Body Mass Index

Subjects: Emergency Medicine

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Increased body mass index (BMI) is a risk factor for cardiovascular disease, stroke, and metabolic diseases. A high BMI may affect outcomes of post-cardiac arrest patients, but the association remains debatable.

body mass index obesity heart arrest cardiopulmonary resuscitation patient outcome assessment meta-analysis

1. Introduction

High BMI may affect the outcomes of post-cardiac arrest patients. Oxygen consumption, carbon dioxide production, and the risk of rapid desaturation are increased in obese patients [1]. Surgical airway and endotracheal intubation as well as bag-mask ventilation can be difficult in obese patients [2]. Proper hand position and compression depth for high-quality chest compressions may be changed in obese cardiac arrest patients [3]. All of these factors may influence the outcomes of obese cardiac arrest patients compared with those in patients with a normal BMI.

However, previous evidence has shown a U- or J-shaped relationship between better outcomes and BMI, termed the “obesity paradox” [4][5]. There is still a debate on the association between BMI and the outcomes in cardiac arrest patients [4][5]. Additionally, in the underweight population, increased risk of poor prognosis after cardiovascular disease may be associated with various clinical factors, such as aging, sarcopenia, and poor nutritional status [6]. Several previous studies have reported that a low BMI (underweight patient) is associated with poor outcomes in critically ill and post-cardiac-arrest patients [7][8][9].

Recent meta-analyses have shown an impact of BMI on the outcomes of post-cardiac-arrest patients, including both in-hospital (IHCA) and out-of-hospital cardiac arrests (OHCA) [10][11]. However, IHCA and OHCA patients differ in age, comorbidities, initial shockable rhythm, and time to resuscitation [12]. Based on these differences, IHCA patients have better outcomes than OHCA patients [12]. Ma et al. showed no difference in survival conditions with OHCA in the subgroup analysis between overweight or obese patients and normal-weight patients [11]. However, previous meta-analysis studies have various errors in data collection and meta-analysis procedures; for example, in one study, both IHCA and OHCA patients were recruited for subgroup analysis, the included population had different inclusion criteria, and the association between underweight status and outcomes in OHCA patients was not presented [11]. Moreover, several studies comparing the outcomes between BMI categories in OHCA patients have been reported recently [13][14].

Early prediction of outcomes in OHCA patients may help to decide appropriate management plan, such as targeted temperature management (TTM). To the best of our knowledge, a meta-analysis identifying the association between BMI and outcomes in patients with ROSC after OHCA has not been performed yet. Therefore, we focused on and compared the neurological and survival outcomes of OHCA in underweight, normal weight, overweight, and obese patients using a meta-analytical approach.

2. Testing

We followed the Meta-analysis of Observational Studies in Epidemiology and the Preferred Reporting Items for Systematic Reviews and Meta-analysis guidelines [15][16]. The protocol is registered at http://www.crd.york.ac.uk/PROSPERO/ (CRD42021220047).

The title, abstract, and study type of each study were examined by two reviewers (H.L. and H.S.). The exclusion criteria were as follows: irrelevant population (IHCA patients, patients without sustained ROSC), irrelevant outcome measure, irrelevant control group, reviews, case reports, editorials, conference abstracts, meta-analyses, reports with animal studies, or studies on pediatrics. Duplicate articles were excluded manually after comparing titles, authors, and year of publication of all identified studies. In case of a disagreement between the two reviewers, a third reviewer (J.O.) intervened, and differences were discussed until a consensus was reached. After eliminating the excluded abstracts, we acquired full-text versions of the selected articles, which were rescreened and evaluated more thoroughly for eligibility using the same inclusion and exclusion criteria.

Two reviewers (H.L. and H.S.) independently extracted the characteristics and results from the selected studies. The following variables were collected from all studies: the name of the first author; year of publication; the country where the study was conducted; inclusion period; study design; study population; number of patients with poor neurological outcome (PNO) and in-hospital mortality; BMI classification; assessment tool of neurological outcome measurement, such as the Cerebral Performance Category (CPC) score; and time points of outcome measurement. Patients were categorized according to the World Health Organization classification as underweight (<18.5 kg/m 2), normal weight (18.5–24.9 kg/m 2), overweight (25.0–29.9 kg/m 2), or obese (≥30 kg/m 2) [17]. The neurological outcome scores were divided into good or poor based on the CPC score (1–2: good neurological outcome; or 3–5: poor neurological outcome). We requested further information concerning the variables of interest that had not been described in the studies from the corresponding author via email. Studies with insufficient data despite contacting the authors were excluded.

In the main analysis, we examined the association between BMI and outcomes in patients with ROSC after OHCA. The strength of the association between BMI and outcomes was calculated as a risk ratio (RR) with a 95% confidence interval (CI) and presented using forest plots. There are two types of statistical models in meta-analysis: random-effects model and fixed effects model. In this study, the random-effects model was used to synthesize the individual data of the included studies, considering variations from the diversity of countries and inclusion periods [18]. Heterogeneity in meta-analysis occurs when observed intervention effects is more different from each other than one would expect due to random errors alone [19]. To measure and quantify heterogeneity, the proportion of between-study inconsistencies using I 2 tests was estimated, with values of 25%, 50%, and 75% considered to be low, moderate, and high, respectively [20]. Subgroup analysis was performed to investigate the potential causes of heterogeneity based on study quality (high quality study vs. low quality study).

The main attributes of all the studies are shown in **Table 1**, and the characteristics of included patients are presented in Supplementary Table S2 . All studies had neurological outcomes as the main outcome measurement, and five studies recorded in-hospital mortality as a patient outcome. The six studies included a total of 2427 patients, with 1639 (67.5%) of those patients having poor neurological outcomes. Of a total of 1910 patients from five studies, 1084 (56.8%) patients had in-hospital mortalities. All the studies assessed neurological outcomes according to the CPC scale. Of the six included studies, five were multicenter, and one was a single-center observational study. The time point of neurological outcome measurement at or after hospital discharge is shown in **Table 1**.

Table 1. Study characteristics.

Author.	Year	Country	Inclusion Period	Study Type	Sample Size	PNO, *n* (%)	Mortality, *n* (%)	BMI Classification	Time Point of Neurologic Outcome Assessment
Aoki	2018	Japan	2012	mPOS	517	36/46 (78.3) 251/331 (75.8) 79/108 (73.2) 30/32 (93.8)	NR	Underweight (<18.5) Normal (18.5–24.9) Overweight (25.0–29.9) Obese (≥30.0)	1 month
Bunch	2007	USA	1990–2006	mPOS	213	37/68 (54.4) 42/78 (53.9) 35/67 (52.2)	37/68 (54.4) 42/78 (53.9) 35/67 (52.2)	Low to normal weight (<25) Overweight (25–30) Obese (>30)	at hospital discharge
Chen	2021	USA	2011–2018	mROS	261	6/6 (100) 60/79 (75.9) 58/88 (65.9) 61/88 (69.3)	5/6 (83.3) 36/79 (45.6) 47/88 (53.4) 56/88 (63.6)	Underweight (<18.5) Normal (18.5–24.9) Overweight (25.0–29.9) Obese (≥30.0)	at hospital discharge
Galatianou	2017	Greece	2014	sPOS	13	0/1 (0.0)	0/1 (0.0)	Normal (<25) Elevated BMI	at ICU discharge

Author.	Year	Country	Inclusion Period	Study Type	Sample Size	PNO, *n* (%)	Mortality, *n* (%)	BMI Classification	Time Point of Neurologic Outcome Assessment
						5/12 (41.7)	5/12 (41.7)	(≥25)	
Geri	2016	France	2005–2012	mPOS	818	21/25 (84.0) 237/352 (67.3) 164/238 (68.9) 114/136 (83.8)	20/27 (74.1) 227/377 (60.2) 159/264 (60.2) 113/150 (75.3)	Underweight (<18.5) Normal (18.5–25) Overweight (25–30) Obese (>30)	at ICU discharge
Lee	2021	Korea	2015–2018	mPOS	605	64/75 (85.3) 213/333 (64.0) 107/163 (65.6) 19/34 (55.9)	47/75 (62.7) 157/333 (47.1) 82/163 (50.3) 16/34 (47.1)	Underweight (<18.5) Normal (18.5–25) Overweight (25–30) Obese (≥30)	at hospital discharge

Abbreviations, PNO, poor neurologic outcome; BMI, body mass index; TTM, targeted temperature management; mPOS, multi-center prospective observational study; NR, not reported; CPC, cerebral performance categories; sPOS, single-center prospective observational study; ICU, intensive care unit.

Of the six studies included in this study, three studies were rated as low-quality studies using the quality scoring system defined in the Methods section [21][22][23]. The major factors that affected study quality were attrition bias by incomplete outcome data and reporting bias. The risk of bias assessment of the studies is summarized in Supplementary Figure S1 .

Subgroup analysis was performed according to the quality of study (three studies, high quality; one study, low quality). Neurological outcomes in underweight patients were significantly poorer than those in normal-weight patients in the high-quality studies (RR = 1.29; 95% CI = 1.18–1.42; $p < 0.001$; I^2 = 0%).

Additionally, underweight patients had increased mortality (RR = 1.28; 95% CI = 1.12–1.47; $p < 0.001$; I^2 = 0%) compared with patients who were not underweight (normal-to-obese). Obese patients had decreased mortality (RR = 0.87; 95% CI = 0.76–1.00; $p = 0.04$; I^2 = 38%) compared with patients who were not obese (underweight-to-overweight). However, there was no significant difference in mortality between underweight-to-normal weight and overweight-to-obese patients ($p = 0.11$) (**Figure 5**).

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