OBSERVATION: BRIEF RESEARCH REPORT

Obesity and COVID-19 in New York City: A Retrospective Cohort Study

Background: Some reports suggest that obesity could be a risk factor for complications in coronavirus disease 2019 (COVID-19) (1). Several mechanisms could explain this. First, adipocytes, which activate the inflammatory cascade, can increase risk for thromboembolism and susceptibility to the cytokine storm described in COVID-19 (2). Second, obesity negatively affects lung mechanics, which could predispose obese persons to more severe respiratory distress and failure (3). Finally, obesity can alter mitochondrial bioenergetics in lung epithelial cells and increase risk for acute lung injury (4). However, some have suggested an obesity paradox in some critical illnesses, including acute respiratory distress syndrome, where patients with obesity may have improved outcomes; whether this phenomenon occurs in patients with COVID-19 is unclear (5).

Objective: To study the association between obesity and outcomes among a diverse cohort of 1687 persons hospitalized with confirmed COVID-19 at 2 New York City hospitals.

Methods and Findings: This retrospective observational cohort study included consecutive adults with confirmed COVID-19 who were hospitalized between 3 March and 15 May 2020 at an 862-bed quaternary referral center or a 180-bed community hospital in New York City. We excluded 46 patients who did not have height or weight data available to calculate body mass index (BMI). Patient data were manually abstracted (1) from the electronic health record through 6 June 2020.

We determined BMI on the basis of the most recent height and weight listed in the electronic health record. Height and weight were collected during hospitalization for 95.5% of the cohort; the remaining BMIs were collected during ambulatory encounters within 3 months of hospitalization. We defined BMI categories as underweight (<18.5 kg/m^2), normal (18.5 to 24.9 kg/m^2), overweight (25.0 to 29.9 kg/m^2), mild to moderate obesity (30.0 to 39.9 kg/m^2), and morbid obesity (≥40.0 kg/m^2).

To examine the association between BMI and in-hospital mortality, we used a Cox proportional hazards model adjusted for age, sex, race, smoking, diabetes, hypertension, chronic obstructive pulmonary disease, asthma, end-stage renal disease, coronary artery disease, heart failure, and cancer. These characteristics were chosen on the basis of risk factors for severe COVID-19 identified by the Centers for Disease Control and Prevention. We also examined for effect modification by age, sex, and race. To examine the association between BMI and respiratory failure, defined as a need for invasive mechanical ventilation, we used a Fine and Gray model to account for the competing risk for death and adjusted for the same 12 variables used in the model for mortality. We excluded the underweight group from this analysis because of low numbers. Finally, we repeated the adjusted Cox proportional hazards model analysis for mortality among persons with respiratory failure, again excluding the underweight group. To account for missing data (12% for race), we did multiple imputation.

We examined 1687 patients, whose median BMI was 27 kg/m^2 (interquartile range, 23.5 to 31.3 kg/m^2); 31.1% were obese. Participants in higher BMI categories were younger (**Table**). At the time of this report, only 69 persons remained hospitalized, including 3 who remained on invasive mechanical ventilation. Median follow-up was 7 days (interquartile range, 4 to 17 days).

We found a J-shaped pattern for in-hospital mortality. The fully adjusted hazard of dying was highest for underweight persons, was lowest for overweight persons, and progressively increased with higher degrees of obesity (**Figure**). This observation was similar across age (P for interaction = 0.32), sex (P = 0.59), and race (P = 0.57). For respiratory failure, the fully adjusted hazard ratio (HR) was lowest among persons with normal weight and progressively increased with higher BMI class (**Figure**). Finally, among those with respiratory failure, we found a similar J-shaped pattern for in-hospital mortality; HRs were similar to those in the full cohort, albeit with wider CIs (normal as the reference: HR, 1; overweight: HR, 0.76 [95% CI, 0.52 to 1.12]; mild to moderate obesity: HR, 0.82 [CI, 0.53 to 1.27]; morbid obesity: HR, 1.29 [CI, 0.58 to 2.86]).

Conclusion: This study of 1687 adults hospitalized with COVID-19 in New York City showed that obesity was an independent risk factor for respiratory failure but not for in-hospital mortality. Our findings, at least in part, explain the extensive use of invasive mechanical ventilation reported in the United States (1), where the prevalence of obesity exceeds 40%. These findings thus support the need to consider the community-specific prevalence of obesity when planning a community's COVID-19 response and also suggest that risk conferred by obesity is similar across age, sex, and race. Our findings also provide insights about a possible obesity paradox in COVID-19.

This study was limited to hospitalized adults in a single geographic location. The association between obesity and adverse outcomes could differ in other settings and thus merits additional investigation.

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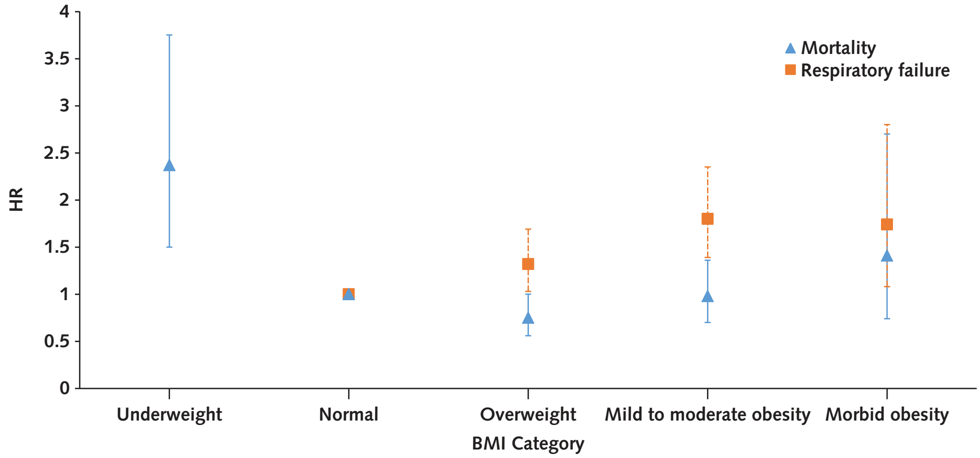
Table. Characteristics of 1687 Hospitalized Patients With COVID-19, According to BMI*

Characteristic	All (*n* = 1687)	Underweight (BMI <18.5 kg/m^2) (*n* = 58)	Normal (BMI, 18.5-24.9 kg/m^2) (*n* = 547)	Overweight (BMI, 25-29.9 kg/m^2) (*n* = 557)	Mild to Moderate Obesity (BMI, 30-39.9 kg/m^2) (*n* = 434)	Morbid Obesity (BMI ≥40 kg/m^2) (*n* = 91)	*P* Value
Demographic characteristics and comorbid conditions							
Median age (IQR), *y*	66.5 (53.7–77.2)	78.7 (62.6–88.1)	71.5 (60.2–83.4)	66.3 (54.4–75.5)	61.5 (50.3–70.3)	52.1 (39.9–62.6)	<0.001
Age							<0.001
18–40 y	156 (9)	7 (12)	40 (7)	41 (7)	44 (10)	24 (26)	
41–64 y	634 (38)	9 (16)	137 (25)	223 (40)	214 (49)	51 (56)	
65–74 y	415 (25)	7 (12)	141 (26)	147 (26)	108 (25)	12 (13)	
≥75 y	482 (29)	35 (60)	229 (42)	146 (26)	68 (16)	4 (4)	
Male sex	1004 (60)	30 (52)	330 (60)	359 (65)	246 (57)	39 (43)	<0.001
Race							<0.001
White	595 (35)	21 (36)	187 (34)	201 (36)	152 (35)	34 (37)	
Black	228 (14)	8 (14)	53 (10)	70 (13)	72 (17)	25 (27)	
Asian	298 (18)	19 (33)	141 (26)	105 (19)	29 (7)	4 (4)	
Other	359 (21)	4 (7)	111 (20)	116 (21)	112 (26)	16 (18)	
Not reported	207 (12)	6 (10)	55 (10)	65 (12)	69 (16)	12 (13)	
Current smoker	81 (5)	3 (5)	19 (3)	28 (5)	26 (6)	5 (5)	0.46
Diabetes	526 (31)	16 (28)	151 (28)	181 (33)	147 (34)	31 (34)	0.21
Hypertension	956 (57)	36 (62)	304 (56)	306 (55)	257 (59)	53 (58)	0.58
Chronic obstructive pulmonary disease	103 (6)	4 (7)	39 (7)	29 (5)	20 (5)	11 (12)	0.056
Asthma	159 (9)	3 (5)	41 (8)	37 (7)	56 (13)	22 (24)	<0.001
End-stage renal disease	101 (6)	6 (10)	44 (8)	29 (5)	17 (4)	5 (5)	0.040
Coronary artery disease	279 (17)	11 (19)	87 (16)	98 (18)	66 (15)	17 (19)	0.79
Heart failure	121 (7)	8 (14)	47 (9)	34 (6)	25 (6)	7 (8)	0.101
Cancer †	121 (7)	4 (7)	53 (10)	35 (6)	25 (6)	4 (4)	0.084
Fever	1162 (69)	25 (43)	351 (64)	386 (69)	331 (76)	69 (76)	<0.001
Cough	1168 (69)	20 (34)	353 (65)	406 (73)	313 (72)	76 (84)	<0.001
Gastrointestinal symptoms	604 (36)	14 (24)	167 (31)	205 (37)	178 (41)	40 (44)	0.001
Myalgias	334 (20)	7 (12)	79 (14)	114 (20)	113 (26)	21 (23)	<0.001
Dyspnea	1079 (64)	22 (38)	310 (57)	370 (66)	304 (70)	73 (80)	<0.001
Vital signs and laboratory values upon arrival to emergency department							
Fever (>38 °C)	277 (17)	5 (9)	78 (14)	81 (15)	95 (22)	18 (20)	0.003
Heart rate ≥125 beats/min	145 (9)	7 (12)	40 (7)	50 (9)	43 (10)	5 (6)	0.38
Systolic blood pressure <90 mm Hg	25 (2)	3 (5)	8 (1)	10 (2)	3 (1)	1 (1)	0.105
Respiratory rate >24 breaths/min	309 (19)	8 (14)	106 (20)	95 (18)	81 (19)	19 (21)	0.72
Highest level of supplemental O_2 required within first 3 h							<0.001
None	765 (45)	37 (64)	276 (51)	235 (42)	184 (42)	33 (36)	
Nasal cannula and venturi mask	602 (36)	9 (16)	157 (29)	224 (40)	174 (40)	38 (42)	
Nonrebreather mask and high-flow nasal cannula	226 (13)	9 (16)	89 (16)	65 (12)	50 (12)	13 (14)	
BIPAP or CPAP	18 (1)	1 (2)	7 (1)	4 (1)	4 (1)	2 (2)	
Invasive mechanical ventilation	76 (5)	2 (3)	18 (3)	29 (5)	22 (5)	5 (6)	
Bilateral infiltrates on chest radiograph	1199 (71)	25 (43)	362 (66)	413 (74)	331 (76)	68 (75)	<0.001
Leukocyte count >10 × 10^9 cells/L	362 (22)	18 (31)	118 (22)	124 (23)	89 (21)	13 (15)	0.188
Platelet count <150 × 10^9 cells/L	359 (22)	21 (37)	136 (25)	114 (21)	78 (18)	10 (11)	<0.001
Serum creatinine level ≥132.6 μmol/L (≥1.5 mg/dL)	358 (22)	19 (33)	137 (25)	103 (19)	84 (20)	15 (17)	0.012
Alanine aminotransferase level >40 U/L	574 (36)	10 (18)	160 (31)	217 (41)	152 (37)	35 (40)	<0.001
Aspartate aminotransferase level >40 U/L	796 (49)	29 (50)	257 (49)	277 (52)	193 (47)	40 (45)	0.53
Total bilirubin level >17.1 μmol/L (>1.0 mg/dL)	304 (19)	14 (24)	111 (21)	100 (19)	67 (16)	12 (14)	0.184
In-hospital events							
Myocardial infarction	81 (5)	5 (9)	31 (6)	22 (4)	20 (5)	3 (3)	0.39
Arrhythmia	172 (10)	0 (0)	57 (10)	61 (11)	46 (11)	8 (9)	0.045
Heart failure	74 (4)	4 (7)	24 (4)	28 (5)	16 (4)	2 (2)	0.56
Venous thromboembolic events	119 (7)	0 (0)	38 (7)	39 (7)	38 (9)	4 (4)	0.085
New-onset renal replacement therapy	105 (7)	2 (4)	25 (5)	33 (6)	38 (9)	7 (8)	0.121
Respiratory failure	444 (26)	6 (10)	116 (21)	152 (27)	145 (33)	25 (27)	<0.001
Death	310 (18)	23 (40)	126 (23)	82 (15)	66 (15)	13 (14)	<0.001

BIPAP = bilevel positive airway pressure; BMI = body mass index; CPAP = continuous positive airway pressure; IQR = interquartile range.
* Values are numbers (percentages) unless otherwise specified.
† Excludes nonmelanoma skin cancer.

Figure. HRs for in-hospital mortality and respiratory failure according to BMI.



HR (95% CI)	Underweight	Normal	Overweight	Mild to moderate obesity	Morbid obesity
Mortality	2.37 (1.50–3.75)	1 (Reference)	0.75 (0.56–1.00)	0.98 (0.70–1.36)	1.41 (0.74–2.70)
Respiratory failure	–	1 (Reference)	1.32 (1.03–1.69)	1.80 (1.39–2.35)	1.74 (1.08–2.80)

The association between BMI and in-hospital mortality (*blue triangle*) is explained by a J-shaped curve, whereas that between BMI and respiratory failure (*orange square*) is linear. The solid blue lines indicate CIs for mortality, and the dashed orange lines indicate CIs for respiratory failure. Covariates in both models included age, sex, race, smoking, diabetes, hypertension, chronic obstructive pulmonary disease, asthma, end-stage renal disease, coronary artery disease, heart failure, and cancer. All analyses were done in STATA 14 (StataCorp) and SAS, version 9.4 (SAS Institute), with 2-sided statistical tests and significance levels of 0.05. HRs are provided with 95% CIs. BMI = body mass index; HR = hazard ratio.

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