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Original Article

Trends and differences in management and outcomes of cardiac arrest in underweight and obese acute myocardial infarction hospitalizations

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Abstract: The influence of weight on in-hospital events of acute myocardial infarction complicated with cardiac arrest (AMI-CA) is understudied. To address this, we utilized the National Inpatient Sample database (2008-2017) to identify adult AMI-CA admissions and categorized them by BMI into underweight, normal weight, and overweight/obese groups. The outcomes of interest included differences in in-hospital mortality, use of invasive therapies, hospitalization costs, and hospital length of stay across the three weight categories. Of the 314,609 AMI-CA admissions during the study period, 268,764 (85.4%) were normal weight, 1,791 (0.6%) were underweight, and 44,053 (14.0%) were overweight/obese. Compared to 2008, in 2017, adjusted temporal trends revealed significant increase in prevalence of AMI-CA in underweight (adjusted OR {aOR} 3.88 [95% CI 3.04-4.94], P<0.001) category, and overweight/obese AMI-CA admissions (aOR 2.67 [95% CI 2.53-2.81], P<0.001). AMI-CA admissions that were underweight were older, more often female, with greater comorbidity burden, and presented more often with non-ST-segment-elevation AMI, non-shockable rhythm, and in-hospital arrest. Overweight/obesity was associated with higher use of angiography, PCI, and greater need for mechanical circulatory support whereas underweight status had the lowest use of these procedures. Compared to normal weight AMI-CA admissions, underweight admissions had comparable adjusted in-hospital mortality (adjusted OR 0.97 [95% CI 0.87-1.09], P=0.64) whereas overweight/obese admissions had lower in-hospital mortality (adjusted OR 0.92 [95% CI 0.90-0.95], P<0.001). In conclusion, underweight AMI-CA admissions were associated with lower use of cardiac procedures and had in-hospital mortality comparable to normal weight admissions. Overweight/obese status was associated with higher rates of cardiac procedures and lower in-hospital mortality.

Keywords: Acute myocardial infarction, cardiac arrest, underweight, overweight, obesity, outcomes research

Introduction

Acute myocardial infarction (AMI) constitutes various risk factor profiles and clinical presentations, with the highest risk patients presenting with shock, multi-organ failure and cardiac arrest (CA) [1-3]. Obesity, a risk factors for cardiovascular events, has been associated with premature coronary artery disease, myocardial infarction, and higher prevalence of co-morbidities, including hypertension, diabetes, insulin resistance and hyperlipidemia [4-7]. However, there are controversial data whether obesity itself is considered an independent risk factor for cardiovascular events, or the mere association of comorbidities accompanied with obesity is the driving factor of these cardiovascular events [4-6]. Moreover, several reports have shown a paradoxical effect of obesity in patients with cardiovascular disease, including those with AMI and CA; demonstrating that obese and overweight patients may have paradoxically lower mortality rates compared to normal or underweight patients [4, 5]. This was illustrated by analysis from registries in the United States of patients with AMI showing overweight, obese and morbidly obese patients had significantly lower rates of 1-year mortality compared with normal weight patients, irrespective of patient's age, gender and presence of diabetes [5].

More recently, underweight patients have been increasingly recognized as a sub-group associated with higher risk for cardiovascular events, including stroke, AMI and coronary artery disease [8, 9]. In fact, in a cross-sectional analysis of 491,773 adult subjects in the United States, it was found that being underweight was the strongest independent risk factor for stroke, myocardial infarction and coronary artery disease [9]. Additionally, studies have noted that underweight patients had lower survival rates in AMI and CA, compared to normal weight patients [10, 11]. This is demonstrated by data from the National Registry for Cardiopulmonary Resuscitation showing underweight patients had lower survival in both shockable and non-shockable rhythms [10]. In light of these data, studying the role of body mass index (BMI) on the trends of clinical care and survival in a population with combined AMI and CA (AMI-CA) is needed to better understand these associations and their impact on outcomes. Hence, through this study, we sought to understand differences in clinical care patterns, trends in in-hospital events of AMI-CA admissions across BMI categories.

Material and methods

Study population

The National Inpatient Sample (NIS) was developed as part of the Healthcare Quality and Utilization Project (HCUP) for the Agency for Healthcare Research and Quality (AHRQ) [12]. It is an all-payer database with data from a 20% stratified sample of community hospital inpatient stays across the United States. Along with demographics, hospital characteristics, and primary payer, each discharge record contains information on up to 40 diagnoses and 25 in-hospital procedures represented using International Classification of Diseases Clinical Modification (ICD-CM) and procedure codes (ICD-PCS). The AHRQ makes these de-identified data publicly available and hence Institutional Review Board approval was not requested [12].

The HCUP-NIS data from January 1, 2008 through December 31, 2017 was used for the purpose of this study. We identified all adult admissions (>18 years) with AMI in the primary diagnosis field and those with a concomitant diagnosis of cardiac arrest using previously validated administrative codes [1-3, 13-19]. These admissions were then categorized into three groups based on BMI. Those with BMI <19.9 kg/m^2 were grouped as underweight, those with BMI between 19.9 kg/m^2 and <24.9 kg/m^2 were grouped as those with normal weight, and all admissions with BMI >24.9 kg/m^2 were considered overweight/obese. Administrative codes used to identify these categories are similar to those used in published literature and are provided in Supplementary Table 1 [20-22]. Comorbidity burden was identified using the previously validated algorithm based on Deyo's modification of the Charlson Comorbidity Index [23]. Details on acute organ failure, use of cardiac procedures, and other non-cardiac organ support were also captured for admissions using previously reported methods (Supplementary Table 1) [1-3, 14, 16-18, 24-36].

The primary outcome was difference in in-hospital mortality of AMI-CA admissions in the three weight categories. Secondary outcomes of interest were differences in utilization of coronary angiography and percutaneous coronary angiography (PCI), mechanical circulatory support (MCS) use, total costs, duration of hospital stay, and disposition among weight groups.

Statistical analysis

We reviewed and addressed all the inherent restrictions of the HCUP-NIS database related to research design, data interpretation, and data analysis [37]. As per HCUP-NIS recommendations, national estimates were generated using survey procedures and discharge weights provided with the database [37]. Trend weights were used for data from 2008-2011 to adjust for the 2012 HCUP-NIS redesign [37]. Categorial variables are presented as percentages and compared using Chi-square tests. Continuous variables are presented as mean ± standard deviation and were compared using t-tests. A multivariable logistic regression analysis incorporating demographics, income status, primary payer, hospital characteristics, comorbid conditions, acute organ failure, cardiogenic shock, receipt of coronary angiography, PCI, pulmonary artery catheterization, MCS, invasive mechanical ventilation, acute kidney injury requiring hemodialysis, palliative care services, presence of do-not-resuscitate status was performed for assessing adjusted temporal trends and associations with in-hospital mortality. For adjusted temporal trends, the variable 'year' was used as a categorical variable to obtain odds ratio per year with reference to the year 2008. Unadjusted trends over time in use of cardiac procedures across weight categories were plotted. Variables included in the multivariable model were based on statistical correlation (liberal threshold of $P<0.20$ in univariate analysis) or clinical relevance. All statistical analyses were performed using SPSS v25.0 (IBM Corp, Armonk NY).

Results

Prevalence and characteristics of AMI-CA across weight categories

Over the study period from January 1, 2008 to December 31, 2017, we identified a total of 6,089,979 AMI admissions of which 314,609 (5.2%) were complicated by CA. Among AMI-CA admissions, 268,764 (85.4%) were grouped as normal weight, whereas 1,791 (0.6%) were underweight, and 44,053 (14.0%) were overweight/obese. Unadjusted and adjusted temporal trends revealed an increase in underweight and overweight/obese AMI admissions experiencing CA, whereas there was a decline in CA in the normal weight admissions (**Figure 1A** and **1B**). Underweight admissions were on average older, more frequently female, with higher comorbidity burden, higher rates of chronic lung disease and cancer, and more often received care at urban teaching hospitals (**Table 1**). AMI-CA admissions that were overweight/obese were significantly younger and had lower comorbidity burden in comparison to underweight and normal weight admissions (**Table 1**).

Clinical presentation and in-hospital events

Compared to the other two cohorts, those who were underweight more often presented with non-ST-segment-elevation AMI, non-shockable rhythm, in-hospital arrest, and had higher rates of acute non-cardiac organ failure (**Table 2**). Cardiac procedures like coronary angiography, PCI, and MCS use were more often used in overweight/obese admissions compared to the other groups whereas underweight admissions had the lowest utilization of these procedures (**Table 2**). These trends were consistent across the entire study period (**Figure 2A-D**). Non-cardiac procedures such as invasive mechanical ventilation and pulmonary artery catheterization were used more frequently in underweight AMI-CA admissions (**Table 2**).

In-hospital mortality and resource utilization

In comparison to those that were normal weight, significantly higher unadjusted in-hospital mortality was identified in underweight AMI-CA admissions (55.6% vs 42.9%; unadjusted OR 1.66 [95% CI 1.52-1.83], $P<0.001$) whereas overweight/obese AMI-CA admissions had lower in-hospital mortality (36.5% vs 42.9%, unadjusted OR 0.76 [95% CI 0.75-0.78], $P<0.001$) (**Table 3**). However, after adjusting for patient and hospital characteristics, comorbidities, and in-hospital characteristics, underweight admissions had comparable mortality to AMI-CA admissions with normal weight (adjusted OR 0.97 [95% CI 0.87-1.09], $P=0.64$) whereas lower in-hospital mortality was identified among overweight/obese AMI-CA admissions (adjusted OR 0.92 [95% CI 0.90-0.95], $P<0.001$) compared to those with normal weight (Supplementary Table 2). A decline in in-hospital mortality of AMI-CA admissions across all weight categories was seen in temporal trend analyses (**Figure 1C** and **1D**). Underweight admissions more often had a do-not-resuscitate status, palliative care consultations and longer lengths of hospital stay compared to normal weight and overweight/obese AMI-CA admissions (**Table 3**). Tracheostomy was more often used in overweight/obese AMI-CA admissions. Overweight/obese admissions had higher hospitalization costs and more frequent discharges to home while underweight admissions had higher proportion of dismissal to skilled nursing facilities (**Table 3**).

Discussion

Over the last decade, the prevalence of CA in AMI admissions with underweight and over-

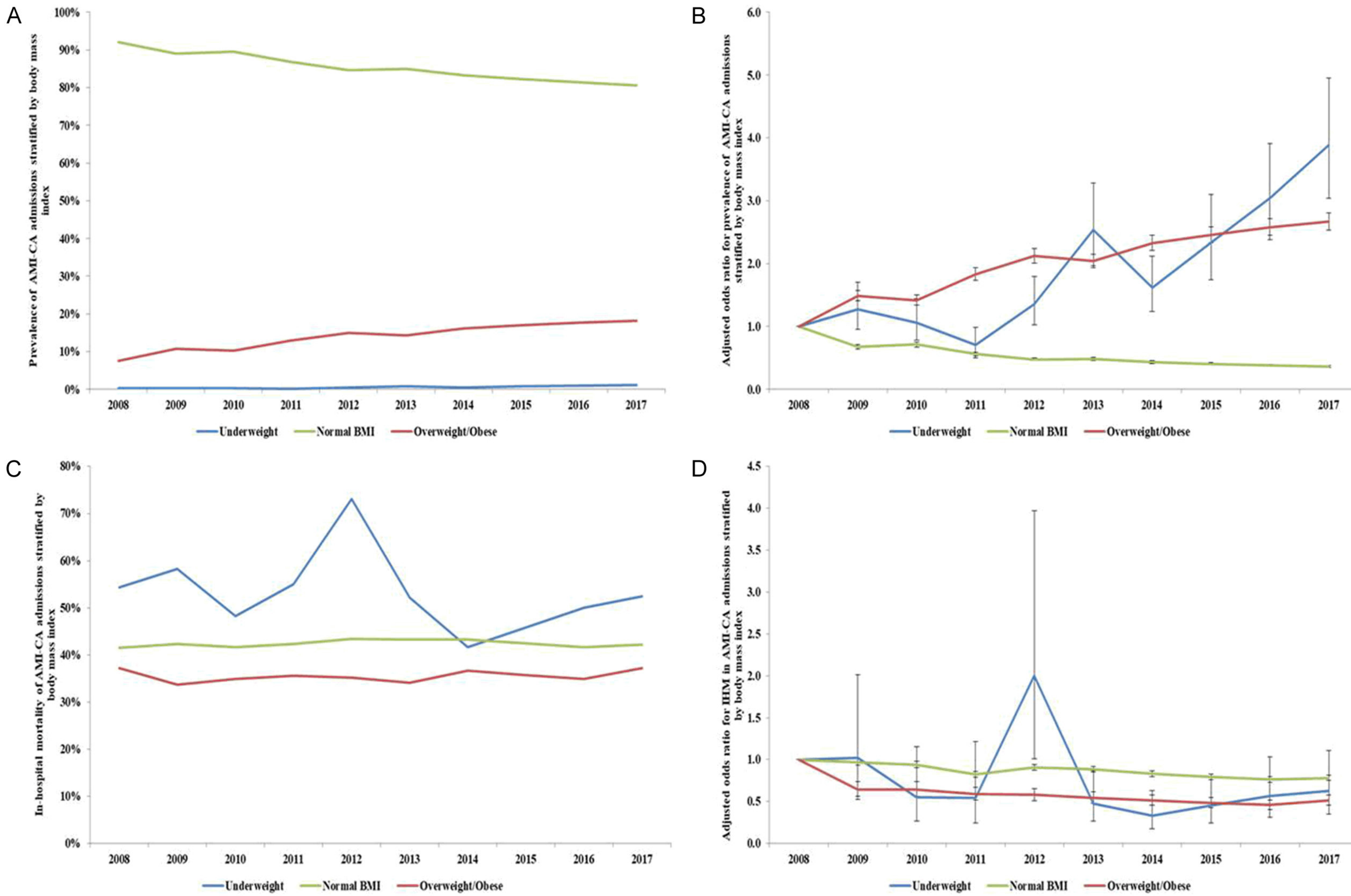

Figure 1. Time trends in the prevalence of AMI-CA and in-hospital mortality of admissions across categories of body mass index. A: Unadjusted trends of the AMI-CA admissions in underweight, normal BMI, and overweight/obese categories (P<0.001 for time trend); B: Adjusted trends for underweight, normal BMI, and overweight/obese AMI-CA admissions prevalence depicted as odds ratio with 2008 as the referent; adjusted for age, sex, race, primary payer, income status, type of AMI, hospital region, hospital location and teaching status, and hospital bed size (P<0.001 for time trend); C: Unadjusted in-hospital mortality in AMI-CA admissions stratified by weight status (P<0.001 for trend over time); D: Adjusted odds ratio for in-hospital mortality by year (with 2008 as the referent) in AMI-CA admissions stratified by weight status (P<0.001 for time trend). Abbreviations: AMI: acute myocardial infarction; CA: cardiac arrest; IHM: in-hospital mortality.

Table 1. Baseline characteristics of AMI-CA admissions stratified by weight status

Characteristic		Underweight (N=1,796)	Normal BMI (N=526,278)	Overweight/Obese (N=56,189)	P
Age, in years		72.4 ± 11.9	67.4 ± 13.6	61.8 ± 11.9	<0.001
Female		47.1	34.7	38.0	<0.001
Race	White	67.8	63.6	69.8	<0.001
	Black	16.8	7.8	8.9	
	Others[a]	15.4	28.6	21.3	
Primary payer	Medicare	72.5	57.0	45.5	<0.001
	Medicaid	9.6	6.6	9.0	
	Private	13.6	27.4	35.4	
	Others[b]	4.3	9.1	10.1	
Quartile of median household income for zip code	0-25th	33.7	23.4	26.4	<0.001
	26th-50th	27.9	26.7	27.0	
	51st-75th	19.3	24.9	25.9	
	75th-100th	19.1	24.9	20.7	
Charlson Comorbidity Index	0-3	19.7	35.8	46.2	<0.001
	4-6	48.4	48.6	39.4	
	≥ 7	31.9	15.6	14.4	
Hypertension		46.8	49.8	66.2	<0.001
Hyperlipidemia		27.9	31.7	51.1	<0.001
Chronic lung disease		35.1	18.2	19.1	<0.001
Cancer		12.6	6.1	4.3	<0.001
Hospital teaching status and location	Rural	8.0	8.8	6.8	<0.001
	Urban non-teaching	28.6	40.8	38.2	
	Urban teaching	63.4	50.4	55.0	
Hospital bed-size	Small	13.5	9.4	9.4	<0.001
	Medium	23.6	24.9	26.5	
	Large	62.9	65.7	64.1	
Hospital region	Northeast	15.6	17.6	13.2	<0.001
	Midwest	26.4	22.3	25.9	
	South	38.5	40.3	39.0	
	West	19.4	19.8	21.8	

Legend: Represented as percentage or mean ± standard deviation; [a]Hispanic, Asian or Pacific Islander, Native American, Others; [b]Self-Pay, No Charge, Others. Abbreviations: AMI: acute myocardial infarction; CA: cardiac arrest.

weight/obese status increased. Compared to normal weight, underweight AMI-CA admissions had greater comorbidity with significantly lower rates of coronary angiography, revascularization, and mechanical circulatory support use. CA in underweight admissions was associated with higher acuity as noted by acute non-cardiac organ failure, non-shockable presentation and non-ST-segment-elevation AMI presentation. In-hospital mortality of AMI-CA admissions was comparable in the underweight and normal BMI categories whereas overweight/obese admissions had significantly lower in-hospital mortality. Resource utilization and lengths of stay were higher in the admissions belonging to both the extremes of weight compared to those with normal BMI.

Obesity has been associated with higher rates of cardiovascular events, including premature coronary artery atherosclerosis and AMI [4, 5]. It remains unclear whether obesity is an independent risk factor for these events, or its association with more comorbidities is the driving factor for the higher events in this population [4, 5]. Studies have demonstrated the finding of 'obesity paradox' regarding survival in patients with AMI and also in CA patients; showing that obese patients had better survival in AMI and CA compared to normal weight patients [4-7]. Data from 2 registries in the United States studying 6,359 patients with AMI showed that overweight, obese and morbidly obese patients had significantly lower rates of mortality over 1 year compared to normal weight patients, and this effect was not modified by patient's characteristics, age, gender and presence of diabetes [5]. Another prospective study involving 124,981 patients with AMI showed that overweight and obese patients

Table 2. In-hospital characteristics of AMI-CA admissions stratified by weight status

Characteristic		Underweight (N=1,796)	Normal BMI (N=526,829)	Overweight/Obese (N=55,638)	P
AMI type	STEMI	41.8	66.8	62.2	<0.001
	NSTEMI	58.2	33.2	37.8	
Cardiac arrest	In-hospital	41.9	30.1	32.6	<0.001
	Not in-hospital	58.1	69.9	67.4	
Cardiac rhythm	Shockable	36.6	52.2	56.8	<0.001
	Non-shockable	63.4	47.8	43.2	
Cardiogenic shock		30.7	27.3	28.3	<0.001
Coronary angiography		52.8	61.5	72.9	<0.001
Percutaneous coronary intervention		35.0	45.7	53.8	<0.001
Coronary artery bypass grafting		8.6	9.6	13.4	<0.001
Acute organ failure	Multiorgan failure	62.7	42.7	48.8	<0.001
Respiratory	57.3	39.8	46.3	<0.001	
Hepatic	16.0	6.1	8.0	<0.001	
Renal	42.2	23.7	31.7	<0.001	
Hematologic	15.9	7.2	8.6	<0.001	
Neurologic	28.1	23.1	24.8	<0.001	
Mechanical circulatory support		16.4	20.3	22.2	<0.001
Pulmonary artery catheterization		3.6	3.5	3.2	0.001
Invasive mechanical ventilation		55.6	47.2	50.5	<0.001
Acute hemodialysis		2.2	1.7	2.0	<0.001

Legend: Represented as percentages. Abbreviations: AMI: acute myocardial infarction; CA: cardiac arrest; NSTEMI: non-ST-segment-elevation myocardial infarction; STEMI: ST-segment-elevation myocardial infarction.

had improved short and long term survival compared to patients with normal weight over 17 years of follow-up, even after adjusting for patients' and treatment characteristics [4]. In our analysis, we found that in-hospital mortality of patients with AMI-CA was significantly lower in overweight/obese patients compared to normal and underweight patients, after adjusting for potential confounding factors, including patient and hospital characteristics. Our findings illustrate that the "obesity paradox" may have contributed to the improved survival in overweight and obese groups in this sick population with AMI-CA. This observation maybe attributed to the following: 1) more aggressive treatment in overweight/obese patients compared to patients with normal weight as noted by more resource utilization and higher rates of invasive cardiac procedures, including coronary angiography, PCI, CABG and mechanical circulatory support use, 2) lower rates of palliative care consultation and do-not resuscitate status, indicating possibly lower acuity in clinical presentation, 3) younger patient population in the overweight/obese group compared to other groups. It is important to note that despite best attempts at confounding, our study may have missed crucial confounders by virtue of being an observational database-related analysis.

Low BMI has been increasingly recognized in the recent years as a risk factor for cardiovascular events [8, 9]. A study involving 10,568 patients with AMI from Korea Acute Myocardial Infarction Registry-National Institute of Health demonstrated that all-cause mortality was significantly higher in patients with low BMI compared with higher BMI at 12-months of follow up. Moreover, investigators found that patients with low BMI had higher rates of minor bleeding and a trend toward higher rates of stroke compared with higher BMI at 12 months [8]. Another study of cross-sectional data from the Behavioral Risk Factor Surveillance System database involving 491,773 adult subjects in the United States demonstrated that being underweight was the strongest independent risk factor for stroke, myocardial infarction and coronary artery disease [9]. In our analysis, we found that underweight patients with AMI-CA were older with greater comorbidity and higher acuity as noted by higher rates of cardiogenic shock, acute non-cardiac organ failure, non-

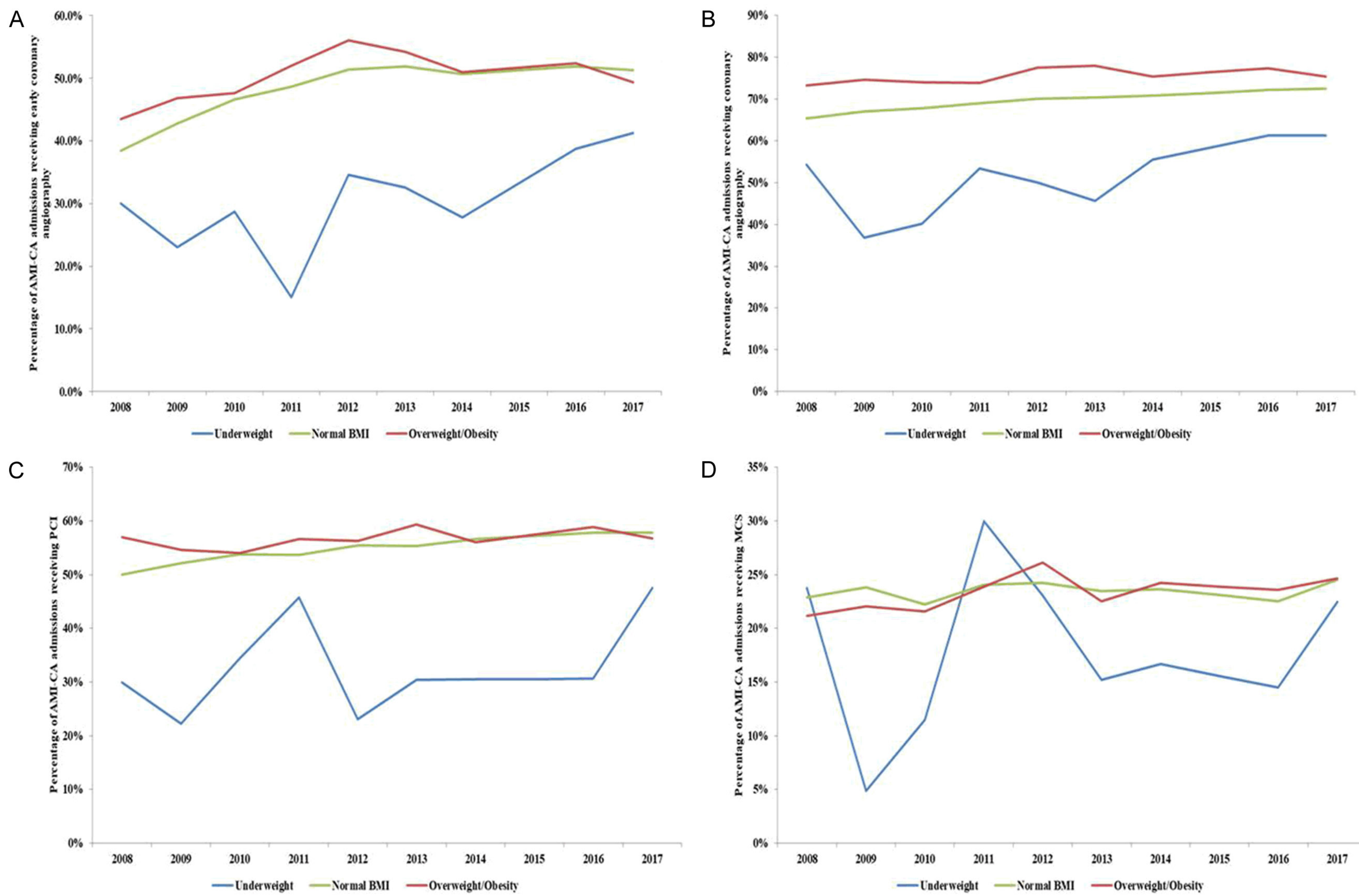

Figure 2. Trends over time in the use of cardiac procedures in AMI-CA admissions over the last decade stratified by weight status. Trends in the proportion of AMI-CA admissions receiving. A: Early coronary angiography; B: Coronary angiography; C: Percutaneous coronary intervention; D: Mechanical circulatory support across weight categories (All P<0.001 for time trend). Abbreviations: AMI: acute myocardial infarction; CA: cardiac arrest; MCS: mechanical circulatory support; PCI: percutaneous coronary intervention.

Table 3. Clinical outcomes of AMI-CA admissions stratified by weight status

Characteristic		Underweight (N=1,796)	Normal BMI (N=526,829)	Overweight/Obese (N=55,638)	P
In-hospital mortality		55.5	45.6	36.7	<0.001
Length of stay (days)		6 (2-14)	5 (2-9)	5 (3-10)	<0.001
Tracheostomy use		2.8	2.2	4.1	<0.001
Do-not-resuscitate status		20.5	5.5	7.5	<0.001
Palliative care consultation		14.2	4.4	6.2	<0.001
Hospitalization costs (x1000 USD)		91.6 (41.9-192.2)	60.3 (27.1-121.9)	88.2 (44.9-170.4)	<0.001
Discharge disposition	Home	26.5	54.6	57.9	<0.001
	Transfer	5.2	12.3	10.3	
	Skilled nursing facility	48.2	21.2	19.4	
	Home with Healthcare	18.4	11.2	11.9	
	Against medical advice	1.8	0.6	0.5	

Legend: Represented as percentage or median (interquartile range). Abbreviations: AMI: acute myocardial infarction; CA: cardiac arrest; HHC: home health care; USD: United States Dollar.

shockable presentation and non-ST-segment-elevation AMI presentation. We also found that underweight patients received significantly lower rates of coronary angiography, PCI, CABG, and mechanical circulatory support use. It is important to note that underweight patients received less invasive cardiac procedures and higher rates of do-not-resuscitate status, which could be attributed to the fear of complications in this group [24, 38]. The higher incidence of complications, especially in women and high-risk patient groups undergoing invasive cardiac procedures, has been shown in both the young and elderly patients; however, this should not preclude these patients from receiving potentially life-saving therapies [24, 39]. We found that underweight patients had higher in-hospital mortality in the unadjusted analysis. However, after adjusting for patients' and hospital characteristics, underweight patients had similar survival to patients with normal weight.

Prior studies on the effects of BMI on clinical presentation and outcomes in patients with CA have shown conflicting evidence [10, 11]. Jain et al, in their study of patients with in-hospital cardiac arrest from the National Registry for Cardiopulmonary Resuscitation, found that in cardiac arrests caused by shockable rhythms, underweight, normal weight and very obese had lower survival to discharge compared to overweight and obese patients. On the other hand, they found that in non-shockable rhythms, underweight patients had the lowest survival to discharge across all groups [10]. A meta-analysis of seven studies involving 25,035 patients, showed that low BMI was associated with lower survival in CA, and overweight patients had higher survival and neurological recovery [11]. These differences could be attributed to logistical challenges in the extremes of BMI regarding efficacy and safety of resuscitation, including chest compressions, attachment of defibrillator pads, initiation of a viable airway, safety and efficacy of defibrillation and medications administered during resuscitation among other factors [11]. It is unclear if our current standard resuscitation measures, including chest compressions and medication doses, are as effective in the underweight population as the normal weight patients. In our analysis, we found that underweight patients with AMI-CA were older, had more comorbidities and had higher rates of respiratory failure requiring mechanical ventilation, which could explain the higher rates of non-shockable cardiac arrest and mortality in this group in the unadjusted analysis. More investigations are needed to understand the differences in the presentation of AMI-CA in the extremes of BMI, assess the efficacy and safety of standard resuscitation measures in these groups and explore the clinical challenges encountered in this vulnerable group of patients.

Limitations

The present study has limitations inherent to those associated with administrative data. The quality control measures of the HCUP-NIS and use of validated administrative codes reduces inherent errors with respect to identification of diagnoses and procedures [19, 40]. Granular information related to disease severity including but not limited to echocardiographic and angiographic reports as well hemodynamic status are not available in the database. Sequence and timing of in-hospital events including CA relative to one another cannot be deduced from the database. Self-reporting could lead to measurement bias in estimates of BMI. Misclassification and/or underestimation can result from missing BMI values or underdiagnosis of weight extremities. Residual confounding from other unavailable confounders may have influenced the observed results. The study results reflect in-hospital outcomes and data on post-discharge outcomes are unavailable in the database. Despite these limitations, important information highlighting the differences in AMI-CA management and outcomes based on weight status are provided in the present study.

Conclusions

There are significant differences in the management and outcomes of AMI-CA hospitalizations based on weight status. Underweight admissions were associated with lower use of cardiac procedures and had in-hospital mortality comparable to those with normal weight, despite higher acuity of illness and older age. Overweight/obese status among AMI-CA admissions was associated with higher rates of cardiac procedures and lower in-hospital mortality. Further qualitative and quantitative data are needed to understand the management and outcomes of CA in the extremes of BMI to help in providing equitable care to this vulnerable population.

Disclosure of conflict of interest

None.

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Supplementary Table 1. Administrative codes used for identification of diagnoses and procedures

Comorbidity	International Classification of Diseases 9.0 Clinical Modification Codes
Acute myocardial infarction	ICD-9CM 410.x and ICD-10CM I21.x-22.x
Cardiac arrest	ICD-9CM 427.5, 427.41, 99.60 and 99.63; ICD-10CM I46.x, I49.01, I49.02; ICD-10PCS 5A12012
Underweight	ICD-9CM 783.22, V85.0 and ICD-10CM R63.6, Z68.1
Overweight/obese	ICD-9CM 278.0-278.03, V85.21-V85.45 and ICD-10CM E66.0, E66.01, E66.09, E66.2, E66.3, E66.8, E66.9, Z68.25-Z68.45
Cardiogenic shock	785.51
Cardiac arrest	427.5, 427.4, 427.41, 427.42, 99.60, 99.63
Coronary angiography	37.22, 37.23, 88.53-88.56
Coronary artery bypass grafting	36.10, 36.11, 36.12, 36.13, 36.14, 36.15, 36.16, 36.19
Percutaneous coronary intervention	00.66, 36.01, 36.02, 36.05, 36.06, 36.07, 88.57
Invasive hemodynamic assessment	89.63, 89.64, 89.66, 89.67, 89.68
Mechanical circulatory support	37.61, 37.68, 39.65
Invasive mechanical ventilation	96.7, 96.70, 96.71, 96.72
Hemodialysis	39.95
Multi-organ failure	570.0, 572.2, 573.3, 573.4
	518.81, 518.82, 518.85, 786.09, 799.1, 96.7, 96.70, 96.71, 96.72
	584, 584.5, 584.6, 584.7, 584.8, 584.9
	286.6-286.9, 287.4, 287.5
	293, 293.0, 293.1, 293.8, 293.81-293.84, 293.89, 293.9, 348.1, 348.3, 348.30, 348.81, 348.39, 780.01, 780.09, 89.14

Supplementary Table 2. Multivariable regression for in-hospital mortality in AMI-CA admissions

Total cohort (N=314,609)		Odds ratio	95% confidence interval		P
			Lower Limit	Upper Limit	
Body mass index	Normal		Reference category		
	Underweight	0.97	0.87	1.09	0.64
	Overweight/Obese	0.92	0.90	0.95	<0.001
Age (years)	≤75 years		Reference category		
	>75 years	1.61	1.57	1.64	<0.001
Female sex		1.24	1.22	1.26	<0.001
Race	White		Reference category		
	Black	1.03	0.99	1.06	0.11
	Others	1.20	1.17	1.22	<0.001
Primary payer	Medicare		Reference category		
	Medicaid	0.71	0.69	0.74	<0.001
	Private	0.60	0.59	0.62	<0.001
	Others	0.94	0.91	0.97	0.20
Quartile of median household income for zip code	0-25th		Reference category		
	26th-50th	0.86	0.84	0.88	<0.001
	51st-75th	0.81	0.79	0.83	<0.001
	75th-100th	0.76	0.74	0.78	<0.001
Hospital teaching status and location	Rural		Reference category		
	Urban non-teaching	1.01	0.98	1.05	0.51
	Urban teaching	1.02	0.98	1.06	0.30
Hospital bed-size	Small		Reference category		
	Medium	1.06	1.03	1.10	0.11
	Large	1.07	1.04	1.11	0.01
Hospital region	Northeast		Reference category		
	Midwest	0.97	0.95	1.00	0.08
	South	1.07	1.04	1.10	<0.001
	West	1.06	1.03	1.09	<0.001
Charlson Comorbidity Index	0-3		Reference category		
	4-6	1.29	1.26	1.32	<0.001
	≥ 7	1.51	1.47	1.56	<0.001
Type of AMI	ST-segment elevation		Reference category		
	Non-ST-segment elevation	0.84	0.82	0.86	<0.001
Cardiogenic shock		1.56	1.53	1.60	<0.001
Multi-organ failure		1.30	1.27	1.33	<0.001
Coronary angiography		0.42	0.41	0.43	<0.001
Percutaneous coronary intervention		0.35	0.34	0.36	<0.001
Coronary artery bypass grafting		0.26	0.25	0.27	<0.001
Pulmonary artery catheterization		0.98	0.93	1.04	0.52
Mechanical circulatory support		1.76	1.72	1.80	<0.001
Palliative care		3.57	3.43	3.71	<0.001
Do-not-resuscitate status		3.63	3.51	3.76	<0.001
Invasive mechanical ventilation		1.27	1.24	1.29	<0.001
Non-invasive mechanical ventilation		0.86	0.81	0.90	<0.001
Acute hemodialysis		1.33	1.25	1.41	<0.001

Abbreviations: AMI: acute myocardial infarction; CA: cardiac arrest.