Resuscitation Plus 20 (2024) 100820

Contents lists available at ScienceDirect

Resuscitation Plus

journal homepage: www.elsevier.com/locate/resuscitation-plus

# Cardiopulmonary resuscitation in obese patients: A scoping review

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ARTICLE INFO

*Keywords:*
Cardiopulmonary Resuscitation
Heart arrest
CPR
Obesity
Body Mass Index

ABSTRACT

*Background:* Given the increasing global prevalence of obesity, the International Liaison Committee on Resuscitation (ILCOR) commissioned this scoping review to explore current evidence underpinning treatment and outcomes of obese patients (adult and children) in cardiac arrest.

*Methods:* This scoping review, conducted using Arksey and O'Malley's framework and reported according to PRISMA-ScR guidelines, included studies of CPR in obese patients. 'Obese' was defined according to each individual study. Medline, EMBASE and Cochrane were searched from inception to 1 October 2024. Narrative synthesis was guided by Synthesis Without Meta-Analysis (SWiM) reporting guidelines.

*Results:* 36 studies were included: 2 paediatric and 34 adult studies. Fourteen studies reported on out-of-hospital cardiac arrest (OHCA), 12 on in-hospital cardiac arrest (IHCA), eight on both OHCA and IHCA: cardiac arrest location was not reported in two studies. The most common outcomes were survival (n = 29), neurological outcome (n = 17) and ROSC (n = 7). In adults there were variable results in neurological outcome, survival to hospital discharge, longer term survival (months to years), and ROSC. In children, there were two studies suggesting that obese children had worse neurological outcomes, lower survival and lower ROSC than normal weight children. Few studies reported resuscitation quality indicators or techniques, and no studies reported adjustments to CPR techniques.

*Conclusion:* The variability in results does not suggest an urgent need to deviate from standard CPR protocols, however there was some evidence that CPR duration may be longer in obese adults, which may have staffing and resource implications.

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https://doi.org/10.1016/j.resplu.2024.100820
Received 16 October 2024; Accepted 26 October 2024

## Introduction

The global prevalence of obesity is increasing: one-billion people across the world now classified as obese.[1] Obesity is an important cause of premature death through its association with cardiovascular disease, diabetes mellitus, and cancer,[2] which are known to increase the incidence of cardiac arrest and poor cardiac arrest outcomes.[3] For obese patients in cardiac arrest, anatomical differences may make it challenging to deliver key cardiac arrest interventions such as high-quality chest compressions, ventilations, vascular access and medications.[4,5] Obesity may also influence the efficacy of defibrillation due to increased transthoracic impedance, and challenges in implementing alternative defibrillation strategies that require rolling of the patient.[4] In some cases, there may be delays in transfer to hospital due to the need for additional personnel or special equipment to facilitate movement to the ambulance.[6].

Given the increasing prevalence of global obesity and specific challenges in treating this patient cohort, the international resuscitation community highlighted the need to summarise the evidence to inform decisions regarding cardiac arrest treatment strategies in obese patients. On this basis, the International Liaison Committee on Resuscitation (ILCOR) Basic Life Support; Paediatric Life Support; Advanced Life Support; and Education, Implementation and Teams Task Forces commissioned this scoping review to explore current evidence underpinning treatment and outcomes of obese patients (adult and children) in cardiac arrest. A scoping rather than systematic review was conducted as the breadth of research regarding CPR in obese patients is unknown. Systematically mapping the published, peer reviewed literature enabled accurate description of what is known, identification of knowledge gaps, and highlighted future research priorities, including potential topics for future systematic reviews.[7] The aim of this scoping review was to explore the published research evidence related to cardiopulmonary resuscitation in obese patients (adults and children).

## Methods

The scoping review was registered *a priori* with ILCOR (see supplementary material). Conflict of interest was managed in accordance with ILCOR guidelines. Where a reviewer was an author of a particular paper, the decision to include that study and data extraction were undertaken by other members of the review group. This scoping review was guided by Arksey and O'Malley's methodological framework[7] and reported according to the Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for scoping reviews (PRISMA-ScR).[8] Synthesis was guided by Synthesis Without Meta-Analysis (SWiM) reporting guidelines[9] and a narrative synthesis method. As this was a scoping review, ethics approval was not required.

### *Eligibility criteria*

The inclusion criteria were studies: i) of adults or children in cardiac arrest in any setting, ii) who were obese, iii) with or without a comparator of normal weight patients or modified CPR, and iv) that reported one or more patient outcomes (neurological outcome, survival, return of spontaneous circulation (ROSC)): CPR quality measures (chest compression rate, chest compression depth, ventilation rate, tidal volume, time to interventions); CPR techniques (chest compressions, defibrillation, ventilation and airway management, vascular access); health-related quality of life; or provider outcomes (such as safety, manual handling, fatigue). Randomised controlled trials (RCTs) and non-randomised studies (non-randomised controlled trials, interrupted time series, controlled before-and-after studies, cohort studies) were eligible for inclusion. Case reports, animal and manikin studies were excluded, as were opinion pieces, conference abstracts, trial protocols and grey literature. All years and languages were included if there was an English abstract. At the time of this review, there was no universal definition of obesity so for the purposes of this scoping review, 'obese' was defined according to each individual study.

### *Information sources and search strategy*

MEDLINE, Excerpta Medica Database (EMBASE) and Cochrane databases were searched from inception to 1 October 2024. The search strategy was developed in consultation with a medical information specialist (Deakin University, Victoria, Australia) using the concepts of: i) obesity and ii) cardiac arrest and cardiopulmonary resuscitation (Appendix 1) and peer reviewed by members of ILCORs Basic Life Support; Paediatric Life Support; Advanced Life Support; and Education, Implementation and Teams Task Forces. Forward (searching for articles that cite included studies) and backward (search of reference lists of included studies) citation searching was also conducted.

### *Selection process*

Citations were uploaded into EndNote 20.0™ and duplicates removed. Title and abstract screening and full text screening were conducted by four pairs of researchers (title/abstract: JC and TK, JB and GO, RB and MS, NKC and KC / full text: JC and RG/KC, GO and NKC, RG and MS, TK and KC) using the Rayyan[10] software program and disagreements were resolved by discussion and consensus.

### *Data charting and data items*

Data were extracted by a single author (JC) and all data were checked for accuracy by co-authors. The following characteristics of each study were extracted: author(s); year of publication; country of origin; aim and study design; population, BMI groups; outcomes measured and main findings. Quality assessment of individual studies was not performed.

### *Synthesis methods*

Given the variation in study design, populations, and outcomes, the synthesis approach was guided by the Synthesis Without Meta-Analysis (SWiM) reporting guidelines[9] and narrative synthesis methods.[11] Interpretation of the synthesis was by discussion within the research team and resuscitation science experts from the ILCOR Task Forces.[12].

## Results

### *Study selection*

In total, 13,509 citations were retrieved, 96 full text publications were screened for eligibility, of which 36 were included (Fig. 1).

### *Study characteristics*

The characteristics of included studies are summarised in Table 1 (further details are presented in Supplementary Tables 1 to 7). There were 7 prospective studies,[13–19] 19 retrospective cohort[20-38] and 9 retrospective registry studies[39-47] and one secondary analysis of data from a randomised controlled trial.[48] Definitions of obesity varied between studies. BMI classifications were used in the majority of studies. The World Health Organization (WHO) Body Mass Index (BMI) criteria (weight in kilograms (kg) divided by square of height in metres ($m^2$)) was most commonly used in adults (underweight BMI $< 18.5$ kg/$m^2$; normal weight BMI 18.5–24.9 kg/$m^2$; overweight: BMI 25.0–29.9 kg/$m^2$; and obese: BMI $\geq 30$ kg/$m^2$) and children (underweight BMI $<$ 5th percentile; obese BMI $>$ 95th percentile).[49] Two studies[28,37] used the WHO BMI criteria for Asian populations.[50] Four studies treated BMI as a continuous variable.[19,26,35,38] In one study, obese patients were identified using the Agency for Healthcare Research and Quality-define co-

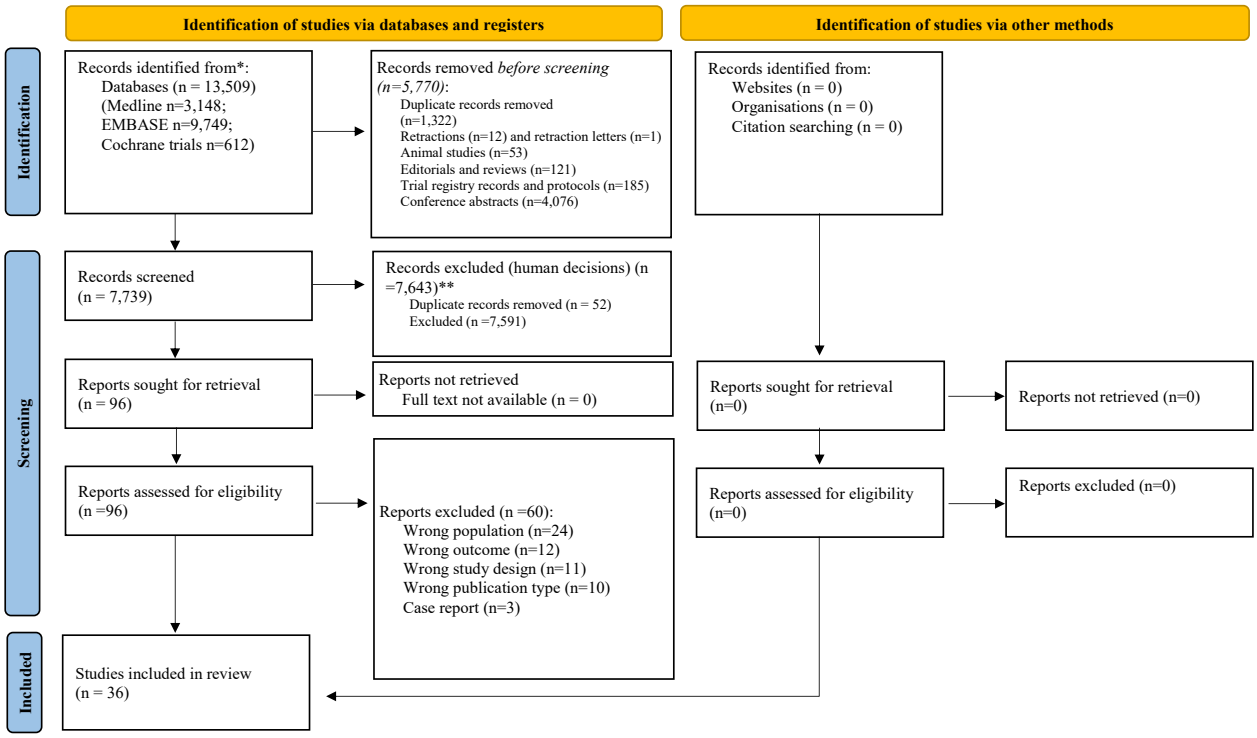


**Fig. 1.** Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) flow diagram.

morbidity measure (CM_Obese)[39] and in two studies, obesity was reported as a diagnosis with no BMI-values reported.[33,40].

The included studies, spanning over four decades (1978[51] to 2024[38]), were mostly from the United States (n = 14).[20,21,26,29,31–33,36,39,41,43-45,48] All but two studies were of adults patients (including one study of pregnant women[15]): there were two studies of children (OHCA[48] and IHCA[45]). Fourteen studies reported on OHCA,[13,14,16–18,21,23,24,29,30,36,40,42,48] 13 studies reported on IHCA,[15,26,27,32,33,35,37,39,41,43-46] eight studies reported on both OHCA and IHCA,[15,19,22,25,28,31,34,38] and in two studies, the cardiac arrest location was not reported.[20,47] Four studies were related to extracorporeal CPR.[27,29,31,42] The most common outcomes reported were survival (n = 29),[13,15-18,20-29,31-36,38-43,45,52] neurological outcome (n = 17)[13,14,18,19,21,24,27–31,34,35,42,45,48,52] and ROSC (n = 7).[33,36,40,41,43,45,46] Survival was reported at hospital admission (n = 1),[21] hospital discharge (n = 19),[15,18,20,22-25,27,31–33,35,36,38,40-42,44,45] ICU discharge (n = 2),[16,22] 24-hours (n = 1),[43] 6-months (n = 2),[28,34] 1-year (n = 2),[17,48] 4-years (n = 1)[29] and 5-years (n = 1).[21] Neurological outcome was reported at hospital admission (n = 1),[40] ICU admission (n = 1),[16] hospital discharge (n = 13),[18,19,21,24,27–29,31,35,36,42,43,45] 1-month (n = 5),[13,14,17,26,30] 3-months (n = 1),[26] 6-months (n = 1),[34] and 12-months (n = 1).[48] A summary of these outcomes is presented in Table 2 with further details in Supplementary Tables 1 to 3. Other outcomes reported were shock success,[36] extracorporeal membrane oxygenation (ECMO) complications,[42] acute resuscitation treatments,[41] CPR duration,[41] injuries sustained during CPR,[47] time to defibillation,[41] and number of shocks[41] (Supplementary Tables 4).

### *Neurological outcome*

Seventeen studies reported neurological outcome (Supplementary Table 1): 15 in adults and two in children. Both paediatric studies (OHCA[48] and IHCA[45]) reported that obese children had worse neurological outcomes at hospital discharge[45] and at 12-months,[48] than normal weight children. One adult study[34] of neurological outcome at 6 months (both OHCA and IHCA) showed no difference between obese and normal weight patients. Three adult studies reported neurological outcome at 1-month: compared to normal weight patients, obese patients were less likely to have favourable neurological outcome in two studies (OHCA[13,14]), and more likely to have favourable neurological outcome in the other study (OHCA[30]). Of the adult studies of neurological outcome at hospital discharge, compared with normal weight patients, five (OHCA,[18,21,24] IHCA,[27] both OHCA and IHCA[28]) reported no difference in obese patients, and six (OHCA,[29,42] IHCA,[35,37] both OHCA and IHCA[19,31]) reported obese patients had lower likelihood of favourable neurological outcomes.

### *Survival*

Twenty-nine studies reported survival (Supplementary Table 2). Five adult studies reported short term survival (survival to ICU admission/discharge or hospital admission). Compared to normal weight patients, one study (OHCA[16]) reported obese patients had higher survival to ICU admission. There were conflicting results regarding survival to ICU discharge (OHCA,[16] and both OHCA and IHCA[22]) and survival to hospital admission (OHCA[36,40]). Compared to normal weight patients, one study reported no difference in survival to ICU discharge[22] and one study reported obese patients had higher survival to ICU discharge;[16] one study reporting no difference in survival to hospital admission[36] and one study reported obese patients had lower survival to hospital admission.[40] The single study (IHCA[43]) of survival to 24 h reported no difference between obese and normal weight patients.[43].

The single paediatric study (IHCA)[45] reporting survival to hospital discharge, found that obese children had worse outcomes than normal weight children. Survival to hospital discharge was reported in 22 adult studies. Nine (OHCA,[18,21,24,36] IHCA,[27,43] both OHCA and IHCA[22,23,25]) reported no difference between obese and normal weight adults, nine (location unknown,[20] OHCA,[29,40,42] IHCA,[32,35,41] both OHCA and IHCA[31,38]) reported lower survival to hospital discharge in obese patients, and three (IHCA,[26,39] both OHCA and IHCA[15]) reported higher survival to hospital discharge in obese patients. One study (IHCA[33]) reported that obese patients had significantly higher survival to hospital discharge overall but subanalysis showed that survival to hospital

**Table 1**
Summary of included studies (n = 36).

| Author, Year, Country | Aim Study Design | Population | BMI groups | Outcomes reported |
|---|---|---|---|---|
| **PAEDIATRIC** | | | | |
| Meert et al. 2016 United States of America | Investigate relationships between cardiac arrest characteristics, and survival and neurobehavioral outcome among children recruited to the Therapeutic Hypothermia after Pediatric Cardiac Arrest Out-of-Hospital (THAPCA-OH) trial. Secondary analysis of data from randomised controlled trial | Children > 2 days and < 18 years) with OHCA (n = 295) and received TTM | BMI-for-age percentiles for children ≥ 2 years of age, and weight-for-length percentiles for children < 2 years of age | Neurological outcome: 12-months |
| Srinivasan et al. 2010 United States of America | Evaluate association between obesity and outcomes among children after IHCA Retrospective registry study | Patients (<18 years) with IHCA from January 2000 to July 2004 (n = 1,268) | Obese (n = 213, 17 %) <2 years: ≥95th weight-for-length percentile ≥2 years: ≥95th BMI-for-age | Favourable neurologic outcome: hospital discharge Survival: hospital discharge ROSC > 20 min |
| **ADULT** | | | | |
| Aoki et al. 2023 Japan | Assess association between BMI and neurological outcomes in OHCA Prospective, multicenter, observational study | Adult patients OHCA aged 16–64 years hospitalised after resuscitation (n = 637) | Normal weight: BMI 18.5–24.9 (n = 312; 48.9 %) Obese: BMI ≥ 30 (n = 80; 12.5 %) | Neurological outcome: 30 days Survival: 30-days |
| Aoki et al. 2018 Japan | Assess association between BMI and neurological outcomes in OHCA Prospective, multicenter, observational study | Adult patients (>18 years) with OHCA hospitalised after resuscitation (n = 1,326) | Normal weight: BMI 18.5–24.9 (n = 829; 62.5 %) Obese: BMI ≥ 30 (n = 106; 8.0 %) | Neurological outcome: 1-month |
| Beckett et al. 2017 United Kingdom | Describe incidence, risks, management and outcomes of cardiac arrest in pregnancy in the UK population Prospective, descriptive study | 66 women who received BLS in pregnancy (OHCA and IHCA) (n = 66) | BMI < 30 (n = 38; 60 %) BMI ≥ 30 (n = 25, 40 %) | Survival: hospital discharge |
| Breathett et al. 2016 Unites States of America | Hypothesized that BMI ≥ 30 is associated with higher risk of mortality than BMI < 30 after therapeutic hypothermia for cardiac arrest Retrospective cohort study | Adults who underwent therapeutic hypothermia following resuscitation (n = 164) CA location not reported | BMI < 30 (n = 96; 59 %) BMI ≥ 30 (n = 68, 41 %) | Survival: hospital discharge |
| Bunch et al. 2008 United States of America | Investigated outcomes of OHCA based on body weight Retrospective cohort study | Adults (not defined) with atraumatic OHCA transferred to a single receiving hospital (n = 213) | Low to normal with: BMI < 25 (n = 68; 32.9 %) Obese: BMI ≥ 30 (n = 67 31.5 %) | Neurological outcome: hospital discharge Survival: 5 years |
| Chavda et al. 2022 Australia | Estimate conditional and causal effects of obesity on mortality in cardiac arrest patients Retrospective cohort study | Adult ICU patients (>16 years) admitted with cardiac arrest (OHCA and IHCA) (n = 13,970) | Non-obese: BMI 18.5–29.9 (n = 9,212, 65.9 %) Obese: BMI ≥ 30 (n = 4,756, 34.1 %) | Survival: hospital discharge |
| Chavda et al. 2020 Australia | Explore association between obesity and outcome in patients following cardiac arrest Retrospective cohort study | Adult ICU patients (age not defined) admitted with cardiac arrest (IHCA and OHCA) with BMI data (n = 112) | Non-obese: BMI < 30 (n = 76, 67.8 %) Obese: BMI ≥ 30 (n = 36, 32.2 %) | Survival: hospital discharge |
| Chen et al. 2021 China | Determine impact of BMI on clinical outcomes in OHCA survivors treated with TTM Retrospective cohort study | Adult OHCA survivors who received TTM (n = 261) | Normal weight: BMI = 18.5–24.9 (n = 79, 30.2 %) Obese: BMI ≥ 30 (n = 88, 34.8 %) | Neurological outcome: hospital discharge Survival to hospital discharge |
| Czapla et al. 2023 Poland | Determine sex differences in prognostic impact of BMI on in hospital mortality in sudden cardiac arrest survivors. Retrospective cohort study | Adults (>18 years) admitted to ICU 2017 and 2022 who had survived an IHCA or OHCA (n = 129) | **Females** Normal weight: BMI = 18.5–24.9 (n = 4, 10.0 %) Obese: BMI ≥ 30 (n = 9, 22.5 %) **Males** Normal weight: BMI = 18.5–24.9 (n = 3, 3.4 %) Obese: BMI ≥ 30 (n = 21, 23.6 %) | Survival to hospital discharge |
| Danciu et al. 2004 United States of America | Identify the most important prognostic factors for survival from IHCA Retrospective cohort study | Adults (>18 years) who underwent IHCA CPR (n = 219) | BMI treated as a continuous variable | Survival: 3-months Survival: 1-month Survival: hospital discharge |
| Galatianou et al. 2017 Greece | Investigate association between BMI and outcome after OHCA in patients not treated with TTM Prospective observational study | Adults (>18 years) with OHCA transferred to ED (n = 84) | Normal BMI (BMI < 25) (n = 16, 19.1 %)Elevated BMI (BMI ≥ 25) (n = 68, 80.9 %) | Survival: ICU discharge Survival: ICU admission |
| Geri et al. 2016 France | Assess influence of BMI on day-30 and 1-year mortality of OHCA patients admitted to ICU Prospective cohort study | Adults admitted to ICU following OHCA and treated with TTM (n = 818) | Normal weight: BMI = 18.5–24.9 (n = 377, 46.1 %) Obese: BMI ≥ 30 (n = 150, 18.3 %) | Survival: 1-year Survival: 30-days |

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**Table 1** (*continued*)

| Author, Year, Country | Aim Study Design | Population | BMI groups | Outcomes reported |
|---|---|---|---|---|
| Gil et al. 2017<br>Italy | Examine association between BMI and clinical outcome in patients with ECPR<br>Retrospective cohort study | Adults with IHCA who had ECPR (n = 200) | Normal weight: BMI = 18.5–24.9 (n = 118, 59 %)<br>Obese: BMI ≥ 30 (n = 15, 7.5 %) | Neurological outcome: hospital discharge<br>Survival: hospital discharge |
| Gupta et al. 2016<br>United States of America | Examine association of obesity with survival to hospital in IHCA<br>Retrospective registry study | Adults (aged > 18 years) undergoing CPR for IHCA (n = 836,289) | Non-obese: n = 769,073 (92 %)<br>Obese: n = 67,216 (8.0 %)<br>Defined using AHRQ-defined co-morbidity measure: CM_Obese. | Survival: hospital discharge |
| Hjalmarsson et al. 2023<br>Sweden | Investigate if obesity, with or without diabetes, affects the survival of patients with OHCA<br>Retrospective registry study | Adults (aged ≥ 18 years) with OHCA (n = 55,483) | Obesity was reported as a diagnosis and no actual BMI-values were reported.<br>Patients were classified into five groups: Obesity only and Obesity and any diabetes are assumed to be obese<br>Type 2 diabetes, Type 1 diabetes and all other are assumed to be non-obese | Survival: hospital discharge<br>Survival: hospital admission<br>ROSC |
| Jain et al 2010<br>United States of America | Examine association between BMI and survival for patients with IHCA<br>Retrospective registry study | Adults (aged > 18 years) with IHCA (n = 21,237) | Normal weight: BMI = 18.5–24.9 (n = 6,935, 32.7 %)<br>Obese: BMI 30–34.9 (n = 3,412, 16.1 %)<br>Very obese: BMI ≥ 35 (n = 3,534, 16.6 %) | Survival: hospital discharge<br>ROSC<br>Acute resuscitation treatments<br>CPR duration<br>Time to defibrillation<br>Number of shocks |
| Jung et al. 2016<br>Korea | Explore association between obesity and clinical outcomes<br>Retrospective cohort study | Adult (aged > 18 years) cardiac arrest survivors (OHCA and IHCA) treated with TTM (n = 468: OHCA n = 378, IHCA n = 90) | Normal weight: BMI = 18.5–22.9 (n = 196, 41.8 %)<br>Obese: BMI ≥ 27.5 (n = 38, 8.2 %) | Neurological outcome: hospital discharge<br>Survival: 6-months |
| Kojima et al. 2023<br>Japan | Investigate association between BMI and clinical outcomes in patients receiving ECPR following OHCA<br>Retrospective registry study | Adults (age not reported) with OHCA of presumed cardiac aetiology who received ECPR (n = 1,044) | Normal weight: BMI = 18.5–24.9 (n = 559, 53.6 %)<br>Obese: BMI ≥ 30 (n = 109, 10.5 %) | Neurological outcome: hospital discharge<br>Survival: hospital discharge<br>ROSC<br>ECMO complications |
| Kosmopoulos et al. 2023<br>United States of America | Investigate effect of BMI on the survival to hospital discharge of refractory OHCA patients treated with ECPR<br>Retrospective cohort study | Adults (aged 56.9 ± 12.0 years) with OHCA and BMI data (n = 283) | Non-obese: BMI ≤ 30 (n = 150, 53.1 %)<br>Obese: BMI > 30 (n = 133, 46.9 %) | Neurological outcome: hospital discharge<br>Survival: 4-years<br>Survival: hospital discharge |
| Lee H et al. 2021<br>Korea | Investigate association between BMI and favourable neurologic outcomes and survival to discharge of patients resuscitated from OHCA<br>Prospective registry study | Adults (aged > 18 years) with OHCA (n = 605) transported to ED | Normal weight: BMI = 18.5- <25 (n = 333, 55.0 %)<br>Obese: BMI ≥ 30 (n = 34, 5.7 %) | Neurological outcome: hospital discharge<br>Survival: hospital discharge |
| Lee S et al. 2021<br>Korea | Investigate prognostic impact of high lean body mass on postcardiac arrest patients<br>Retrospective cohort study | Adults (not defined) treated with TTM and admitted to ICU following OHCA (n = 155) | Normal weight: BMI = 18.5–22.9 (n = 65, 42.0 %)<br>Obese: BMI ≥ 25 (n = 43, 27.7 %) | Neurological outcome: 1-month |
| Lewandowski et al 2024<br>Poland | Explored predictors of mortality among patients admitted to ICU following cardiac arrest<br>Retrospective cohort study | Adults (aged > 18 years) with non-traumatic cardiac arrest (OHCA and IHCA) (n = 161: Asystole/PEA n = 90; VF/pVT n = 71) | BMI treated as continuous variable | Survival: hospital discharge |
| Ogunnaike et al. 2016<br>United States of America | Examine association between BMI, defibrillation success, and survival outcomes of VT/VF arrest<br>Retrospective registry study | Adults (not defined) with VF/VT IHCA (n = 7,110) | Normal weight: BMI = 18.5–24.9 (n = 2,061, 29.0 %)<br>Obese: BMI 30–34.9 (n = 1,296, 18.2 %)<br>Extremely obese: BMI ≥ 35 (n = 1,310, 18.4 %) | Survival: 24 h<br>Survival: hospital discharge<br>ROSC ≥ 20 min<br>First shock termination of VF/VT |
| Patlolla et al. 2021<br>United States of America | Understand differences in AMI complicated IHCA across BMI categories | Adults (>18 years) with primary diagnosis of AMI with IHCA (n = 314,609) | Normal weight: BMI = 20 − <24.9 (n = 268,764, 81.1 %)<br>Overweight / obese: BMI ≥ 25 (n = 44,053, 18.4 %) | Survival: hospital discharge |
| Shurr et al. 2021<br>United States of America | Describe the survival, non-neurologic, and neurologic outcomes in patients with cardiac arrest (OHCA or IHCA) with CPR and VA-ECMO support<br>Retrospective cohort study | Patients with cardiac arrest with CPR and VA-ECMO support (n = 89) following OHCA or IHCACannulated either after ROSC<br>(n = 39) or during ongoing cardiac arrest (n = 50) | Non-obese: BMI < 30 (n = 53, 59.6 %)<br>Obese: BMI ≥ 30 (n = 36, 40.4 %) | Neurological outcome: hospital discharge<br>Survival: hospital discharge |
| Shahreyer et al. 2017 | Assess impact of morbid obesity on outcomes in patients with IHCA | Adults (≥18 years) with IHCA (non-VF arrest, n = 26,412; VF arrest = 5,192) | Non-VF arrest<br>Morbidly obese: BMI ≥ 40 (n = 13,633, 51.6 %) | Survival: hospital discharge |

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**Table 1** (*continued*)

| Author, Year, Country | Aim Study Design | Population | BMI groups | Outcomes reported |
|---|---|---|---|---|
| United States of America | Retrospective national database study with matched samples | | Non-obese: BMI < 30 (n = 12,779, 48.4 %)<br>VF arrest<br>Morbidly obese: BMI ≥ 40 (n = 2,676, 51.5 %)<br>Non-obese: BMI < 30 (2,516, 48.5 %) | |
| Swindell et al 2021<br>United States of America | Formulate an ABCD score based on four high-yield predictors to predict post-CPR survival probability<br>Retrospective cohort study | IHCA in patients aged > 50 years from 2012 to 2015 (n = 463,530) | Normal weight (not defined) (n = 381715, 82.3 %)<br>Obese patients: ICD-9/10 diagnosis codes containing word 'obesity' and/or codes specifying BMI ≥ 30 (n = 70395, 15.2 %) including 33,995 morbidly obese patients (not defined) | Survival: hospital discharge<br>ROSC |
| Testori et al. 2021<br>Austria | Examine effect of obesity on outcome after cardiac arrest Retrospective cohort study | Adults with non-traumatic cardiac arrest (OHCA or IHCA) and ROSC admitted to the ED between January 1992 and December 2007 (n = 1,915) | Normal weight: BMI 18.5–24.9 (n = 768, n = 40 %)<br>Obese: BMI ≥ 30 (n = 329, 17 %) | Neurological outcome: 6 months<br>Survival: 6 months |
| Wang et al 2020<br>Taiwan | Investigate association between central obesity and outcomes following IHCA<br>Retrospective cohort study | Adults with IHCA during 2006–2015 (n = 648) | Normal weight: BMI 18.5–23 (n = 268, n = 41.4 %)<br>Obese: BMI ≥ 27.5 (n = 91, 14.0 %) | Neurological outcome: hospital discharge<br>Survival: hospital discharge |
| Wang et al 2018<br>Taiwan | Investigated whether body size correlates with outcomes of IHCA<br>Retrospective cohort study | Adults with IHCA 2006 to 2015 and sustained ROSC > 20 min (n = 766) | BMI treated as continuous variable | Neurological outcome: hospital discharge<br>Survival: hospital discharge |
| Wang et al. 2023<br>China | Secondary analysis of National Emergency Cardiac Arrest Treatment (NECAT) database data<br>Retrospective registry study | Adults (≥18 years) with non-traumatic IHCA CA (in ED), time from collapse to CPR > 10 min, and no DNR order (n = 535: cardiac origin n = 179 and non-cardiac origin n = 356) | BMI < 25 (n = 355, 66.4 %: cardiac origin n = 129, non-cardiac origin n = 226)<br>BMI ≥ 25 (n = 180, 33.6 %: cardiac origin n = 50, non-cardiac origin n = 130) | ROSC |
| Wannasri et al. 2021<br>Thailand | Examine prevalence of internal organ injuries sustained from CPR<br>Retrospective registry study | Adults (≥18 years) that died following cardiac arrest and received an autopsy, without trauma to chest and abdomen from 2012 to 2016 (n = 154) | Normal weight: BMI 18.5–22.9 (n = 38, 24.7 %)<br>Obese: BMI 25.0–29.9 (n = 45, 29.2 %)<br>Morbidly obese BMI ≥ 30 (n = 35, 22.7 %) | Injuries sustained during CPR |
| White et al. 2004<br>United Stated of America | Examine influence of body weight on defibrillation, resuscitation, and survival in patients with OHCA requiring defibrillation<br>Retrospective cohort study | Patients (66 ± 14 years) with OHCA, received defibrillation with non-escalating, impedance-compensating, 150-J biphasic waveform defibrillator (n = 62) | Underweight or normal weight: BMI < 25 (31 %)<br>Obese: BMI ≥ 30 (24 %)<br>Extremely obese BMI ≥ 40 (4 %) | Survival: hospital admission<br>Survival: hospital discharge<br>ROSC<br>Shock success |
| Wolff et al. 2009<br>Sweden | Examined effect of rapid mild therapeutic hypothermia (time to target temperature and time to coldest temperature) on cardiac arrest outcome<br>Prospective cohort study. | Adults with OHCA or IHCA with ROSC > 5 min within 60 min of cardiac arrest, time to CPR < 20 min and comatose post −arrest state (n = 49) | BMI treated as continuous variable | Neurological outcome: hospital discharge |

AHRQ = Agency for Healthcare Research and Quality; AMI = acute myocardial infarction; BMI = Body mass index kg/m2, CA = cardiac arrest; DNR = do not resuscitate; ECMO = extracorporeal membrane oxygenation; ECPR = extracorporeal cardiopulmonary resuscitation; ICU = intensive care unit, IHCA = in-hospital cardiac arrest; OHCA = out-of-hospital cardiac arrest; pVT = pulseless ventricular tachycardia; ROSC = return of spontaneous circulation; TTM = targeted temperature management; VF = ventricular fibrillation.

discharge was lower in specific subgroups (age 60–69, Charlson comorbidity index 2–3 or greater than 8, and CPR on hospital days 0–3 or day 6).

Of adult studies reporting survival from one to five years, two (OHCA[17,29]) reported no difference in 4-year[29] or 1-year[17] survival between obese and normal weight patients, and one (OHCA[21]) reported obese patients were less likely than normal weight patients to be alive at 5 years. Of adult studies reporting survival from 1 to 6 months, two (both OHCA and IHCA[28,34]) reported no difference in survival at 6-months between obese and normal weight patients, two (OHCA[13,17]) reported obese patients had lower 30-day survival than normal weight patients, and one study (IHCA[26]) that treated BMI as a continuous variable reported that increasing BMI improved survival at 1 and 3 months.

*ROSC*

Seven studies reported ROSC (Supplementary Table 3). The only paediatric study that reported on ROSC showed that obese children had significantly lower ROSC than normal weight children (IHCA).[45] In adults, two studies (one OHCA[36] and one IHCA[43]) reported no difference between obese and normal weight patients.[36,43] Two studies (one OHCA[40] and one IHCA[41]) reported obese patients had significantly lower ROSC than normal weight patients, and one study (IHCA[33]) reported significantly higher ROSC in obese patients. One study (IHCA[46]) reported mixed results. In patients with cardiac arrest of cardiac origin, univariate analysis showed lower ROSC in obese patients but multivariable analysis showed no difference in ROSC between obese and normal weight patients.[46] In patients with cardiac arrest of non-cardiac origin, there was no significant difference in ROSC between obese and normal weight patients.[46].

*CPR quality or techniques*

Other outcomes reported from adult studies were ECMO

**Table 2**
Summary of results (number of studies).

| | Total number of studies | Worse outcomes in obese patients (number of studies) | | | No difference (number of studies) | | | Better outcomes in obese patients (number of studies) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | OHCA | IHCA | Both OHCA /IHCA | OHCA | IHCA | Both OHCA /IHCA | OHCA | IHCA | Both OHCA /IHCA |
| **Adult studies (n=34)*** | | | | | | | | | | |
| Favourable neurological outcome (various time points) | **15** | 4 | 2 | 2 | 3 | 1 | 2 | 1 | 0 | 0 |
| Survival to hospital discharge^ | **22** | 3 | 3 | 2 | 4 | 2 | 3 | 3 | 2 | 0 |
| Longer term survival (months to years) | **7** | 2 | 0 | 0 | 2 | 0 | 2 | 0 | 1 | 0 |
| ROSC | **6** | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 0 |
| **Paediatric studies (n=2)** | | | | | | | | | | |
| Favourable neurological outcome (various time points) | **2** | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Survival to hospital discharge | **1** | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| ROSC | **1** | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

^ One study reporting worse survival to discharge in obese patients had unknown location.

complications (OHCA),[42] shock success (OHCA,[36] IHCA[43]) time to defibrillation (IHCA),[41,43] CPR duration (IHCA)[41] and patient injuries (location unclear).[47] There was no difference in between obese and normal weight patients in ECMO complications,[42] shock success,[36] percentage of shocks delivered in less than 2 min,[41,43] or VF/VT termination[43] (Supplementary Table 4). One study of 21,237 IHCA at 328 hospitals,[41] reported longer CPR duration in obese patients with VF/VT when ROSC was not achieved. When ROSC was achieved there was no difference in CPR duration between obese and normal weight patients.[41] For PEA or asystolic arrests, CPR duration was longer in obese patients, irrespective of ROSC.[41] One study[47] reported no significant relationship between BMI category and injuries sustained during CPR, however the cardiac arrest location(s) was unclear.

## Discussion

This scoping review exploring the research evidence related to related to CPR in obese patients identified 34 adult studies and 2 paediatric studies. The included studies spanned both OHCA (n = 22) and IHCA (n = 20).

Patient outcomes had conflicting results and differences in measurement. In adults, there were variable results in neurological outcome, survival to hospital discharge, longer term survival (months to years), and ROSC. In children, two studies[45,48] suggested that obese children had worse neurological outcomes, lower survival, and lower ROSC than normal weight children. The focus of this scoping review was the impact of obesity on cardiac arrest outcomes, however there are many factors that influence survival from cardiac arrest. In obese children, it is possible that the optimal chest compression depth in obese patients may be potentially different in obese versus non-obese patients.[53] The common use of length based tapes for resuscitation, or weight estimation formulae for medication doses in children may also impact on cardiac arrest outcomes in obese children.[54–56].

Several of the included adult studies reported that obesity made no difference to patient outcomes, or that obese patients had better outcomes than normal weight patients: these studies spanned both OHCA and IHCA. Whilst not the focus of this scoping review, low BMI has been associated with worst outcomes following cardiac arrest than normal weight, overweight or obese patients:[57–59] the outcomes of underweight cohorts in some of the included studies that dichotomised groups as obese and non-obese groups may have influenced the outcome profile of obese patients in this review. In this review, when patients were grouped as underweight, normal weight, overweight and obese (+/- very obese), only normal weight and obese (+/- very obese) were compared. The variability in reported outcomes for adults suggest that obesity does not necessarily result in worse outcomes, therefore high quality CPR and early defibrillation should be standard of care, acknowledging potential manual handling and mechanical challenges of CPR in obese patients. Many of the included studies adjusted their analyses to mitigate the influence of other variables, however there was variability in the confounders addressed. Also, the observational nature of most included studies makes it difficult to make a direct link between obesity and cardiac arrest outcomes.

Few studies reported resuscitation quality indicators or techniques, and no studies reported adjustments to CPR techniques. No studies reported on the effect of obesity on time to, or quality of, chest compressions or ventilations in either adults or children, highlighting a major knowledge gap. There were studies reporting successful resuscitation of obese patients (adults and children) with application of standard protocols, implying that high quality CPR is possible, however whether there is a need for alterations to chest compression technique in obese patients is unknown. Computed tomography (CT) studies in patients not in cardiac arrest have shown a chest compression depth of 5–6 cm in adults, is unlikely to provide a sufficient ejection fraction during CPR in obese patients with BMI $\geq$ 30 kg/m$^2$.[60] In paediatrics, the majority of paediatric patients' one-third external anterior-posterior chest diameters were not concordant with age specific chest compression depth targets, especially for most infants and nearly all overweight/obese adolescents.[53] In adults who had chest CT prior to IHCA, ROSC was higher when thoracic cage dimension and posterior subcutaneous adipose tissue depth were smaller.[61] Manikin studies have shown that chest compression performance was significantly better on normal-sized manikins than obese and morbidly obese manikins.[62–64] The limited results reported regarding adult defibrillation suggest that obesity did not affect shock success in either OHCA or IHCA or time to defibrillation in IHCA. No defibrillation data was reported in children. In adults, was one study reporting longer CPR duration in obese patients but the reasons for this are not well understood and there may have been other drivers for longer CPR duration (for example, the average age of patients was mid 60 s).[41].

No studies reporting on provider outcomes such as safety or manual handling were identified, highlighting another important area for future research. Previous ILCOR scoping reviews have not identified any studies reporting rescuer physical harm.[65] Previous ILCOR reviews do report rescuer fatigue adversely affects the quality of chest compressions after 2 min in the context of manikin studies of compression only CPR,[66] and the challenges in maintaining chest compression quality in obese manikins has been highlighted above. Studies detailing specific provider challenges when preparing for, or performing, CPR on obese patients are currently lacking.

### *Knowledge gaps*

This scoping review has highlighted several knowledge gaps. There are few studies of CPR in obese infants, children and adolescents. A standardised definition of obese, or population specific definition of

obese, for the purpose of resuscitation research is lacking. More robust adjustment for the many influences on CPR outcomes is needed if conclusions about the impact of obesity on CPR outcomes are to be used to shape clinical practice. Further research is needed on the effect of obesity on CPR quality (such as chest compressions, airway management ventilation, defibillation), and time to, and delivery of, resuscitation interventions (such as vascular access and medications, use of mechanical CPR devices or ECMO). Further research is also needed to determine whether degree of obesity influences CPR performance or outcomes following CPR including health-related quality of life. Finally, studies of CPR in obese patients with a focus on provider outcomes (physical exertion, manual handling, fatigue) are urgently needed given the global prevalence of obesity.

### *Limitations*

In the absence of a universal definition of obesity, 'obese' was defined according to each individual study. The majority of included studies used the WHO Body Mass Index (BMI) criteria[49] and only two of eleven studies conducted in Asia used the WHO BMI criteria for Asian populations.[50] This scoping review was limited to patients in cardiac arrest thus did not capture data from other settings, for example, anaesthesia or critical care studies of airway interventions, ventilation or use of ECMO in obese patients (adults or children). There was little detail regarding how BMI data were sourced, particularly for studies of OHCA. In all included studies of OHCA that used BMI, patients were transported to ED and, or admitted to hospital: it is likely that in these, BMI was calculated in the hospital setting but this detail is unclear. As is usual for a scoping review, no formal quality assessment was conducted, therefore drawing conclusions for clinical practice from these findings is not feasible.

## Conclusions

This scoping review provides a comprehensive overview of the literature to date regarding CPR in obese patients (adults and children) and highlights significant knowledge gaps regarding CPR in obese patients. The variability in results does not suggest an urgent need to deviate from standard CPR protocols, however there was some evidence that CPR duration may be longer in obese adults, which may have staffing and resource implications.

## CRediT authorship contribution statement

**Julie Considine:** Formal analysis, Investigation, Methodology, Project administration, Validation, Writing – original draft, Writing – review & editing. **Keith Couper:** Conceptualization, Formal analysis, Investigation, Methodology, Writing – original draft, Writing – review & editing. **Robert Greif:** Conceptualization, Formal analysis, Investigation, Methodology, Writing – review & editing. **Gene Yong-Kwang Ong:** Conceptualization, Formal analysis, Investigation, Methodology, Writing – review & editing. **Michael A. Smyth:** Conceptualization, Formal analysis, Investigation, Methodology, Writing – review & editing. **Kee Chong Ng:** Conceptualization, Formal analysis, Investigation, Methodology, Writing – review & editing. **Tracy Kidd:** Conceptualization, Formal analysis, Investigation, Methodology, Writing – review & editing. **Theresa Mariero Olasveengen:** Conceptualization, Formal analysis, Investigation, Methodology, Writing – review & editing. **Janet Bray:** Conceptualization, Formal analysis, Investigation, Methodology, Writing – review & editing.

## Funding

This scoping review was funded by the American Heart Association, on behalf of The International Liaison Committee on Resuscitation (ILCOR). None of the following authors received payment from this funding source to complete this scoping review.

## Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: 'All ILCOR task force members complete annual conflict of interest disclosures, and conflict of interest was managed per ILCOR guidelines. All authors external to ILCOR completed a conflicts of interest disclosure.' Authors JB and KC are Editors for Resuscitation Plus. Authors JB and KC are members of the Editorial Board of Resuscitation and authors RG and TMO are members of the editorial board of Resuscitation Plus. RG is Editor-in-Chief of Trends in Anaesthesia and Critical Care. None of the authors were involved in the peer review process or editorial decision-making of this paper.

## Acknowledgements

The authors would like to thank the following International Liaison Committee on Resuscitation Task Force members, associate members and emeritus members who provided input to the review protocol, interpretation of the results and on the manuscript as experts in resuscitation:

*Basic Life Support:* Anthony T. Lagina; Baljit Singh; Bridget Dicker; Carolina M. Hansen; Christopher M. Smith; Fredrik Folke; Guillaume Debaty; Katie N. Dainty; Maya Dewan; Nicholas J Johnson; Rebecca E. Cash; Takanari Ikeyama; Tatsuya Norii; Violetta Raffay; Ziad Nehme; Aloka Samantaray; George Lukas; Vihara Dassanayake; Chika Nishiyama; Christian Vaillancourt; Federico Semeraro; Giuseppe Ristagno; Siobhan Masterson; Sung Phil Chung and Tetsuo Hatanaka.

*Advanced Life Support:* Ian R. Drennan; Markus B. Skrifvars; Katherine M Berg; Ari Moskowitz; Asger Granfeldt; Brian Grunau; Carolyn M Zelop; Karen G. Hirsch; Mathias J. Holmberg; Nikolaos I. Nikolaou; Rakesh Garg; Shannon M. Fernando; Shinichiro Ohshimo; Sonai D'Arrigo; Claudio Sandroni; Tommas Scquizzato; Yew Woon Chia; Carrie Kah-Lai Leong; Conor P. Crowley; Neville Vlok; Bernd W. Böttiger, Brian O'Neil, Charles D. Deakin, Jasmeet Soar, Michael JA Parr, Michelle Welsford, Peter J. Kudenchuk, Robert W. Neumar, Tonia Nicholson, Jerry P. Nolan.

*Paediatric Life Support:* Barnaby R Scholefield; Alexis A. Topjian; Andrea Christoff; Antonio Rodriguez-Nunez; Arun Bansal; Florian Hoffmann; Hiroshi Kurosawa; Jana Djakow; Jason Acworth; Jimena del Castillo; Joseph W Rossano; Lokesh Kumar Tiwari; Michelle Myburgh; Raffo Escalante-Kanashiro; Stephan Katzenschlager; Tia T. Raymond; Ester Ambunda; James Gray; Jesus Lopez-Herce; Anne-Marie Guerguerian; Janice A. Tijssen; Gabrielle A. Nuthall; Stephen M. Schexnayder; Thomaz Bittencourt Couto; Laurie J. Morrison; Dianne L. Atkins; Allan R De Caen Vinay M. Nadkarni.

*Education, Implementation and Teams:* Adam Cheng; Aaron Donoghue; Alexander Olaussen; Barbara Farquharson; Chih-Wei Yang; Cristian Abelairas-Gomez; Heike Geduld; Kasper G. Lauridsen; Andrew S.Lockey; Kathryn Eastwood; Kevin Nation; Sabine Nabecker; Sebastian Schnaubelt; Tasuku Matsuyama; Taylor L. Sawyer; Ying-Chih Ko; Yiquin Jeffrey Lin; Katherine S. Allan; Andrea Cortegiani; Jan Breckwoldt; Ming-Ju Hsieh.

The authors also wish to thank Peter Morley, ILCOR Scientific Advisory Committee for his review of this work; Lousie Spain, Australian Resuscitation Council for assistance with screening; and Louisa Sher, Information Specialist, Deakin University for assistance in development and review of the search strategy.

## Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.resplu.2024.100820.

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