Intensive Care Unit Outcomes Are Not Adversely Affected by Obesity in Patients with Respiratory Failure

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Citation

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Abstract

Objective: To examine the effect of obesity on mortality and healthcare resource utilization, including cost, in a heterogenous group of intensive care unit (ICU) patients with respiratory failure.Design: Retrospective cohort reviewSetting: A 24-bed University adult non-cardiac medical and surgical ICUPatients and Participants: Patients >16 years-of-age admitted to the ICU Monday through Friday from January 2, 1999 to January 1, 2000. Patients with respiratory failure (N=201) were retrospectively identified and grouped as underweight (BMI <19.9 kg/m^2), normal (BMI of 20-29.9 kg/m^2), or obese (BMI>30 kg/m^2). Underweight patients and those undergoing routine post-operative ventilator weaning were excluded.Interventions: NoneMeasurements: Measured dependent variables included ICU and hospital length of stay (LOS), ICU and hospital mortality, cost per admission, and discharge disposition. Discharge locations were as follows: home, home with home health or skilled nursing facility (SNF)[equivalent to nursing home for our analyses], long-term acute care facility (LTACH) [facilities designed for long-term patients who require prolonged ventilator weaning or other high-level care], or hospice. APACHE III scores were used to calculate predicted ICU and hospital mortality, and ICU and hospital LOS. The total cost for each patient was the sum of all direct and indirect costs excluding physician professional fees.Results: Groups were evenly matched for severity of illness, chronic health, and case mix. Obese patients had a lower PaO_2:FiO_2 ratio (214+133 vs. 173+108, p=0.04). Patients with primary respiratory failure were less sick than those without a primary respiratory cause (predicted mortality 30.9-31.4% vs. 43.9-44.8%). There were no differences in mortality, ICU or hospital LOS, or cost between the normal weight and obese patients. The results of multivariate analysis failed to show a significant association between obesity and mortality, LOS, cost, or disability among survivors.Conclusions: Obese patients in the ICU requiring mechanical ventilation for respiratory failure have similar mortality, LOS, and cost outcomes as normal weight patients. In addition, have similar levels of disability independent of BMI.

INTRODUCTION AND OBJECTIVE

Obesity is a health epidemic of industrialized countries including the United States, United Kingdom, and Eastern Europe and has been associated with substantial morbidity and mortality in the general population. This is not, however, a universal finding among patients within the intensive care unit (ICU). While some investigators have reported increased mortality and resource consumption in the obese compared to the non-obese [1-4], others have not [5-9]. In fact, it has been reported that obese patients who survive of their hospitalization have improved functional status at hospital discharge [7] and lower odds of death compared with their non-obese counterparts [8]. Furthermore, two non-population based studies of mechanically ventilated obese patients with acute lung injury (ALI) and acute respiratory distress syndrome (ARDS) failed to show worse outcomes [8,10]. A more recent population based study of ALI/ARDS also failed to show an association between body mass index (BMI) and mortality, but did demonstrate the most severely obese patients utilized greater health care resources [11]. In contrast to prior reports, the most obese survivors were more often discharged to a rehabilitation or skilled nursing facility, suggesting impaired functional status at discharge. Actual cost data to support other metrics of health care utilization has rarely been reported.

The objective of the current study was to examine the effect of obesity on mortality and healthcare resource utilization, including cost, in a heterogeneous group of patients with respiratory failure requiring mechanical ventilatory support in the ICU.

METHODS

The Trauma and Life Support Center (TLC) at the University of Wisconsin Hospital and Clinics (UWHC) is a 24-bed adult ICU, admitting non-cardiac medical and surgical patients. It is a Level 1-Trauma Center and supports one of the largest organ transplant programs in the United States. Admission sources include the emergency department, hospital wards and clinics, and transfers from surrounding community and rural health centers.

During a 12-month period from January 2, 1999 to January 1, 2000, patient weight and height were directly measured by members of the nutrition support service on all patients greater than 16 years-of-age admitted to the TLC Monday through Friday, and BMI was subsequently calculated. Data were collected prospectively in 764 patients using the hospital's electronic medical records and the patient's paper charts. Actual cost data was obtained using the UWHC cost-accounting system. Basic demographic information, including age, gender, and chronic health conditions, were recorded at admission. Admission source and other data required to calculate the APACHE III severity of illness scores were gathered within 24 hours of admission to the TLC using APACHE III software (Cerner, McLean, VA.) by an outcomes coordinator trained in data collection. All patients were followed to death or discharge. The protocol was approved by the University of Wisconsin institutional review board. The requirement for informed consent was waived.

From this original prospective cohort, patients with respiratory failure requiring mechanical ventilation were retrospectively identified and stratified into one of 3 groups; underweight (BMI <19.9 kg/m^2), normal (BMI of 20-29.9 kg/m^2), or obese (BMI>30 kg/m^2). Underweight patients and those admitted post-operatively for routine post-operative weaning from the ventilator were excluded. The study population consisted of 201 patients who fulfilled the entry criteria.

Measured dependent variables included ICU and hospital length of stay (LOS), ICU and hospital mortality, costs per admission, and discharge disposition. For survivors, discharge locations were as follows: home, home with home health or skilled nursing facility (SNF)[equivalent to nursing home for our analyses], long-term acute care facility (LTACH) [facilities designed for long-term patients who require prolonged ventilator weaning or other high-level care], or hospice. APACHE III scores were used to calculate predicted ICU and hospital mortality, and ICU and hospital LOS. The total cost for each patient was the sum of all direct and indirect costs excluding physician professional fees.

STATISTICAL METHODS

Group comparisons were made by Wilcoxon rank sum test and chi-squares for continuous and categorical variables, respectively. Statistical significance was defined as a two-sided p value < 0.05. In the first analysis, the relationship between obesity, hospital LOS, and total cost was evaluated by multivariate linear regression analysis after data underwent log transformation. Age, gender, BMI, admit diagnosis body system, severity of illness, predicted mortality, severity of lung injury (as measured by PaO_2:FiO_2 ratio), and discharge diagnoses were entered as covariates with hospital LOS as the dependent variable. Subsequently, hospital LOS was added as a covariate with total cost set as the dependent variable. Parameter estimates were examined for evidence of co linearity. In the second analysis, the relationship between obesity and discharge disposition was examined by logistic regression with hospital discharge set as the response variable. Gender, BMI, admit diagnosis body system, severity of illness, predicted mortality, and severity of lung injury (as measured by PaO_2:FiO_2 ratio) were entered as effect variables. Employing a backward elimination procedure, effects not satisfying a 0.05 significance level were removed from the model. All covariates were selected based upon clinical judgment as we hypothesized them to be confounders of the relationship between BMI and outcomes. All analysis was performed using SAS statistical software version 9.1 (SAS Institute, Cary, NC.).

RESULTS

The study population consisted of 201 patients, 150 normal and 51 obese. Comparisons of baseline characteristics are shown in table 1.

Figure 1

Table 1

Table 1. Baseline characteristics by group

Characteristics	Normal	Obese	p-value
Age, yrs	54.8±18.4	56.6±14	0.67
Gender, n(%)			
M	99(66)	28(55)	0.16
F	51(34)	23(45)	
Acute physiology score	75.8±32.9	74.4±31.1	0.78
PaO_2:FiO_2 ratio	214±133	173±108	0.04*
Predicted mortality, %	40.9	38.6	0.73
Admit diagnosis by body system, n(%)			0.17^
Respiratory	43(28.7)	21(41.2)	
Cardiovascular	44(29)	14(27.5)	
Genitourinary	3(2)	2(3.9)	
Gastrointestinal	15(10)	4(7.8)	
Metabolic/Endocrine	2(1.3)	1(1.9)	
Muscle/Soft tissue	1(0.7)	1(1.9)	
Neurological	18(12)	1(1.9)	
Trauma	24(16)	7(13.7)	
Admit source, n(%)			0.4^^
Emergency ward	75(50)	21(41.1)	
Hospital	45(30)	13(25.5)	
Transfer	30(20)	17(33.3)	

*p<0.05 ^Fisher's exact test ^^Global chi-squares

Groups were evenly matched for severity of illness, chronic health, and case mix. Commensurate with the severity of illness, both groups had high predicted mortality. Lung injury was significantly worse among obese patients within the first 24 hours of admission as reflected by a lower PaO_2:FiO_2 ratio (173+108 vs.214+133, p=0.04). Obese patients also tended to be admitted more often for primary respiratory system related disease (41.1% vs. 28.7%, p=0.09) than their non-obese counterparts. The predicted mortality, indicating a higher severity of illness, was higher in patients from both groups admitted with a non-respiratory system disease compared with a primary respiratory system disease (table 1).

Outcomes were similar across study groups as shown in table 2.

Figure 2

Table 2

Table 2. Outcomes between groups

Outcome measure	Normal	Obese	p-value
ICU mortality, %			
Actual	19.3	23.5	0.52
Predicted	30.4	27.6	0.81
Hospital mortality, %			
Actual	29.3	33.3	0.59
Predicted	40.9	38.6	0.73
ICU length of stay, days			
Actual	10.23±10.7	9.1±8.4	0.23
Predicted	6.4±1.8	6.5±1.9	0.42
Hospital length of stay, days			
Actual	27.3±26.9	27.4±27.1	0.66
Predicted	14.8±4.4	14.8±5.4	0.84
Discharge disposition, survivors, n(%)			0.7^^
home	39(36.8)	12(36.4)	
SNF	50(48)	16(48.5)	
LTAC	14(13.5)	6(18.2)	
Hospice	2(1.9)	0(0)	
Total cost, $	52,493±55,061	55,918±59,818	0.75

^^Global chi-squares including death as a discharge disposition

Compared to APACHE III predicted outcomes, observed ICU and hospital mortality where lower in both groups while ICU and hospital LOS were longer than predicted.

Multivariate analysis identified several significant associations, but none between obesity and our predefined outcomes of mortality, LOS, cost, or disability. Significant positive relationships were found between total cost and hospital LOS, a respiratory diagnosis, and the PaO_2:FiO_2 ratio. Every additional hospital day was associated with a 2.6% increase in total cost. Admission for a primary respiratory diagnosis was associated with a 17.5% decrease in total cost compared to other body system related diagnoses, and total cost increased 5.7% for each decrease in PaO_2:FiO_2 ratio of 100 from 500. The logistic regression analysis added little to the overall results other than confirming the utility of the APACHE III system by showing significant associations between predicted mortality and death.

DISCUSSION

The main findings of our study are that obese patients (defined as a BMI>30 kg/m^2) did not have increased mortality, ICU/hospital LOS, or total cost compared to non-obese patients with respiratory failure requiring mechanical ventilation. Additionally, survivors had similar levels of disability upon hospital discharge as reflected by similar discharge disposition, irrespective of BMI category. The lack of effect of obesity upon mortality found is in agreement with a growing body of evidence that has examined this question both among general populations of critically ill patients and in heterogeneous groups with respiratory failure and ALI/ARDS. In a secondary analysis of 861 patients who had participated in the National Heart, Lung, and Blood Institute's multicenter, randomized trials of the Acute Respiratory Distress Syndrome Network, obese patients with ALI had similar mortality, rate of unassisted ventilation by day 28, and number of ventilator-free days after risk adjustment compared to normal weight patients [10]. In a later study, the same authors reported similar results among nearly 1500 patients suffering from ALI derived from the Project Impact (PI) database [8]. In fact, the adjusted odds of death were 33% lower in obese patients versus other BMI groups (adjusted OR, 0.67; 95% CI, 0.46-0.97) in that study. More recently, these observations have been extended by a prospective, population-based cohort study involving 825 patients from an ALI/ARDS registry showing no mortality difference in any BMI category versus normal weight controls [11].

Consistent with a several other studies [6-8], no differences in resource consumption between normal weight and obese individuals were found in our study population. This may reflect small numbers of the most severely obese (BMI>40 kg/m^2) included in our study population. Greater levels of

obesity, specifically morbid obesity, have been reported by other investigators to negatively impact ICU and hospital resource consumption among general medical-surgical ICU patients and in patients with ALI/ARDS [1-2, 7]. This effect has been attributed to prolonged mechanical ventilation among obese survivors [11]. Insofar as there were no differences in LOS or cost among obese and non-obese patients in our study, differences in days of mechanical ventilation is not sufficient to explain the results and justifies the omission of ventilator days as a data point in our study.

Our findings relating to total cost, a measure not previously reported in this population, extends prior observations from general ICU patients [6]. In a single center, prospective study of 2,148 patients admitted to the 9-bed medical ICU of a 650-bed tertiary care hospital, Ray et al. found no differences in total or variable cost among five BMI categories, including obese and severely obese compared with others.

Only one other study has reported the effect of obesity on discharge disposition in a population of ICU patients with respiratory failure [11]. Morris et al. reported the adjusted odds of ALI/ARDS patients being discharged to be a skilled nursing or rehabilitation facility to be 4.3-6 times that of normal controls.

We acknowledge our study has several limitations. First, it is retrospective in nature and includes patients whose data was extracted from a previously prospectively collected data set. As with any study of similar methodology, lack of control over treatments rendered may have influenced the results. This effect is minimized by inclusion of a specific subset of patients who typically receive similar interventions. In addition, our data was collected prior to the widespread use of lower tidal volumes and particular attention to limiting airway pressures in patients suffering ALI/ARDS. An a priori decision was made to omit data on tidal volumes (V_t) because of colinearity between BMI and V_t (calculation of tidal volume is dependent upon the patient's weight) [11]. Second, as previously stated, we were unable to examine the effect of severe obesity (BMI>40 kg/m^2) on outcomes apart from the remainder of our population due to small numbers and the consequent lack of power to make relevant assertions. Lastly, insofar as the ability of any model to predict or explain the studied outcome rests largely on adjustment for variables that have been hypothesized on theoretic grounds or have been shown in previous research to be confounders of the relationship being studied [12], residual confounding from unmeasured or excluded variables could have affected our ability to detect associations.

In sum, we have demonstrated that obese patients are no more likely to die or consume resources during their hospital stay. Additionally, they have similar discharge disposition to normal weight controls indicating similar levels of disability among survivors. Lastly, the total cost is the same among normal and obese patients. Thus, when objectively scrutinized, obese patients with respiratory failure have similar outcomes to their non-obese counterparts. The observations from this study and several others suggest that predicting ICU outcomes in the obese population should be similar to that for the non-obese.

References

1. El-Solh A, Sikka P, Bozkanat E, et al. Morbid obesity in the medical ICU. Chest 2001;120:1989-97.
2. Goulenok C, Monchi M, Chiche JD, et al. Influence of overweight on ICU mortality: a prospective study. Chest 2004;125:1441-45
3. Nasraway SAJ, Albert M, Donnelly AM, et al. Morbid obesity is an independent determinant of death among surgical critically ill patients. Crit Care Med 2006;34:964-70.
4. Brown CV, Neville AL, Salim A, et al. The impact of obesity on severely injured children and adolescents. J Pediatr Surg 2006;41:88-91.
5. Reeves BC, Ascione R, Chamberlain MH, et al. Effect of body mass index on early outcomes in patients undergoing coronary artery bypass surgery. J Am Coll Cardiol 2003;42:668-76.
6. Ray DE, Matchett SC, Baker K, et al. The effect of body mass index on patient outcomes in a medical ICU. Chest 2005;127:2125-31.
7. Tremblay A, Bandi V. Impact of body mass index on outcomes following critical care. Chest 2003;123:1202-7.
8. O'Brien JMJ, Phillips GS, Ali NA, et al. Body mass index is independently associated with hospital mortality in mechanically ventilated adults with acute lung injury. Crit Care Med 2006;34:738-44.
9. Minutello RM, Chou ET, Hong MK, et al. Impact of body mass index on in-hospital outcomes following percutaneous coronary intervention (report from the New York State Angioplasty Registry). Am J Cardiol 2004;93:1229-32.
10. O'Brien JMJ, Welsh CH, Fish RH, et al. Excess body weight is not independently associated with outcome in mechanically ventilated patients with acute lung injury. Ann Intern Med 2004;140:338-45.
11. Morris AE, Stapleton RD, Rubenfeld GD, et al. The association between body mass index and clinical outcomes in acute lung injury. Chest 2007;131:342-47.
12. Katz M. Multivariable analysis: a primer for readers of medical research. Ann Intern Med 2003;138:644-50.

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