Impact of C-reactive protein and BMI on patient outcome in respiratory ICU in Abbassia Chest Hospital
Taher A. EL Naggar\textsuperscript{a}, Khaled M. Wagih\textsuperscript{a}, Hossam S. Mohamed\textsuperscript{b}

Introduction  C-reactive protein (CRP) is the most widely used biomarker of infection in critically ill patients and some data are available on the morbidity and mortality in obese patients in the medical intensive care setting, but it is widely held that their outcomes are poor.

Aim of the work  This study aimed to evaluate the impact of CRP and BMI on the outcome of patients admitted in the respiratory ICU (RICU) in Abbassia Chest Hospital.

Materials and methods  This prospective study was carried out on 71 patients admitted to the RICU at Abbassia Chest Hospital from January 2011 to July 2011. A full assessment of history, a thorough clinical examination, length of stay (LOS), and need for mechanical ventilation were assessed, and BMI and CRP were measured.

Results  There was a highly significant correlation between BMI categories and outcome in which the mortality rate was high among underweight patients; there was also a significant correlation with complications, wherein septicemia was more common in underweight patients. Complications of mechanical ventilation were more common in morbidly obese patients and nosocomial infection was more common in obese patients. The results showed an insignificant correlation between smoking, need for mechanical ventilation, duration of MV, LOS in ICU, and outcome in terms of the CRP level.

Conclusion  The study concluded that CRP exerted an independent effect on the duration of mechanical ventilation (MV) and LOS in RICU. The mortality rate was high in underweight patients, but not in overweight, obese, or severely obese patients.  

Egypt J Broncho 2015 9:238–244  
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Keywords: BMI, C-reactive protein, length of stay, respiratory ICU

\textsuperscript{a}Pulmonary Medicine Department, Faculty of Medicine, Ain Shams University \textsuperscript{b}Abbassia Chest Hospital, Cairo, Egypt

Correspondence to Khaled Mohamed Wagih, 26 Otman Ebnaaftan Street, Helipolis Cairo, Egypt
Tel: +20 100 124 0282; fax: +20 26202814; e-mail: khaledwagih1970@yahoo.com

Received 08 April 2015  Accepted 23 April 2015

Introduction  C-reactive protein (CRP) is a marker of inflammation that has been used to monitor the course of infection and inflammatory diseases. CRP has been considered not only as a biochemical marker of inflammation but also as an active modulator of the inflammatory response [1].

Numerous studies have reported increased CRP levels in patients with sepsis [2], but their relation to multiple organ dysfunctions and failure has not been well evaluated. Some studies have suggested that CRP may be an indicator of organ failure [3].

Serum CRP level began to be used as a diagnostic tool useful in determining the degree of activity and as a therapeutic guide for a number of conditions that commonly lead to marked changes in the plasma concentrations of acute-phase proteins [4].

The impact of obesity on outcome in critically ill patients has not been well studied. There are only a few comprehensive reviews that detail the management of obese critically ill patients. Hospitalized obese patients are at an increased risk of developing respiratory and other complications [5].

During the last decade, the increase in the incidence of obesity in the general population has led to a higher number of obese patients being hospitalized in ICUs. However, the direct influence of excessive body weight on ICU mortality remains controversial. Few data are available on morbidity and mortality in obese patients in the medical intensive care setting, but it is widely held that their outcomes are poor [6].

Problems in obese patients in the ICU may include difficulties with airway maintenance, disordered ventilation and gas exchange, impaired circulation, and altered drug pharmacokinetics. Procedures are more challenging, whether nonoperative (e.g. airway intubation, vascular access, neural blocks, urinary catheterization) or operative. Safe transport, repositioning, image acquisition, and mobilization can be major challenges requiring careful planning and execution. Of the many effects of obesity on various organ systems, we have chosen to focus on the following obesity-related disorders encountered commonly in the ICU that indicate the diverse effects through which obesity increases morbidity and complicates management [6].

All previously published studies of impact of CRP and BMI on patient outcome in critically ill patients have
addressed this relation in either medical, surgical, or trauma ICUs, but never in a specialized respiratory ICU (RICU). We hypothesized that there would be a relation between BMI, CRP, and the patient outcome in the RICU.

**Aim of the work**
The aim of our study is to evaluate the impact of CRP and BMI on the outcomes of patients admitted in the RICU in Abbassia Chest Hospital.

**Material and methods**
This prospective study was carried out on 71 patients admitted to the RICU at Abbassia Chest Hospital from January 2011 to July 2011.

**Inclusion criteria**
Patients older than 20 years of age.

Patients’ first admission in the ICU who stay more than 24 h.

**Exclusion criteria**
Patients younger than 20 years of age.

Patients whose body weight cannot be measured (because of loss of consciousness or because they are bedridden).

All the patients were subjected to the following:

1. Full assessment of history either from the patient or his/her relative.
2. Thorough clinical examination.
3. Investigations: These included the following:
   a. Plain chest radiograph.
   b. Arterial blood gas analysis.
   c. Laboratory investigations; these included the following: blood sugar, liver profile, renal profile, complete blood count, and electrolytes.
   d. CRP assay using (Rapid Tex CRP Latex Test).
   e. Height and weight measurements in the first 2 h of admission.

The BMI was calculated as follows [7]:
Weight in kilograms/(height in meter)$^2$.

Patients were classified as follows:
Underweight: <18.5; normal weight: 18.5–24.9; overweight: 25–29.9; obese: 30–39.9; morbidly obese: ≥40.

(f) ECG 7–Special investigations were performed according to the clinical condition, for example, echocardiography, ultrasonography, and computed tomography scan if needed.

(4) Length of stay (LOS), requirement of mechanical ventilation, or oxygen therapy.

**Expected values**
Normal adult levels of CRP are reported to be less than 12 mg/l. The CRP levels in patients with strongly positive CRP reactions had been detected to be as high as 330 mg/l [8].

**Statistical analysis**
The collected data were revised, coded, tabulated, and entered in a PC using the Statistical Package for Social Science. Data were presented and suitable analysis was carried out according to the type of data obtained for each parameter.

**Results**
This study included 71 patients admitted to Abbassia Chest Hospital in the ICU from January 2011 to July 2011.

This study included 44 men and 27 women, mean age 51.9 ± 15.2 years; the mean BMI was 26.65 ± 8.12 and the mean CRP was 19.39 ± 8.25.

Forty-two patients were mechanically ventilated; the mean duration of mechanical ventilation was 7.12 ± 7.23, the mean LOS in the ICU was 11.07 ± 8.5 days, and the mortality rate was 46.5%.

The relationship between the CRP result and mechanical ventilation among the study participants showed an insignificant correlation between the CRP result and mechanical ventilation, although increased CRP with mechanical ventilation (Table 1).

The relationships between the CRP result and outcome among the study participants are shown in Table 2 and Fig. 1 shows insignificant correlations between the CRP result and outcome, although mortality was high in patients with elevated CRP.

There was an insignificant correlation between the CRP result and length of ICU stay as shown in Table 3.

There was an insignificant correlation between the CRP result and the duration of mechanical ventilation as shown in Table 4 and Fig. 2.

There was an insignificant correlation between sex, smoking, different BMI groups, mechanical ventilation,

| CRP | Mechanical ventilation [N (%)] | P | Significance |
|-----|---------------------------------|---|--------------|
| Elevated | 33 (78.6) | 23 (79.3) | 0.940 | NS |
| Normal | 9 (21.4) | 6 (20.7) |      |    |

CRP, C-reactive protein.
There was an insignificant correlation between BMI groups in terms of age, serum CRP level, duration of mechanical ventilation, and LOS in ICU as shown in Table 6.

There was an insignificant correlation between BMI groups in relation to sex, smoking, serum CRP level, and need for mechanical ventilation; however, there was a significant correlation in terms of complications. Septicemia was more common in underweight patients. Complications of mechanical ventilation were more common in morbidly obese patients, nosocomial infection was more common in obese patients, whereas there was a highly significant correlation of outcome with the mortality rate, which was higher in the underweight group as shown in Table 7.

There was a highly significant correlation between the patients who died and those who survived in terms of complications; the most common cause of death was ARDS and septicemia as shown in Table 8.

Table 9 shows a highly significant correlation between the patients who died and those who survived in terms of complications.
of diagnosis, and those diagnosed with malignancy had a poor outcome.

There was a highly significant correlation between patients with and without nosocomial infections in terms of LOS and duration of MV; patients with nosocomial infection had longer stay in ICU and the duration of MV was prolonged as shown in Table 10.

Discussion
During the last decade, the increase in the incidence of obesity in the general population has led to a higher number of obese patients being hospitalized in ICUs. However, the direct influence of obesity on ICU mortality remains controversial. Some data are available on morbidity and mortality in obese patients in the medical ICUs, but it is widely held that their outcomes are poor [6].

In the present study, there were 56 patients with elevated CRP; of those, 27 (48.2%) patients were smokers and 20 (35.7%) patients were nonsmokers, whereas nine (16.1%) patients were ex-smokers. We found that 33 (59%) patients needed mechanical ventilation, whereas 23 (41%) patients did not. Also, estimated 27 (48.2%) patients survived, whereas 29 (51.8%) patients died.

Table 6 Comparison between patients with different BMIs in terms of age, C-reactive protein, duration of mechanical ventilation, and length of ICU stay

| BMI group (mean ± SD) | P Significance |
|----------------------|---------------|
| Normal | Underweight | Overweight | Obese | Morbidly obese |
| Age (years) | 49.56 ± 12.66 | 43.54 ± 19.39 | 52.94 ± 17.02 | 58.65 ± 12.46 | 55.33 ± 3.27 | 0.085 | NS |
| CRP level (mg/l) | 19.87 ± 8.69 | 17.45 ± 7.80 | 19.50 ± 10.59 | 19.85 ± 7.09 | 21.00 ± 6.00 | 0.936 | NS |
| Duration of MV (days) | 6.40 ± 8.24 | 7.55 ± 6.70 | 7.57 ± 8.87 | 7.11 ± 7.75 | 7.00 ± 5.57 | 0.997 | NS |
| Length of hospital stay | 11.89 ± 11.28 | 10.15 ± 8.15 | 10.06 ± 7.47 | 11.82 ± 6.00 | 11.33 ± 10.17 | 0.954 | NS |

CRP, C-reactive protein.

Table 7 Description and relations between sex, smoking, C-reactive protein, mechanical ventilation, complications, and outcome among patients with different BMIs

| BMI group [N (%)] | P Significance |
|------------------|---------------|
| Normal | Underweight | Overweight | Obese | Morbidly obese |
| Sex | | | | | | |
| Male | 15 (83.3) | 7 (53.8) | 9 (62.9) | 10 (58.8) | 3 (50.0) | 0.300 | NS |
| Female | 3 (16.7) | 6 (46.2) | 8 (47.1) | 7 (41.2) | 3 (50.0) |
| Smoking | | | | | | |
| Nonsmoker | 5 (27.8) | 5 (38.5) | 8 (47.1) | 7 (41.2) | 3 (50.0) | 0.115 | NS |
| Ex-smoker | 4 (22.2) | 1 (7.7) | 0 (0.0) | 4 (23.5) | 3 (50.0) |
| Smoker | 9 (50.0) | 7 (53.8) | 9 (52.9) | 6 (35.3) | 0 (0.0) |
| CRP | | | | | | |
| Normal | 2 (11.1) | 2 (15.4) | 5 (29.4) | 4 (23.5) | 2 (33.3) | 0.620 | NS |
| Elevated | 16 (88.9) | 11 (84.6) | 12 (70.6) | 13 (76.5) | 4 (66.7) |
| Mechanical ventilation | | | | | | |
| Yes | 10 (55.6) | 11 (84.6) | 7 (41.2) | 9 (52.9) | 5 (83.3) | 0.108 | NS |
| No | 8 (44.4) | 2 (15.4) | 10 (58.8) | 8 (47.1) | 1 (16.7) |
| Complications | | | | | | |
| None | 9 (50.0) | 1 (7.7) | 11 (64.7) | 12 (70.6) | 2 (33.3) | 0.020 | S |
| Nosocomial Infections | 1 (5.6) | 3 (23.1) | 2 (11.8) | 3 (17.6) | 1 (16.7) |
| ARDS | 2 (11.1) | 1 (7.7) | 2 (11.8) | 1 (5.9) | 0 (0.0) |
| Septicemia | 3 (16.7) | 7 (53.8) | 0 (0.0) | 1 (5.9) | 1 (16.7) |
| MV complications | 3 (16.7) | 1 (7.7) | 2 (11.8) | 0 (0.0) | 2 (33.3) |

Outcome | | | | | | |
| Lived | 8 (44.4) | 1 (7.7) | 12 (70.6) | 14 (82.4) | 3 (50.0) | 0.001 | HS |
| Died | 10 (55.6) | 12 (92.3) | 5 (29.4) | 3 (17.6) | 3 (50.0) |

CRP, C-reactive protein.

Table 8 Comparison between the patients who died and those who survived in terms of complications

| Complications [N (%)] | P Significance |
|----------------------|---------------|
| None | Hospital-acquired infections | ARDS | Septicemia | Complications of MV |
| Outcome | | | | | |
| Lived | 32 (91.4) | 4 (40.0) | 0 (0.0) | 0 (0.0) | 2 (28.5) | 0.001 | HS |
| Died | 3 (8.6) | 6 (60.0) | 6 (100.0) | 11 (100.0) | 5 (71.5) | | |
The mean ± SD LOS among patients with elevated CRP was 10.37 ± 5.02 days, compared with patients with normal CRP, which was 11.55 ± 9.17 days, and the duration of MV among patients with elevated CRP was 6.18 ± 5.84 days, compared with those with normal CRP, which was 10.56 ± 10.71.

This study found that there was an insignificant correlation between CRP in terms of smoking, need for MV and duration of MV, outcome, and LOS in ICU.

These results are not in agreement with those of Lobo et al. [9], who found that increased CRP concentrations were associated with organ failure, prolonged ICU stay, and high infection and mortality rates; the difference in the results between this study and our study was because of the different numbers of patients, different age groups, and the fact that the study was not carried out in the RICU.

The present study is in agreement with Wang et al. [10], who found an independent association between CRP level and ICU mortality.

This current study found that there was an insignificant correlation between CRP and need for mechanical ventilation, and this is not in agreement with Schuetz et al. [11]; these differences may have been because of the inclusion of patients with different diseases in our study, whereas the study of Schuetz et al. [11] was carried out only on H1N1 patients.

The present study showed that there was an insignificant correlation between the CRP results and the duration of MV, but Zimmerman et al. [12] showed that both BMI and CRP can be used to estimate the risk of prolonged MV in critically ill trauma patients and concluded that BMI less than 23.3 kg/m² or CRP greater than 10 mg/l at the time of discontinuation of MV were independent predictors of more than 7 days' duration of MV.

The present study found an insignificant correlation in the LOS and CRP level and this is not in agreement with Bhattacharya et al. [13], who found that higher CRP levels result in longer duration of hospital stay and poor clinical and radiological recovery in patients with community-acquired pneumonia.

For BMI, in the present study, we found that 38 (53.5%) patients survived and 33 (46.5%) patients died; the patients who died were categorized in terms of BMI as follows: 10 (55.6%) patients were normal weight, 12 (92.3%) patients were underweight, five (29.4%) patients were overweight, three (17.6%) patients were obese, and three (50.0%) patients were morbidly obese.

The present study reported that there was high significance between different BMI categories and outcome, wherein the mortality rate was high among underweight patients, but this result was not in agreement with that of Lobo et al. [9], who found an increased risk of morbidity and mortality for morbidly obese patients, and critically ill morbidly obese patients had higher ICU mortality compared with nonobese patients. Because missing data were not detected because of the retrospective design of the study, it was difficult to draw a conclusion on the exact influence of BMI on mortality in this study; also, Honarmand and Safavi [14] showed that obese patients had a mortality rate that was 3.9 times greater than that of the normal-weight group. In addition, Lissner et al. [15] found that obesity defined as BMI greater than 27 was associated with a higher mortality rate among ICU patients. Also, Goulenok et al. [16] reported that, after they controlled for comorbidities, obesity was not associated with increased mortality in 'seriously ill' hospitalized patients, whereas Galanos et al. [17] showed that abnormal BMI had no significant influence on ICU mortality. In contrast to previous reports, the obese group showed a trend toward reduced mortality and reduced duration of ICU care and hospital stay compared with the underweight and normal groups.

### Table 9 Comparison between patients who died and those who survived in terms of diagnosis

| Diagnosis | N (%) | P  | Significance |
|-----------|-------|----|--------------|
| Infections | 9 (34.6) | 20 (80.0) | 4 (50.0) | 0 (0.0) | 0.001 | HS |
| COPD/asthma | 17 (65.4) | 5 (20.0) | 4 (50.0) | 6 (100.0) |

COPD, chronic obstructive pulmonary disease.

### Table 10 Comparison between patients with and without nosocomial infection in terms of length of hospital stay and duration of mechanical ventilation

| Nosocomial infection | (mean ± SD) | P  | Significance |
|----------------------|-------------|----|--------------|
| Length of ICU stay (days) | 9.19 ± 6.49 | 20.33 ± 10.93 | 0.0001 | HS |
| Duration of MV (days) | 4.34 ± 4.83 | 16.00 ± 6.55 | 0.0001 | HS |
The data of the present study are in agreement with those of Lim et al. [18], who found increased mortality in the underweight patients in the medical and emergent surgical groups, but not in the elective surgical group, and also El-Solh et al. [6] in agreement with the present study as he found that low BMI was associated with increased mortality and worsened hospital discharge.

Obese patients have higher levels of leptin. Bornstein et al. [19] reported a positive association between leptin concentrations and survival of septic patients, suggesting that leptin could play a role in the adaptive response to critical illness. Also, Tremblay and colleagues [20,21] found increased mortality associated with underweight and obese patients, particularly in patients with higher levels of obesity, relative to the normal-weight category. Moreover, mortality was significantly higher among patients acquiring more than one nosocomial infection than in paired controls. The same results have been reported by Gendall et al. [31].

Conclusion
The study concluded that:

1. CRP is not a good marker of morbidity and mortality in RICU patients.
2. CRP exerted an independent effect on duration of MV and LOS in RICU.
3. Mortality rate was high in underweight patients, but not in overweight, obese, or severely obese patients.
4. BMI exerted no effect on duration of mechanical ventilation and LOS in the RICU.

Acknowledgements
Conflicts of interest
None declared.

References
1. Povoça P, Coelho L, Almeida E, Fernandes A, Meialha R, Moreira P, Sabino H. C-reactive protein as a marker of infection in critically ill patients. Clin Microbiol Infect 2005; 11:101–108.
2. Pinto-Plata VM, Mullerova H, Tosój FJ, et al. C-reactive protein in patients with COPD, control smokers, and non-smokers. Thorax 2006; 61:23–28.
3. Lobo SM, Lobo FR, Botê DP, Lopes-Ferreira F, Soliman HM, Meléot C, Vincent JL. C-reactive protein levels correlate with mortality and organ failure in critically ill patients. Chest 2003; 123:2043–2049.
4. Pepys MB, Hirschfield GM. C-reactive protein: a critical update. J Clin Invest 2003; 111:1805–1812.
5. Rose DK, Cohen MM, Wigglesworth DF, et al. Critical respiratory events in the post anesthesia care unit. Patient, surgical, and anesthetic factors. Anesthesiology 1994; 81:410–418.
6. El-Solh A, Sikka P, Bozkant E, et al. Morbid obesity in the medical ICU. Chest 2001; 120:1969–1977.
7. National Institute for Health and Clinical Excellence. Clinical guideline 43. Obesity: the prevention, identification, assessment and management of overweight and obesity in adults and children. London: Mosby; 2006.
8. Nilsson LA. Expression of C-reactive protein in the human respiratory tract, Acta Path Microbiol Scand 1968; 73:129.
9. Lobo FR, Bote DP, Lopes-Ferreira F, Soliman HM, et al. C-reactive protein levels correlate with mortality and organ failure in critically ill patients. Chest 2003; 123:2043–2049.
10. Wang F, Pan W, Pan S, Wang S, Ge Q, Ge J. Usefulness of N-terminal pro-brain natriuretic peptide and C-reactive protein to predict ICU mortality in unselected medical ICU patients: a prospective, observational study. Crit Care 2011; 15:R42.
11. Schuetz P, Müller B, Nüsbaum C, Wieland M, Christ-Crain M. Circulating levels of GH predict mortality and complement prognostic scores in critically ill medical patients. Eur J Endocrinol 2009; 160:157–163.
12 Zimmerman O, Rogowski O, Aviram G, Mizrahi M, Zeltser D, Justo D, et al. C-reactive protein serum levels as an early predictor of outcome in patients with pandemic H1N1 influenza A virus infection. BMC Infect Dis 2010; 10:288.

13 Bhattacharya B, Prashant A, Vishwanath P, et al. Prediction of outcome and prognosis of patients on mechanical ventilation using body mass index, SOFA score, C-reactive protein, and serum albumin. Indian J Crit Care Med 2011; 15:82–87.

14 Honarmand A, Safavi M. Do C-reactive protein and body mass index predict duration of mechanical ventilation in critically ill trauma patients?. Ulus Travma Acil Cerrahi Derg 2008; 14:284–291.

15 Lissner L, Odell PM, D'Agostino RB. Variability of R body weight and health outcomes in the Framingham population. N Engl J Med 2009; 324: 1839–1844.

16 Goulenok C, Monchi M, Chiche JD, Mira JP, Dhainaut JF, Cariou A. Influence of overweight on ICU mortality: a prospective study. Chest 2004; 125:1441–1445.

17 Galanos AN, Pieper CF, Kussin PS, Winchell MT, Harrell FE Jr, et al. Relationship of body mass index to subsequent mortality among seriously ill hospitalized patients. SUPPORT Investigators. The Study to Understand Prognoses and Preferences for Outcome and Risks of Treatments. Crit Care Med 1997; 25:1962–1968.

18 Lim SY, Kim SI, Ryu YJ, et al. The body mass index as a prognostic factor of critical care. Korean J Intern Med 2010; 25:162–167.

19 Bornstein SR, Licinio J, Tauchnitz R, Engelmann L, Negró AB, Gold P, Chrousos GP. Plasma leptin levels are increased in survivors of acute sepsis: associated loss of diurnal rhythm, in cortisol and leptin secretion. J Clin Endocrinol Metab 1998; 83:280–283.

20 Tremblay A, Bandi V. Impact of body mass index on outcomes following critical care. Chest 2003; 123:1202–1207.

21 Garrouste-Orgeas M, Troche G, Azoulay E, et al. Body mass index. An additional prognostic factor in ICU patients. Intensive Care Med 2004; 30:437–443.

22 Peake SL, Moran JL, Ghelani DR, Lloyd AJ, Walker MJ. The effect of obesity on 12-month survival following admission to intensive care: a prospective study. Crit Care Med 2006; 34:2929–2939.

23 O'Brien JM Jr, Welsh CH, Fish RH, Ancukiewicz M, Kramer AM, National Heart, Lung, and Blood Institute Acute Respiratory Distress Syndrome Network. Excess body weight is not independently associated with outcome in mechanically ventilated patients with acute lung injury. Ann Intern Med 2004; 140:338–345.

24 KM Flegal, BI Graubard, DF Williamson, MH Gail. Excess deaths associated with underweight, overweight, and obesity. JAMA 2005; 293:1861–1867.

25 Landi F, Onder G, Gambassi G, Pedone C, et al. Body mass index and mortality among hospitalized patients. Arch Intern Med 2000; 160:2641–2644.

26 Allison DB, Gallagher D, Heo M, Pi-Sunyer FX, Heymsfield SB. Body mass index and all-cause mortality among people age 70 and over: the Longitudinal Study of Aging. Int J Obes Relat Metab Disord 1997; 21:424–431.

27 Calle EE, Thun MJ, Petrelli JM, Rodriguez C, Heath CW. Body mass index and mortality in a prospective cohort of U.S. adults. N Engl J Med 1999; 341:1097–1105.

28 Valencia M, Torres DJ. Ventilator-associated pneumonia. Curr Opin Crit Care 2009; 15:30–35.

29 Fagon JY, Chastre J, Hance AJ, Montravers P, Novara A, Gi bert C. Nosocomial pneumonia in ventilated patients: a cohort study evaluating attributable mortality and hospital stay. Am J Med 1993; 94:281–288.

30 Pittet D, Tarara D, Wenzel RP. Nosocomial bloodstream infection in critically ill patients. Excess length of stay, extra costs, and attributable mortality. JAMA 1994; 271:1598–1601.

31 Gendall KA, Raniga S, Kennedy R, Frizelle FA. The impact of obesity on outcome after major colorectal surgery. Dis Colon Rectum 2007; 50:2223–2237.