

Association of Body Mass Index With Morbidity in Patients Hospitalized with COVID-19

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Online Supplement

Lab Value (Highest Value)	Underweight (BMI < 18.5 kg/m ²) N = 5	Normal Weight (BMI 18.5 - 24.9 kg/m ²) N = 101	Overweight (BMI 25.0 - 29.9 kg/m ²) N = 130	Obese (BMI 30.0 - 39.9 kg/m ²) N = 129	Morbidly Obese (BMI > 40.0 kg/m ²) N = 20
White Blood Cell (10 ³ /uL)	10 (8 - 15)	14 (9 - 19)	13 (10 - 18)	13 (9 - 16)	12 (9 - 14)
Missing	0	1	1	2	0
Platelet (10 ³ /uL)	202 (139 - 306)	282 (193 - 358)	297 (228 - 374)	278 (217 - 350)	262 (211 - 302)
Missing	0	1	1	4	0
Creatinine (mg/dL)	1.14 (1.01 - 2.82)	1.31 (0.88 - 2.16)	1.40 (0.87 - 2.49)	1.35 (0.92 - 2.63)	1.37 (1.08 - 2.31)
Missing	0	1	2	3	0
Alanine Aminotransferase (U/L)	29 (29 - 274)	46 (23 - 82)	49 (28 - 86)	47 (31 - 82)	71 (51 - 93)
Missing	0	7	3	3	0
Aspartate Aminotransferase (U/L)	86 (59 - 272)	62 (40 - 94)	64 (40 - 98)	57 (42 - 94)	89 (70 - 180)
Missing	0	9	4	6	1
Bilirubin Total (mg/dL)	1.10 (0.60 - 1.20)	0.70 (0.50 - 1.50)	0.80 (0.50 - 1.15)	0.70 (0.50 - 1.08)	1.10 (0.60 - 1.50)
Missing	0	4	3	3	0
Glucose Level (mg/dL)	170 (149 - 183)	186 (144 - 229)	176 (139 - 242)	170 (133 - 236)	162 (126 - 301)
Missing	0	1	2	3	0
Ferritin Level (ng/mL)	2393 (1294 - 3832)	1447 (875 - 1990)	1535 (884 - 2023)	1260 (802 - 1838)	875 (807 - 1242)
Missing	1	45	57	58	8
Creatine Kinase (U/L)	1143 (1143 - 1143)	160 (65 - 291)	223 (95 - 455)	138 (62 - 360)	460 (166 - 1028)
Missing	4	39	49	50	5
D-Dimer (ng/mL)	2150 (961 - 3195)	1147 (550 - 3674)	1087 (531 - 3005)	2127 (597 - 8544)	909 (451 - 3718)
Missing	1	36	49	57	5
Lactate Dehydrogenase (U/L)	951 (712 - 1036)	545 (422 - 784)	574 (432 - 812)	592 (443 - 788)	647 (465 - 915)
Missing	2	38	46	52	7
C-Reactive Protein (mg/dL)	20 (12 - 22)	22 (15 - 29)	25 (16 - 31)	24 (17 - 30)	27 (23 - 32)

Missing	2	33	49	48	5
Sedimentation Rate (mm/hr)	79 (43 - 104)	78 (62 - 100)	89 (63 - 120)	85 (61 - 108)	91 (84 - 102)
Missing	2	54	82	82	10
Fibrinogen (mg/dL)	NA (NA - NA)	601 (430 - 754)	680 (454 - 861)	677 (578 - 868)	638 (585 - 699)
Missing	5	58	84	86	15
Procalcitonin (ng/mL)	1 (0 - 6)	1 (0 - 8)	1 (0 - 2)	1 (0 - 2)	0 (0 - 4)
Missing	1	32	44	44	5
Lab Value (Lowest Value)					
White Blood Cell ($10^3/\mu\text{L}$)	8.0 (7.5 - 12.2)	9.9 (6.4 - 13.5)	9.9 (7.1 - 12.4)	8.9 (6.8 - 12.1)	8.1 (7.5 - 9.6)
Missing	0	1	1	2	0
Absolute Lymphocyte Count ($10^3/\mu\text{L}$)	0.80 (0.40 - 0.80)	0.58 (0.30 - 0.83)	0.80 (0.50 - 1.10)	0.70 (0.48 - 0.90)	0.90 (0.60 - 1.10)
Missing	0	10	17	9	0
Platelet $10^3/\mu\text{L}$	201 (139 - 242)	217 (147 - 295)	250 (182 - 319)	229 (178 - 286)	212 (178 - 256)
Missing	0	1	1	4	0

Statistics presented: median (25th-75th percentile, IQR)

Table S2. Ventilator Parameters of Intubated Patients with COVID-19 by Obesity Class with Number of Missing Values					
Values (Days 1, 3 and 7)	Underweight (BMI < 18.5 kg/m ²) N = 5	Normal Weight (BMI 18.5 - 24.9 kg/m ²) N = 66	Overweight (BMI 25.0 - 29.9 kg/m ²) N = 76	Obese (BMI 30.0 - 39.9 kg/m ²) N = 97	Morbidly Obese (BMI > 40.0 kg/m ²) N = 16
PCO ₂ (mmHg)					
PCO ₂ Arterial 1	42 (41 - 45)	42 (37 - 52)	44 (38 - 53)	46 (40 - 53)	46 (40 - 49)
Missing	0	8	4	5	0
PCO ₂ Arterial 3	32 (30 - 38)	44 (40 - 50)	46 (41 - 54)	49 (42 - 53)	47 (42 - 49)
Missing	2	14	7	10	3
PCO ₂ Arterial 7	56 (56 - 56)	46 (39 - 54)	50 (42 - 57)	51 (45 - 58)	47 (43 - 54)
Missing	4	16	18	20	3
PO ₂ (mmHg)					
PO ₂ Arterial 1	138 (62 - 180)	96 (72 - 126)	93 (75 - 130)	90 (76 - 123)	95 (79 - 138)
Missing	0	7	2	2	0
PO ₂ Arterial 3	68 (63 - 105)	78 (66 - 93)	73 (65 - 90)	81 (70 - 99)	69 (64 - 77)
Missing	2	14	5	9	2
PO ₂ Arterial 7	87 (87 - 87)	74 (63 - 85)	72 (66 - 84)	74 (62 - 82)	72 (69 - 86)
Missing	4	16	18	18	3
PEEP (cmH ₂ O)					
PEEP 1	10.0 (8.0 - 10.0)	10.0 (8.0 - 10.0)	10.0 (10.0 - 12.0)	10.0 (10.0 - 12.0)	14.0 (10.0 - 15.0)
Missing	0	4	2	3	1
PEEP 3	8.0 (8.0 - 9.0)	10.0 (8.0 - 12.0)	12.0 (8.0 - 12.0)	12.0 (10.0 - 14.0)	14.0 (10.0 - 15.0)
Missing	2	6	5	9	3
PEEP 7	8.0 (7.0 - 9.0)	10.0 (8.0 - 13.0)	10.0 (8.0 - 12.0)	12.0 (8.0 - 14.0)	12.0 (10.0 - 14.5)
Missing	3	15	15	25	5
Plateau Pressure (cmH ₂ O)					
Plateau Pressure 1	24.5 (21.2 - 27.8)	23.5 (20.0 - 27.0)	24.0 (21.0 - 28.0)	26.0 (21.0 - 30.0)	30.0 (27.0 - 30.0)
Missing	3	28	24	35	7
Plateau Pressure 3	23 (22 - 24)	24 (19 - 27)	24 (20 - 28)	25 (22 - 29)	27 (23 - 33)
Missing	3	31	32	32	7
Plateau Pressure 7	44.0 (44.0 - 44.0)	27.0 (22.5 - 30.8)	26.0 (22.0 - 28.0)	24.0 (22.5 - 28.5)	27.0 (22.0 - 30.0)
Missing	4	40	41	58	7
PaO ₂ / FiO ₂ Ratio					
PaO ₂ /FiO ₂ Ratio 1	188 (152 - 207)	116 (84 - 160)	108 (91 - 146)	115 (84 - 151)	96 (62 - 129)
Missing	0	5	1	5	1
PaO ₂ /FiO ₂ Ratio 3	134 (124 - 144)	128 (105 - 180)	148 (110 - 174)	140 (110 - 168)	103 (83 - 147)

Missing	3	8	5	10	2
PaO ₂ /FiO ₂ Ratio 7	200 (200 - 200)	141 (93 - 172)	138 (109 - 160)	142 (116 - 179)	154 (112 - 186)
Missing	4	14	10	22	4
Tidal Volume per Predicted Body Weight (mL/Kg)					
Tidal Volume / PBW 1	5.53 (5.29 - 5.95)	6.74 (6.26 - 7.76)	6.97 (6.15 - 8.38)	7.34 (6.42 - 8.21)	8.02 (7.43 - 9.66)
Missing	0	4	4	5	2
Tidal Volume / PBW 3	5.29 (5.17 - 5.62)	6.21 (5.95 - 6.82)	6.68 (6.06 - 7.13)	6.57 (6.03 - 7.03)	7.02 (6.26 - 7.73)
Missing	2	15	13	12	5
Tidal Volume / PBW 7	5.05 (5.05 - 5.05)	6.43 (5.97 - 7.02)	6.70 (6.15 - 7.49)	6.83 (6.27 - 7.60)	6.97 (6.76 - 7.30)
Missing	4	33	32	45	6
Static Compliance (mL/cmH ₂ O)					
Static Compliance 1	29 (20 - 36)	30 (22 - 39)	29 (23 - 40)	28 (22 - 38)	29 (27 - 36)
Missing	0	5	5	7	2
Static Compliance 3	25 (24 - 29)	30 (24 - 38)	29 (23 - 39)	31 (22 - 39)	31 (23 - 35)
Missing	2	15	13	16	5
Static Compliance 7	11 (11 - 11)	25 (20 - 33)	31 (21 - 39)	28 (24 - 37)	25 (22 - 36)
Missing	4	34	34	48	7
Driving Pressure (cmH ₂ O)					
Driving Pressure 1	9.5 (8.8 - 10.2)	12.2 (10.0 - 16.0)	14.0 (11.0 - 18.0)	14.0 (11.0 - 19.0)	15.0 (14.0 - 17.0)
Missing	3	28	24	36	7
Driving Pressure 3	14.0 (13.0 - 15.0)	12.0 (10.0 - 16.0)	12.0 (10.0 - 15.2)	13.0 (9.5 - 16.0)	15.5 (12.0 - 18.2)
Missing	3	31	32	34	8
Driving Pressure 7	34.0 (34.0 - 34.0)	15.0 (12.2 - 17.5)	13.0 (11.0 - 17.0)	13.0 (11.2 - 17.0)	14.0 (8.0 - 16.0)
Missing	4	40	41	59	7
Ventilatory Ratio					
Ventilatory Ratio 1	1.27 (1.22 - 1.44)	1.63 (1.24 - 2.18)	1.88 (1.64 - 2.23)	1.87 (1.54 - 2.49)	2.21 (1.84 - 2.59)
Missing	0	10	7	12	3
Ventilatory Ratio 3	1.44 (1.17 - 1.44)	1.72 (1.43 - 2.10)	2.03 (1.62 - 2.60)	2.17 (1.73 - 2.65)	2.22 (1.96 - 2.51)
Missing	2	18	11	19	6
Ventilatory Ratio 7	0.99 (0.99 - 0.99)	1.80 (1.52 - 2.34)	2.19 (1.68 - 2.63)	2.26 (1.88 - 2.64)	2.39 (1.98 - 3.03)
Missing	4	23	26	30	5

Statistics presented: median (25th-75th percentile, IQR)

Outcome	Normal Weight (BMI 18.5 - 24.9 kg/m ²) N = 104	Overweight (BMI 25.0 - 29.9 kg/m ²) N = 138	Obese (BMI 30.0 - 39.9 kg/m ²) N = 137	Morbidly Obese (BMI > 40.0 kg/m ²) N = 23
Discharge to Home	21 (20%)	31 (22%)	42 (31%)	10 (43%)
Length of Stay	26.5 (15.5 - 52.1)	34.0 (20.6 - 50.9)	33.9 (15.6 - 54.2)	21.3 (14.3 - 48.1)
Length of Stay (Survivors Only)	48.8 (29.2 - 69.9)	40.9 (26.1 - 56.5)	41.9 (26.7 - 66.1)	27.1 (17.4 - 57.3)
Tracheostomy	32 (32%)	47 (36%)	50 (39%)	5 (22%)
Vent-Free (28) Days	0 (0 - 9)	0 (0 - 14)	0 (0 - 12)	0 (0 - 17)
Vent-Free (60) Days	0 (0 - 39)	26 (0 - 46)	23 (0 - 44)	23 (0 - 49)

Baseline values are presented as median (25th-75th percentile) for continuous variables and N (%) for categorical variables.

BMI		Normal	Underweight	Overweight	Obese	Morbidly Obese
Discharge to Home	Odds Ratio	—	0.53	1.3	1.3	2.6
	95% CI ¹	—	0.26 - 1.0	1.0 - 1.8	1.0 - 1.7	1.5 - 4.7
	Q-value ²		0.079	0.072	0.1	0.004
Length of Stay (Days)	Estimate	—	-7.8	2.6	3.5	-1.5
	95% CI ¹	—	-16 - 0.23	-0.73 - 5.9	0.03 - 7.0	-7.8 - 4.8
	Q-value	—	0.11	0.17	0.11	0.64

¹ CI = Confidence Interval

² Q-value: False discovery rate correction for multiple testing

BMI		Normal	Underweight	Overweight	Obese	Morbidly Obese
Discharge to Home	Odds Ratio	—	0.55	1.1	0.83	1.1
	95% CI ¹	—	0.26 - 1.1	0.80 - 1.4	0.61 - 1.1	0.63 - 2.2
	Q-value ²		0.2	0.67	0.31	0.67
Length of Stay	Estimate	—	-7.5	2.7	4.3	0.85
	95% CI	—	-16 - 0.57	-0.66 - 6.0	0.70 - 7.9	-5.6 - 7.3
	Q-value		0.23	0.29	0.1	0.95

¹ CI = Confidence Interval

² Q-value: False discovery rate correction for multiple testing

* adjusted for age, sex and race only

Table S6. Unadjusted Outcomes by Obesity Class in Intubated Cohort					
BMI	Normal	Underweight	Overweight	Obese	Morbidly Obese
VFD ¹ (60 Days)					
Estimate	—	4.1	5.9	6	7.7
95% CI ²	—	-15 - 23	0.36 - 11	0.46 - 12	-2.1 - 17
Q-value ³	—	0.68	0.075	0.075	0.16
VFD (28 Days)					
Estimate	—	4.3	1.7	1.1	3.6
95% CI	—	-3.1 - 12	-0.44 - 3.8	-1.0 - 3.3	-0.19 - 7.3
Q-value	—	0.31	0.24	0.31	0.24
Length of Stay					
Estimate	—	-24	4.6	2.8	-6.4
95% CI	—	-55 - 6.5	-4.1 - 13	-5.9 - 12	-22 - 9.1
Q-value	—	0.49	0.53	0.53	0.53
Discharge to Home					
Odds Ratio	—	1	1.1	1.7	3
95% CI	—	0.05 - 7.1	0.62 - 2.2	1.0 - 3.2	1.2 - 7.9
Q-value	—	>0.99	0.89	0.14	0.089
Tracheostomy					
Odds Ratio	—	0	1.2	1.4	0.59
95% CI	—		0.68 - 2.0	0.80 - 2.4	0.18 - 1.6
Q-value	—	0.98	0.75	0.67	0.67

¹ VFD = Ventilator Free Days

² CI = Confidence Interval

³ Q-value: False discovery rate correction for multiple testing

Table S7. Partially Adjusted Outcomes by Obesity Class in Intubated Cohort*					
BMI	Normal	Underweight	Overweight	Obese	Morbidly Obese
VFD ¹ (60 Days)					
Estimate	—	0	3.9	3.2	0.29
95% CI ²	—	-18 - 18	-1.4 - 9.1	-2.2 - 8.6	-9.3 - 9.9
Q-value ³		>0.99	0.42	0.42	>0.99
VFD (28 Days)					
Estimate	—	2.5	1	0.13	0.82
95% CI	—	-4.6 - 9.7	-1.0 - 3.1	-2.0 - 2.2	-2.9 - 4.6
Q-value		0.7	0.54	0.9	0.84
Length of Stay					
Estimate	—	-25	3.4	0.09	-8.9
95% CI	—	-56 - 5.5	-5.4 - 12	-8.9 - 9.1	-25 - 7.2
Q-value		0.22	0.5	0.98	0.45
Discharge to Home					
Odds Ratio	—	0.91	1	1.5	2.1
95% CI	—	0.04 - 7.6	0.50 - 1.9	0.78 - 2.9	0.69 - 6.3
Q-value		0.93	0.93	0.44	0.44
Tracheostomy					
Odds Ratio	—	0	1.1	1.3	0.57
95% CI	—		0.66 - 2.0	0.74 - 2.3	0.17 - 1.6
Q-value		0.98	0.98	0.77	0.77

¹ VFD = Ventilator Free Days

² CI = Confidence Interval

³ Q-value: False discovery rate correction for multiple testing

* adjusted for age, sex and race only

Table S8. Adjusted Length of Stay by Obesity Class Among Survivors in Admitted Cohort*					
BMI	Normal	Underweight	Overweight	Obese	Morbidly Obese
Length of Stay (Days)					
Estimate	—	-5.7	1.7	5.2	1
95% CI ¹	—	-17 - 5.2	-2.4 - 5.7	0.83 - 9.6	-6.7 - 8.8
Q-value ²		0.77	0.91	0.20	0.95

¹ CI = Confidence Interval

² Q-value: False discovery rate correction for multiple testing

* Adjusted for age, sex, race, diabetes, hypertension, chronic obstructive pulmonary disease, asthma, end stage renal disease, coronary artery diseases, heart failure, cerebrovascular accident and cancer

Table S9. Adjusted Length of Stay by Obesity Class Among Survivors in Intubated Cohort*					
BMI	Normal	Underweight	Overweight	Obese	Morbidly Obese
Length of Stay (Days)					
Estimate	—	-30	-4.2	-5.2	-13
95% CI ¹	—	-85 - 24	-17 - 8.3	-18 - 7.8	-36 - 9.7
Q-value ²		0.69	0.78	0.73	0.69

¹ CI = Confidence Interval

² Q-value: False discovery rate correction for multiple testing

* Adjusted for age, sex, race, diabetes, hypertension, chronic obstructive pulmonary disease, asthma, end stage renal disease, coronary artery diseases, heart failure, cerebrovascular accident and cancer

Figure S1. Rolling weekly average number of intubations across body mass index (BMI) groups.

