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DOES OBESITY INFLUENCE THE RETURN OF SPONTANEOUS CIRCULATION AMONG OUT-OF-HOSPITAL CARDIAC ARREST PATIENTS? A RETROSPECTIVE COHORT STUDY

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ABSTRACT

INTRODUCTION: Several factors influence spontaneous circulation (ROSC) return in out-of-hospital cardiac arrest (OHCA) patients, and obesity can be one of them. The aim of this study was to investigate the influence of obesity on ROSC in patients following OHCA.

MATERIAL AND METHODS: We conducted a retrospective study and analyzed 4,925,214 emergency medical system (EMS) records. Finally, data from 33,636 OHCA patients in Poland for whom EMS personnel responded between January 2021 and June 2022 were analyzed.

RESULTS: The univariate analysis showed an association between ROSC and age ($p < 0.001$, OR: 0.981), location of the incident ($p < 0.001$, OR: 1.6), OHCA initial rhythm ($p < 0.001$, OR: 2.056), obesity ($p \approx 0.003$ OR: 1.1.06) and some comorbidities. In the first multivariate model (whole population sample), significant predictors of ROSC were initial rhythm (Asystole/PEA; $p < 0.001$; OR: 0.516), age ($p < 0.001$; OR: 0.986), location of the incident ($p < 0.001$; OR: 1.468) and obesity ($p = 0.023$; OR: 0.924). In the second model (patients without obesity), the significant predictors ($p < 0.001$) of ROSC were initial rhythm (Asystole/PEA, OR: 0.263), public location of the incident (OR: 2.158) and age (OR: 0.986). In the third model (patients with obesity), the significant predictors of ROSC were initial rhythm (Asystole/PEA, $p = 0.002$; OR: 0.443), public location of the incident ($p < 0.001$; OR: 2.101), age ($p < 0.001$; OR: 0.981), and stroke ($p = 0.005$; OR: 2.047).

CONCLUSIONS: In the study population of OHCA patients, obesity significantly predicted the odds of the prehospital return of spontaneous circulation, reducing the odds by 8.2%. In the overall study population and the groups of patients with and without obesity, OHCA in public places and ventricular fibrillation/pulsless ventricular tachycardia (VF/pVT) initiating rhythm were predictors of increased odds of ROSC and older age reduced these odds.

KEYWORDS: out-of-hospital cardiac arrest; return of spontaneous circulation; obesity; cardiopulmonary resuscitation

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INTRODUCTION

Out-of-hospital cardiac arrest (OHCA) is a sudden and unexpected event associated with a high mortality risk and serious neurological complications [1]. Following advanced life support (ALS), the return of spontaneous circulation (ROSC) at the scene was reported to occur in 10 to 50% of OHCA patients [2]. Over the past few decades, significant advances in ALS have improved survival rates after OHCA [3]. Nevertheless, numerous factors can still influence the outcome of emergency medical teams' rescue efforts and, among these, ROSC.

Obesity, as a global health problem, has increased significantly over recent years. Its prevalence in adult and child populations is increasing alarmingly, with serious public health implications [4]. According to the World Health Organization (WHO), up to 13% of the world's population struggles with obesity [5] Several studies have shown that obesity affects both the risk of CVD (such as hypertension, coronary heart disease, and heart failure) and increased complications in people with these conditions [6–9]. On the other hand, some studies have shown that obesity does not affect the outcome of patients following CA [10].

It is worth pointing out that this condition is essential not only because of the presence of comorbidities in patients but also due to the difficulty in meeting ERC guidelines. An example is maintaining the correct depth of chest compressions due to differences in anatomy [11, 12]. In such a case, it is also challenging for the emergency teams to perform endotracheal intubation or insert an intravenous or intraosseous line [13]. According to the current ERC guidelines, ALS procedures in patients with obesity are not different from the treatment of an adult patient of normal weight, and they do not give specific recommendations in this regard [11].

The aim of this study was to investigate the influence of obesity on ROSC in patients following OHCA.

MATERIAL AND METHODS

Study design and setting

We performed a retrospective analysis of the medical records of patients for whom emergency medical services (EMS) were called in Poland from January 2021 till June 2022. The data were obtained from the Command Support System of the National Emergency Medical Service and made available by the Emergency Medical Services Monitoring Centre with the permission of the Polish Ministry of Health.

Study population

A total of 4,925,214 EMS records were analyzed. All patients with a recorded ICD 10 — I 46 diagnosis who received cardiopulmonary resuscitation (CPR) at the scene were included in the study. Patients in whom OHCA occurred due to crime, suicide, trauma, etc., in whom death occurred prior to EMS arrival, and in whom the rhythm initiating OHCA was not recorded were excluded from the study. Finally, data from 33,636 patients were analyzed. In the next step, information on the presence of obesity (ICD10: E66 or the word diagnosis "obesity") was exported from both the ICD10 section and the "descriptive diagnosis" section of the medical records to divide the patients into two groups: patients without obesity and patients with obesity (Fig. 1). The following data were then analyzed: age, sex, initiating rhythm, location of OHCA (public place, non-public place), information on the presence of comorbidities such as diabetes mellitus (DM), hypertension (HT), heart failure (HF) and history of acute coronary syndrome (ACS) and stroke.

Ethical considerations

The study was conducted following the principles of the Declaration of Helsinki and was approved by the independent Bioethics Committee of Wrocław Medical University (No. KB-776/2022). The study followed the STROBE guidelines (Strengthening the Reporting of Observational Studies in Epidemiology).

Statistical analysis

Data extraction and preprocessing were performed in Python 3.10.7 using standard packages (pandas 1.4.4, numpy 1.21.4). Statistical analysis was performed in STATISTICA 5.0.96. The data were visualized using the following Python packages: matplotlib 3.5.3 and zepid 0.9.1.

Analysis of continuous variables was performed with the t test based on its assumptions (normality: as analyzed on a histogram, homoscedasticity: based on Levene's test). Analysis of categorical variables was performed with the χ^2 test. Odds ratios (ORs) associated with variables in contingency tables were calculated using univariate logistic regression. Further analysis was performed with the use of multiple logistic regression — utilizing the stepwise

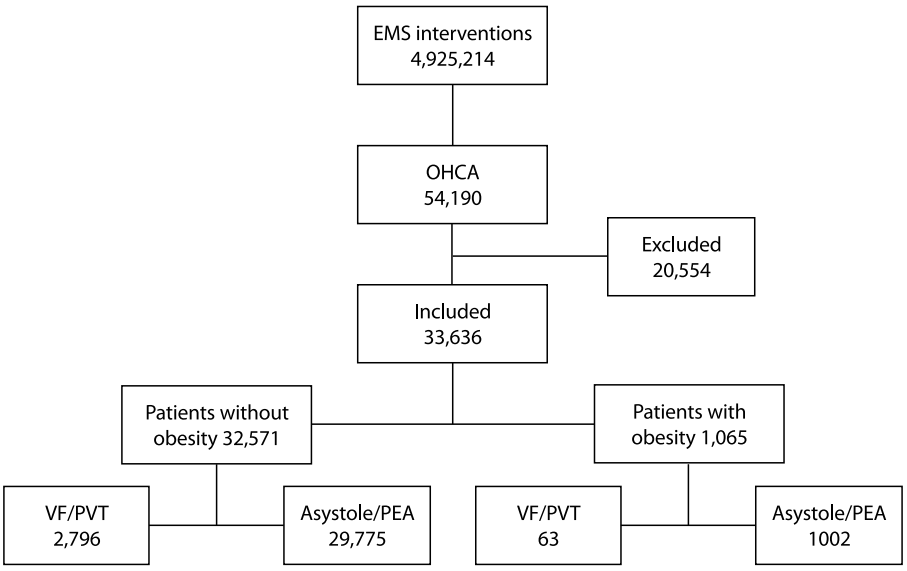

FIGURE 1. Flow chart of the study; OHCA — out-of-hospital-cardiac-arrest; PEA — pulseless electrical activity; pVT — pulseless ventricular tachycardia; VF — ventricular fibrillation

regression algorithm (p cut-off: 0.05) based on Wald and Lagrange multiplier (score) tests.

RESULTS

Factors of ROSC in the whole dataset

The univariate analysis (Tab. 1) showed an association between ROSC and age ($p < 0.001$), location of the incident ($p < 0.001$), OHCA initial rhythm ($p < 0.001$), obesity ($p \approx 0.003$), DM ($p \approx 0.028$), HT ($p \approx 0.015$) and ACS ($p < 0.001$). With a one-year increase, the odds of ROSC incidence dropped by approximately 1.94%. If the incident occurred in a public place, the odds of ROSC were 1.60--fold higher compared to the domicile location. Over 2-fold (2.056) higher odds of ROSC were observed in individuals with the ventricular fibrillation/pulsless ventricular tachycardia (VF/pVT) initial rhythm, compared to the Asystole/PEA. Obesity and diabetes decreased ROSC odds by approximately 10.6% and 3.5%, respectively. HT decreased these odds by approximately 3.4%, while acute coronary syndrome increased the odds by 15.1%. Neither sex nor stroke or HF affected the odds of ROSC (p: 0.079, 0.721, 0.367, respectively).

The derived multivariate model (Tab. 3A) utilized the information on initial rhythm ($p < 0.001$), age ($p < 0.001$), OHCA location ($p < 0.001$) and obesity ($p \approx 0.023$). The VF/pVT OHCA initial rhythm showed approximately 1.92-fold lower ROSC odds than the VF/pVT initial rhythm. A one-year increase in age decreased these odds by approximately 1.01%. Obesity decreased the odds by approximately 8.70%.

Factors of ROSC depending on obesity status

After splitting the population sample based on obesity status (Tab. 2), both strata showed an association between the odds of ROSC and age ($p < 0.001$), OHCA location ($p < 0.001$), and initial rhythm ($p < 0.001$). A one-year increase in age decreased the odds by approximately 1.94% in patients without obesity and 2.35% in patients with obesity. If the incident occurred in a public place, the odds for ROSC increased by approximately 60.1% and 55.8% (compared to the domicile location) in nonobese and obese individuals, respectively. Likewise, as shown in the whole dataset, the VF/pVT initial rhythm was associated with higher odds of ROSC compared to the Asystole/PEA in nonobese (2.065-fold higher odds) and obese (1.652-fold higher odds) individuals. The difference between the nonobese and obese strata lay in the association between the odds of ROSC and stroke (45.1% increase in the odds in the obese, no association in the nonobese), HT (no association in the obese, 3.1% decrease in the odds in the nonobese) and acute coronary syndrome (no association in the obese, 15.3% increase in the odds among the nonobese). Results of univariate logistic regression measuring the odds of ROSC after stratification by obesity status (only the significant ORs) are shown in Figure 2.

Table 1. The univariate association between selected factors and the odds of return of spontaneous circulation (ROSC) in the whole population sample

Variable	Desc. Stat.	ROSC: No	ROSC: Yes	p value	OR	OR — 95%	OR 95%
Age	n	21431	11924	< 0.001	0.981	0.980	0.983
	Mean ± SD	69.37 ± 15.08	65.01 ± 17.07				
Sex: male	n (column %)	13818 (63.98)	7818 (64.94)	0.079	1.021	0.998	1.045
Location — a public place: Yes	n (column %)	2914 (13.49)	3435 (28.53)	< 0.001	1.600	1.556	1.645
Initial rhythm: VF/pVT	n (column %)	932 (4.32)	1927 (16.01)	< 0.001	2.056	1.973	2.141
Obesity: Yes	n (column %)	730 (3.38)	335 (2.78)	0.003	0.905	0.847	0.966
Diabetes: Yes	n (column %)	3504 (16.22)	1843 (15.31)	0.028	0.966	0.937	0.996
Stroke: Yes	n (column %)	1157 (5.36)	656 (5.45)	0.721	1.009	0.961	1.060
Hypertension: Yes	n (column %)	4879 (22.59)	2582 (21.45)	0.015	0.967	0.941	0.994
Heart failure: Yes	n (column %)	1801 (8.34)	970 (8.06)	0.367	0.981	0.942	1.022
Acute Coronary Syndrome: Yes	n (column %)	776 (3.59)	566 (4.70)	< 0.001	1.151	1.089	1.216

CI — confidence interval; n — number of patients; OR — odds ratio; VF/pVT — ventricular fibrillation/pulseless ventricular tachycardia

The multivariate models (Tab. 3B, 3C) utilized the information on age, OHCA initial rhythm and location, regardless of obesity status. Additionally, the model analyzed for obese individuals used the information on stroke incidence ($p \approx 0.005$). The adjusted ORs in the nonobese or obese strata were 0.263 or 0.443 (Asystole/PEA vs VF/pVT), 0.986 or 0.981 (upon increase in age by one year), and 2.158 or 2.101 (a public place vs at home), respectively. Obese individuals who suffered from stroke were of approximately 2.047-fold higher odds of ROSC. Results of multivariate logistic regression models measuring the odds of ROSC (only the significant ORs) are shown in Figure 3.

DISCUSSION

Out-of-hospital cardiac arrest remains the most critical condition in EMS practice, and the prognosis of a patient with this condition remains poor. With the growing problem of obesity worldwide, paramedics are encountering an increasing number of patients with obesity in the line of duty [14]. The main aim of this study was to assess the impact of obesity on ROSC in patients with OHCA. Obesity was a significant predictor of ROSC in univariate and multivariate models. In multivariate analysis among the entire population sample, the odds of ROSC increased when OHCA occurred in a public place and decreased when the initiating rhythm was asystole/PEA and with increasing patient age. This phenomenon was observed in all patients and when patients were divided into groups of those with and without obesity. These findings are well-known and are supported by the results of previous studies [15–19]. In a multivariate analysis in the group that included all patients, obesity was a significant predictor and reduced the odds of ROSC by 8.2%. Since obesity is associated with many diseases, such as CVD, this finding may be not surprising [20]. The results on the impact of obesity on ROSC are inconsistent. Some studies show that patients with obesity were relatively younger and more likely to present with shockable initial rhythms, which could be explained by a higher incidence of prehospital ROSC [21–23]. Performing high-quality CPR on patients with obesity can be difficult for several reasons, including the increased anterior-posterior dimension of the chest [24]. Secobame et al. pointed out that the presence and distribution of adipose tissue around the chest (quantified by computed tomography at an average of 36.53 mm anteriorly and 50.73 mm posteriorly) in this group of patients may reduce compression efficacy [25]. Obesity can also cause difficulties in managing airway patency and restoring a normal heart rhythm in inpatients requiring defibrillation [26, 27]. The authors of some studies have found that obesity (measured by body mass index) after OHCA is associated with better outcomes in sudden cardiac arrest (SCA) survivors. They refer to this as

Table 2. The univariate association between selected factors and the odds of return of spontaneous circulation (ROSC) in the context of variable obesity status

Variable	Desc. Stat.	Obesity: No						Obesity: Yes					
		ROSC: No	ROSC: Yes	p value	OR	OR — 95%	OR 95%	ROSC: No	ROSC: Yes	p value	OR	OR −95%	OR 95%
Age	n	20709	11592	< 0.001	0.981	0.980	0.983	722	332	< 0.001	0.977	0.969	0.985
	Mean±SD	69.36 ± 15.10	64.96 ± 15.18					69.61 ± 14.60	64.10 ± 16.32				
	Missing data	158	112					8	3				
Sex: male	n [column %]	13384 [64.14]	7612 [65.04]	0.104	1.020	0.996	1.044	434 [59.45]	206 [61.49]	0.528	1.044	0.914	1.192
Location — a public place: Yes	n [column %]	2818 [13.51]	3345 [28.58]	< 0.001	1.601	1.556	1.647	96 [13.15]	90 [26.87]	< 0.001	1.558	1.325	1.831
Initial rhythm: VF/pVT	n [column %]	903 [4.33]	1893 [16.17]	< 0.001	2.065	1.982	2.153	29 [3.97]	34 [10.15]	< 0.001	1.652	1.278	2.136
Diabetes: Yes	n [column %]	3181 [15.24]	1701 [14.53]	0.085	0.972	0.942	1.004	323 [44.25]	142 [42.39]	0.570	0.963	0.845	1.097
Stroke: Yes	n [column %]	1121 [5.37]	623 [5.32]	0.850	0.995	0.946	1.047	36 [4.93]	33 [9.85]	0.002	1.451	1.135	1.856
Hypertension: Yes	n [column %]	4509 [21.61]	2410 [20.59]	0.031	0.970	0.943	0.997	370 [50.68]	172 [51.34]	0.841	1.013	0.890	1.153
Heart failure: Yes	n [column %]	1651 [7.91]	895 [7.65]	0.392	0.982	0.941	1.024	150 [20.55]	75 [22.39]	0.494	1.056	0.903	1.235
Acute Coronary Syndrome: Yes	n [column %]	738 [3.54]	544 [4.65]	< 0.001	1.153	1.090	1.220	38 [5.21]	22 [6.57]	0.371	1.131	0.863	1.483

CI — confidence interval; n — number of patients; OR — odds ratio; VF/pVT — ventricular fibrillation/pulseless ventricular tachycardia

Table 3. The multivariate association between selected factors and the odds of return of spontaneous circulation (ROSC): in the whole population sample (A), among the nonobese (B) and obese (C) only

(A) Whole population sample; algorithm: stepwise regression, p value cut-off: 0.05									
Effect (variable)	Reference category	Tested category	β	β SE	Wald statistic	p value	OR	OR — 95% CI	OR 95% CI
β_0 (intercept)	–	–	1.049	0.065	264.29	< 0.001	2.854	2.515	3.239
Initial rhythm	VF/pVT	Asystole/ PEA	−0.662	0.021	960.87	< 0.001	0.516	0.494	0.538
Location: a public place	No	Yes	0.384	0.015	668.27	< 0.001	1.468	1.426	1.512
Age	–	–	−0.014	0.001	313.28	< 0.001	0.986	0.985	0.988
Obesity	No	Yes	−0.079	0.035	5.18	0.023	0.924	0.863	0.989
(B) Nonobese individuals; algorithm: stepwise regression, p value cut-off: 0.05									
Effect (variable)	Reference category	Tested category	β	β SE	Wald statistic	p value	OR	OR — 95% CI	OR 95% CI
β_0 (intercept)	–	–	1.406	0.068	423.66	< 0.001	4.078	3.567	4.663
Initial rhythm	VF/pVT	Asystole/ PEA	−1.337	0.043	953.12	< 0.001	0.263	0.241	0.286
Location: a public place	No	Yes	0.769	0.030	649.43	< 0.001	2.158	2.034	2.290
Age	–	–	−0.014	0.001	295.91	< 0.001	0.986	0.985	0.988
(C) Obese individuals; algorithm: stepwise regression, p value cut-off: 0.05									
Effect (variable)	Reference category	Tested category	β	β SE	Wald statistic	p value	OR	OR — 95% CI	OR 95% CI
β_0 (intercept)	–	–	1.086	0.397	7.49	< 0.001	2.962	1.361	6.445
Location: a public place	No	Yes	0.743	0.171	18.92	< 0.001	2.101	1.504	2.936
Age	–	–	−0.019	0.004	18.590	< 0.001	0.981	0.972	0.989
Initial rhythm	VF/pVT	Asystole/ /PEA	−0.815	0.272	8.98	0.002	0.443	0.260	0.754
Stroke	No	Yes	0.716	0.258	7.71	0.005	2.047	1.235	3.395

CI — confidence interval; OR — odds ratio; PEA — pulseless electrical activity; VF/pVT — ventricular fibrillation/pulseless ventricular tachycardia

the "obesity paradox" [28, 29]. This phenomenon has also been repeatedly described in life-threatening conditions that can lead to SCA, such as ACS or HF [30]. The authors explain that this phenomenon may be influenced by age — patients with obesity are often younger (in our analysis, the people with obesity in whom ROSC was obtained were also younger) [31]. Additionally, previous diagnosis and treatment, for example, of CVD (obese people are more likely to undergo preventive screening), could also play a role in this phenomenon [20]. In patients admitted to intensive care, adipose tissue can serve as a nutrient when metabolism increases rapidly [32]. However, the claim is most commonly used when BMI is used to assess obesity, which has many limitations, such as not differentiating between obesity phenotypes and not taking into account body composition (amount of body fat, muscle tissue) or edemaedema in patients with HF [33]. Sharma et al. [34] rightly pointed out that in most cases, a more appropriate name for this phenomenon is the 'BMI paradox'. Recent studies, both in patients after OHCA and in other life-threatening conditions, suggest that the 'obesity paradox' does not exist and that the protective effect of obesity should not be considered [35, 36]. Taking into account all the possible consequences of obesity (both problems with life support and health complications), the ERC guidelines rightly emphasize the need for CA prevention, including early detection and treatment

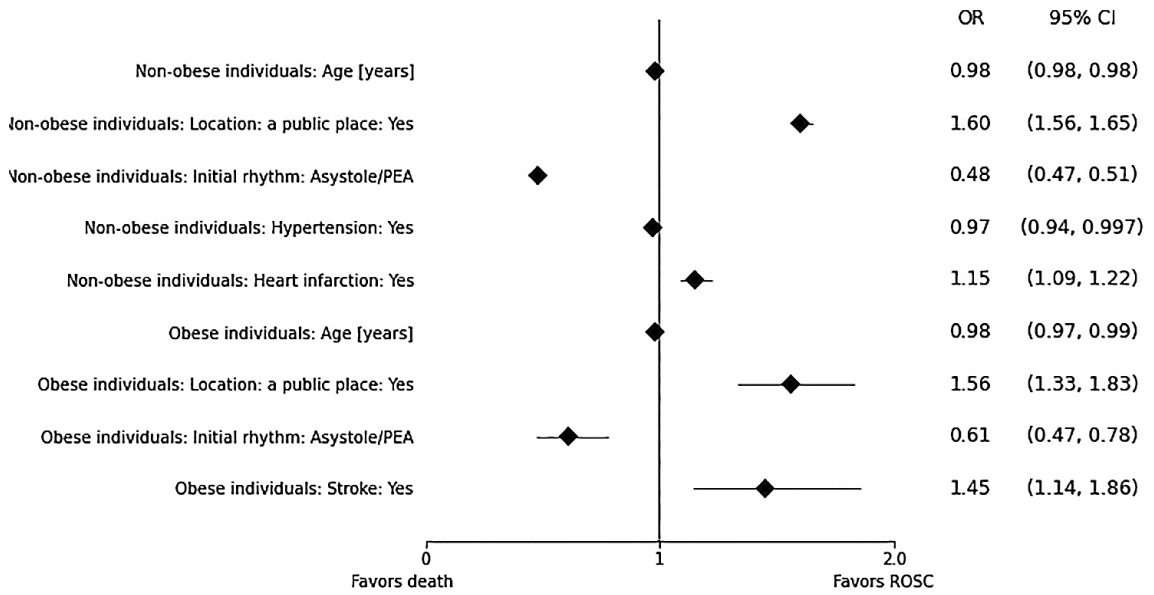

FIGURE 2. Univariate odds ratios (ORs) associated with return of spontaneous circulation (ROSC); CI — confidence interval

of, for example, coronary heart disease, with which obesity is strongly correlated [1, 37]. In multivariate analysis among patients with obesity, there was a higher chance of ROSC among individuals who suffered from stroke. There are reports in which patients with OHCA in the etiology of stroke had a higher chance of ROSC but a lower chance of favorable neurological outcome and even 30-day survival in relation to cardiac etiology [38]. However, due to limited data from the medical records of the OHCA cases studied, this result should be interpreted highly cautiously and requires further prospective studies in this area.

Study limitation

The limitations of this study are related to its retrospective nature and the database characteristics used. First, data on comorbidities, for example, are uncertain because in many cases, the ambulance service may not have had contact with the family witnesses to the incident or access to the patient's medical history. For example, it is not possible to determine from the medical records examined whether the stroke occurred immediately before the OHCA or whether it was in the past. No specific field in the emergency medical record indicates whether witnesses to the incident started CPR before the team arrived or how long CPR lasted, so it was impossible to include this parameter in the analysis. The medical records were anonymous, so looking at long-term survival was impossible. A strength of the study was undoubtedly the large sample size, which included the entire Polish population.

CONCLUSIONS

In the study population of out-of-hospital cardiac arrest patients, obesity significantly predicted the odds of the prehospital return of spontaneous circulation, reducing the odds by 8.2%. In the overall study population and the groups of patients with and without obesity, cardiac arrest in public places and VF/pVT initiating rhythm were predictors of increased odds of return of spontaneous circulation and older age reduced these odds. Studies on the obesity status of OHCA patients need to be further investigated.

Article information and declarations

Data availability statement

The selected range of data and materials is available after direct contact with the correspondence author.

Ethics statement

The study was conducted following the principles of the Declaration of Helsinki and was approved by the independent Bioethics Committee of Wrocław Medical University (No. KB-776/2022). The study followed the STROBE guidelines (Strengthening the Reporting of Observational Studies in Epidemiology).

Author contributions

Conceptualization, P.F. and M.C.; methodology, P.F., Ł.L. and M.C.; software, P.F.; validation, P.F.; formal analysis, P.F., Ł.L. and M.C.; investigation, P.F.; resources, P.F. and J.S.; data curation, P.F. and J.S.; writing — original draft preparation, P.F., Ł.L., M.C., I.U. and J.S.; writing — review and editing, P.F., J.S. and M.C.; visualization, P.F. and Ł.L.; supervision, M.C.; project administration, P.F. and M.C.; funding acquisition J.S and M.C. All authors have read and agreed to the published version of the manuscript.

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Not applicable.

Conflict of interest

None of the authors has declared a conflict of interest.

Supplementary material

None.

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