.5604/01.3001.0015.2692.
- Mao, L., Jin, H., Wang, M., Hu, Y., Chen, S., He, Q., ... Hu, B. (2020). Neurologic manifestations of hospitalized patients with coronavirus disease 2019 in Wuhan, China. *JAMA Neurology*, 77(6), 683-690. doi:10.1001/jamaneurol.2020.1127.
- Mbonde, A. A., O'Carroll, C. B., Grill, M. F., Zhang, N., Butterfield, R., Demaerschalk, B. M. (2022). Stroke features, risk factors, and pathophysiology in SARS-CoV-2-infected patients. *Mayo Clinic Proceedings: Innovations, Quality & Outcomes*, 6(2), 156-165. doi: 10.1016/j.mayocpiqo.2022.01.003.
- Merkler, A. E., Parikh, N. S., Mir, S., Gupta, A., Kamel, H., Lin, E., ... Navi, B. B. (2020). Risk of ischemic stroke in patients with coronavirus disease 2019 (COVID-19) vs patients with influenza. *JAMA Neurology*, 77(11), 1366-1372. doi: 10.1001/jamaneurol.2020.2730.
- Morassi, M., Bagatto, D., Cobelli, M., D'Agostini, S., Gigli, G. L., Bnà, C., Vogrig, A. (2020). Stroke in patients with SARS-CoV-2 infection: case series. *Journal of neurology*, 267, 2185-2192. doi: 10.1007/s00415-020-09885-2.
- Musuka, T. D., Wilton, S. B., Traboulsi, M., Hill, M. D. (2015). Diagnosis and management of acute ischemic stroke: speed is critical. *CMAJ*, 187(12), 887-893. doi: 10.1503/cmaj.140355.
- Nannoni, S., de Groot, R., Bell, S., Markus, H. S. (2021). Stroke in COVID-19: a systematic review and meta-analysis. *International Journal of Stroke*, 16(2), 137-149. doi: 10.1177/1747493020972922.
- Nicholas, L. E., Brookshire, R. H., MacLennan, D. L., Schumacher, J. G., Porrizzo, S. A. (1988). The Boston Naming Test: revised administration and scoring procedures and normative information for non-brain-damaged adults. *Clinical aphasiology*, 18, 103-115. ISBN 0-316-71779-7.
- Ornello, R., Degan, D., Tiseo, C., Di Carmine, C., Perciballi, L., Pistoia, F., ... Sacco, S. (2018). Distribution and temporal trends from 1993 to 2015 of ischemic stroke subtypes: a systematic review and meta-analysis. *Stroke*, 49(4), 814-819. doi: 10.1161/STROKEAHA.117.020031.
- Oxley, T. J., Mocco, J., Majidi, S., Kellner, C. P., Shoirah, H., Singh, I. P., ... Fifi, J. T. (2020). Large-vessel stroke as a presenting feature of Covid-19 in the young. *New England Journal of Medicine*, 382(20), e60. doi: 10.1056/NEJMc200978.
- Pąchalska, M. (1994). *Polska Wersja Bostońskiej Baterii Nazywania*. [ang. Polish Version of the Boston Naming Battery]. Kraków: Fundacja na Rzecz Osób z Dysfunkcjami Mózgu.
- Pąchalska, M. (2019). Integrated self system: microgenetic approach. *Acta Neuropsychologica* 17(4), 349-392.
- Pąchalska, M., Trystuła, M. (2020). Health-related quality of life in a patient following aneurysmectomy of rare mega-gigant aneurysm of the common carotid artery. *Acta Neuropsychologica*, 18, 411-423. doi: 10.5604/01.3001.0014.4549.
- Pąchalska, M., Kaczmarek, B. L. J., Kropotov, J. D. (2014). *Neuropsychologia kliniczna: od teorii do praktyki*. [ang. Clinical neuropsychology: from theory to practice]. Warszawa: WN PWN. ISBN 978-83-01-17841-3.
- Pąchalska, M., Kaczmarek, B. L. J., Kropotov, J. D. (2021). *Ja utracone i odzyskane*. Kraków: Oficyna Wydawnicza Impuls.

- Paul, S. L., Sturm, J. W., Dewey, H. M., Donnan, G. A., Macdonell, R. A., Thrift, A. G. (2005). Long-term outcome in the North East Melbourne Stroke Incidence Study: predictors of quality of life at 5 years after stroke. *Stroke*, 36(10), 2082-2086. doi: 10.1161/01.STR.0000183621.32045.31.
- Qin, C., Zhou, L., Hu, Z., Yang, S., Zhang, S., Chen, M., ... Wang, W. (2020). Clinical characteristics and outcomes of COVID-19 patients with a history of stroke in Wuhan, China. *Stroke*, 51(7), 2219-2223. doi: 10.1161/STROKEAHA.120.030365.
- Qureshi, A. I., Baskett, W. I., Huang, W., Shyu, D., Myers, D., Raju, M., ... Shyu, C. R. (2021). Acute Ischemic Stroke and COVID-19: An Analysis of 27 676 Patients. *Stroke*, 52(3), 905-912. doi: 10.1161/STROKEAHA.120.031786.
- Requena, M., Olive-Gadea, M., Muchada, M., Garcia-Tornel, A., Deck, M., Juega, J., ... Ribo, M. (2020). COVID-19 and stroke: incidence and etiological description in a high-volume center. *Journal of Stroke and Cerebrovascular Diseases*, 29(11), 105225. doi: 10.1016/j.jstrokecerebrovasdis.2020.105225.
- Sadeghi Dousari, A., Taati Moghadam, M., Satarzadeh, N. (2020). COVID-19 (Coronavirus Disease 2019): A New Coronavirus Disease. *Infection and drug resistance*, 13, 2819-2828. doi: 10.2147/IDR.S259279.
- Sagris, D., Papanikolaou, A., Kvernland, A., Korompoki, E., Frontera, J. A., Troxel, A. B., ... Ntaios, G. (2021). COVID-19 and ischemic stroke. *European journal of neurology*, 28(11), 3826-3836. doi: 10.1111/ene.15008.
- Sashindranath, M., Nandurkar, H. H. (2021). Endothelial dysfunction in the brain: setting the stage for stroke and other cerebrovascular complications of COVID-19. *Stroke*, 52(5), 1895-1904. doi: 10.1161/STROKEAHA.120.032711.
- Shahjouei, S., Tsivgoulis, G., Farahmand, G., Koza, E., Mowla, A., Vafaei Sadr, A., ... Zand, R. (2021). SARS-CoV-2 and stroke characteristics: a report from the multinational COVID-19 stroke study group. *Stroke*, 52(5), e117-e130. doi: 10.1161/STROKEAHA.120.032927.
- Shan, L., Shan, J., Saxena, A., Robinson, D. (2015). Quality of life and functional status after carotid revascularisation: a systematic review and meta-analysis. *European Journal of Vascular and Endovascular Surgery*, 49(6), 634-645. doi: 10.1016/j.ejvs.2015.03.020.
- Sturm, J. W., Donnan, G. A., Dewey, H. M., Macdonell, R. A., Gilligan, A. K., Srikanth, V., Thrift, A. G. (2004). Quality of life after stroke: the North East Melbourne stroke incidence study (NEMESIS). *Stroke*, 35(10), 2340-2345. doi: 10.1161/01.STR.0000141977.18520.3b.
- Sweid, A., Hammoud, B., Bekelis, K., Missios, S., Tjoumakaris, S. I., Gooch, M. R., ... Jabbour, P. (2020). Cerebral ischemic and hemorrhagic complications of coronavirus disease 2019. *International Journal of Stroke*, 15(7), 733-742. doi: 10.1177/17474930200937189
- Tan, Y. K., Goh, C., Leow, A. S., Tambyah, P. A., Ang, A., Yap, E. S., ... Tan, B. Y. (2020). COVID-19 and ischemic stroke: a systematic review and meta-summary of the literature. *Journal of thrombosis and thrombolysis*, 50(3), 587-595. doi: 10.1007/s11239-020-02228-y.
- Taquet, M., Geddes, J. R., Husain, M., Luciano, S., Harrison, P. J. (2021). 6-month neurological and psychiatric outcomes in 236 379 survivors of COVID-19: a retrospective cohort study using electronic health records. *The Lancet Psychiatry*, 8(5), 416-427. doi: 10.1016/S2215-0366(21)00084-5.
- Trystuła, M. (2017). *Jakość życia chorych po rewaskularyzacji krytycznego zwężenia tętnicy szyjnej wewnętrznej*. Kraków: Oficyna Wydawnicza Impuls.
- Trystuła, M. (2018). Health related quality of life of the patients after transient ischaemic attack: is carotid endarterectomy (CEA) or carotid artery stenting (CAS) more influential? *Acta Neuropsychologica*, 16(1), 61-68. doi: 10.5604/01.3001.0011.7065.
- Trystuła, M., Pórola, P., Kropotov, J. (2016). Usage of perioperative anxiety neuromarker for improving the quality of life of a patient operated on for critical stenosis of the internal carotid artery. *Annals of Agricultural and Environmental Medicine*, 23, 612-617. doi: 10.5604/12321966.1226855.
- Trystuła, M., Tomaszewski, T., Pačalska, M. (2019). Health-related quality of life in ischaemic stroke survivors after carotid endarterectomy (CEA) and carotid artery stenting (CAS): confounder-controlled analysis. *Advances in Interventional Cardiology/Postępy w Kardiologii Interwencyjnej*, 15(2), 226-233. doi: 10.5114/aic.2019.84441.

- Van der Worp, H. B., van Gijn, J. (2007). Acute Ischemic Stroke. *New England Journal of Medicine*, 357(6), 572-579. doi: 10.1056/NEJMcp072057.
- Ware, J. E., Sherbourne, C. D. (1992). The MOS 36-item short-form health survey (SF-36): I. conceptual framework and item selection. *Medical Care*, 30(6), 473-483.
- Warren-Gash, C., Blackburn, R., Whitaker, H., McMenemy, J., Hayward, A. C. (2018). Laboratory-confirmed respiratory infections as triggers for acute myocardial infarction and stroke: a self-controlled case series analysis of national linked datasets from Scotland. *European Respiratory Journal*, 51(3), 1701794. doi: 10.1183/13993003.01794-2017.
- Yaghi, S., Ishida, K., Torres, J., Mac Grory, B., Raz, E., Humbert, K., ... Frontera, J. (2020). SARS-CoV-2 and stroke in a New York healthcare system. *Stroke*, 51(7), 2002-2011. doi: 10.1161/STROKEAHA.120.030335.

Corresponding author:

Ksenia Cielebąk

Chair of Neuropsychology and Neurorehabilitation

Andrzej Frycz Modrzewski Kraków University,

Herlinga-Grudzińskiego 1 30-750 Kraków, Poland

e-mail: cielebakksenia@gmail.com